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Ecosystem services and socio-economic benefits of Mediterranean grasslands

Edited by:
A. Kyriazopoulos, A. López-Francos, C. Porqueddu, P. Sklavou

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Ecosystem services and socio-economic benefits of Mediterranean grasslands

Editors: A. Kyriazopoulos, A. López-Francos, C. Porqueddu, P. Sklavou

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Foreword

Mediterranean grasslands (including rangelands, pastures, meadows, fodder crops) are important resources with a surface area covering up to 48% of the whole Mediterranean region. Although these ecosystems have traditionally played an important role in the evolution of human societies, and are still the key element in the production of high quality animal products, they have been considered merely as a source for providing feed for domestic ruminants. Grasslands are essentially providing a range of ecosystem services besides forage production, such as biodiversity conservation, habitat for wildlife, carbon fixation, prevention of erosion and nutrient storage. Sustainable management should match environmental conservation, livestock production and socio-economic development. Both intensive utilization (i.e. overgrazing) and land abandonment have negative consequences on grassland resources and cause soil erosion, losses of land-use diversity and biodiversity. Although there are socio-economic differences between the different Mediterranean regions, they share common issues on grasslands. There is a need for a greater adaptation of grasslands to increasing drought periods and seasonal variability that are predicted by climate change scenarios. Multidisciplinary research is needed to identify the best-adapted and most productive grassland species and mixtures to produce high-quality livestock products in the different regions, along with the most appropriate grazing management. Multidisciplinary experiments are also needed to monitor the pastoral resources, environmental outputs and ecological services associated with Mediterranean grasslands, to ensure a better understanding of the complexity of grassland ecosystems and to inform management decisions and measures for mitigation of climate change. More on-farm experimentation and participatory knowledge transfer to farmers are also required to optimize the sustainability of grassland systems.

This publication is the outcome of the 15th Meeting of the FAO-CIHEAM Inter-regional Cooperative Research and Development Sub-Network on Mediterranean Pastures and Fodder Crops titled "Ecosystem services and socio-economic benefits of Mediterranean grasslands" which was organised in Orestiada (Greece) from 12 to 14 April 2014, and it includes the invited and selected papers presented at the Meeting. The 15th Meeting was jointly organized by the Mediterranean Agronomic Institute of Zaragoza of the International Centre for Advanced Mediterranean Agronomic Studies (IAMZ-CIHEAM), the Democritus University of Thrace (DUTH - Greece), the Aristotle University of Thessaloniki (AUTH - Greece) and the Hellenic Range and Pasture Society (HERPAS – Greece).

The seminar covered a range of topics that were allocated to four sessions:

1. Managing ecosystem services and livestock production in the Mediterranean region.
2. Improvement of range, pasture and forage species including alternative uses.
3. Socio-economic benefits of sustainable grassland management.
4. Rehabilitation of Mediterranean grasslands.

Almost 90 scientific contributions were presented and discussed including introductory and invited papers, short oral communications and poster presentations. Also the contributions given at the Round Table on "Connecting research, policy and stakeholders challenges for the sustainability of grasslands" are included.

At this point we want to thank all authors for submitting papers, all the members of the Scientific Committee that carried out the revision of the contributions and all members of the Organizing Committee for preparing this conference. Finally we express our gratitude to the Mediterranean Agronomic Institute of Zaragoza (CIHEAM-IAMZ, Spain) for the support of our Sub-Network in terms of Meeting secretariat, proceedings publication, grants, etc.

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"Ecosystem services and socio-economic benefits of Mediterranean grasslands"

(Orestiada, Greece, 12-14 April 2016)

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Introductory Session

Ecosystem services and socio-economic benefits of Mediterranean grasslands

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Abstract. The Ecosystem Services (ES) framework is increasingly being adopted by researchers and practitioners to underline the many services that Mediterranean grasslands provide to society at large, beyond tangible provisioning services. Incorporating the social dimension in the supply and demand of these services implies acknowledging the different preferences and values of stakeholders and the likely spatial-temporal mismatches between providers and beneficiaries. The consideration of grasslands as socio-ecological systems seems crucial to acknowledge the human component needed for their maintenance and hence for the generation of ES. The description of ES provided by Mediterranean grasslands has already been undertaken by several studies; however, their quantification from an economic point of view seems a central issue to raise awareness about the protection and maintenance of these systems. This article presents some key concerns related to the classification of these ES that should be born in mind when attempting to estimate the economic value of these systems, so as not to incur in inconsistencies such as double-counting. Despite the undoubtable benefits of quantification, this article also shows the importance of counting on qualitative assessments of social preferences, especially for services, such as cultural ones, that are difficult to encompass or appraise by standard economic valuation methods.

Keywords. Economic valuation – Double-counting – Social-ecological systems – Qualitative methods.

Les services écosystémiques et les bénéfices socio-économiques des pâturages méditerranéens

Résumé. *Le cadre des Services Écosystémiques (SE) est de plus en plus adopté par les chercheurs et praticiens pour souligner les nombreux services que les pâturages méditerranéens fournissent à la société en général, au-delà des services tangibles d'approvisionnement. Incorporer la dimension sociale dans l'offre et la demande de ces services implique de reconnaître les différentes préférences et valeurs des parties prenantes et les éventuelles discordances spatio-temporelles entre fournisseurs et bénéficiaires. La considération des pâturages en tant que systèmes socio-écologiques semble cruciale pour la reconnaissance de la composante humaine nécessaire à leur maintien et donc pour la création de SE. La description des SE fournis par les pâturages méditerranéens a déjà été entreprise par plusieurs études; cependant leur quantification sous l'angle économique s'avère une question centrale pour sensibiliser quant à la protection et au maintien de ces systèmes. Cet article présente quelques éléments-clés liés à la classification de ces SE dont il convient de tenir compte lorsqu'il s'agit d'estimer la valeur économique de ces systèmes, pour ne pas tomber dans des inconsistances comme le double-comptage. Malgré les bénéfices indubitables de la quantification, cet article montre également l'importance de disposer d'évaluations qualitatives des préférences sociales, en particulier pour les services, tels que ceux d'ordre culturel, qui sont difficiles à aborder ou apprécier par les méthodes standard d'évaluation économique.*

Mots-clés. *Évaluation économique – Double-comptage – Systèmes socio-écologiques – Méthodes qualitatives.*

I – Introduction

Mediterranean grasslands include rangelands, meadows, pastures and fodder crops (Porqueddu *et al.,* 2014). Their existence is tightly linked to extensive grazing, a land use that takes place on areas generally unsuitable for intensive cultivation due to several reasons. They are mainly seen through their provisioning role of food and fibers (Nieto-Romero *et al.*, 2014), although they can provide a multiple array of other services such as erosion control, carbon sequestration, recreational opportunities or cultural identity. In this sense the ecosystem service (ES) approach may help unveiling the contributions of these ecosystems to societal wellbeing.

The qualitative description of the ecosystem services provided by grasslands has to some extent been accomplished, and a significant challenge ahead consists of quantifying them and if possible doing so in monetary units. This quantification is seen as essential to add value to these ecosystems and it is considered a research priority (FAO, 2013).

A crucial aspect when assessing ES of Mediterranean grasslands is their consideration as socio-ecosystems. It highlights the fact that the ecosystem services (ES) they provide are far from being "natural", but on the contrary are tightly linked to human activities (Hutsinger and Oviedo, 2014).

The future societal demands due to increased population and the constraints imposed by climate change in the Mediterranean may increase the pressure on regulating and supporting services to guarantee the flow of provisioning services. Therefore, navigating the trade-offs between provisioning, regulating, cultural, and supporting ecosystem services, as well as maintaining natural capital that is critical to generate future services, is essential for achieving sustainability (Cavender-Bares *et al.*, 2015).

Management of social-ecological systems requires understanding both the biophysical constraints that create trade-offs among ecosystem services and human values to understand the preferences of the stakeholders and the services that contribute to their well-being (Cavender-Bares *et al*., 2015). In addition, issues such as property rights, thresholds, hysteresis, nonlinear dynamics and resilience of these socio-ecosystems should be incorporated into the ES agenda.

This article revises some basic concepts on the ES terminology and classification. It also provides a review of some studies addressing the social dimension of ES assessment both from a quantitative and qualitative perspective. It also signals some of the caveats in the ES approach and proposes the concepts that should be incorporated in such debate.

II – Ecosystem services as a working framework

1. Introduction: concept definition

The Ecosystem Services (ES) concept has become increasingly popular in the last decades and it is usually employed to emphasize the contributions of ecosystems to human welfare. Although the recognition of the capacity of natural systems to provide benefits to society was already present, the concept of ES provides a framework where the contribution of ecosystems to societal wellbeing is highlighted.

Furthermore, this approach calls for a more fundamental multidisciplinary focus, promoting a dialogue between biology and economics (Lele *et al.*, 2013) by considering both the ecological production and the economic value (Bauer and Johnston, 2013). It allows to distinguishing the contribution of benefits to society supplied by ecosystems from those provided by human capital or labour (Bateman *et al.,* 2011; Brown *et al*., 2007), offering a framework to link changes in ecosystem processes and outputs to its effects on social welfare.

The most popular and widespread definition of ES was that provided by the Millennium Ecosystem Assessment (MEA, 2005) where ES are defined as the outputs of natural systems that benefit society. However, in the last years, a number of authors have tried to produce a more refined set of working definitions that allow a quantification and mapping of ES in a consistent way, for example avoiding double counting or highlighting where the beneficiaries of a given ES may be.

The review and blueprint proposal for ES assessment in Crossman *et al*. (2013) provides with a comprehensive set of definitions compiled from a number of authors. In this study ES are defined as the contributions of ecosystem structure and function –in combination with other inputs- to human wellbeing (Burkhard *et al*., 2012). A key difference is established between intermediate and final ES. Intermediate ES comprise the ecosystem processes (all the changes and reactions occurring in the ecosystems and includes physical, chemical or biological processes) (MEA 2005) and also the ecosystem functions that give the capacity to the ecosystems to provide services that satisfy human needs, such as pollination, water purification or carbon sequestration. Final ES are the direct contributions to human well-being, such as clean water provision, storm protection or harvest production (Fisher *et al.,* 2009). To transform these final ES into benefits for society typically other forms of capital are required (such as labor or produced assets (e.g. to consume fruits and vegetables or to make water available at domestic level).

Under this view services and benefits are not the same and hence some authors consider the valuation of ecosystem services alone (Fisher *et al.,* 2009; Boyd and Banzhaf, 2007), while others are in favor of defending the valuation of both ES and benefits as separate elements (Wallace**,** 2007).

In an economic sense, ES are distinguished from other ecosystem functions in that there are beneficiaries willing to pay for the use or preservation of those scarce services (Chan *et al*., 2006; Caparrós, 2012). Final outputs are traded in markets or consumed by society as they are, and are usually the focus of economic analysis, while intermediate outputs are used to create final outputs (Caparrós *et al.*, 2012).

This distinction is crucial so as to avoid double-counting. In the case of grasslands, if the farmer sells a grass-fed sheep, the final output (i.e. the benefit), is the sheep sold, while the grass intake by the animal is the intermediate input or service. Grass clearly has a value that can be quantified. Hence its value should not be computed twice, once as the ecosystem service ''grazing'' and a second time as a part of the final benefit, the sheep. Defining an economic value and establishing the methods for valuing ecosystem services requires a precise definition of those services as final or intermediate outputs.

To sum up, the establishment of a more accurate definition allows to highlight that not everything can be considered an ES and that the services are often benefit-dependent, so that the benefits we're interested in assessing will dictate what we understand as ES.

2. Ecosystem services classifications

The MEA (2005) has achieved perhaps the greatest scientific consensus in the recent years with respect to providing a classification of ES into four main classes:

- Provisioning services: are the products people obtain from ecosystems, such as food, fuel, fiber, fresh water, and genetic resources.
- Regulating services are the benefits people obtain from the regulation of ecosystem processes, such as air quality maintenance, erosion control or water purification.
- Cultural services are the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, recreation, and aesthetic experiences.
- Supporting services are those that are necessary for the production of all other ecosystem services, such as primary production, and soil formation.

The perspective we adopt and the classification is crucial, so as to differentiate intermediate ecosystem functions from final ecosystem services and avoid double counting (e.g., Boyd and Banzhaf, 2007; Brown *et al.,* 2007; Fisher *et al.,* 2009; Wallace, 2007)

Because accounting for supporting services may lead us to incur in double counting, some classifications do not consider supporting services as finals services or outputs, but as intermediate processes and functions. Such is the case of the Common International Standard for Ecosystem Services (CICES) (2015). The focus of the CICES on environmental accounting and the risk of incurring in double counting, led to this classification to recognize these outputs from ecosystems to be provisioning, regulating and cultural services. Supporting services are treated as part of the underlying structures, process and functions that characterize ecosystems.

3. Challenges faced by this approach

Describing, quantifying and mapping ES is nowadays challenging due to the scarcity of information or the need to reframe existing data into the ES framework. We still have relatively little understanding of the ecology behind the provision of ecosystem services (Kremen and Ostfeld 2005). The number of studies assessing the services provided by different ecosystems is increasing; however, most services are assessed individually and only in a few instances studies deal with interactions among more than two services (MEA, 2005). This raises a concern on the fact that the emphasis is put on optimizing a small number of ES, which may jeopardize environmental sustainability (Plieninger *et al*. 2015).

Taking into account several services simultaneously brings the difficulty of dealing with trade-offs (Isselstein 2014). The trade-off concept in the context of agrarian systems has been effective to account for the negative effects of production (i.e. when a provisioning service is maximized) and typically affects regulating services or create what is known as disservices (Power, 2010; Sanderson and Wätzold, 2010). As Bennett *et al.* (2005) highlight, it is very frequent to focus on a very narrow set of ES, and try to maximize them, incurring in unexpected trade-offs or sudden declines in other ES.

Provisioning services have been more profusely studied, which are widely recognized as essential for meeting human needs for nutrition, shelter, and safety. Regulating services are more complex but have been brought to public attention by discussions of climate change and recent natural disasters. Supporting services are fundamental to all other services, but their relationship to human needs can be indirect and complex. In contrast, most cultural services are directly experienced and intuitively appreciated, often helping to raise public support for protecting ecosystems (Daniel *et al.*, 2012).

However, quantification of the actual flow and use of these services is a key challenge; without quantification, the value of most services is not easily understood. Quantification has to deal with the spatial mismatch of ecosystems that provide value and the people that enjoy the services, as sometimes these two sides of the chain may be distant from each other. Bagstad *et al.* (2013) among other authors have developed models to link ES with their beneficiaries, highlighting the spatial connectivity between both ends.

Economic quantification of ES is shaped by two economic assumptions (Winthrop, 2014): The first of them is a stock-flow model that assumes a stock of natural capital from which a flow of ES, similar to interest or dividends (de Groot *et al*,.2010), links the ecological and economic systems (Norgaard, 2010). On second place, if we intend to estimate environmental values, these are understood as an aggregation of citizens' willingness-to-pay. These two assumptions may be too simplistic when dealing with complex interactions in the ecosystems, thresholds, hysteresis and non-linearities, which are not taken into account by these previous assumptions rooted on the neoclassical economics.

Furthermore, the adoption of a quantitative approach may not be well suited when it comes to cultural ecosystem services. Hence a qualitative approach may be need for a good characterization of these. Often considered secondary to financial concerns, cultural services can have critical influence on landowner decisions and subsequently on efforts to manage privately owned land. Cultural ecosystem services also motivate rural and urban residents to engage with public or community land. Cultural ecosystem services can also inform landscape planning (Albert *et al.*, 2014).

Last but not least, some attention has to be placed on the ES term. It implies that ESs are a function of natural processes but in many cases human interaction may be key to the production of many of them (Hutsinger and Oviedo, 2014).This risk should especially be born in mind when addressing ecosystems such as grasslands. To varying degrees these ecosystems have been modified or even created by human activity. Hence, problems arise when the human activity is disregarded as a factor in the cogeneration of these ecosystems, either because it is perceived as harmful or because it is not taken into account as a driver. As Hutsinger and Oviedo (2014) propose, thinking of such services as "social-ecological" services can reinforce the importance of human culture, perspectives, and economies to the production of ES and change the conception that rather than thinking of something coming from an ecosystem has cultural value, we indicate that cultural activities cogenerated the service.

III – Mediterranean grasslands and ecosystem services

1. Key features and dynamics of Mediterranean grasslands

According to Peeters *et al.* (2014) grasslands correspond to land devoted to the production of forage for harvest by grazing/browsing, cutting, or both, or used for other agricultural purposes such as renewable energy production. The vegetation can include grasses, grass-like plants, legumes and other forbs; woody species may also be present. This definition encompasses the temporary or permanent character of grasslands and also makes a distinction between meadows and pastures, depending on whether they have been harvested by mowing or by grazing, respectively.

In the Mediterranean, livestock use is in general dominated by sheep and goats (Porqueddu *et al.,* 2014) able to profit from these type of pastures. A key feature of Mediterranean grasslands is the complementarity of herbaceous species with a woody component and with agricultural systems (e.g. stubble grazing) that provides stability to the grazing activity.

Most of them to a greater or lesser extent can be defined as "semi-natural" grasslands, since they have been created and maintained by human activities although their plant communities are natural. Hence the continuation of cutting, and more commonly grazing activities are crucial for the protection of the species they harbor.

Livestock grazing is the key element in these ecosystems (Cosentino *et al.,* 2014) for its dual role in maintaining these ecosystems and strongly driving its dynamics (Perevolotsky, 2005). This calls for their consideration as socio-ecological systems acknowledging that pastoralism is a culture that cogenerates the services. This consideration also helps to understand that the distinctly different socio-economic and political factors in both parts of the basin, have also played a significant role in forming the structure of agricultural practices (Aw *et al*.*,* 2010). Therefore, conservation efforts should also recognize the need to maintain the human activity to sustain the services (Hutsinger and Oviedo, 2014).

Two main socio economic drivers have played a key role in shaping Mediterranean grasslands and agroecosystems in general: rural abandonment of mountainous and less productive areas, particularly on the northern fringe on the Basin, and land-use intensification of fertile areas where grasslands have been converted into arable land (Bernués *et al.,* 2011).

The reduction in the number of farms in northern Mediterranean countries is associated with two processes depending on the CAP: large increments of herd size and dependency on premiums (Bernués *et al*.*,* 2011), although at the same time some agro-environmental policies have tried to counteract this process. The abandonment process has brought encroachment of woody vegetation that may in the future produce some environmental benefits (Rey Benayas *et al.,* 2007; Quero *et al*., 2013). However, at the landscape scale, the loss of mosaic structure and increased homogenization makes these transitional landscapes quite fire prone (Moreira *et al.,* 2011). In absence of appropriate landscape management, it will be the fire suppression capacities that will configure the future landscapes (Regos *et al.*, 2014).

The situation in southern Mediterranean regions shows an increasing demand for animal products derived from the rapid increase in human populations. The contribution of grassland to livestock feed has gradually decreased from 80% in the 1980s to <30%, increasing the feed intake of grains (Ryan *et al*., 2008), while production systems based on extensive grazing are concentrated in arid areas and suffer an increasing pressure (Le Houerou, 2000; Porqueddu *et al*., 2014).

Climate change is expected to have a high impact in the Mediterranean basin due to increase in temperature and inter-annual variability (IPCC 2014). Changes in these ecosystems are related to carbon stocks and pasture productivity, affecting the length of the grass growing season and hence the forage quality and quantity and indirectly through livestock disease increase (IPCC, 2014). Therefore, addressing the adaptation of grassland ecosystems to these changes in order to identify the species and dynamics that can better cope with these changes, to increase their resilience and improve the adaptation capacities seems crucial. However, socio-economic changes are expected to have a still greater effect on mitigation and adaptation potentials (Schmidhuber and Tubiello, 2007); among those, pressure on livestock production systems is expected to increase together with competition on grains between animal and human feeding (Ates *et al*., 2014).

2. Ecosystem services provided by Mediterranean grasslands

Applying the ES framework to grassland and livestock farming systems may help in considering regulating, supporting and cultural ES that these ecosystems provide to society and also to integrate those at the same level with provisioning ES, which is the dimension that so far seems to be more studied. This approach may also contribute to the assessment of the multiple trade-offs and synergies that exist between ES, allowing for a better integration of agricultural policies in other sectors (Rodríguez-Ortega *et al.*, 2014).

Due to the fact that grassland management is quite diverse, the flow of ES may greatly differ from one system to the other, depending among other factors on the intensity of the production systems. Hence services and disservices can take place along a gradient of intensity in the use of the resources.

Grasslands are mainly acknowledged for their provisioning services; this is the most prominent service and has motivated their existence. Furthermore, provisioning services (i.e. grazing) produce a series of benefits, such as meat or milk, which are private market goods appraised by the famer. Many times, these farm products have special sensorial and nutritive qualities linked frequently to labels such as products with Denomination of Origin. Hence, beyond this provisioning dimension, these products may also raise values linked to cultural heritage for consumers (Zander *et al*., 2009). This cultural value may play an important role in connecting rural and urban populations.

Hence, the provisioning services provided by these spaces that have a clear private components in terms of benefits for the farmer that appraises them, are intertwined with cultural and heritage values linked to these traditional breeds and also with reduced impacts on regulating services. The later services have features of public and semi-public goods and hence are not appraised by the farmer and internalized in the system.

Managed grasslands are usually ecosystems with high species diversity (Ribeiro *et al*., 2014). Biodiversity as a whole is usually considered as a supporting service as it enables the ecosystem processes and functions needed to deliver non-supporting services. The ecosystem properties that underlie ecosystem services depend largely on biodiversity and especially on functional diversity (the presence or abundance of particular functional groups or functional traits) rather than on species number (Hooper *et al.*, 2005; Le Roux *et al.,* 2008).

In particular, a growing knowledge on plant functional traits (e.g. leaf dry matter content, vegetative height and date of flowering onset) is making it possible to quantify ecosystem services based on responses of functional traits to environmental change and/or effects on ecosystem properties (Diaz *et al.* 2007; Lamarque *et al.* 2011).

Grasslands provide regulating services storing important carbon stocks. Cultivation and urbanization of grasslands, desertification or overgrazing can be significant sources of carbon emissions. Grasslands can act as carbon sinks, although under certain climate conditions (drought or heat waves) they can switch from carbon sinks to carbon sources (Freibauer *et al.,* 2004). Most of the soil organic carbon content of grasslands is not in the biomass, but in the soil as a large part of the grassland biomass production is located in the rot biomass, unlike many arable production system (Huyghe *et al.,* 2014). However, this has been little studied in Mediterranean grasslands and hence coordinated experiments in different Mediterranean regions are required to quantify the carbon sequestration contribution of natural and semi-natural grasslands, as well as the contributions of key pasture species (Porqueddu *et al.*, 2014).

Soil erosion is a severe problem in Mediterranean countries. Grasslands as a permanent soil cover reduce the likelihood of soil losses (Schnabel *et al*., 2009). On the other hand, overgrazing by livestock is considered one of the causes of soil erosion in the Mediterranean (Papanastasis, 1998) and hence a disservice.

Grasslands contribute to maintain the openness of Mediterranean cultural landscapes characterize by its mosaic-like configuration (Farina, 2008). Considering the contribution of these areas to cultural services such as improving the aesthetic experience and recreational opportunities is difficult to elucidate. Aesthetic preferences are highly subjective and incorporate social constructs (Rodríguez-Ortega *et al*., 2014). However, diverse studies show that people tend to prefer diverse landscapes, and openness is a key feature in determining their preferences (Sayadi *et al*., 2005). The maintenance of open spaces with low biomass content in the landscape is key for reducing fire risk at the landscape scale (Ruiz-Mirazo *et al.,* 2011) and increase suppression opportunities.

IV – Operationalizing the ES concept: socio-economic benefits

Some of the major barriers to effective resource planning arise because different stakeholder groups hold different preferences for services (Martín-López *et al*., 2012), and these differ in their spatial or temporal patterns of benefits and costs (Laterra *et al.,* 2012). Hence, we need a variety of tools derived from the social sciences to appraise social preferences, needs, values, norms, behaviors of stakeholders and individuals, institutions and organizations towards ES (Cowling *et al*., 2008). Addressing the social dimension of ES means tackling the demand of ESs together with its supply, rather than focusing on the supply side alone (Termorshuizen and Opdam, 2009).

Methods in economics allow to identify issues on property rights and assess the willingness of stakeholders to trade-off ES from a quantitative perspective, attaching a monetary value to these trade-offs.

Typically pasture-based LFS suffer displacement by other economic activities. From a strictly financial dimension, abandonment or land use change seem as more profitable options rather than maintaining the flow of services these systems provide to society. When the biodiveristy/genetic resources conservation generates economic values that are not captured in the market place, it generates a distortion where the incentives are against genetic resources conservation and in favour of the economic activities that erode such resources (Pearce and Moran, 1994). In fact, failing to account for these non-market values (such as future option values or socio-cultural values) works against the sustainability of the system.

This situation is related to non-enforceable property rights related not to the property of the land, but uttermost to the property over the services and the benefits derived for people. Most environmental services fall under the economic category of pure public goods or open access/common goods. A distinctive characteristic of a pure public good is that consumers do not have the option for not consuming it, e.g. carbon sequestration. The reason for the under provision of public goods is that the owner or provider cannot appropriate the full benefits. These public goods as positive externalities derived from the management of these ecosystems. However, the market system fails to 'price' this interdependence, as a result of which the affected party is uncompensated. Reasons for it are a lack of or weak property rights. At the European level agricultural systems fail to provide the services that society as a whole is demanding (Cooper *et al*., 2009).

In this context valuing these ES, that is quantifying them in monetary units, is emerging as a framework within which policies targeted to halting the degradation of the natural environment are developed. While ecological models define the relationships and trade-offs among services that represents an "efficiency frontier", these, together with methods in economics that combine preferences that define the willingness of stakeholders to trade off ecosystem services on the efficiency frontiers, illuminate desirable outcomes that meet human needs and secure sustainability of the system (Cavender-Bares *et al.*, 2015).

1. Quantitative methods to assess the demand (and supply) of ES

The Total Economic Value (TEV) is an analytical framework used in economic valuation to link ecosystem process and functions with the benefits it provides for society, which can be assigned monetary economic values. The concept of TEV has been developed as a guarantee that the benefits are considered systematically and comprehensively, without any double counting. The TEV is the sum of use values and non-use values. Use values are further broken down as follows: 1. Direct use value, includes interaction with the ecosystem through consumptive use such as the harvesting of crops, or may be non-consumptive such as recreational activities.2. Indirect use value, derived from ecosystem services, such as cleaner water to downstream users, carbon sequestration, and flood control or erosion prevention. 3. Option value: considers having the option of using the resource in the future, directly or indirectly. Among non-use values we can distinguish: 1. Altruistic value: is derived from the satisfaction of knowing that other people have access to benefits of the farming system provides. 2. Bequest value: arises from the interest in preserving a certain ecosystem or species for future generations. 3. Existence value: is derived from the knowledge of the existence of a particular ecosystem or species.

Despite that use values are prevailing in the agricultural sector and farming systems, there is an increasing social demand for non-use values provided by agricultural landscapes and precisely these give name to the so-called multifunctionality of agricultural systems. Typically use values are observable in the market (e.g. meat price) or in surrogate markets (e.g. recreational value of a landscape through the estimation of the expenses visitors incurred in). However, values linked to non-use components need of economic valuation methodologies to be estimated, usually through surveys where people’s welfare from preserving or enhancing the grassland ecosystem, for example, is measured as their willingness-to-pay for such an enhancement.

The following are some examples of valuation studies conducted to assess the non-market values linked to agrarian ecosystems. Bernués *et al*. (2014) assess the TEV of key ES of a Mediterranean mountain agroecosystem, most of them extensive grazing ecosystems. They conducted a survey to assess preferences for landscape changes (towards abandonment or encroachment), threatened species (bearded vulture), occurrence of fire events and quality products linked to the territory. In their study they also show how local population holds different preferences when compared to these of regional citizens who will not be directly affected by landscape management measures with local population more concerned about the ES related directly to their farming activity and regular citizens showing a more general concern. Hasund *et al.* (2010) conducted a survey to estimate the willingness-to-pay of the population for different types of elements and other environmental qualities of the agricultural landscape. This CE is designed to estimate the marginal values of 8 grassland types, 10 types of field elements and 9 agri-environmental-quality attributes. The attributes were carefully selected to be applicable as criteria for agrienvironmental payments. Their results show that people are willing to pay to preserve field elements, and value elements having more biodiversity, visual or cultural heritage interest considerably higher than those lacking these attributes, being the oak-wooded grassland the most highly valued landscape. Varela *et al.* (2014) conducted a survey in southern Spain that shows that the population values positively the fuel break maintenance by controlled grazing over traditional heavy machinery methods to control biomass content. Zander *et al.* (2013) assess the TEV of conserving two local Italian cattle breeds. The non-market values accounted by the conservation of these species accrue around 80% of the value of these species, including landscape maintenance, existence and future option values; the positive direct use values (market values) account for 20% of this TEV and are linked to product markets. Finally, economic valuation methods can also be employed to assess the willingness to accept of farmers, that is the supply side, and hence provide with useful information for the set-up of payment schemes that consider additionality among other issues (e.g. Vedel *et al.,* 2015).

Despite a vast array of valuation studies have been conducted to assess the non-market benefits of agroecosystems, of which we have just mentioned some examples, using these methodologies from the ES perspective still is challenging. The ecosystem service perspective seeks to distinguish benefits provided by natural ecosystems from those provided by human capital, labor, and technology (Bateman *et al.,* 2011, Brown *et al.,* 2007, Johnston and Russell, 2011). However, such differentiation is not needed in non-market valuation.

2. Qualitative methods to assess the demand of ES

Despite the appeal of quantitative studies, these may not be so well suited to grasp some dimensions of ES, such as the cultural or heritage dimension. Qualitative methodologies may then be needed to assess these dimensions from a non-monetary perspective. Socio-cultural valuation methods to elucidate social benefits include consultative and participatory methods, and even deliberative participatory valuation (Christie *et al.,* 2012).

Rodríguez-Ortega *et al.* (2014) provides a thorough review of studies on ES assessment in grassland ecosystems. Examples of these studies include the surveys conducted by Deraka *et al.* (2014) and Palomo *et al*. (2013) to quantify cultural services and the importance stakeholders allocate to different services, employing multicriteria participatory assessment and participatory mapping respectively. Lamarque *et al*. (2011) used qualitative surveys to check the ES that stakeholders identify (which ES for whom), the relative rankings of these ecosystem services, and how stakeholders perceive the provision of these ecosystem services to be related to agricultural activities. They identified a common set of ecosystem services that were considered important by stakeholders across the three regions, including soil stability, water quantity and quality, forage quality, conservation of botanical diversity, aesthetics and recreation (for regional experts), and forage quantity and aesthetic (for local farmers). They also observed contrasting representations of the relationships between soil fertility and diversity. Similarly, Plieninger *et al.* (2012) showed how residential owners and producers are concerned with different bundles of ES. Understating the perception of the service providers/managers is essential in the development of efficient policies. Oteros-Rozas *et al*. (2012 and 2013) identified the ES related to transhumance in Spain by carrying out socio-cultural assessments. The most important ES for social well-being were fire prevention, air purification and livestock production. Bernués *et al.* (2013) used focus groups to quantify the importance that farmers and non-farmers attached to the ES delivered by mountain agriculture. They found that aesthetics (landscape/vegetation), gene pool protection (biodiversity maintenance) and natural hazard prevention (forest fires), together with opportunities for recreation and culture, were the most important ES delivered by mountain livestock systems. This information was used on a later stage to conduct a valuation survey.

Therefore, when the stakeholders are considered an extra level of complexity is added, as the simultaneous provision of ES and trade-offs when addressed rom the stakeholder perspective means that different stakeholders pursue different goals on a given landscape. As a consequence, they need to develop a common view on problem and collectively design solutions. Methodologies such as fuzzy cognitive mapping (Kok, 2009) may help in involving stakeholders in the exploration and design of common solutions. Some EU projects are incorporating stakeholders' views in land-use planning and adaptation, combining expert and stakeholder views to develop future land use and water management scenarios (e.g. Volante and Bewater projects).

3. Consideration of the farm level

Consideration of social demand and stakeholders preferences has to come hand in hand with viability assessment at farm level. On-farm working condition (FWC) plays a substantial role in dropping number of farm in pasture-based livestock farming systems (Bernuès *et al.,* 2011).This working conditions may relate to monetary and also non-monetary concerns.

The big challenge in this situation is how farmers achieve their personal household/survival/production goals while maintaining and improving the resource base upon which they depend and the wider functions of their grassland ecosystem that the world demands. In the open markets where livestock producers have to trade, they act typically as price takers, meaning that reducing input costs is the main mechanism they can use to remain financially viable. And this has to be made under a conservative approach to maintain the resilience of the farm as a system able to cope with global changes.

Payments to pastoralists may then be needed to support wider environmental goals, as otherwise the income generated through livestock breeding has to cover the cost of maintaining the benefits and also the ecosystem processes and functions that deliver non-marketed services.

4. Frameworks for integration

The integration of all these components in frameworks and modelling approaches is evolving. There is a growing array of tools for analyzing how alternative ecosystem management interventions generate trade-offs in the provision of different ecosystem services (e.g. Raudsepp-Hearne *et al.*,2010; Kareiva *et al.,* 2007).

Assessment of trade-offs among services and the implications these trade-offs have for social well-being have been based on assessing projected changes in land use/land cover (e.g., White *et al*., 2012) or combined land-use/land-cover and climate change (e.g., Bateman *et al.,* 2013).

However, it is still scarce the development of analytical frameworks that encompass ecological mechanisms underpinning ecosystem services, biophysical trade-offs, preferences of stakeholders and system dynamics to account for the evolution through time is growing; such assessments can be linked explicitly to spatial information on service supply to show who benefits and who bears costs with changes in the bundle of services (Cavender-Bares *et al.,* 2015).

5. Policy implications

In broad terms, socioecological systems able to deliver a multiplicity of services beyond provisioning marketed services largely coincide with low agricultural inputs, low stocking densities and often labor-intensive management practices. Particularly important are the small-scale farming systems that are responsible for creating and maintaining the species-rich semi-natural grasslands, which are often true hot spots for biodiversity (EU, 2008).

Overall, the focus of the agricultural policy design for these systems should not focus only on provisioning ES, because this can result in decisions that reduce the TEV of the system (Bateman *et al*., 2013).

However, European policies are contradictory with grassland socio-ecosystems; some parts of it acknowledge the relevance of these systems, but on the other hand such policy framework that hinder their existence (Beaufoy and Poux, 2014). Examples of it are the CAP payments versus the EU biodiversity targets that support the maintenance of many semi-natural permanent pastures in farmlands within the Natura 2000 European network of protected areas and the maintenance, enhancement and restoration of ecosystem services (EC, 2011).

The consideration of these socioecological systems as a whole, beyond segregated conservation strategies, including a full recognition of silvopastoral systems (Moreno *et al*., 2014) is crucial to set coherent policy frameworks. Unfortunately, in the 2014–2020 CAP, the definition of permanent grasslands is far too restrictive; CAP subsidies favor open pastures (based only on herbaceous forage plants) in preference to silvopastoral systems, in which the presence of trees and shrubs frequently produces a reduction in the subsidy received by farmers (Porqueddu *et al*., 2014). This policy could seriously compromise the long-term persistence of many European silvopastoral systems, such as the Iberian dehesas and other traditionally grazed woodland pastures and shrublands (future for wood pastures).

Finally, Agri-Environmental Schemes (AESs) are currently designed to deliver improved biodiversity, among other things, but are not explicitly linked with ecosystem services. While many of the reported relationships between ecosystem services and biodiversity are based on sensible predictions,. Although biodiversity can in itself provide a range of ‘cultural’ ecosystem services (most of which are likely to be hard to value economically), what is urgently needed is an evidence-base on which to move forward (Whittingham, 2001), bearing in mind that it is farmers who implement AESs, and so it is crucial that such stakeholders are included in the design of the schemes. One option is to design incentive schemes for bundles of multiple ecosystem services (Martín-López *et al*., 2012)

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Greece's grazing / forage resources for livestock production

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Abstract. In Greece, grazing animal nutrition widely derives from a combination of grazing lands, such as grasslands, woodlands, pasturelands, agricultural crops and grazed forests. Grasslands (i.e. land dominated by herbaceous vegetation) and woodlands (i.e. shrublands and forested pastures) constitute the majority of Greece's grazing lands covering more than 40 % of the country's area; they are called rangelands and are public lands, officially under state ownership. Grassland forage has a seasonal variability which produces two feed gaps, the first one during summer and the second one during winter. Shrublands may play an important role to grazing animal production because their shrub component provides green forage (evergreen shrubs: all the year round; deciduous shrubs: summer) when grassland forage is dry and of low nutritive value or absent. Moreover the shrub and herb component of shrublands complement one another ensuring an ideal feed for grazing animals almost throughout the year. Forests are the most common forage resource related to rangelands in Greece, especially when they are in open form, which allows the production of high amounts of forage in their understory composed by both herbaceous and shrubby plants. Stubble fields are used as complementary forage resource during summer while hay and concentrates produced on arable lands are used as supplements during winter. It is suggested that for a specific area the combination of several forage resources on a yearly basis must be organized in order to establish a successful, strong and viable animal husbandry system. National and EU policies have an impact on grazing lands, since land that is being used or managed for livestock farming is not be eligible for payments; since the way of how is determined what is or not eligible is of crucial importance for permanent grasslands, it has to be revised.

Keywords. Grasslands – Fodder plants – Forests – Grazing policy – Pastures – Rangelands – Shrublands.

Les ressources en pâturages et fourrages de la Grèce pour la production animale

Résumé. *En Grèce, la nutrition des animaux brouteurs provient largement d'une combinaison de pâturages, tels que prairies, terres boisées, pacages, cultures agricoles et forêts pâturées. Les prairies (à savoir les terres dominées par la végétation herbacée) et les terres boisées (arbustes et pâturages forestiers) constituent la majorité des pâturages de la Grèce, couvrant plus de 40 % de la surface du pays; on les appelle parcours ou terres publiques, officiellement propriété de l'État. Le fourrage des prairies présente une variabilité saisonnière qui entraîne deux périodes de soudure, la première en été et la seconde en hiver. Les arbustes peuvent jouer un rôle important pour la production d'animaux brouteurs car la composante arbustive apporte du fourrage vert (arbustes à feuilles persistantes: sur toute l'année; arbustes à feuilles caduques: en été) lorsque l'herbe des pâturages est sèche avec une faible valeur nutritive ou est absente. De plus les composantes arbustive et herbacée des zones d'arbustes se complémentent mutuellement assurant un aliment idéal pour les animaux brouteurs sur presque toute l'année. Les forêts sont la ressource fourragère la plus courante liée aux parcours en Grèce, en particulier lorsqu'ils sont ouverts, ce qui permet la production de grandes quantités de fourrage dans leur étage inférieur composé à la fois de plantes herbacées et arbustives. Les chaumes sont utilisées comme ressource fourragère complémentaire en été tandis que le foin et les concentrés produits sur les terres arables sont utilisés comme supplément en hiver. Il est suggéré pour une zone spécifique d'organiser une combinaison de plusieurs ressources fourragères sur une année pour établir un système d'élevage performant, fort et viable. Les politiques nationales ainsi que celles de l'UE ont un impact sur les pâturages, vu que la terre qui est utilisée ou gérée pour l'élevage n'est pas éligible pour les paiements; et vu que la façon de déterminer ce qui est ou n'est pas éligible est d'une importance cruciale pour les pâturages permanents, il faudrait réviser ce point.*

Mots-clés. *Prairies – Plantes fourragères – Forêts – Politique sur le pâturage – Pâturages – Parcours – Arbustes*

I – Introduction

Greece with an area of 132 thousands km^2 is an east Mediterranean country. Its climate is typically Mediterranean, ranging from the arid to the perhumid of Emberger's (1955) classification with a prolonged drought during summer. There are, however, variations among geographic areas (e.g., north - south or mainland - island) and among zones of the same area with different altitude (e.g., low plain, sub-mountainous and mountainous). The most significant of its features from the standpoint of forage production and management is that water is the main limiting and regulating factor for plant growth. Increase in soil water storage could contribute to an increase in biomass production, particularly in the driest zones; through improved evapotranspiration efficiency and greater precocity of plant growth (precipitation is concentrated in winter and early spring). Monthly temperature and rainfall details for specific areas of Greece's are shown in the dataset was produced by the Climatic Research Unit (CRU) of University of East Anglia (UEA): http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisRegion=Europe&ThisCCode=GRC.

Livestock is economically important to the agricultural population of Greece. According to the Hellenic Statistical Service of Greece (2015), there are about 4.9 million goats which are of mixed indigenous types, 8.8 million sheep which are of mixed breed exhibiting a variety of coat colors and patterns, and 611 thousands cattle. Sheep and goats have many desirable characteristics that favor production in the less - developed regions of the country and can be produced with a low investment in land and labor. Biologically they have proven to be especially well adapted to the poor grazing conditions of the Mediterranean climate.

World livestock production is based in forage, which is produced in grazing lands and crops. The term grazing land refers to areas producing forage from native or introduced plants and harvested directly by animals without reference to land tenure or other land uses (Allen *et al*., 2011). On a worldwide basis, grazing lands encompassing about 60% of the land area of the earth (Vallentine, 1990) and according their vegetation type are classified into several grazing land types (Stoddart *et al*., 1975). In Greece, grazing lands have been separated into categories such as rangelands, pasturelands, grazed forests and grazed croplands. Rangelands determined as non-arable lands on which the present forage stand is projected for unlimited continuation (Vallentine, 1990) or according to Allen *et al*. (2011), as land on which the indigenous vegetation (climax or sub-climax) is predominantly grasses, grass-like plants, forbs or shrubs that are grazed or have the potential to be grazed, and which is used as a natural ecosystem for the production of grazing livestock and wildlife. Pasturelands are distinguished from rangelands by the fact that periodic cultivation is used to maintain introduced (non-native) forage species, and agronomic inputs such as irrigation and fertilization are applied annually (Holecheck *et al*., 2004). Grazed forests and crop fields are lands providing forage as a secondary product which can be used during certain periods (e.g., grazing after the primary crop is harvested in a wheat field). Greece's grazing lands were never systematically surveyed and mapped, and only estimations are done by data collection from different sources. An authoritative estimation was done by Papanastasis and Pittas (1984) and according to that grazing lands cover more than 7.0 million ha but only a 5.2 million ha should be considered as rangeland, i.e. uncultivated land that will provide the necessities of life for grazing and browsing animals, for which scientific management could be applied (i.e. manipulation of rangeland components to obtain the optimum combination of goods and services for society on sustained basis; Holecheck *et al*., 2004).

Over-grazing by livestock has caused major land degradation and soil erosion and this has a negative effect on animal production. Low livestock production levels and poor conditions are generally found throughout the country. The purpose of this study is to identify the forage/grazing resources of Greece and their use by grazing animals; and how it is affected by the National and European policies.

II – Ruminant livestock grazing systems

Ruminant livestock production is a major segment of Greek agriculture. The 2012 Census of Agriculture counted 179,525 farms with 14,284,805 animals (Table1). Cattle number has slightly reduced in the last years (2010 - 2012; reduction 3%); similarly, a reduction in sheep and goats was observed (1.4 and 4.5%, respectively). Sheep and goats are considered as the most significant livestock sector in Greece. Sheep and goat husbandry systems found in country have a strong tradition and they can be classified into four basic categories (Papanastasis, 1990; Hatziminaoglou *et al*., 1995), namely, (i) home-fed, (ii) intensive/semi-intensive (9 % of the sheep and 19 % of the goat population is estimated to classify into these two livestock production systems), (iii) extensive without transhumance (the majority of sheep (82 %) and goats (73 %) are classified into this system) and (iv) extensive with transhumance (nomadic system; nowadays only 8 % of Greece's goat and 9 % of sheep population are classified into this system). Both latter systems are found in less favored areas, in rather small sized flocks, based on the natural vegetation of grazing lands and produce both meat and milk which is transformed mainly into Feta cheese. In the extensive without transhumance, the animals stay in permanent installations near the villages and graze nearby. The grazing period ranging from 5 to 12 months, depending on the topography of the area where the farm is located and the grazing land types are found. In the extensive system with transhumance, the animals belong to hardy local breeds and are usually moved from low altitude areas to high altitude areas, exploiting the differences of vegetation growth. The animals remain in the high altitudes from May to September and their nutrition is mainly based on grazing, and only during late pregnancy and early lactation are they offered some supplementary feed while in the rest use the grazing lands of the low altitudes and/ or they are fed indoors.

Table 1. Number of livestock farming and animal population in Greece in 2012 (Hellenic Statistical Service of Greece, 2015)

Animal species	Farm number	Total heads	Heads/farm
Cattle	17,241	611,131	35
Sheep	90,911	8,778,430	97
Goats	71,373	4,895,244	69
Total	179,525	14,284,805	

Grazing cattle (approximately 350,000 heads) consists of suckled cows, which belong to indigenous local cattle breeds or cross-bred of Limousin, Simental, Schweiz, Charolais and Hereford and represents a low cost pastoral beef production system (Zervas, 1998). Feed for maintenance of herds of beef cattle and the production of their offspring comes primary from grazing lands. In general, the offspring of ruminants kept in grazing systems are nursed by their mothers, suckled with milk, learn to forage early in their life, have social contact with other young and mature animals and have space enough to exercise and play.

The total meat production of cattle, sheep and goats in 2012 was 70,000, 92,100 and goats 52,000 tons, respectively while the milk production was 779,000, 778,000 and 462,900 tons, respectively. There are not data for the contribution of grazing lands on the livestock products but it is estimated that the grazing land forage consumed by grazing ruminants contributes about 35% to the livestock products but it has the potential to increase to 60%.

III – Forage/ grazing resources

The vegetation in Greece is typical of Mediterranean regions and consists of a rich variety of plant species which are well adapted to the climatic conditions. A series of vegetation manipulations by man throughout the centuries, such as irrational felling of woody plants, overgrazing and extensive clearing for formation of crop-fields, have contributed the most to today's landscape, which consists of a variety of vegetation types. The main land uses of the country, which are related with livestock, are agricultural crops, forests and rangelands (Table 2). Up to 1991, rangeland data were separately collected by Statistical Service of Greece but after that a part of rangelands (10.9% of land area) is recorded as agricultural land and the largest part of them (30.3% of land area) is recorded as forest land (Geotechnical Chamber of Greece, 2014).

Table 2. Evolution of land uses (ha) in Greece from 1961 to 1991 (source: Statistical Service of Greece)

Year of survey	Agricultural land	Forests	Rangelands
1961	3,909,252	2,826,283	5,507,291
1971	3,962,080	2,971,560	5,269,566
1981	3,948,873	2,958,353	5,256,359
1991	3,948,873	2,945,146	5,216,738
Mean (%)†	29.8	22.2	43.5

†Percentage (%) of Greece's total land area.

1. Rangelands

Rangelands in Greece are one of the most important natural resources covering more than 40 % of the country's land area (Geotechnical Chamber of Greece, 2014). They are broadly classified into (i) grazing lands dominated by herbs and phrygana and (ii) wooded rangelands (dominated by woody plants), which are composed of shrublands and forested rangelands and expand in all geographical divisions and elevation zones of the country. There are not accurate data concerning the surface of them but according to the Geotechnical Chamber of Greece (2014) it is estimated that the grazing lands dominated by herbaceous species add up 1.4 million ha and the grazing lands dominated by woody plants 3.7 million ha. It is valuable that in '60s the grazing lands dominated by herbaceous vegetation amounted to 1.7 million ha, which means that a part of them transformed to woodlands due to their misuse.

A. Grasslands

Grasslands are covered predominantly with herbaceous plants, such as grasses, grass-like plants and forbs, in a percentage at least 80% while woody species are present in percentages ranging from 10 to 20% (Papanastasis and Ispikoudis, 2012). This definition is similar to that is given by Holecheck *et al*. (2004) for grasslands and include grazing land, which is described by Allen *et al*. (2011) and Peeters *et al*. (2014) as native/ natural grassland. Among herbaceous plants sovereign in terms of biomass are the grasses, while broad-leaved (legumes and other forbs) dominate species number. The vegetation of the grasslands consists of a wide variety of plant species which are annuals or perennial. In general, in lowland (0-600 m) grasslands dominate the annual plants, in sub-mountainous (600-800 m) are found both annual and perennial while in the sub-alpine zone (1,500 m) are found only perennial plants. Among grasses, which contribute much more than other herbaceous plants in forage production, dominate species belonging to the genera of *Festuca*, *Bromus*, *Brachypodium*, *Poa*, *Phleum*, *Agrostis*, *Stipa* and *Dactylis* (Papanastasis and Ispikoudis, 2012).

The annual forage production of grasslands depends on the climate zone, the composition of the vegetation, the soil type and their use from grazing animals. Their main use is grazing by farm and wild animals. The total area of grasslands in Greece is estimated to be 1.4 million hectares or 27 % of Greece's total rangeland area and include lowland plain, hilly transition sub-mountainous and mountainous/sub-alpine pastures - half of them found in northern Greece. Their forage has a seasonal variability depending on the bioclimatic - elevation zone as well as a yearly one depending on the climatic conditions. Papanastasis (1982) reported that herbage yields of 1,100 kg/ha in the lowland grasslands, 1,300 kg/ha in the sub-mountainous grasslands and 3,000 kg/ha in the mountainous grasslands are typical in Northern Greece, while Nastis (1990) reported that herbage production of the three grassland categories were estimated to be 2,000, 3,000 and 5,000 kg/ha, respectively. Based on research data throughout the country, it is estimated that the herbage production of lowland grasslands ranges from 500 to 1,500 kg/ha, of sub-mountainous grasslands from 1,500 to 2,500 kg/ha and mountainous grasslands from 2,500 to 3,500 kg/ha.

The most important decision for successful rangeland management is setting a proper stocking rate. The stocking rate affects rangeland health and productivity, livestock production, and economic returns (Holecheck *et al*., 2004). The number of animals a piece of land can support on a long-term basis without causing damage to the grazing resource is the carrying capacity of the land. Stocking rate is the relationship between the number of animals and the total area of the land in one or more units utilized over a specified time; an animal-to-land relationship over time (Allen *et al*., 2011). In other words, the stocking rate is the number of animals (livestock or wildlife) a land manager places or maintains on a piece of land over a specified period of time while carrying capacity is set by Mother Nature, through soil and climate characteristics. The stocking rate is expressed as animal units (AU) per section of land. The term AU is widely used in grazing management, but there is not universal agreement on the quantity it expresses. For example, in USA, AU is defined as a 450 kg beef cow with or without a nursing calf with a daily requirement of 11.8 kg of dry matter forage; but in Greece a 400 kg beef cow with or without a nursing calf with a daily requirement of 10 kg of dry matter forage. Recently, Allen *et al*. (2011) defined that an AU is one mature, non-lactating bovine (middle-third of pregnancy) weighing 500 kg and fed at a maintenance level for zero gain (8.8 kg dry matter per day). The amount of forage required by one animal unit (AU) for one month is called an Animal Unit Month (AUM); thus the term AUM according to the latter definition is equal to 264 kg.

With regard to those reported above, we estimate that the proper stocking rate for grasslands should be 3.3 (AUM)/ha. However, this estimation may provide rangeland managers with a partial basis for making management decisions because on one hand, the herbage produced in grasslands is concentrated in the spring and summer while on the other, the herbaceous material starts to dry out by late spring thus its nutritive value declines. It has been found (Papanastasis, 1982; Forest Research Institute, unpublished data) that the forage abundance lasts from May to August in the lowland and sub-mountainous grasslands, but by June crude protein content of herbage begins to decline and is insufficient to meet even basic maintenance requirements of grazing animals. In the mountainous grasslands forage abundance lasts from June to October and its crude protein content seems to be sufficient for animal maintenance requirements, but not for any production or weight gain. Generally, the forage production of grasslands in Greece has a seasonal growth causing two feed gaps - the first one during summer (related to nutritive value) and the second one during winter (related to availability).

B. Phryganic lands

Fhryganic lands are dominated by brushwood (or phrygana), which is dwarf-shrubs that display the phenomenon of seasonal dimorphism, i.e. the replacement of large winter leaves with small summer leaves in late spring, in order to reduce the transpiration (loss of water) and to cope with so long and dry summer. The main phryganic rangeland types of Greece are those that dominated by *Sarcopoterium spinosum*, *Phlomis fruticosa*, *Thymus vulgaris* and *Cistus* spp., and they are found in xerothermic areas of the country, for example Aegean islands, Crete and/ or in western and southern part of the inland. There is no data concerning their surface and the largest part of them included in the grassland surface (i.e. in the rangeland type described just before). Their annual forage production ranges from 300 to 800 kg/ha in lowlands, from 800 to 1,300 kg/ha in sub-mountainous and from 1,300 to 1,800 kg/ha in mountainous areas. The proper stocking rate for this rangeland type should be 1.7 AUM/ha. Because the phryganic forage is of low palatability, fire has been used by herders in attempts to improve its nutritive value by replacement of other vegetation types; however, there is evidence that this management deteriorate the rangeland conditions.

C. Shrublands

The landscape of the low, and a part of the sub-mountainous and mountainous elevation zone of Greece is dominated by woody vegetation which is a complex mix of evergreen or deciduous shrubs with an herbaceous understory. The area of these grazing lands is estimated to be the half of the wooded rangelands reported above. Both woody (browse) and herb (herbage) components of shrublands are vitally important for small ruminant production in the region. The annual forage production of shrublands ranges from 600 to 1,200 kg/ha in lowlands, from 1,200 to 1,800 kg/ha in sub-mountainous and from 1,800 to 2,000 in mountainous areas and it is suggested to be stocked by 3.2 AUM/ha.

The evergreen kermes oak (*Quercus coccifera* L.), is the predominant vegetation of a large part of shrublands, covering 50 % of Greece's total shrubland area. A combination of kermes oak pastures of varying cover over the total shrubland area considered ensures not only forage but water for off-site use, wildlife habitat, soil protection of erosion and wood production as well (e.g., firewood, fence posts). This suggests that removing a part of the woody vegetation in Mediterranean shrublands results in increased forage production (available herbage and useable browse) and improved forage quality and availability for small ruminants. Goats seem to be the appropriate animal species for grazing on such rangelands, since they have the ability to consume large amounts of kermes oak browse throughout the year (diet content ranging from 46.8 % in spring to 73.7 % in winter). Moreover, levels of crude protein of goats' diets grazing in shrublands satisfy the maintenance or/ and part of production requirements for goats during all seasons (Papachristou and Nastis, 1993b; Papachristou and Nastis, 1996). In summary, shrublands appear to be a significant forage resource ensuring forage throughout the year and according to our estimation (assumption that the produced forage is accessible to animals) their carrying capacity is of about 17 million goat unit months.

D. Forested rangelands

Forested rangelands called the grazing lands that carries an overstory of forest trees with a canopy cover lower than 40%; therefore, they have a rich understory of either herbaceous or shrubby species that supplies forage to grazing animals. The forested rangelands are represented by three broad types in respect of the overstory vegetation, (i) the coniferous forested rangelands are characterized by evergreen pines mostly of the species *Pinus halepensis*, *Pinus brutia* and *Pinus nigra*, (ii) the broadleaf evergreen forested rangelands with an overstory of evergreen oaks and (iii) the broadleaf deciduous forested rangelands whose the overstory consists mainly by deciduous oaks. This type of grazing land is of great economic value because it is used by all animal species and covers large areas. Also they produce and other goods and services such as wood products, water, wildlife habitat, soil protection and recreation. They are found at all elevations and mainly on the fringes of forests, which means that they come from forests, which are thinned in excess, due to various anthropogenic actions. Forested rangelands have the potential to be a valuable forage resource and according to our estimations the annual forage production of forested rangelands ranges from 400 to 1,000 kg/ha in lowlands, from 1,000 to 1,600 kg/ha in sub-mountainous and from 1,600 to 2,200 in mountainous areas and it is suggested to be stocked by 2.2 AUM/ha.

2. Grazed forests

Livestock grazing is an old practice in the forests of the Mediterranean region and any attempt to exclude it by Greek forests it was failed. Liacos (1980) stated that the livestock is an integral part of Mediterranean forests and argued that it is beneficial for some forest types, since grazing animals are helpful to the functioning of such grazed forest ecosystems because they contribute to nutrient cycling and thus to an increase of their productivity. Also, he argued that grazing animals can be used as silvicultural means because they control the undergrowth vegetation and eliminate its competition with trees for water, which is a critical factor in the Mediterranean environment. Moreover, the role of domestic herbivores in reducing fuel is somewhat that is need more attention and there is evidence that the lack of grazing leads in increase of fuel material, therefore, results in frequent fires and increase of burnt forest areas (Papanastasis, 2009). However, the environmental and ecological impacts of grazing activity within forests need further research and the social, cultural and economical conditions of each area have to be taken into account for successful integration.

According to Papanastasis and Pittas (1984) a large part of the forests (approximately 1.9 million ha than those of Table 2) is used for grazing and a secondary income is provided by the livestock grazing to the people living close to forests. This happens because the understory vegetation, composed of shrubby and herbaceous species, can be grazed during periods when other forage resources (e.g., grasslands) do not meet animal requirements. However, their understory forage production varies according to forest type and tree species. Experimental data (Liacos, 1980) indicate that the forage production in pine forests (*Pinus brutia* Ten.) is 2,500 kg/ha when the canopy tree cover is open (3 x 3 m) and can result in a meat production of 60 kg/ha. Nastis (1990), also, reported that pine forests with shrubby and herbaceous understory carry approximately 1,000 kg/ha and 1,500 kg/ha, respectively.

In grazed coppice oak forests, Papachristou and Platis (2011a) found that the herbage availability was similar in forest stands with different coppicing age 2, 5 and 8 yrs after the clear cutting and averaged 2,614 kg/ha (). However, there was a significant difference in forage production among seasons of year; the lowest herbage production was recorded in spring (1,546 kg/ha) and the highest in autumn (3,214 kg/ha) while intermediate production was recorded in summer and winter (2,845 and 2,851 kg/ha, respectively). The foraging behavior of grazing animals may be an important management tool which can help livestock and forestry integration. For example, Papachristou and Platis (2011a) found that cattle grazing on coppice oak forests were taking almost the whole of their bites on herbage for all periods but goats had a greater number of bites on oak sprouts (37 bites/min) than herbage (19 bites/min).

3. Pasturelands

Pasturelands (i.e. land (and the vegetation growing on it) devoted to the production of introduced or indigenous forage for harvest by grazing, cutting, or both; Allen *et al*. 2011), with grasses or legumes are grown on arable lands, cover an area of 0.05 million ha and their forage production is estimated to be 3,000 kg/ha. Although these grazing lands have the potential to produce great amounts of forage of high nutritive value, there is a tendency to be reduced and used rather for crop fields than livestock production.

4. Other forage resources

In Greece there are several short-term grazing lands and/ or forage resources, which are arable lands on which grazing is presently being realized, but under limited duration or they are seeded by fodder plants that harvested and stored to be used as animal feed. Introduced forage species are mostly utilized, but native species responsive to high management and cultural inputs maybe included (Papachristou, 2000). This land covers an area of 0.4 million ha (Hellenic Statistical Service of Greece, 2015) and consists of: (1) New-sown leys, which are lands temporarily under barley, oats and vetch and used by grazing animals during winter with a forage production amount to an average of 4,000 kg/ha, (2) Meadows, which are usually natural and used for grazing by animals after the spring hay harvest and their forage production is estimated to be 2,500 kg/ha and (3) Hay crops with alfalfa (*Medicago sativa* L.) and vetch (*Vicia sativa* L.) are the most important resources for hay. These lands have the potential to produce great amounts of forage (> 10,000 kg/ha), especially when they are irrigated. This material is harvested, stored and given to grazing animals during critical periods (e.g., winter) or to indoor animals on a yearly basis.

Also, a significant temporarily grazing resource is fallow lands that are ploughed fields, not sown temporarily, and estimated to cover an area of about 0.4 million ha with a forage production of 1,500 kg/ha. In the same category is cereal stubble which is estimated to be 1.2 million ha and is used by grazing animals during summer after the cereal harvest.

IV – Grazing land management

Grazing management is principally involved in managing and manipulating the grazing animal-forage plant-soil complex to obtain specified objectives. This is accomplished by blending ecological, economic and animal management principles. Common to the management of all grazing lands must be forage plant consideration such as plant growth requirements, providing for plant vigor and reproduction, defoliation and other animal impacts, and seasonality and fluctuations in forage production. But equally high in priority are animal considerations including animal performance, animal behavior, nutrient intake levels, forage quality relative to animal needs, and forage palatability/ animal preference. However, grazing is applied in the whole of the country's grazing lands without established principles of proper utilization. Consequently, rangeland productivity has deteriorated, as has the productivity of other forage resources such as forestlands. Grazing animals, especially goats, are considered despoilers of grazing lands. However, with good management all grazing animals can make a positive contribution to the natural resource base by enhancing soil quality and increasing plant and animal biodiversity (El Aich and Waterhouse, 1999; Papanastasis *et al*., 2015).

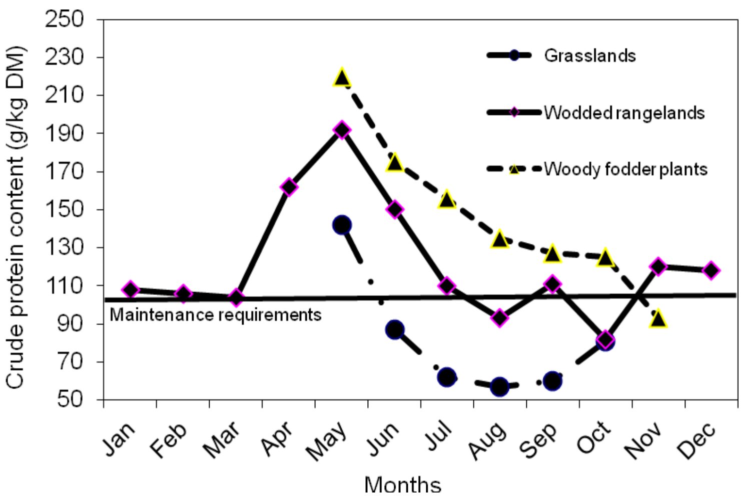

Fig. 1. Combination of different forage resources grazed by goats in an area with altitude 600 m in Northern Greece.

Over the past decades, considerable research data have appeared in the literature on the ecology and management of grazing lands of Greece. These studies indicate that there is the scientific basis for the application of sustainable grazing management which will ensure the optimum combination of goods and services for society (e.g. Papachristou *et al*., 2005; Papanastasis *et al*., 2015). An important finding is that browse is an important forage source for goats throughout the year and for sheep during the dry periods when herbage was limited. Especially, in kermes oak shrublands the available forage (browse and herbage) is not a limiting factor to animal production (Liacos *et al*., 1980; Papachristou and Nastis, 1993a). Papachristou and Nastis (1993a) found that the forage availability in a shrubland area with a shrub cover ranging from 50 to 70 % was 1,170 (browse: 953; herbage: 217) kg/ha in spring, 2,212 (browse: 1,813; herbage: 399) kg/ha in summer, 2,009 (browse: 1,869; herbage: 140) kg/ha in autumn and 1,611 (browse: 1,436; herbage: 175) kg/ha in winter. In this shrubland, grazing goats selected large amounts of browse, mainly kermes oak, throughout the year (from 46.8 % in spring to 73.7 % in winter). However, goats selected a diet of 53 % herbs (grass: 23.0 and forbs: 30.0 %) during spring (April - June), when they were green and in abundance. During summer, although the herbage availability was high, herbs in the goats' diet decreased (35 %) because of maturity. Dietary levels of crude protein exceeded maintenance requirements for goats during all seasons (Fig. 1), but when digestibility was considered the forage of kermes oak shrubland is questionable regarding meeting animal requirements during other seasons except in spring (Papachristou and Nastis, 1993b). During summer and autumn, the nutritional status of goats is elevated when they graze shrublands dominated by deciduous broad-leaved species such as *Carpinus* sp. and *Fraxinus* sp. (Papachristou and Nastis, 1996).

The proportion of woody and herbaceous vegetation and seasonal changes in Mediterranean rangelands affect the diet selection and nutrition of grazing animals (Papachristou and Nastis, 1993 a, b). Therefore, it was suggested that the creation of a heterogeneous landscape, which increases and diversifies forage production, increases livestock production (Liacos *et al*., 1980; Kirmse *et al*., 1987; Tsiouvaras, 1987; Schacht and Malechek, 1989; Papachristou *et al*., 1997), limits the risk of uncontrolled fires, and ensures other services such as wildlife habitat or aesthetic landscapes (Liacos, 1982). A creation of such diversified shrubland (shrub density ranging from 20 to 60%) was achieved by Papachristou (1997) and Papachristou *et al*. (1997) using clear cutting and slashing. Clearing and slashing resulted in higher amounts of available herbaceous forage and useable browse. Herbaceous biomass was generally 2–3 times higher in the treated shrublands than in the control at least for 3 years after vegetation improvement, and while browse biomass was slightly less (1,078 versus 1,533 kg/ha), the forage was easily accessible because of the open structure and the lower height of the sprouting shrubs; therefore, grazing animals (sheep and goats) had a higher bite rate (15.7 vs. 8.6 bites/min). Forage selected by animals grazing on treated, as opposed to untreated, shrublands was higher in crude protein, more digestible and lower in NDF, ADF and lignin. Based on these studies, they suggest that the woody component of rangelands should to be maintained at less than 50% of the total land cover as this produces the best overall foraging conditions and animal performance due to enhanced plant diversity. A further improvement by augmenting woodlands with evergreen or deciduous fodder shrubs and tree species can be achieved (Papachristou and Papanastasis, 1994; Papachristou *et al*. 1999; Papanastasis, 1999a). It was proposed for kermes oak shrublands that goats can be allowed to graze in them during the day and then at the end of the day, be allowed to have access to pastures with different browse combinations of fodder woody species. In this way, a mixing of plant species is ensured and the goats are provided with different types of biochemicals that enhance food intake.

Research data from Greek grasslands indicate that their productivity varies widely depending on the particular climatic and soil conditions. In general, grasslands in lower altitudes have less herbage production than the higher ones and there is a great variation for the same grassland between years (Papanastasis, 1999b). Moreover, the nutritive value of herbage may not follow the trends of forage production. For example, the quantity of forage in grasslands located in areas with altitudes lower than 800 m is adequate from May to August but its content in CP decline from May (130 g/kg DM) to August (70 g/kg DM). However, in the grasslands found in altitudes higher than 800 m the quantity of forage is adequate from June to October and its content in CP ranging in relatively high amounts (90 – 130 g/kg DM).

In conclusion, the use of several grazing land types satisfies better the requirements of grazing animals in both forage allowance and nutritive value throughout the year. In the past, it was achieved by transhumance, i.e. the seasonal movement of grazers with their livestock between fixed summer and winter grasslands exploiting the ecological differences of grasslands located in different altitudes. Nowadays, the livestock production systems are extensive without transhumance, which means that animals use the grazing lands that are available in the wider area from the barn. Therefore, the best management is the combined used of different grazing land types. For example, a realistic approach for a goat farm located in northern Greece in an area with altitude 600 m is the use of grasslands, shrublands, forested rangelands and artificial plantations with woody fodder species; this combination ensures sufficient amount of forage of high nutritive value (Fig. 1).

V – Impact of national and EU policy on grazing lands

1. National policy

The majority of rangelands (75%), which are the largest forage resource of grazing lands, are state-owned areas. The right of distribution of these public rangelands to the grazers belongs to the municipalities whereon rangelands are located and the right of grazing belongs to the livestock owners of each municipality. Public rangelands are freely grazed, which means that every shepherd utilize freely the rangeland that is allocated to him. However, this leads to uncontrolled grazing and degradation of rangelands because municipalities and/ or users do not follow any guideline of proper rangeland/ grazing management.

Up to now any attempt for appropriate rangeland management has failed although there is the scientific basis from research data to be applied. The only management efforts were limited in the establishment of facilities for watering livestock and vegetation improvements throughout fertilization, seeding and control of undesirable plants (Papanastasis, 2001). However, even these attempts had poor performance either because to faulty design or to the following uncontrolled grazing.

The most important of all grazing management decisions from the standpoint of vegetation, livestock, wildlife and economic return is the setting of the appropriate stocking rate. Recently (117394/ 2932 Ministerial decision, 2014), the state recognized the rangeland importance for livestock and decided to manage them with an appropriate way. According to this decision for the rangeland use of each municipality is needed a management plan, which will include (1) classification of rangelands into the types reported above, (2) estimation of carrying capacity for each rangeland type and for the total of rangelands in a specific municipality, (3) numeration of livestock using rangelands for each municipality and the grazing system applied, (4) calculation of stocking rate, i.e., the number of livestock that can graze on rangelands surveyed for the desired grazing period, (5) establishment of facilities (watering holes, shade shelters, stables, roads) and (6) proposition for the appropriate vegetation and grazing management according to the health/ condition of a specific rangeland.

2. Common agricultural policy (CAP)

As it was reported, grazing lands include a range of vegetation types and shrubs and trees (browse, as distinct from herbage) have been an integral part of grazing systems for centuries. The CAP has supported farming on the full range of grazing lands for several decades in Greece like it did in other countries such as France, UK and Spain. When support was paid per head of livestock, there was no question of an active farmer not receiving CAP support because his grazing land had the wrong type of vegetation. The farmer and his stock could and did receive support while using any legally available grazing land. But with the move away from coupled payments per head of livestock to decoupled area payments, the delineation of eligible land has becomes a far more significant issue. Nowadays, decisions need to be taken about what land is eligible to claim support.

During the period of CAP ended in 2013, some Member States have taken a more restrictive approach and have excluded considerable areas of grazing lands with shrubs and trees from support, probably influenced by a combination of the CAP definition of permanent pasture and its focus on "herbaceous grazing lands", plus the Commission guidance on eligibility. In Greece, for example, from a total 5.2 million ha grazing lands only a 25% was considered as eligible. There are major inconsistencies between Member States in the way that grazing lands with shrubs and trees are treated in relation to Pillar 1 payments. Some take an inclusive approach, and include large areas of actively-farmed wooded pastures in their eligible areas, while very large areas of similar farmland are excluded from Pillar 1 support in other Member States. These inconsistencies in the CAP have important implications for the achievement of EU goals for biodiversity and ecosystems, because many of the excluded types of grazing lands are habitats of European importance that require continued farming use for their conservation. It is recognized that there is a decline tendency of permanent pastures under active farming use, especially in more marginal farming situations. There is a concern for that by authorities and general public, therefore, mechanisms are introduced in CAP by 2003 to maintain permanent pasture and to prevent their conversion to arable land; however, the increasingly abandonment of grazing shrublands or wooded pastures and their forestation did not take in account that biodiversity may also declines as woody plants colonize rangelands and transform them into dense and impenetrable wood stands. There is evidence that the Greece's rangeland landscape has changed due to the abandon of grazing lands, which were exempted by the CAP Direct Payments. The lack of proper grazing management results in (i) the concentration of grazing livestock on eligible "permanent pastures", (ii) the livestock decline in some remote areas causing social structural changes and (iii) the invasion of woody plants into grasslands.

In the new CAP 2014-2020 (Regulation EU, 2013), the definition of Permanent Pasture is "permanent grassland and permanent pasture (together referred to as permanent grassland) means land used to grow grasses or other herbaceous forage naturally (self- seeded) or through cultivation (sown) and that has not been included in the crop rotation of the holding for five years or more; it may include other species such as shrubs and/or trees which can be grazed provided that the grasses and other herbaceous forage remain predominant as well as, where Member States so decide, land which can be grazed and which forms part of established local practices where grasses and other herbaceous forage are traditionally not predominant in grazing areas". Moreover, Member States have to establish criteria to be met by farmers in order to fulfill the obligation to maintain permanent grassland suitable for grazing and to define the minimum activity to be carried out on permanent grassland naturally kept in a state suitable for grazing. During, this period Greece's authorities have to decide which of the rangeland types reported above will be considered as eligible for CAP support and which of established local practices rationalize the eligibility of wooded rangelands. However, in order to be ensured legal certainty for all these, the Commission shall be empowered to adopt delegated acts.

Up to now the major problem with farm inspections in Greece was that land eligibility was the main issue during the inspection. Wooded rangelands were usually classed as ineligible land regardless of the grazing and their contribution to livestock. Therefore, in the current CAP, all these lands or at least a great part of them have to be included to the eligible land under Single Farm Payment. This aspect is supported by the fact that wooded rangelands in Mediterranean region are important forage resources because they supply green forage either throughout the year when they are dominated by evergreen shrubs or in the critical summer period when they are occupied by deciduous woody plants (Papachristou and Nastis, 1993a, b; Papachristou and Nastis, 1996; Papachristou, 1997; Papachristou *et al*., 1999). A good example is the kermes oak shrublands, which are suitable grazing land for goats and for cattle and sheep when they are sparse. The browse of kermes oak and accompanied woody plants in mixture with herbage consist an ideal feed for goats. For example, Papachristou *et al*. (1999) and Papachristou and Platis (2011b) found that goats gained weight (approximately 100 g/d) when they ate browse of kermes oak and deciduous browse species, such as *Carpinus orientalis*, *Fraxinus ornus*, *Robinia pseudoacacia, Morus alba* in contrast to the goats ate only kermes oak (lost weight, 70 g/d). Therefore, it was suggested not only the maintenance of the woody component on such rangelands but the introduction of woody fodder plants of high nutritive value into grasslands.

Greek shrublands not only meet the needs of animals in forage in periods when the herbaceous plants are absent but they give in the produced livestock products especially quality characteristics. For example, the milk produced is high-casein, which contributes to the production of high quality cheese and high fat ingredients. Ecosystems, in addition to the production of forage and livestock products, through control of biomass via livestock grazing also serve several other ecosystem functions of particular interest. Among these are: (a) reduction of fire risk and subsequent release of carbon and soil erosion, (b) preserving open landscapes with a variety of vegetation and high aesthetic value and (3) maintenance of high biodiversity habitats, which are ruled by Directive 79/409 (1979) and 92/43 (1992) for the birds and habitats directives, respectively. Therefore, it is important all these grazed ecosystems to continue to be grazed because otherwise they become impenetrable and environmental and socioeconomic values that constitute indispensable public goods will be lost. On the other hand, there is the risk to qualify the eligibility rules of EU support system such grazing lands to be managed irrationally. For example, eradication of woody vegetation in unorthodox ways (e.g. fire) and creation of eligible open grazing lands. In this case and the goal will not be achieved, as woodland will immediately be declared for forestation, since they are ruled by forest law, and the environmental and economic consequences will be the same, if not more, devastating, like the withdrawal of grazing. For this reason, the national and Community policy should aim to preserve the environmental role of these areas and the simultaneous production of products (e.g. milk, meat, firewood).

VI – Conclusions

The forage/grazing resources in Greece consist of a variety of vegetation types and the combined use of them can support viable animal agricultural systems. Therefore, the establishment of combined forage resources including rangelands, fodder shrub plantations, pastures, grazed forests and arable lands is a promising alternative for the Greek pastoral systems. In the past, shepherds achieved this with the temporal and spatial movement of their flocks and the combination of more than one resource grown in different ecological environments and elevation zones. However, nowadays the animal agricultural systems are rather extensive without transhumance, which means that animals have to satisfy their feed requirements in the wider grazing land area, but not too far from the permanent stall. In this case the herder has to combine the available forage resources in this given area enduring the restricted factors (e.g., short grazing period). National and EU policies have to ensure the integrity of all grazing lands that support livestock by including them in the payments schemes of Pillars I and II.

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Overview on grassland and farming systems in Evros regional unit

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Abstract. Agriculture is the most important activity of the economy in Evros regional unit followed by livestock farming. Arable land covers 42.35% of the total area. The main cultivation is sunflower representing around 50% of the total production in Greece. Forage crops production is limited and consists mainly of alfalfa. Livestock usually graze at natural and semi-natural grasslands and woodlands. Inappropriate grazing management due to the lack of grazing management plans led to overgrazing or land abandonment. High yielding forage crops are necessary to provide the animal feed. An essential increase in artificial pastures cultivated with drought-resistant grasses and legumes will be a step to combine agricultural and livestock production. Grassland management plans are important in order to sustain grassland and woodland ecosystems and to increase livestock production.

Keywords. Forage production – Grasslands – Grazing – Greece – Thrace.

Vue d'ensemble sur les systèmes herbagers et les systèmes agricoles dans l'unité régionale d'Evros

Résumé. *L'agriculture est l'activité la plus importante de l'économie dans la province d'Evros suivie par l'élevage. Les terres arables couvrent 42,35% du total de la zone. La principale culture est le tournesol représentant environ 50% de la production totale en Grèce. La production de cultures fourragères est limitée et consiste principalement en luzerne. Le bétail broute habituellement dans des pâturages herbeux ou boisés naturels ou semi-naturels. Une gestion inappropriée du pâturage en raison de l'absence de plans de gestion de pâturage conduit au surpâturage ou à l'abandon de terres. Les cultures fourragères à haut rendement sont nécessaires pour fournir l'alimentation animale. Une augmentation essentielle de pâturages artificiels cutivés avec des herbes résistantes à la sécheresse et des légumineuses sera une étape pour combiner la production agricole et animale. Les plans de gestion des prairies sont importants afin de maintenir les écosystèmes des régions boisées et des terres herbeuses et d'accroître la production de bétail.*

Mots-clés. *Production de fourrage – Prairies – Pâturages – Grèce – Thrace.*

I – Introduction

Greece is divided in 74 regional units. Evros regional unit (part of Thrace region) is a less favored area located in the northeastern part of Greece. It borders Turkey to the east across the river Evros and Bulgaria to the north and the northwest (Fig 1). Evros is a lowland region, as 62.4% of its area consists of plains. Agriculture is the most important activity of the local economy. The crop production includes mainly winter cereals (as wheat and barley), sunflowers, cotton, maize and alfalfa. Traditionally, extensive livestock farming is a fundamental activity, especially for the north part of Evros region (Parissi *et al.*, 2010). Sheep and goats farming is the most important activity in the animal production sector of Evros.

Fig. 1. Location and map of Evros regional unit.

II – Land use cover and farming systems in Evros region

The total area of Evros regional unit is 424,800 hectares. Arable land covers 42.35% (Table 1) (HSA, 2000). Thus, Evros regional unit ranks among the top regional units of Greece in terms of the ratio of cultivated lands to total area, representing 5.38% of the total agricultural land in Greece (Table 2). After agricultural lands, forest and other non-cultivated lands are predominant. Pastures cover only 4.29%, but grazing is a common activity in open oak woodlands, shrublands, as well as in forests (Table 1). This means that the area used for livestock production in Evros exceeds 35% of the total area.

Table 1. Land uses at Evros regional unit

	Evros Prefecture	% of Evros
Agricultural Land	***240,000***	***56.50***
Arable land	179,900	42.35
Permanents crops	5,350	1.26
Pastures - Grazing lands	18,250	4.29
Other agricultural area	36,500	8.59
Woodlands - Forests	***166,170***	***39.12***
Forests	99,840	23.50
Open woodlands	37,290	8.78
Shrublands	29,040	6.29
Fresh water	***12,880***	***3.03***
Artificial areas	***5,750***	***1.35***
TOTAL	***424,800***	***100.00***

Source: Hellenic Statistical Authority (HSA) (2000).

Table 2. Number of agricultural and livestock enterprises in Greece and in Evros regional unit

	Mixed agricultural and livestock enterprises		Agricultural enterprises		Livestock enterprises	
	Number	Land area (ha)	Number	Land area (ha)	Number	Land area (ha)
Greece	115,461	1,172,200	575,525	2,091,000	18,463	118,400
Evros regional unit	2,178	30,300	12,040	112,600	98	700
% of Greece	1.89	2.58	2.09	5.38	0.53	0.59

Source: Hellenic Statistical Authority (HSA) (2013a).

High-quality plants such as sunflower, wheat, cotton, sugar beet corn and some vegetables are grown in Evros (Table 3). Sunflower cultivation covers more than a fifth of the total cultivated land in Evros. It is by far the dominant crop in the northern part of Evros. It has to be noted that around 50% of sunflower cultivation area in Greece is located in Evros. Forage crops production is limited and consists mainly of alfalfa.

Table 3. Important crops in Evros (2014)

	Area (ha)	%
Sunflower	30,930.5	21.9
Wheat	28,311.4	20.0
Other winter cereals	18,041.4	12.8
Cotton	20,341.5	14.4
Alfalfa	10,128.3	7.2
Maize	3,224.3	2.3
Vegetable	2,260.5	1.6
Sugar beet	1,709.4	1.2
Other crops and fallow lands	26,554.1	18.8
TOTAL	141,501.4	100

Source: Statistics from the Directorate of Rural Economy and Veterinary of Regional Unit of Evros (2014).

III – Grassland farming and livestock farming in Evros

The total number of livestock and mixed enterprises in Evros is around the national mean (Table 2). The number of goats in Evros is also around the national mean, while cattle and horses exceed it (Table 4) mainly due to the plain topography. Extensive livestock farming of goats and sheep is dominant in the area, while cattle are mainly dairy cows (Table 4 and 5). In order to increase sustainability and profitability, high-quality forage production should be encouraged and supported as the 70-80% (depending on the type of farming system) of capital cost in farming management is related to the purchase or production of feed (Manousidis *et al.*, 2012). The establishment of artificial pastures could also contribute to a more sustainable intensive dairy sheep farming system (Manousidis *et al.*, 2011).

Forage crops are produced in about 10,600 hectares in Evros and this value corresponds to 7.2% of total cultivated area. The dominant forage crop is alfalfa (Table 6), following the same trend of the country. Availability of local seeds and traditional knowledge of farmers are among the main reasons for its dominance (Abraham *et al.*, 2009). The majority of forage crops are cultivated for hay production, while artificial pastures for grazing are covering only 0.4% of the total forage crop area. Thus, grazing is practiced in natural and semi-natural grasslands and woodlands. They are mainly public lands. The forage production in these grazing lands and the grazing capacity are generally low (Parissi *et al.*, 2010).

Table 4. Number of livestock animals (heads) in Evros and Greece

	Cattle	Water buffalo	Sheep	Goats	Horses
Greece	614,992	5,479	8,686,117	3,654,793	26,239
Evros Prefecture	19,138	0	115,605	71,690	959
% of Greece	3.11	0	1.33	1.96	3.65

Source: Hellenic Statistical Authority (HSA) (2013b).

Table 5. Milk and feta cheese production in Evros and Greece (2014)

	Cow	Sheep	Goat	Feta cheese*
Greece	617,131,608	538,164,571	126,494,814	91,698
Evros Prefecture	17,794,878	3,683,349	2,270,754	1,268
% of Greece	2.88	0.68	1.80	1.38

Source: Hellenic Organization of Milk and Meat (ELOGAK) (2014). *2008.

Table 6. Forage crops in Evros

	Area (ha)	%
Alfalfa	10,128	94.8
Clover	237	2.2
Vetch	177	1.7
Maize (silage)	12	0.1
Grasses	39	0.4
Barley – Oat	83	0.8
TOTAL	10,678	100

Source: Statistics from the Directorate of Rural Economy and Veterinary of Regional Unit of Evros (2014).

Grazing period for sheep and goats lasts 9 to 10 months. Animals kept indoors only during the winter months and are fed mainly on alfalfa hay (Manousidis *et al.*, 2014). Due to the deficit of green and nutritious herbaceous forages during summer goats browse woody species especially oak (Manousidis *et al.*, 2016).

IV – Grassland management in Evros

Grazing management in Evros, as well as in Greece, is very poor, practically is absent (Papachristou, 2016). Inappropriate grazing management might be either land abandonment or overgrazing (Bouju, 2000). Abandonment of grasslands commonly leads to encroachment and development of woody vegetation, with increased wildfire risk (Moreira *et al.*, 2011) and reduction in floristic diversity (Bartolome *et al.*, 2005). This phenomenon is common in some grasslands of northern Evros, which are encroached by *Juniperus oxycedrus*. Heavy encroachment of this less palatable species decreases forage production and floristic diversity (Kyriazopoulos *et al.*, 2012).

Grasslands and woodlands in Greece are used in a communal way, as they are either state-owned or community-owned, and this arrangement also leads to their degradation due to overgrazing (Papanastasis, 2009). The use of publicly owned lands as grazing lands is often associated with the absence of monitoring and planning of stocking rates. Overgrazing in various areas in northern Evros has been reported (Parissi, 2010). In contrast, there is evidence that moderate grazing intensity results in an increased floristic biodiversity in grasslands (Keisoglou *et al.*, 2013) and oak woodlands (Lempesi *et al.*, 2013) of Evros.

Greece has been pushed through to change legislation about grassland management due to the new CAP reform (2014-2020). According to the new laws (2014, 2015) grassland management plans are obligatory. This management plans will be useful tools for the sustainable grassland management in the future.

V – Conclusions

Crop production dominates the livestock production in Evros regional unit. Nevertheless, forage crops production is generally low. The combination of limited and degraded grasslands with the low production of forage crops is resulting in an increased cost of animal feed. Therefore, high yielding forage crops are necessary to provide the animal feed. An essential increase in artificial pastures cultivated with drought-resistant grasses and legumes will be a step to combine agricultural and livestock production. Grassland management plans are important in order to sustain grassland and woodland ecosystems and to increase livestock production.

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Session 1
Managing ecosystem services and livestock production in the Mediterranean region

Methods and approaches used for assessing ecosystem services provided by grazing systems

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Abstract. To date, scientific literature provided a vast amount of studies on Ecosystem Services (ES) underpinning their benefits to human well-being. Livestock grazing systems occupy a vast area of the terrestrial surface and are essential to the livelihood especially for vulnerable communities. Grazinglands are able to provide a wide array of ES depending on management practices and intensity. In this perspective and according to the Millennium Ecosystem Assessment (MA) framework, the paper reviews the methods and the approaches used in the analysis of the main ES provided by grazing systems. The search criteria produced a scarce amount of papers (few referred to Mediterranean climate areas), also because many authors did not consider 'goods' or 'benefits' (e.g. food) as ES. The bibliography review highlighted that: i) some papers misunderstood the concept of ES as defined by MA (e.g. biodiversity considered as ES; lack of anthropocentric vision); ii) ES planning need management and development options to be based on systems' internal dynamics; iii) ES multiscale and multisectoral analysis emerged in many papers but just few included stakeholder (SHs) involvement; iv) a better SHs awareness of the well-being provided by ES in livestock grazing systems could foster agri-environmental schemes and the willingness to pay for their services.

Keywords. *Grazinglands – Livestock – Primary production – Habitat – Food – Land degradation – Water quality and flow – Climate regulation.*

Méthodes et approches utilisées pour évaluer les services écosystémiques fournis par les systèmes pastoraux

Résumé. *À ce jour, la littérature scientifique a fourni une grande quantité d'études sur les services écosystémiques (SE) qui montrent leurs avantages pour le bien-être humain. Les systèmes pastoraux occupent une vaste zone de la surface terrestre et sont essentiels à la subsistance en particulier pour les communautés vulnérables. Les pâturages sont en mesure de fournir un large éventail de SE en fonction des pratiques et de l'intensité de gestion. Dans cette perspective et conformément au cadre Millennium Ecosystem Assessment (MA), le document passe en revue les méthodes et les approches utilisées dans l'analyse des principaux SE fournis par les systèmes de pâturage. D'après les résultats, l'examen fournit des recommandations pour les recherches futures dans les régions méditerranéennes. Les critères de recherche ont produit une quantité insuffisante de documents (quelques-uns visant les zones à climat méditerranéen), en partie parce que de nombreux auteurs ne considèrent pas les «biens» ou «avantages» (par exemple aliments) en tant que SE. L'examen de la bibliographie a souligné que: i) des articles ont mal compris le concept de SE tel que défini par la MA (par exemple biodiversité considérée comme SE, manque de vision anthropocentrique); ii) la planification des SE a besoin d'options de gestion et de développement pour être basée sur la dynamique interne des systèmes; iii) l'analyse multisectorielle multi-échelle des SE a émergé dans de nombreux documents, mais seulement quelques-uns ont inclus l'implication des parties prenantes (SHs); iv) une meilleure prise de conscience des parties prenantes sur le bien-être fourni par les SE dans les systèmes pastoraux pourrait favoriser des programmes agroenvironnementaux et la volonté de payer pour leurs services.*

Mots-clés. *Pâturages – Élevage – Production primaire – Habitat – Aliment – Dégradation des terres – Qualité de l'eau et débit – Régulation du climat.*

I – Introduction

Although the first references about the concept of 'ecosystem functions, services and values' are dated around 1960s, the amount of scientific publications concerning Ecosystem Services (ES) grew exponentially in the last few decades (de Groot *et al.*, 2002). The Millennium Ecosystem Assessment (MA, 2003; 2005) represents one of the most extensive and accepted ever study on the links between human well-being and the world's ecosystems. The MA defines i) the ecosystem as *"a dynamic complex of plant, animal* (including humans), *and microorganism communities and the non-living environment interacting as a functional unit"* and ii) the ecosystem services as "*the benefits people obtain from ecosystems"*.

MA distinguished four groups of ES: i) Supporting: services necessary for the production of all other ES (e.g. soil formation and nutrient cycling) whose impacts on people are either indirect or occur over a very long time; ii) Provisioning: products obtained from ecosystems, such as food and fresh water; ii) Regulating: benefits obtained from the regulation of ecosystem processes, such as climate and disease regulation; iii) Cultural: non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences.

A second key study concerning ES is the Economics of Ecosystems and Biodiversity (TEEB, 2010) which defines ES as *'the direct and indirect contributions of ecosystems to human well-being'*, separates the concept of services from benefits (welfare gains generated by ES) and considers supporting services just as ecological processes and not strictly as ES.

If in one hand every ecosystem is able to produce a large amount of ES (MA, 2003; 2005), on the other hand, ecosystems may also produce Ecosystem Disservices that are harmful or detrimental to human well-being (von Döhren and Haase, 2015). Thus, the term "ecosystem service" is anthropocentric and to be intended with a positive sense.

ES are spatial-scale and time-scale dependent and the risk of scale mismatch between ecological processes and decision-making is likely to occur. For these reasons the need of an integrated approach that takes into account also the local knowledge of stakeholders (SHs) is a key requirement in assessing ES (MA, 2003; 2005; Reed *et al.*, 2008; Tarrasón *et al.*, 2016).

According to MA (2003) and TEEB (2010), ecosystems and biodiversity are closely related concepts although the latter it is not considered strictly an ES but rather a source or a regulator of the former (Harrison *et al.*, 2014). The gap of knowledge on the linkages or difficulties in understanding the relationships between ES and biodiversity was highlighted by many authors (e.g. Jax and Heink, 2015; Sircely and Naeem, 2012; Harrison *et al.*, 2014).

Livestock systems occupy about a third of the planet's ice-free terrestrial surface and represent an important source of income or even are essential for vulnerable human communities' survival. In these systems, grazinglands could deliver a large and differentiated amount of ES. These services in turn are dependent on different management practices (Fischer *et al.*, 2010; Steiner *et al.*, 2014), such as different grazing regimes (Ford *et al.*, 2012).

The aim of this paper is to review the methods and the approaches used in the analysis and planning of the main ES provided by grazing systems and to derive recommendations for future research in Mediterranean areas.

II – Grazing systems: classification criteria and terminology

To date no unique classification of livestock systems is available (Robinson *et al.*, 2011). Broadly defined, livestock systems are a subset of farming systems (Ruthenberg, 1980), in which livestock contribute more than 10 percent to total farm output (Seré and Steinfeld, 1996), with similar enterprise patterns, livelihoods and resource base (Dixon *et al.*, 2001).
A more livestock-oriented classification of farming systems was developed by Seré and

Steinfeld (1996) for solely livestock systems split into grassland-based (LG) and landless (LL) systems. LG and LL systems are those in which dry matter fed to animals is higher and lower than 10 percent produced in the farm, respectively; and in which annual average stocking rates are below and above 10 standard livestock units per hectare of agriculture land, respectively. An interactive map of their distribution is provided by Global Livestock Production and Health Atlas (GLiPHA) of FAO (2016).

Ecosystem classification is performed according to the various fields of research. Biomes are the most basic units that ecology use to describe global patterns of ecosystem form, process, and biodiversity (Ellis and Ramankutty, 2008). Historically, biomes were identified and mapped based on general differences in vegetation type associated with regional variations in climate (Matthews, 1983; Olson *et al.*, 2001). Further classifications dealing with the potential land uses for agriculture in a geographical context are agro-ecological zones devised by FAO, which found a wide range of applications at global, regional and national levels (FAO, 2011; FAO and IIASA, 2007). Considering the first classification just some biomes provide the necessary conditions for livestock systems (e.g. tundra, taiga, steppe, savanna). In the second classification, ecological zones are divided based on the length of the grazing period and potential evapotranspiration.

In the attempt to relate livestock systems and agro-ecosystems, land use types emerge. 'Rangelands' include land on which the indigenous vegetation (climax or subclimax) is predominantly grasses, grass-like plants, forbs or shrubs that are grazed or have the potential to be grazed, and which is used as a natural ecosystem for the production of grazing livestock and wildlife (natural grasslands, savannas, shrublands, many deserts, steppes, tundras, alpine communities and marshes). 'Grazinglands' extend the potential land use from natural compositions to any vegetated land that is grazed or has the potential to be grazed by animals (domestic and wild) (Allen *et al.*, 2011). This term is all-inclusive and covers all kinds and types of land that can be grazed (rangelands and artificial pastures).

Within both the ecosystem and the agro-ecological classifications, a set of terms is in use to distinguish between systems and management practises. The applied terms mainly reflect the relationship between the exploitation of land and vegetation type, such as pastoralism (Land-use systems in which grasslands and shrublands are exploited through grazing) and silvopastoralism (Land-use systems and practices in which trees and pastures are deliberately integrated with livestock components). While the first and second terms relate directly to the management practice, agroforestry (Land-use systems or practices in which trees are deliberately integrated with crops and/or animals on the same land management unit) indicates just a relationship between forestry and agriculture on a territorial unit.

In the context of this review, grazing systems include the production systems in which grazing is one of the main management practices adopted through all the grazing lands.

III – Linkages between biodiversity and ecosystem services

Biodiversity is the variability among living organisms and includes diversity within and among species and ecosystems. It is the source of many goods and services, such as food and genetic resources, and changes in biodiversity can influence the supply of ES (MA, 2003). Later the MA (2005) defined biodiversity as a necessary condition for the delivery of all ES and, in most cases, greater level of biodiversity is associated with a larger or more dependable supply of ES.

According to MA (2005) biodiversity is both a response variable affected by global change drivers (e.g. climate or land use change) and a factor modifying ecosystem processes and services and indirectly, human well-being (e.g. health or freedom of choice and action). Changes in human well-being may lead to modify management practices with direct effects on ecosystem processes and biodiversity (Fig. 1).

Despite MA describes a unilateral relationship between biodiversity and ES, some authors consider biodiversity as a service in its own right and for example, as the basis of nature-based tourism (van Wilgen *et al.*, 2008), while some others consider biodiversity and ES as synonyms (Mace *et al.*, 2012).

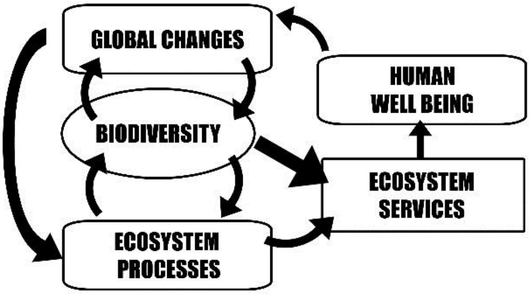

Fig.1. Interrelation among biodiversity, ecosystem functioning and ES (modified from MA, 2005).

Habitat provisioning is one of the main ecosystems services linking the effects of livestock grazing to the biodiversity of the host ecosystem (FAO, 2014). Habitat services arise from the direct interaction of animals with their environments, hence are related to land management practices, especially in grazing systems. Despite MA (2003, 2005), the TEEB (2010) considers Habitat services as a separate category. In accordance with these documents, this review considers habitat services within supporting services, because of their interconnected nature, as well as their shared roles in underpinning the delivery of the other services.

IV – Bibliography analysis: methods and tools

The review is based on the ES provided by grazing systems as categorised and found to be prominent by FAO (2014) (Tab. 1). Among those, the ES on the base of the expertise and background of the authors were analysed in detail.

A general database of papers dealing with ES was created using the Web of Science^{TM} in January 2016 selecting 'topic' as the searching option. The basic string: *"ecosystem service*" and ("grassland*" or "rangeland*" or "shrubland*" or "scrubland*") and "grazing"* was used as input in the 'field search' ('basic search') including 'all years' as 'timespan'. The term "*mediterranean*" was than added to understand how deeply the ES were studied within Mediterranean climate areas. In order to select papers for each analysed ES, specific search terms were added to the basic string according to the keywords (Tab. 1) included in FAO (2014). The search terms are reported in detail in each ES section.

The query returned a total of 157 papers of which only 10 were referred to Mediterranean (MED) areas. Multiple occurrence of different ES within single papers (more than 50% of the papers deals with two and three ES simultaneously) result in a total amount of 531 findings (40 in MED areas) (Table 1).

This review did not take into account: i) papers dealing with ES not analysed, ii) reviews and meta-analysis, and iii) papers not adopting the MA framework.

The methods used for assessing ES (e.g. direct, indirect, modelling, indicators), applied treatments and the spatial and temporal scale of assessment were examined in the analysed papers. The use of multiscale and multisectoral assessment framework (MA, 2003) or other approaches (e.g. participatory), especially regarding those dealing with planning and providing of ES was analysed

Table 1. Number of papers returned by the search strings used for each ES, provided by grazing systems (modified from FAO, 2014)

ES group	Ecosystem service[1]	Description	N° of papers[2,3]
Supporting	Maintenance of soil structure and fertility (n.a.)	Nutrient cycling on farm and across landscapes, soil formation	12 (1)
	Primary production	Improving vegetation growth/cover	73 (7)
	Habitat services *(as part of supporting services)*		
	Maintenance of life cycles of species	Habitat for species, especially migratory species	79 (5)
	Habitat connectivity (n.a.)	Seed dispersal in guts and coats	2 (0)
	Maintenance of genetic diversity	Gene pool protection and conservation	0
Provisioning	Food	Meat, milk, eggs, honey, wool, leather, hides, skins, etc.	12 (2)
	Fertilizer (n.a.)	Manure and urine for fertilizer	9 (0)
	Fuel (n.a.)	Manure and CH_4 for energy, manure biogas, etc.	11 (0)
	Power	Draught animal power	0
	Genetic resources (n.a.)	Basis for breed improvement and medicinal purposes	10 (0)
	Biotechnical/Medicinal resources	Lab. animals, test-organisms, biochemical products	0
Regulating	Waste recycling and conversion of non-human edible feed (n.a.)	Recycling of crop residues, household waste, swill, primary vegetation consumption	1 (0)
	Land degradation and erosion prevention	Maintenance of vegetation cover	26 (5)
	Water quality regulation/purification	Water purification/filtering in soils	8 (1)
	Regulation of water flows	Natural drainage and drought prevention, influence of vegetation on rainfall, timing/magnitude of runoff/flooding	44 (4)
	Climate regulation	Soil C sequestration, GHG mitigation	60 (4)
	Moderation of extreme events	Avalanche and fire control	19 (3)
	Pollination (n.a.)	Yield/seed quality in crops and natural vegetation; genetic diversity	17 (0)
	Biological control and animal/human disease regulation (n.a.)	Destruction of habitats of pest and disease vectors; yields	3 (0)
Cultural	Opportunities for recreation (n.a.)	Eco/agro-tourism, sports, shows and other recreational activities involving specific animal breeds	50 (1)
	Knowledge systems and educational values (n.a.)	Traditional and formal knowledge about the breed, the grazing and socio-cultural systems of the area	23 (0)
	Cultural and historic heritage (n.a.)	Presence of the breed in the area helps to maintain elements of the local and/or culture that are valued as part of local heritage; cultural identity	21 (2)
	Inspiration for culture, art and design (n.a.)	Traditional art /handicraft; fashion; cultural, intellectual and spiritual enrichment and inspiration; pet animals, advertising	12 (0)
	Natural (Landscape) heritage	Values associated with landscape as shaped by animals themselves or as a part of landscape, e.g. aesthetic values, sense of place, inspiration	39 (5)
	Spiritual and religious experience	Values related to religious rituals, human life-cycle such as religious ceremonies, funerals or weddings	0

[1] n.a.: ES not analysed; [2] between parentheses, papers within Mediterranean climate areas; [3] multiple occurrence of different ES within single papers present.

V – Ecosystem services

Primary production (PP) is a fundamental supporting service defined in MA (2003) as assimilation (gross) or accumulation (net) of energy and nutrients by green plants. Maintaining or enhancing the productive capacity and resilience of grazingland ecosystems is critical for the continued support of livelihoods and the ES that benefit society at large (Teague *et al.*, 2015). We extracted papers according to the additional string *("primary production" or "vegetation growth" or "vegetation cover" or "vegetation" or "NPP" or "net primary production")*. The analysis resulted of 73 papers of which 7 in Mediterranean area. In the analysed papers PP in grazinglands is commonly recognised as basic ES for the livestock systems functioning (e.g. Loucougaray *et al.*, 2015), but few researches refer to the approach and the classification as provided by MA (e.g. Oñatibia *et al.*, 2015). PP was mainly assessed as aboveground biomass, often in combination with other characteristics (e.g., mainly belowground component, but also litter, vegetation cover, herbage nutritive value, etc.) in several rangeland ecosystems, under different site, climate and management conditions.

Different methods and approaches were used for assessing PP. Direct field-based surveys (e.g. Oñatibia *et al.*, 2015), but also calibrated measurements (e.g. Loucougaray *et al.*, 2015), were used at different spatial and temporal scale. Field-plots experiments assessed the effects of different management (e.g. mowing, grazing and undisturbed or abandonment) and intensities on PP in short (e.g. Zeng *et al.*, 2015) but also long-term (e.g. Marriot *et al.*, 2010) monitoring. In these researches, plots dimensions varied from minimum of 0.45 (Marriot *et al.*, 2010) up to 170 ha (Medina-Roldán *et al.*, 2012) in designs with 2-4 replicates and included enough heterogeneity to reduce pseudo-replication effects. In other cases, landscape scale was applied to take into account management or site conditions in farms (Loucougaray *et al.*, 2015) or along transects. In multiple zonal grazinglands along climatic and management gradients (e.g. Bai *et al.*, 2012; Medina-Roldán *et al.*, 2012; Sasaki *et al.*, 2012), transects were used to assess the effects of grazing on the PP (e.g. above- and below-ground and litter biomass, C : N : P stoichiometry). The same methodologies were used to assess the dynamic trade-offs, synergies and relationships of PP with other ES in response to diverse site-specific, land use and management conditions to provide support for the sustainable development of production systems and grazinglands conservation. Examples are the analysis of the effect of vegetation cover on the soil loss and run off (van Oudenhoven *et al.*, 2015) and on drought (Gaitán *et al.*, 2014) or the CO_2 enrichment on the plant composition and production under grazing (Newton *et al.*, 2014).

To overcome the limits to account for spatial and temporal variation of the field-based methods remote sensing and simulation models were used to assess and monitor grazinglands dynamics and their ability to provide ES according to management strategies. Sant *et al.* (2014) used high resolution imagery as enhanced ground samples to assess the vegetation cover as indicator of range condition to develop improved management prescriptions. On other sites, several authors (Lima *et al.*, 2011; Schaldach *et al.*, 2013; Teague *et al.*, 2015), used models both for the simulation of ecological, environmental and economic effects under various combinations of changing livestock, climate and management conditions and for an integrated analysis of land cover changes. The results of the simulation approach resulted as useful tools allowing a more complete analysis of the impacts of different management when integrated with field data. ES method is recognised as a suitable tool (e.g. Schaldach *et al.*, 2013) to support climate adaptation strategies integrating both ecological and socio-economic aspects. Neverthelss, none of the analysed papers highlighted the inclusion of participatory process or stakeholder involvement as done by Tarrasón *et al.* (2016).

Habitat services (HS) facilitate the life cycles of animals and plants, the prevention of succession to less valuable ecological states through encroachment of bush and/or invasive species, and the conservation of wildlife and protected areas found in coevolved landscapes (FAO, 2014). The most important clusters of HS provided by livestock are those that support the

maintenance of species life cycles and those related to the connection of habitats (FAO, 2014). We extracted papers according to the additional criteria *("species" or "habitat" or "life cycle")* and obtained 79 papers. Plants resulted the most studied (e.g. Duru *et al.*, 2015) followed by pollinator (e.g. Cole *et al.*, 2015) and not pollinator (e.g. Cole *et al.*, 2012) insects; earthworms (e.g. Kovács-Hostyánszki *et al.*, 2013) and arbuscular mycorrhizal (e.g. Morris *et al.*, 2013).
The literature review highlighted that HS assessment methods are species (animal, plants, etc.) and mainly spatial-scale dependent. Transect surveys were mostly used for species sampling at different scales, varying from 16 m (e.g. for carabidae diversity, Cole *et al.*, 2012) to 700 km along a precipitation gradient (e.g. for botanical composition, Bai *et al.*, 2012). Random sampling was used in field-plot experiments (e.g. Boughton *et al.*, 2013) or at farm level (Loucougaray *et al.*, 2015) for assessing species diversity/abundance and vegetation cover. Point quadrat method (e.g. Klumpp and Soussana, 2009) and abundance/dominance method (Fontana *et al.*, 2014; Bagella *et al.*, 2013) were the main used for vegetation survey. Most frequent indicators used both for plant and animal species were: species richness (e.g. Duru *et al.*, 2013), abundance (e.g. Stein *et al.*, 2014), Shannon diversity (e.g. Fontana *et al.*, 2014), Eveness (e.g. Cole *et al.*, 2015) and Simpson (e.g. Franzén and Nilsson, 2008). GIS, sometimes in combination with remote sensing technologies were used to analyse land use (e.g. Fontana *et al.*, 2014) and diachronic vegetation changes (e.g. Su *et al.*, 2015) or for identifying scenarios of biodiversity trajectories (e.g. Lindborg *et al.*, 2009). Modelling was used to simulate vegetation dynamics, also in relation with other ES (e.g. cattle grazing and elk hunting, Hussain and Tschirhart, 2013), and to identify scenarios related to climate change (e.g. Peringer *et al.*, 2013) or to land use management options (e.g. for the biodiversity conservation, Lindborg *et al.*, 2009). Others researches used SHs involvement to provide supporting tools for the sustainable management of grazinglands (Fisher *et al.*, 2011).

Food and other livestock related products (FP) in grazed ecosystems include provision of high-protein meat and dairy products along with leather and other by-products of livestock production (Steiner *et al.*, 2014). A main effect of grazing for livestock is a clear positive impact on the nutritive quality of the resulting products, especially regarding antioxidants, lipid quality and fat soluble vitamins. The quality is clearly related to the botanical biodiversity of the pastures that is associated with a diversity of plant active compounds influencing the animals' metabolism (Leiber *et al.*, 2014).

From this analysis, extraction string *("meat" or "milk" or "honey" or "wool" or "leather" or "hide" or "skin" or "wax")* revealed 12 publications out of which 10 were not relevant, while just two of them were conceived in the ES framework. Both publications (Bagella *et al.*, 2013 and Koniak *et al.*, 2011) are from Mediterranean area and address issues related to honey production. Koniak *et al.* (2011) developed a mathematical model which predicts the dynamics of multiple services in response to management scenarios (grazing, fire and their combination), mediated by vegetation changes. In this paper, the potential contribution to honey production was combined with other ES from different groups, despite their different nature, into one 'ES basket'. Bagella *et al.* (2013) monitored honey production and the quality of pollen present in its sediments in an experimental apiary in a typical Mediterranean agro-pastoral system. The research was performed to identify the most effective plant communities for honeybee foraging by highlighting the relationship between flowering phenology and pollen occurring in honey sediments.

Land degradation and soil erosion (LD) are not seen just as a loss of soil and fertility but also as deterioration of balanced ecosystems and the loss of ES (Nachtergaele *et al.*, 2011). The additional string *("land degradation" or "erosion" or "cover crop*" or "vegetation cover")* resulted of 26 papers of which 5 in Mediterranean areas. According to the analysis criteria, just 3 out of 26 papers were eligible for this review because LD was not analysed as an ES.

A participatory methodological framework was used to identify features of LD and linkages with ES provision (Tarrasón *et al.*, 2016). This study designed a four-step methodological framework to integrate local and scientific knowledge within a participatory assessment of land degradation in a pastoral system. Field visits, in-depth interviews with key informants and farmers produced information that was integrated with scientific knowledge, validated by focus groups and then used in a state-and-transition conceptual model. Field data on cover vegetation and plot life forms were used in thematic working groups with different SHs to discuss about the results of previous phase and to develop adaptive management options to maintain or improve ES. The same model was validated by Miller *et al.* (2011) with field studies conducted in a semiarid grassland ecosystem of USA quantifying structural and functional attributes related to the states and processes represented in the model. Moreover, a wind erosion simulation model was used to investigate effects of measured biophysical attributes on predicted rates of wind-driven soil movement at plot scale. A global scale research was performed by Petz *et al.* (2014a) using a combined approach of literature review, data and models (e.g. 'IMAGE-USLE') to study the interactions between input data, livestock density and ES.

Water quality regulation/purification (WQ) is an ES that directly links human populations' welfare. Ecosystems can be a source of impurities in fresh water but also can help to filter out and decompose organic wastes introduced into inland waters (MA, 2003). The additional extraction string *("water quality" or "water regulation" or "water purification" or "water filtering in soil")* resulted of 8 papers of which 3 were eligible for the analysis.

Fisher *et al.* (2011) explored the variation in ES delivery resulting from different management practices in UK wetlands. In particular, the role of species-led (both animals and plants) management on biodiversity was focused. In a following step, a consultation of the SHs and experts was done through workshops and meetings to elaborate specific details of management impacts on ES, including hydrology. Three categories of key ES (and disservices) were identified and linked to the range of management. These results are particularly relevant for the drafting of management plans that should carefully balance the effects of management practices. For example taking into account grazing-related effects on some ES such as water-quality parameters like turbidity and temperature (Van Horn *et al.*, 2012).

Other authors examined the effects of grazing management at plot scale (Jackson *et al.*, 2006), analysing the consequence of grazing and un-grazing on nitrate concentrations of the leachate from annual grassland.

Regulation of water flows (WF) in MA (2003) deals with the timing and magnitude of runoff, flooding, and aquifer recharge that can be strongly influenced by changes in land cover, including alterations of the water storage potential of the system. The specific search terms *("water" or "natural drainage" or "drought prevention" or "runoff" or "rainfall" or "flooding")* added to the basic string produced 44 papers.

To avoid potential mismatches between the scales at which ecological process occurs and at which management decisions are taken ES assessment requires the use of a proper scale (MA, 2003). In this view the analysis revealed different approaches used in the papers. At large scale, Fisher *et al.* (2011) analysed WF with WQ by using the same approach previously described in WQ. At catchment scale, Petz *et al.* (2014b) evaluated alternative land management scenarios with SHs involvement by mapping and modeling multiple ES, including water supply. The latter was estimated using the long-term average annual water yield as an indicator and the InVEST tool (Kareiva *et al.*, 2011) to quantify and map water yield using hydrological and vegetation data. Other authors used the InVEST model to assess water supply. At catchment scale Pan *et al.* (2015) studied the effects of spatial/temporal variation and the effects of land use change on water supply. The input variables and parameters for InVEST were land use and cover and the territorial characteristics derived by a digital elevation model (DEM).

Field experiments were conducted by Ford *et al.* (2012) to estimate ES from grasslands in three replicate experimental blocks, each containing three 10x10 m plots identifying different management treatments (different grazing animals and stocking, un-grazed). Soil/vegetation characteristics and invertebrates were analysed to assess the effects of management on WF. Inauen *et al.* (2013) studied the effect of the reduction of the grazing in four alpine grasslands types on the water balance and consequence the provisioning of fresh water and on the potential of hydroelectric power production. Lysimeters were used in field experiments under free-air CO_2 enrichment, to solve the hydrological water balance.

Climate regulation (CR) is a service obtained by the regulation of ecosystem processes. It is receiving increasing attention since the effects of climate change over the next century is projected to affect, directly and indirectly all types of ecosystems and ES (MA, 2005). The extraction string *("climate" or "soil carbon" or "greenhouse gas*" or "GHG" or "CO_2" or "CH_4" or "N_2O")* provided 59 papers mostly dealing with climate change scenarios.

Many papers conducted field experiments dealing with soil C pool at different scales. For example, in fixed sand dune grasslands of UK, Ford *et al.* (2012) used replicate experimental blocks investigating C stock from soil, roots, litter and shoots under different management. Marriott *et al.* (2010) investigated soil total C and N in pastures under different management options with an automated Dumas combustion technique. Other field experiments were carried out by Bagchi and Ritchie (2010) assessing soil C input (plant tissue plus the amount returned as dung) and soil C stock under different grazing conditions in Trans-Himalayas of northern India. Landscape scale approach was used for assessing N and C cycling in grazed and non-grazed upland grassland of northern England (Medina-Roldán *et al.*, 2012). Transect analysis was carried out by Farley *et al.* (2013) to examine soil and aboveground C in 8 sites in Ecuador.

Some authors perfomed mesocosms experiments in greenhouses for quantification of N_2O emissions using a closed flux chamber (Abalos *et al.*, 2014). Klumpp and Soussana (2009) extracted monoliths from two contrasted long-term field treatments (high vs. low grazing disturbance) and exposed to both low and high (simulated grazing) disturbance during a 2 years experiment. Subsequently, a mathematical framework was used to predict changes in C fluxes after grazing disturbance.

Predictive models for grasslands dynamics were used by Peringer *et al.* (2013) in pasture-woodlands while Scheiter *et al.* (2015) used a dynamic vegetation model to project how climate change and fire management might influence future vegetation in northern Australian savannas. C fluxes from natural grasslands under different grazing pressures were assessed by dynamic carbon models (Dong *et al.*, 2012). Koniak *et al.* (2011) applied a mathematical model to study the relationships between C retention in woody plants and other ES. Concerning the expected progressive increment of CO_2 concentration in atmosphere experiments related to changes in botanical composition in grassland were carried out by Newton *et al.* (2014) and Inauen *et al.* (2013) using Free Air Carbon Dioxide Enrichment (FACE) technique.

To identify the most desirable management options for lowland wet grassland, Fisher *et al.* (2011) analysed management plans and annual reports of 22 UK reserves. Service and disservices including GHG fluxes were used in SHs meetings as support tools to the discussion and learning. Lavorel *et al.* (2015) compared four Australian ecosystems using a four-step framework based on the identification of adaptation services under different scenarios of climate and management change.

From the literature review emerges a deep analysis of soil C pool and CO_2 fluxes while other GHG like CH_4 and N_2O were less investigated.

Moderation of extreme events (EE) is mainly referred to the ability of livestock grazing to provide prevention of landslides, avalanches and wildfires (FAO, 2014). The additional string *("avalanche*" or "fire" or "extreme event*")* produced 19 papers of which 3 in Mediterranean areas. The extracted papers deal just with ‘fire’ highlighting a lack of studies on other EE.

Rather than an ‘extreme event’, fire is analysed by the papers as a management tool to enhance ES (e.g. habitat provisioning, prevention of wildfires, etc.). Joubert *et al.* (2014)

investigated the effect of annual burning on plant species richness, composition and turnover in three firebreak types under different cattle grazing levels. Boughton *et al.* (2013) conducted an 8 year split-plot experiment studying the effect of season of burn on plant composition in semi-natural grassland of Florida (USA) where, in addition to prescribed winter burns, natural historical wildfires occur in abandoned ranchlands. The responses of vegetation disturbance was studied by Hancock and Legg (2012) with prescribed fire managements in pine forests and ericaceous heathlands of UK.

Other approaches compared tree canopy cover and height distributions between areas of contrasting management in the Lowveld savanna with LiDAR (Wessels *et al.*, 2011); survey-based choice experiments where SHs focused on the prevention of forest fires is a key ES delivered by grazing agroecosystems. A mathematical model was developed to simulate the vegetation dynamics and ES in response to management scenarios involving grazing, fire and their combinations in Israel as tools for land managers (Koniak *et al.*, 2011).

Landscape (LS) is mentioned in MA among cultural services and includes the values as shaped by the animals themselves or as a part of the landscape e.g. aesthetic values (FAO, 2014). In this sense, and not in others, it was analysed in the bibliography review. The additional string *("landscape" or "aesthetic" or "inspiration")* produced 39 publications of which just 2 analysed the landscape as a cultural service (Bernués *et al.*, 2014; Fontana *et al.*, 2014). In the others papers landscape was considered: i) for the effects that could have on biodiversity (e.g. Bagella *et al.*, 2013; Cole *et al.*, 2015; Kearns and Oliveras, 2009; Lindborg *et al.*, 2009; Littlewood *et al.*, 2012; Sanderson *et al.*, 2007); ii) as support for improving or maintaining other ES (e.g. Lavorel *et al.*, 2011, 2015; Schaldach *et al.*, 2013); iii) as an assessment scale of other ES (e.g. Hussain and Tschirhart, 2013**;** Peringer *et al.*, 2013; Kimoto *et al.*, 2012); iv) for the effects that different drivers had on it without directly analysing the consequences on its cultural value (e.g. Cousins *et al.*, 2015; Lamarque *et al.*, 2014; Schaich *et al.*, 2015).

The low number of papers dealing with landscape as cultural ES has to be related to its difficult measurement and to the still low number of available indicators (Feld *et al.*, 2009; TEEB, 2010).

Fontana *et al.* (2014) analysed the effects of management changes of larch grasslands in the Italian Alps (abandonment and intensification vs. traditional management) also on the valuable cultural ES (scenic beauty and traditional healing plants). They conducted a phyto-sociological study on plots randomly selected by using GIS. For each plant species recorded, three out of eight plant traits were chosen explicitly for their relevance for ES provision: flower colour, high diversity of pollination agents and occurrence of edible or healing value for traditional meals and medicines. The provision of scenic beauty and other ES were associated to specific management to be addressed to future subsidies planning and specific financial support towards traditional agro-forestry system. Bernués *et al.* (2014) tried to elucidate the socio-cultural and economic value of some ES (e.g. aesthetic and recreational values of the landscape) delivered by mountain agroecosystems in northeast Spain by identifying the SHs willingness to pay for their provision. Focus groups and survey-based stated-preference methods were combined to identify the effects on ES of three different scenarios deriving from different policies and to test the willingness to pay for ES compared to the current EU agro-environmental payments.

VI – Conclusions

The extraction criteria used for the bibliography review produced a scarce amount of papers of which just ten clearly to be referred to the Mediterranean climate areas and even less to Mediterranean basin. ES was the divide term between a vast literature and the minimal results obtained. Indeed, if some other terms would have been added to the basic string other results would have been obtained. For example, adding *or "good*"* to the string used for 'Food and other livestock related products', the total amount of papers will increase from 12 to 38. This fact highlights that many authors did not consider food as an ES limiting the ability of these products to be included in a process of enhancement at the level of the overall production system. Similar consideration could be stated for the other analysed ES.

Despite the Millennium Ecosystem Assessment is the largest accepted ES assessment framework since 2003, the analysis of the extracted papers highlighted misunderstandings concerning the concept of ES. A clear example is the confusion around biodiversity that in several papers, contrary to MA, it is considered as an ES *per se* (e.g. Lindborg *et al.*, 2009).

The anthropocentric vision is one of the recurring critiques of the concept of ES. According to Schröter *et al.* (2014) the ES concept is not meant to replace biocentric arguments but bundles a broad variety of anthropocentric arguments for protection and sustainable human use of ecosystems. Not in all the analysed papers this view is understood or accepted. For example some authors propose biocentric solution to reverse inner dynamics of systems without taking into account SHs opinions or needs (e.g. Bai *et al.*, 2012).

ES were analysed in several ecosystems, under many site, climate and management conditions with different but also contrasting results. A clear example are the contrasting effect of grazing on primary production reported by Oñatibia *et al.* (2015) and mentioned by Bai *et al.* (2012). These considerations highlight as management and development options should take into account the internal dynamics of systems. Biophysical components, but also socio-economics, socio-cultural and institutional features should be considered (Caballero and Fernández-Santos, 2009). In this vision, most of the analysed ES were assessed according to different spatial and temporal scales. To reduce the risk of scale mismatches between ecological processes and decision-making the adoption of a proper assessment scale seems to be crucial. In this respect, Loucougaray *et al.* (2015) applied a landscape scale but at the same time identified both farm and field scale as key features for grassland conservation management.

The need to examine the supply and condition of each ES as well as the trade-offs (e.g. Marriot *et al.*, 2010; Oñatibia *et al.*, 2015) and interactions among them as requested by MA (2003) was applied in many of the analysed papers (e.g. Gaitán *et al.*, 2016; Koiniak *et al.*, 2011; Newton *et al.*, 2014; van Oudenhoven *et al.*, 2015; Petz *et al.*, 2014a).

Just few authors integrated a multi-stakeholders approach in the analysis of ES and their interactions (Bernués *et al.*, 2014; Petz *et al.*, 2014b; Tarrasón *et al.*, 2016). Many tools commonly used also in the scientific activity like mathematical models, indicators and biophysical data were used by the authors to engage the SHs. In other papers, future scenarios were generated from scientific data to facilitate the discussion with and among SHs. The effects of different management options on their well-being were discussed by using ES as focus lens. The need of SHs involvement emerged in some papers that underpinned how the ES concept was not familiar to SHs (e.g. Bernués *et al.*, 2014; Tarrasón *et al.*, 2016) and often confused, for example with responsibility of humans to preserve nature. The integration of local and scientific knowledge generated hybrid knowledge encouraging ownership of local SHs in the decision-making process. This allowed the identification of adaptive strategies for key services to be maintained in future (Lamarque *et al.*, 2014; Francioni *et al.*, 2014), for example through the implementation of in-situ experiments on native pasture management (Tarrasón *et al.*, 2016).

In the analysed literature cultural ES were poorly studied despite considered the most relevant for local and general SHs (Bernués *et al.*, 2014), constraining the ES framework only to agricultural related aspects. A better SHs awareness of the well-being provided by ES in livestock grazing systems could foster agri-environmental schemes and the willingness to pay for their services.

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The use of cattle grazing as a management tool for sustainable Mediterranean woodlands

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Abstract. Grazing has become an effective and accepted tool for managing open areas for different uses other than meat production, such as minimizing fire risk and increasing species diversity. Although woodlands in Israel are utilized for cattle grazing, the effect of grazing on woody vegetation has not been assessed quantitatively. The aim of this study was to characterize the effect of biotic and management factors, especially animal density, on the structure, composition and regeneration of woody vegetation. The study was conducted in the Western Galilee of Israel. A woodland plot of 211 ha was divided into four sub-plots, with two replications of two grazing intensities. Changes in the woody vegetation were monitored in 56 transects of 20 m length each, sampled at the onset of the study and after four annual grazing cycles. Woody plants up to height 2.1 meter growing along each transect were documented. From these records we derived indices to characterizing vegetation structure, woody biomass removal, species richness and woodland regeneration. It is shown that the extent of grazing effect depends mainly on cattle density, as well as on the type and state of the vegetation. The woody vegetation cover was reduced under the two grazing intensities, but grazing did not affect species richness and sapling abundance. Therefore, it was concluded that the use of cattle is an important tool for sustainable management of Mediterranean woodlands.

Keywords. Animal density – Vegetation type – Cattle utilization – Basal cover.

Utilisation d'animaux brouteurs comme outil pour la gestion durable des zones boisées méditerranéennes

Le broutage est devenu un outil efficace et accepté pour la gestion de zones ouvertes pour différents usages autres que la production de viande, tels que la minimisation du risque d'incendie et l'augmentation de la diversité d'espèces. Bien que les zones boisées en Israël soient utilisées comme pacage pour le bétail, l'effet de brouter la végétation ligneuse n'a pas été évalué quantitativement. Le but de cette étude était de caractériser l'effet de facteurs biotiques et de gestion, en particulier la densité animale, sur la structure, composition et régénération de la végétation ligneuse. L'étude était menée dans l'ouest de la Galilée en Israël. Une parcelle boisée de 211 ha a été divisée en quatre sous-parcelles, avec deux répétitions de deux intensités de broutage. Les modifications de la végétation ligneuse ont été suivies dans 56 transects de 20 m de longueur chacun, échantillonnés au début de l'étude et après quatre cycles annuels de broutage. Les plantes ligneuses jusqu'à une hauteur de 2,1 mètres poussant le long de chaque transect ont été documentées. À partir de ces données, on a dérivé des indices pour caractériser la structure de végétation, le prélèvement de biomasse ligneuse, la richesse en espèces et la régénération des zones boisées. Il a été montré que l'ampleur de l'effet de broutage dépend principalement de la densité de bétail, ainsi que du type et de l'état de la végétation. La couverture de végétation ligneuse était réduite sous les deux intensités de broutage, mais le broutage n'a pas affecté la richesse en espèces et l'abondance en jeunes arbres. Toutefois, il a été conclu que l'utilisation de bétail est un outil important pour une gestion durable des zones boisées méditerranéennes.

Mots-clés. *Densité animale – Type de végétation – Utilisation du bétail – Couverture basale.*

I – Introduction

Over the last thousands of years Mediterranean evergreen oak woodlands have been utilized efficiently by traditional grazing of mixed herds, mostly consisting of goats. Grazing maintains an open woodland formation, reduces biomass, thus minimizing risk of fire, increases species diversity and facilitates recreational use of the landscape (Perevolotsky and Seligman, 1998; Gutman *et al*., 2000; Henkin *et al*., 2011). In recent years, goat grazing in the woodlands of Israel has decreased, while grazing by cattle herds has become more common. Cattle herds were introduced into the woodlands with the aim of increasing meat production, while replacing goat grazing for woodland management. However, unlike goats, which are adapted to browsing in Mediterranean woodlands, the woody vegetation is considered unsuitable for cattle due to its poor nutritional quality, partly caused by its high tannin content (Perevolotsky *et al.*, 1993; Papachristou *et al*., 2005). Furthermore, the limited accessibility of the dense woody vegetation, poor productivity of the herbaceous vegetation and the generally difficult topographic conditions make cattle grazing more difficult. Although today woodlands in Israel are utilized for cattle grazing, the effect of grazing on the woody vegetation has not been assessed quantitatively. This study aims to characterize the effect of vegetation type and grazing animal density on the structure, composition and regeneration of woody vegetation in the Mediterranean woodlands.

II – Materials and methods

The study was conducted at the Hatal experimental farm in the Western Galilee, Israel (long. 35º15', lat. 33º01', alt. 200–500 m a.s.l.). The study area is characterized by a combination of closed woodland vegetation dominated by *Quercus calliprinos* Webb., and an open woodland dominated by *Callicotome villosa* (Poiret) Link and *Sarcopoterium spinosum* (L.) Spach. Herbaceous vegetation appears as patches in the open areas within the woody vegetation, and provides 3-4 months of high-quality forage during winter and spring. A woodland plot of 211 ha was divided into four paddocks of 40–66 ha each. The treatments were two animal densities: low (0.33 cow·ha^{-1}) and high (0.55 cow·ha^{-1}), which were replicated twice. For a period of four years (2007-2011), 94 Baladi×Hereford cows grazed on the experimental paddock from mid-March to mid-November and were given supplementary feed according to the state of the vegetation. During the rest of the year the cows were kept in holding plots outside of the experimental area.

At the beginning of the study, the area was classified into three vegetation types using aerial photography and ERDAS imaging, which were verified at the landscape level: Dense woodland (80-100% tree cover), Open woodland (50-80% tree cover) and Garrigue (<50% tree cover). The effect of grazing intensity on woodland structure and composition was assessed by comparing permanent vegetation transects that were sampled at the commencement of the study (2007), and once again after four cycles of annual grazing (2011). Transects 20 m long were placed in each of the four paddocks in two vegetation types that we thought will be more affected by grazing - Dense woodland and Open woodland. A total of 56 permanent transects (7 transect x 2 cattle densities x 2 replicates of each density x 2 vegetation types in each paddock) were monitored. All plants up to a height of 2.1 m (maximum height of vegetation for cattle grazing) along each transect were recorded and sketched, including plant locations. Vegetation variables that characterize vegetation structure, woody biomass removal, species richness and woodland regeneration by saplings were recorded:

a. Above canopy: canopy cover in each of the 20 meter transect.
b. Species richness: number of trees, shrubs and climber species.
c. Number of individuals by plant size: large tree (> 80 cm), small tree (10-80 cm), large shrub (> 40 cm), small shrub (10-40 cm), twigs shrub and twigs tree (number of twigs in the transect from plants not rooted in the transect).
d. Basal cover: vertical projection of rock, litter and soil, tree and shrubs.

e. Available canopy surface for cattle grazing: surface contour of woody vegetation, assessed by measuring the contour of each plant with flexible measuring tape.
f. Sapling: tree, shrub and climber less than 10 cm height

Changes in the vegetation after four grazing periods were assessed by calculating the absolute differences of above vegetation variables between the beginning and end of the study. Data were analyzed using two way Anova, with animal density and vegetation type as fixed factors. Since significant differences in the initial state of the transects were found, we used the initial state of the vegetation (2007 sampling) as covariant. T-tests were conducted to determine whether changes in the vegetation variables after four grazing seasons were significantly different from zero. Statistical analyses were carried out with the JMP software, version 7.1 (SAS Institute, Cary, NC).

III – Results and discussion

The main consequences of cattle grazing in terms of the woody vegetation were expressed via changes in vegetation removal, especially in the high animal density treatment. After four grazing seasons, basal tree cover decreased by 20% (1.0±0.3m; *P*=0.0008) (Fig. 1). Consequently, woody vegetation overlap decreased by 25% and bare ground and plant litter cover increased. This happened at a higher rate in open woodland compared to dense woodland (18% and 2.5%, respectively; *P*=0.002). In contrast, under the lower cattle density, no significant changes were found in tree basal cover and in the cover of bare ground and litter. Grazing reduced shrub cover by 16% with no effect of cattle density. Available canopy surface for cattle consumption was the most affected vegetation variable in both grazing treatments. Total canopy surface was reduced by 41% (9.2±1.1m) under the high cattle density compared to 27% (5.7±1.3m) under the low density. Canopy surface of rooted trees decreased by 40% *vs* 25% (*P*=0.008) and rooted shrubs decreased by 37% *vs* 18% (*P*=0.002) in the high and low grazing intensities, respectively. Above canopy cover increased slightly (8%; *P*<0.05), except for that of the dense woodland that was under high grazing density.

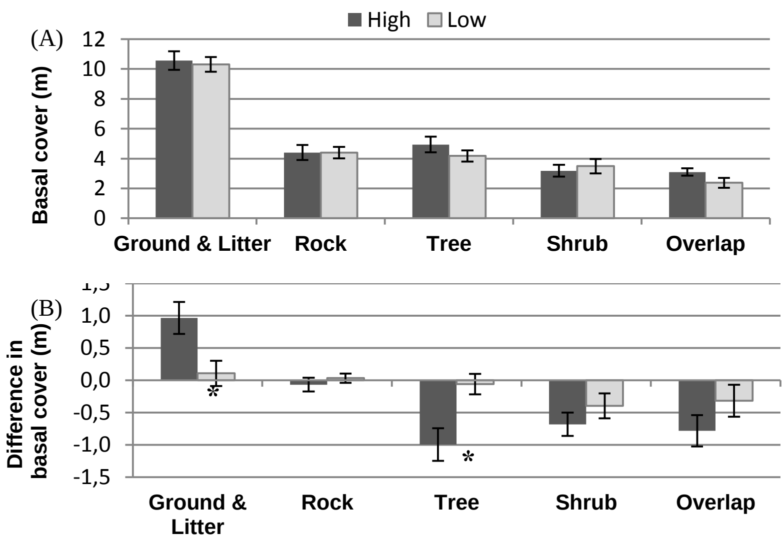

Fig. 1. Basal cover of trees, shrubs, rocks, ground and litter and overlap of woody plants in 20 m transects at study onset (2007) (A) and the change (difference) after four grazing periods (B), under high (dark) and low (light) cattle density .Data are mean ± SE.
** Indicates significant differences between cattle densities (P< 0.05).*

Despite the changes in vegetation cover found at the two levels of cattle density, the effect of four grazing seasons on species richness was relatively minor. Richness increased or decreased only by 0.5 species per transect on average, with no effect of cattle density on this change. Similarly, grazing did not have a detrimental effect on woodland regeneration by saplings. On the contrary, the number of saplings increased by 19% after four grazing seasons, especially in the dense woodland (P=0.003). Furthermore, the number of individuals of woody species present in the transects increased marginally (P=0.1), with a larger increase shown by young trees lower than 80 cm (4.1 ± 1. in the dense woodland compared to 1.5 ± 1.2 in the open woodland; P<0.001), with no effect of grazing intensity. In the current study both low and high cattle densities resulted in the removal of woody biomass at a quantity which was larger in paddocks under the higher grazing intensity. On the other hand, since the rate of change of the woody components was slow, no effect was found on species richness during the time span of the current experiment. Similarly, we could not detect a negative impact of grazing on the regenerative capacity of the woodland via saplings. Saplings continued to appear and grow into small trees. Nevertheless, it is possible that the effects of grazing on species composition and vegetation structure would have manifested themselves after longer periods of grazing.

IV – Conclusions

Quantitative analysis of changes in woodland vegetation showed that four consecutive grazing periods resulted in relatively high biomass removal, especially in the high animal density, but had no detrimental effect on woody species richness or regeneration from saplings. Therefore, cattle grazing in the present animal densities can protect woodlands from fires without damaging regeneration, thus supporting the use of cattle as a tool for sustainable management of Mediterranean woodlands. As a general rule, sustainable management of cattle grazing on woodland must be based on ecological and landscape considerations, in addition to meat productivity as a source of livelihood for herders. Such a management plan will lead to optimal utilization of woodland landscapes without damaging them, while improving cattle performance. In this way, it should be possible to minimize the conflicts between herders' interests and nature conservation concerns, thus enabling the use of cattle grazing as an efficient, multi-purpose tool for open landscape management in the Mediterranean woodlands.

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Functional classification by NIRS of plant parts selected by sheep on a shrubby rangeland

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Abstract. The diet of livestock foraging on rangelands is highly diversified and changes daily, seasonally and annually. Thus, a classical assessment of diet nutritive value with forage sampling followed by chemical analysis would be too challenging. We explore an alternative method to characterize the diversity of food offered based upon the classification of food items into a limited number of "functional" nutritive classes. The area of study was a Mediterranean *garrigue* rangeland, grazed by sheep in spring. Based on sheep foraging behaviour, 103 food items were identified as "bite categories" (BCs), from 60 plant species; 245 samples were taken. They were oven dried and grinded before Near-infrared spectra (NIRS) collection. Hierarchical classification of NIRS spectra produced "functional" classes of BCs. A few classes were homogeneous while others gathered plants from diverse botanical origins, but displaying similar characteristics such as chemical composition. Other Mediterranean rangelands and other grazing periods need to be studied in order to validate the functional nutritive classes identified. This method paves the way to better characterize the potential nutritive value of rangelands by taking into account foraging selection at bite level.

Keywords. Rangeland – Nutritive value – Classification – Sheep – Near infrared spectroscopy.

Classification fonctionnelle par SPIR des parties de plantes sélectionnées par des brebis sur un parcours embroussaillé

Résumé. *Le régime alimentaire des troupeaux sur parcours est très diversifié et change selon les jours, les saisons, les années. Les méthodes classiques d'appréciation de la valeur nutritive du régime basées sur l'échantillonnage et les analyses chimiques seraient trop compliquées et coûteuses à mettre en place. Nous explorons ici une méthode alternative, basée sur une classification comportant un nombre limité de « classes nutritives fonctionnelles ». La zone d'étude était un parcours de garrigue méditerranéenne pâturé par des brebis au printemps. Sur la base du comportement alimentaire, 103 aliments ont été identifiés en tant que « plantes x prises » (PP), sur 60 espèces végétales, et ont donné lieu à 245 échantillons. Ceux-ci ont été séchés puis broyés et passés au spectromètre de proche infrarouge. La classification hiérarchique des spectres a donné des classes « fonctionnelles » de PP. Certaines classes étaient homogènes, d'autres regroupaient des plantes d'origines botaniques variées, mais avec une composition chimique similaire. Pour valider les classes fonctionnelles, il sera nécessaire d'étudier d'autres parcours méditerranéens et d'autres saisons de pâturage. Cette méthode ouvre la voie vers une meilleure caractérisation de la valeur nutritive potentielle des parcours, en prenant en compte la sélection alimentaire à l'échelle de la bouchée.*

Mots-clés. *Parcours – Valeur nutritive – Classification – Ovins – Spectrométrie dans le proche infrarouge.*

I – Introduction

In the Mediterranean area, large parts of landscape are covered by heterogeneous vegetation made of contrasting mosaics of semi-natural swards, scrublands and woodlands. Such rangelands have been increasingly disregarded by farmers who often do not consider them as a proper feed resource, especially for animals with "high nutritional requirements" (Jouven *et al*., 2010). Rangelands from southern Europe are still largely marginalized and under-utilized, mainly because they cannot be evaluated and managed with the same knowledge and criteria as for cultivated grasslands. The feeding value of mixed rangeland results from the selection by the grazing animals of feeding patches, plant species and plant parts. Selection of plant parts varies according to vegetation communities' structure, diversity and characteristics of the full range of reachable food items, conditions and daily grazing schedules, feeding requirements, as well as previous feeding experience and habits of the animals (Meuret and Provenza, 2015).

The objective of our study was to test an original mixed approach to characterize the nutritive value of Mediterranean rangelands. Based on previous studies (Bonnet *et al.,* 2015), we hypothesize that rangeland vegetation can be described with functional nutritive categories applied to the different plant parts potentially ingested. Besides, since animals select plant parts based not only on protein and energy content but also on multiple primary and secondary compounds (Meuret and Provenza, 2015), we based our classes on the NIRS spectra, which contain the whole range of information available about sample chemical composition.

II – Material and methods

1. Study area

The study area was a mixed grassy, scrubby and wooded rangeland, dominated by stretches of live oak (*Quercus ilex* L.) coppice, located 35 km North from Montpellier, which represented a typical Mediterranean rangeland on calcareous and dry soils. The area is usually grazed in spring (April-June) and late autumn (November-December) by a flock of 150 ewes of *Raïole* breed and their lambs. For our study, we chose to work on sites that had not been grazed yet. Three sites within a radius of 10 km were chosen for the collection of food samples: 1) a live oak coppice and its edges, with trees, undergrowth shrubs and creepers; 2) clearings with many trees and shrubs regrowths after logging operations that occurred 4-5 years earlier; 3) swards dominated by annual plants and comprising short bushes.

2. Sample collection and preparation

The samples (245 samples of 103 BCs) were collected by hand-plucking between the 27th of April and the 5th of May 2015, as a reproduction of the bites taken by sheep in the same grazing sites and within the same season. To cope with the diversity of ingestive bites, we used the "bite categories" (BC) method, initially developed for continuous bite monitoring (Agreil and Meuret, 2004; Bonnet *et al*., 2015). The samples collected were made of plant parts, defined as possible bites taken by the grazing sheep. Each sample was related to a given plant species and a distinctive BC, then stored in a paper bag identified with a code and then quickly frozen at -21°C. Later, the samples were dried (55°C) and ground in a cutter mill with a 1 mm sieve for further analysis and spectra collection.

3. NIRS-based analysis of samples

Samples were scanned in duplicate on a monochromator spectrometer NIRSystem 5000 (FOSS, Laurel, MD, USA) in reflectance mode from 1100 nm to 2500 nm (with 2 nm steps). A mathematical pre-treatment was applied to spectra (2nd derivative, normalization and de-trending) in order to minimize non-informative content. Unsupervised classification of samples was applied directly on the mathematically pre-treated spectra. Hierarchical ascendant classification (Ward aggregation criterion) was performed with XLSTAT software (Addinsoft, Paris, France). Chemical composition was predicted for each sample on the basis of its NIRS spectrum using existing calibrations (Meuret *et al.*, 1993 ; Cirad, unpublished) updated with reference laboratory analyses performed on a selection of 30 samples from this study. The parameters considered were: crude protein (CP, Kjeldahl method); fiber fractions (NDF, ADF, ADL; Van Soest *et al.*, 1991); *in vitro* organic matter digestibility (IVOMD; Aufrère *et al.,* 2007).

III – Results and discussion

The hierarchical classification led us to choose seven classes (Table 1), as a compromise between statistical significance (sufficient difference between the classes) and technical applications (classes which can be interpreted in terms of animal foraging and nutrition). Apart for class F, exclusively composed of grass species, the classes were composed of a variety of botanical groups, and a given botanical group could be found in more than one class; for example, *Fabaceae* could be found in classes C, D, E. The seven classes all had a morphological and chemical consistency (Table 1 and Table 2). Tender, digestible BCs poor in fibre such as fruit, flower and soft leaves made up class D. Moderately lignified organs of shrubs and trees, mostly from aromatic plants, made up class C, while class G contained the most fibrous and lignified and the least digestible BCs.

Table 1. General description of the 7 functional classes

Class	Main type	Botanical dominants	Plant parts dominants
A	Developed dicotyledon leaves	Various non fabaceae dicotyledon	Leaves, leaves with stems
B	Young shrub organs	Non Fabaceae dicotyledons, Liliaceae	Shoots and young leaves
C	Lignified shrubs and trees	Dicotyledons including Fabaceae; Gymnosperms; aromatic plants	Leaves; some stems and shoots
D	Fruits, flowers, soft leaves	Liliaceae, Fabaceae, Morus	Fruits, flowers, shoots
E	Shoots	Fabaceae, various dicotyledons	Young leaves, shoots, flowers
F	Grasses and sedges	Poaceae and Carex	Young leaves, panicles
G	Coriaceous organs	Cupressus, Smilax, Ruscus	Leaves and stems

Table 2. Chemical composition of the 7 functional classes (mean), predictions based on the NIRS spectrum. Different letters within a row indicate statistical difference (ANOVA, p<0.05)

Class (No samples)	A (52)	B (37)	C (58)	D (23)	E (47)	F (16)	G (12)
DM (%)	35.7^{b}	26.3^{cd}	38.4^{ab}	20.8^{d}	28.8^{c}	33.7^{bc}	44.9^{a}
CP (% DM)	10.2^{cd}	13.0^{b}	9.2^{d}	15.4^{ab}	17.1^{a}	12.9^{bc}	7.3^{d}
NDF (%DM)	43.8^{c}	42.8^{cd}	43.8^{c}	29.5^{e}	38.7^{d}	65.3^{a}	51.8^{b}
ADF (%DM)	29.6^{b}	28.8^{b}	31.4^{b}	18.2^{d}	23.8^{c}	32.4^{ab}	39.4^{a}
ADL (%DM)	12.4^{b}	12.9^{b}	18.4^{a}	6.3^{c}	10.5^{b}	4.1^{c}	20.9^{a}
Other C* (%DM)	$38.5^{b.c}$	36.8^{c}	$41.6^{a.b}$	46.7^{a}	$37.6^{b.c}$	14.8^{d}	34.8^{c}
IVOMD (%)	59.9^{c}	60.0^{cd}	53.3^{de}	81.8^{a}	68.7^{b}	48.5^{ef}	41.9^{f}

*Other compounds (soluble carbohydrates, lipids and essential oils, polyphenols and other secondary compounds), calculated as: [100 - ash – CP – NDF]

These seven categories were complementary to each other in nutritional terms for the grazing animals: certain categories had intermediate values for chemical compounds (A, B, C) while others contained much fibre (F, G) or crude protein (D, E). Intra-class variability for major compounds remained high, leading to overlapping between classes for a few chemical parameters. However all classes were statistically different from others for 2 or more measured parameters. But they also probably differed in other chemical characteristics (Table 2, "other compounds": soluble carbohydrates, lipids and essential oils, secondary compounds) that were not measured in this study but which influenced the spectra and thus the classification.

By coupling unsupervised NIRS classification and BCs approaches, we have confirmed that the nutritional quality of most feed items from rangeland is often more related to the type of organ and the structural attributes of the plant parts than to a botanical group or plant species *per se* (Meuret, 1997; Bonnet *et al.*, 2015). Our approach produced a description of a heterogeneous Mediterranean pasture which should make sense in terms of animal feeding behaviour: each functional class provides specific compounds, so different combinations of classes within a mixed diet should enable to meet different nutrient requirements of the grazing animals.

IV – Perspectives

The classification produced will need to be validated and refined by adding new samples, taken in other grazing sites and during other grazing seasons. The final objective is to obtain a stable classification, applicable to other sites and possibly also to a range of conserved feeds which could be distributed as supplements to the grazed diet. Such classification, combined with criteria about the accessibility and abundance of BCs to be given on plant species, as well as experience and other grazing conditions of animals, could be used to characterize more properly the feed profile of mixed rangelands and possibly improve their management and utilization as valuable forage resource.

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Historical development and future perspective of conservation agriculture practices in crop-pasture rotation systems in the Mediterranean region of South Africa

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Abstract. The Mediterranean region of South Africa is confined to the south-western parts of the country and is divided into two sub-regions: The Swartland and the southern Cape sub-regions, which receive ca. 80 and 60% of their rainfall in winter, respectively. The original vegetation is classified as lowland coastal renosterveld, which is a short, fire-prone, sclerophyllous shrubland. Renosterveld is associated with fine-textured, low to moderately-fertile, shale-derived soils, with a low natural carrying capacity of 12 to 25 hectares per livestock unit. Ninety three per cent of the area has been transformed to crop and crop-pasture production systems with wheat and other small grains, canola, lupins, lucerne and medics used in various combinations in the rotation. The fodder component of these systems supports mostly sheep farming. The aim of this paper is to provide a synthesis of the challenges and opportunities related to issues involving soil conservation in the Mediterranean region of South Africa. This paper highlights the importance of research on soil quality and conservation agriculture, to ensure sustainability of crop and pasture production. The agricultural and ecological significance of soil tillage, crop rotation sequence, soil organic matter and soil microbial functionality will be discussed.

Keywords. Cover crop – Medics – Organic carbon – Tillage – Wheat.

Histoire du développement et perspectives d'avenir des pratiques d'agriculture de conservation dans les sytèmes de rotation cultures/pâturages dans la région méditerranéenne d'Afrique du Sud

Résumé. *La région méditerranéenne d'Afrique du Sud est confinée dans la partie sud-ouest du pays et divisée en deux sous-régions: le Swartland et le sud du Cap, qui reçoivent respectivement ca. 80 et 60% de pluviosité en hiver. La végétation originale est classée comme 'renosterveld" de plaine côtière, caractérisée par des arbustes buissonnants de sclérophylles. Le renosterveld est associé à un sol à texture fine, presque stérile ou modérément fertile dérivé de schiste argileux, ayant une faible capacité naturelle d'hébergement, à raison de 12 à 25 hectares par tête de bétail. Quatre-vingt treize pour cent de la région ont été transformés en systèmes de pâturages et de champs de plantation de blé et de graines de petite taille, canola, lupin, luzerne et médicago alternés différemment dans des combinaisons de rotation. Les fourrages de ces systèmes sont principalement pour le pâturage de moutons. L'objectif de ce document est d'apporter une synthèse sur les défis et les opportunités ayant trait à la conservation du sol dans la région méditerranéenne d'Afrique du Sud. Il souligne l'importance de la recherche sur la qualité du sol et l'agriculture de conservation, afin d'assurer la durabilité de l'élevage et la production des cultures et des pâturages dans la région. Les pratiques de labour ayant des conséquences agricoles et écologiques, la séquence des rotations, la matière organique du sol et la fonction microbienne du sol seront aussi discutées.*

Mots-clés. *Blé – carbone organique – Culture de couverture – Medics – Labour.*

I – Introduction

South Africa is classified as a dry country. The seasonality of rainfall is determined largely by the sea surface temperatures of the Atlantic and Indian Oceans, and topography. South Africa could broadly be subdivided into three regions in terms of seasonality of rainfall. The summer-rainfall region covers the majority of the country. All-year rainfall occurs in a narrow strip on the southern seaboard. The Mediterranean region is confined to the south-western parts of the country. This region covers ca. 70,000 km^2 (Dallman, 1998). The Mediterranean region is divided into two agriculturally important sub-regions: The Swartland and the southern Cape, which receive ca. 80 and 60% of their rainfall in winter, respectively. Mean annual rainfall varies from ca. 200 mm in the northern parts of this region to ca. 500 mm in the southern and south-eastern parts. Soils in the Mediterranean region are highly variable and shallow (<500 mm deep) with poor drainage, and are prone to erosion and soil surface crusting. Shale derived soils of duplex, podzolic, plinthic, gleyic and lithic soil groups are the most common (Soil Classification Working Group, 1991). These are classified by the IUSS Working Group (2006) as Solonetz, Luvisols, Podzols, Plinthosols, Eluvic, Orthic and Glossic soils.

The original vegetation is classified as lowland coastal renosterveld, which is a short, sclerophyllous shrubland. This forms part of the Cape Floristic Region, which has a very high level of endemism (Goldblatt and Manning, 2000). Lowland coastal renosterveld is associated with fine-textured, low to moderately-fertile soils, with a low natural carrying capacity of 12 to 25 hectares per livestock unit. Due to its inherently low livestock production potential, ca. 93% of the area has been transformed to crop and crop-pasture production systems (Kemper *et al.,* 1999). Although the importance of preserving the natural vegetation for our future generations could not be stressed enough, the rural economies are dependent on the success and sustainability of agriculture. Agriculture will remain central within the current global and regional economic environment as it is primarily responsible for supporting food security. Farmers have come to understand that agriculture should not only be high yielding, but also protect the environment. This means that both sustainability and continuous production from soil should be ensured. Ensuring sustainable agricultural production demands maintaining or enhancing soil quality. The aim of this paper is to provide a synthesis of the challenges and opportunities related to issues involving soil conservation in the Mediterranean region of South Africa.

II – History of cropping systems in the Mediterranean region

The first Europeans established a Dutch colony in the Cape in 1652, as a re-supply point and way-station on the sea-route between the Netherlands and the east. The first farmers were given land by the Dutch East India Company (VOC) to produce wheat. The VOC had the rights as the only legal purchaser of wheat and fixed the wheat price. The farmers took out three-year loans from the VOC for purchase and repair of equipment need for farming operations. Wheat was the only commodity accepted for the repayment of debt to the company. Wheat production was further stimulated through legislation which gave the VOC exclusive rights on the selling of other farm produce. Therefore, initial expansion of farm land was driven by wheat production systems, and not for expansion of grazing lands as normally occurred with colonisation of other countries. During the 1800s and 1900s, increasingly more Europeans flocked to the Cape which provided further impetus to expand wheat production. Import tariffs on grain products were doubled in 1920s, which led to increased areas and over production. The first and second world wars, and later on, isolation from the global economy due to apartheid, encouraged political interventions which supported wheat production to ensure self-sufficiency for the country. These interventions encouraged expansion into areas of marginal production potential. Until the 1980s, wheat was cultivated mostly in monoculture, and yields declined through time. The Western Cape Department of Agriculture subsequently promoted crop rotation systems and subsidised seed, lime and planting operations to establish annual *Medicago* species. This has increased sheep production, as the foraging component of these systems improved. Deregulation of the agricultural economy in the 1990s required major changes to farming system. Most marginal lands were removed from cereal production and, from early 2000s, most farms have converted to conservation agriculture (CA) systems. Currently, pasture and/or cover crops play an integral role to ensure economic sustainability of these cropping systems.

III – Conservation agriculture systems

Conservation agriculture can be viewed as a combination of management practices that ensure more sustainable agriculture and include reduced tillage, residue or cover crop management and crop rotations (FAO, 2015). The majority of grain producing farmers in the South African Mediterranean region have adopted minimum-tillage and crop rotations. The cropping systems are based on wheat, barley, oats and canola. These cash crops are cultivated in rotation with lupins, clovers, lucerne and annual medics. Inclusion of cover crops, with prominent root systems, as organic carbon (OC) builders are also widely promoted. However, the most important source of OC, namely the root systems, needs more research attention.

Research in the Mediterranean wheat producing region has shown that the effect of tillage differs between its two sub-regions. The hot and dry summers in the Swartland are not conducive to rapid OC build-up. In this region undisturbed Renosterveld has OC content of ca. 1.8%, whereas the OC content in cultivated lands range from 0.2 to 1.2%. In the southern Cape region OC contents of Renosterveld may be in excess of 3.0% while that of cultivated soil varies between 1.0 and 2.5%. The comparatively high concentrations relative to the Swartland could be ascribed to the differences in rainfall distribution. Two long-term trials evaluating tillage practices along a gradient of soil disturbance were conducted in the Swartland and southern Cape regions. The low OC concentrations of cultivated soil in the Swartland renders the soil with low buffer capacity against practices that tend to degrade soils. Within six years after introducing conventional tillage to what used to be a reduced tillage regime, active C in the Swartland was reduced ($P<0.05$) from 619 to 522 mg kg^{-1}. This effect continued with time, and became more pronounced. Conversely, buffer capacity of the soils in the southern Cape are improved as a result of the elevated C content. Active C in this region was not affected by soil disturbance. Similar responses were recorded for aggregate stability. The study also showed that microbial diversity and activity is lower in the Swartland than the southern Cape. Conventional tillage resulted in the lowest microbial activity and diversity at both sites.

Crop rotation is one of the three principles of CA. Although difficult to achieve, the ideal should be to include three or more non-related crops in the system. Inclusion of a legume is of absolute importance for both reducing nitrogen input costs and ensuring optimum C:N to stimulate N mineralisation and microbial diversity and activity. Optimum soil C:N can be achieved by carefully selecting legumes (low C:N) and crops with a high C:N in a crop rotation system, some of which are managed as cover crops. Due to the activity in the rhizosphere, living roots must occupy the soil for as long as practically possible. Cover cropping could be a viable option in the southern Cape where it can be cultivated in sequences between cash crops. There is an urgent need for a legume cash crop to be included in short-term cash crop systems to replace unproductive lupin especially in the Swartland and southern Cape. The aforementioned long-term trials showed the negative effect of lack of crop diversity as wheat monoculture resulted in the lowest microbial diversity and activity. The effect of crop rotation was however less drastic on active carbon and aggregate stability compared to soil disturbance as a result of tillage.

IV – Challenges and opportunities

The advantages of CA in the Mediterranean region of South Africa surpass the disadvantages and it has therefore become a dominant management approach to manage cropping systems. However, there are still a number of specific pressing concerns and challenges experienced by farmers in CA systems in this region. Since the soils are prone to surface crusting and compaction, efficient establishment of crops without soil disturbance is a challenge. Currently, farmers rely on tine openers. However, due to the success with disc openers especially in South America, the interest in planters using disc openers is increasing. Moreover, minimum-tillage has led to increased OC levels which are skewed to the soil surface (Swanepoel *et al*., 2015). This might have a significant impact on the quality of the seedbed, which may lead to easier establishment of crops. To date, the effectiveness of preparing a seedbed with a tine has not yet been compared to placing seed directly in the soil using a disc on soils that have increased OC level due to several years of continuous CA practices. Elsewhere in the world, such information is also lacking, especially in terms of assessment of microbial activity, which might be stimulated by limited disturbance with a tine, but less so when a disc is used.

Cultivating pasture or cover crops all year round is challenging in the Mediterranean climate, since hot, dry summers do no not support crop growth, especially in the Swartland. Soil in summer and autumn months are consequently covered only by stubble material from the previous annual crop. Often, insufficient material is retained, which expose the soil to direct sunlight, rain-drop impact and microbial degradation, which encourage surface crusting, soil erosion and compaction. Establishing annual crops during the summer months is not a common practise, due to insufficient soil moisture and since any soil water present must be stored for autumn plantings. However, lucerne is used in the southern Cape region where its deep root system is able to survive the dry summer months. In these systems, some farmers experience a decline in soil quality, due to the sparsity of aboveground biomass and hoof-impact of sheep. More research is required to evaluate the effects of long-rotation of lucerne on soil quality in these crop rotation systems, as it is not clear whether the lucerne varieties used are most suitable to ensure good soil health. Similarly, residual herbage of annual medic pastures, produced in the cool season, is utilized by sheep during summer. All material is often removed, which exposes the soil to the extreme temperatures that occur during the summer months. Guidelines for grazing and forage conservation need to be established that ensure the retention of residual herbage during summer towards promoting an improvement in soil quality, without compromising the livestock component of these systems. Furthermore, there is a need to introduce new pasture and cover crops to enhance OC levels deeper into the soil profile.

Fertiliser and lime guidelines for these cropping systems were developed in the 1960s when the soil was still conventionally tilled. With adoption of minimum-tillage and CA, the soil has undergone significant changes in terms of organic matter build-up and distribution of nutrients, which is skewed towards the soil surface. The top soil has been altered physically, chemically and biologically. Active and stable proportions of C have increased, along with microbial and mychorrizial activity. However, after the changeover to CA, the same lime and fertiliser guidelines that were developed for conventional tillage systems were still followed. Guidelines must be re-assessed to ensure sound CA-based crop and crop-pasture production systems.

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Diet selection of grazing goats in an oak silvopastoral system in Northern Greece using a Markov Chain Monte Carlo simulation

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Abstract. The diet selection of goats is affected by several factors, the most important of which are seasonality and forage availability. The purpose of this study was to investigate the seasonal changes in forage selection of goats grazing in an oak silvopastoral system in the Mediterranean region. The dietary preferences of a local breed flock were recorded using the direct observation method for two consecutive years and during three seasons (spring, summer and autumn). After a monitoring of 236 goats and their individual daily diet preferences, the basic diet profiles of the selected plant species were calculated. A multivariate analysis was performed and a clustering of profiles was obtained using Markov Chain Monte Carlo (MCMC) simulation. Woody species were involved in most of the diet profiles with *Quercus frainetto* being the dominant species selected mainly during dry periods. Herbaceous vegetation was selected predominantly during spring and whenever it was in abundance. An important part of goats' diet was acorns during autumn of oak's mast year. According to the results, goats selected mainly woody vegetation but they were able to adapt their diet in the seasonal forage availability by consuming herbaceous species.

Keywords. Diet profiles – Dietary preferences – Goats – Direct observation – Mediterranean shrubland.

Sélection alimentaire de chèvres pâturant dans un système sylvopastoral du Nord de la Grèce, en utilisant une simulation Monte-Carlo par chaînes de Markov

Résumé. *La sélection alimentaire des chèvres est affectée par plusieurs facteurs, dont les plus importants sont la saisonnalité et la disponibilité du fourrage. Le but de cette étude était d'analyser les changements saisonniers dans la sélection alimentaire de chèvres pâturant dans un système sylvopastoral en région méditerranéenne. Les préférences alimentaires d'un troupeau de race locale ont été enregistrées selon la méthode de l'observation directe pendant trois saisons (printemps, été et automne) et deux années consécutives. Après enregistrement de 236 chèvres et de leurs préférences alimentaires individuelles quotidiennes, les profils d'alimentation sur la base des espèces de plantes sélectionnées ont été déterminés. Une analyse multivariée a été effectuée et un regroupement des profils a été obtenu en utilisant une simulation de type Monte-Carlo par chaînes de Markov (MCMC). Des espèces ligneuses ont été identifiées dans la plupart des profils,* Quercus frainetto *étant l'espèce dominante, sélectionnée principalement pendant les périodes sèches. La végétation herbacée a été sélectionnée principalement au printemps et à chaque fois qu'elle était abondante. Les glands constituaient une partie importante de l'alimentation des chèvres pendant l'automne des années de forte fructification des chênes. Selon les résultats, les chèvres choisissaient principalement la végétation ligneuse, mais elles ont réussi à adapter leur alimentation à la disponibilité saisonnière du fourrage en consommant des espèces herbacées.*

Mots-clés. *Profils d'alimentation – Préférences alimentaires – Chèvres – Observation directe – Arbustes méditerranéens.*

I – Introduction

Oak woodlands cover an essential area of the total territory of Greece and 44% of the total forest cover (Papachristou *et al.*, 2005). These ecosystems are an important forage source for goats in the Mediterranean basin (Perevolotsky *et al.*, 1998). Goats are characterized as selective feeders (Ngwa *et al.*, 2000) and their diet selection is affected by several factors, the most important of which are seasonality and forage availability (Goetsch *et al.*, 2010).

The botanical composition of goats' diet is usually estimated as the average percentage of each plant or plant group selected by the animal per season or per month. This approach however, does not provide information about the daily diet profile of each individual goat, nor about the diversity of these profiles within each season or month. For this reason, a multivariate approach is needed, that considers the diet profiles as vectors in a multidimensional space. Following this approach, the diet profiles can be clustered using a variety of existing methods, thus avoiding the use of interdependent variables, as are percentages and relative frequencies.

The purpose of this study was to investigate the seasonal changes in forage selection of goats grazing in an oak silvopastoral system in the Mediterranean region, considering daily diet profiles, clustered using a Monte Carlo Markov Chain simulation.

II – Materials and methods

The study was carried out in an open oak forest in MegaloDereio, Evros region, Northeastern Greece, at 380 m a.s.l. The climate of the area is characterized as sub-Mediterranean. The average annual precipitation is 560 mm and the mean temperature is 13.7^{o}C. The vegetation composition of the area on average consists of: *Quercus frainetto (8.93*%), *Juniperus oxycedrus*(8.46%), *Cistus creticus*(15.85%),other woody species (0.72%),grasses *(35.76%),* legumes *(14.24%)* and forbs(16.04%). The area is grazed mainly by goats and to a lower extent by sheep and cattle.

The dietary preferences of a flock of 650 local breed goats were recorded using the direct observation method for two consecutive years and during three seasons (spring, summer and autumn). Grazing behavior data from 10 adult goats, randomly selected each time, were recorded for four consecutive days during each test period according to the sampling method of Altman (1974). The observations were performed sequentially from the morning to the afternoon with an interval of 10 to 20 minutes to collect forage samples for species identification. Each animal was monitored for 5 minutes and the total observation period was 50 min per day, covering a large part of the grazing time for each day.

After monitoring of 236 goats and their individual daily diet preferences (diet profiles), the basic diet profiles of the selected plant species were calculated using the behavioral data as the number of bites per plant species and bite size as the average of hand plucked samples to those consumed by the animals (El Aich *et al*., 2007). The consumed species were grouped into 8 major categories: *Quercus frainetto, Juniperus oxycedrus*, *Cistus creticus,* Other Woody, Grasses, Legumes, Forbs and Acorns.

All diet profiles were clustered using a Markov Chain Monte Carlo (MCMC) simulation, in order to achieve an accurate and objective selection of well differentiated profile clusters, via Geneland and a specific algorithm for field data (Guillot *et al*. 2012), after 100000 iterations, sampled for each 100 values. Frequencies of the clusters for each season and year were estimated.

III – Results and discussion

According to the MCMC simulation and the modeling approach, twelve diet profiles (DP) have emerged (Table 1). *Quercus frainetto* was involved in a high percentage (more than 70%) in the

95 (DP: 1, 5, 6, 10, 11) of the 236 total diet profiles indicating that it is a basic component of the dietary pattern of goats and the most significant species in their diet. It is worth mentioning that the above diet profiles were observed mainly during the summer for both years of the experiment (Table 2), due to the low availability of the herbaceous vegetation during the dry seasons, and during the autumn of 2011, when the other palatable deciduous woody species had started to drop their leaves.

The DP_3, DP_4 and DP_9 were the profiles where herbaceous vegetation was involved in a relatively high proportion. Grasses contributed in a rate of 25.4% and 14.7% in DP_3 and DP_4 respectively (Table 1), legumes 28.3% and 36.7% in DP_3 and DP_9 respectively, forbs 26.7%, 19.0% and 50.4% in DP_3, DP_4 and DP_9 respectively. All these profiles were recorded mainly during spring (Table 2). This finding is in accordance with others authors who referred that goats select vigorously herbaceous vegetation when is available (Glasser *et al*., 2012).

TheMCMC simulation can identify all the significant diet profiles and the season in which they occur, even the rareones (DP_1, DP_9 and DP_11). This indicates that this method can identify both typical and opportunistic diet profiles as it uses data of each individual goat.

Table 1. The contribution (%) of each plant group species in the diet profiles (DP) of goats

Diet profile	*Quercus frainetto*	*Juniperus oxycedrus*	*Cistus creticus*	*Other woody*	Grasses	Legumes	Forbs	Acorns	N
DP_1	74.9	6.7	1.0	0.0	10.4	5.2	1.8	0.0	**1**
DP_2	51.3	0.0	0.0	47.9	0.2	0.6	0.0	0.0	**18**
DP_3	19.6	0.0	0.0	0.0	25.4	28.3	26.7	0.0	**18**
DP_4	29.9	3.4	5.7	15.5	14.7	11.8	19.0	0.0	**20**
DP_5	94.1	0.0	2.8	2.9	0.2	0.0	0.0	0.0	**29**
DP_6	98.2	1.6	0.0	0.0	0.2	0.0	0.0	0.0	**37**
DP_7	3.1	4.5	23.2	0.0	24.1	3.5	1.7	39.9	**19**
DP_8	43.3	15.7	4.0	0.0	13.6	17.9	5.5	0.0	**39**
DP_9	0.0	0.0	0.0	1.8	11.1	36.7	50.4	0.0	**1**
DP_10	72.2	5.4	7.4	14.7	0.3	0.0	0.0	0.0	**22**
DP_11	82.9	0.0	0.2	2.5	3.7	0.0	10.7	0.0	**6**
DP_12	18.6	28.2	21.0	0.0	4.0	0.0	0.0	28.2	**26**

N= the number of diet profiles.

The most frequent diet profiles during spring in both years were DP_8, DP_4 and DP_3 with a frequency in the total profiles of 0.360, 0.278 and 0.250 respectively during 2010 and 0.525, 0.175 and 0.125 during 2011.

There were differences between 2010 and 2011 as regards the summer diet profiles. During the summer of 2010 more diets profiles were recorded than in the summer of 2011 (Table 2) although all of them had as the main component *Quercus frainetto* or other woody species (Table 1). This diversification was probably observed because the flock was leaded by the shepherd to regions where there were more palatable species available. Baumont *et al*. (2000) referred that the grazing management decision of shepherds is an important factor that influences the dietary preferences of goats.

Acorns participated to a high rate mainly in DP_7 and DP_12 (39.9% and 28.2% respectively) (Table 1). Both profiles were observed during autumn 2010 in a high frequency of 0.475 and 0.375 respectively (Table 2). A lot of acorns were available as a feed during autumn 2010 which was a masting year. On the contrary, there were no acorns during autumn 2011 and the most frequent diet profiles were DP_5, DP_10 and DP_6 at a rate of 0.350, 0.325 and 0.200 respectively. It is worth noting that these diet profiles were typically recorded during summer.

Table 2. The frequency of participant of each diet profile (DP) in seasons for the two years

Diet profile	Spring_10	Summer_10	Autumn_10	Spring_11	Summer_11	Autumn_11
DP_1	0	0	0	0.025	0	0
DP_2	0	0.025	0	0.050	0.350	0.025
DP_3	0.250	0.025	0.075	0.125	0	0
DP_4	0.278	0.075	0	0.175	0	0
DP_5	0	0.075	0	0.025	0.275	0.350
DP_6	0	0.400	0	0	0.325	0.200
DP_7	0	0	0.475	0	0	0
DP_8	0.360	0.050	0.075	0.525	0	0
DP_9	0.028	0	0	0	0	0
DP_10	0	0.150	0	0.025	0.050	0.325
DP_11	0.028	0.100	0	0	0	0.025
DP_12	0.056	0.100	0.375	0.050	0	0.075

IV – Conclusions

MCMC simulation is a method of analysis for diet selection of grazing goats that allows to study, based upon individual dietary patterns, the frequency and seasonal distribution of diet profiles, even the identification of typical and opportunistic seasonal diets. Woody species were involved in most of the diet profiles with *Quercusfrainetto* being the dominant species selected mainly during the dry periods and secondarily during autumn of 2011.Herbaceous vegetation was selected predominantly during spring and whenever it was in abundance. An important part of goats' diet was acorns during autumn 2010 (oak's mast year). According to the results, goats selected mainly woody vegetation, but they were able to adapt their diet in the seasonal forage availability by consuming herbaceous species.

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The rates of desirable grazing plant species in rangelands: effect of different animal species and grazing pressures

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Abstract. The objective of the study was to determine whether increased grazing pressure (GP) or introducing different grazing animal species (AS) such as a different class of stock (DCS), like sheep or goats into a cattle system in pasture communities might be associated with reduced desirables and pasture condition score or increased invaders in the aboveground vegetation. In this study, natural pasture communities grazed by cattle (C: 100%) or by a mix of species (DCS: 41.7% sheep, 15.2% goats and 43.1% cattle) were selected, and the GPs were classified as <0.30 (very low, VL), 0.31 to 0.60 (low, L), 0.61 to 0.90 (high, H) and 0.91< (very high, VH) livestock unit days ha^{-1}. The percentages of shrubs and herbaceous invasive species were higher and lower for communities grazed by C than by DC, respectively. The L and VH showed higher values for decreasers compared to the VL and H. The percentage of shrubs in the communities under H was lower, whereas the percentages of herbaceous invasive species in the communities under VH were lower compared to the other GP. The interaction effects of grazing AS×GP on all studied parameters were significant. The results suggest that increasing GP depending on grazing AS prevents animals from grazing selectively and can contribute to the control of some weeds.

Keywords. Stocking rates – Weed control – Livestock – Botanical composition.

Le taux souhaitable de plantes ou d'espèces herbacées dans des pâturages naturels broutés par différentes espèces animales et soumis à différentes pressions de pâturage

Résumé. *L'objectif de l'étude était de déterminer si l'augmentation de la pression de pâturage ou l'introduction d'autres espèces d'animaux brouteurs, comme des brebis ou des chèvres, dans un système d'élevage avec pâturage, pourraient amener les communautés à être associées à une réduction des espèces désirables et de l'état des pâturages ou à une augmentation d'invasives dans la partie aérienne de la végétation. Dans cette étude, on a sélectionné les communautés des pâturages naturels pâturées par des bovins (100%, B), ou par un mélange d'espèces (MCB: 41,7% moutons, 15,2% chèvres et 43,1% bovins) et les unités de bétail jours ha^{-1} ont été classées comme <0,30 (très faible, TF), de 0,31 à 0,60 (faible, F), de 0,61 à 0,90 (haut, H) et 0.91< (très haut, TH). Les pourcentages des arbustes et des espèces herbacées envahissantes étaient plus élevés et plus bas pour les communautés pâturées par B et par MCB, respectivement. L et TH ont montré des valeurs plus élevées pour les décroissants par rapport à TF et H. Le pourcentage d'arbustes dans les communautés sous H a été plus faible, tandis que les pourcentages d'espèces herbacées dans les communautés sous TH ont diminué par rapport aux autres pressions de pàturage. Les effets de l'interaction de pâturage DP×DL sur tous les paramètres étudiés ont été importants. Les résultats suggèrent que l'augmentation de DL en fonction du pâturage Comme empêche les animaux de pâturer de manière sélective et peut contribuer à contrôler certaines mauvaises herbes.*

Mots-clés. *Taux de stockage – Contrôle des mauvaises herbes – Élevage – Composition botanique.*

I – Introduction

Grazing animal species and grazing pressure (GP) affect the desirable pasture species and/or the invasion of weeds. The understanding of the interactions between plant species and grazing animals in rangelands is a key factor for preserving and maintaining both species diversity and optimum rangeland health or to controlling the invasive plants. Although grazing animals play a key role in altering plants diversity in rangelands (Rook and Tallowin, 2003), the long-term ecological consequences of the administration of various livestock grazing systems such as single and multi-species grazing remain poorly understood. Therefore, we hypothesized that grazing by different animal species in rangelands subjected to different grazing pressures can alter the rates of desirable for grazing plant species in these rangelands. Accordingly, the objective of this investigation was to determine whether different GP or introducing a different class of stock (DCS), like sheep or goats into a cattle system in rangelands, might be associated with reduced desirables and rangeland condition score (RCS) or with increased invaders.

II – Materials and methods

In this study, the botanical composition of rangelands in the Zonguldak province located on the Western Black Sea Region of Turkey (41°27′ N and 31°49′ E) at 40 to 86 m a.s.l., was evaluated. Approximately 2.2% of the studied area is under pastoral land use. The major pastoral system is extensive grazing by cattle on very large properties in the province with a mix of sheep, goats and cattle on the smaller properties in some parts of the province. Animal density in the studied area range between 0.04 and 1.79 livestock unit (LU) ha^{-1} (mean 0.54 LU ha^{-1}). Pastoral property sizes range from 0.62 to 58.7 ha (mean 10.9 ha). Summers are warm and humid, while winters are cool and damp with a mean annual temperature of 13.7 °C ranging from 7.0 °C in winter to 21.2 °C in summer. Average annual rainfall is 1233 mm (TSMS, 2015).

To determinate the rangeland condition, plant species in rangeland community were grouped as decreasers (high producing, palatable plants, and thus more desirable for grazing species), increasers (lower producing and less palatable plants) and invaders (introduced or native plants invade the rangeland as the decreasers and increasers are reduced by grazing). In calculating RCS, the lesser amount of each decreaser and increaser species was used, but invaders were not counted (Dyksterhuis, 1949). To evaluate the effects of grazing animal species (AS) and GP on decreaser, increaser, invader species and RCS we used a factorial arrangement of 2 AS and 4 GP in the completely randomized design. The 8 resulting treatments with 6 replicates were evaluated in a total of 21 rangeland communities (avg size = 10.9±1.47 ha) grazed *ad libitum* throughout the year for a long time and varied in animal density and grazing system. Ungrazed rangeland was not studied as a control. The AS categories were single-species grazing (100% cattle, C) and a DCS or multi-species grazing (composed of 41.7% sheep, 15.2% goats and 43.1% cattle). The GP was the animal unit (<0.30, 0.31 to 0.60, 0.61 to 0.90 and 0.90< LU days ha^{-1}) demand per unit of rangeland area, designated as very low (VL), low (L), high (H) and very high (VH), respectively. Standard deviation (mean±1 or 2 SD) was used as the criteria of grouping GP into the different classes. Animal numbers were obtained from Zonguldak Directorate of Food, Agriculture and Livestock. The total frequency of all plant species were calculated from plants observed using the step point method (Evan and Love, 1957). Then, invasive shrubs and herbaceous species were expressed as a percentage of the invader species.

According to experimental design, data were submitted to a two-way analysis of variance using the GLM procedure of SPSS and the Tukey's multiple range test was used to determine significant differences (SPSS 21.0; SPSS Inc., Chicago, IL, USA).

III – Results and discussion

In studied rangelands, vegetation was a mixture of 49 plant families, and the families such as *Fabaceae* (22.6%), *Gramineae* (16.0%), *Astraceae* (14.6%) and *Rosaceae* (7.1%) dominated the botanical composition. The rates of invasive shrub and herbaceous species were affected by both the AS and GP while that of the decreaser only by the GP treatment (p<0.05, Table 1). The percentage of shrub and herbaceous invasive species in the communities grazed by C were higher and lower than that grazing by DCS, respectively. The L and VH levels of the GP treatments had higher values for decreasers compared to the VL and H. The percentage of shrubs in the communities under H was lower, whereas the percentages of herbaceous invaders under VH were lower compared to the other GPs. The decreasers in communities grazed by C under the VH level of GP had the highest percentage, whereas that in communities grazed by DCS under the L level of GP had the highest rate. The increasers of rangeland communities grazed by C under the VL level of GP had the lowest rate, whereas that of rangeland communities grazing by DCS under the VL and VH levels of GP had the lowest percentage. Regarding of the invaders' percentage, the highest values were recorded on rangelands grazed by C under the VL level and by DCS under the VH level of GP.

Table 1. The percentages of desirable for grazing species, the invaders and rangeland condition score in the natural rangeland communities grazing by different animal species and subjected different grazing pressure

AS	GP	Decreasers	Increasers	Invaders			RCS
				Shrub	Herbaceous	Total	
C	VL	2.47c	12.77b	39.92ab	44.85bc	84.77a	15.23c
	L	6.92abc	16.36ab	32.82abc	43.92bc	76.72ab	23.28bc
	H	11.73abc	14.29b	25.95abc	48.03bc	73.98ab	26.03bc
	VH	17.65a	18.84ab	17.50c	46.01bc	63.51b	36.49a
DCS	VL	5.74c	15.80ab	19.32bc	59.14a	78.46ab	21.54c
	L	17.01ab	18.05ab	15.99c	49.02bc	64.85b	35.06ab
	H	7.43abc	22.84a	12.00c	57.73b	69.73ab	30.27b
	VH	6.28bc	10.75b	43.80a	39.18c	82.98a	17.03c
AS	C	9.69	15.57	29.05a	45.70b	74.74	25.26
	DCS	9.11	16.85	22.78b	51.26a	74.04	25.96
GP	VL	4.10c	14.28	29.62ab	51.99a	81.61	18.39
	L	11.24a	17.18	24.41b	46.45ab	70.86	29.14
	H	9.58b	18.57	18.98c	52.88a	71.85	28.15
	VH	11.96a	14.80	30.65a	42.59b	73.24	26.76
SEM		1.208	0.909	1.658	1.547	3.057	2.057
Main effect of							
AS		NS	NS	*	*	NS	NS
GP		*	NS	*	*	NS	NS
AS × GP		*	*	**	*	*	*

AS: animal species, GP: grazing pressure, C: cattle, DCS: different class of stock, like sheep or goats into a cattle system, LV: very low (>0.30 LU days ha^{-1}), L: low (0.30 – 0.60 LU days ha^{-1}), H: high (0.61 – 0.90 LU days ha^{-1}) and VH: very high (0.90< LU days ha^{-1}), PCS: rangeland condition score. Means with different letters in the same raw are different (P < 0.05). *: P < 0.05, ** P < 0.01.

The multi-species grazing systems can be an effective management tool to control undesirable vegetation or the grazing of one livestock species can influence negatively the botanical composition despite it provides benefits (or facilitate) to other grazing livestock species (Abaye *et al*., 1997). In this study, the DCS treatment was only beneficial to reduce the percentage of shrubs. Goats (or browsers) who graze primarily on shrubs and sheep (or intermediate feeders) who exhibit no particular preferences among grasses, shrubs or herbaceous invasive species, reduced shrubs cover. Hence, our results support the idea that including sheep and goats in an extensive management system could have highly beneficial results in terms of vegetation composition (Walker *et al*., 1988). As reported by Abaye *et al*. (1997), rangelands grazed by goats, sheep and cattle had more invasive herbaceous species than rangelands grazed by cattle alone. Therefore, it can be argued that the current problem with invaders in the studied rangelands may be resulted from declining sheep and goat numbers during the past 20-30 years (TUIK, 2015). Indeed, many of the worst weeds in the C-grazed rangelands were shrub and herbaceous invasive species that sheep and goats find palatable such as leafy spurge, yellow star thistle, and spotted knapweed (Rutter *et al*., 2004). However, invasive herbaceous species such as *Dryopteris filix-mas* L. and Schott and *Galega officinalis* L. in the DCS-grazed rangelands were higher compared to the C-grazed rangelands.

The GP is important to express dietary preferences of grazing animals (Tallowin *et al*., 2005). Although preferences of grazing animals is typically problematic over the long term because of decreasing the more desirable species and increasing the less desirable ones (Baumont *et al*., 2005) as the GP increase, it is not necessarily always true, as reported herein. Our results on RCS may be attributed to the positive effects of the grazing herd on the range ecosystem relative to growth and diversity of plants and ecological succession (Bokdam, 2001).Therefore, invasion of weeds do not make the land unhealthy, they appear because the land is unhealthy, as reported by Hickman *et al*. (2004).

IV – Conclusion

The results of the present study indicate that differences in grazing pressure caused by variations in stock density for a long time did not dramatically affect selective grazing and that single-species grazing can have an adverse impact on the botanical composition of studied rangelands due to the fact that it increased the rate of shrubs. These results suggest that increasing GP depending on grazing AS prevents animals from grazing selectively and can be contributed to the control of some invaders. Generally, maintaining more desirable species in rangelands may increase the sustainability of the farming system.

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Atriplex halimus: halophyte plant as potential forage for ruminants in the arid area of South-East Algeria

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Abstract. The area of El Haouche in South-East of Algeria is considered as an extremely arid zone. Chenopodiaceous shrubs (*Salsola vermiculata*, *Sueada mollis*, *Atriplex halimus*) and the tree *Tamarix africana* are endemic species grazed specially by small ruminants and dromedary in this region. The physiognomic map of the study area vegetation reveals the predominance of *Atriplex halimus*. This is a perennial shrub tolerates well harsh conditions. Trace elements concentrations (Cu, Fe, Mn, Zn, Cd and Pb) were measured in *A*. *halimus*. Potential intake of Cu and Zn satisfy the requirement of small ruminants. Levels of Fe were high. Mn concentrations were lower. Cd and Pb contents correspond to the background level.

Keywords. *Atriplex halimus* – Chemical composition – Trace metal – Arid zone.

Le potentiel fourrager de la plante halophyte* Atriplex halimus *dans la région aride au sud-est de l'Algérie

Résumé*. La région d'El Haouche au sud-est de l'Algérie est considérée comme une zone extrêmement aride. Les arbustes* Salsola vermiculata*,* Sueada mollis*,* Atriplex halimus *et l'arbre* Tamarix africana *sont des espèces endémiques dans cette région, pâturées spécialement par les petits ruminants et le dromadaire. La carte physionomique de la zone d'étude révèle la prédominance de* l'Atriplex halimus*. C'est un arbuste vivace qui tolère bien les conditions difficiles. Des recherches récentes ont démontré sa capacité à tolérer une forte concentration de métaux lourds. Les éléments traces (Cu, Fe, Mn, Zn, Cd et Pb comme élément toxique) ont été mesurés dans cet arbuste. Les teneurs en Cu et en Zn peuvent satisfaire les besoins des petits ruminants. Les concentrations du Fe sont élevées, par contre celles du Mn sont plus faibles. Les teneurs en Cd et en Pb sont naturelles.*

Mots-clés*.* Atriplex halimus *– Composition chimique – Élément trace – Zone aride.*

I – Introduction

Arid regions in South-East of Biskra in East of Algeria contain soils and water resources that are too saline for most common crops. Vegetation at the edges of the Chott Melghir in this region comprises mainly taxa of the Chenopodiaceae family (such as *Atriplex* ssp., *Salsola* ssp., *Suaeda* ssp.) and the Tamaricaceae family, *Tamarix africana* grazed specially by goats, dromedary and sheep in this region. *Atriplex halimus* is a perennial spontaneous shrub of South-East of Biskra with an excellent tolerance to drought and salinity (Nedjimi, 2012). Moreover, recent researches demonstrated their ability to tolerate high concentration of heavy metal (Lotmani and Mesnoua, 2011).Trace elements (Cu, Mn, Fe, Zn…) function as activators of enzyme systems or as constituents of organic compounds. The ruminant may be exposed to toxic concentration of heavy metal (Cd, Pb) and other trace elements (Cu) by consuming contaminated forage in pasture. The aim of this study was to evaluate and compare seasonally through year the trace mineral levels (Cu, Mn, Fe, Zn) ; Cd and Pb as toxic element in *Atriplex* *halimus* (endemic Chott halophyte) in order to assess contributions, deficit and excess in animals requirements.

II – Materials and methods

The study was conducted in El Haouche (5 ° N 28 'E 30 ° 15') on the edge of Chott Melghir 30-35 km South-East of Biskra in South of Algeria. This area is characterized by a high salinity of the soil. Average annual precipitation is 140 mm (Haddi *et al*., 2009). The main soil has high pH value (7.5-8.2), the type soil is gypsum-lime, characterized by high salinity, and its conductivity ranges from 20 to 36 µS/cm (Haddi *et al*., 2009). Samples of *Atriplex halimus* were collected in different phonological stages. Due to overgrazing, edible green aerial parts of plants were not quantitatively available at each sampling period. Only edible green aerial parts, from 15 to 25 cm of length, were hand clipped. Edible parts were dried in air forced oven at 55°C for 72 h. The dried samples were ground in K-Janke mill (1 mm screen) and stored in polypropylene bottles at room temperature for subsequent analysis. The wet digestion with nitric and perchloric acid (Elmer, 1994) was made to obtain extracts for the determination of trace minerals (Cu, Mn, Fe and Zn) using the flame Atomic Absorption Spectrophotometry (Shimadzu model AA 6800). Cd and Pb were analyzed with a graphite furnace after dry ashed at 550°C for 16 h (Afri-Mehennaoui *et al*., 2009). Data were analyzed statistically, using the SAS software, by one -way ANOVA, to determine differences between means.

III – Results and discussion

The Cu concentration of *A. halimus* has no significant difference (P>0.05) in all seasons except for autumn (Table 1). The higher level was observed in winter (14.7 mg/kg) and the lower (11.5 mg/kg) in autumn. Cu levels were sufficient to meet maintenance requirements for goats (NRC, 1981; Kessler, 1991 and Ramirez-Orduna *et al*., 2005), sheep and cattle (Meschy, 2010).

Table1. Trace minerals levels (mg/kg DM) in *Atriplex halimus*

Season	Cu (mg/kg)		Mn (mg/kg)		Fe (mg/kg)		Zn (mg/kg)	
	Mean	SD†	Mean	SD†	Mean	SD†	Mean	SD†
Autumn	11.50^{b}	2.12	19.30^{a}	1.41	541^{b}	63	49^{b}	10,04
winter	14.70^{a}	5.96	18.50^{a}	2.21	679^{a}	264	59^{b}	13,40
Spring	14.50^{a}	6.50	19.17^{a}	6	578^{a}	140	67^{a}	6,40
Summer	13.15^{a}	4.60	11.50^{b}	1.84	608^{a}	101	69^{a}	6,00
Ruminants requirements (mg/kg M)[1]	10		50-60		30		50-60	
Goat requirements (mg/kg M)[2]	9		30		35		30	

Means with different letters are significantly different (P<0.05), †SD: standard deviation.

[1]Recommended requirement (Meschy, 2010), [2] Recommended requirement (NRC, 1981; Kessler, 1991 and Ramirez-Orduna *et al*., 2005).

The Mn concentrations of *A. halimus* has no significant difference in all seasons (P>0.05) except for summer. The high level was observed in autumn (19.3 mg/kg DM) (Table 1). However, Mn did not meet the requirement of goats, sheep and cattle as it was below the reported value (30 and 50-60 mg/kg DM) (Table 1). Manganese availability is inversely related to soil pH. The highest Mn concentrations are found in forages growing on acid soil (MacPherson, 2000). It is known that gypsum-lime soil has high level of Ca to lead a low level of Mn in plant. In our study area, the lower Mn concentrations in *Atriplex* are possible due to high concentration of Ca in soil.

Fe concentrations in *A. halimus* has no significant difference in all seasons, except autumn (Table 1). The higher concentration was in winter (679 mg/kg DM) and the lower one in autumn (541 mg/kg DM). The high levels of soil Fe about 29 g/kg (unpublished data) suggest a Fe translocation in high quantity to *A. halimus* growth in this soil. Mean Fe levels were higher than the requirements for ruminants in all seasons (Table 1). Concentration of Fe >300 mg/kg DM has a deleterious effect on Cu availability (MacPherson, 2000; Givens *et al*., 2000). As reported by Ramirez-Orduna *et al*. (2005) Fe in levels from 250 to 1200 mg/kg may negatively affect Cu status of cattle and sheep.

The concentration of Zn varied from 49 mg/kg in autumn to 69 mg/kg in summer (Table 1). *A. halimus* in all season except for autumn had such Zn concentration to satisfy range cattle and sheep requirements (Table 1).These concentrations are above the Zn requirements for goat (NRC, 1981; Kessler, 199 and Ramirez-Orduna *et al*., 2005).

The Zn levels of *Atriplex* in South Algeria is higher than that measured in South Africa at Lovedale (11mg/kg DM) (Van Niekerk *et al*., 2004), site with an average annual rainfall of approximately 130 mm, similar to our arid area.

In this study Cd levels ranged from 0.06 mg/kg in summer to 0.35 mg/kg in winter, which was the significant highest concentration (Table 2). The forage Cd levels are dependent on the background level in soil. According to European directives Cd is limited in ruminant feed to 1 mg/kg DM (Meschy, 2010). Underwood and Suttle (1999) considered that Cd level varied from 0.5 to 5 mg/kg DM in the diet is high.

Table 2. Cadmium and lead (mg/kg DM) levels in *Atriplex halimus*

Season	Cd (mg/kg)		Pb (mg/kg)	
	Mean	**SD**	**Mean**	**SD**[†]
Autumn	0.20[b]	73	3[b]	0.62
Winter	0.35[a]	80	3[b]	0.81
Spring	0.08[c]	27	5[a]	3.73
Summer	0.06[c]	14	3[b]	2.13
Diet (mg/kg DM) Cattle and Sheep[†]	0.1-0,2		1-6	N. Normal
	0.5- 5		20- 1000	H. High
	> 50		> 2000	T. Toxic

Means with different letters are significantly different (P<0.05); SD: standard deviation.

[†]Underwood and Suttle (1999).

According to the results, *A. halimus* has a natural Cd content. Due to their electronic configuration close, Cd, Cu, Fe and especially Zn are competing against protein intestinal absorption. Excess cadmium can decrease their absorption and induce deficiencies in these elements. Cadmium toxicity is due to its accumulation in the liver and especially in the kidneys, and symptoms of Cd poisoning are similar to those in partnership with Zn deficiency (Meschy, 2010).

Lead (Pb) is among the most common heavy metals that cause toxicity to animal and humans. Pb level in whole plant (Table 2) was high (P<0.05) in spring (5 mg/kg DM), while it had no significant differences in the other seasons (P>0.05). Those levels were lower than that observed in contaminated area. According to Zafar et al. (2012) maximum tolerable levels of Pb by animals is 30 mg /kg DM. High tolerance may have been due to the insoluble source used, toxicity is likely to be reduced when diets rich in calcium are fed (Underwood and Suttle, 1999).

IV – Conclusions

According to the results themean levels of trace metals in *Atriplex halimus* are high for Fe, close to the recommended value by INRA for Cu and Zn, deficient for Mn and close to the background level for the Cd and Pb. Levels of Fe in the plants are very high suggesting a high level in soil. The range small-ruminants grazing the *Atriplex halimus* in these areas must be supplemented with Mn throughout the year in order to sustain goat and sheep productivity. The knowledge of bioavaibility of these trace minerals in ruminant's asks for a detailed study in the future.

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Effect of stocking rate on the pasture and sheep production in winter and spring lambing systems

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Abstract A two-year study investigated the effect of stocking rate on the pasture productivity and lamb performance in winter and spring lambing systems. Pastures were grazed at low (16-20 ewes + lambs ha^{-1}), medium (24-28 ewes + lambs ha^{-1}) and high (32-36 ewes + lambs ha^{-1}) stocking rates in spring 2012 and 2013. Annual pasture dry matter (DM) productions ranged from 8.9 to 10.2 t ha^{-1} but were not affected by the stocking rate. The average daily live weight gains of the winter born lambs were 73 and 10 g head^{-1}d^{-1} for low and medium stocking rates, respectively, while the lambs at the high stocking rate lost 10 g head^{-1}d^{-1} in spring 2012. The spring born lambs grew at 245, 189, 133 g head^{-1}d^{-1} for low, medium, and high stocking rates, respectively, in spring 2013. High stocking rates did not have any negative effect on the pasture production but they resulted in poor sheep performances.

Keywords. Grazing intensity – Lambing system – Live weight gain – Pasture.

Effet de la densité d'occupation animale sur le pâturage et la production ovine dans les systèmes d'agnelage d'hiver et de printemps

Résumé. *Une étude de deux ans a investigué l'effet de la densité d'occupation animale sur la productivité des pâturages et les performances des agneaux dans les systèmes d'agnelage d'hiver et de printemps. Les pâturages étaient broutés à densité d'occupation animale faible (16-20 brebis + agneaux par hectare), moyenne (24-28 brebis + agneaux par hectare) et élevée (32-36 brebis + agneaux par hectare) au printemps 2012 et 2013. La production annuelle en matière sèche (MS) pâturée variait de 8,9 à 10,2 t par hectare mais n'a pas été affectée par la densité d'occupation animale. Le gain moyen quotidien de poids vif des agneaux nés en hiver était de 73 et 10 g par tête et par jour pour la densité d'occupation animale faible et moyenne, respectivement, tandis que les agneaux exposés à une densité d'occupation animale élevée ont perdu 10 g par tête et par jour durant le printemps 2012. Les agneaux nés au printemps ont gagné 245, 189, 133 g par tête et par jour pour la densité d'occupation animale faible, moyenne et élevée, respectivement, au printemps 2013. Les taux élevés de cette densité n'ont pas eu d'effet négatif sur la production des pâturages mais ont abouti à de faibles performances des moutons.*

Mots-clés. *Intensité du pâturage – Système d'agnelage – Gain de poids vif – Pâturage.*

I – Introduction

Stocking rate is the key management variable and primary determining factor of the individual and total live weight production in pasture based feeding systems (Sollenberger, 2005). While grazing at high stocking rates may be detrimental to the plant species that are less tolerant to grazing, low stocking rates may allow the animals to be more selective in their grazing, and reduce the competitiveness of the more palatable plants. Lambing and weaning dates need to be in conformity with the grazing management, pasture growth rates and production for successfully matching the requirements of animals at varying physiological stages with forage supply and quality. Based on the management practices on mating and lambing dates coupled with the decision on the stocking rate, the efficiency of the sheep production in pasture based feeding systems may vary greatly (Penning, 1991).

The purpose of this research is to investigate the effect of stocking rate on animal and pasture productivity in winter and spring lambing systems in the Central Anatolian region of Turkey.

II – Materials and methods

This study was conducted at Bahri Dagdas International Agricultural Research Institute (37° 51' N, 32° 33' E; 1008 m asl), Konya, Turkey, from April 2011 to November 2013. A 2.3 ha paddock was cultivated and split into three blocks before sowing. The pasture mixtures comprised of *Festuca arundinacea, Dactylis glomerata, Lolium perenne, Lotus corniculatus* and *Trifolium repens* were sown in a randomized complete block design with three replications on 14 April 2011. Each block was split in three paddocks (64 x 40 m) giving a total of nine grazing plots. These plots within each replicate were randomly allocated to the treatments of low (LSR), medium (MSR) and high (HSR) stocking rates during the spring 2012 and 2013. In 2012, single lambs born during winter (mid-January) and their dams were set stocked after weaning at 20 (LSR), 28 (MSR) and 36 (HSR) ewe + lamb ha^{-1} during 24 April − 11 July. In 2013, single suckling lambs born in spring (early March) and their dams were set stocked at 16 (LSR), 24 (MSR) and 32 (HSR) ewe + lamb ha^{-1} during 19 April − 5 July. Anatolian Merino ewes (mean LW = 47.8 ± 5.3 kg in 2012 and 48.1 ± 5.9 kg in 2013) and their single lambs (mean LW = 28.0 ± 2.6 kg in 2012 and 17.1 ± 1.7 kg in 2013) were classified according to their live weights (LW) and allocated randomly to the main plots for the spring grazing experiments in both years.

Dry matter production and daily growth rates of the pasture plots at three stocking rates were measured inside 1 m^2 exclosure cages in spring, summer and autumn. All herbage from the quadrat cuts was dried in an oven (70 ºC) until constant weight. Mean daily pasture growth rates (kg DM ha^{-1} d^{-1}) were calculated at each harvest by dividing total DM production (kg DM ha^{-1}) by the duration of regrowth since the previous harvest. Live weight gain (LWG) was determined by weighing the ewes and lambs prior to and following each grazing period. Sheep were held overnight without access to feed and weighed "empty" the following morning. LWG per head was calculated from the change in weight between each LW measurement date.

Pasture dry matter production and pasture growth rates were analysed by ANOVA in randomized complete block design for each measurement period. The effect of stocking rates on LWG per head was analyzed by one−way ANOVA with repeated measures. Significant differences among treatment means were compared by Fisher's protected LSD at P= 0.05.

III – Results and discussion

Total DM production of the pastures exceeded 10 t ha^{-1} and was nearly equal for all the three pasture stocking rates in 2012 (Fig.1 a). DM production of pastures in 2013 ranged from 8.9 to 10.1 t ha^{-1} but the stocking rates had no effect (P >0.05) on the seasonal or annual DM production. Similarly stocking rates had no significant effect (P >0.05) on the mean daily pasture growth rates (Fig.1 b). The absence of a stocking rate effect on the DM production of the pastures that consisted of perennial species was probably due to the relatively short duration of the different stocking rates imposed only in the spring seasons. Similarly, Thompson *et al*. (1994) for annual pastures grazed at stocking rates ranging from 8 to 40 sheep ha^{-1} in Australia, and Ates *et al*. (2013) for pastures grazed at 8.3 and 13.9 sheep and their twin lambs ha^{-1} in New Zealand, reported that spring stocking rates did not affect total annual pasture production.

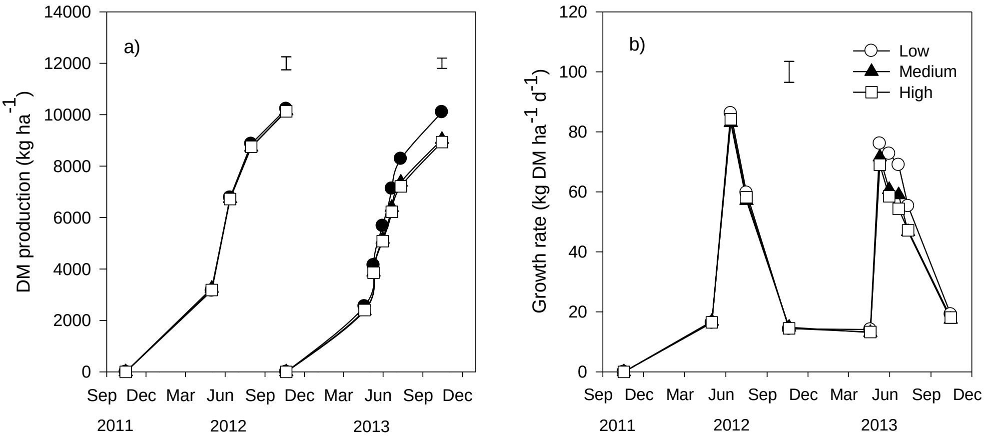

Fig. 1. Pasture DM production (kg ha^{-1}) (a) and growth rates (kg DM ha^{-1} d^{-1}) (b) at spring stocking rates of 16-20 (low), 24-28 (medium) and 32-36 (high) ewes with single lambs ha^{-1} from 2011 to 2013. Bars represent the SE for (a) and maximum SE for (b).

In 2012, an interaction was detected between LWG and measurement period for LWG of lambs (Table 1). Lambs had increases in their LWs at various levels ranging from 89 to 144 head^{-1} d^{-1} during the first period, whereas during the second period the lambs at MSR and HSR had significant LW losses the and lambs at LSR showed negligible LW gains. The mean lamb LWGs per head in 2013 were 245, 189, and 133 head^{-1} d^{-1} at LSR, MSR and HSR, respectively. An interaction occurred that year between stocking rate and the measurement period for LWG of the lambs because only the lambs at LSR had increases in their LWs at the final period, whereas lambs at MSR and HSR lost weight during the same period. The final LWs of lambs (at mean 177 d old age) in winter lambing system was 33.7, 28.8 and 27.2 kg for LSR, MSR and HSR, respectively, whereas the final LWs of lambs (at mean 120 d old age) in spring lambing system was 36.0, 31.7 and 27.3 kg for LSR, MSR and HSR, respectively. These findings indicate that the LWGs of lambs need to be maximized during spring and lambs weaned and drafted before the end of June when the pastures have a major decline in their daily growth rates due to increasing temperatures and summer dormancy. Furthermore, applying lower grazing rates and/or supplemental feeding may be necessary particularly in winter lambing system to maintain the high lamb growth rates before the onset of high summer temperatures.

Significant decreases in ewe LWG per head occurred over the grazing periods but the magnitude of decline in ewe LWG losses was greater ($P<0.05$) at MSR and HSR than LSR. This caused a significant interaction between stocking rate and period both in 2012 and 2013. Ewes have the ability to adapt to nutritional constraints through mobilization or accumulation of body reserves in forage based feeding systems that often consist of underfeeding and re-feeding periods depending on the seasonal pasture growth and stocking rate. Despite the higher stocking rates imposed in the spring grazing in 2012 compared to 2013, the weight losses that were observed on ewes were not as dramatic as in 2013. As lambs on these ewes achieved high growth rates compared to winter-born lambs, the results suggest that the suckling lambs may have benefitted from the buffering effect of the mobilization of adipose reserves to maintain milk production which commonly occurs early stages of lactation (Blanc *et al*., 2006). The implication of weight loss during lactation is that ewes grazing at HSR need to gain more body weight during summer and early autumn to meet pre-mating live weight targets for the improvement of conception rates.

Table 1 Mean live weight gain per lamb and ewe (g head^{-1} d^{-1}) in 2012 at 20 (low), 28 (medium) and 36 (high) ewes with single lambs ha^{-1} and in 2013 at stocking rates (SR) of 16 (low), 24 (medium) and 32 (high) ewes with single lambs ha^{-1}

Year	Period	Lamb			Ewe		
		Low	Medium	High	Low	Medium	High
2012	24 Apr–30 May	144	104	89	187	132	123
	30 May–11 July	2	−84	−108	−38	−125	−168
	Mean	73	10	−10	75	3	−23
	SE*		7.2			9.3	
	$P_{\text{Stocking rate (SR)}}$		0.01			0.01	
	$P_{\text{Period (P)}}$		0.01			0.01	
	$P_{\text{SR x P}}$		0.01			0.05	
2013	19 Apr–10 May	319	294	292	157	98	69
	10 May–31 May	272	239	180	6	−52	−220
	31 May–21 June	251	170	58	29	−104	−124
	21 June–5 July	95	−2	−51	−69	−121	−128
	Mean	245	189	133	31	−44	−101
	SE*		16.3			25.5	
	$P_{\text{Stocking rate (SR)}}$		0.01			0.01	
	$P_{\text{Period (P)}}$		0.01			0.01	
	$P_{\text{SR x P}}$		0.01			0.01	

*Maximum S.E (standard error) for the interaction (SR × P).

IV – Conclusions

Medium stocking rates in early spring with reduced stocking rate towards summer would be a good strategy for optimum pasture management in both lambing and grazing systems.

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Vegetation cover and species composition under different grazing intensity in mountainous grasslands of Northern Greece

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Abstract. Grazing disrupts plant communities and affects the composition of species. The composition of species depends on season, frequency and especially on the intensity of grazing. The main purpose of this research is to study the effect of grazing intensity on species composition of mountainous grasslands. The vegetation cover and species composition were measured under three different grazing intensities (no grazing, moderate grazing and heavy grazing) at the peak of the plant's growth for two consecutive years (2013-2014) in grasslands of mountain Cholomontas in Northern Greece. Woody species predominated in no-grazing compared to both grazing treatments in both years of measurements while forbs only the first year. Grasses were higher on grazing treatments than in non-grazing for the two years, while legumes were higher in the heavy grazing treatment. Legumes and grasses increased gradually from the no-grazing to heavy grazing conditions both years of measurements. Litter was lower and higher in no-grazed grassland compared to moderate and to heavy grazed grasslands the first and second year of measurements respectively.

Key words. Grasses – Legumes – Forbs – Ungrazing – Moderate grazing – Heavy grazing.

La couverture végétale et la composition des espèces sous différentes intensités de pâturage dans des prairies montagneuses du nord de la Grèce

Résumé. *Le pâturage perturbe les communautés végétales et a des effets sur la composition des espèces. La composition des espèces dépend de la saison, la fréquence et en particulier l'intensité du pâturage. Le but principal de cette recherche était d'étudier l'effet de l'intensité du broutage sur la composition des espèces des prairies montagneuses. La couverture de végétation et la composition en espèces ont été mesurées sous trois différentes intensités de pâturage (sans pâturage, pâturage modéré, et pâturage intensif) à l'apogée de la croissance des plantes pendant deux années consécutives (2013-2014) dans les prairies des montagnes Cholomontas du nord de la Grèce. Les espèces ligneuses ont prédominé dans la situation sans pâturage par rapport au pâturage sur les deux années de mesures, tandis que les herbacées seulement la première année ; les graminées ont été plus fréquentes dans les deux traitements de pâturage pendant les deux années d'étude, tandis que les légumineuses ont été plus fréquentes dans la situation de pâturage intensif. Les légumineuses et les graminées ont augmenté graduellement à mesure que l'intensité de pâturage était augmentée pour les deux années de mesures. La litière était inférieure et supérieure dans les pâturages non broutés par rapport à ceux pâturés modérément et intensivement pour la première et la deuxième année de mesures respectivement.*

Mots clés. *Graminées – Légumineuses – Plantes herbacées – Pâturage – Modéré – Intensif ¬– Non-pâturage.*

I - Introduction

Plant species composition and species response to grazing are fundamental for planning the managing of grasslands (Vesk *et al*., 2004). According to Landsberg *et al.* (2002) quantifying the impacts of livestock grazing on natural communities has become a major issue in the management of grasslands. The most obvious effects of grazing disturbance on plant communities include changes to vegetation structure and composition of species (Pettit *et al*., 1995). Depending on the grassland and the intensity, grazing by livestock animals can dramatically change the structure of the vegetation (Pettit *et al*., 1995). Vegetation changes in response to grazing management decisions often modify primary plant and animal production and economic returns from the system, as well as other benefits like conservation value (Diaz *et al*., 2001).

The main purpose of this research was to study the effect of the intensity of grazing in vegetation cover and species composition of mountainous grasslands.

II – Methods and materials

The research was conducted in the University Forest of Taxiarchis in Cholomontas mountain, Chalkidiki (40°23' – 40°28' N, 23°28' – 23°34' E), at 800 m a.s.l., at the peak of plant's growth (May-June) for two consecutive years (2013 and 2014). The climate of the area is classified as subhumid Mediterranean, with a mean annual air temperature of 11.1° C and an annual rainfall of 767 mm.

The whole forested area is, around 5800 ha (3918 ha forested areas, 276 ha partially forested areas, 1563 ha agricultural areas and 86 ha abandoned fields). Grasslands are about 2500 ha. They are public and are communally grazed by 1200 goats and 900 sheep during the year.

Three sites of similar vegetation type but different grazing intensity in terms of Forage Utilization Percentage (FUP) (data not shown) were selected: (1) Ungrazed (FUP=0%), (2) Moderate grazed (FUP<50%) and (3) Heavy grazed (FUP>60%) (Taxiarchis Forest Service Station, 2013). The ungrazed area is private and has not been grazed for over 40 years. Each area covered approximately 2 ha. In each condition, 10 transects of 25 meters each were taken randomly and the cover of vegetation using the line-point method was measured (Cook and Stubbendieck, 1986). The species composition was derived from the measurements of cover, after deducting the litter, bare soil and stones.

General linear models procedure of SPSS statistical software (IBM SPSS 21 for windows) was used for ANOVA. The Duncan criterion at the 0.05 probability level was used to detect the differences among means (Steel and Torrie, 1980).

III – Results and discussion

The heavy grazing area had significantly lower and higher percentage of vegetation cover and bare soil respectively than the moderate and no-grazing ones (Table 1). On the other hand, the percentage of litter did not significantly differ among the grazing intensities in both years of measurements (Tables 1 and 2). Increased percentages of bare soil and low vegetation cover in heavy grazing areas have been also reported by Alrababah *et al*. (2007).

Table 1. Mean plant cover (%) in the three grazing treatments (year 2013)

Category	Heavy grazing	Moderate grazing	No-grazing
Vegetation	90.9 b	95.9 a	95.3 ab
Litter	5.8 a	3.6 a	4.2 a
Bare soil	3.3 a	0.5 b	0.5 b

[1]Means in the same line followed by the same letters are not significant different at the 0.05 level of significance.

Karakosta *et al*. (2010) reported that the total vegetation cover was significantly decreased due to grazing in the same study area.

Table 2. Mean plant cover (%) in the three grazing treatments (year 2014)

Category	Heavy grazing	Moderate grazing	No-grazing
Vegetation	87.6 a	91.1 a	91.3 a
Litter	7.2 a	6.5 a	8.5 a
Bare Soil	5.2 a	2.4 ab	0.2 b

[1]Means in the same line followed by the same letters are not significant different at the 0.05 level of significance.

Regarding the species composition, the percentage of woody species was significantly higher in ungrazed site compared to moderate grazed, while they were completely absent in the heavy grazed plots in both years of measurements (Tables 3 and 4). It is well documented that reduced livestock grazing results in an increase of shrub cover (Perevolotsky *et al.*, 1998). Inversely, intense selective grazing pressure reduces the populations of large woody shrubs (Anderson and Hoffman, 2007). Moreover, shrub encroachment is widely recognised as one of the major threats to biodiversity in rangeland ecosystems (Dalle *et al.*, 2006). On the other hand the loss of woody shrubs may increase the risk of soil erosion or disrupt nutritient cycling (Pettit *et al.,* 1995).

The percentage of grasses and legumes was significantly lower in the ungrazed site compared to moderate and heavy grazed sites in both years of measurements. Inversely, the percentage of forbs was significantly higher in the ungrazed in comparison to moderate and heavy grazed at least in the 1st year of observations. According to the results, the grazing exclusion affected the plant community composition, favouring mainly the forbs. On the contrary, Oba and Kotile (2001) reported a low cover of grasses and high cover of forbs in grazed sites compared to the ungrazed ones in arid zone grazing lands. According to Diaz *et al.* (2006) grazing does not uniformly favour forbs, graminoids or woody species. The plant composition in grazed lands is affected by numerous ecological and management factors (Gusmeroli *et al.*, 2012).

Table 3. Mean plant composition (%) in the three grazing treatments (year 2013)

Category	Heavy grazing	Moderate grazing	No-grazing
Grass	63.53 a[1] (11)[2]	64.00 a (15)	28.90 b (8)
Legumes	16.06 a (3)	11.23 ab (8)	7.50 b (11)
Forbs	20.41 b (15)	23.17 b (27)	40.77 a (37)
Woody	0.00 b (0)	1.60 b (6)	22.83 a (6)

[1] Means in the same line followed by the same letters are not significant different at the 0.05 level of significance. [2]Number of species.

The second year of the measurements (2014) was unusually warm during the growing season (data not shown). This had as a result the drying some species (especially annuals) very early at the end of growing season. This fact could explain the absence of legumes in the no- grazing treatment.

Table 4. Mean plant composition (%) in the three grazing treatments (year 2014)

Category	Heavy grazing	Moderate grazing	No-grazing
Grass	59.2 a[1] (11)[2]	54.8 a (20)	39.9 b (6)
Legumes	16.2 a (14)	8.4 b (14)	0.7 c (5)
Forbs	24.6 a (16)	34.6 a (39)	34.2 a (30)
Woody	0.0 b (0)	2.2 b (1)	25.2 a (5)

[1]Means in the same line followed by the same letters are not significant different at the 0.05 level of significance. [2]Number of species

IV - Conclusions

Grazing pressure resulted in the decrease of vegetation cover and the increase of bare soil while litter remained stable. Grazing exclusion affected the plant community composition, favouring mainly the forbs.The present of woody species was higher in the ungrazed site compared to moderate grazed, while they were completely absented to the heavy grazed.

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Carcass traits and meat quality of lambs from two grassland ecosystems in the Middle Atlas area

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Abstract. Timahdite sheep (TH) are the native breed of the Moroccan Middle Atlas. The objective of this study is to compare carcass and meat quality of TH lambs from two grassland ecosystem i.e. mountain and steppe ecosystems, in the Middle Atlas area. For that purpose a total of ten TH female lambs from each ecosystem were slaughtered at an average age of 179±2 days and a mean live weight of 23.3 ±3.6 kg to study carcass conformation indices and instrumental and sensory meat quality. Results showed no significant differences between systems neither in carcass quality (P>0.05), except the carcass compactness index (P=0.002), nor in ultimate-pH, WHC and *semimembranous* muscle color (P >0.05). However, meat sensory evaluation showed that lamb from steppe was discerned by the panel tasters as more tender than that from mountain (P <0.05). These results show that raising lambs on two different grassland ecosystems affect significantly the carcass compactness and the consumer's perception of tenderness, but do not affect the instrumental meat quality.

Keywords. Grassland ecosystem – Meat and carcass quality –Timahdite lambs –Middle Atlas –Morocco.

Qualité de la carcasse et de la viande des agneaux élevés sur pâturage dans deux écosystèmes différents dans la région du Moyen Atlas

Résumé. *La Timahdite (TH) est la race ovine locale dans le Moyen Atlas marocain. L'objectif de cette étude est de comparer la qualité de la carcasse et de la viande des agneaux broutards TH élevés dans deux écosystèmes différents, montagneux et steppique, dans la région du Moyen Atlas. Pour cela, un total de dix agnelles TH de chaque écosystème ont été abattues à un âge moyen de 179 ± 2 jours et à un poids moyen de 23,3± 3,6 kg pour étudier les indices de conformation de carcasse et la qualité instrumentale et sensorielle de la viande. Les résultats ont montré qu'il n'y a pas de différences significatives entre les agneaux ni pour la qualité de carcasse, excepté l'index de compaction (P = 0,002), ni pour le pH ultime, la capacité de rétention de l'eau ou la couleur du muscle semi-membraneux (P > 0,05). Toutefois, l'évaluation sensorielle des viandes a montré que l'agneau de steppe a été discerné plus tendre par les dégustateurs du panel par rapport à celui de montagne (P <0,05). Ces résultats montrent qu'élever des agneaux sur deux pâturages d'écosystèmes différents affecte significativement la compaction de la carcasse et la perception du consommateur quant à la tendreté de la viande, alors que ceci n'affecte pas la qualité instrumentale de la viande.*

Mots-clés. *Écosystème de Pâturage – Qualité de la viande et de la carcasse – Agneau Timahdite – Moyen Atlas – Maroc.*

I – Introduction

In Morocco, lamb meat from the Middle Atlas area is known as one of the best meats in the country (Boujenane, 2005). It is considered as a nutritious and lean meat since it is mainly produced on pastures. Middle Atlas is characterized by differences in altitude, generating diversity in topography, climate, feed resources, and eventually in ecosystems. Based on this, the relationship between these ecosystems and the quality of the produced grass-lamb meat needs to be clarified. Indeed, few studies compared lamb meat produced on different types of pastures. In this sense, the aim of the present study is to determine the effect of grazing on two different pastures on the main indicators of quality in traditional ovine meat and carcass of local sheep raised in the Eastern Middle Atlas area in Morocco.

II – Materials and methods

A total of 20 weaned Timahdite female lambs, mean age and live weight 89 ± 2 days and 15.3 ± 1.7 kg, originated from a same agro-silvo-pastoral farm in the Middle Atlas area, were used for our study. Lambs were chosen based on sex, age and weight. They had been raised, from March until May 2014, either on steppe (P1, n= 10) or forestry (P2, n= 10) pastures. No supplementary feeding was provided during the trial. Lambs were slaughtered at age of 179 ± 2 days and a mean live weight 23.3 ± 3.6 kg. The steppe pasture was dominated by the following plant species: *Poa* sp. and *Artemisia herba-alba*, *Stipa tenassissima*, *Thymus ciliates* and *Hordeum murinum*. The forestry pasture harbored as predominant plants *Quercus rotundifolia*, along with various shrubs species like *Thymelaea* sp. and *Genista quadriflora*, and lower proportions of herbs. During the trial, the average measured temperatures on P1 and P2 was 27ºC and 21ºC, respectively. The average spent time on pasture was 9 and 12h for P1 and P2 lambs, respectively.

After slaughter, hot carcasses were weighed and the dressing percentages were calculated as follows: **HCW/SLW** (%) = Hot carcass weight x 100 / slaughter live weight. Measurements on carcasses were carried out using a ribbon and a distance gauge to determine carcass conformation indices as cited by Bonvillani *et al.* (2010): internal carcass length (**L**), carcass compactness (**HCW/L**), hind limb length (**F**), buttock width (**G**) and hind limb compactness (**G/F**).Then, carcasses were let for 6 h at ambient temperature and then transported to a cold room set to 4°C. *Semimembranous* muscles were excised to measure meat color and ultimate-pH. A Minolta CR410 spectro-colorimeter was used to obtain *L*, a*,* and *b** readings on caudal subcutaneous fat color at 0 and 24h post mortem and on *semimembranous* muscle color at cutting time (0 h) and after 24h of air exposure. Additional reflectance data collected include Hue angle *H**, a measurement where a vector radiates into the red-yellow quadrant, and the color saturation index Chroma *C**. These indices were calculated according to Murray (1995), as Hue angle = arctangent (b^*/a^*) x [360°/ (2x3.14)] and Chroma = $(a^{*2}+b^{*2})^{0.5}$. At 24 h after cutting time, ultimate-pH was measured by a meat pH-meter, and samples of 20 g from every *semimembranous* muscle were taken to determine the Water Holding Capacity (**WHC**), according to Grau and Hamm (1953) method. In parallel, meat tenderness was evaluated using the Lab Pro Tenderometer. The hardness of the meat is expressed by the maximum value of this force. Meat sensory evaluation was performed with two tests i.e. a scoring test, which evaluated the intensity of different sensory parameters using a scoring grid for each, and a triangle test to detect differences between the two meat origins. Thick pieces were prepared by slow cooking as the Moroccan traditional dash "*Tagine*" during 1.30 hour then served warm with sauce to 20 panelists. During two sessions, panelists were asked to evaluate the intensity of: tenderness, juiciness and meat flavor, using a scoring grid (scale 1–5) for each parameter, of two samples presented in randomized order. Then they were asked to determine the difference between 3 samples (of which 2 of similar origin), presented at randomized order in plates with three labeled letter codes.

Analysis of variance was performed by GLM procedure (SAS, 1997). The effect of the pasture as a fixed effect on all variables was analyzed. For the triangle test, the significance thresholds were evaluated according to the Norme AFNOR (2002), which shows in its first table the minimum number of correct answers that make a significant difference at different levels for the triangle test (5%, 1% and 1 ‰).

III – Results and discussion

Mean values for live weight at slaughter, carcass characteristics and subcutaneous fat color per pasture group are given in Table 1. Lambs on the P1 were significantly lighter at slaughter than those on P2 (P <0.05). This might be related to the abundance of pasture on the mountain area after snow melting compared to the steppe area. However, lambs from both groups presented similar dressing percentages. In addition, grazed pasture did not affect the hind limb compactness (P >0.5) but affected significantly the carcass compactness index (P <0.05). Lambs raised on P1 presented lower HCW/L ratio than those raised on the P2. This is probably due to the highest internal carcass length (Carrasco *et al.*, 2009). On the other hand, there was no difference in the subcutaneous fat color coordinates ($L*a*b*$) at 0 and 24 h. .

Table1. Effect of the pasture's type on live weight at slaughter, carcass characteristics and subcutaneous fat color

Site	P1	P2	SEM	Effect
SLW (kg)	19.75^{a}	26.10^{b}	7.24	**
HCW (kg)	9.51^{a}	12.64^{b}	0.57	***
HCW/SLW (%)	48.20	48.44	0.27	N.S
G/F	0.93	0.91	0.22	N.S
HCW/L (kg/cm)	0.15^{a}	0.18^{b}	0.87	**
$L*_{0\,h}$	75.84	71.26	1.71	N.S
$a*_{0\,h}$	3.51	4.60	0.93	N.S
$b*_{0\,h}$	7.83	9.19	1.31	N.S
$L*_{24h}$	77.18	73.94	1.50	N.S
$a*_{24h}$	4.76^{a}	7.15^{b}	3.12	N.S
$b*_{24h}$	11.96	11.50	0.46	N.S

P1= steppe pasture; P2=forestry pasture; SE =standard error; *L**=Lightness; *a**=Redness index; *b**=Yellowness index; N.S: no significant; *P≤0.05; **P≤0.01; ***P≤0.001.[a,b] Values within a row with different superscripts differ significantly at P≤0.5.

Table 2 shows that data regarding meat characteristics, i.e. pH, meat color, WHC and texture, were not significantly affected by the type of pasture (P> 0.05). Absence of statistical significance in carcass and meat characteristics is likely due to the small number of animals investigated (Dell *et al.*, 2002).

Table 2. Effect of pasture's type on instrumental quality of *semimembranous* muscle

Site	P1	P2	SEM	Effect
Ultimate-pH	5.68	5.45	1.97	N.S
$L*_{0\,h}$	44.44	40.77	1.09	N.S
$a*_{0\,h}$	17.91	18.10	0.18	N.S
$b*_{0\,h}$	3.20^{a}	1.66^{b}	2.95	*
$H*_{0\,h}$	10.15	5.28	2.84	*
$C*_{0\,h}$	18.19	18.20	0.002	N.S
$L*_{24h}$	45.37	44.03	0.43	N.S
$a*_{24h}$	19.08	20.67	1.70	N.S
$b*_{24h}$	7.13	7.35	0.26	N.S
$H*_{24h}$	20.52	19.66	0.35	N.S
$C*_{24h}$	20.39	21.97	1.89	N.S
WHC (%)	26.61	27.92	0.28	N.S
Shear force (N)	20.19	23.05	0.64	N.S

P1= steppe pasture; P2=forestry pasture; SE =standard error; *L**=Lightness; *a**=Redness index; *b**=Yellowness index; *H*= Hue angle; C*= Chroma;*N.S: no significant; *P≤0.05; **P≤0.01; ***P≤0.001.[a,b] Values within a row with different superscripts differ significantly at P≤0.5.

On the other hand, results of the triangle test showed that there was no difference between the three samples of lamb meat. The number of correct answers needed to conclude the presence of a difference was less than that of the standards of Norme AFNOR (2002) with a certainty of 95% (8 *vs* 11, respectively).

Least square means for the sensory attributes of the M. *semimembranosus* samples are presented in Table 3. The ANOVA results show that lamb meat tenderness differed significantly between the two pastures P1 and P2 (P <0.05), while similar juiciness and flavor is detected for the two meats (P >0.05). Difference in slaughter live weight can explain the panelist's perception of tenderness (Martínez-Cerezo *et al.,* 2005). However, the shear force values were not linear with the taste test results and were similar for both treatments (P > 0.05).

Table 3. Effect of pasture's type on sensory quality of *semimembranous* muscle

Site	P1	P2	SEM	Effect
Tenderness	4.29^{a}	3.70^{b}	0.11	**
Juiciness	3.67	3.38	0.11	N.S
Flavor	3.65	3.68	0.11	N.S

P1= steppe pasture; P2=forestry pasture; SE =standard error; **P*≤0.05; ***P*≤0.01; ****P*≤0.001.[a,b] Values within a row with different superscripts differ significantly at *P*≤0.5.

IV – Conclusion

This investigation highlights that raising lambs on two grassland ecosystems affected only the carcass compactness index and the lamb meat tenderness. Observed differences were attributed to the difference in live weight at slaughter and carcass measurements, while absence statistical significance in carcass and meat characteristics was explained by the small number of investigated animals. More investigations on fatty acids as well as lipid and protein oxidation are needed to detect any additional effects.

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Does transhumant sheep system provide ecosystem services for climate change adaptation in Mediterranean environment?

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Abstract. Since adaptation to climate changes has become a major challenge for the scientific communities, provisioning Ecosystem Services as Climate Regulation are growing in research interest. Greenhouse gasses are widely considered drivers of climate change and it has been demonstrated how different agro-ecosystems can influence the climate by either taking or realising greenhouse gases. Land use change does affect the soil C pool and many authors showed how the conversion of permanent vegetation (forests or grasslands) to cultivated crops led to a loss of soil C. On the contrary, many researches highlighted how croplands re-converted in grasslands ensure a soil C increment. Central Italy cropping system is characterised by rainfed winter cereals in rotation with preparative crops in the hilly areas and with high value crops (mainly, horticultural crops or vegetables) in the river valleys. Within this system, the presence of transhumant sheep farms allowed the conversion of annual crops in long lasting alfalfa grasslands (up to 10 years) grazed by flocks during the winter period. In this paper, we compared two conventional crop fields with a five-years lasting alfalfa grassland analysing heterotrophic soil respiration effluxes and soil C stock. Results suggest that transhumant system is able to increase the soil C sequestration.

Keywords. Soil Carbon Pool/flux – Mediterranean – Grazing *vs* cropping systems – Ecosystem services.

Le système de moutons transhumants est-il capable de fournir les services écosystémiques pour l'adaptation au changement climatique dans les systèmes de culture méditerranéens ?

Résumé. *Depuis que l'adaptation aux changements climatiques est devenue un enjeu majeur pour les communautés scientifiques, les services écosystémiques d'approvisionnement comme la "régulation climatique" sont de plus en plus importants aux yeux de la Recherche. Les gaz à effet de serre sont largement considérés comme des facteurs de changement climatique et il a été démontré comment les différents écosystèmes peuvent influencer le climat par l'effet de serre dite "prise ou libérée". L'utilisation des terres affecte la couche carbonique du sol et de nombreux auteurs ont montré comment la conversion de la végétation permanente (forêts ou prairies) vers des champs cultivés, a conduit à une perte de C du sol. De nombreuses recherches ont mis en évidence la façon dont les terres agricoles reconverties en prairies assuraient un incrément de carbone du sol. Le système de culture de l'Italie centrale est caractérisé par les céréales d'hiver pluviales en rotation avec des cultures de préparation dans les zones montagneuses et les cultures à haute valeur (principalement, les cultures horticoles ou de légumes) dans les vallées fluviales. Dans ce système, la présence d'élevages de moutons transhumants a permis la conversion de cultures annuelles, en champs de luzerne durables (jusqu'à 10 ans), broutés par les troupeaux pendant la période d'hiver. Dans cet article, nous avons comparé deux champs de culture classique avec une prairie de luzerne (en place depuis 5 ans), pour analyser la respiration du sol et son efflux de carbone. Les résultats suggèrent que le système transhumant est en mesure d'augmenter le stock de C dans le sol.*

Mots-clés. *Pool/flux de carbone dans le sol – Méditerranée – Pâturage* vs *systèmes de culture – Services écosystémiques.*

I – Introduction

Many scientific evidences demonstrate how climate change (CC) is altering the function of ecosystems (Nelson *et al*., 2013) especially in the Mediterranean basin which became one of the most threaten areas of the world (Bangash *et al*., 2013). Therefore, adaptation to CC has become one of the most compelling issues that must be faced by stakeholders (scientists, policy makers and farmers). Regulating Ecosystem Services are the benefits that people obtain from the regulation of ecosystem processes, including mitigation climate change effects (MA, 2003). Soil respiration is one of the main terrestrial contributors to CO_2 fluxes in the global carbon cycle (Gong *et al*., 2014). Site-specific management practices affect C losses by soil respiration and, in turn, the soil C budget (Batjes, 1999). Therefore, agro-ecosystems play a crucial role concerning climate regulation as well as their management affect soil C processes. Central Italy cropping system is characterised by rainfed winter cereals in rotation with preparative crops in the hilly areas and with high value crops (mainly, horticultural crops or vegetables) in the river valleys. Within this system, the presence of transhumant sheep farms allowed the conversion of annual crops in long lasting alfalfa fields (up to 10 years) grazed by flocks during the winter period. In this work we test the hypothesis that land use and management based on transhumant can generate ecosystem services in terms of soil C sequestration. Therefore objectives in this paper are to evaluate the grassland management effects on (i) chemical-physical properties of soil; (ii) seasonal dynamics of soil respiration; and (iii) amount of soil C losses.

II – Materials and methods

The study area is located in Marche Region, central Italy (43°22'24.9" N; 13°35'23.4"E) and it is representative of the plain area cropping system composed by a mixture of high values annual crops (vegetable crops, winter cereals etc.) The climate is Mediterranean with an average annual precipitation of 769 mm and a mean annual temperature of 13.7°C. In November 2014 we identified three adjoined fields: two intensively cultivated (INT A and INT B) and one used as a pasture by a transhumant sheep farm (TRH). Rather than envisage a plot scale experimental design we adopted a system analysis approach identifying representative fields with comparable soil and climate characteristics. Similar studies have been carried out studying one representative site for each land use rather than try to replicate it across the ecosystem (e.g. Almagro *et al*., 2009). Heterotrophic Soil respiration (HSR) efflux was measured in situ using a portable, closed chamber, soil respiration system (EGM-4 with SRC-1, PP-Systems, Hitchin, UK) with a measurement time of 120 s. In November 2015 three PVC collars per field (10 cm inner diameter and 10 cm long, with perforated walls in the first 5 cm) were inserted into the soil to a depth of 9 cm. Soil was isolated with a PVC cylinder (40 cm diameter, 40 cm high) opened at both ends, following the method described by Alberti *et al*. (2010). During each CO_2 efflux measurement, the SRC-1 chamber was fitted to a collar. Measurements started in January 2015 and ended in September 2015. Soil T°C and Soil Water Content (SWC) were measured at each plot at the same time of CO_2 efflux measurement using, respectively, a build-in T°C probe EMG-4 and a FieldScout TDR 100 Soil Moisture Meter. SWC and T°C were measured, respectively, in the top 20 cm of soil and at 10 cm depth. Soil analysis have been carried out to define the management effects of the two systems produced on the soil characteristics. The past fields management have been assessed by interviews. Linear and non linear regression analysis have been performed in order to investigate HSR dependence on soil T°C and SWC. Differences in HSR within date of measurement have been verified with one way ANOVA.

III – Results and discussion

The crop rotation of the two intensive fields is in line with the ordinary management of the area where the main crops are vegetables and winter cereals. Within these fields, alfalfa generally lasted 2 years as cover crop for soil improvement purposes and has an extremely low economic value. Despite this, transhumant management maintains alfalfa as temporary grassland used by sheep flocks during winter and mowed 2/3 times during summer (Fig. 1).

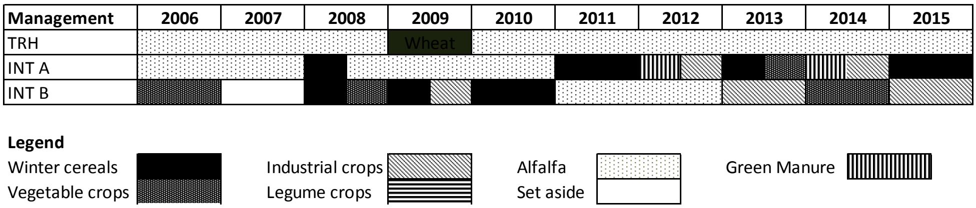

Fig. 1. Use of soil from 2006 in the three fields of the study area.

The comparison of soil analysis of the three fields (mean ± standard error) showed a similar texture (sand 19% ± 2.35; silt 46% ± 0.18; clay 34% ± 2.49), pH (8.3 ± 0.05), field Capacity (29.3% ± 0.76) and wilting point (20.4% ± 0.54). ANOVA on soil analysis shows significant differences among the managements with a larger C loss on INT A and INT B. Moreover, TRH shows a higher amount of soil N, NO_3- and a higher C/N ratio.

Table 1. Chemical-physical properties (mean ± standard error) of the soils obtained from three soils samples for each field at a 30 cm depth. Statistical significance has been assessed with LSD test (“a”=p<0.05; “A”=p<0.01)

Management	TOC (g/kg)	TEC (g/kg)	NO_3- (mg/kg)	Total N (g/kg)	C/N
TRH	13.60 ± 0.46^A	7.24 ± 0.12^A	8.37 ± 0.15^a	1.38 ± 0.04^a	9.43 ± 0.24^a
INT A	11.17 ± 0.07^B	6.16 ± 0.03^B	7.33 ± 0.37^b	1.22 ± 0.02^{ab}	8.73 ± 0.07^{ab}
INT B	11.50 ± 0.15^B	6.66 ± 0.03^C	5.63 ± 0.48^c	1.27 ± 0.02^b	8.70 ± 0.06^b

TOC: Total Organic Carbon (Springer-Klee method); TEC: Extractable Organic Carbon (According to DM 13/09/1999); NO_3- (According to DM 13/09/1999); Total N (Kjeldahl Method).

Exponential and linear regression analysis were performed to test respectively the relationships between (i) HSR and T°C (HSR= $a\ e^{b\ x}$) and (ii) HSR and SWC (HSR = $a + bx$) (Ray *et al*., 2002). When the SWC was lower than 21.5% the regression analysis shows significance between HSR and SWC in TRH and INT A (p<0.05) (Tab. 2).

Table2. Regression parameters of HSR= a $e^{b\ x}$ (where x is T°C) and HSR = a + bx (where x is SWC) (*p<0.05; **p<0.01)

Management	HSR f(x)	SWC < 21.5%					SWC < 21.5%				
		a	b	R^2	p	DF	a	b	R^2	p	DF
TRH	SWC	0.14	-0.18	0.57	*	8	0	1.32	0.00		8
	T°C	0.39	0.05	0.07			0.63	0.05	0.78	**	
INT A	SWC	0.12	-0.08	0.42	*	8	-0.08	3.08	0.07		8
	T°C	0.14	0.09	0.17			0.44	0.06	0.70	**	
INT B	SWC	0.02	0.88	0.05		8	0.05	0.08	0.03		8
	T°C	0.58	0.03	0.28			0.53	0.04	0.30		

As observed by Rey *et al*. (2002) soil respiration dynamics within soil use show a temporal variability imputable to SWC and T°C dynamics. ANOVA of HSR within date of measurement shows significant differences ($p<0.05$) in 1st April; 26th May, 25th June, 26th August and 23rd October, and for $p<0.01$ in 4th March, 3rd July and 24th September (Fig. 2).

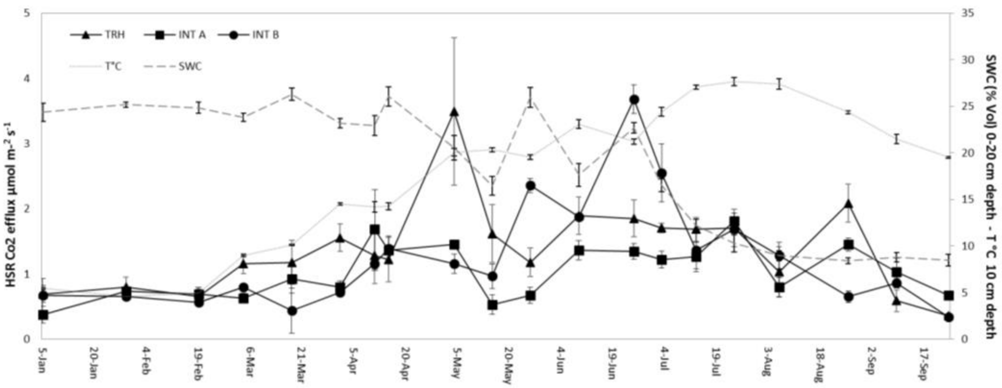

Fig. 2. Temperature (°C), Soil Water Content at 10 cm depth and HSR dynamics of the study area. The bars represent the standard error.

IV – Conclusions

Our results suggest that Soil Respiration dynamics are dependent both on soil temperature and water content therefore in line with scientific literature. Soil CO_2 emissions are higher in the alfalfa filed compared to the intensively cultivated fields. On the other hand, soil C content turned out to be higher where the transhumant farms system is present. The disappearance of the transhumant system in central Italy would increase soil C losses due to the management practices of the intensively cultivated fields. In order to estimate the potential of transhumant system in providing ecosystem services for climate regulation/adaptation, further analysis are needed to complete the study such as biodiversity assessment and Carbon Budget Assessments.

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Steppic ecosystem in the area of M'Sila, Algeria: state and perspective of rehabilitation

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Abstract. In the present study, we are interested in the management of the rangelands of the area of M'Sila; one of the principal wilayas (departments) of the Algerian steppe (rainfall between 100 and 400 mm/ year). We conducted interviews with thirty sheep breeders, representing the different existing breeding systems in the area. The exploitation systems of rangelands are the pastoral system (13.3%) in regression, and the agro-pastoral system (86.7%) which is in expansion. Livestock numbers keep increasing. Consequently, pastures (rangelands) are chronically overloaded, sometimes all year around. This practice induces a rapid degradation of the rangelands (64.5% of soils are degraded). So, to maintain livestock alive, breeders use food supplementation. Given this worrisome situation, new strategies to be considered should be based on both rehabilitation (natural regeneration and/or sowing forage plants) and on alternative systems of associations of breeding-farming, and through a better technical management of sheep livestock.

Key words. Algerian steppe – M'Sila – Ovine breeding – Degradation – Rehabilitation.

L'écosystème steppique dans la région de M'Sila, Algérie : Etat et perspectives de réhabilitation

Résumé. *Dans la présente étude, on s'intéresse à la gestion des parcours de la région de M'Sila, l'une des principales wilayas (départements) de la steppe algérienne (pluviométrie entre 100 et 400 mm/an). Nous avons mené des entretiens auprès de trente éleveurs, ce qui représente les différents systèmes d'élevage ovin existant dans la région. Les systèmes d'exploitation des parcours sont le système pastoral (13,3%), en régression, et le système agro-pastoral (86,7%) en expansion. Les cheptels continuent à augmenter. En conséquence, les pâturages (parcours naturels) se trouvent chroniquement en état de surcharge, parfois toute l'année. Cette situation induit une rapide dégradation des parcours (64,5 % des sols sont très dégradés pour seulement 17,6% intacts), ce qui pousse les éleveurs à faire appel à une complémentation alimentaire pour le maintien en vie de leur cheptel. Devant cette situation préoccupante, de nouvelles stratégies à envisager devraient s'appuyer à la fois sur des réhabilitations (régénération naturelle et/ou plantation pastorale) et sur des systèmes alternatifs d'associations élevage-agriculture, et par une meilleure gestion technique des troupeaux ovins.*

Mots-clés. *Steppe algérienne – M'Sila – Élevage ovin – Dégradation – Réhabilitation.*

I – Introduction

Algerian steppe is known as "the country of the sheep"; where 80% of the national livestock sheep exist. Extensively exploited, this species is best adapted for valuing the natural fodder resources of the area.

The changes in the agro-socio-economic systems led to an imbalance in the exploitation of the natural resources, in particular the rangelands. Today, we witness exhaustion and serious degradation of rangelands. The conservation and the restoration of the steppe, as well as the development of other feed resources for livestock to make up the existing food deficit are national order priorities of intervention (Bensouiah, 2003.).

II – Material and methods

To reach our objectives, we chose the area of M'Sila (Fig.1). This choice is based on animal and pastoral potentialities that the area conceals (1.6 million sheep per 1 million hectares of rangelands). Field interviews to thirty sheep breeders representing various breeding systems were realized.

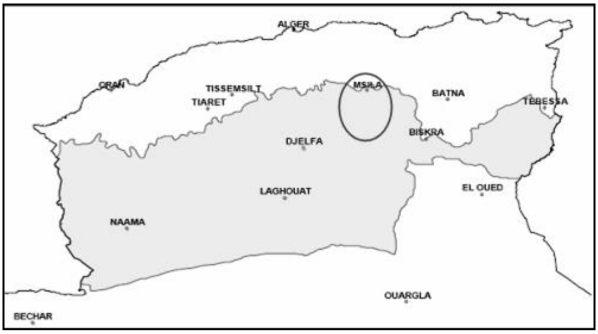

Fig.1. Location of the study area (Nedjraoui, 2004) (adapted).

III – Results and discussion

1. Production systems in the steppe rangelands

Two breeding systems were revealed: a pastoral system (in decline) and an agro-pastoral system (an increase, 86.66% of the investigated cases). The current systems of sheep breeding are characterized generally by a passage of a pastoral to an agro-pastoral mode. As well as a generalization of the food complementation on rangeland “passage of grass to the concentrate”.

2. Inventory of fixtures of the rangelands of the area of M’Sila

Data collection on the potentialities of the rangelands for pastoral use emphasizes that the rangelands covering an area of 839,212 ha are in a degraded state (73.45%of the total) (Table1).

Table 1. State of the rangelands of the wilaya of M’Sila

State	Surface (ha)	%
Very good	/	/
Good	201,265	17.62%
Mediocre	102,020	8.93%
Degraded	102,799	9.00%
Very degraded	736,413	64.46%

Source: HCDS, 2010..

The field investigations reveal that the leading causes which contributed to the degradation of the rangelands of the area of study summarize primarily in the following points:

(i) Overgrazing. An effective charge nine times higher than what the rangelands can support.

(ii) Clearings of the rangelands. The eradication of perennial plants, expose the already thin soils to wind and water erosion.

(iii) The drought. The effect of drought on the spontaneous vegetation can be multiplied if it is combined with the effect of overgrazing.

(iv) Poor policies of management of the steppe. Overexploitation and expansion of cereal crops on areas of rangelands are the result of ill policies applied in steppe region.

3. The fodder balance-sheet

The coefficients of conversion into UF selected are the following: Stubble: 300 UF/ha, Straw: 0.33 UF/kg, Barley in grains: 100 UF/Qx, Fodder crops: 1500 UF/ha (Boutonnet, 1989), and rangelands: 64.92 UF/ha on average (HCDS, 2010).

It should be noted that the production of the rangelands represents practically half of the total production of the area (49.57%) (Table2).

Table 2. Fodder availabilities in M'Sila region during 2011

Food sources	Surface (ha)	Production (Qx)	Production/ha	Fodder units (UF)	%
Fodder crops	19,600	-	1 500 UF/ha	29,400,000	19.65%
Rangelands	1,142,497	-	64.92 UF/ha	74,167,040	49.57%
Barley grains	-	240,000	100 UF/Qx	24,000,000	16.04%
Stubble	39,600	-	300 UF/ha	11,880,000	7.94%
Straw	-	308,000	33 UF/Qx	10,164,000	6.79%
Total	-	-	-	149,611,040	100%

In accordance to the steppe being regarded as "the country of the sheep", we note that 81.73% requirements are expressed by the ovine species (Table 3). The rest are divided among the other existing domestic herbivore.

Table 3. Livestock numbers and evaluation of their annual requirements in M'Sila region (DSA, 2011)

Animals category	Numbers (heads)	Requirements (UF)	Requirements in UF/ species (%)
Sheep	1,600,000	427,920,000	81.73%
Goat	140,000	26,352,000	5.03%
Cattle	26,800	64,665,120	12.35%
Camel	1,600	4,650,000	0.89%
Total	1,768,400	523,587,120	100%

The food availabilities of the study area cover only 28.57% of the requirements for the livestock of the wilaya (Table 4). The deficit, which rises to 373,976,080 UF or 71.43% of the requirements, needs to be filled by imported feeds. The insufficiency is partly due to the reduction in the fodder productivity of the rangelands as a result of overexploitation.

Table 4. Fodder balance-sheet (UF)

Animal requirements	Fodder availabilities	Deficit	Coverage rate
523,587,120	149,611,040	-373,976,080	28.57%

4- Strategy of exploitation and management of the steppe rangelands

Indeed, a practical and feasible step proves to be essential for similar study. It is in this direction that we recommend the strategy which follows and which takes account of three principal scenarios of management and planning and which are summarized mainly in:

A. Scenario one: Symbiosis between pastoral areas and agricultural middles

The axes of development in this direction can be drawn according to two concerns:

intensification of the fodder production and the valorisation of agricultural by-products. The improvement of the fodder production can be made through the associations “grass-leguminous species” (tare-oats, alfalfa-barley, etc). Also, a multitude of adapted fodder species to soil and climatic conditions of the area can be introduced. In addition, and to avoid the insufficiency and the irregularity of precipitations which experience the area, a rational and optimal use of existing water resources is very necessary. Furthermore, the valorisation of the straw proves to be paramount. The technique of straw treatment with urea proved a notable improvement on the food value of the straw: increase in UF and nitrogenous substances supplementation.

B. Scenario two: Natural regeneration of the rangelands

The technique of assisted natural regeneration in rangelands can be employed for a faster reconstitution of the vegetation. In other words, it is about the acceleration of the process of regeneration, by plowing in contour lines, which will increase the ground roughness and consequently effects in trapping the seeds, the organic residues and the rain waters. The combination of assisted natural regeneration and the prohibition of grazing is the best method to induce the increase of the natural vegetation of these degraded rangelands.

C. Scenario three: Rehabilitation of the rangelands by the pastoral species plantation

This technique is the recommended technique for the highly degraded areas, where vegetation cover cannot be regenerated by the previous described methods. Several indigenous and exotic species can be used, among which we can quote those having already given encouraging results, like the Atriplex genus (*Atriplex canescens, Atriplex halimus, Atriplex nummilaria*) and the *Medicago arbor*ea. However, trials of other pastoral species are also necessary.

IV – Conclusions

In front of this situation which endured the rangelands in the area of M’Sila, the projects of protection and management of the rangelands are essential. However, these measures alone are not enough; they must be accompanied by expansion and intensification of fodder crops and valorisation of agricultural by-products.

All in all, the success of the projects of management implies the implication of all the intervening actors in pastoral sector. The agro-pastoral management will not be durable, if it is not registered within a framework of development which touches the whole of the economic activities of the area.

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Multiple-benefits of Mediterranean grasslands: livestock and honeybee foraging values and pasture qualities

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Abstract. A long-term study was conducted to determine the multiple responses of pasture and livestock to different management systems in Mediterranean grassland. A grazing trial was set in the eastern Galilee, Israel, comprising two stocking densities (0.55 and 1.1 cows ha-1) and two protocols, continuous and split-paddock grazing. Growth dynamics, botanical composition, diversity and nutritional quality of the pasture were determined. Livestock production, foraging potential of honeybees and landscape visual qualities were defined as well. It was shown that intensive use of Mediterranean grassland with high stocking density during the growing season can be economically feasible. Species diversity was found to be remarkably stable across all grazing treatments. Lower relative growth rates under grazing were detected as heavier stocking density reduced standing biomass, but herbage quality increased along with grazing intensity. Cattle grazing did not decrease the forage potential of open landscapes for honeybees; some of the examined parameters even revealed positive effects. In addition to animal production, Mediterranean grasslands have significant landscape values that are becoming increasingly important, they provide a wide range of ecological services. The multiple benefits of these landscapes can justify the expense of necessary interventions that cannot be justified by any single benefit.

Keywords. Beef cattle, botanical composition, diversity, herbaceous biomass, honeybees.

Bénéfices multiples des prairies méditerranéennes : Valeurs fourragères et de butinage et qualités du pâturage pour bétail et abeilles mellifères

Résumé. *Une étude à long terme a été menée pour déterminer les réponses multiples du pâturage et du bétail à différents systèmes de gestion dans les prairies méditerranéennes. Un essai de pâturage a été conduit dans l'est de la Galilée, Israël, comprenant deux densités de chargement (0,55 et 1,1 vache ha^{-1}) et deux protocoles, pâturage continu et pâturage en parcelles divisées. La dynamique de croissance, la composition botanique, la diversité et la qualité nutritionnelle du pâturage ont été déterminées. La production du bétail, le potentiel de butinage des abeilles mellifères et les qualités visuelles du paysage ont également été définis. Il a été montré que l'usage intensif des prairies méditerranéennes avec une forte densité de chargement pendant la saison de croissance peut être économiquement faisable. La diversité des espèces s'est avérée remarquablement stable sur tous les traitements de pâturage. Des taux relativement faibles de croissance sous pâturage ont été détectés tandis qu'une densité de chargement lourde réduisait la biomasse sur pied, mais la qualité de l'herbage a augmenté en même temps que l'intensité de pâturage. Le pâturage des bovins n'a pas diminué le potentiel de butinage dans les paysages ouverts pour les abeilles mellifères ; certains des paramètres examinés ont même révélé des effets positifs. En plus de la production animale, les prairies méditerranéennes ont des valeurs paysagères significatives qui deviennent de plus en plus importantes, car elles fournissent une vaste gamme de services écologiques. Les multiples bénéfices de ces paysages peuvent justifier de dépenser pour des interventions nécessaires qui ne sont pas justifiables par un seul bénéfice pris isolément.*

Mots-clés. *Bovins à viande – Composition botanique – Diversité – Biomasse herbacée –* Abeille mellifère.

I – Introduction

Domestic livestock have been grazing Mediterranean ecosystems for at least 10,000 years. The millennia of human use for agriculture and pastoralism have shaped a highly heterogeneous "Mediterranean mosaic landscape" (Naveh, 1998). Traditional yearlong grazing, usually at high stocking rates, generated open vegetation, resilient to heavy grazing pressure and to fire (Perevolotsky and Seligman, 1998). In the past, in Israel, the open landscapes were mainly subjected to traditional heavy grazing of goats. At present, beef cattle husbandry has become the main alternative livestock-related use of these areas. Lately a comprehensive, multifunctional grazing system approach has been developed, which, in addition to meat production, economic and social aims, also considers ecological, cultural, recreational and political issues (Henkin, 2011).

Generally, Mediterranean grasslands are dominated by annuals (Seligman, 1996), they generate high levels of biodiversity and as a consequence a range of other environmental services (Bugalho and Abreu, 2008). Land management decisions regarding these ecosystems have led to changes in vegetation, which, in turn, result in changes in the multiple benefits that can be obtained from the land (Koniak and Noy-Meir, 2005). In Israel, open areas that are dominated by Mediterranean herbaceous vegetation are situated mainly in the eastern Galilee, and the southern Carmel. The control of grazing to enhance multiple-use of these areas is a challenge for landscape management. It was shown that structural criteria are an efficient and objective methodology for evaluating the effects of grazing on the recreational value of Mediterranean woodland mosaic landscapes (Henkin *et al*., 2007). Koniak and Noy-Meir (2005) suggested that the maximum potential contribution to picnicking value was found in herbaceous patches as in a relatively high tree formation.

A considerable fraction of Israel's natural open landscapes are used simultaneously as a source for feeding animals and for honeybee forage (Kaminer, 2011; Shapira, 2014). Since cattle grazing directly affect plant richness, abundance and composition, it also affects bee activity and honey yield during spring. Therefore, beekeepers are concerned that cattle grazing decreases the forage potential of flowers for bees, through its effect on plant diversity and abundance. The aim of this paper is to present ways by which grazing can be implemented in the context of the Mediterranean rangelands of Israel to enhance animal production, foraging potential, nature conservation, landscape visual qualities and the production of honeybees.

II – Materials and methods

The study was conducted at the Karei Deshe experimental farm, which is located in the eastern Galilee in the north-east of Israel (long. $35^0$35'E; lat. $32^0$55'N; altitude 60 - 250 m a.s.l.). The topography is hilly, covered with basaltic rocks. The area has a Mediterranean climate, characterized by wet, mild winters and hot, dry summers. The average seasonal rainfall is 560 mm, falling mostly in winter and spring with wide variation among years and months. The vegetation is a hemicryptophytic grassland dominated by *Hordeum bulbosum* L., *Echinops* spp., *Bituminaria bituminosa* L. and many annual species. The study area is based on a long-term grazing trial that was initiated in 1994 (Henkin *et al*., 2015) and maintained for more than 20 years, to cover a range of grazing scenarios. The study includes four main treatments: two stocking densities, moderate (1.8 ha. per cow) and high (0.9 ha. per cow) and two management protocols: continuous stocking and split paddock where each paddock was divided into two equal sub-paddocks for early and late grazing. The paddocks were stocked with medium-frame crossbred cows with about 20% blood from local eastern Mediterranean breeds. Supplementary feeding (poultry litter) was given as a source of nitrogen (N) at the end of the abundant dry pasture period and during the dry period in the summer.

Pasture utilization, supplementary feed consumed, live weight and conception rate of herds were measured. Standing biomass and plant composition were evaluated along permanent transects in all paddocks. In addition, plant and bee surveys were conducted in grazed paddocks and compared to those of adjacent ungrazed paddocks in three different geographic locations in Israel: Karei Deshe experimental station, Ramat Hanadiv and Lachish. In each site data were collected in 3-6 rounds of sampling during the green season.

III – Results and discussion

Animal production in Mediterranean rangelands is one of the most important economic uses of the landscape, but as for other multiple benefits beyond grazing, its direct and indirect effects on the environment could be both positive and negative. Under present-day conditions, grazing by cattle as a sole means of management will not always lead to the formation of landscape vegetation and/or composition that meets all the criteria for multiple uses of natural lands. This depends mainly on the initial vegetation formation and the grazing management applied in terms of density and timing. In the case of livestock production it was shown (Henkin *et al*., 2015) that on Mediterranean grassland, intensive use of the pasture, which included high stocking density during the growing season, can increase weaned live-weight per area unit with no discernible long-term damage to the pasture (Fig. 1). In addition, it was found that herbage quality was significantly higher in paddocks grazed continuously or early in the season and with the increasing of grazing intensity, since these practices ensured younger herbage and plant re-growth (Henkin *et al*., 2011). On the other hand, heavier stocking density reduced standing biomass at the end of the growing season (Henkin *et al*., 2015).

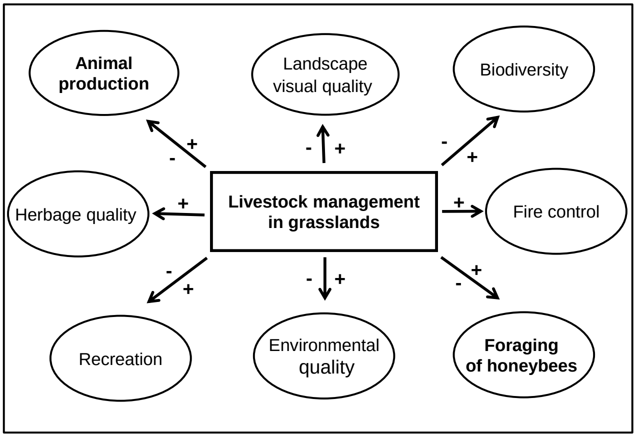

Fig 1. Multiple benefits and losses of Mediterranean grassland as a result of cattle grazing.

The main effects of grazing on the relative cover of plant functional groups were related to early *vs*. late seasonal grazing. A reduction in tall grass cover at higher stocking densities was found to be correlated with increased cover of less palatable groups such as annual and perennial thistles, as well as shorter and prostrate groups such as short annual grasses, but, species diversity and equitability were remarkably stable across all grazing treatments (Sternberg *et al*., 2015). Consequently, in two different studies, Kaminer (2011) and Shapira (2014) showed that honeybee forage activity of the grazed landscape is strongly correlated to floral abundance and especially to particular plant species phenology. Crucifers seemed to be important nectar suppliers and the flower abundance of only few nectar plant species decreased significantly after grazing; this is probably the result of the long evolutionary history of grazing known in this area. So, combining the result of both studies shows that overall, honeybee forage seemed to benefit from the grazing and mainly from the moderate grazing density.

In addition, (Divinski, personal communication) landscape visual qualities were determined by a questionnaire given to the public inquiring about their preferences. The answers showed that the control treatment, landscape with no grazing was selected as the most preferred. As for environmental quality, it was found (Noy-Meir and Oron, 2001) that conservation of the geophyte flora in Mediterranean vegetation required livestock grazing at moderate to high intensities in part of the area of each community and light or no grazing in other parts.

IV – Conclusions

In addition to animal production, Mediterranean grasslands have significant landscape values that are becoming increasingly important. They provide a wide range of ecological services. The multiple benefits of these landscapes can justify the expense of necessary interventions that cannot be justified by any single benefit. We conclude that if landscape values are taken into account when making management decisions relating to grazing systems, the overall benefits derived from the rangeland can be increased.

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Effects of grazing intensity on some morphological parameters of *Carpinus orientalis*

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Abstract. *Carpinus orientalis* is an essential woody forage source for small ruminants, especially goats, grazing during summer in Mediterranean region. However, grazing affects the morphology of woody species, and consequently, their growth. The aim of this study was to examine the effects of relative grazing intensity on some morphological parameters (maximum diameter, height, volume, leaf dry matter content, leaf area, and specific leaf area) of *Carpinus orientalis*. The research was conducted in an open canopy *Quercus frainetto* forest, in Evros region, north-eastern Greece and is grazed by goats. The distance from a goat corral was used to represent relative grazing intensity. In June 2015, morphological parameters were measured and leaf samples were collected along transects placed at 50, 150, 300, 600 and 1200 m from the goat corral, running perpendicular to four replicates. According to the results, grazing intensity significantly altered leaf traits, while light and moderate grazing seems to favour the growth characteristics of *Carpinus orientalis*.

Keywords. Oriental hornbeam – Shrubs – Silvopastoral system – Leaf traits – Growth.

Effets du pâturage intense sur certains paramètres morphologiques de **Carpinus orientalis**

Résumé. Carpinus orientalis *est une source de fourrage ligneux essentielle pour des petits ruminants, les chèvres en particulier, paissant pendant l'été dans la région méditerranéenne. Cependant, le pâturage affecte la morphologie des espèces ligneuses et par conséquent, leur croissance. Le but de cette recherche était l'examen des effets du pâturage relatif intense sur certains paramètres morphologiques (diamètre maximum, hauteur, volume, teneur en matière sèche des feuilles, surface foliaire, surface foliaire spécifique) de* Carpinus orientalis*. Cette recherche a été effectuée en plein air, dans la région d'Evros, au nord-est de la Grèce, dans une forêt avec voûte de feuillage de* Quercus frainetto *que l'on fait paître par des chèvres. La distance à un corral de chèvres a été utilisée pour présenter l'intensité relative de pâturage. En juin 2015, des paramètres morphologiques ont été mesurés et des échantillons ont été prélevés le long de transects se trouvant à 50, 150, 300, 600 et 1200 m du corral, perpendiculairement à quatre répétitions. Selon les résultats, l'intensité de pâture a changé considérablement les caractéristiques des feuilles, tandis que la pâture légère et modérée semble favoriser les caractéristiques de croissance de* Carpinus orientalis*.*

Mots-clés. Carpinus orientalis *– Arbrisseaux – Système sylvopastoral – Caractéristiques des feuilles – Croissance*.

I – Introduction

Although grazing is one of the fundamental interactions in ecology, its effect on vegetation spatial pattern has received little attention so far (Seifan and Kadmon, 2006). It is one of the most important drivers affecting morphology and physiology of plants and controlling structure and functioning of ecosystems (Zheng *et al.,* 2010). Furthermore, range management is based on the response of plant species and communities to grazing intensity. The identification of easily measured plant functional traits that consistently predict grazing response in a wide spectrum would be a major advance for sustainable range management (Diaz *et al.,* 2001).

Grazing by livestock can influence ecosystems in various ways, including altering plant communities as well as influencing woody plant growth and encroachment (Allred, 2012). Goat grazing in particular, has been widely blamed of causing environmental degradation, even though there is evidence that this activity is in harmony with local conditions of climate, terrain, vegetation, and even pathogens over centuries in many areas (García-Moreno *et al.*, 2012). Recent studies have focused mostly on leaf-level traits or community level weighted traits to predict species responses to grazing and the consequent change in ecosystem functioning (Zheng *et al*., 2010). These studies are of great importance for a sustainable grazing management of these ecosystems (Arévalo *et al*. 2011).

Carpinus orientalis Mill is a small tree or large shrub, rarely attaining 15 m in height. It is native of south-eastern Europe and western Asia. It occurs in Italy and Sicily, reaching its northern limit in Istria, Croatia, Slavonia, Banat and Transylvania and extending southwards through the Balkan States to FYROM and Greece (Elwes and Henry, 2007). It is widely distributed in the semi-mountainous regions of northern Greece and is browsed by goats (Papachristou *et al.*, 1999) as its foliage consists an essential source of protein for small ruminants during the dry Mediterranean summer (Papachristou, 1997). Nevertheless, the effects of grazing on its morphological parameters have not been studied in details.

The main objective of the present study was to examine the effects of relative grazing intensity on some morphological parameters (maximum diameter, height, volume, leaf area, specific leaf area and leaf dry matter content) of *Carpinus orientalis*.

II – Materials and methods

The research was conducted in the area of Pentalofos, which is located in Evros region, NE Greece. The oak forest of Pentalofos occupies a total area of 10199 ha. It mainly serves the needs of the local population for firewood while it is also used for livestock grazing. The dominant oak species are *Quercus frainetto, Quercus petraea*, *Quercus pubescens* and *Quercus cerris*. The spread of oak covers almost the entire area of the forest. Other common woody species include *Carpinus orientalis, Fraxinus ornus*, *Juniperus oxycedrus*, *Cornus mas*, *Tilia tomentosa*, *Phillyrea latifolia* and *Acer monspessulanum*. The climate of the area is classified as sub-Mediterranean, with cold, moist winters and warm, dry summers. The average maximum temperature which occurs in July is 30.5 ˚C and the average minimum which occurs in January is -7.0 ˚C. The annual precipitation is 539.5 mm. The study area is grazed mainly by goats.

The distance from a goat corral was used to represent relative grazing intensity. In June 2015, leaf samples of *Carpinus orientalis* were selected along transects of 20 m long running perpendicular to four replicates. The transects were placed at 50, 150, 300, 600 and 1200 m from the goat corral. These distances stand for very heavy, heavy, moderate, light and very light grazing respectively. Leaves were taken from five individual shrubs near the transect. Additionally, the height (H), the maximum (D1) and vertical diameter (D2) as well as the percentage of dead canopy of these shrubs were measured and the volume was calculated as $V= [\pi*(D1/2)*(D2/2)*H]/2$. Leaf samples were weighed hydrated (FWL) and dried (WL), while leaf area (LA) of dried leaves was measured using Image – Pro Plus 6.0. The specific leaf area (SLA) and leaf dry matter content (LDMC) were calculated as SLA = LA/WL, LDMC = WL/FWL.

One-way ANOVA was used to analyse the effect of grazing intensity on some morphological parameters of *Carpinus orientalis*. The LSD at the 0.05 probability level was used to detect the differences among means (Steel and Torrie 1980). The obtained data were analysed using the SPSS statistical software v. 17.0 (SPSS Inc. Chicago, IL, USA).

III – Results and discussion

Grazing intensity did not significantly affect maximum diameter, height, volume, and dead canopy percentage of *Carpinus orientalis* (Table 1). Plant height has been reported among the best single predictor of plants grazing response (Diaz *et al*., 2001). The fact that it was not affected by grazing intensity indicates that this species is tolerant to grazing. Moderate grazing tended to favor *Carpinus orientalis* growth, but these differences did not produce any significant results.

Table 1. Effect of goat grazing intensity on maximum diameter (D1), plant height (H), volume (V) and dead canopy (DC) of *Carpinus orientalis*

Distance from the corral (m)	D1 (cm)	H (cm)	V (m^3)	DC (%)
50	145.7 a	103.6 a	1.56 a	2.3 a
150	192.2 a	100.1 a	2.04 a	7.8 a
300	183.5 a	178.1 a	3.18 a	12.6 a
600	142.1 a	128.5 a	2.18 a	7.4 a
1200	156.4 a	110.1 a	1.62 a	1.1 a
Significance	*NS*	*NS*	*NS*	*NS*

*Means in the same column followed by the same letter are not significantly different (P≤0.05)

Leaf fresh weight (FWL), leaf dry weight (WL) and leaf dry matter content (LDMC) of *Carpinus orientalis* did not affected by grazing intensity (Table 2). Significantly lower LA (leaf area) was recorded at the distances close to the goat corral indicating that leaf area decreased gradually as grazing intensity increased. Hui and Guoqi (2014) supported that LA generally decreases with increasing grazing intensity as an avoidance strategy adopted by plants in order to decrease the palatability and selectivity by herbivores. Additionally, SLA (Specific leaf area) was significantly lower at the closest distance to the goat corral (Table 2), indicating that SLA decreased as grazing intensity increased. SLA is a comparatively poor predictor of grazing response (Diaz *et al.*, 2001). Moreover, the SLA, or more precisely the factors affecting the value of SLA, partly determines the response of a species in a specific habitat or a disturbance (Arendonk and Poorter, 1994).

Table 2. Effect of goat grazing intensity on leaf fresh weight (FWL), leaf dry weight (WL) leaf area (LA), specific leaf area (SLA) and leaf dry matter content (LDMC) of *Carpinus orientalis*

Distance from the corral (m)	FWL (gr)	WL (gr)	LA (cm^2)	SLA ($g^* cm^{-2}$)	LDMC ($m^*g^*g^{-1}$)
50	0.0244 a	0.0121 a	2.27 c	201 b	0.52 a
150	0.0212 a	0.0102 a	2.42 c	277 a	0.50 a
300	0.0247 a	0.0115 a	2.74 bc	261 ab	0.45 a
600	0.0244 a	0.0128 a	3.49 a	312 a	0.54 a
1200	0.0216 a	0.0110 a	3.39 ab	323 a	0.53 a
Significance	*NS*	*NS*	*0.66*	*62.5*	*NS*

*Means in the same column followed by the same letter are not significantly different (P≤0.05).

IV – Conclusions

Grazing intensity did not significantly affect most growth parameters of *Carpinus orientalis* indicating that this species has high tolerance to grazing. Heavy grazing reduced leaf area (LA) and specific leaf area (SLA). As moderate grazing had a minimal effect upon the analyzed parameters, it can be a viable way of managing ecosystem sustainability.

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Effect of drinking salt water on live weight change and grazing behavior of Barbarine sheep during pregnancy and lactation periods

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Abstract. This study had three objectives: (i) estimation of biomass availability of grassland, (ii) assessment of the effect of water salinity on feeding behavior and live weight change ofBarbarine sheep, and (iii) compare between their performance during pregnancy and lactation period. We used seventy lactating ewes, an average 5 years old, randomly assigned to two treatments consisting of water containing different levels of salt (treatment 1 = 0.5 g of NaCl /l of water, C-ewes;treatment 2= 10g NaCl / 1l of water, S-ewes). Pregnant or lactating stressed sheep decreased their body live weight during the 3thmonth of pregnancy and/or lactation. This effects was insignificant (*P*>0.05). However, drinking salt water increased body live weight only at the end of each physiological status (*P*<0.05). Feeding behavior was affected by period and the water salinity. During pregnancy and lactation periods, drinking salt water increased the time spending in searching for and consuming herbaceous vegetation.This is noteworthy that drinking salt water decreased the preference of pregnant ewe to graze.

Keywords. Grazing ewes – Behavior – Salt – Water.

Influence de la qualité de l'eau d'abreuvement sur le comportement alimentaire des brebis Barbarines des régions du centre-ouest tunisien selon les différentes phases physiologiques

Résumé. *Dans le but d'étudier l'effet d'un stress salin sur le comportement alimentaire selon les différentes phases physiologiques de brebis alimentées à base de pâturage des régions du centre-ouest tunisien, on a utilisé 70 brebis de la race Barbarine âgées de 5 ans. Les animaux ont été répartis de façon aléatoire en deux groupes et ont reçu soit de l'eau enrichie de sel (10 g NaCl / 1l d'eau) (S) soit de l'eau potable (0,5 g / l) (C) pendant la phase de gestation et de lactation. Le poids vif a varié en fonction de la qualité de l'eau d'abreuvement et de la phase physiologique (P<0,05). Le poids vif a diminué durant les trois premiers mois de gestation suite à l'abreuvement avec de l'eau saline. Après 90 jours, la salinité de l'eau a permis d'améliorer le poids vif des brebis gestantes. Durant la phase de lactation, la variation du poids vif a été indépendante de la qualité de l'eau d'abreuvement (P>0,05). Les brebis recevant de l'eau saline ont passé plus de temps à rechercher et consommer l'herbe durant la phase de gestation et moins de temps pour le pâturage durant la phase de lactation, que celles qui ont reçu de l'eau du robinet (P<0,01). Cependant, la salinité de l'eau n'a pas affecté la consommation d'eau et d'aliments indépendamment de la phase physiologique (P>0,05). Dans ces zones, le pâturage des ovins sur les halophytes ou l'abreuvement avec eau saline ont des avantages tactiques pour la gestion des ressources fourragères dans les exploitations agricoles.*

Mots-clés. *Sel – Brebis – Pâturage – Comportement – Consommation.*

I – Introduction

In the semi-arid zone of East Tunisia, livestock is predominately managed in traditional production systems.The feeding of sheep is based on the exploitation of rangeland resources, which aresubject to large quantitative and qualitative annual and interannual variations. The utilization of these resources for livestock production is based on the indigenous knowledge of farmers. The farmers have extensive knowledge of many of the interactions existing between animals and their environment, particularly those involved in grazing and shelter-seeking behavior (Komwihangilo *et al.,*2001). Unfortunately, most varietyof forage species may content high level of salt and secondary metabolites which can possibly affect the growth performance of sheep.

The objectives of this study were to compare the behaviour of sheep when grazing and browsing on natural pasture in a semi-arid zone during different physiological status in order to determine the effect of drinking salt water on water and food intakes.

II – Materials and methods

A total of seventy, five year old Barbarine sheep, weighing on average 45 kg, were held at the Livestock Research Centre of National Institute of Agronomic Research at Ouslatia, Tunisia. From the first day of pregnancy, sheep were divided in two groups: experimental sheep drink salt water (10g/l NaCl; S- sheep; n = 35) or control sheep drink fresh potable water, with normal content on salt (0.5g/l NaCl; C-sheep; n = 35). Sheep grazed pastures (about 15 ha of rangeland during the day and were kept in the barn during the night. A supplementation of barley grain and hay were distributed depending on the physiological status and needs.

Ten sampling quadrats (100cm x 100cm) were randomly set in each plot to estimate the biomass yield, according to Huang *et al.,* (2007). Animals were weighted monthly using a digital weighing balance.

During the end month of pregnancy and lactation period, we recorded the behaviour activities on course such as grazing, walking and resting by one observer per animal every 30 min.To determine feed and water intakes, sheep from each treatment were housed in individual boxes equipped with feed troughs and drinkers.

All the data were statistically analyzed using Proc Mixed Model of SAS (SAS, 2004) to examine the effect of treatment, period and interaction.

III - Results and discussion

The quantity, nutritive value and digestibility of available herbage varied significantly from late spring to autumn. It was reported by O’Reagain and McMeniman (2002) that selective grazing by ewes on rangelands can lead to large differences between quality of herbage ingested and of herbage offered. Selection for higher quality plants or plant parts is more pronounced and increased herbage quality with increased grazing intensity. Nutrient contents of pasture varied in general between leaves and twigs. Overall these edible parts are relatively high in dry matter and ash but low in nitrogen.

Sheep from the salt treatment showed an increase body weight between days 90 and 150 of pregnancy and a decrease body weight between days 30 and 90 of lactation compared to whose from control treatment (P <0.05; Fig. 1). Most grazing experiments with sheep on saltbush (*Atriplex*) reported an initial period of rapid weight gain, followed by slower gain and eventually weight loss (Parsons *et al.,* 2002). The rapid initial gain is mostly attributed to body water accumulation associated with the salt diet (Warren *et al.,*1995). Seynaeve *et al.* (2000) reported a weight loss was indifferent to the dietary salt levels during gestation and lactation of sows.

Sheep drinking salt water spent most of their time searching for and walking more than for consuming herbaceous vegetation (P <0.05) (Table 1). Feeding behaviour was affected by physiological status. Ben Salem *et al.* (2004) showed that supplementing kids in native scrubland with olive cake-based feed blocks or with a mixture of small amounts of *A. nummularia* L. foliage and cactus pads had no effect on their behaviour in the rangeland.

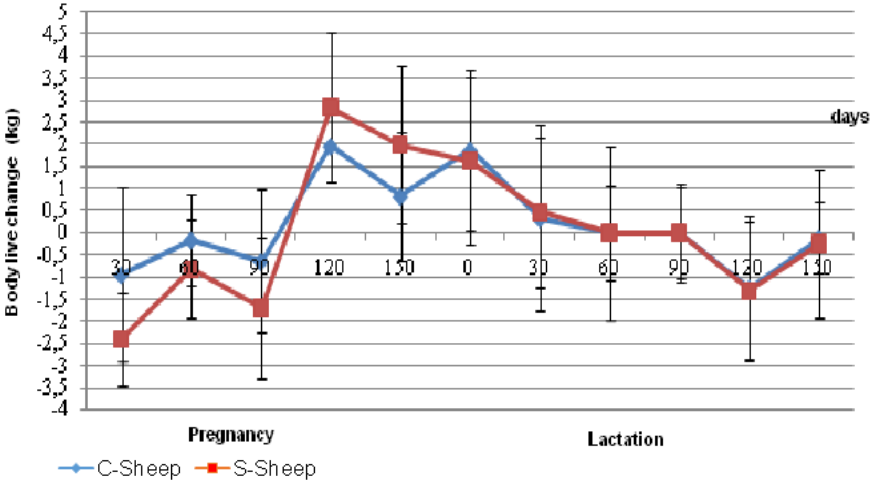

Fig. 1. Effect of drinking salt water on body live change during pregnancy and lactation periods.

Table 1. Effect of drinking salt water on feeding behaviour during pregnancy and lactation period

Behavioral activities	Physiological status	Water type		Average	Water	Period	Interaction
		F	HS				
Grazing time (%, TT)	Pregnancy	34.8	37.7	36.3	ns	*	ns
	Lactation	55.6	43.4	49.5			
Walking time (%TT)	Pregnancy	41.3	33.4	37.4	*	**	*
	Lactation	31.9	41.9	36.9			
Resting time (%TT)	Pregnancy	17.3	14.8	16.1	ns	ns	ns
	Lactation	12.4	14.6	13.5			

TT: total time; F: fresh water (0.5% NaCl); HS: salt water (10% NaCl); $*P<0.05$, $**P<0.01$.

No treatment effects were observed in water and food intakes neither on pregnant nor on lactating ewes (P >0.05) (Table 2). These results agree with other researchers who studied the effect of saline water in Argentinean sheep (Revelli *et al.*, 2005) and cattle (Bahman *et al.*, 1993). This trend is similar to reports on ewes fed *Sorghum stover* (Godwin and Williams, 1986) and Omani ewes fed non-conventional diets and *Rhodes grass* (Mahgoub *et al.,* 2008) and Omani ewes fed salt-tolerant sorghum (Al-Khalasi *et al.,* 2010).

IV – Conclusion

High salt consumption induces one major homeostatic response: a decrease in food intake on pasture marked by an increase in time spending in searching for and walking without any change in water intake and body weight.

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Table 2. Effect of drinking salt water on water and food intakes during pregnancy and lactation period

Parameters	Physiological status	Water type		Average	Water	Period	Interaction
		F	HS				
Water intake							
l/d	Pregnancy	5.76	5.43	5.60	ns	**	ns
	Lactation	3.94	3.95				
l/kg W 0.75	Pregnancy	0.34	0.32	0.33	ns	***	ns
	Lactation	0.093	0.13				
l/kg DM intake	Pregnancy	0.17	0.16	0.17	ns	***	*
	Lactation	1.52	1.53				
Feed intake							
Hay intake (kg DM/d)	Pregnancy	0.93	1.42	1.18	ns	ns	ns
	Lactation	1.98	1.88				
Concentrate intake (kg DM/d)	Pregnancy	0.45	0.57	0.51	ns	ns	ns
	Lactation	0.6	0.69				
Total (kg DM/d)	Pregnancy	1.37	2.00	1.69	ns	*	ns
	Lactation	2.58	2.57				
kg/kg $W^{0.75}$	Pregnancy	0.13	0.14	0.13	ns	ns	ns
	Lactation	0.062	0.063				

F: fresh water (0.5% NaCl); HS: salt water (10% NaCl); *P<0.05, ***P<0.001.

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Plant cover, floristic diversity and similarity of wet meadows grazed by free-ranging cattle in Axios Delta, Greece

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Abstract. Wet meadows constitute valuable habitats for the wild flora and fauna and important resource for extensive animal husbandry, despite their limited extent. The objective of this research was to study the plant cover, floristic diversity and similarity of wet meadows under the effect of grazing. The study area was located in Axios Delta, northern Greece which has been grazed by free-ranging cattle throughout the year. Five subareas were selected in a distance of 500 and 1400 m away from the cattle shed (indicating differences in grazing intensity) namely; 'riparian-1400m', 'central-500m', 'central-1400m', 'channel-500m', 'channel-1400m'. The riparian area received higher amount of freshwater compared to the channel and central areas. Measurements of cover and vegetation composition were performed in eight plots in each of the subareas. Differences between the five subareas were tested by means of one way ANOVA and LSD test. The subarea riparian-1400m presented the highest rates of plant cover and floristic diversity, mainly due to the high soil moisture and low grazing intensity. Plant cover tended to be increased away from the shed, probably because of the decrease of grazing intensity. The similarity index was higher in the drier central subareas with higher soil salt content owing to the halophytes dominance in them.

Keywords. Wet grasslands – *Tamarix* species – Halophytes – Cows – Riparian areas.

Couverture végétale, diversité floristique et similarité de prairies humides pâturées par des bovins en liberté dans le delta d'Axios, Grèce

Résumé. *Les prairies humides constituent des habitats précieux pour la flore et la faune sauvage ainsi qu'une ressource importante pour l'élevage extensif, en dépit de leur faible étendue. L'objectif de cette recherche était d'étudier la couverture végétale, la diversité floristique et la similarité des prairies humides sous l'effet du pâturage. La zone d'étude, située dans le delta d'Axios au nord de la Grèce, a été pâturée en liberté tout au long de l'année. Cinq sous-zones ont été sélectionnées à une distance de 500 et 1400 mètres de l'étable (indiquant une intensité de pâturage différente), appelées : « riveraine-1400m », « centrale-500m », « centrale-1400m », « canal-500m », « canal-1400m ». La zone riveraine a reçu la plus grande quantité d'eau douce par rapport aux zones canal et centrale. Les mesures de recouvrement et de composition de la végétation ont été réalisées en huit emplacements dans chacune des sous-zones. Les différences entre les cinq sous-zones ont été testées au moyen d'une analyse de variance ANOVA et du test de LSD. La sous-zone riveraine-1.400m a présenté les taux de couverture végétale et de diversité floristique les plus élevés, principalement en raison de la forte humidité du sol et la faible intensité du pâturage. La couverture végétale a eu tendance à augmenter avec l'éloignement de l'étable, probablement en raison de la diminution de l'intensité de pâturage. L'indice de similarité était plus élevé dans les sous-zones centrales sèches avec une teneur plus élevée en sel dans le sol en raison de la domination des halophytes dans ces zones.*

Mots-clés. *Prairies humides – Espèces de* Tamarix *– Halophytes – Vaches – Zones riveraines.*

I – Introduction

Wet meadows are covered by characteristic plant communities composed of species adapted to periodically flooded soils, either along the river flood zones or in lakeside zones. Despite their limited extent, they constitute valuable habitats for the wild flora and fauna and important resource for extensive animal husbandry. The grazing of free-ranging cattle is a traditional management practice suitable for wet meadows for several reasons such as the constant supply of freshwater, the high forage productivity even during the dry summer periods and flat terrains. These characteristics constitute wet meadows as ideal grazing lands for cattle. (Tsougrakis, 1995). Overgrazing is mentioned as a potential threat for the majority of Greek wetlands sites, indicating the need of constant monitoring of their conservation status (Papaporfyriou *et al*., 2014). The monitoring of the effect of grazing on wetlands could be achieved by a variety of measurements such as plant cover, floristic diversity and similarity indices (Tsougrakis, 1995; Buttolph and Coppock, 2004).

The objective of this research was to study the effect of grazing by free-ranging cattle on wet meadows by the use of the three above-mentioned parameters.

II – Materials and methods

The study area is located in Axios Delta, northern Greece and its altitude varies from -1m up to +2m a.s.l. The climate of the area is classified as semiarid with a mean annual air temperature of 14.7°C and a mean annual precipitation of 427.9 mm. It is covered by three vegetation (habitat) types of European Community interest (Council Directive 92/43/EEC): i) '1420 – Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)', ii) '1310 – *Salicornia* and other annuals colonising mud and sand' and iii) '92D0 – Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)'. The area is protected by Ramsar Convention of Wetlands (signed in Iran, 1971) thanks to its unique avifauna interest. The study area belongs to the National Park of Axios-Loudias-Aliakmonas Delta which was legislated by Joint Ministerial Decision in Greece in 2009. The study area has been grazed since 1930s when Axios Delta was created after the diversion of Axios River. Nowadays, this area is grazed by 200 free-ranging cattle all over the year.

Six subareas were selected in a distance of 500 and 1400 m away from the cattle shed namely; 'riparian-500m', 'riparian-1400m', 'central-500m', 'central-1400m', 'channel-500m', 'channel-1400m'. During the period of field data collection, it was impossible to obtain measurements in the subarea riparian-500m because that area was fenced. The riparian area (1400m) received higher amount of freshwater compared to the channel and the central areas. Measurements of cover and vegetation composition were performed in each of the subareas during June in 2015. Plant cover was recorded along each transect using the line-point method (Cook and Stubbendieck, 1986). Eight transects of 25 meters long were placed vertically along a measure tape of 50m every six meters, starting from 0m to 42m., The species abundance, the diversity indices of Shannon-Wiener, evenness, Berger-Parker and Simpson (Magurran, 1988) were estimated for each transect.

All data were analyzed statistically by using one way ANOVA in SPSS ver.20 (IBM Corp. Released 2011) concerning the plant cover and floristic diversity and PAST ver.3.0 (Hammer *et al*., 2001) concerning the Morisita similarity index (Morisita, 1959). The LSD test was applied to detect the differences among means at 0.05 level of significance (Steel and Torrie, 1980).

III – Results and discussion

Plant cover was found significantly higher only in the riparian-1400m subarea (Table 1). This finding may be attributed to the beneficial effect of freshwater and the high distance from the shed. In addition, plant cover tended to be higher, although not significantly, in all the distant from the shed subareas.

The floristic diversity indices (Table 1) presented their highest values in the riparian-1400m. More specifically, species abundance was found significantly higher in the riparian-1400m subarea compared to the central-500m and channel-1400m subareas, probably for the same reasons that cover was significantly higher in this subarea. Likewise, the Shannon-Wiener diversity and Berger-Parker index were found also significantly higher in the riparian-1400m in comparison with the central-500m and channel-1400m subareas. No significant differences were detected for the evenness index between the subareas. Simpson index was found increased in the riparian-1400m subarea, but this trend was statistically significant only in comparison to the channel-1400m subarea, probably because the latter was dominated by a small number of species.

Table 1. Mean values of plant cover, number of taxa and the diversity indices of Shannon-Wiener, evenness, Berger-Parker and Simpson in the studied subareas

Subareas	Plant Cover	Taxa (S)	Shannon - Wiener (H)	Evenness	Berger - Parker	Simpson 1/D
Central-500m	78.13b	8.06bc	1.40b	0.62a	0.54a	3.65a
Channel-500m	69.13b	9.25ab	1.75ab	0.65a	0.40b	4.08a
Riparian-1400m	92.44a	11.56a	1.92a	0.62a	0.35b	4.82a
Central-1400m	79.63b	9.00abc	1.64ab	0.60a	0.46b	3.72ab
Channel-1400m	79.38b	5.88c	0.92c	0.64a	0.70a	2.17b

Different letters in the same column indicate significant differences among the five subareas ($p \le 0.05$).

Morisita similarity index (Table 2), indicated high similarity (0,89) between the central subareas (central-500m and central-1400m). This could be attributed to the fact that these subareas represent the most extreme environments in the terms of soil dryness and salt content and for this reason are dominated by few stress-tolerant species. Furthermore, maybe the higher intensity of grazing in these subareas favors a homogenization of floristic composition. The central-500m subarea has been overgrazed for several years, especially during the early phenological stage of grasses and forbs which led to the dominance of halophytes. The central-1400m subarea is also dominated by halophytes but in this case, this may be attributed mostly to the higher salt content of soil. High similarity (0.83) was also found between the central-500m and channel-1400m subareas, possibly due to the presence of halophytes in the latter subarea, despite the dominance of *Tamarix* sp. shrubs.

Table 2. Values of Morisita similarity index between the studied subareas

Subareas	Central-500m	Channel-500m	Riparian-1400m	Central-1400m	Channel-1400m
Central-500m	1.00				
Channel-500m	0.33	1.00			
Riparian-1400m	0.28	0.54	1.00		
Central-1400m	0.89	0.18	0.21	1.00	
Channel-1400m	0.83	0.31	0.39	0.69	1.00

IV – Conclusions

Plant cover and diversity indices presented the highest values in the subarea riparian-1400m, mainly due to the high soil moisture and low grazing intensity. Plant cover tended to be increased away from the shed, probably owing to the decrease of grazing intensity. The similarity index was higher between the most extreme (dry soils and with high salt content) or highly grazed habitats because both factors have led to the dominance of few halophytes.

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Multipurpose plants in the Northern Libya rangeland area of Syrt

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Abstract. Urbanization and irrigation plans strongly implemented by the passed Gheddafi's government started the abandonment of rangeland in the northern part of Libya. Sedentarization also caused the loss of nomad traditions, including knowledge of wild forages, food and medicinal plants that could become new industries in the future after selection and analytical scientific investigation. A trial was carried out in 2009 in the Syrt rangeland just before the start of the war, in order to identify existing wild multipurpose plants and their traditional uses. The trial was managed thanks to agreements of The Italian Agronomic Institute for Overseas (Foreign Ministry), the University of Florence, and the University of Syrt (now destroyed). The results have shown the existence of a wide plant diversity and a good balance of the plants' specific contributions. The most common plants include wild grasses and legumes and few shrubs of the steppe vegetation. In spite of the traditions being lost, herders still know traditional uses of many plants, uses that have not been yet scientifically investigated. Further research would be needed as soon as new security conditions in the area will make them possible again.

Keywords. Multipurpose plants – Multifunctional rangeland.

Les plantes polyvalentes dans la zone de parcours de Syrte au nord de la Libye

Resumé. *L'urbanisation et les plans d'irrigation fortement mis en œuvre par le Gouvernement Kadhafi, avaient intensifié l'abandon de terres de parcours dans la partie nord de la Libye. Avec la sédentarisation des nomades les traditions ont été perdues, y compris la connaissance des plantes fourragères sauvages, des plantes vivrières et médicinales, qui pourraient devenir de nouvelles industries dans l'avenir après sélection et analyse des enquêtes scientifiques. Un essai a été réalisé en 2009 dans le parcours de Syrte juste avant le début de la guerre, afin d'identifier les plantes polyvalentes sauvages existantes et leurs utilisations traditionnelles. Le processus a été géré grâce aux accords de l'Institut Agronomique pour l'Outre-Mer (Ministère Italien des Affaires Étrangères), de l'Université de Florence et de l'Université de Syrte maintenant détruite. Les résultats ont montré l'existence d'une large diversité végétale et un bon équilibre de leur contribution spécifique. Les plantes les plus communes comprennent des herbes sauvages et des légumineuses et quelques arbustes de la végétation de steppe. Malgré la perte des traditions, les éleveurs connaissent encore des utilisations traditionnelles de nombreuses plantes, utilisations qui n'ont pas encore été étudiées scientifiquement. Des recherches supplémentaires seraient nécessaires dès que de nouvelles conditions de sécurité dans la région les rendront à nouveau possibles.*

Mots-clés. *Plantes polyvalentes – Parcours multifonctionnels.*

I – Introduction

The former Lybian Government have promoted sedentarization and strongly supported settled irrigated agriculture over 650,000 ha by the construction of the GMMR (*Great Man-Made River*) that was completed before the war of 2010 (Abdelrhem *et al*., 2008; Adrawi, 2009).

In the period before the rangeland had been overexploited and there was reduced productivity and biodiversity. Nonetheless animal rearing remains an important tradition and the reduced presence of livestock is a new opportunity for equilibrated grazing (Pardini *et al*., 2009). Equilibrated grazing is necessary mainly along the *wadis* (seasonal rivers), where livestock go to drink and consequently exploit the rangeland more often. The *wadis* are also important for the conservation of rare plant species that could be useful not only as forage but also for new industrial and pharmaceutical industries (Azaizeh *et al*., 2006).The research has been done thanks to the collaboration of University of Florence (School of Agriculture) and the Agronomic Institute for Overseas of the Italian Ministry of Foreign, and the Al Tahadi University of Syrt, with funds of the Italian Cooperation.

is a preliminary investigation of the rangeland *wadis* of Shabiyat of Misurata (Bani Walid) and Syrt (As-Sultan and Marsa al Uwayja) which represent the pre-desert environment.

II – Materials and methods

rangeland of Syrt have been investigated (Bani Walid, As Sultan, Marsa al Uwayja). Each of the three areas had three sub-areas. Each sub-area had one area that is normally grazed and one nearby area that is not t grazed, a total 18 sub-areas. However, the condition of grazed or ungrazed areas is not strictly respected because there are no fences. The following measurements have been done in each area and sub-area:

(i) *Botanical composition*. Linear analysis: three transects in each of the three sub-areas in grazed and ungrazed areas, a total of 54 transects.

(ii) *Biomass*. Grass mowing per 1 m^2 beside each transect. After mowing and weighing fresh, samples of 500 grams were oven dried and weighted again to calculate DM percentage.

(iii) *Forage value*. Interviews of shepherds and local technicians (palatability) and comparison with scientific literature (chemical composition and palatability). These two parameters have been used to classify plant species into quality classes from 0 (minimum quality) to 9.

(iv) *Traditional uses of the plants found*. Interviews of shepherds and experts from the University of Sirte. Comparison with scientific literature (El Hennawy, 1997; El Darier and El Mogaspi, 2009). We considered forage and alternative uses, mainly medicinal.

All data were collected in February and March 2009, in the short period with good climate. The values of both parameters decreased rapidly in the following months due to severe drought. The research was conducted near *wadis* (occasional rivers), where the soil remains moist longer and can sustain the vegetation better. Grazing animals are mainly mixed herds of sheep and goats, with small groups of dromedars.

III – Results and discussion

1. Botanical composition

In total 98 species have been found, belonging mainly to *Asteraceae* (18 species), *Leguminoseae* (13), *Graminaceae* (12), *Chenopodiaceae* (6), *Brassicaceae* (6), *Plantaginaceae* (5), *Lamiaceae* (4), *Polygonaceae* (3). Only few species had high contributions (Table 1).

A few plant species had important contributions. In Bani Walid there was mainly *Reatama raetam* (18.02% of the average of grazed and ungrazed areas), *and Periploca angustifolia* (10.93%. In As-Sultan there were *Hordeum murinum* (16.26%), *Plantago phaeostoma* (15.50%) and *Matricaria aurea* (11.28%). In Marsa Al Uwayja there was mainly *Diplotaxis muralis* (13.62%) and *Plantaqo phaeostoma* (12.57%).In these locations we found the highest biodiversity (33 species).

Table 1. Botanical composition of grazed and ungrazed *wadis* in the three areas investigated. Percentage of the four most frequent species

Area and species	Specific Contribution (%)		
	Grazed	Not grazed	Average
Bani Walid			
Retama raetam	22.54	13.50	18.02
Periploca angustifolia	7.36	14.50	10.93
Haplophyllum tuberculatum	15.97	1.57	8.77
Avena fatua	16.83	0.00	8.41
As-Sultan			
Hordeum murinum	3.70	28.82	16.26
Plantago phaestoma	5.14	25.86	15.50
Matricaria aurea	4.17	18.40	11.28
Malva parviflora	9.92	0.00	4.96
Marsa Al Uwayja			
Diplotaxis muralis	13.83	13.41	13.62
Plantago phaestoma	19.40	5.73	12.57
Matricaria aurea	14.30	5.68	9.99
Hordeum murinum	4.90	12.25	8.57

2. Biomass

average quantity of biomass measured (Table 2) was very low (2.14 t ha^{-1}), as it usually is in arid environments. The average quantity of biomass available in the best months in the three areas was much larger in the ungrazed areas (2.72 t ha^{-1}) than in those grazed (1.56 t ha^{-1}); this also confirms the assumption that in the three areas investigated an equilibrated stocking rate was beneficial to vegetation rehabilitation.

Table 2. Biomass in the three areas investigated. Data with different letters in columns are significantly different at P=0.05, ANOVA by Sistat

Area	Biomass DM t ha^{-1}		
	Grazed	Not Ungrazed	Average
Bani Walid	1.27 b	3.17 a	2.22 a
As-Sultan	1.24 b	1.46 b	1.35 b
Marsa al Uwayja	2.18 a	3.53 a	2.86 a
Average	1.56	2.72	2.14

3. Forage value

Almost all the species found were of low quality classes (from 0 to 3). Only 4 species were graded as high as 6 or more (*Avena fatua* = 6, *Lolium rigidum* = 7, *Medicago polymorpha* = 7, *Vicia villosa* = 8). Unfortunately, all the high quality species had very short life cycles and were already dry in spring. This classification of the vegetation according to quality classes reduced by 35 times the rangeland carrying capacity of the area that could be calculated by common formulas that consider only the presence of biomass and not its quality.

4. Multiple uses

We found 38 species that are considered good forage by locals (like *Frankenia hirsuta, F. laevis, Haloxylon salicornicum, Neurada procumbens).* Moreover, 19 species were considered useful medicines and more than half of the uses mentioned by locals have not been investigated scientifically so far. Among these plants, some are much appreciated by locals for haemorrhoids, hypertention, menstrual cycle, diuretic, intestinal gases and hypertension, cough. Other Twelve other plants are traditional foods (for example, seeds of *Avena fatua* and *Bromus rigidus,* leaves of *Cynara cardunculus).* to by local people included 24 species with uses not yet described by scientific literature.

IV – Conclusions

Only few species found contributed prominently to the biomass, but they have short life cycles. Efforts should be made to increase the presence of shrubs that remain green longer than grass.

Only few species were of good quality in terms of palatability and chemical composition. The best species had probably been eaten early and could not set seeds. A management practice with equilibrated stocking rates could bring to renewed distribution of the high quality species.

Local people have much knowledge of alternative uses of the plants of the rangeland, although scientific literature has not yet investigated many of these plants and their possible uses. Any possible efforts should be made to preserve the species that are useful to rural populations and may play a role in the future development of new industries.

Biomass quantity is extremely low, and even after restoring good conditions for the vegetation, it cannot rise much. Consequently some integrated uses of the rangeland should be taken into consideration, including honeybees and tourism. This will also enhance the integration of rural people within the whole national economy.

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Impact of different grazing intensities on rangelands soil characteristics in central Greece

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Abstract. Grazing is a crucial factor that influence soil characteristics and restrict some of its components. The purpose of this study was to investigate the effect of grazing of small ruminants on soil characteristics in Central Greece. Two rangelands were selected, one with heavy grazing (80%) and one with moderate grazing (40%). In each of the above experimental areas, soil samples were taken from two depths, 0–10 and 10–20 cm, for chemical analyses, pH, organic matter, macronutrients (N, P, K, Ca, Mg, Na) and micronutrients (Cu, Fe, Zn, Mn). According to the results, heavy grazing had no effect on organic carbon (C %),organic matter and the macronutrients N, P, K, although the concentrations of Na and Ca and Fe were decreased under the heavy grazing compared to the mediate one. The concentration of N and K was significantly higher at depth of 0-10 cm. Moreover, the micronutrients Fe and Zn were positively affected by soil depth, while Cu and Mn were not affected by grazing intensity or soil depth. Finally, soil pH had increased under heavy grazing.

Keywords. Small ruminants – Plant biomass – Soil – Organic matter – Nutrients.

Effet de différentes intensités de pâturage sur les caractéristiques du sol des parcours dans le centre de la Grèce.

***Résumé**. Le pâturage est un facteur crucial qui influence les caractéristiques du sol et limite certaines de ses composantes. Le but de cette étude est d'examiner l'effet du pâturage des petits ruminants sur les caractéristiques du sol des parcours en Grèce centrale. Deux parcours ont été choisis, l'un avec pâturage intensif (80%) et l'autre avec pâturage modéré (40%). Dans chacune des zones expérimentales ci-dessus mentionnées, des échantillons de sol ont été pris sur deux profondeurs, 0-10 et 10-20 cm, pour les analyses chimiques de pH, matière organique, macronutriments (P, K, Na, Ca, N, C) et micronutriments (Cu, Fe, Zn, Mn). Selon les résultats, le pâturage intensif n'a eu aucun effet sur le carbone organique, la matière organique et les macronutriments N, P, K, bien que les concentrations de Na, Ca et Fe aient diminué dans ce type de pâturage en comparaison avec le pâturage modéré. La concentration de N et K est significativement plus élevée dans la profondeur de 0-10 cm. En outre, les micronutriments Fe et Zn ont été positivement affectés par la profondeur du sol, alors que le Cu et le Mn n'ont pas été affectés par l'intensité de pâturage ou la profondeur du sol. Enfin, le pH du sol a augmenté sous le pâturage intensif.*

***Mots-clés.** Petits ruminants – Biomasse des plantes – Sol – Matière organique – Nutriments.*

I – Introduction

Grazing is recognized as an important ecological factor in rangelands which can affect soil attributes as well as ecosystem functions (Liebig *et al.,* 2006). Livestock influence soil properties through two main mechanisms: trampling compress the soil which increases bulk density (Warren *et al.,* 1986; Trimble and Mendel, 1995) and grazing decreases plant cover (Coughenour, 1991). However, when grazing is well managed, it can be valuable to the environment since it enhances nutrient cycling (Bilotta *et al.,* 2007). On the other hand, heavy grazing with improper management can lead to environmental degradation (Noellemeyer *et al.,*

2006) and soil erosion. The aim of this study was to evaluate the effect of different grazing intensities of small ruminants on two rangelands soil characteristics.

II – Materials and methods

The study was conducted in the village Rodia, prefecture of Larisa, Thessaly, central Greece on altitude of 140 m. The climate is continental semi-arid (Mavromatis, 1978) with a mean annual temperature of 14.73^{o}C and mean annual precipitation of 579 mm. The average maximum temperature is 25.6^{o}C and minimum is 6.1^{o}C. Most soils are clay loam, but there are some that are loamy or sandy loam or sandy (Municipality of Tirnavos, 2002). The area is mainly grazed by sheep and goats. Two rangelands with different vegetation composition and different grazing intensity were selected, one with heavy grazing (80%) and one with moderate grazing intensity (40%). Grazing intensity was determined from the forage utilization percentage (FUP), (Heady and Child, 1994). Thus, in each rangeland, two plots of 9 m^2 were fenced in the spring of 2013 in order to protect the vegetation from grazing. The difference among herbage yields of fenced and open plots was used to calculate the FUP.

Soil samples were taken from the two experimental areas during May of 2014. In each area, three samples were collected at 0–10 cm and 10–20 cm depth, respectively. All soil samples were air dried and sieved through 2 mm mesh screens. Particle size distribution of mineral soil was determined according to Bouyocos (1962) and the pH of the mineral soil was determined on a soil water suspension (1:1, by weight) using a glass electrode. Soil organic matter was determined by means of wet oxidation (Nelson and Sommers, 1982). Organic N was determined by the Kjeldahl method (Stevenson, 1982) and available P was extracted with 0.5N $NaHCO_3$ at pH 8.5 and measured spectophotometrically (Olsen and Sommers, 1982). Exchangeables Ca, Mg, K and Na were determined using the CH_3COONH_4 – pH 7 method (Grant, 1982).The extracted cations were then measured by atomic absorption spectophotometry and heavy metal concentration by the DTPA method (Lindsay and Norvell, 1978).

For all measured parameters, differences between the two grazing intensities and the two soil depths were calculated using two-ways ANOVA. All statistical analyses were performed using the Gen stat v.11application. The LSD at the 0.05 probability level was used to detect the differences among means (Steel and Torrie, 1980).

III – Results and discussion

The soil pH (across soil depth) was significantly higher for the site with heavy grazing intensity (Table 1). Increase of soil pH due to grazing was also found by Ruess and McNaughton (1987) in rangelands. The organic carbon (C %), organic matter, and concentration of N, P and K were not significantly ($p>0.05$) affected by grazing intensity (Table 1). This result is on line with that of Dahlgren *et al. (*1997) who founded that light to moderate grazing intensity had no effect on soil organic matter in a *Quercus douglasii* woodland. The concentration of macronutrients Ca, Mg and Na was significantly lower in the heavy grazed rangelands than in moderate grazed ones. The difference for Na concentration is probably due to the different exposure in relation to air currents starting from sea level (Papaioannou, 2015). Moreover, difference in Ca concentration maybe due to the bedrock. Similar result was found by Li *et al*. (2005) who reported that the amount of Na was significantly higher under moderate than heavy grazing. Cayley *et al.* (2002) and Fornara and du Toit (2008) had also found that Mg concentration in soil decreased under higher grazing intensity.

Table 1. Effect of grazing intensity and soil depth on pH, organic matter, carbon, and concentration of macro and micronutrients of the rangelands soil characteristics

	Treatments		Depth (cm)	
	Heavy grazing	**Moderate grazing**	**0-10**	**10-20**
pH	5.695a	5.442b	5.597a	5.54a
Organic carbon (%)	1.65a	2.13a	2.06a	1.72a
Organic matter (%)	2.84a	3.67a	3.55a	2.96a
P mg/100gr soil	1.69a	2.34a	2.54a	1.49a
Ca (cmol/kg)	5.59b	7.33a	6.61a	6.31a
K (cmol/kg)	0.366a	0.253a	0.391a	0.228b
Na (cmol/kg)	0.0882b	0.1269a	0.1042a	0.1109a
Mg (cmol/kg)	1.55b	2.165a	1.699a	2.016a
Fe (μg/gr)	29.8b	38a	37.6a	30.2b
Zn (μg/gr)	1.41a	1.39a	2.02a	0.79b
Cu (μg/gr)	0.68a	3.51a	2.46a	1.72a
Mn (μg/gr)	7.44a	11.03a	11.07a	7.4a

Means in the same row for the same parameter followed by the same letter are not significantly different ($P \geq 0.05$)

On the other hand, Parissi *et al.* (2014) found that grazing had no effect on Mg, Na and K of herbage production in a coppice *Quercus frainetto* forest. Concerning the micronutrients, there were no significant differences in the tested micronutrients expect for Fe which was significantly higher under moderate grazed rangelands than under heavy grazed. Similarly, in the same study, the authors found that grazing had no significant effect on the above micronutrients including Fe.

Soil pH, organic carbon (C%), organic matter and soil P were not significantly different between the two depths and across the grazing intensity (Table 1).The concentration of N and K was significantly higher at 0–10 cm. The highest concentration of N at 0–10 cm was probably due to the animal excrement and urine (Tamartash *et al.,* 2007). High K values in the topsoil of areas with heavy grazing are probably due to rapid decomposition and release of this component from the organic materials and thus the faster enrichment of mineral soil due to the greater mobility of this monovalent cation (Staaf and Olsson, 1994). As long as micronutrients are concerned there was no significant difference in the concentration of Cu and Mn in soil depth. On the contrary, concentrations of Fe and Zn were significantly higher for 0-10 cm depth probably due to small claims in mineralogical composition of bedrock.

IV – Conclusions

Heavy grazing by small ruminants impaired soil properties of rangelands and caused significant decrease in some of their components such as Ca, Mg, Na and Fe. Moreover, soil depth affected the concentrations of some macronutrients (N, K) and micronutrients like Zn and Fe as well. However, there was no effect of grazing intensity or soil depth on C% and organic matter.

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Comparison of quadrate and transect survey methods to evaluate pastoral value (PV) in SE Sardinian rangelands

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Abstract: Pastoral resources are considered economically less profitable and less valuable from the environmental point of view, when compared to forest resources. This underestimation is in contradiction with the new important services that are attributed to grazing resources. Natural or semi-natural rangelands, in addition to providing forage resources, similarly to forest resources, represent fundamental ecosystems for the maintenance of biodiversity. The present study reports a comparison of three survey methodologies used to determine the pastoral value of grassland plant communities, as well as their species composition and biodiversity value. The research aimed also to remark the importance of integrating different methodological approaches to provide effective tools for a sustainable management of grassland. Surveys to evaluate the plant communities were based on Daget-Poissonet (transect), Braun-Blanquet methodology (quadrate) and Argenti *et al*. (transect). According to our results there were significant differences between the three methods, with diverse accuracies in terms of the total number of recorded species and pastoral values.

Keywords. Pastoral value – Grassland management – Plant community.

Comparaison des méthodes des carrés et des transects pour évaluer la valeur pastorale (PV) dans des parcours au SE de la Sardaigne

Résumé. *Les ressources pastorales sont considérées en comparaison avec les ressources forestières, économiquement moins rentables et aussi moins importantes du point de vue environnemental. Cette sous-estimation est en contradiction avec les nouveaux et importants services qui sont attribués aux ressources pastorales. Les parcours naturels ou semi-naturels, en plus de fournir des ressources fourragères, similaires aux ressources forestières, représentent des écosystèmes fondamentaux pour le maintien de la biodiversité. L'étude présente une comparaison entre trois méthodes utilisées pour déterminer la valeur pastorale des pâturages naturels, ainsi que leur composition floristique et leur biodiversité. La recherche visait également à souligner l'importance d'intégrer différentes approches méthodologiques dans le but de fournir des outils efficaces pour la gestion durable des prairies. L'étude pour évaluer les communautés végétales a été basée sur les méthodologies de Daget-Poissonet (transect), Braun-Blanquet (carré), Argenti et al. (transect). Nos résultats montrent des différences significatives entre les trois méthodes, avec diverses précisions en termes de nombre total d'espèces enregistrées et valeurs pastorales.*

Mots-clés. *Valeur pastorale – Gestion des prairies – Communauté végétale.*

I – Introduction

Rangeland management must be supported by a deep knowledge of natural resources and by an accurate timing and level of grazing. It often happens that planning of pastoral and forestry resources use does not consider the characterization of forage resources. In particular, there is often a low interest on natural grasslands which disregards their value. This usually happens because the pastoral resources are considered economically less profitable and less important from an environmental point of view when compared to forest resources and because their evaluation is often carried out without the necessary pastoral knowledge (Sabatini *et al.*, 2001).

Argenti *et al.* (2006) proposed a simplified method for the assessment of pastoral resources, remarking that limited importance is often given to them due to the inadequate skills of forest technicians, as well as the need to reduce the effort of sampling procedures. This underestimation, however, is in contradiction with the renewed importance nowadays attributed to grazing resources. In fact, rangelands, in addition to the traditional role as forage resources providers, are fundamental ecosystems favouring the maintenance of biodiversity.

The quality of pastures might be influenced by a number of factors (e.g., seasonal availability and the palatability of plants, Hussain and Durrani, 2009) and change along seasons and environmental gradients. The attribution of a Specific Index to each plant of a given rangeland (i.e., species, subspecies or lower taxon), can be relevant for studies aimed at a preliminary evaluation of the rangelands productive potential.

The present study aims to compare three survey methodologies and to test their effectiveness in determining the pastoral value of grassland plant communities, as well as their species composition and biodiversity value.

II – Materials and methods

The research was carried out between May 2013 and July 2015 in the mountainous area of Ogliastra, located in central-eastern Sardinia (Italy) at an altitude ranging between 500 and 1,350 m a.s.l., on approximately 25,000 ha of land. The study focused on the rangelands included in the territories managed by the Sardinian Forest Agency (EFRS). These rangelands are also partly included within Sites of Community Importance (SCIs) and Special Protection Areas (SPAs) according to the Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. The vegetation is characterised by conifer plantations, meso-Mediterranean silicicolous maquis, Sardinian holm-oak forests, Sardinian supra-Mediterranean holm-oak forests, Mediterranean riparian elm forests, Southern and Sicilian Italian *Quercus pubescens* woods, Mediterranean xeric grasslands, evergreen oak matorral and Juniper matorral, according to the CORINE biotopes legend (1991) and to the Map of the Habitats of Sardinia (Camarda *et al.,* 2010). Plant specimens were collected, pressed, dried and identified; nomenclature follows Arrigoni (2006-2015). According to the traditional management, different kinds of animals (sheep, goats, pigs, cattle, horses, donkeys), commonly graze this area, throughout the year. Field surveys aiming to characterise the plant communities and the pastoral values (PV) were carried out according to three different survey methods:

(1) Daget-Poissonet method (DPM) (1969): on a linear transect of 25 m, species presence was recorded for 50 points, at a constant distance of 50 cm. The evaluation of the PV was based on the Specific Indices (SI) for forage plants (scale 0-5, according to Delpech, 1960) reported by Roggero *et al.* (2002) and on original SI assessed during the field surveys of the present research. Pastoral Value was calculated as : $PV= 0.2 \times (\Sigma CSP_i \times SI_i)$, where CSP_i is the Specific Contribution (%) of a single species *i* and SI_i is its Specific Index (Roggero *et al*. 2002; Cavallero *et al.* 2007), $CSP_i=(FSI_i/\Sigma FSI_i)x100$. CSP- indicates the Specific Contribution Species; FS_i - specific frequency; SI_i - Specific Index (from 0 to 5 according to Delpech, 1960).

(2) Minimal area method (MAM): this methodology follows Braun-Blanquet (1951), with some modifications. Three vegetation layers were considered (tree, shrub, and herbaceous layer). The plot size was determined by constructing a species-area curve. There were sampled nested plots in a homogeneous area starting from a minimum size of 50x50 cm and then doubling the area of the survey until reaching an asymptotic trend in the cumulative curve of species richness. The average plot size corresponding to the asymptotic trend was 16 m^2. For each species the cover was recorded according to the Braun-Blanquet scale, replaced by the average value per class (Tommaselli, 1956): r = 0,1; + = 2,5; 1 = 7,5; 2 = 17,5; 3 = 37,5; 4 = 62,5; 5 = 87,5. This was used to calculate the specific coverage coefficient (CRS) and then obtain the Specific Contribution (CSP_i) (Bagella, 2001). $CSP_i=(CRS_i/CRS_{tot})$ x100, where: CSR_i

= Specific Coverage coefficient for each *i* species; CSR_{tot} = Specific Coverage coefficient of the community; therefore PV- Pastoral Value, was calculated as: PV= 0.2 x (ΣCSP_i x SI_i), where CSP_i stands for the Specific Contribution (%) of a single species *i* and SI_i is its Specific Index (Roggero *et al*., 2002; Cavallero *et al.,* 2007).

(3) Pastoral simplified method (PSM) for pastures assessment (Argenti *et al.*, 2006): it is based on a 25 m linear transect, with 50 points at a constant distance of 50 cm. This method considers only a limited number of plant categories and one corresponding value for each of them, as follows: 1) Palatable Grasses (PG): 1.95; 2) Not Palatable Grasses (NPG): 0.00; 3) *Fabaceae* (Fa): 2.99; 4) Others (Ot): 0.29; 5) Thorny/Poisonous: (TP): 0.00; 6) Shrubs (Sh): 0.03.

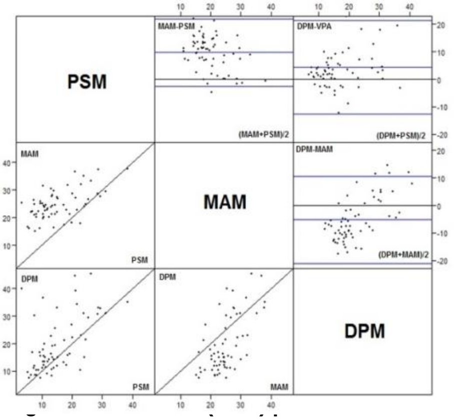
These three methods were applied on 64 plots, grazed by the end of May until the end of October, i.e. for about 150 days of grazing.

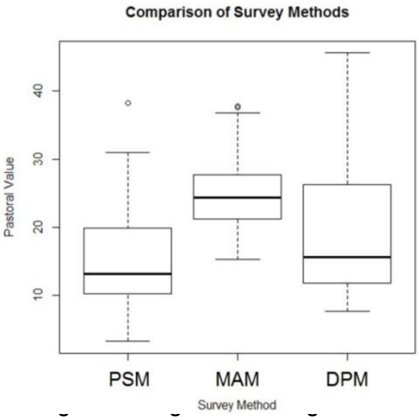
III – Results and discussion

Around 300 plant species were recorded in the 64 plots distributed in the study area, mainly *therophytes*, *hemicryptophytes* and *geophytes*, belonging to 49 Families, mainly to *Poaceae*, *Fabaceae* s.l. and *Asteraceae*, including many Sardinian or Sardinian-Corsican endemic species such as *Pancratium illyricum* L., *Plantago sarda* C. Presl, *Armeria sardoa* Spreng, *Paeonia morisii* (Viv.) Cesca, Bernardi et N. G. Passal, *Astragalus genargenteus* Moris, *Genista morisii* Colla and *Ptilostemon casabonae* (L.) Greuter. Each method has a different accuracy level when determining the PV and the total number of species. Pastoral Value ranged from 37.8 to 15.2 using the MAM, from 45.6 to 7.6 with the DPM and from 38.3 to 3.2 with the PSM. The three survey methods provided significantly different results (one way ANOVA, F value 24.26, p value 4.35 e^{-10}). Tukey multiple comparisons of means highlighted that the highest significant difference is found between the Pastoral simplified method (PSM) and the Minimal area method (MAM). This is certainly due to the very simplified categorisation of plant species used in the PSM. As the three different methods were applied to each single plot, we compared the PV resulting scores using Bland-Altman (B&A) plot (Fig.1) and Passing and Bablok (1983) regression (Fig.2) with the R package "MethComp" (Carstensen *et al*., 2015). The B&A plot is a simple way to evaluate a bias (mean difference) between two different quantitative assessments, estimating an agreement interval, within which 95% of the differences of the second method compared to the first one are included. This plot allows visualizing the intercept (α) as a measure of the systematic differences between the two methods and the slope (β) as a measure of the proportional differences. The 95% confidence interval for the intercept and for the slope can be used to test the hypothesis that $\alpha = 0$ and $\beta = 1$. These hypothesis can be accepted only if the confidence interval for α contains the value 0 and β contains the value 1. If the hypothesis is rejected α and β are significantly different from 0 and 1 respectively and both methods differ at least by a constant amount. The B&A plot only defines the intervals of agreements, it does not say whether those limits are acceptable or not.

IV – Conclusions

Rangelands provide fundamental provisioning and regulating ecosystem services such as the conservation of plant species diversity and forage resources. The results of the present research show that there are marked differences among the three assessed methods, in the evaluation of the pastoral value. The difference between the maximum and minimum values obtained with the phytosociological method is much lower than that obtained with the transect method where Specific Indices are used. This difference of the pastoral value becomes higher when species are grouped into a few classes. Therefore, the decision of using one of the three methods rather than the other should always take into account these differences and the purposes of the assessment.





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Livestock farming in Algerian semi-arid forests: the case of Boutaleb forest

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Abstract. Agriculture and livestock breeding have always existed in the forest of Boutaleb, Northeastern Algeria. A study was carried out in 2008, and aimed to collect data on agriculture and breeding systems to set up a development project. The study involved 116 farmers and dealt with households, production units and their relationships with the forest resources. The data collected was analyzed using multiple correspondence and hierarchical clustering methods. The average seasonal grazing period of small ruminants in the forest of Boutaleb is 6 months per year. The breeding was deemed a good way to enhance and take advantage of the region's silvopastoral resources. The typology has distinguished four farming systems: (1) Small and very extensive, (2) Small and moderately supported, (3) Medium-size and supported, (4) Large and relatively intensive. In addition, the study showed that 97% of farms are family-run and reserve 96% of their agricultural area for wheat and barley production for human and animal consumption to compensate for the lack of silvopastoral resources during the lean season. Subsequently, proposals to protect the environment and promote the synergy between silvopastoral resources and ruminant breeding were recommended.

Keywords. Algeria – Boutaleb semi-arid forest – Breeding systems – Silvopastoral resources use – Development project.

L'agriculture et l'élevage dans les forêts semi-arides algériennes – cas du massif forestier du Boutaleb

Résumé. *Le massif forestier du Boutaleb, situé au nord-est algérien, est marqué par la présence de l'agriculture et de l'élevage depuis toujours. La présente étude, menée en 2008 dans le cadre d'un projet d'aménagement, avait pour objectif de recueillir des données sur l'agriculture et l'élevage. 116 exploitations d'élevage ont été approchées à travers l'étude du ménage, les structures de production, la conduite des troupeaux et le rapport de l'élevage à la forêt. Les données collectées ont fait l'objet de typologie utilisant l'analyse des correspondances multiples suivie par la classification ascendante hiérarchique. La durée de séjour moyen des petits ruminants dans la forêt est de six mois par an, et l'objectif recherché est de valoriser le maximum de ressources sylvopastorales. Par ailleurs, l'étude a montré que 97 % des exploitations sont à caractère familial et réservent 96 % de la surface agricole aux cultures de blé et d'orge pour la consommation familiale et animale. Les animaux sont complémentés en périodes de manque de ressources sylvopastorales lors des périodes déficitaires. En outre, la typologie a permis de distinguer 4 systèmes d'élevage : (1) petits élevages strictement extensifs, (2) petits élevages moyennement soutenus (3) moyens élevages soutenus (4) grands élevages semi- intensifs. A la lumière de ces résultats, des propositions pour protéger les ressources de la forêt et promouvoir la synergie entre l'élevage et la forêt ont été dégagées.*

Mots-clés. *Algérie – Forêt semi-aride de Boutaleb – Systèmes d'élevage – Sylvopastoralisme – Projet d'aménagement.*

I – Introduction

In Algeria, forests cover 3.6 million ha and are an important environmental and socio-economic heritage (Naggar, 2000). In North-eastern part of Algeria, the forest of Boutaleb offers many ecosystem goods and services for the montanious community to create activities that allowed it to settle and provide benefits. Livestock, which is the most important economical activity of the community, transforms the unwanted silvopastoral vegetation into animal products, increase income of farmers and improve nutritional statut of farms.

The Boutaleb forest is disadvantaged because of its marginalisation and low level of productivity, as other mountainous areas. In order to sustain the forest, and due to the importance of its area (28,416 ha), Boutaleb benefited in 2008 of a development project. This research fits precisely within that framework and deals with livestock in the region through its socioeconomic and technical issues, and aims to identify the diversity of farms, understand the use of silvopastoral resources by livestocks, and suggest actions for enhancing the forest/breeding partnership to sustain the forest.

II – Study area and methodological approach

1. Study area

The forest of Boutaleb is located between the Setif high plains and the Hodna basin (Bertraneu, 1952), and constitute a link between them. It covers 28,416 ha and peaks at 1,890 m. The region's rainfall contrasts between years, and depends on the exposure; the rainfall varies from 550 to 600 mm / year on the North hillside, and can reach 754 mm high up, but receive only 312 mm/year on the South hillside. Extreme temperatures of the coldest and warmest month recorded averages of -2.3 ° C and + 32 ° C (Boudy, 1955). Hence, agriculture in this region is practiced in a disparate biophysical environment.

2. Methodological approach

A preliminary survey of different institutions (municipalities, agricultural services authority and its subdivisions) was conducted. The goal was to collect basic data on the population and its activities, particularly agriculture and livestock, in order to identify local trends. Then, 116 livestock farms, spread across the silvopastoral dedicated areas identified in the first phase were randomly investigated. The investigation was conducted in one single visit and took 30 to 60 minutes per farm.

To start with, we carried out a descriptive analysis to summarize the farms' characteristics. Then a Multiple Correspondence Analysis (MCA) followed by a hierarchical clustering (HCA), were carried out to create typologies. We selected eleven variables related to the farm's structural aspects (livestock species and numbers), functional aspects (food, reproduction) as well as those related to the use of the silvopastoral vegetation.

III – Results and discussion

1. General description

Descriptive analysis showed that the average of the total cultivated area per farm is 5 ha, of which 96% is allocated to the cultivation of cereals for human consumption (wheat) and animal feed (barley and oats), while vegetable and tobacco crops take place in farms with water resources. The study also showed that small family farms represent 97% and do not use hired labor.

Livestock in the forest of Boutaleb is silvopastoral and low input oriented; farmers involve mainly small ruminants, which are from local breeds, hardy and well adapted to their environment. Flocks, as in the other southern Mediterranean regions, are largely run by small farmers, unorganized and are not receiving supervision (Naggar, 2000). Sheep farming is present at 99% of farms, due to high demand of market for its meat, which is traditionally the most appreciated by the North African population (Rondia, 2006). It is reared alone (25%), or in mixture; with goat (44%), with cattle (16%) or with both (15%). Cattle breeding are more present on the north side areas since they provide more food resources than the south side, thanks to a higher rainfall. Herds' size per farm is often limited (2 cows), which are kept to provide milk for the household while calves are raised and fattened to allow additional incomes. Cattle are fed with products from agricultural activity, and concentrates purchased on the market, but do not utilize forest resources. Consequently, analysis of livestock systems has taken into consideration only small ruminants livestock.

2. Livestock systems

The analysis of small ruminants breeding systems allows distinguishing four different systems, ranging from most extensive to more sustained (Table 1):

Table1. Main features of the 4 livestock systems

		Type1 (36%)	Type2 (28%)	Type3 (16%)	Type4 (20%)
Numbers	Sheep	<25	25 to 50	25 to 50	50 to 400
	Goats	<10	Variable	> 22	Variable
	Cattle		Absent		Present
Period of grazing forest vegetation (number of months)		5 to 6 (autumn + winter)	2 to 3 (winter)	5 to 6 (autumn + winter)	5 to 6 (autumn + winter)
Nature and level of feed supplementation		Enough roughage and little or no concentrate	Average amounts of straw and wheat bran	small amounts of straw and wheat bran	Average amounts of hayn, straw and enough concentrate
Period of feed supplementation		Period of bad weather	Lack of silvopastoral resources and periods of bad weather		Lack of silvopastoral resources, bad weather, critical physiological stages
Purpose of feed supplementation		Ensure the animals' survival	Compensate for grazing	Compensate for grazing	Ensure the herd's good performance
Period of presence of rams in the herd		Reproduction period	Reproduction period	Reproduction period	Permanent
Lambing period		Late (end autumn, winter)	Late (end autumn)	Peak season (mid-autumn)	Peak season (mid-autumn)
Type of product		Lean	Lean	Lean, fattened	Lean, fattened
Selling period		As needed	As needed, summer	As needed, Aïd El Kebir religious Festival	As needed, Aïd El Kebir religious Festival

- **Small extensive pastoral sheep and goat farms.** Breeders in this group rely for feeding their livestock on grazing, especially the silvopastoral resources, which provides the dominant part of the flock feeding during the year; the majority of breeders give occasionally concentrate as feed complementation, except when survivability of animals is a challenge. Feeding practices lead to late lambing towards the end of autumn or even winter. Animal products are sold without fattening, to earn some cash for the household's daily needs.
- **Moderately sustained pastoral livestock with sheep and goat.** It involves herds of less than fifty heads of different sizes. These herds graze in the forest for a shorter period than the first group. In this group the distribution of concentrated supplements is substantial, leading to earlier births, when compared to the first group. Products are sold without fattening, but are sometimes wholesaled in the summer, after grazing during the period of pastoral resources availability.
- **Sustained pastoral farms.** In this group, farms have sheep flocks of fewer than 50 heads and rather big goat herds, more than 22 heads, when compared to the other groups. In addition to grazing for a long part of the year, these herds benefit from feed supplements (concentrate and cereal stubbles), but less than the previous group. After the period of

grazing, marketable products are submitted to a fattening period of 2 to 3 months before being sold during the religious festival of Eid-el-Kebir. Despite a lower supplementation than for the previous group, the lambing takes place early, in mid-autumn, probably due to the quality of pastoral resources and their impact on body condition and reproduction of flocks.

- **Supported and diversified large farms** They are found only in the northern part of the forest. Farmers own large sheep flocks, the size can be up to 400 heads, merged with goat herds of different sizes. Farms possess also cattle and other species (beekeeping, poultry). This group practice a diversified agriculture (cereals, fodder, vegetables and tobacco) too, which provides food and additional incomes to ensure more security to the house hold, and permit also the development of the production system. The animals intended for slaughter are subject to a longer and more intensive fattening period than the previous groups.

IV – Conclusion

The results of our study emphasize the importance of pastoral resources of Boutaleb forest for the security and sustainability of livestock systems of farmers settling in the forest and at its border. The diversity of breeding systems depends on the presence of agriculture and the silvopastoral potential of the forest, which led and driven the objectives and the strategy of the farm. The diversity in livestock systems leads also to a diversity of product (meat) on the market at different periods of the year.

As part of this management project, development actions should consider the local community and their activities, specially agriculture and animal breeding with an emphasis on their diversity, as the focal points. In addition, seeing that feed is a limiting factor for livestock development in Boutaleb region, especially in small farms, we suggest, as principal actions, the multiplication of water-points in order to develop irrigation of fodder crops. The management plan of forest areas should also contribute to limit and protect them against fires, while offering more silvopastoral feed resources to local community, by integrating and organizing the grazing activity. This silvopastoral management plan will be a vital and important action to sustain the forest vegetation and improve silvopastoral resources.

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The impact of transhumance abandonment on land use changes in Mount Pindos (Greece)

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Abstract. Transhumance was one of the main income sources for the inhabitants of Avdella village in Mount Pindos, until a few decades ago. This land use management created a mosaic of different ecological habitats. However, due to urbanization and technology evolution, transhumance was reduced, leading to significant changes for the mountainous grasslands. The purpose of this paper was to determine the changes in vegetation during the period 1983-2003, using landscape metrics. Metrics were calculated with Patch Analyst (ArcGIS) in order to assess human impact on biodiversity and landscape characteristics. The analysis showed that changes in land cover during 1983-2003 were the result of transhumance decline and the abandonment of intensive human activities. Landscape metrics indicated expansion of forests and shrublands and reduction of grasslands due to the reduction of grazing animals. The landscape in Avdella tends to become more fragmented and land use patch distribution more uneven. Landscape metrics imprinted in detail the change of the landscape during the period of investigation.

Keywords. Landscape metrics – Geographical Information Systems (GIS) – Grazing animals.

L'impact de l'abandon de la transhumance sur l'utilisation des sols dans les montagnes de Pindos (Grèce)

Résumé. *La transhumance était l'une des principales sources de revenus pour les habitants du village de Avdella au Mont Pindos, il y a quelques décennies. Cette gestion de l'utilisation des terres a créé une mosaïque de différents habitats écologiques. Cependant, en raison de l'urbanisation et de l'évolution technologique, la transhumance a été réduite, ce qui conduit à des changements importants pour les prairies de montagne. Le but de cette étude était de déterminer les changements dans la végétation de 1983 à 2003, en utilisant des indicateurs paysagers. Des métriques ont été calculées avec Patch Analyst (ArcGIS) afin d'évaluer l'impact humain sur la biodiversité et les caractéristiques du paysage. L'analyse a montré que la baisse de la transhumance et l'abandon des activités humaines intensives, de 1983 à 2003, ont eu comme résultat les changements de la couverture terrestre. Les métriques paysagères ont indiqué une expansion des forêts et de la végétation arbustive et une baisse des pâturages en raison de la diminution des animaux de pâturage. Le paysage de Avdella tend à devenir plus fragmenté et la distribution d'utilisation des terres plus inégale. Les métriques paysagères ont imprimé en détail le changement du paysage au cours de la période d'enquête.*

Mots-clés. *Métriques paysagères – Systèmes d'Information Géographique (SIG) – Animaux au pâturage.*

I – Introduction

Transhumance is the vertical movement of livestock farmers with their animals from mountainous to lowland grasslands during winter and vice versa, during summer (Susmel *et al.*, 2004). It has created many habitats with special characteristics in the Mediterranean region (Grove *et al.*, 1993). Transhumance on Mts Pindos formed a diverse mosaic of land uses and provided habitat for various species of plants and animals, thus having an impact on ecological functions and biodiversity (Ispikoudis, 2004).

During the last decades, the grasslands of Greece have changed profoundly due to urbanization, technological advancement and different management policies in combination with climate change (Karatassiou *et al.*, 2014). Moreover, transhumance is gradually replaced by semi-extensive livestock farming where animals graze around the sheds (Sidiropoulou *et al.*, 2015). As a result, many landscape changes occurred and the abandoned grasslands continue their ecological succession to climax communities (Vrahnakis *et al.*, 2005).

Landscape metrics are a set of structural parameters which are used to estimate the interactions between landscape spatial configuration and ecological processes (Turner, 1990). Spatial configuration refers to the spatial character and arrangement, position, or orientation of patches, e.g. the basic units of the landscape which are defined as relatively homogeneous areas that differ from their surroundings (McCarigal and Marks, 1995).

Landscape metrics were used in the present research in order to determine changes in land use/cover caused by pastoralism abandonment in Avdella village on Mount Pindos during the period 1983-2003.

II – Materials and methods

The study area is Avdella village, 40°01′ N 21°07′ E, at 1300 m asl altitude, located on Mount Pindos in North-West Greece and Avdella covers 4,345 ha. The vegetation zone is Vaccinio-Picetalia, and many rare species of flora and fauna occur in the area. In Avdella village, livestock farmers used grasslands for animal grazing from spring until late summer and in autumn they moved towards the Thessalian plain.

The land use/cover map of 1983 was based on aerial photographs from the National Cadastre and Mapping Agency S.A. (NCMA S.A., 1945) (scale 1:5000). The land use/cover map of 2003 was based on satellite images from Google Earth™ 6.0. Data were imported in ArcGIS ™ 9.3.1 (ESRI, 2011) and the following landscape metrics were calculated, using Patch Analyst Extension (McCarigal and Marks, 1995): a) Patch density, size and variability metrics: Number of patches (NumP), Mean patch size (MPS), b) Edge metrics: Edge density (ED) c) Shape metrics: Mean shape index (MSI) and d) Diversity metrics: Shannon’s diversity index (SDI), Shannon’s evenness index (SEI).

The number of grazing animals and the population of the village were retrieved from the Hellenic Statistical Authority (H.S.A, 1978; 1998). There are no statistical data about the number of grazing animals for 1981, thus, the data from 1971 were used.

III –Results and discussion

Silvopastoral systems, forests and shrublands increased by 0.94%, 4.78% and 0.69% respectively around Avdella village, while grassland decreased by 6.72% (Fig. 1). These land use changes were the result of demographic and agricultural evolution of the area. The village of Avdella never had permanent residents, with the exception of two or three families.

Livestock farmers moved to the Thessalian plain during winter and returned to the village in the summer. Although traditional transhumance still exists, the number of grazing animals, mainly sheep and goats, has decreased significantly (Table 1). The increase in cattle number has small impact on the landscape since they are mostly for dairy production and rarely graze outdoors. This gradual abandonment of transhumance, therefore the decrease of sheep and goats, combined with the relocation of many villagers to urban areas led to the undergrazing of grasslands. Conclusively, shrubs invaded grasslands and forest and silvopastoral systems increased (Mitka, 2009).

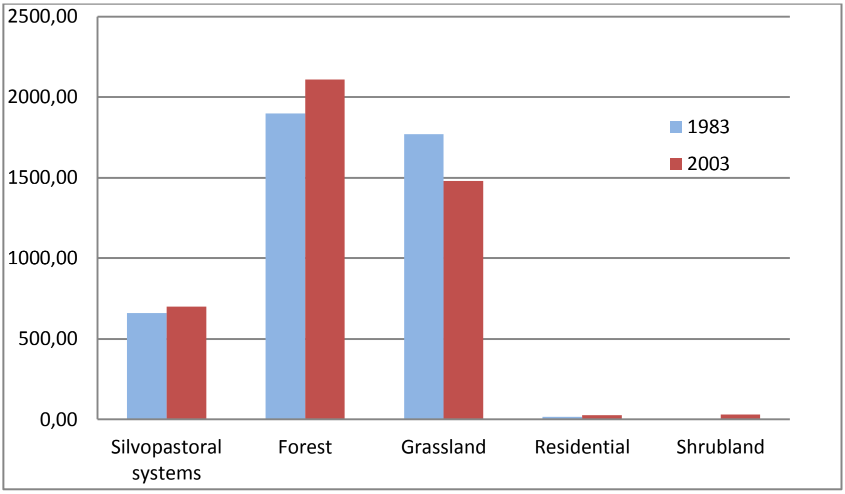

Fig. 1. Land use/cover changes in Avdella between 1983-2003.

Table 1. Livestock in Avdella village (Hellenic Statistical Authority, 1978).

Years	Cattle	Sheep	Goats
1971	14	12,061	3,291
2010	228	4,879	200

The increase in number of patches (NumP) suggests the breaking of vegetation areas into smaller parcels and in combination with the decrease of mean patch size (MPS) indicate an increase in landscape fragmentation (Table 2) (Sidiropoulou, 2011). Shannon's diversity index (SDI) remains almost the same, therefore landscape diversity is maintained (Caballero *et al.*, 2009). Shannon's evenness index (SEI) however decreases, resulting to a more uneven distribution of land use patches. Mean shape index (MSI) values indicate a decrease of patch shape complexity, which is an eminent result of the reduction of grazing animals (Mitka, 2009).

Table 2. Changes in landscape metrics, as calculated by Patch Analyst

Landscape Metrics	1983	2003
NumP	64,00	78,00
SDI	1,03	1,07
SEI	0,74	0,66
MSI	1,93	1,72
ED	76,31	78,22
MPS	67,89	55,71

IV – Conclusions

The present study showed that the landscape of Avdella village became more fragmented, as a result of transhumance abandonment. Without the intense human presence and with decreased grazing intensity, grasslands continued their ecological succession to shrublands. Forests and silvopastoral systems also increased but the distribution of land use types became more uneven. Landscape metrics provided useful insights on land use changes in Avdella during 1983-2003 and can be used as an effective manner of monitoring landscape fragmentation and diversity.

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Grazing effects on mountain rangeland diversity in north-eastern Tunisia

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Abstract. Although the effects of controlled grazing, heavy grazing and no grazing on vegetation structure have been extensively studied in a wide range of ecosystems, the effects of grazing on mountain lands are still largely unknown in Tunisia. Two areas traditionally grazed by sheep and goats in northeastern Tunisia (continuously grazed and controlled grazing) and an ungrazed area were sampled to evaluate the effects of grazing intensity on mountain rangelands. We examined the respective effects of heavy grazing, controlled grazing and no grazing on total vegetation cover, species richness and the Shannon-Wiener diversity index. Sampling was done from 2009 using permanent transects under different grazing intensities. Results show that vegetation dynamics in mountain rangelands respond strongly to changes in grazing management. The controlled grazing impact maintains resilient rangelands and ensures a sustainable flow of rangeland goods and services to livestock. The resting periods in the controlled grazing allow plants to recover before they are grazed again. The vegetation cover, species richness, Shannon-Wiener diversity index and species composition were significantly greater on the un-grazed site and significantly lower on the heavily grazed site.

Keywords. Mountain rangelands – Grassing pressure – Richness – Diversity.

L'effet du pâturage sur la diversité des parcours dans la montagne du nord de la Tunisie

Résumé. Bien que les effets du pâturage contrôlé, intensif et du non pâturage sur la structure de la végétation aient été largement étudiés dans les différents types d'écosystèmes, les effets du pâturage sur les terres de montagne sont encore inconnus en Tunisie. Deux zones traditionnellement pâturées par les moutons et les chèvres, dans le nord de la Tunisie (en pâturage intensif et pâturage contrôlé) et une zone non pâturée ont été échantillonnées pour évaluer les effets de l'intensité du pâturage sur les différents parcours. Nous avons examiné les effets du pâturage intensif, du pâturage contrôlé et du non pâturage sur le couvert végétal, la richesse en espèces et l'indice de diversité de Shannon-Wiener. L'étude a été faite pendant l'année 2009 en utilisant des transects permanents dans les différents systèmes de pâturage. Les résultats montrent que la dynamique de végétation dans le parcours en montagne réagit fortement aux changements du système du pâturage. L'impact du pâturage contrôlé permet de maintenir les parcours résilients et d'assurer la durabilité des parcours afin d'améliorer les biens et services à l'élevage. Les périodes de repos en pâturage contrôlé permettent aux plantes de récupérer avant qu'elles soient pâturées à nouveau. Le couvert végétal, la richesse en espèces, l'indice de diversité de Shannon-Wiener et la composition floristique du parcours étaient significativement plus élevés sur le site non pâturé et le site de pâturage contrôlé et significativement très faible sur le site pâturé d'une manière intensive.

***Mots-clés.** Parcours de montagne – Pression de pâturage – Richesse – Diversité.*

I – Introduction

In Tunisia, the northern rangelands are largely depopulated because many pastoralists have opted for livelihood opportunities in other sectors of the economy. Heavy grazing has been reported to reduce the diversity of herbs and shrubs in the range land (Zhao *et al.,* 2006), and while some species have disappeared, others have survived through the use of morphological or other adaptations (Wang *et al.,* 2002). Moderate grazing can be effective in promoting greater diversity in vegetation (Holechek, 1991). Species richness and diversity tended to decrease with increased grazing pressure, but the difference was not significant between ungrazed and moderately grazed rangelands (Gamoun, 2014b). One of the objectives of this work was to evaluate the influence of rangeland utilization and management practices on plant communities. For this purpose, the three systems of heavy grazing, controlled grazing and ungrazed treatment were instituted to evaluate the effect of grazing intensity on plant communities in the mountain rangelands in northeastern Tunisia.

II – Materials and methods

The study was carried out on the mountain rangelands of El Haouaria, which is a coastal ecosystem located in the peninsula of Cap Bon, in the eastern part of Tunisia. This mountain has an average altitude of 390 m above sea level and has a sub-humid Mediterranean climate.

Two areas traditionally grazed by sheep and goats, one continuously grazed and one with controlled grazing, and one ungrazed area were sampled to evaluate the effects of grazing intensity on mountain rangelands. The vegetation measurements presented here were taken in spring 2009. Three parameters related to vegetation were analyzed in each area: (1) plant cover; (2) diversity; (3) species richness. In each measurement, the vegetation was surveyed using the permanent transect method (Daget and Poissonet, 1971). The Shannon's index of diversity H' (Shannon, 1948) is calculated from centesimal frequencies of species:

$H' = - \Sigma((f_i / N) * \log_2(f_i / N))$;

with f_i: the number of i species in the samples, and N: the overall number of species.

Effects of grazing intensity on cover and plant diversity were analyzed by one-way ANOVA, within an experimental error of 0.05. All data analyses were conducted using SPSS software. Accordingly, the chosen methods were Correspondence Analysis (CA) and Cluster Analysis (HA).

III – Results and discussion

1. Results

A total of 57 species were recorded from the study site, respectively 12 species in continuously grazed areas, 48 species in controlled grazing areas and 52 in the ungrazed area. Species richness in ungrazed and grazed rangelands manifested a significant difference ($P < 0.001$). In the continuously grazed area the perennial species richness was of about 12 species, but there were about 16 species in the controlled grazing area and 24 species in the ungrazed area.

The continuous grazing negatively affects vegetation cover and highly desirable species and promotes the appearance of dominant species not appreciated by livestock. Results showed that grazing intensity significantly altered total vegetation cover ($F=164.730$, $P< 0.001$). Vegetation cover increased significantly on the ungrazed site (68.9 %). In contrast, vegetation cover decreased significantly in the heavily grazed or continuously grazed site (11.6 %).

The diversity index in the controlled grazed area (2.24) was always lower than that under the ungrazed condition (2.38), but much higher than that of the continuously grazed area (1.15). ANOVA analyses showed that there were significant differences in diversity index between grazing intensities ($F=64.976$, $P<0.001$).

Using multivariate analysis (CA) according to the diversity indicator, three groups of rangelands are distinguished following the grazing system (Fig. 1), which was justified by the Cluster Analysis. The dendrogram illustrating the presence of 03 groups using the analysis of 30 sites in the study area (Fig. 2). Cluster Analyses broadly divided the rangeland into three assemblies which could be clearly seen in two main branches of the dendrogram; (i) green: ungrazed, (ii) red: continuously grazed, (iii) purple: controlled grazed (i). The vegetal rug is analyzed by three principal grazing systems.

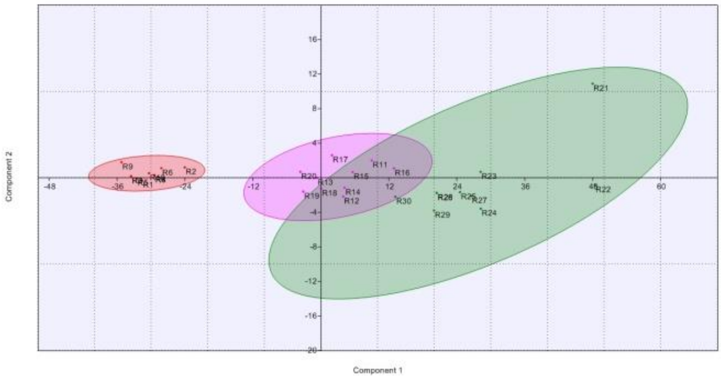

Fig. 1. Correspondence analysis map of 30 sites species: (i) green: ungrazed site, (ii) red: continuously grazed site, (iii) purple: controlled grazing site.

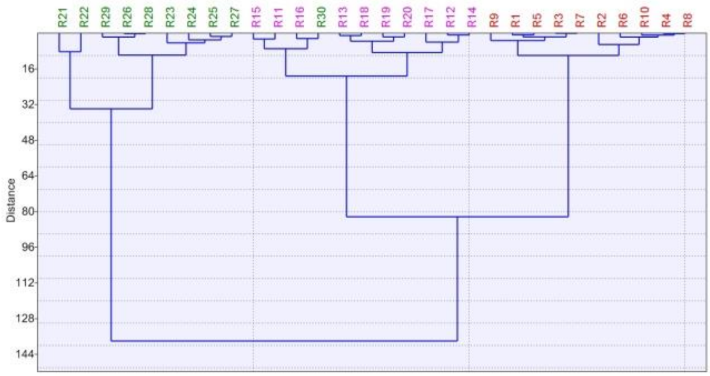

Fig. 2. Dendrogram of 30 sites' species after Cluster Analysis: (i) green: ungrazed site, (ii) red: continuously grazed site, (iii) purple: controlled grazing site).

2. Discussion

A previous study has indicated that continuous grazing has a wide range of effects on the composition, diversity, and vegetation cover (Gamoun, 2014a, 2014b, 2015). Livestock grazing has caused severe degradation of vegetation both directly (by eating it) and indirectly (by trampling) (Gamoun, 2015). Excluding grazing improved plant cover and flora richness (Deng *et al.,* 2013; Gamoun, 2015). Under the overgrazing effects, the natural vegetation cover decreases, the unpalatable plants dominate and the ecosystem biodiversity is reduced (Vavra *et al.,* 2007). However, our results show that the controlled grazing leads to a remarkable regeneration of natural vegetation. Similar results were recorded by (Ayyad and El Kadi, 1982). In fact, controlled grazing can provide adequate forage for livestock while maintaining environmental quality. This management practice seems to be efficient for the sustainability of the floristic heritage and helps in nature conservation. Therefore, according to certain authors (Ayyad and El Kadi, 1982), controlled grazing might be of better consequences than full protection.The continuous grazing resulted in re-grazing of plants and overgrazing. There would also be many plants that were completely ungrazed. There would be plants of low quality but in high quantity; similar results were reported by Gamoun (2014a).

IV – Conclusions

This study indicates that controlled grazing facilitates greater plant species richness on grazing land than both heavy grazing and a complete absence of grazing. This study suggests that controlled grazing can be used as a beneficial management method to maintain species diversity and mountain rangelands productivity.

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Habitat use by free grazing water buffaloes at the Kerkini Lake

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Abstract. Habitat use by water buffaloes (*Bubalus bubalis*) in the wet grasslands around the Kerkini Lake was investigated during the wintering period 2014-2015. Three different grasslands were identified as available habitats for water buffaloes according to the dominant grass species (*Paspalum paspalodes*, *Cynodon dactylon* and *Poa trivialis*). The use of these grasslands by buffaloes, as well as of the riparian *Salix* forest, was evaluated using the dung – counting method. Grassland patches dominated by the species *Cynodon dactylon* and *Poa trivialis* were used more intensively by water buffaloes compared to the *Salix* forest (P = 0.001 and P < 0.001 respectively). On the contrary, grasslands dominated by the *Paspalum paspalodes* were used less significantly (P < 0.001) by these herbivores in relation to all the other available habitats. Feeding activities of water buffaloes are concentrated in *Cynodon dactylon* and *Poa trivialis* patches while *Paspalum paspalodes* patches are currently an underutilized natural resource.

Keywords. Dung counting method – Grassland –Herbivores – Wet meadows.

Utilisation de l'habitat par des buffles d'eau pâturant en liberté au lac Kerkini

Résumé. *L'utilisation de l'habitat par des buffles d'eau (*Bubalus bubalis*) dans les prairies humides autour du lac Kerkini a été investiguée durant la période d'hivernage 2014-2015. Trois prairies différentes ont été identifiées comme habitats disponibles pour les buffles d'eau selon l'espèce herbacée dominante (*Paspalum paspalodes*,* Cynodon dactylon *et* Poa trivialis*). L'utilisation par les buffles de ces prairies et de la forêt riveraine de Salix, a été évaluée en utilisant la méthode de comptage des excréments. Les zones de prairies dominées par l'espèce* Cynodon dactylon *et* Poa trivialis *étaient utilisées plus intensément par les buffles d'eau comparées à la forêt de* Salix *(P = 0,001 et P < 0,001 respectivement). Au contraire, les prairies dominées par* Paspalum paspalodes *étaient utilisées moins significativement (P < 0,001) par ces herbivores par rapport à tous les autres habitats disponibles. Les activités alimentaires des buffles d'eau se concentraient sur les zones à* Cynodon dactylon *et* Poa trivialis *tandis que les zones à* Paspalum paspalodes *étaient présentement une ressource naturelle sous-utilisée.*

Mots-clés. *Méthode de comptage des excréments – Prairies – Herbivores – Prairies humides.*

I – Introduction

Understanding the principles shaping spatial distribution patterns of herbivores is a prerequisite for the sustainable rangeland management. Abiotic (e.g. slope, distance to water, physical barriers etc.) and biotic (e.g. vegetation composition, productivity and quality of forage, etc.) components of habitats have been well documented as critical factors influencing the use of space by large-herbivores (Owen-Smith, 1988). In most cases however, the availability of forage resources plays crucial role as herbivores usually spend more time in areas where the resource levels are high (Senft *et al.*, 1987). Water buffaloes (*Bubalus bubalis*) may exert major influences on plant communities through their grazing activities, which however, under appropriate management scheme, may be beneficial to both the primary producers and the consumers (Kazoglou *et al.*, 2004; Wiegleb and Krawczynski, 2010).

The aim of this study was to investigate the use of available habitats for free grazing water buffaloes at Kerkini Lake, northern Greece. Investigating the use of habitats by buffaloes, indubitably, will contribute to a more sustainable and profitable use of the grazing wet grasslands at Kerkini Lake.

II – Materials and methods

The study area is defined as the grassland at the northern and eastern parts of the Kerkini Lake. Kerkini Lake is a National Park included in the list of the wetlands of international importance for waterbirds (according to Ramsar convention) and is a Special Protection Area (SPA). Due to the lake's operation as an irrigation reservoir, its water level fluctuates by 5 m and its surface usually decreases from 75km^2 to 50km^2 yearly (higher levels in May – June and lowest in August - September). As a consequence, the study area is available for grazing for about 4-8 months per year, usually from August to December-January, but in dry years grazing period may be prolonged till February-March. This depends mainly on the amount of precipitation and its annual fluctuations.

Habitat use of water buffaloes was evaluated in the non-marshy grassland (i.e. about 400-450m away from the shoreline), approximately 900 ha, located at the northern (from Mandraki eastwards) and eastern parts of the Kerkini Lake. About half of this area is dominated mainly by the grass species *Paspalum paspalodes*. Within the study area, there are also scattered grassland patches in a mosaic pattern, dominated either by *Cynodon dactylon* or *Poa trivialis*. In addition, a remnant riparian *Salix* spp. forest covers about 20% of the study area with an understorey dominated mainly by *Paspalum paspalodes*. This forest is a suitable habitat for many bird species and supports the largest colony of cormorants (*Phalacrocorax* spp.). However, this forest is under risk mainly due to the lack of regeneration. The study area is the main feeding place of about 2,000 free grazing water buffaloes (unherded), a rising farming industry which is a very important economic activity both at the local and the national level (Cazacu *et al.*, 2014). The relative use of the three grassland patches dominated by different grass species, as well as of the riparian *Salix* forest, was evaluated using the dung – counting method (Litvaitis *et al.*, 1996), in 50 randomly selected plots (50 x 50 m) per habitat (i.e. 200 plots in total). The number of faeces deposited in these plots was recorded at late November 2014. During the study (wintering period 2014-2015), flooding was occurred from early December 2014 onwards, thus buffaloes' grazing period was about four months (August to November 2014). The use of available habitats was estimated by excluding disturbed and water-covered sites, dense *Rubus* spp. stands, roads, etc., which are not available for grazing by buffaloes. Marshy habitat near the shoreline (less than 400-450m away) was also excluded, as the use of this habitat by buffaloes was negligible (Manly *et al*. 2002; Markkola *et al.* 2003).

Dung-count data were subjected to one-way analysis of variance (ANOVA). The four available feeding habitats for buffaloes (three grasslands and the *Salix* forest) were treated as different levels of a fixed factor. Levene's test was performed prior the analysis in order to check the homogeneity of variances. Tukey's test was used to evaluate differences between the average number of buffaloes' dung per habitat. Differences were considered significant at $P \leq 0.05$ (Petrie and Watson, 1999).

III – Results and discussion

Patches dominated by the species *Cynodon dactylon* and *Poa trivialis* were used by water buffaloes significantly more ($P = 0.001$ and $P < 0.001$ respectively) than the remnant riparian *Salix* forest (Fig. 1), which however, was used significantly more than the grassland patches dominated by the species *Paspalum paspalodes* ($P < 0.001$). No significant differences were evaluated between the grassland patches dominated by the species *Cynodon dactylon* and *Poa trivialis* ($P = 0.413$).

Water buffaloes tend to concentrate their grazing efforts in the grassland sites dominated by the grass species *Cynodon dactylon* and *Poa trivialis*. This behaviour of buffaloes is probably a consequence of their tendency to reduce the consumption of *Paspalum paspalodes* biomass, which is the most available food resource in the study area. However, in order to improve this valuable for domestic and avian herbivores grassland, distribution of buffaloes should be regulated in a more evenly way, using mild management practices to minimize possible adverse effects on bird populations. Under this aspect, management practices such as placement of salt and supplement and favouring preferred plant species could be implemented, in order to attract buffaloes to the patches dominated by *Paspalum paspalodes* and to lightening the use of the other two identified grassland habitats and of the *Salix* forest. Such practices have been implemented successfully to modify and control grazing distribution of large herbivores (Bailey *et al.*, 1996).

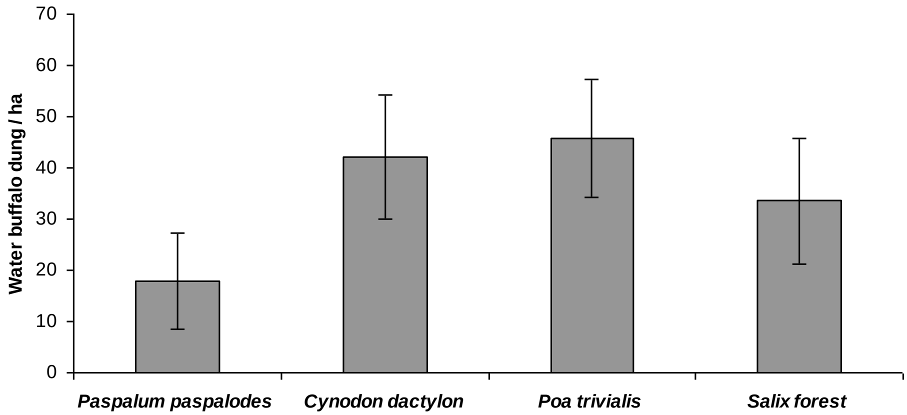

Fig. 1. Average number of water buffalo dung (± SD) deposited in the grassland sites dominated by the grass species *Paspalum paspalodes*, *Cynodon dactylon*, *Poa trivialis*, and in the riparian *Salix* forest in the non-marshy area at Kerkini Lake, during the four month grazing period (August to November) of 2014. Different letters between columns indicate significant differences (a = 0.05).

Grazing has direct and indirect impact on plants influencing their growth, survival and reproduction, therefore it is considered as a powerful tool influencing plant population dynamics as well as the abundance, spacing and the feeding strategies of wild herbivores (Holechek *et al.*, 2004). It is well documented that the slow passage of food from the digestive system of buffaloes makes them capable to consume low quality forage, high in fiber (Laca *et al.*, 1994; Perrin and Brereton-Stiles, 1999). Buffalo grazing may cause massive changes in vegetation composition and structure (Letts *et al.*, 1979; Braithwaite *et al.*, 1994; Skeat *et al.*, 1996) and they tend to select high quality forage if this is available (Winnie *et al.*, 2008). Future research should address the issue of possible effects of buffaloes on the plant and bird communities in the wet meadows and especially of the riparian *Salix* forest at Kerkini Lake. This forest supports the greatest colony of wintering cormorants in Greece, its ecological significance is high and is under threat from lack of regeneration, grazing pressure of buffaloes and other degrading influences (Kazantzidis and Naziridis, 1999). This knowledge is valuable in developing an appropriate grazing management scheme incorporating the needs both of free grazing buffaloes and bird fauna in the wet meadows at Kerkini Lake.

IV – Conclusions

Grassland patches dominated by the species *Cynodon dactylon* and *Poa trivialis* were used by water buffaloes significantly more than the riparian *Salix* forest, while those dominated by the species *Paspalum paspalodes* were used less than any other available habitat. The implementation of mild management practices, e.g. placement of salt and supplement and favouring preferred plant species in the latter patches may attract buffaloes and is expected to improve their distribution throughout the study area. This approach is also expected to lower the grazing intensity of buffaloes in the riparian *Salix* forest.

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Session 2
Improvement of range, pasture and forage species including alternative uses

Improvement of pasture and forage legumes and grasses for Mediterranean climate zones

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Abstract. Mediterranean climate zone pastures produce valuable animal products and sustain crop production. Well-managed natural grasslands in the Mediterranean basin contain a diversity of species that are adapted to survive the extremes of hot, dry summers and intermittent droughts. Many of these plants have also been introduced to other regions with similar climates, such as southern Australia. Extensive breeding and selection of pasture and forage species in Australia has led to a flourishing seed industry and the resulting cultivars have been sown world-wide in Mediterranean climates. Among the annual legumes, subterranean clover (*T. subterraneum*) and annual medics (*Medicago* spp.) have been widely utilised, while several other species have been released recently. Lucerne (*M. sativa*) is the most important perennial legume in Mediterranean climates, while early flowering, free-seeding white clover (*T. repens*) types are suited to higher rainfall parts of the zone. The temperate grasses, *Lolium perenne*, *Dactylis glomerata*, *Festuca arundinacea* and *Phalaris aquatica*, are important in higher rainfall areas of the Mediterranean zone, but require summer dormancy for persistence in drier parts. The summer-active perennial grasses, *Megathyrsus maximus*, *Chloris gayana* and *Pennisetum clandestinum*, have also been sown in parts of southern Australia with milder winter temperatures. Future cultivar improvement will make additional productivity and sustainability gains, particularly utilising local germplasm, but faces the issues of drier and more variable seasons, soil constraints, and greater profitability of cropping. Strong cooperation between scientists in Mediterranean climates and greater vertical integration between basic and applied science will provide the best solutions to farmers, in the face of declining research and development funds.

Keywords. Annual legumes – Perennial legumes – Perennial grasses – Cultivars – Australia.

Amélioration des légumineuses et graminées des pâturages et cultures fourragères dans les zones à climat méditerranéen

Résumé. *Les pâturages des zones à climat méditerranéen donnent des produits animaux intéressants et permettent la production de cultures. Les prairies naturelles bien gérées du bassin méditerranéen contiennent une diversité d'espèces qui sont adaptées pour survivre à des étés extrêmement chauds et secs et à des sécheresses intermittentes. Plusieurs de ces plantes ont aussi été introduites dans d'autres régions à climat semblable, comme le sud de l'Australie. L'amélioration et la sélection extensives des espèces pastorales et fourraggères en Australie ont crée une industrie des semences florissante et les cultivars résultants ont été semés dans le monde entier en climats méditerranéens. Parmi les légumineuses annuelles, le trèfle souterrain (*T. subterraneum*) et les medics annuelles (*Medicago *spp.) ont été largement utilisés, tandis que de nombreuses autres espèces ont été récemment commercialisées. La luzerne (*M. sativa*) est la légumineuse vivace la plus importante en climats méditerranéens, tandis que les types de trèfle blanc à floraison précoce, à ré-ensemencement (*T. repens*) sont adaptés aux parties plus pluvieuses de la zone. Les graminées tempérées,* Lolium perenne, Dactylis glomerata, Festuca arundinacea *et* Phalaris aquatica, *sont importantes dans les zones à plus forte pluviométrie de la région méditerranéenne, mais nécessitent une dormance d'été pour la persistance dans les zones plus sèches. Les graminées vivaces actives en été,* Megathyrsus maximus, Chloris gayana *et* Pennisetum clandestinum, *ont aussi été semées dans des zones du sud de l'Australie ayant des températures hivernales plus douces. L'amélioration future de cultivars permettra une productivité additionnelle et des gains en durabilité, en particulier en utilisant le germoplasme local, mais elle doit affronter les défis de saisons plus variables et plus sèches, de contraintes du sol, et d'une meilleure rentabilité des cultures. Une forte coopération entre scientifiques des climats méditerranéens et une plus grande intégration verticale entre science fondamentale et science appliquée apportera les meilleures solutions aux agriculteurs, face à la réduction de la recherche et des fonds de développement.*

Mots-clés*. Légumineuses annuelles – Légumineuses vivaces – Graminées vivaces – Cultivars – Australie.*

I – Introduction

Mediterranean climate zones are characterized by mild, wet winters and hot dry summers. Buddenhagen (1990) defines a Mediterranean climate as one where mean annual precipitation ranges from 250 to 900 mm, with at least 65% occurring in the autumn-to-spring period. Such climates typically occur within the latitudes 28° and 45° as transition zones between temperate and dry tropical climates. The Mediterranean basin, which includes the countries surrounding the Mediterranean Sea and extending east to Iraq and Iran, covers approximately 1067 million ha, or 60% of this area. Of the other regions with a Mediterranean climate, southern Australia occupies 22%, California 10%, central Chile 5% and South Africa 3% of the total area, respectively (Nichols *et al.* 2012). Other relatively small areas have quasi-Mediterranean-type climates with a higher proportion of summer rainfall, including parts of south-eastern Australia, New Zealand and Argentina, where plants adapted to Mediterranean climates also grow well.

Farming systems based on grasslands, defined by Peeters *et al.* (2014) as land devoted to the production of forage for harvest by grazing/browsing animals, cutting, or both, are important for Mediterranean regions, and help satisfy the increasing global demand for animal products. Porqueddu *et al.* (2016) note that the Mediterranean climate zones of the Mediterranean basin, southern Australia and Chile support 308 million sheep, 109 cattle and 105 goats. Cereal production is also important. In southern Australia and Chile, this is generally conducted in rotation with legume pastures, where grasslands are predominantly grazed, while cereal-fallow rotations are more typical in the Mediterranean basin (Porqueddu *et al.* 2016).

Mediterranean climates pose significant challenges to plant growth. Plants must cope with summer drought coupled with high solar radiation levels, cool winter temperatures during the growing season, and highly erratic and variable rainfall. Germination-inducing rainfall events followed by periods of drought, referred to as 'false breaks', are common and result in widespread death of establishing seedlings. This climate results in highly seasonal growth which favours annual and drought-tolerant perennial species. Annual plants escape this drought by forming seeds for germination in subsequent autumn-winter periods, while perennials need to have sufficient drought tolerance or drought avoidance mechanisms to survive. Well-managed natural grasslands in the Mediterranean basin are species-rich, particularly for annuals (Blondel and Aronson, 1999). These species have evolved a suite of strategies that enable them to survive the rigours of the climate and human-related disturbance, including seed dormancy and delayed germination, genotypic and phenotypic responses to interactions between temperatures and moisture, and morphological traits predisposing the fruits to dispersal by grazing animals or to soil burial (Blondel and Aronson, 1999).

Many of the plants native to the Mediterranean basin were introduced by early European settlers to other regions with similar climates, such as southern Australia, central Chile, California and the Cape region of South Africa (Nichols *et al.* 2012). Pasture species commonly used in Great Britain and northern Europe, such as lucerne (*Medicago sativa*), white clover (*Trifolium repens*), perennial ryegrass (*Lolium perenne*) and cocksfoot (*Dactylis glomerata*), were deliberately introduced to increase animal production - and remain important today. However, other plants, particularly annuals, were introduced accidentally, by means of seed contaminants in fodder and wool fleeces or as weed seeds, and became naturalized in many of the grasslands in these regions (Nichols *et al.* 2012). In Australia active cultivar development programmes have operated since the 1950s with the evaluation of germplasm collected from the Mediterranean basin and more recently from breeding programmes (Nichols *et al.* 2012). Such commercialisation has been accompanied by the development of a specialized pasture seed industry and many of these cultivars have subsequently been sown in the Mediterranean basin and other Mediterranean-climate areas to improve grassland productivity.

This paper outlines the breeding and selection of pasture and forage legumes and grasses for rainfed, (non-irrigated) Mediterranean climates and the future needs and opportunities for cultivar development. The emphasis is on the Australian situation, where much of this activity has taken place, but reference is made to the Mediterranean basin and other regions with Mediterranean climates where appropriate. We also focus on grasslands in which introduced (improved) grass and legumes have been sown, rather than those based on native vegetation.

II – Grassland improvement in Australia – An historical perspective

Whereas agriculture has been practised in the Mediterranean Basin for up to 10,000 years, it only commenced in Australia slightly more than 200 years ago with British colonization. Prior to the 1920s much of southern Australia was managed in very large landholdings (>100,000 ha) on which grazing animals, primarily sheep for wool, were run on grasslands dominated by native Australian grasses. These landholdings were then subdivided into much smaller properties, which necessitated the intensification of agriculture, resulting in the sowing of improved pasture species and much greater fertiliser usage. Native grasses remain important under extensive grazing systems in high rainfall, non-arable areas of south-eastern Australia, but their use under more intensive farming systems has rarely been successful.

Mixed farms now dominate the low and medium rainfall zones (250-600 mm), with cropping (particularly wheat) being the major agricultural industry, in rotation with wool, sheepmeat and beef production. Grasslands in these areas have traditionally been based on annual legumes grown in rotation with crops (Nichols *et al.* 2007, 2012). Higher rainfall areas tend to have a greater livestock focus, with permanent or semi-permanent pastures based on annual legumes, often with the addition of temperate perennial grasses and lucerne, particularly in south-eastern Australia (Nichols *et al.* 2012). Apart from native grasses and some halophytic shrubs (particularly *Atriplex* spp.) in lower rainfall areas, all other grassland species in southern Australia have been imported, mostly originating from the Mediterranean basin.

1. Annual legume improvement

The majority of native legumes are unsuited to the farming systems of southern Australia and many are toxic. A range of annual legumes, particularly subterranean clover (*T. subterraneum*) and annual medics (*Medicago* spp.), have been introduced into Australia, and are now widespread across the Mediterranean climate regions (Nichols *et al.* 2012). Subterranean clover, first marketed in 1907, is the most widely sown pasture legume, having been sown on moderately acidic soils over an estimated 29.3 M ha (Nichols *et al.* 2012). Fifty cultivars have been registered, enabling it to be grown in environments with annual average rainfall (AAR) ranging from 250–1200 mm (Nichols *et al.* 2013). Nine annual medic species with 40 registered cultivars have been commercialized since 1938, having been sown over an estimated 24.6 M ha (Nichols *et al.* 2012). These consist of the three most widely sown species, *M. truncatula*, *M. littoralis* and *M. polymorpha*, and the less-important species, *M. tornata*, *M. scutellata*, *M. sphaerocarpos*, *M. rugosa*, *M. murex* and *M. orbicularis*.

Other annual legume species have been developed for soil types and farming systems not suited to subterranean clover and annual medics. Cultivars have been based on germplasm collected from Mediterranean basin grasslands. Loi *et al.* (2005) and Nichols *et al*. (2007; 2012) describe 36 annual legume species from among the genera *Astragalus*, *Biserrula*, *Lathyrus*, *Medicago*, *Melilotus*, *Ornithopus*, *Trifolium* and *Vicia*, with Australian registered cultivars. The most important of these species include *B. pelecinus*, *O. compressus*, *O. sativa*, *T. michelianum*, *T. vesiculosum*, *T. spumosum*, *T. resupinatum* and *T. vesiculosum* (Nichols *et al.* 2007, 2012). *Melilotus siculus* is also undergoing commercialisation for saline soils prone to winter waterlogging. These new species were needed because of: (i) poor adaptation of subterranean clover and annual medics to difficult soils; (ii) poor adaptation to false seasonal breaks; (iii) depletion of subterranean clover seed banks from increased cropping frequencies; (iv) soil erosion caused by subterranean clover and annual medic seed harvesting; (v) the build-up of herbicide-resistant weeds; (vi) the need for lower cost seed for re-sowing pastures; (vii) the need for specialist fodder legumes; (viii) the requirement for longer-season plants to maximise production; and (ix) the need for greater diversity within paddocks (Loi *et al.* 2005; Nichols *et al.* 2007, 2012).

Underpinning these programs has been a large genetic resource of almost 60,000 accessions. The first Australian expedition to collect annual legume germplasm was conducted in 1951 and more than 90 expeditions have since been made (S.J. Hughes, pers. com.). Subterranean clover and annual medics were the initial targets, whereas alternative legumes have been the main targets since 1990 (Nichols *et al.* 2007, 2012). A key factor in the development of new legumes has been the selection of root nodule bacteria able to form nitrogen (N)-fixing symbioses (Loi *et al.* 2005). Novel low-cost pasture establishment systems utilizing hard seeds, either under-sown with a grain crop or into dry soil over the summer, are being developed to stimulate increased use of annual legume pastures (Loi *et al.* 2008, 2012). Such systems are now possible with the development of new granular clay inoculum systems, which enable rhizobial survival in dry soil.

There has been a major reduction in annual legume breeding and selection activity in Australia since 2005, following reduced funding by government agencies for pasture breeding, with some support from private seed companies.

2. Perennial legume improvement

Pastures with perennial forage species have advantages over those based only on annuals by extending the feeding season into autumn-early winter and late spring, when annuals have senesced (Volaire 2008). They reduce soil erosion by maintaining year-round groundcover and reduce deep drainage, thereby reducing the potential for dryland salinity. However, few perennial species are suited to the severe summer dry spells experienced in Mediterranean climates (Annicchiarico *et al.* 2011; 2013). Required traits include dormancy or low growth during the summer drought period (Volaire *et al.* 2013) and high water-use efficiency during the growing season (Lelièvre *et al.* 2011). A combination of strategies to overcome drought are present in some plants, including: (i) dehydration avoidance, (Volaire and Lelievre 2001); (ii) dehydration tolerance (Volaire, 2008); and (iii) summer dormancy (Norton *et al*., 2006; 2012).

A. Lucerne

Lucerne is widely used for dryland grazing and for the production of high quality fodder, particularly in south-eastern Australia. Until the late 1970s, more than 95% of Australian-sown lucerne was the cultivar, Hunter River, derived from original populations introduced by the early settlers (Nichols *et al.* 2012). In 1977 arrival of the aphids, *Acyrthosiphon kondoi* and *Therioaphis trifolii*, caused widespread lucerne devastation, as Hunter River was highly susceptible. This resulted in several publicly-funded breeding programs to develop lucernes with aphid resistance and 21 cultivars were registered by 1990 (Oram 1990). Two public breeding programs continue to operate, in partnership with private seed companies. Australian cultivars with better grazing tolerance, disease resistance and winter productivity have been bred, with over 70 registered by 2012 (Nichols *et al.* 2012). Increasing private sector investment in lucerne improvement is likely to continue, with further declines in public sector investment.

B. White clover

The greatest use of white clover is in temperate climates. In Australia it only reliably exists as a perennial in wet coastal or irrigated areas or in cooler, elevated environments with summer-dominant rainfall. The most significant Australian contribution to white clover development was the release in 1971 of the cultivar Haifa (Oram 1990), which is better suited to Mediterranean climates than traditional forms of the species. Its early flowering and prolific seeding allows cv. Haifa to persist by also utilising an annual habit, because summers are too long and dry in most Mediterranean climatic regions for the species to survive as a perennial. Other cultivars have since been released, but Haifa continues to be important in Australia and internationally. In many ways it woke up the World to the potential of white clover in Mediterranean climate zones.

C. Other species

Of other perennial legumes for Mediterranean dryland regions, *T. fragiferum* has been the most widely sown, particularly in summer-moist areas prone to winter waterlogging, while smaller areas have been sown to *Lotus corniculatus* and *L. uligonosis* (Nichols *et al.* 2012). *Dorycnium hirsutum* and *T. tumens* have recently been released, but it is too soon to judge their commercial success. Although *Hedysarum coronarium* is widely used in parts of the Mediterranean basin, it has been little used in Australia, but the release of better adapted cultivars may see its use increase. *Bituminaria bituminosa* var. *albomarginata* is a promising new perennial legume being developed in Australia and Spain (Oldham *et al.* 2013), with extreme drought-tolerance (Foster *et al.* 2015). Other perennial legumes from the Cape regions of South Africa are also being evaluated by Murdoch University (Howieson *et al.* 2008). Interest in developing alternative perennial legumes has arisen from a need to overcome soil and climatic constraints affecting lucerne performance and to develop deep-rooted perennial species for soils not suited lucerne, aimed at reducing deep drainage (Nichols *et al.* 2012).

3. Perennial grass improvement

A. Temperate grasses

Initial sowings of imported perennial ryegrass and cocksfoot by the early settlers generally failed because of their poor adaptation to the hotter and often drier Australian conditions. In the few regions where they did survive natural selection produced types better adapted to the Australian climate. Seed production from the 1920s was based on these naturalised populations (Reed 2014). The widely used perennial ryegrass cultivars, Victorian and Kangaroo Valley, are examples of this germplasm (Oram 1990). After the Second World War, exotic temperate C3 perennial grasses including perennial ryegrass, cocksfoot, tall fescue (*Festuca arundinacea*) and phalaris (*Phalaris aquatica*) became more widely sown in the higher rainfall areas of south-eastern Australia. This led to germplasm collections to the Mediterranean Basin from the 1950s aimed at finding germplasm of these species better adapted to more intensive grazing systems under Mediterranean climates (Neal-Smith 1955). The germplasm from these expeditions resulted in a range of grass cultivars, including Medea perennial ryegrass, Currie and Kasbah cocksfoots, Demeter and Melik tall fescues and Sirocco phalaris. Medea, Kasbah, Melik and Sirocco all have summer dormancy, which has proved to be a very important trait for adaptation to Mediterranean climate zones, as it improves survival during drought. This trait has consequently extended the adaptation zone of these grasses into regions previously considered too dry. Indeed, summer-dormant germplasm could enhance adaptation to Mediterranean regions in the future to mitigate the predicted effects of increasing drought periods.

Publically-supported Australian perennial ryegrass and tall fescue improvement programs operated in the 1990s and 2000s, but have since terminated. However, phalaris breeding is continuing. Phalaris is an interesting species because, although it is of Mediterranean origin (Anderson 1961), it is rarely sown in the Mediterranean Basin, even though of the four grasses it is the most productive during spring (Norton *et al.* 2008) and persists through drought (Oram and Freebairn 1984). Its use is primarily restricted to Australia, where it is sown over 2.7 M ha. The reason why phalaris is little used in other Mediterranean climate zones is probably related to historical reasons associated with species commercialisation choices during seed industry development in Europe. Around 1900, when phalaris was first introduced and promoted in Australia, there were no other suitable temperate, perennial grasses, due to failure of European imported populations. Thus, Australian farmers came to appreciate its advantages while coping with occasional toxicity problems (R.A. Culvenor, pers. com.).

B. Sub-tropical grasses

Summer-active, C4 perennial grasses have been widely sown in sub-tropical areas of north-eastern Australia. However, since 2000 they have been increasingly sown in Mediterranean areas, particularly in Western Australia (WA). *Megathyrsus maximus* and *Chloris gayana* have been sown on >50 000 ha of infertile sandy soils in the agricultural area north of Perth, which has relatively mild winter temperatures (Moore *et al.* 2014). These grasses have excellent drought tolerance, persisting through extended hot, dry periods of 6–7 months over summer–autumn. A key to their use has been an agronomy package to increase establishment reliability in the Mediterranean climate zone (Moore *et al.* 2014). *Pennisetum clandestinum* has been sown along the coastal strip of southern and south-western Australia for many years, where summer temperatures are milder than most Mediterranean areas with a higher proportion of summer rainfall. Its use has increased markedly over the past 20 years, with >150 000 ha sown in the south-coast region of WA alone (Moore *et al.* 2014). Producer interest in these grasses is due to increased pasture production in autumn–early winter, provision of out-of-season green feed, and their ability to reduce wind erosion by maintaining groundcover throughout the year and reduce deep drainage. Until recently sub-tropical grass cultivars used in the Mediterranean climate zone have originated from selection programs for sub-tropical areas. However, two new cultivars of *M. maximus* have been selected for their adaptation to a Mediterranean climate.

III – Issues, future challenges and opportunities for pasture and forage improvement in Mediterranean climate zones

1. Climate change

Climate change is forecast to have a great impact on agricultural production systems in regions with Mediterranean climates. In south-western Australia, rainfall has declined by 10% over the past 30 years, with this decrease most evident in the autumn-winter period, while projections to 2050 indicate a further decline and increased inter-annual variability in rainfall, accompanied by average annual temperature increases of 0.7-1.2ºC (Watterson *et al.* 2007). Similar changes are expected in the Mediterranean basin (Giorgi and Lionello, 2008). This change in climate has important implications for Mediterranean grassland productivity and farming systems will need to adapt. Shorter growing seasons are likely to have the greatest impact on pasture growth (Revell *et al.* 2012).

Drought escape is the main adaptive strategy of annual species, as they survive the dry summer period as seeds. In legumes, seed dormancy is determined by hardseededness. This enables a proportion of seeds in the seed-bank to remain dormant for germination in subsequent seasons, allowing regeneration after years of little or no seed-set. The amount of hard seeds and the timing of their softening differ between and within species, and often the timing of seed softening may be more important than the level of hardseededness (Loi *et al.* 2005; Nichols *et al.* 2007). The predictions of lower, more variable autumn rainfall and shorter springs mean that annual legumes will need: (i) earlier maturity for reliable seed set in shorter growing seasons; (ii) more delayed softening of hard seeds, to reduce seedling losses from false breaks; (iii) greater hardseededness, to allow for more frequent seasons of little or no seed set; and (iv) a less determinate flowering habit to take advantage of longer growing seasons when they occur (Revell *et al.* 2012).

Warmer, drier climates will pose significant productivity challenges to perennial-based pastures. The major research need is to identify traits that confer enhanced drought survival, including: (i) increasing the depth and density of grass root systems to strengthen dehydration avoidance; (ii) exploring the biochemical, molecular and hydraulic bases of dehydration tolerance and improving techniques to measure them ; (iii) breaking the trade-off between summer dormancy and forage yield potential and improving understanding of environmental, biochemical and genetic controls over summer dormancy; and (iv) identifying non-toxic endophyte strains compatible with summer-dormant tall fescue cultivars to enhance its drought survival. While not directly associated with climate change it will be necessary to ensure that new cultivars have sufficient seed production to be commercially viable. The development of agronomic management packages for promoting stable mixtures combining perennial grasses and legumes will also be required.

2. Overcoming soil constraints

Soil acidity is increasing in much of southern Australia (Scott *et al.* 2000). If liming becomes uneconomic, it will require cultivars of existing species with more acid tolerance or replacement of them with more acid-tolerant species. Phosphorus (P) fertiliser is becoming more expensive and the response of many farmers has been to reduce their application rates, which usually reduces pasture production. The development of more P-efficient pasture legumes, that can produce the same amount of biomass with less P inputs, would result in greater profitability (Simpson *et al.* 2011).

3. Development and commercialisation of locally adapted cultivars

Improved forage legumes and grasses are seen as crucial to increase productivity of Mediterranean grassland systems and there is an urgent need to develop new cultivars. In the Mediterranean basin a wide range of species is currently used but very few locally adapted cultivars are sown, apart from lucerne, due to the lack of a pasture seed industry. Seed of most available perennial grassland species is selected and multiplied in Central Europe, Denmark and New Zealand, whereas most annuals are selected, multiplied and imported from Australia. For example, over the past 40 years cultivars of annual legumes, particularly subterranean clover and annual medics selected in Australia, have been increasingly utilized in the Mediterranean basin, but, these cultivars have often been poorly adapted to local conditions (Porqueddu *et al.* 2016). Native genotypes of these species have been selected, but efforts to promote their seed multiplication have largely been unsuccessful. Selection among local strains is likely to identify the most promising types for these regions, but this needs to be accompanied by the development of a pasture seed industry. Indeed, involvement with seed companies is essential to develop these markets to ensure they are profitable and sustainable.

4. Increased recognition of the value of pastures in cropping systems

On mixed farms, the perceived value of pastures is related to the value of livestock products compared to grain prices. As a result of higher grain prices, traditional crop-pasture rotations have changed in southern Australia over the past two decades. More farms have reverted to continuous cropping and fewer pastures are managed for high legume content, with crops reliant on inorganic N. This has resulted in a generation of farmers, extension officers and consultants with little pasture knowledge. This has been mirrored in research-funding priorities, with increased priority given to cropping, at the expense of pastures. Future investment in improved pastures and cultivars, however, is likely to increase at some stage. A major issue for mixed farming systems concerns the management of crop weeds, with many target weeds now resistant to common herbicides (Nichols *et al.* 2007, 2012). The pasture phase is likely to become increasingly important for controlling crop weeds. The issue of soil residues of some crop herbicides, particularly the sulfonylurea group, also needs to be addressed, as they can severely affect germination and growth of pasture legumes. Therefore, weed management strategies need to be deployed that better integrate pastures into mixed farming systems (Nichols *et al.* 2012). The cost of N fertiliser is likely to increase and its application may eventually become uneconomic. This will stimulate better management of legume-based pastures to increase N supply for subsequent crops. Furthermore, under future climate scenarios livestock production is likely to provide greater resilience to mixed farming systems by reducing risk and providing cash flow to farmers in seasons unfavourable for cropping.

5. Improved ecosystem services and amenity value of grasslands

Well-managed grasslands produce positive externalities, such as recreational activities, public goods and generic environmental services, which are of particular importance in the Mediterranean basin (Porqueddu *et al.* 2016). Improved pasture and forage plants, in conjunction with sustainable grazing management, can enhance grassland ecosystem services and amenity value. They can be used to rehabilitate degraded landscapes from soil erosion or overgrazing; such plants need an ability to bind the soil and persist under grazing. Grasslands play an important role in the global carbon (C) cycle with more productive grasslands resulting in higher C sequestration. However, more studies are required to quantify the contributions of key pasture species (Porqueddu *et al.* 2016).

Australian data indicate 70% of agricultural methane emissions come from ruminant livestock as a bi-product of microbial fermentation of feed in the rumen (Garnaut 2008). Studies have shown variation between fodder species for methanogenic potential in the rumen, suggesting that pasture plants can be developed with low methanogenic potential, thereby helping mitigate greenhouse gas emissions (Makkar and Vercoe 2007).

Research in southern Australia has shown adapted perennial pasture species can have major benefits to farming system sustainability, largely through increased soil water use. This acts to reduce nitrate leaching, which in turn reduces soil acidification, and also reduces the risks of dryland salinity (Ridley *et al.* 1990).

6. Use of pasture and livestock production modelling

In Australia there has been an increasing emphasis since the late 1990s on use of biophysical models, such as Grassgro and the SGS Pasture Model, to predict both pasture and associated grazing livestock production (Moore *et al.* 1997). These models are driven by weather data, while also accounting for local edaphic and grazing management factors that impact on forage production. The predictive capability of modelling has meant this approach is greatly valued by farmer advisors and consultants. Leading graziers are also increasingly using these models as it allows them to compare different pasture species and livestock production enterprises and strategies. However, such models have their limitations. For example, neither Grassgro nor the SGS Pasture model predict pasture plant demography (Moore *et al.* 1997) and have limited ability to predict outcomes of the severe droughts that can cause wide-scale pasture plant deaths in Mediterranean environments. Nevertheless, as the robustness of such models increase, they are likely to become increasingly useful for decision making at the farm-scale, in addition to determining research and policy priorities.

7. The role of biotechnology in developing improved grassland cultivars

DNA-based molecular marker technologies have a range of potential applications for pasture and forage improvement programs, but this is only likely in the most economically important species. They can be used for marker-assisted selection (MAS) to select among genetically variable breeding populations for closely-linked target traits, while major reductions in the cost of genome sequencing and high throughput technologies have heralded ‘genomics-assisted breeding’, in which selection can be conducted for many traits simultaneously using molecular markers. Their applications are likely to increase as more molecular markers for specific traits are developed and they become more economic to use. A more controversial technology is genetically modified (GM) plants, in which genetic material is incorporated from other species. Such technology has the potential to deliver quantum leaps in productivity, but public and industry concerns need to be allayed before they can be introduced onto the market.

Among pasture legumes, the genomes of barrel medic (Young *et al.* 2011) and subterranean clover (Nichols *et al.* 2012) have been sequenced in Australia. Core collections, which maximise species diversity in a small number of varieties, have been developed and will allow better utilisation of genetic resource collections for screening new traits and parent selection. Molecular markers for important traits are also being developed in these species. However, no white clover, red clover or lucerne breeding programs have used MAS to date, due to their complex polyploid and out-crossing genetics. Among the grasses, genomic selection methodologies are being developed in the Australian phalaris breeding program.

Some investment in molecular biology technologies for pasture and forage improvement is justifiable, as they have the potential to deliver outcomes that conventional plant breeding programs may never achieve. However, such programs are expensive, technically challenging and likely to be confined to the major species. To achieve commercial outcomes strong linkages are needed to practical breeding and agronomy programs to ensure traits are relevant to cultivar improvement and developed products perform well agronomically in the field.

8. Changed funding landscape

Porqueddu *et al.* (2016) raise concerns about decreasing public sector support for grassland research and development (R & D). This is particularly evident for pasture breeding and selection. With the withdrawal of public funding for applied R & D, it is not clear where new on-farm innovations will come from. Private industry will provide some input, but only for the most profitable species. This means the smaller Mediterranean seed markets are likely to be poorly serviced. Conversely, the priority for Universities will continue to be more fundamental research. In Australia many pasture breeding activities have transferred in the last decade from the public to the private sector. With the perennial grasses, the larger transnational companies acknowledge that the relatively small global market for Mediterranean regions means they are unlikely to invest heavily in breeding for these regions. Indeed, it is invariably cheaper for these companies to import varieties bred in Europe and North America into Australia, in the hope that some will be adapted, rather than initiating specific breeding programs. As this trend continues it is likely that new perennial grass cultivars will exhibit narrower adaptation to Australian conditions than the older publically-bred varieties. These developments are also likely to impact on other Mediterranean regions, given their previous reliance on Australian-bred cultivars.

The implication for applied grassland R & D is the need for greater international cooperation between the remaining scientists and institutions in Mediterranean areas of the World, in order to provide innovative and sustainable solutions to farmers. With Australian R & D rapidly declining in this area, other countries will need to take a greater leadership role. Researchers should also involve farmers as a key priority – they keep research applied and relevant, there are learning opportunities from farmer's observations and experiences, and it means research outputs are more likely to be adopted. However, while such participatory research is important, there is still the need to write papers to properly document research.

IV – Conclusions

Mediterranean climate regions continue to be important for high quality animal products and cereal production. Plants in natural Mediterranean grasslands have evolved to cope with the extremes of hot, dry summers and intermittent droughts, while sown cultivars have been developed to optimise pasture and forage production. Further cultivar improvements are needed to make additional productivity and sustainability gains, particularly utilising local germplasm from the Mediterranean basin, but this needs to be accompanied by development of a local pasture seed industry. Multidisciplinary investigations are needed to identify the best-adapted and most productive grassland species, cultivars and mixtures for animal production in each region, along with the most appropriate grazing management. This work must occur in the face of drier and more variable seasons, soil constraint issues, an increased focus on cropping at the expense of animal production, and declining R & D investment in grassland science. Greater cooperation between scientists and agencies in Mediterranean climates will help maximise technological advancements from a smaller R & D base, while involvement of farmers in R & D will help maximise adoption rates. Greater vertical integration between basic and applied science will also provide greater opportunities for innovative solutions to reach farmers.

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Effects of plant development phases on some morphological, agronomical and chemical traits of *Bituminaria bituminosa* genotypes

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Abstract. This study was conducted with 25 *Bitbit* genotypes collected from Central Black Sea Region of Turkey in order to determine the effects of plant development phases on some morphological, agronomical and chemical traits of *Bituminaria bituminosa* genotypes. The highest plant height and hay yield values were determined at the seed setting development stage as 118.7 cm and 205 g/plant, respectively. A sharp decrease in leaf ratio was observed from elongation stage (78.5%) to blooming stage (30.8%). Crude protein content also linearly decreased from 23.41% (pre-elongation stage) to 7.28 % (seed setting stage). ADF and NDF proportions were measured as 19.80 and 27.37%, respectively, at the pre-elongation stage. RFV values decreased from 249.7 to 86.0 through the following growth stages. Except calcium and magnesium, mineral contents of *Bitbit* genotypes decreased at each following stage. Considering K, Ca and Mg relations, no possible problem on K/(Ca+Mg) rates, but Ca/P rates over than recommended level of 2 at all stages. In consideration to all aspects, *Bitbit* plants should be harvested at the beginning of blooming stage to obtain ideal hay yield.

Keywords. *Bituminaria bituminosa* – Nutrients – Agronomic traits – Quality.

***Effet des phases de développement végétal sur certains caractères morphologiques, agronomiques et chimiques des génotypes de* Bituminaria bituminosa**

Résumé. *Cette étude a été menée sur 25 génotypes Bitbit collectés dans la région centrale de la mer Noire en Turquie pour déterminer l'intervalle de variation de: hauteur de la plante, rendement en foin, protéine brute, ADF, NDF et certains composants minéraux et valeurs alimentaires relatives (RFV) aux stades pré-élongation, élongation, bourgeonnement, floraison et formation de graines en 2014; ce sont les paramètres étudiés. Les plus fortes valeurs de hauteur des plantes et de rendement en foin, déterminées au stade formation des graines, sont de 118,7 cm et 205 g/plante, respectivement. Une baisse très nette du ratio foliaire fut observée du stade élongation (78,5%) au stade floraison (30,8%). La teneur en protéines brutes diminue linéairement, de 23,41% (au stade pré-élongation) à 7,28 % (au stade formation de graines). Les proportions d'ADF et NDF mesurées au stade pré-élongation sont de 19,80 et 27,37%, respectivement. Ces deux valeurs augmentent continuellement en parallèle aux phases de croissance et atteignent 47,17 et 56,38% au stade formation de graines. Les valeurs de RFV diminuent au cours des stades de croissance en passant de 249,7 à 86,0. Excepté pour le calcium et le magnésium, les teneurs en minéraux des génotypes Bitbit diminuent avec les stades de croissance successifs. Vues les relations de K, Ca et Mg, pas de problème possible pour les taux de K/(Ca+Mg), mais les taux de Ca/P dépassent le niveau recommandé de 2 à tous les stades. En tenant compte de ces résultats, les plantes de Bitbit doivent être récoltées au début du stade floraison pour obtenir un rendement idéal en foin.*

Mots-clés. *Bituminaria bituminosa – Nutriments – Caractères agronomiques – Qualité.*

I – Introduction

Bituminaria bituminosa is a perennial herbaceous species in *Bituminaria* genus. Its origin is Mediterranean environment and distributed to all Mediterranean basin (Davis, 1970). In the last decade *Bitbit*s ability to stay green in dry summer conditions has attracted attention from the scientific community (Acar *et al*., 2001; Ventura *et al*., 2004). In northern parts of Turkey, *Bitbit* plants keep their greenery all over the year and livestock graze on the pastures of this plant

(Kumbasar, 2015). Nutritive values and chemical composition of forage crops are alterable when environment and harvesting stages change (Tan and Serin, 1996). Chemical composition, agronomic traits and quality properties of *Bitbit*'s hay could change at different development stages and at different parts of plants (Ventura *et al*., 2004). Nutrient contents and RFV values considerably change in the leaves and stems of *Bitbit* plants (Gulumser *et al*., 2010).

In the scope of this study, morphological, agronomical traits and nutrient contents of *Bitbit* genotypes collected from Central Black Sea region of Turkey were determined at pre-elongation, elongation, budding, blooming and seed setting development phases in order to determine the effects of plant development phases on those traits of *Bitbit* genotypes.

II – Materials and methods

Seed samples of *Bitbit* genotypes were collected from Middle Black Sea Region in 2012. Measurements and observations were realised at pre-elongation, elongation, budding, blooming and seed setting stages of 25 genotypes in the second year of the plants (2014). Morphological and agronomic traits were determined on samples of 10 plants for each genotype. The samples were analysed by using Near Infrared Reflectance Spectroscopy (NIRS Foss 6500) device with IC-0904FE package program with 3 replicates. All data obtained from this study was analysed by using SPSS 17.0 program. The differences amongst the mean values were calculated according to DUNCAN test.

III – Results and discussion

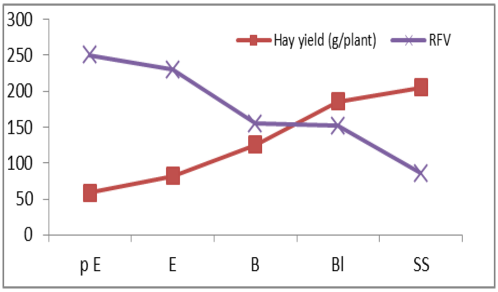
Table 1. Mean values about morphological, agronomic and some chemical properties of Bitbit genotypes*

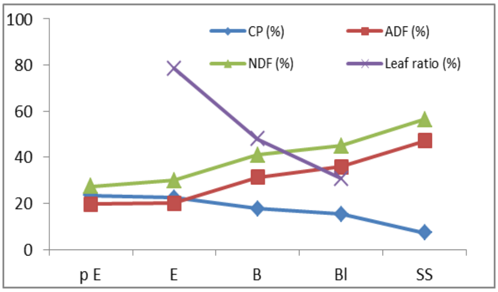
Traits/Harvest stages	Pre-longation	Elongation	Budding	Blooming	Seed setting
Plant height (cm)	26.3 d	36.5 c	79.2 b	116.4 a	118.7 a
Hay yield (g/plant)	58.4 c	81.6 c	125.3 b	185.6 a	205.0 a
Leaf ratio (%)	-	78.5 a	48.0 b	30.8 c	-
Crude protein (%)	23.41 a	22.55 b	17.70 c	15.29 d	7.28 e
ADF (%)	19.80 d	20.16 c	31.46 b	35.84 b	47.14 a
NDF (%)	27.37 e	29.90 d	41.05 c	44.90 b	56.38 a
RFV (%)	249.7 a	229.5 b	154.8 c	151.5 d	86.0 e
Ca (%)	1.87 a	1.61 b	1.35 d	1.30 e	1.41 c
K (%)	2.33 c	2.55 b	2.59 a	2.01 d	0.51 e
Mg (%)	0.40 a	0.39 a	0.37 b	0.35 c	0.37 b
P (%)	0.39 a	0.40 a	0.39 a	0.33 b	0.18 c
Ca/P	4.78 b	4.15 c	3.42 e	3.74 d	7.98 a
K/(Ca+Mg)	1.03 d	1.27 c	1.58 a	1.30 b	0.29 e

There are no differences amongst the mean values indicated the same letter at the same line at 0.05 probability level.

Mean values about some morphological, agronomic and chemical traits obtained from 25 *Bitbit* genotypes are shown on Table 1. The increase of plant height almost stopped at the blooming stage, while dry matter accumulation reached to maximum level at seed setting stage. The highest plant height and hay yield values were determined at the blooming and seed setting development stages (Table 1 and Fig. 1). In the region, *Bitbit* plants keep their greenery throughout summer period, thus they continue their growing more or less (Acar *et al*., 2001; Gulumser *et al*., 2010).

Leaf ratios of *Bitbit* genotypes decreased continuously through the each following stage. A sharp decrease in leaf ratio was observed from elongation stage (78.5%) to blooming stage (30.8%). Similar to leaf ratio, crude protein content also decreased linearly from 23.41% at pre-elongation stage) to 7.28% seed setting stage. Due to the increase of stem and branch ratio at last development stages (Gulumser *et al*., 2010), leaf and crude protein rates were declined (Table 1, Fig. 2).





(pE-pre-elongation, E-Elongation, B-Budding, Bl-blooming, SS-Seed setting)

Fig. 1. Hay yield and RFV of *Bitbit* genotypes at different development phases.

Fig. 2. Crude protein, leaf ratio, ADF and NDF rates of *Bitbit* genotypes at different development phases.

ADF and NDF proportions were measured as 19.80 and 27.37%, respectively, at the pre-elongation stage. These two values increased continuously in parallel to growth phases and they reached 47.17 and 56.38% at seed setting stage (Table1 and Fig. 2). As a consequence of increasing stem ratio at each following stage (Ventura *et al*., 2004; Gulumser *et al.,* 2010) ADF and NDF values were decreased. The most important factors affecting RFV values are ADF and NDF proportions of feed. Contrary of ADF and NDF, RFV values decreased as plants growing stages increased (Table 1 and Fig. 1). Regarding all values of CP, ADF, NDF and RFV, hay quality of *Bitbit* genotypes were considered as prime or premium (NRC, 2001) from pre-elongation to blooming stages. However, after blooming stage, hay quality was dramatically decreased.

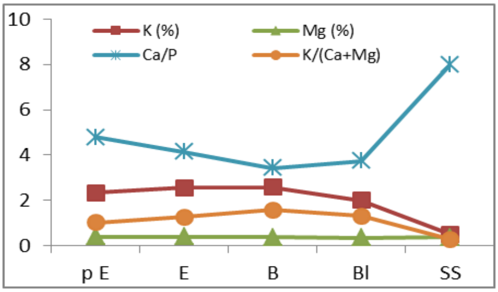


Fig. 3. K and Mg rates; Ca/P and K/(Ca+Mg) of Bitbit genotypes at different development phases.

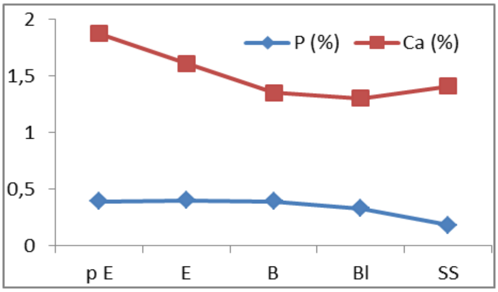


Fig. 4. P and Ca rates of Bitbit genotypes at different development phases.

Calcium content of *Bitbit* genotypes sequentially decreased till blooming stage and then it slightly increased. On the other hand, phosphorus content stayed stable up to budding phase and then it started to decrease. While there was a little change on magnesium content of *Bitbit,* potassium content were almost at the same level from beginning to budding stage, however it sharply decreased after budding stage. K/(Ca+Mg) values followed a similar path to potassium content. Ca/P rates started to decrease from beginning to budding phase then it increased. The increasing between blooming and seed setting phases was very sharp depending on Ca and P contents (Table 1, Fig. 3 and 4). Calcium, phosphorus, magnesium and potassium contents of hay samples were over the recommended values for livestock (NRC, 2001; Tekeli and Ates, 2005). K/(Ca+Mg) values did not exceed the value of 2.2 at the all stages; thus it cannot cause tetany problem (Jefferson *et al*., 2001). Ca/P rate should be between the values of 1 and 2 (Miller and Reetz, 1995). If this ratio is over 2.0, milk fever could possibly observed in livestock (Acikgoz, 2001). Ca/P rates of *Bitbit* hay samples were over 2 at the all stages.

IV – Conclusions

There were significant changes on morphological, agronomical and chemical traits of *Bitbit* genotypes according to growth stages. While hay yield, plant height, ADF and NDF values increased, crude protein, leaf ratio, and RFV values decreased at subsequent stages. Except calcium and magnesium, mineral contents of *Bitbit* genotypes decreased at each following stage. In consideration to all aspects, *Bitbit* plants should be harvested at the beginning of blooming stage to obtain ideal hay yield.

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Annual clovers performance in a dairy cows grazing system compared to perennial ryegrass. I – Yield, nutritive value and fatty acids composition of pasture during the spring grazing season

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Abstract. This paper presents a comparison, in terms of dry matter yield, nutritive value and fatty acid composition of two swards: a mixture of a hybrid ryegrass with three annual clovers (Berseem clover, Crimson clover and Persian clover ssp. *resupinatum*) and a pure perennial ryegrass pasture which were rotationally grazed by dairy cows during the spring season in the Atlantic area of Galicia (NW Spain). Pasture quality quickly decreased with the advance of grazing season for both treatments, and the hybrid ryegrass with clovers sward showed higher average values for crude protein (133.55 *vs* 103.5 g kg^{-1} dry matter) and lower neutral detergent fiber content (471.9 *vs* 553.8 g kg^{-1} dry matter) compared with the perennial ryegrass all along the season whilst sugar content and digestibility was better for the perennial ryegrass pasture. The hybrid ryegrass with clovers sward showed lower concentration in the dry matter of total fatty acids, polyunsaturated fatty acids and alpha-linolenic acid compared with perennial ryegrass. Due to the semi-prostrated habit of annual clovers, post-grazing pasture mass in the mixture was much higher along the grazing season compared with the ryegrass sward. Despite the initially good nutritive value of the herbage from the hybrid ryegrass with clovers sward, the low efficiency of herbage utilization by cows in this sward and the rapid decline in quality possess a serious inconvenient for the inclusion of annual clovers in the dairy grazing systems.

Keywords. Annual clovers – Grazing – Nutritive value – Fatty acids.

Comparaison des performances de trèfles annuels et de ray-grass pérenne au sein de systèmes d'alimentation de vaches laitières en pâturages. I – Rendement, valeur nutritive et composition en acides gras de l'herbage au cours de la période d'alimentation printanière.

Résumé. *Ce travail de recherche décrit la comparaison entre deux types d'herbe cultivée en pâturage, en termes de rendement en matière sèche, valeur nutritive et composition en acides gras: un mélange de ray-grass hybride et de trois espèces de trèfles annuels (Berseem clover, Crimson clover et Persian clover ssp. resupinatum) comparé à ray-grass pérenne en rotation, tous broutés par un troupeau de vaches laitières au cours du printemps. Toutefois, la qualité globale du mélange légumineuse/ray-grass s'est avérée supérieure à celle du ray-grass pérenne, avec des valeurs moyennes de protéine brute (133,55 vs. 103,5 g* kg^{-1} *matière sèche) plus élevées et des valeurs de fibres neutres (471,9 vs. 553,8 g* kg^{-1} *matière sèche) plus faibles. Le mélange ray-grass/légumineuses a conduit à des taux d'acides gras totaux, acides gras polyinsaturés et acide alpha-linolénique plus faibles que le ray-grass pérenne. Dans les deux cas, la qualité de l'herbage s'est vue diminuée avec l'avancée de la saison des bovins en pâture. En raison du comportement semi-couché des trèfles annuels, la masse de fourrage obtenue en « post-pâturage » des bovins fut beaucoup plus élevée que la masse de fourrage de ray-grass dans les mêmes conditions d'élevage. Malgré la bonne qualité nutritive obtenue avec le mélange ray-grass/légumineuses, la faible efficacité d'utilisation de l'herbage disponible par les bovins constitue un inconvénient sérieux en vue de l'inclusion de trèfles annuels au sein des systèmes d'alimentation en pâturage de bovins laitiers*.

Mots-clés: *Trèfles annuels – Pâturages – Valeur nutritive – Acides gras.*

I – Introduction

In a context of a growing global population with a food production systems exerting an increased pressure on fossil energy and environment where agricultural land has limited possibilities to be expanded, it is necessary to strength the research efforts towards a sustainable intensification of agriculture permitting an increase in productivity whilst reducing its environmental impacts (Foley *et al*., 2011). In this scenario it has been recognized the role of forage legumes, which inclusion in the agricultural systems-grown alone or in mixtures with grasses is an important strategy for achieving the goals of food security and environmental integrity (Smith and Gregory, 2013).

In recent years the results of the evaluation of annual legumes of genus *Trifolium* in Galicia (Northwest Spain), showed a high productivity and a good nutritive value of these species grown in winter for a silage cut at the end of April-early May, integrating a rotation of two crops per year with forage maize in summer (Pereira-Crespo *et al*., 2012a). This all-silage alternative is well-fitted to the needs of the Galician dairy farms, but there is not available information about the behaviour of the annual clovers when used for grazing. In the present study, it is evaluated the nutritive value and fatty acid composition of a mixture of three annual clovers (Berseem clover, Crimson clover and Persian clover ssp. *resupinatum*) with a hybrid ryegrass compared with a perennial ryegrass pasture which were rotationally grazed by dairy cows during the spring-early summer season.

II – Materials and methods

This study was carried out at the Centro de Investigacións Agrarias de Mabegondo (CIAM) research station farm (Galicia, NW Spain, 43° 15´ N, 8° 18´ W, 100 m above the sea level) on a silt loam soil. The two swards evaluated were a mixture of three annual clovers composed by Berseem clover (*T. alexandrinum* L. cv. Alex), Crimson clover (*T. incarnatum* L. cv. Viterbo) and Persian clover (*T. resupinatum* L. ssp. *resupinatum* cv. Nitroplus) with a hybrid ryegrass (*Lolium hybridum* Hausskn. cv. Barsilo) (ALR), and a perennial ryegrass (*Lolium perenne* L. cv. Barsintra) (PR). Both plots, with a size of 2.0 ha each, were sown in the autumn of 2014 with a seeding rate of 30 kg ha^{-1} of PR pasture and a rate of 10 kg ha^{-1} (hybrid ryegrass), 5 kg ha^{-1} (Crimson clover), 5 kg ha^{-1} (Berseem clover) and 3 kg ha^{-1} (Persian clover) of ALR pasture. Each sward was strip-grazed by 10 dairy cows managed with electric wire fences in the spring-early summer season of 2015, from the last week of April to mid-July. The PR sward received a dressing of 50 kg ha^{-1} of nitrogen (N) in mid-March and after the first grazing, whilst the annual legumes mix did not receive any N fertilization.

At weekly intervals the herbage samples of three square quadrats (0.36 m^2) that were randomly chosen in each fresh pasture strip offered to the cows, were manually cut to a 5 cm stubble height. In a similar fashion, post-grazing samples were taken when the cows were moved into a new strip of pasture. The samples were weighed and divided into two subsamples to determine: (1) dry mater content, nutritive value and fatty acids composition and (2) botanical composition. Dry matter (DM) content of pasture samples was determined by oven-drying (80 ºC, 16 hours) and dry samples were ground in a Christy-Norris hammer mill to pass a 1 mm screen. The chemical composition, digestibility and fatty acids (FA) composition of ground samples were estimated by NIRS using two calibrations equations obtained at the CIAM (Pereira-Crespo *et al*., 2012b; Pereira-Crespo *et al*., 2014). Data were subjected to ANOVA and comparison of means by Fisher's LSD procedure using Proc GLM of SAS (SAS Institute, 2009).

III – Results and discussion

The seeded species accounted for 982 and 984 g kg^{-1} of sampled herbage DM in ALR and PR pastures. Botanical composition of the ALR pasture was dominated by legumes (941.4 g kg^{-1}

DM on average). But the proportion of each legume component of the ALR pasture changed strongly as the season progressed. The proportions of Crimson, Berseem and Persian clovers were 467, 222 and 216 g kg^{-1} DM in the first, and 7, 834 and 136 g kg^{-1} DM, respectively in the last grazing periods. Average pasture on offer was markedly higher for the ALR compared with the PR pasture (4.87 *vs* 2.41 t DM ha^{-1}) and pasture utilization by dairy cows was clearly lower for the legumes mixture (32.4%) compared with the ryegrass pasture (48.8%), with values ranging from 44.3 to 30.2% and from 61.7 to 40.0% for the first and last period, ALR and PR pastures, respectively. It is noteworthy that results observed in this experiment could be influenced by the severe drought beginning in the end of the spring of 2015 which accelerated the maturity of pasture and influenced a poor utilization of herbage on offer. It was registered a total rainfall of 9.6 mm in the months of June to mid-July compared with a normal average of 87.1 mm in this period.

Pasture chemical composition and nutritive value (Table 1) were different for the two types. ALR pasture had significantly ($p<0.001$) higher CP and lower NDF contents compared with PR pasture that showed a higher content in DM, WSC, NSC, IVOMD and energy value. The herbage quality decreased for both pastures with the advance towards maturity, being observed a reduction in the CP content of -5.1 and -2.4 g kg^{-1} DM $week^{-1}$ and of -13.3 and -16.5 g kg^{-1} $week^{-1}$ in the IVOMD value respectively, for the ALR and the PR swards. In contrast, there was an increase in the cell-wall content (FND) of 9.8 and 15.2 g kg^{-1} DM $week^{-1}$ and in FAD content of 7.0 and 7.5 g kg^{-1} DM $week^{-1}$, for ALR and PR pastures, respectively. The rapid loss of protein and energy value in ALR confirms the observations of Pereira-Crespo *et al*., (2012a) who reported a marked reduction in the nutritive value of the annual clovers once they reach the flowering stage.

Table 1. Effect of pasture type and interaction of pasture type x period on dry matter content (g/Kg), chemical composition (g/kg DM), in vitro organic digestibility (g/kg) and net energy of lactation (Mcal/kg DM)

	Pasture type			Pasture type x Period								
	ALR	PR	p	ALR				PR				p
				P1	P2	P3	P4	P1	P2	P3	P4	
DM	204.8	251.7	***	114.9	140.2	224.5	339.5	199.4	211.1	239.8	356.4	**
OM	911.1	914.7	ns	895.8	906.7	919.9	922.0	905.2	900.9	912.9	939.7	ns
CP	133.5	103.5	***	162.6	139.2	115.9	116.2	106.6	107.7	114.8	85.0	*
ADF	361.7	310.0	***	331.4	345.7	374.6	395.1	288.3	299.9	295.1	356.5	ns
NDF	471.9	553.8	***	431.3	448.0	488.6	519.6	504.3	535.0	534.4	641.7	*
WSC	86.7	192.8	***	100.0	120.0	80.4	46.4	245.5	212.5	176.2	136.9	ns
NSC	126.6	212.2	***	130.4	145.2	127.9	103.0	254.8	213.7	202.0	178.5	ns
IVOMD	652.5	701.9	***	702.8	693.4	631.0	582.8	760.5	733.2	702.3	611.8	ns
NEL	1.34	1.47	***	1.44	1.43	1.30	1.19	1.60	1.52	1.47	1.29	ns

ALR: mixture three annual clovers with a hybrid ryegrass; PR: perennial ryegrass; P: period; P1: 27 April-17 May; P2: 18 May-7 June; P3: 8 June-28 June; P4: 29 June-19 July; DM: dry matter; OM: organic matter; CP: crude protein; ADF: acid detergent fiber; NDF: neutral detergent fiber; WSC: water-soluble carbohydrates; NSC: non-structural carbohydrates; IVOMD: *in vitro* OM digestibility; NEL: net energy of lactation; *p<0.05; **p<0.01; ***p<0.001; ns: non significant.

Fatty acids composition of both pasture types followed the polyunsaturated-dominant profile typical of forage pastures (Table 2), accounting the alpha-linolenic acid (C18:3n3) for 55.6 and 68.4% of the total FA (TFA) of the annual legumes mixture and the PR pasture, respectively). Higher concentrations of TFA, polyunsaturated FA (PUFA), alpha-linolenic acid and palmitic acid were found in PR compared with ALR, showing average values, respectively, of 7.71 *vs.* 6.51, 6.23 *vs* 4.98, 5.28 *vs* 3.62 and of 1.13 *vs* 0.93 g kg^{-1} DM. Inversely, ALR showed a higher content in linoleic acid and in oleic acid compared with PR (1.33 *vs* 0.93 and 0.21 *vs* 0.12 g kg^{-1} DM), respectively.

Fatty acid concentration in the DM decreased with advancing maturity of pasture. The TFA and the alpha-linolenic contents in the last period of grazing, compared with that of the first period, were, respectively, 38% and 26% for ALR and 50 and 41% for PR, showing a faster loss in the FA content for the mixture of annual legumes than for the perennial ryegrass pasture.

Table 2. Effect of pasture type and interaction of pasture type x period on composition of fatty acids (g/kg DM)

	Pasture type			Pasture type x Period								
				ALR				PR				p
	ALR	PR	p	P1	P2	P3	P4	P1	P2	P3	P4	
C16:0	0.93	1.13	**	1.04	1.08	0.89	0.72	1.19	1.23	1.17	0.94	ns
C18:1n9c	0.21	0.12	***	0.11	0.14	0.22	0.37	0.10	0.15	0.13	0.12	***
C18:2n6c	1.33	0.93	***	1.63	1.67	1.21	0.81	0.91	0.99	0.91	0.92	**
C18:3n3	3.62	5.28	***	5.90	4.79	2.59	1.20	6.41	6.43	6.14	2.15	*
TFA	6.51	7.71	*	9.11	8.11	5.29	3.53	8.73	9.09	8.63	4.39	ns
SFA	1.28	1.32	ns	1.40	1.43	1.22	1.09	1.29	1.47	1.38	1.15	ns
MUFA	0.24	0.15	***	0.14	0.17	0.24	0.40	0.11	0.17	0.17	0.15	***
PUFA	4.98	6.23	**	7.56	6.49	3.83	2.02	7.33	7.45	7.07	3.08	***

ALR: mixture three annual clovers with a hybrid ryegrass; PR: perennial ryegrass ; P: period; P1: 27 April-17 May; P2: 18 May-7 June; P3: 8 June-28 June; P4: 29 June-19 July; C16:0 palmitic acid; C18:1n9c9 oleic acid; C18:2n6c linoleic acid; C18:3n3 alpha-linolenic acid; TFA: total fatty acids; SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; *p<0.05;**p<0.01; ***p<0.001; ns: non significant.

IV – Conclusions

The ALR pasture showed higher DM yield but the low efficiency of herbage utilization by cows, caused by the semi-prostrated habit of growth of these species, indicating a major constraint for their inclusion in dairy grazing systems. This fact and the rapid decline of their initial good nutritive value suggest that these species are more suitable for silage production in mid-spring.

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Annual clovers performance in a dairy cows grazing system compared to perennial ryegrass.
II – Milk yield and composition

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Abstract. A grazing experiment was carried out in Galicia (NW Spain) to examine the effects of sward type on dairy cow performance and milk quality during spring. Twenty Holstein-Friesian dairy cows were randomly assigned to two grazing groups (n=10) which rotationally grazed a mixture of a hybrid ryegrass and three annual clovers (Berseem clover, Crimson clover and Persian clover ssp. *resupinatum*) (ALR) sward or a perennial ryegrass (PR) sward from last week of April to mid-July, preceded by a pre-experimental period of three weeks. Grazing was performed between the morning and evening millings and cows remained in the barn during the night, consuming a mixture composed of (on a dry-matter basis per cow) 5 kg of maize silage, 1 kg of grass hay and 2.5 kg of a commercial concentrate. Dairy cow yields of milk, milk fat and milk protein were similar for both treatments, showing the ALR an initially higher milk yield followed by a more rapid drop compared to the PR treatment. It is concluded that there is no evidence, from a productive point of view, that grazing of annual legumes is an alternative to the classical perennial ryegrass swards in the conditions of the Galician dairy cow farming.

Keywords. Annual clovers – Grazing – Milk production – Fatty acids.

Comparaison des performances de trèfles annuels et de ray-grass pérenne au sein de systèmes d'alimentation de vaches laitières en pâturages. II. Rendement et composition du lait produit.

***Resumé**: Une expérience d'alimentation en pâturage a été conduite au cours du printemps en Galice (NO Espagne) dans le but d'évaluer les effets du type d'herbage sur les performances des vaches laitières en termes de production et qualité du lait. Vingt vaches Holstein-Friesian furent assignées de manière aléatoire à deux groupes en pâturage (n=10) qui broutaient en rotation soit un mélange de ray-grass hybride et de trois espèces de trèfles annuels (Berseem clover, Crimson clover et Persian clover ssp. resupinatum) (ALR), soit un ray-grass pérenne (PR), le tout depuis la dernière semaine d'avril jusqu'à la mi-juillet précédé d'une période pré-expérimentale de trois semaines. Entre les deux traites, les bovins furent placés en pâturage durant la journée, après quoi ils furent alimentés à l'étable avec un mélange (sur la base de la quantité de matière sèche par animal) composé de 5 kg d'ensilage de maïs, 1 kg d'herbe ensilée et 2,5 kg de concentré. Les rendements obtenus en termes de production de lait, % de protéine totale et % de graisse totale furent similaires pour les deux traitements. Toutefois, les essais menés avec l'ALR ont permis d'observer dans un premier temps une plus grande production de lait mais suivie d'une baisse rapide de cette même production comparée au rendement du système basé sur le PR. D'un point de vue productif, ces essais nous permettent de conclure que l'alimentation de bovins basée sur des légumineuses annuelles ne constitue pas une alternative réelle au modèle classique basé sur du ray-grass pérenne, dans les conditions d'élevage de bovins laitiers en Galice.*

***Mots-clés**: Trèfles annuels – Pâturages – Production de lait – Acides gras.*

I – Introduction

Galician agriculture is highly specialized in dairy milk production. Dairy farms manage about one third of Utilized Agricultural Area and generate 40% of the Gross Value Added of the agricultural sector in the region (López-Iglesias *et al*., 2013). Dairy cow's production is 2.5 million tonnes, accounting for more than 40% of total milk cow's production in Spain. This figure makes Galicia, the NW Atlantic region of Spain, to be amongst the 10 EU regions with the highest level of dairy cow's production (Eurostat, 2013). The dairy production model in Galicia has evolved towards an intensive use of land, in which the rotation of Italian ryegrass with forage maize in a double cropping system is dominant amongst the more productive farms (Fernández-Lorenzo *et al*., 2009). In order to increase the protein output of this system there is evidence that annual clovers can play a role when grown for silage as a winter crop and harvested in mid-spring, based on their good productivity (Valladares *et al*., 2012) and high protein content (Pereira-Crespo *et al*., 2012).

On the other hand, there has been a growing interest among Galician dairy farmers about the possibility of differentiating their milk on the base of its fatty acids (FA) profile, taking advantage of better prices from the dairy industry. With this purpose, it is generally adopted a feeding strategy in which expensive sources of polyunsaturated vegetable oils (e.g. linseed) are included in the diet. Another approach, followed by a minor group of farmers, relies on the grazing of pastures composed mainly by perennial ryegrass, which is the dominant specie in Galician swards. It is well-known that feeding of fresh pastures to dairy cows improve the polyunsaturated FA concentration in milk fat (Dewhurst *et al*., 2006) in a more economical and rational fashion compared with the supplementation of the diet of stall-fed cows. With this scope, the use of legume species in the pastures offer additional advantages compared with the use of ryegrass-dominant swards, based not only in an enhanced milk yield and FA profile (Dewhurst *et al.,* 2009), but in the economy of nitrogen inputs in the farm and in a positive effect on the reduction of greenhouse gas emissions (Peeters *et al*., 2006).

There is a lack of published information about the potential of annual clovers to be used in the feeding of dairy cows as a grazing resource. In the present work it is studied the effect of grazing a mixture of three annual clovers and a hybrid ryegrass sward, compared with a pure perennial ryegrass sward, on milk yield and FA composition with the objective of gaining insight in the role of annual legumes for improving the forage systems in the Atlantic dairy production area of Spain.

II – Materials and methods

A field experiment was performed from April to July 2015 at the Centro de Investigacións Agrarias de Mabegondo (CIAM) research station farm (Galicia, NW Spain, 43° 15´N, 8° 18´W, 100 m altitude). In the autumn of 2014 two plots of 2.0 ha each were seeded with a mixture of annual clovers composed by Berseem clover (*T. alexandrinum* L. cv. Alex), Crimson clover (*T. incarnatum* L. cv. Viterbo) and Persian clover (*T. resupinatum* L. ssp. *resupinatum* cv. Nitroplus) and a hybrid ryegrass (*Lolium hybridum* Hausskn. cv. Barsilo) (sward ALR) or a pure stand of perennial ryegrass (*Lolium perenne* L. cv. Barsintra) (sward PR). Twenty Holstein-Friesian cows with a milk yield of 37.5 ± 6.8 kg/head/day and a live weight of 590 ± 66 kg were randomly distributed into two equal groups of ten cows each (two primiparous cows per group) and assigned to one of the two pastures. Cows were managed with electric fencing to strip-graze the paddocks from the last week of April to mid-July. Grazing was allowed after the morning milking, during a 10 hours per day (8:00 am to 18:00 pm), after which cows were fed in the barn a mixture composed of (on a dry-matter basis per cow) 5 kg of maize silage, 1 kg of grass hay and 2.5 kg of a commercial concentrate with a 25% of crude protein (CP).

Individual milk yield was recorded daily at the parlor using the DeLaval Alpro System and milk samples were taken per animal in the morning and evening milking of 3 consecutive days in the weeks 3, 6, 9 and 12 of the experiment (n=480). Milk samples were immediately stored at 4°C and transported to the Laboratorio Interprofesional Galego de Análise do Leite (LIGAL) where they were subjected to routine FTMIR analysis using a MilkoScan™ FT6000 (Foss Electric A/S, Hillerød, Denmark). The milk samples were analyzed for: chemical composition (fat, protein, lactose and non-fat solids), urea and FA profile. Blood samples were taken from the tail vein of each cow using vacutainer sampling tubes and analyzed for the urea content by the enzymatic method in a veterinary laboratory.

Data were subjected to ANOVA analysis using the model $y= \mu + \alpha_i T + \beta_j P + (\alpha\beta)_{ij} TxP + X_{ijk} + \varepsilon_{ijk}$, where T is the pasture type (fixed factor), P is the week of the experiment (random factor) and X stands for the covariates (days in milk, parity, initial yield and initial live weight) used in the analysis. The separation of means was performed by Duncan's multiple range procedure and all the analyses were done using Proc GLM and Proc Mixed procedures of SAS package (SAS Institute, 2009).

III – Results and discussion

Daily yield of milk, milk fat and milk protein (mean values of 27.94 and 27.12, 1.09 and 1.05, 0.78 and 0.75 kg cow^{-1} day^{-1} for ALR and PR, respectively) were not affected by pasture type (Table 1).

Table 1. Effect of pasture type and interaction of pasture type x period on milk yield and composition

	Pasture type			Pasture type x Period								
	ALR	PR	*p*	ALR				PR				p
				P1	P2	P3	P4	P1	P2	P3	P4	
Yield (kg cow^{-1} day^{-1})												
Milk †	27.94	27.12	*ns*	32.37	28.16	24.75	25.95	27.51	28.38	26.32	26.26	***
Fat	1.09	1.05	*ns*	1.27	1.10	0.96	0.99	1.07	1.07	1.02	1.05	***
Protein	0.78	0.75	*ns*	0.88	0.77	0.70	0.74	0.74	0.81	0.74	0.71	***
Non-fat solids	2.22	2.14	*	2.56	2.25	1.98	2.05	2.20	2.29	2.07	2.01	***
Milk composition (%)												
Fat	4.16	4.16	*ns*	4.23	4.19	4.15	4.08	4.11	3.87	4.19	4.48	***
Protein	2.97	2.97	*ns*	2.93	2.95	2.99	3.03	2.85	2.94	3.03	3.04	***
Lactose	4.72	4.66	***	4.74	4.79	4.74	4.60	4.70	4.57	4.67	4.68	***
Non-fat solids	8.48	8.41	*	8.48	8.54	8.52	8.37	8.38	8.31	8.46	8.48	*ns*
Milk fatty acids (% total FA)												
SFA	70.93	69.83	**	70.84	70.90	71.00	70.99	68.81	70.07	70.61	69.87	*ns*
MUFA	23.74	24.30	*ns*	23.70	23.04	23.72	24.56	25.06	23.04	23.68	25.39	*ns*
PUFA	1.67	1.71	*ns*	2.14	1.54	1.44	1.53	2.04	1.45	1.61	1.74	**
Urea												
Milk urea (mg L^{-1})	168	129	***	163	150	151	210	93	77	144	202	***
Blood urea(mg dL^{-1})	18.66	16.21	***	15.48	15.37	21.17	23.24	13.11	13.41	17.46	20.93	*ns*

ALR: mixture of three annual clovers with a hybrid ryegrass pasture; PR: perennial ryegrass pasture; P: period; P1: 27 April-17 May; P2: 18 May-7 June; P3: 8 June-28 June; P4: 29 June-19 July

† Fat and protein corrected milk production (3.5% fat, 3.5% protein); SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; * p<0.05; ** p<0.01; *** p<0.001; ns: non significant.

Non-fat solids yield showed a slight, although significant (p<0.05) higher value for ALR compared with PR (2.22 *vs* 2.14 kg cow^{-1} day^{-1}). Fat and protein concentration in milk (overall average values of 4.16 and 2.97%, respectively) were not significantly different between the ALR and the PR treatments, whilst the milk contents of lactose (4.72 *vs* 4.66%, p<0.001) and non-fat-solids (8.48 *vs* 8.41%, p<0.05) were higher for the ALR pasture compared with PR, respectively. Milk fat from the PR pasture showed a less saturated profile compared with ALR (p<0.01) with mean values of saturated fatty acids (SFA) of 69.83 and 70.93 % total FA, respectively, whilst no differences (p>0.05) were found between the two pastures for the monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids content of milk. Milk and blood urea from cows grazing the ALR pasture showed higher values (p<0.001) compared with those fed in the PR pasture (milk urea 168 *vs* 129 mg L^{-1} and blood urea 18.66 *vs* 16.21 mg dL^{-1}, ALR and PR respectively), probably reflecting a higher protein/energy ratio in the ALR sward, although urea values in both treatments are in a range that can be considered as normal in the dairy cow's feeding.

It was noted a faster decrease in the daily yields of milk, milk fat and milk protein with the advancement of the lactation for the cows grazing the ALR pasture, with a weekly variation per cow of -0.71 *vs* -0.13 kg of milk, -31.1 *vs* -2.0 g of fat and -15.5 *vs* -3.3 g of protein, reflecting a more accelerated loss of quality of the ALR pasture compared with the PR pasture with the advance of the grazing season (Veiga *et al*., 2016). On the other hand, the SFA and MUFA content of milk fat remained almost constant during the grazing season, being observed a more rapid loss of the PUFA profile for the cows grazing the ALR sward.

IV – Conclusions

No relevant differences were found between cows grazing a mix of annual legumes and ryegrass sward comparing to a perennial ryegrass sward in terms of milk yield and milk composition of cows during the mid-spring mid-summer grazing period. From this point of view, it was not observed any advantage of the use of annual legumes over the predominant grass species in the dairy grazing systems of the Atlantic NW zone of Spain.

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Study of productivity pattern over 3 years of some annual grass and legume fodders carried as pure and as mixture in rainfed cereal based system in Algerian semiarid area

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Abstract. In the aim to improve sustainability and resilience of fallow-wheat system highly vulnerable against climatic change (REFORMA Arimnet project), over the years 2012/2013, 2013/2014 and 2014/2015, 1 triticale, 1 oat (grass), 2 peas (tall and semi-dwarf), 1 common vetch and 1 Narbonne vetch varieties have been tested in a device mimicking a fodder - wheat rotation in a rainfed system. Elementary experimental plots of 12 m^2 each (6 pure, 8 doubles and 2 complexes) are divided into 4 blocks. The wheat is sown on a plot similar to that of the set of all fodder plots within each block. The measurements concerns dry biomass productivity and botanical composition. Results vary depending on weather conditions, particularly the rainfall total amount and its seasonal distribution. The spring rains appear having decisive effect on productivity whatever the annual amounts received. Productivity of hay appears higher in grasses relative to the legumes in pure, with an advantage for oats. Among legumes, erect pea distinguished itself by an interesting and somewhat fluctuating productivity during the years while the common vetch and Narbonne vetch recorded low results. Binary associations showed better yields than complex. In each of the two combinations, those containing triticale gave the best yields while combinations containing oats have experienced lower productivity but showed a better balance regarding the botanical composition. Wheat yields were variable and generally follow the amount of rain received. On the whole, it appears that the farms practicing this system can replace the nude fallow by a rainfed pure or association fodder culture which will strengthen their livelihoods and sustainability by fighting against soil erosion.

Keywords. Legumes – Grasses – Fodder associations – Productivity – Phenology – Algeria – Semi-arid.

Comportement et performances pendant 3 années de certains cultivars fourragers menés en pur et en association dans un système céréalier pluvial en zone semi-aride algérienne

Résumé. *Dans le but d'améliorer la durabilité et la résilience des systèmes céréaliers-jachère face aux changements climatiques (projet REFORMA – ARIMNET), au cours des années 2012/2013, 2013/2014 et 2014/2015, une variété de triticale, une d'avoine (graminées), 2 de pois, une de vesce commune et une de vesce de Narbonne ont été mises en expérimentation dans un dispositif mimant une rotation au sein d'un système blé-fourrages mené en pluvial. Les parcelles élémentaires expérimentales de 12m2 chacune sont réparties en 4 blocs (6 en pur, 8 en doubles et 2 complexes). Le blé est semé sur une parcelle équivalente à celle de l'ensemble de toutes les parcelles de fourrages dans chaque bloc. Les mesures effectuées concernent la productivité en biomasse sèche et la composition botanique. Les résultats varient en fonction des conditions climatiques notamment la quantité de pluie et sa répartition saisonnière. Les pluies printanières apparaissent à cet effet déterminantes quelles que soient les quantités annuelles reçues. La productivité en foin est plus élevée chez les graminées relativement aux légumineuses semées en pur, avec un avantage pour l'avoine. Chez les légumineuses, le pois fourrager érigé s'est distingué par une productivité intéressante et peu fluctuante durant les années alors que la vesce commune et la vesce de Narbonne ont enregistré des résultats plus faibles. Les associations binaires ont enregistré de meilleurs rendements que les complexes. Dans chacune des combinaisons, celles contenant le triticale ont donné les meilleurs rendements alors que les associations contenant l'avoine ont enregistré une productivité plus faible mais elles ont montré un meilleur équilibre en ce qui concerne la composition botanique. Les rendements de blé ont été variables et suivent globalement la quantité de pluie reçue. D'une manière globale, il apparaît que les exploitations pratiquant ce système peuvent remplacer la jachère nue par une* *culture fourragère en pur ou en association qui renforcera leurs sources de revenus et la durabilité de leur système tout en luttant contre l'érosion des sols.*

Mots-clés. *Légumineuses – Graminées – Associations fourragères – Productivité – Phénologie – Algérie – Semi-aride.*

I – Introduction

Semi-arid rainfed cereal – livestock systems are very widespread in Algeria (30 % of the agrarian area) and constitute the productive base of the major part of the cereal sector (80%). The small average of farm size (< 8 ha) and natural unfavorable conditions (shallow soils, high erosion risks) are the traits of a certain vulnerability of these systems. These one are threatened than by a marked insufficiency of high-protein feedstuff, the overexploitation of pastoral resources, the increasing costs and/or the decreasing availability of irrigation water and mineral fertilizers, and the increasing drought and heat stress arising from climate change. Natural feeding resources are unable to satisfy the growing needs of livestock following the deterioration of grazing lands. In the past, large farms found free of charge feeding resources (fallow, meadows, rangelands), but with reducing farm size, farms are abandoning pastoral sheep more exigent on large natural pastures and are developing progressively bovine on rainfed or/and irrigated fodder productions (Abbas, 2013). The diversification of fodder production possibilities on rainfed conditions such as forage legumes and legumes / grasses associations could be of a paramount importance for stakeholders (Abdelguerfi, 1976). Among arable forage legumes in cereal semi -arid zones of Algeria the genus *Pisum* (peas) could constitute a base of sustainable fodder systems well adapted and integrated into cereal rotations. Grown on fallow in pure stand and / or in combination with one or more annual grasses forages could provide an abundant and of excellent quality hay (Rihawy *et al,* 1987). To test efficiency of such forages, this paper gives the results of 3 successive years in the semi-arid region of Sétif (Algeria).

II – Material and methods

The experiment was carried out in 2012-2013, 2012-2013 and 2014-2015 at Sétif INRAA station (36° 9'26.30"N, 5°22'17.78"E, and altitude: 970m). In 2011/2012, land was driven as fallow. Trials were put in rotation with wheat. The soil was clay-loam with low organic matter, a total rate of 35% limestone and pH 7.2. The soil tillage was light and consisted in 3 passages of cover-crop machinery. Seeding was made on October 27, 2012 and mowing on May, according to the physiological stages of each culture. Weather conditions were close to the typical climate of the region: mild and dry autumn, cold and somewhat rainy winter, wet spring, hot and dry summer. Forage resources used are shown in Table 1.

Table 1. Characteristics of crop material used

Crop material	Species	Varieties	Origin	Observation
Triticale	*Tritical secal*	Amarillo	CRA/ FLC (Italy)	
Common oat	*Avena sativa*	Genziana	CRA/ FLC (Italy)	
Pea 1 (P1)	*Pisum sativum*	Kaspa	CRA/ FLC (Italy)	Semi-dwarf
Pea 2 (P2)	*Pisum sativum*	*Linea* 1-27b	CRA/ FLC (Italy)	tall
Common vetch	*Vicia sativa*	*Barril*	CRA/ FLC (Italy)	
Narbon vetch	*Vicia narbonensis*	Bozdag	Turkey	

The experimental design consisted in a completely randomized block design (blocks). Each block contained elementary plots of 4 X 3 m (12 m^2) for each experimental crop grown in pure stand and each mixture between 2 fodders (one grass and one legume) and 4 fodders (2 legumes and 2 grasses). The number of elementary crop variants was 64 (16 X4). Seeding was made manually in lines spaced 25 cm with doses presented in Table 2.

Table 2. Seed doses employed (kg/ha)

Crop material	Pure stand	Binary mixture (pure stand/2)	Complex mixture (pure stand/4)
Kaspa (P1)	168.73	84.37	42.18
Linea 1/27/b (P2)	159.16	79.58	39.79
Narbon vetch (N)	144.90	72.45	36.23
Common vetch (V)	81.05	40.53	20.27
Oat (O)	91.37	45.68	22.84
Triticale (T)	103.16	51.58	25.79

Grasses were fertilized with 160 kg N ha^{-1} while the pure legumes or associations profited from 50 kg N ha^{-1}. The pure grasses received 50% nitrogen fertilizer at planting and the rest at tillering. Phosphorus fertilisation was 120 kg P/ha for pure grasses and 300 kg P/ha for legumes in pure stand and in association. Mowing was performed manually on the entire surface of each plot. Cuts were done at following stages: waxy pods for legumes and early heading for grasses. Fresh weight was assessed on site and the dry weight was obtained after oven-drying (65 °C for 72 h) a sample of 200 g of each micro plot. A sample corresponding to the yield of 1 m^2 was used for determining the rate of the different botanical components. Statistical analysis was performed by XLSTAT ® software. Temperatures and rainfall were very variable between months and years. Winter was very cold and received the most rainfall (when crops did not need). In the spring, when the vegetation was in optimal growth, rainfall decreased and temperatures increased quickly. Differences between years were in favour of the two first years (respectively 422 and 407mm against 360mm between September and June). The third one had a very cold winter and dry autumn and spring. First year was more rainy but at final plant cycle, dryness occurred strongly.

III – Results and discussion

Year had a significant effect on dry biomass production (Table 3). **Pure legumes**: DM yields increased progressively to reach more than 6 t.ha^{-1} in 2015 especially peas and common vetch. Both tall and semi-dwarf pea cultivars seemed more adapted regarding this parameter. Narbon vetch showed a significantly lower yield (< 4 t.ha^{-1}). **Pure grasses**: oats and triticale gave very close productions, around 8 t ha^{-1}. First year production was probably affected by the rainfall deficit in late spring. **Binary mixtures**: in most combinations, it was observed an increase of productivity over time, despite the weather variability. The positive effect of wheat legume/mixtures rotation (soil nitrogen fertility) could be the main factor of these results. Pea's mixtures with triticale and/or with oat were the well performing. Common vetch gave also acceptable results with the 2 tested grasses. Narbon vetch did not give, however, satisfactory results. Complex mixtures showed less importance relatively to binary mixture. In the 2 last years Narbon and common vetches seemed more efficient than peas unlike pure and grasses binary mixtures. Wheat production was significantly increasing over the experiment period (1.1, 1.55 and 2.65 t.ha^{-1}) confirming the well effect of this rotation on whole system productivity.

The weeds rate was very variable. Its amount was in average rather important, around 30% of the total dry biomass. The experiment land long fallow use (3 successive years) could explain this situation. On the other hand, we assisted to a progressive decrease of weed infestation, except in grasses and complex mixtures. Bromine gender was very important especially with wheat. More fallow resorption by fodders could certainly reduce weed amounts. Legume's rate in mixtures varied significantly between the first and the second year. It seemed to be stabilized among the second and the third year. It reached around 35% in average. This result was not optimal but could progress positively over time. Legume cultivars used could be less resistant than grasses to extreme weather conditions like frosts and snow occurring every year in winter and early spring. This phenomenon could explain losses in legumes. Peas with triticale registered the best rates (close to 40%). Oat cultivar was more aggressive against the used legumes. Narbon vetch did not give satisfactory results in mixtures. Legume's rate in complex mixtures showed a positive evolution reaching more than 40 %. The two pea cultivars were more adapted than vetches. The outcomes of the trials were very close to those obtained in Tunisia, Greece and Turkey in humid conditions (Hechmi, 1999; Lithourgidis *et al.*, 2011; Yilmaz *et al.*, 2015).

Table 3. Productivity parameters of the different tested crops (O: oat, T: triticale, P1: tall pea, P2: semi dwarf pea, V: common vetch, N: Narbon vetch, In bold significant high an low values)

	Total DM yield (t/ha)			Weeds free total yield (t/ha)			Legumes % of total yield			Weeds % of total yield		
Crops	2012/ 2013	2013/ 2014	2014/ 2015	2012/ 1013	2013/ 2014	2014/ 2015	2012/ 2013	2013/ 2014	2014/ 2015	2012/ 2013	2013/ 2014	2014/ 2015
N	**2.02**	**2.83**	**3.82**	0.90	2.00	2.16	100.0	70.67	56.54	55.55	29.33	43.46
NO	4.27	5.73	5.97	2.45	3.28	3.96	0.05	**20.94**	23.63	**42.78**	**42.77**	33.76
NT	3.98	**8.42**	3.88	2.14	4.53	2.92	0.07	**17.42**	15.56	**46.17**	**46.17**	24.71
NVOT	3.00	**7.65**	**7.14**	1.98	**5.90**	4.44	0.05	19.07	43.40	34.02	22.86	37.84
O	4.53	**8.38**	**8.91**	3.86	**6.43**	**5.66**	0.00	0.00	0.00	14.85	23.25	36.52
P1	2.72	3.79	**7.16**	2.14	3.13	4.15	100.0	82.70	58.03	21.33	17.30	**41.98**
P1 O	3.47	7.39	6.63	2.36	5.04	4.45	0.10	35.96	25.63	31.85	31.85	32.92
P1 T	2.10	7.12	6.13	1.42	4.50	4.12	0.08	30.03	28.56	32.56	36.82	32.70
P1P2OT	4.86	6.47	6.61	3.07	5.44	4.41	0.12	27.46	61.37	**36.82**	15.94	33.34
P2	3.69	4.09	**6.97**	2.61	3.76	4.29	100.0	91.91	61.59	29.32	8.09	**38.41**
P2 O	3.45	**6.69**	**8.22**	2.44	4.73	**5.64**	100.0	33.12	34.82	29.34	29.34	31.45
P2 T	4.30	**6.66**	**9.02**	2.80	4.34	**5.69**	0.15	31.58	39.77	34.84	34.84	36.88
T	3.81	**8.69**	**7.54**	3.35	**7.14**	4.93	0.00	0.00	0.00	12.11	17.78	34.59
V	2.02	4.16	6.50	0.90	3.60	3.91	100.0	86.65	60.11	100.0	13.35	39.89
VO	4.63	6.63	7.05	2.86	4.09	4.46	0.03	30.83	21.70	**38.25**	38.26	36.73
VT	3.11	8.05	5.92	1.95	5.05	3.91	0.05	30.75	27.62	**37.28**	37.28	33.96

IV – Conclusions

Narbon vetch was clearly confirmed as inappropriate for mixtures and the cultivar tested was not adapted as pure stand crop. Tall and semi-tall peas tested cultivars gave interesting results and could be included as part of sustainable strategies of fallow in cereal based semiarid areas. Triticale showed good values and could be also another part of this strategy with oats.

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Antioxidant compounds and nutritional quality of eight Tunisian populations of echinus medic (*Medicago ciliaris* L.)

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Abstract. Analysis of the nutritional value of dry biomass, pods and straw of eight populations of *Medicago ciliaris* L. was undertaken. Classic composition, total phenol and tannins, condensed tannins and antioxidants compounds were analyzed. Results showed significant differences for crude protein content in biomass and pods, chlorophyll b in pods and lycopene in straw. Crude protein content varied from 7 to 24 % in dry biomass and from 9 to 21 % in pods. Chlorophyll b in pods varied between 0.6 and 4.6mg/g DM while lycopene in straw ranged from 0.1 to 0.3 mg/g DM. Populations 9144, 9140, 9142 and 9153 are the most interesting for their nutritional values and their antioxidants compounds. These results showed the importance of this species in animal nutrition and allowed us to exploit the populations according to their vocation (green or dry pastures).

Keywords. *Medicago ciliaris* L. – Local populations – Antioxidants compounds – Phenols and tannins.

Composés antioxydants et qualité nutritionnelle de huit populations tunisiennes de* Medicago ciliaris *L.

***Résumé.** L'analyse de la valeur nutritionnelle de la biomasse sèche, des gousses et de la paille de huit populations de* Medicago ciliaris *L. a été étudiée dans le présent travail. La composition classique, les tanins et les phénols totaux, les tanins condensés ainsi que les antioxydants ont été analysés. Les résultats ont montré des différences significatives pour les protéines brutes dans la biomasse sèche et les gousses, la chlorophylle b dans les gousses et le lycopène dans la paille. La teneur en protéines brutes varie de 7,5 à 23,9 % dans la biomasse sèche et de 9 à 21,7 % dans les gousses sèches. La chlorophylle b varie de 0,6 à 4,6 mg / g MS dans les gousses alors que le lycopène varie de 0,1 à 0,3 mg / g MS dans la paille. Les populations 9144, 9140, 9142 et 9153 sont les plus intéressantes pour leurs valeurs nutritionnelles et leurs composants antioxydants. Les résultats ont montré aussi l'importance de cette espèce dans l'alimentation des animaux et nous permettent d'exploiter ces populations selon leur vocation (pâturage vert ou sec).*

Mots-clés. Medicago ciliaris *L. – Populations locales – Composés chimiques antioxydants – Phénols et tanins.*

I – Introduction

Tunisian flora is particularly rich in species, some are proving of great agricultural value, as they are used as fodder for livestock or as food plants and others have medicinal application. In order to enhance plant genetic resources in Tunisia, knowledge on forage and pastoral species is an essential concern. This work focused on chemical and nutritional analysis of the dry biomass, pods and straw of eight local populations of *M. ciliaris* belonging to the genus *Medicago*. The evaluation of forage quality is a very important factor affecting both animal health and animal products. In vetches, phenolics may act as antioxidants and they have an important role in the defense system of the seeds (Stanisavljević *et al*., 2014).

II – Materials and methods

Eight populations of *M. ciliaris* L. collected from different regions of the country and stored at INRAT were used in this work. The ecological characteristics of collection sites of the studied populations are given in Table 1.

Table 1. Main characteristics of the collection sites of *M. ciliaris* L. populations

Code population	Site name	Bioclimate	Direction	Altitude (m)	Rainfall (mm)	Max T (°C)	Min T (°C)
9140	Siliana	Semiarid	NW	575	341.1	38.6	1.6
9141	OuedMessouge	Semiarid	NW	500	367.1	38.6	1.6
9142	Dougga	Sub humid	NW	320	493.5	21.7	9.9
9144	Ghzala	Humid	NE	5	554.2	31.8	6.7
9153	Ghar El Melh	Humid	NE	6.19	497.8	32.9	6.7
9150	Zana	Humid	NE	10	507.0	31.8	6.7
9151	Raoued El Hessiane	Semiarid	NE	5.75	398.5	35.1	5.4
9152	KalaatAndalous	Semiarid	NE	5.85	398.5	35.1	5.4

Only ground samples of dry biomass and pods were analyzed for dry matter (DM), organic matter (OM) and crude protein (CP) according. They were also analyzed for secondary compounds (total phenol and tannins and condensed tannins) according to Makkar (2003) and saponins according to Hiai *et al.* (1976). However, antioxidants components (β- carotene, lycopene and chlorophylls a and b) were determined on dry biomass, pods and straw using the method of Nagata and Yamashita (1992). All pigments in sample were extracted with acetone – hexane mixture (4:6) at once, the absorbance of the filtrate was measured at λ = 453, 505, 645 and 663 nm by spectrophotometer at the same time. Contents of β- carotene and lycopene were calculated according to the following equations: β- carotene (mg/100ml) = $0.216A_{663} - 0.304A_{505} + 0.452A_{453}$; lycopene (mg/100ml) = $- 0.0458A_{663} + 0.372A_{505} + 0.0806A_{453}$; chlorophyll a (mg / 100 ml) = $0.999A_{663}-0.0989A_{645}$; chlorophyll b (mg / 100ml) + = $-0.328A_{663}+1.77A_{645}$.

Data were subjected to analysis of variance with two factors of classification (population, replication) using the GLM produced by SAS (1998). Duncan's test for comparison was applied to the measured parameters.

III – Results and discussion

1. Classic chemical composition and secondary compounds

DM, OM, CP and secondary metabolites contents of dry biomass and pods are presented in Table 2. Results show that OM and DM contents varied significantly among populations while the secondary metabolites are not variables. CP of the dry biomass ranged from 12 to 24 % with an average of 17%, similar to that of sulla (16%) and slightly lower than that of *Scorpiurus* (22%) (Zoghlami *et al.,* 2008). CP content is higher in biomass than in pods (17 % *vs* 14% DM, respectively).The contrary was showed by Fois *et al.,* (2000) in *M. polymorpha*. Total phenols and tannins, condensed tannins and saponins did not vary significantly between populations. Total phenols varied between 3.6 and 4.2 g eq.ac.tann/kg DM with an average of 3.9 g eq. ac. tann/kg DM. Total tannins varied from 1 to 3 g eq. ac. tann/kg DM with an average of 2 g eq. ac.tann/kg DM; condensed tannins is very low for all accessions and saponins varied from 6 to 12 g/kg DM with an average of 9 g/kg DM).

Table 2. Chemical composition of dry biomass and pods

Populations		Dry biomass						Pods
	DM%	OM%	CP%	TPh*	TT*	CT*	SAP*	CP%
9140	13.8	80.5	22.6a	4.24	3.3	0.003	9.3	13.3b
9153	14.9	80.8	18.7ab	4.21	2.8	0.004	9.2	13.1b
9144	15.5	78.5	23.9a	4.2	1.2	0.006	5.8	14.9ab
9142	14.1	72.9	11.8dc	4	3.1	0.015	6.4	19.5a
9151	15.1	80.3	12.8c	3.8	3.2	0.002	9.3	13.8b
9141	16.5	79.2	13.0c	3.7	3	0.006	11.9	-
9152	14.1	72.4	17.5ab	3.6	2.5	0.013	8.3	10.9b
9150	14.4	70.3	16.3bc	3.7	2.6	0.005	9.9	12.4b
2	*14.7*	*77.4*	*17*	*3.9*	*2.2*	*0.006*	*8.9*	*14*
Standard error	*-*	*4.9*	*2.7*	*0.3*	*1.7*	*0.005*	*3.7*	*2.9*
Pr	*0.44*	*0.19*	*0.0002*	*0.25*	*0.17*	*0.31*	*0.64*	*0.09*

DM: dry matter content; CP: crude protein; OM: organic matter; TPh : total phenols ; TT: total tannins; SAP : saponins; *: g tannic acid equivalent/kg of DM.

2. Antioxidants components

Levels of antioxidants compounds are presented in Table 3. Results showed that only chlorophyll b in pods and lycopene in straw varied significantly among populations. Chlorophyll a is higher than chlorophyll b in dry biomass while chlorophyll b is higher in dry pods and straw. Same result was obtained by Haffani Ksontini (2015) in fresh biomass of vetches. For our populations, chlorophyll a varied from 0.6 mg/g DM in straw to 3.7 mg/g DM in dry biomass. Low content of β-carotene (0.05, 0.1 and 0.01 mg/g DM) in pods, biomass and straw, respectively could be attributed to its degradation by light and/or high temperature (Ilahy, 2015, personal communication). These values are higher than those found by Karadas *et al.* (2006) in alfalfa concentrate (0,005mg/g DM). Lycopene content varied from 0.2 mg/g DM in straw to 0.6mg/g DM in both dry biomass and pods.

Significant correlations were found between chlorophyll b and CP, β- carotene and lycopene in dry pods (r=-0.59**, n= 19; r=0.64**, n=20; r=0,74***, n=20, respectively) and between chlorophyll b β- carotene (r=0.86***, n=22) in straw.

Table 3. Antioxidants compounds analyzed in different parts of the plant (dry biomass, pods and straw) (mg/g DM) in *Medicago ciliaris* L.

Population	Pods				Biomass				Straw			
	β-carot	Lyco	Chla	Chlb	β -carot	Lyco	Chl a	Chl b	β-carot	Lyco	Chla	Chlb
2	0	1.1	0.7	3.6a	0a	0.5	3.7	0.5	0	0.1c	0.4	0.3
9153	0.1	1	1.4	4.6a	0.1	0.4	3.8	1.3	0.05	0.2bc	0.3	4.4
9144	0	0.9	1.6	2.3ab	0.4	0.4	3.4	1.4	0a	0.34a	0.3	1.5
9142	0	0.4	0.7	0.6b	0.1	0.7	4.2	0.9	0a	0.3ab	1.3	0.9
9150	0	0	0.8	2.6b	0.3	0.4	4.6	1.9	0a	0.2abc	0.	0.5
9141	0.1	0.5	0.5	0.8b	0	0.8	3.9	2	0a	0.2abc	0.7	0.5
9152	0.1	0.2	0.5	1.4ab	0	0.6	3.2	2.5	0.03	0.2bc	0.7	0.6
9150	0	0.5	1.1	1.7ab	0	0.3	1.3	0.3	0	0.1c	0.4	0.4
Mean	*0.05*	*0.6*	*0.9*	*2.2*	*0.1*	*0.6*	*3.7*	*1.5*	*0.01*	*0.2*	*0.6*	*1.2*
Standard error	*0.1*	*0.6*	*0.6*	*0.1*	*0.3*	*0.4*	*1.8*	*1.1*	*0.04*	*0.1*	*0.5*	*2.5*
Pr	*0.8*	*0.4*	*0.5*	*0.16*	*0.79*	*0.86*	*0.82*	*0.52*	*0.74*	*0.03*	*0.6*	*0.5*

β-carot= β- carotene, lyco=lycopene; Chl a= chlorophyll a; Chl b= chlorophyll b.

IV – Conclusion

The study of nutritional value of dry biomass, pods and straw of eight populations of *M. ciliaris* showed significant variation among populations for crude protein, organic matter, lycopene and chlorophyll b. Populations 9144, 9140, 9142 and 9153 are the most interesting for their nutritional value and antioxidant composition. Based on the positive correlations between chlorophyll b and β- carotene in straw and chlorophyll b and lycopene in pods, summer grazing of dry pods and straw of echinus medic is recommended for the growth of sheep.

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Forage potential of *Piptatherum miliaceum* (L.) Coss (smilo grass)

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Abstract. *Piptatherum miliaceum* (L.) Coss smilo grass, is a Mediterranean perennial native grass species whose forage potential is unexplored. Little information is available about smilo grass seasonal production and biomass quality. CNR-ISPAAM activity focused on the evaluation for forage use of some smilo grass accessions collected in Sardinia in comparison with conventional forage species. Eight smilo grass accessions were grown in spaced plant stands, using tall fescue and cocksfoot as control. Plots were harvested three times during the years 2013-2015 and DMY and forage quality were assessed. Significant differences were found among DMYs of conventional forage species and smilo grass, with smilo grass producing less than tall fescue but more than cocksfoot in each harvest season except for the end of spring. The content of crude protein of smilo grass was significantly higher than that of conventional species in all seasonal cuts, as well as NDF, while ADL was higher at the end of spring. On the basis of these preliminary outcomes, the potential role of smilo grass into rainfed extensive farming systems is discussed.

Key-words. *Piptatherum miliaceum* – Native species – Forage.

Potentiel fourrager de* Piptatherum miliaceum *(L.) Coss (piptathère faux millet)

Resumé. *Le* Piptatherum miliaceum *(L.) Coss (piptathère faux millet) est une plante herbacée vivace indigène de la Méditerranée dont le potentiel fourrager est non exploité. Peu d'informations sont disponibles sur la production saisonnière et la qualité de la biomasse. Les activités du CNR-ISPAAM ont été concentrées sur l'évaluation fourragère de certaines populations naturelles de* P. miliaceum *collectées en Sardaigne, en comparaison avec des espèces fourragères traditionnelles. Huit accessions de* P. miliaceum *ont été semées en parcelles et comparées à la fétuque et au dactyle utilisés comme témoins. Les parcelles ont été fauchées trois fois au cours de l'année (saison 2013-2015) en évaluant le rendement en matière sèche (RMS) et la qualité du fourrage. Des différences significatives de rendements ont été trouvées entre les espèces fourragères traditionnelles et* P. miliaceum *dont le rendement est inférieur à celui de la fétuque mais plus élevé que celui du dactyle et ceci pour chaque coupe, sauf à la fin du printemps. La teneur en protéines brutes et en NDF était significativement plus élevée chez* P. miliaceum *que chez les deux espèces classiques pour toutes les coupes saisonnières, mais l'ADL était plus élevée à la fin du printemps. En se basant sur ces résultats préliminaires, le rôle potentiel de* P. miliaceum *dans les systèmes d'élevage extensif pluviaux a été discuté.*

Mots-clés. Piptatherum miliaceum – *Espèces indigènes – Fourrage.*

I – Introduction

Perennial grasses show economic and environmental advantages that make them attractive for agronomic exploitation in grasslands. They usually show a better water use efficiency than annual grasses, an adequate productivity and ability to grow in poor soils, they bring ecological benefits for soil and wildlife habitats and when they are native, their impact on the environment is even more sustainable. Currently, the native germplasm of Mediterranean perennial grasses is little investigated for forage purposes (Annicchiarico *et al*., 2013).

Piptatherum miliaceum (L.) Coss, is a perennial native winter-active growing species. It produces palatable forage and it is grazed by livestock in natural environments (Celik, 1998). Its attractiveness relies on its ability to face summer drought and to grow on marginal soils, as slopes, roadsides, rocky soils. Moreover, the species had showed a potential to be used as multipurpose species (bioenergy, environmental restoration, etc.) (Sulas *et al*., 2015).

This study aimed to evaluate seasonal DMY and forage quality of smilo grass in comparison with tall fescue and cocksfoot.

II – Materials and methods

The trial was carried out in the experimental field of CNR-ISPAAM in Sassari (40° 45' N, 8° 25' E, 24 m a.s.l.). The soil was sandy-clay-loam, poor in total nitrogen (0.96‰), with adequate content of phosphorous and organic matter and alkaline pH.

Eight native accessions of *P. miliaceum* were transplanted in the field in April 2012. Seedlings were obtained by seeds collected from wild populations growing in Sardinia. Two high-yielding conventional perennial forage species as *Festuca arundinacea* cv. 'Flecha' and *Dactylis glomerata* ecotype 'Ottava' were used as control. Twenty-four seedlings per species and accession were transplanted in plots (1.50 x 2.0 m) arranged in a completely randomized design with three replicates. In each plot, 8 spaced plants were grown in two rows (0.5 x 0.5 m). Plots were entirely under rainfed conditions. A cleaning cut was made in July 2012. A first mowing at the end of the first growing season was done in July 2013 (data not shown). In this study we considered the harvesting carried out at the end of autumn, winter and spring in the years 2013-2014 and 2014-2015. At each harvest, two plants per plot were cut and weighted in the lab. After being oven-dried at 60 °C up to constant weight, plant samples were re-weighted and aboveground dry matter yield (DMY) estimated. Dried samples of the season 2013-2014 were ground to determine crude protein content (CP) by Kjeldahl method, ashes, neutral and acid detergent fibres (NDF and ADF) and acid detergent lignin (ADL) by the procedure of Van Soest *et al*. (1991).

For statistical analyses, one-way ANOVA was carried out using the software Statgraphics Centurion xv to calculate the differences between accessions during the two growing seasons. Homoscedasticy of data was assessed by Bartlett's test. Mean differences among treatments were separated by Fisher's least significant difference (LSD) at 0.05 probability level.

III – Results and discussion

1. Meteorological pattern

In the first year of observations (July 2013-June 2014) cumulated rainfall exceeded the average rainfall for the area (550 mm) reaching 625 mm. Rainfall was well distributed between September and March (90%) with a peak in November (135 mm). From July 2014 to June 2015, the total rainfall was 470 mm. The greater amount (60%) of total rainfall was concentrated in two months: November (129 mm) and February (136 mm). Temperatures differed between the two years in winter months. In November and December 2014, minimum monthly temperatures were higher (+2.2 and +4.1 °C, respectively) than in the corresponding months of the previous year.

2. Dry matter yield

In the first year of observation, which includes the first three cuts, the mean DMY of accessions, regardless of species, was higher than in the second year (Table 1), probably due to the higher water availability. Cumulated DMY per plant ranged between 264 g in *D. glomerata* and 877 g in *F. arundinacea* and between 94 g in PM22 and 411 g in *F. arundinacea* in the first and second year, respectively. The mean DMY in *P. miliaceum* was 508 g in the first year and 205 g in the second year (data not shown). For both years, the PM18 accession of *P. miliaceum* showed

DMYs not differing from that of *F. arundinacea*. In autumn and winter, tall fescue showed the best production in absolute values, as expected from a selected variety. Nonetheless, in autumn, the DMY of several *Piptatherum* accessions (3 among 8 in autumn 2013 and 5 among 8 in autumn 2014) were statistically similar to those of *Festuca.* This is noteworthy, being the observed genotypes from native populations. *P. miliaceum* was characterized by a higher DMY than conventional forage species in spring when *F. arundinacea* and *D. glomerata* dried up their aboveground biomass to cope with summer drought. Smilo grass showed later flowering and later leaf senescence than conventional species as reported by Sulas *et al*. (2015). DMY of *P. miliaceum* ranged between 15 and 309 g plant^{-1}, 25 and 206 g plant^{-1} and 45 and 213 g plant^{-1} in autumn, winter and spring, respectively.

Table 1. Dry matter yield of *P. miliaceum* accessions (PM), *D. glomerata* (DA) and *F. arundinacea* (FE). Different letters in the same column indicate that means are statistically different (LSD, p<0.05)

Accession	DMY (g plant^{-1})					
	23.12.2013	**10.04.2014**	**01.07.2014**	**22.12.2014**	**02.04.2015**	**25.06.2015**
DA29	96.6 c	92.9 c	74.7 b	30.6 bc	72.4 b	63.7 cde
FE28	362.0 a	460.7 a	54.8 b	98.7 a	243.5 a	69.0 bcde
PM13	186.3 bc	137.4 bc	136.6 ab	54.9 abc	56.0 b	135.5 a
PM14	207.0 bc	185.2 bc	145.8 ab	61.0 abc	45.2 b	115.0 abcd
PM15	278.7 ab	123.8 bc	95.5 b	77.5 abc	29.9 b	122.0 abc
PM16	309.0 ab	164.5 bc	194.9 a	83.3 ab	43.3 b	86.9 abcde
PM18	282.4 ab	206.0 b	213.5 a	100.7 a	55.4 b	126.6 ab
PM19	199.8 bc	168.8 bc	76.1 b	15.1 c	30.6 b	56.8 de
PM22	121.7 c	79.5 c	82.2 b	23.9 bc	24.9 b	45.0 e
PM24	226.6 bc	157.4 bc	87.3 b	26.7 bc	33.1 b	115.8 abcd

3. Quality of biomass

The overall quality of *P. miliaceum* was medium-low in each season. NDF values were relatively high starting from autumn production (>60%) and increases, as expected (Bullitta, 1993) with the phytomass maturity (Table 2). However, no significant differences for NDF content were observed between smilo grass accessions and the two conventional forage species in autumn. The two accessions of smilo grass (PM13 and PM22) showed similar values of NDF to *D. glomerata* and lower values than *F. arundinacea* in winter. ADF showed the most suitable values for animal nutrition in autumn and winter as well as ADL. A wide range of variation was observed among smilo grass accessions for ADF along seasons. Nonetheless, *P. miliaceum* showed satisfactory contents of crude protein (>15% and 8% in in autumn and spring, respectively), comparable or higher to those of *F. arundinacea* and *D. glomerata* (in autumn and spring) and higher than both conventional species in winter production (>13%). Ash content was generally high; it was higher in smilo grass accessions than in conventional grasses in winter and comparable to them in autumn and spring.

IV – Conclusions

P. miliaceum showed an interesting potential as forage plant (i.e. accessions PM13 and PM18). The strength of smilo grass as feed relied mainly on the amount of DMY and its quality harvested in autumn and winter. Although its production was lower than in Festuca in these seasons, the variation for this trait shown by the accessions of *P. miliaceum* may offer the chance to carry out future selection and breeding programmes to maximise both forage production and its quality. Moreover, the crude protein content in the biomass may be exploited despite the high levels of NDF. Nonetheless, this trait could be improved by agronomic management aiming to maintain active growth of *P. miliaceum*. Under rainfed Mediterranean conditions, smilo grass seems suitable for dual use as forage in the early stage of growth and as lignocellulosic feedstock for bioenergy at the end of growing season (senescent plants). Moreover, it can be more acceptable by farmers than rhizomatous species thanks to its easy establishment (seed propagation) and harvesting.

Table 2. Nutrient content of dry matter of *P. miliaceum, F. arundinacea* and *D. glomerata* in autumn, winter and spring for the first year (2013-2014). Different letters in each column and date indicate significant differences in mean values (p<0.05)

Accession	NDF (%)	ADF (%)	ADL (%)	Crude protein (%)	Ashes (%)
	23.12.2013 (autumn production)				
DA29	57.3 b	39.4 a	7.4 a	13.3 c	17.2 a
FE28	58.0 ab	36.3 c	6.4 a	15.8 bc	13.9 b
PM13	61.6 ab	33.4 d	6.8 a	18.0 ab	12.5 bcd
PM14	62.6 a	36.9 bc	6.1 a	15.4 bc	11.5 cd
PM15	61.0 ab	38.6 ab	6.8 a	21.4 a	11.2 cd
PM16	61.5 ab	37.5 abc	6.7 a	21.5 a	10.8 d
PM18	61.5 ab	33.9 d	5.7 a	17.5 ab	12.7 bc
PM19	61.1 ab	34.3 d	4.9 a	17.7 ab	12.4 bcd
PM22	60.8 ab	33.2 d	6.0 a	18.8 ab	13.5 b
PM24	61.9 ab	34.3 d	6.3 a	17.9 ab	12.6 bc
	10.04.2014 (winter production)				
DA29	58.3 d	37.7 ab	2.9 c	8.3 d	14.5 abcd
FE28	62.7 bc	40.0 a	3.2 bc	9.0 d	9.7 e
PM13	58.9 d	35.0 bc	3.7 abc	15.6 bc	16.3 ab
PM14	62.8 bc	37.5 ab	3.4 abc	13.7 c	16.3 ab
PM15	64.2 ab	37.0 ab	3.2 bc	18.9 ab	13.3 d
PM16	67.4 a	37.4 ab	4.3 a	24.2 a	13.9 cd
PM18	64.4 ab	35.9 bc	3.9 ab	17.2 bc	15.9 abc
PM19	64.9 ab	32.4 c	3.7 abc	15.3 bc	14.6 abcd
PM22	60.4 cd	34.4 bc	3.6 abc	18.2 bc	16.6 a
PM24	63.5 bc	34.5 bc	3.8 abc	18.2 bc	14.4 bcd
	01.07.2014 (spring production)				
DA29	64.6 e	44.7 a	7.2 bc	6.1 b	14.0 a
FE28	61.8 f	39.8 d	5.2 d	6.9 b	15.4 a
PM13	70.7 b	40.5 d	12.7 a	8.8 ab	9.5 bcde
PM14	73.5 a	44.5 ab	8.5 bc	7.9 ab	9.2 cde
PM15	70.4 bc	43.5 ab	7.1 bc	10.7 ab	8.7 de
PM16	73.1 a	44.5 ab	8.5 bc	10.2 ab	7.9 e
PM18	70.8 b	44.4 ab	9.0 b	13.5 a	9.9 bcd
PM19	68.9 bcd	44.8 a	7.4 bc	8.5 ab	10.9 b
PM22	68.5 cd	41.3 cd	6.9 c	8.8 ab	10.7 bc
PM24	68.2 d	42.7 bc	6.7 cd	9.5 ab	10.7 bc

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Productivity of alfalfa cultivars in dryland Mediterranean environments of central Chile

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Abstract. Deep-rooted perennial legumes such as lucerne (*Medicago sativa*) can be an alternative for dryland production systems increasing pasture availability for grazing during autumn-winter as well in early summer, where it is more limited in Mediterranean environments. The objective of this study was to evaluate plant survival and biomass production of nine alfalfa cultivars from Australian and North American breeding programs in four Mediterranean environments of central-south of Chile. Cultivars were evaluated in four Mediterranean environments of central-south Chile during three seasons (2012/13-2014/15). The sites located at the Andean foothills (Yungay) and coastal dryland (Hidango) presented the highest values of soil water content on the top 100 cm. Plants survival varied between 71 and 97% of the plants established. Plant biomass production during winter differed between sites and among cultivars, and was positively correlated to the winter activity class of cultivars. The total biomass production was significantly ($P < 0.05$) different among environments; in 2013/14 was higher in the Andes foothill (Yungay) and in 2014/15 was higher in the interior dryland (Cauquenes).

Keywords. *Medicago sativa* – Biomass production – Survival rate – Cultivars.

Productivité de cultivars de luzerne en environnements méditerranéens dans les terres arides du centre du Chili

Résumé. *Les légumineuses vivaces profondément enracinées telles que la luzerne (*Medicago sativa*) peuvent être une alternative pour les systèmes de production des terres arides en augmentant la disponibilité des pâturages pour le broutage au cours de l'automne-hiver ainsi qu'au début de l'été, où elle est plus limitée en milieu méditerranéen. L'objectif de cette étude était d'évaluer la survie des plantes et la production de biomasse de neuf cultivars de luzerne des programmes d'amélioration australiens et nord-américains dans quatre environnements méditerranéens du centre-sud du Chili. Les cultivars ont été évalués dans quatre environnements méditerranéens du centre-sud du Chili au cours de trois saisons (2012/13-2014/15). Les sites localisés sur les contreforts des Andes (Yungay) et les terres arides côtières (Hidango) ont présenté les plus hautes valeurs de teneur en eau du sol sur les premiers 100 cm. La survie des plantes a varié entre 71 et 97% des plantes établies. La production de biomasse végétale pendant l'hiver différait entre les sites et entre les cultivars, et était positivement corrélée au type d'activité hivernale des cultivars. La production totale de biomasse était significativement différente (P < 0,05) parmi les environnements ; en 2013/14 elle a été plus élevée sur les contreforts de la cordillère des Andes (Yungay) et en 2014/15 elle a été plus élevée dans les terres arides de l'intérieur (Cauquenes).*

Mots-clés. Medicago sativa – *Production de biomasse – Taux de survie – Cultivars.*

I – Introduction

In Mediterranean regions pasture productivity and its distribution along the year is of great importance for livestock production. Unfortunately, the growth rate of annual legumes is usually low during autumn and winter, and also plant senescence starts by the end of spring due to low soil water availability. Deep-rooted perennial legumes of Mediterranean origin have emerged as new alternative for dryland production systems (Dear *et al.,* 2003; Davies, 2005; Li *et al*., 2008).

Medicago sativa (lucerne) is one of the most drought tolerant perennial legumes (Li *et al*., 2008) and can survive long dry periods because of its deep root system (Fillery and Poulter, 2006; Benabderrahim *et al*., 2015). When the availability of soil water is low or absent in summer, lucerne is dormant, and when the rains begin in early autumn, growth restarts (Humphries and Auricht, 2001). In dryland Mediterranean environments, lucerne can attain high yields (Dear *et al*., 2003; Testa *et al*., 2011) and amounts of nitrogen fixation.

The objective of this study was to evaluate plant survival and productivity of nine alfalfa cultivars from Australian and North American breeding programs, differing in dormancy rate and sensitivity to drought, in four Mediterranean environments of central-south of Chile.

II – Materials and methods

Nine alfalfa cultivars from Australia and USA, with different winter activity class (WAC) were evaluated in four Mediterranean environments of central-south Chile during three seasons (2012-2104) Within the Australian cultivars, Sardi ten (WAC 10), Sardi seven (7) Sardi five (5) Sardi Grazer (6), Venus (5), Aquarius (8) and Genesis (7) were evaluated. The cultivars from USA were: WL458HQ (6) WL326HQ (4). The sites were: Hidango (34º21'; 72º00') located in the coastal dryland (marine terrace, Mollisol); Cauquenes (35º57'; 72º19') and Los Guindos (36º30'; 72º12'), located in the interior dryland (granitic soils, Alfisol); and Yungay (37º07'; 72º01'), located in the Andes foothill (volcanic ashes, Andisol). Long term average precipitations were 800, 650, 850 and 1200 mm, respectively. Soil water content (% v/v) was evaluated using EC-5 sensors (Decagon Device, USA), installed at 20, 40, 80, and 100 cm depth and connected to a data logger EM50 (Decagon Device, USA).

Two months old seedlings of each cultivar were planted at a density of 60 plants per plot in four replicates, in June-July 2012. Seedlings were grown in a glasshouse from seeds inoculated and lime pelleted with strain WSM2141. Fertilization free of nitrogen was applied at seedling establishment, using 90 kg ha^{-1} of P_2O_5, 2000 kg ha^{-1} of $CaCO_3$, 100 kg ha^{-1} of K_2SO_4 and 20 kg ha^{-1} of boron calcite.

The percentage of surviving plants was evaluated at the end of the summer period; February 2013 and April 2014; Aboveground biomass was evaluated at the end of the growing season (December) in the first year of the experiments, and in September, November and January in the second and third seasons. For dry matter determination the whole plot was harvested at 5 cm of ground and samples were oven-dried at 70 °C until reaching a constant weight.

III – Results and discussion

The Chilean Mediterranean climate is characterized by a strong concentration of the precipitations during winter (May to August) and by a prolonged period of water deficit from October to April, particularly in the interior dryland (Cauquenes and Los Guindos; Fig. 1). The sites located at the Andean foothills (Yungay) and coastal dryland (Hidango) presented the highest values of soil water content between 0 and 100 cm. At Yungay, the soil is derived from volcanic ashes (Andisol) and presents very high content of organic matter (14.8%) and water holding capacity. At Hidango, the soil is derived from marine terrace (Mollisol), with high content of organic matter (3.9%) and clay, also present high water holding capacity. By contrast, in both sites of the interior dryland (Cauquenes and Los Guindos), the soils are granitic (Alfisols) of sandy loam texture and very low content of organic matter, therefore present much lower water holding capacity.

Alfalfa cultivars presented high plant survival in the four environments, varying between 71 and 97% of the plants established at the beginning of the season, with no statistical differences between environments or cultivars (Table 1). Even in the interior dryland (Cauquenes and Los Guindos) the survival was < 80% where soil water content in summer is very low (Fig. 1), and confirm previous reports that referred alfalfa as a drought tolerant species (Dear *et al.*, 2003). During summer lucerne becomes dormant and regrowth after the firsts rainfall in autumn (Humphries and Auricht, 2001).

Biomass production during winter differed between sites and among cultivars, but the interaction GxE was not significant (P>0.05). The average winter production (mean of the four sites and two seasons) for each cultivar was positively correlated (r = 0.80; P < 0.01) with winter activity class, and cv. Aquarios was the more productive. The total dry matter production was significantly (P <0.05) different among environments; in 2013/14 was higher in the Andes foothill (Yungay) and in 2014/15 was higher in the interior dryland (Cauquenes). There were no significant differences (P> 0.05) among cultivars (Table 1). At the Andean foothill (Yungay) the winter growth was lower due to lower temperatures compared to the costal or interior dryland. However, dry matter production during the whole growing season was higher at Yungay, which was the most favorable environment in terms of soil water availability (Fig. 1).

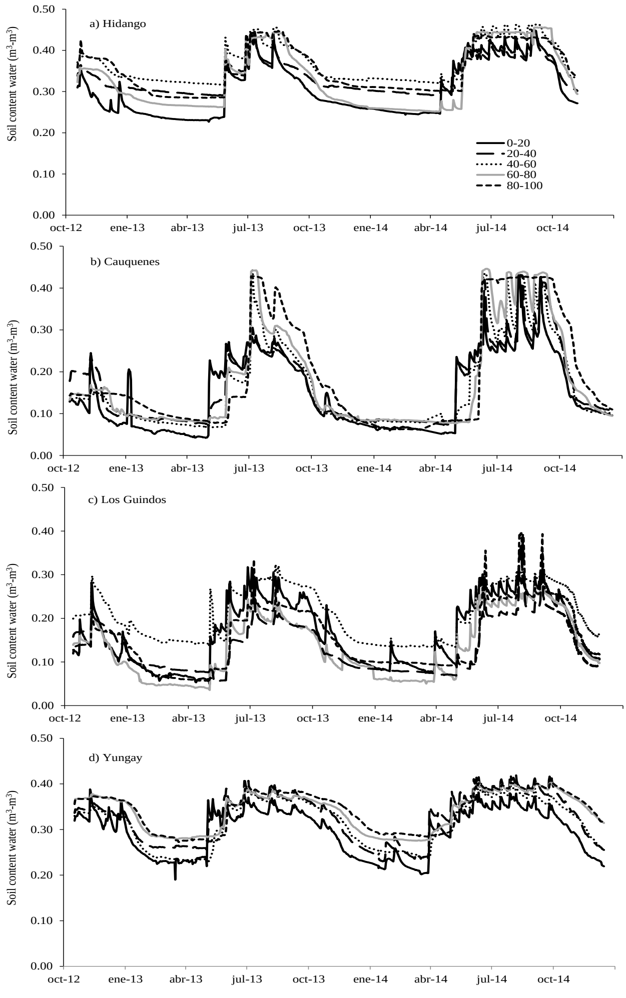

Fig. 1. Volumetric water content in the soil at five depths and four sites in the Mediterranean region of Chile, between October 2012 and November 2014.

The total dry matter production obtained by the alfalfa cultivars at the interior dryland of Cauquenes in the second and third years were comparable to that obtained by annual legumes like cvs of *B. pelecinus* and *O. compressus*, in the third year of evaluation (del Pozo and Ovalle, 2009). However, there are differences between perennial and annual legumes in the distribution of the production; in the former the growth and dry matter production during autumn and winter is much higher than in annuals. Thus, the incorporation of alfalfa into farming systems would increase pasture availability for grazing during the time where it is more limited in Chilean Mediterranean environments. In addition, the use of alfalfa into cropping rotations can contribute to the improvement of soil structure and increase crop yield in the following crop (Dear *et al*., 2003). There were no signs of cold or waterlogging damage, nor aluminum, toxicity in the nine cultivars evaluated in the four sites.

Table 1. Means ± standard deviation and F values of ANOVA for plant survival (%) and dry matter production (DM, g m^{-2}) during winter period and total biomass, for nine cultivars of alfalfa grown at four Mediterranean environments in central Chile. Results of ANOVAs are also shown; G is genotype and E is environment

Trait	Year	Hidango	Cauquenes	Los Guindos	Yungay	G	E	G x E
Plant survival	2013	87.7 ± 5.2	95.4 ± 1.5	91.8 ± 4.8	80.3 ± 4.8	n.s	*	n.s
	2014	86.2 ± 5.5	84.8 ± 3.6	93.4 ± 4.8	91.2 ± 4.8	n.s	*	n.s
Winter DM	2013	141 ± 21	162 ± 37	251 ± 34	132 ± 12	*	**	n.s.
	2014	191 ± 29	199 ± 32	156 ± 28	88 ± 19	*	**	n.s.
Total DM)	2012	154 ± 17	161 ± 13	75 ± 5	233 ± 20	n.s.	**	n.s.
	2013	434 ± 40	732 ± 90	707 ± 40	939 ± 110	n.s.	**	n.s.
	2014	365 ± 28	924 ± 106	493 ± 44	n.a.[1]	n.s.	**	n.s.

*: P < 0.05; ** : P < 0.001; n.s.: not significant.
n.a: data not available because the plots were accidentally grazed by the end of spring.

IV – Conclusions

Australian and North American alfalfa cultivars have high survival rates and productivity under conditions of severe summer water stress that prevailed in the Mediterranean zone of central Chile. Furthermore, the production in late spring-early summer can prolong animal grazing for approximately two months, compared with grazing with annual legumes.

Acknowledgements

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Morphological variability in some persian clover (*Trifolium resupinatum* L.) populations from Ordu province (Turkey)

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Abstract. The characterization of native populations is of extreme importance for the identification of elite genotypes to be considered for breeding programs. For that reason, the objective of this study was to determine the variability of some morphological characteristics of 15 local Persian clover (*Trifolium resupinatum* L.) populations from the 5 coastal counties of Ordu (Turkey). These populations were classified according to plant height, crown diameter, stem diameter, number of stems/plant, leaflet length, leaflet width and dry weight. For this purpose, data were analyzed by Principal Component Analysis (PCA) and Hierarchical Cluster analysis (HCA). According to HCA, the local populations of Persian clover were grouped in 4 clusters and resulted similar in rates ranging from 54.11% to 90.46%.

Keywords. *Trifolium resupinatum* L. – Principal component analysis – Cluster analysis – Similarity.

Variabilité morphologique de certaines populations de trèfle de Perse (*Trifolium resupinatum *L.), recueillies dans la province d'Ordu (Turquie)

Résumé. *La caractérisation des populations indigènes de plantes est extrêmement importante pour l'identification des génotypes d'élite à inclure dans les programmes de sélection. Pour cette raison, l'objectif de cette étude était de déterminer la variabilité des caractéristiques morphologiques de 15 populations de trèfle de Perse recueillies dans la province d'Ordu (Turquie). Ces populations ont été classées en fonction de la hauteur des plantes, diamètre de la couronne, diamètre de la tige, nombre de tiges/plante, longueur de la foliole, largeur de la foliole et poids sec. À cet effet, les données ont été analysées par analyse en composantes principales (ACP) et analyse de classification hiérarchique (ACH). Selon l'ACP, les populations locales de trèfle de Perse ont été regroupées en quatre clusters et étaient semblables selon des taux allant de 54,11% à 90,46%.*

Mots-clés. Trifolium resupinatum L. *– Analyse en composantes principales – Analyse de classification – Similitude.*

I – Introduction

Persian clover is tolerant to waterlogging (Anonymous, 2012), adapted to loam to clay loam soils with ph 6-8, but its cold tolerant is fair (Philipp *et al.,* 2016). It has high regrowth capability after grazing and cutting so it has high feeding value as a pasture or hay (Celen, 2009). Coastal regions of Turkey has Mediterranean climate, and has some problems such as drainage, drought, salinity etc. An annual Persian clover is useable for hay and pasture in this area. However, the cultivation of persian clover is not common in our country. There is only one native registered cultivar in Turkey. New cultivars are required for the increasing of its cultivation and pasture improving, starting from collection of native populations, as essential gene pool for plant breeding.

The assessment of genetic diversity among populations is potentially an important tool for plant breeding purpose. This diversity gives plant breeders the opportunity to select more diverse germplasm to include within their breeding programme (Aitken and McNeil, 2010).

Phenotypic observations in the real farm conditions have importance for the plant breeding programs. PCA and HCA is a useful guide to evaluation of different populations. Aim of the study was to evaluate by relationship among important characteristic of phenotypic observations of some local Persian Clover populations.

II – Materials and methods

Fifteen local population of Persian clover were collected from the 5 coastal counties (Ünye, Fatsa, Perşembe, Altınordu, Gülyalı) of Ordu in Turkey. The counties where local populations were collected are demonstrated on map of Ordu province (P1-P15) (Fig. 1). There are 77 km between Ünye and Gülyalı. While soil pH changes between 5.8 and 7.4, soil texture is clay, clay-loam and sandy. Ten plants from each of the populations were picked up randomly at flowering period in 2011.

Morphology of plants was assessed directly on the picked up plants by measuring the following traits: plant height (PH, cm), number of stems/plant (SN), stem diameter (SD, mm), leaflet width (LW, mm), leaflet length (LL, mm), crown diameter (CD, mm), dry weight/plant (DW, gr). In order to find the main variation trends among important morphological characters (variables) in the local Persian clover populations, the data were analysed by Pearson's Correlation analysis, Principal Component Analysis (PCA) and Hierarchical Component Analysis (HCA).

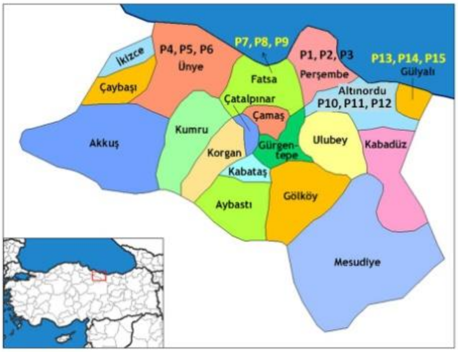

Fig.1. Map of Ordu Province (Turkey) *Numbers on map are demonstrated population number.

First, Pearson's correlation coefficient was computed and then PCA (Promax rotation) was applied to the morphological characters. The suitability of PCA was determined by the Bartlett's test of sphericity and the KMO index to measure sampling adequacy. PCA, a data reduction technique, to construct new, uncorrelated variables or principal components (PCs). The PCs with eigenvalues greater than 1.0 were considered in the analysis. Following PCA, variables were grouped using HCA according to the factor scores derived from PCA. Ward's method used because it joins at each stage the cluster pair whose merger minimizes the increase in the total within-group error sum of squares, based on the Euclidean distance between centroids. All data analyses were performed by using IBM SPSS 23 and Minitab 17 statistical software.

III – Results and discussion

The overall mean values for all morphological characters (variables) measured and their standard deviations were presented in Table 1. While plant height ranged from 15.85 to 41.80 cm, dry weight changed between 0.15 and 9.22 g. PCA requires that it should be some correlations greater than 0.30 between the variables included in the analysis. For this set of variables, all correlations in the matrix were higher than 0.30, satisfying this requirement (Table

2). Furthermore, the KMO measure was 0.832 and Bartlett's test of sphericity was significant (χ^2 =793.804, p<0.001).

Table 1. Means and standard deviations of variables obtained from populations (n=10). P: Populations

P	Plant height	Stem number/plant	Stem diameter	Leaflet width	Leaflet length	Crown diameter	Dry weight/plant
1	29.68± 6.62	8.00±2.26	2.82±0.90	10.48±1.44	15.46±2.01	4.89±1.68	2.19±1.50
2	30.25±9.46	5.40±2.76	1.56±0.37	9.63±1.59	13.35±2.53	3.26±0.91	0.70±0.55
3	17.07±3.55	2.40±1.51	1.22±0.28	6.85±1.13	10.29±1.77	2.27±0.72	0.15±0.12
4	40.78±9.83	6.00±1.83	3.17±0.83	13.04±1.69	20.12±2.54	4.78±1.11	3.86±2.33
5	23.96±10.22	10.00±4.37	3.35±1.39	9.64±2.95	13.48±3.63	5.29±2.72	2.54±2.77
6	34.45±10.83	8.60±5.44	2.88±1.14	12.17±2.71	16.60±4.30	5.77±3.77	4.18±5.39
7	35.12±10.52	10.20±5.35	3.81±1.47	12.08±3.26	17.09±4.03	8.18±3.08	9.22±8.19
8	31.93±13.76	3.90±2.33	2.44±0.70	10.09±1.81	16.33±2.58	3.93±1.84	1.74±2.19
9	15.85±5.25	3.30±1.57	1.55±0.69	6.35±1.414	11.23±2.16	2.60±1.38	0.49±0.53
10	38.72±16.63	8.40±2.50	2.74±1.37	8.28±1.43	12.66±1.84	6.88±2.23	6.13±4.78
11	37.82±9.54	5.90±2.23	2.26±0.94	9.71±1.64	14.46±2.12	5.24±1.76	2.61±1.73
12	31.96±16.95	6.40±2.37	2.60±0.90	10.48±2.08	15.01±3.28	5.00±2.10	2.18±2.32
13	41.80±6.17	5.70±2.00	2.06±0.73	9.99±1.14	14.08±2.34	5.19±0.90	2.78±2.58
14	37.22±11.38	8.00±2.16	2.07±0.52	10.28±2.34	15.08±3.86	6.52±1.50	3.67±4.08
15	37.05±10.41	9.90±4.36	2.17±0.57	10.06±2.17	13.79±2.50	6.54±2.63	4.88±3.15

As the scree plot indicate there are two factors in the model of the PCA. Eigenanalysis of the correlation matrix shows that the first two principal components (PCs) eigenvalues more than 1.0 (PC1, 4.49 and PC2, 1.052). Eigenvalue of the third component (PC3) is 0.540. Although the factor loading of the PC3 influenced the commonalities of each element, it was not extracted because its eigenvalue is less than 1.0. The major characters described by the PC1 and PC2 are presented in Table 3. PC1 was mainly loaded by morphological characters. Clearly the first factor of the initial solution was much more important than the other. PC3-PC7 was discarded because of very low variance contributions.

According to Table 3, PC1 included the variables PH, SN, SD, CD and DW; PC2 includes the variables LW and LL (>±0.3). The components explained 79.21% of the total variance in the variables which was included on the components. Therefore, these variables have emerged as important for the selection study.

HCA was utilized to investigate the similarities and dissimilarities among the local populations with respect to morphological characters. The similarity levels (%) showing the relationships between the fifteen populations through the HCA was shown in the cluster dendrogram (Fig. 2). The dendrogram clearly showed that the populations grouped into two major clusters based on similarity indices. There is one minor cluster (Cluster IV) in the first major cluster. Another major cluster again divided into three sub-minor clusters, while the first sub-minor cluster having six populations (Cluster I), four populations include to the second sub-minor cluster (Cluster II) and the third sub-minor cluster is represented by three populations (Cluster III). Maximum number of accession (6 populations) was clustered in to cluster I, whereas minimum number of accession (2 populations) was in cluster IV. The clusters were similar in rates ranging from 54.11 (Cluster III) to 90.46% (Cluster IV). Among the 15 populations, 3 and 9 in the first major cluster (Cluster IV) showed highest similarity indices. Those populations were collected, because of the shortest, thin and small leafed plants in the all populations. Even though they belonged to different districts of Ordu province, their collecting places close to each other. In addition to these, memberships of the clusters and their average distance from centroid obtained from HCA were determined and presented in Table 4. While the highest average distance from centroid of intra-cluster was found 1.748 in Cluster III, the lowest average distance from centroid of intra-cluster was found 0.408 in Cluster IV.

Table 2. Pearson's correlation coefficients amongst variables.

	PH	SN	SD	LW	LL	CD
SN	0.50**					
SD	0.50**	0.60**				
LW	0.44**	0.43**	0.51**			
LL	0.51**	0.40**	0.53**	0.88**		
CD	0.65**	0.79**	0.69**	0.49**	0.50**	
DW	0.65**	0.68**	0.69**	0.43**	0.50**	0.81**

** Correlation is significant at the 0.01 level.
PH: Plant height (cm), SN: Stem number/plant, SD: Stem diameter (mm), LW: Leaflet width (mm), LL: Leaflet Length (mm), CD: Crown diameter (mm), DW: Dry weight/plant (gr)

Table 3. Eigenanalysis of the rotated correlation matrix of the first two PC.

Characters	PC1	PC2
PH	**0.660**	0.160
SN	**0.907**	-0.097
SD	**0.713**	0.168
LW	-0.018	**0.973**
LL	0.021	**0.956**
CD	**0.947**	-0.022
DW	**0.930**	-0.040
Eigen Value	4.492	1.052
% Total community	64.171	15.035
Cumulative variance (%)	64.171	79.207

Table 4. Membership populations of the clusters and their average distance from centroid according to HCA

Clusters	Membership Populations	Avg. distance from centroid
I	1, 2, 8, 11, 12, 13	1.118
II	5, 10, 14, 15	1.349
III	4, 6, 7	1.748
IV	3, 9	0.408

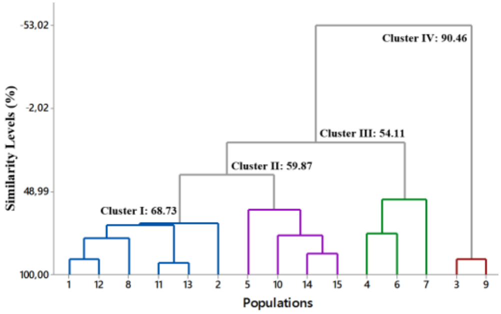

Fig. 2. Similarity levels of populations according to dendogram of HCA.

IV – Conclusion

In this study, a high variability of morphology amongst the some local Persian clover populations selected from Ordu was found. The variables plant height, stem number/plant, stem diameter, crown diameter, dry weight, leaflet width and leaflet length were found as principle components for determine to genetic similarity. The local populations 3 and 9 completely differed from the others with respect to these variables. Those populations were collected, because of the shortest, thin and small leafed plants in the all populations, even though they belonged to different districts of Ordu province. While the highest similarity was found among those populations, the lowest similarity was found among the local populations 4, 6 and 7. These populations have big leaflet. This study can assist geneticists and breeders to identify populations with desirable characteristics for inclusion in Persian clover breeding programs.

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Biomass production and chemical characteristics of four grass species for bioenergy

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Abstract. The aim of the present study was to investigate the potential use of the grasses *Avena sterilis*, *Bromus inermis*, *Hordeum bulbosum* and *Phalaris aquatica* as bioenergy crops. Their dry matter production was measured at two phenological stages (inflorescence and fruiting) and the contents of neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), macronutrients K, Na, Mg and ash were determined. According to the results, the dry matter production was not affected by the phenological stage, while *Phalaris aquatica* was the most productive followed by *Avena sterilis* and *Bromus inermis*. The higher content in NDF, ADF and ash was detected at the fruiting stage and in K, Na in the inflorescence one, while the content in ADL and Mg was not affected by the phenological stage. *Bromus inermis* had the lower content in NDF, ADF, ADL, Na, Mg and higher in K than the other species, while *Phalaris aquatica* had the lower content in ash. Combined with dry matter production, *Phalaris aquatica* at the fruiting stage had the optimal chemical composition for use as bioenergy crops**.**

Keywords. *Avena sterilis* – *Bromus inermis* – *Hordeum bulbosum* – *Phalaris aquatica* – Biofuel.

La production de biomasse et les caractéristiques chimiques de quatre espèces de graminées pour la bioénergie

Résumé. *Le but de la présente étude était d'examiner l'utilisation potentielle d'*Avena sterilis*,* Bromus inermis*,* Hordeum bulbosum *et* Phalaris aquatica *en tant que cultures bioénergétiques. La production de matière sèche a été mesurée à deux stades phénologiques (floraison et fructification) et les teneurs en fibre au détergent neutre (NDF), fibre au détergent acide (FDA), lignine au détergent acide (ADL), K, Na, Mg et cendres ont été déterminées. Selon les résultats, la production de matière sèche n'a pas été affectée par le stade phénologique, tandis que* Phalaris aquatica *était la plus productive suivie par* Avena sterilis *et* Bromus inermis*. La teneur la plus élevée en NDF, ADF et cendres a été détectée au stade de fructification et en K, Na au stade floraison, tandis que la teneur en ADL et Mg n'a pas été affectée par le stade phénologique.* Bromus inermis *a eu la plus faible teneur en NDF, ADF, ADL, Na, Mg, et teneur plus élevée en K que les autres espèces, tandis que* Phalaris aquatica *avait la plus faible teneur en cendres. En combinaison avec la production de matière sèche,* Phalaris aquatica *et* Avena sterilis *au stade de fructification ont la composition chimique optimale pour une utilisation en tant que cultures de bioénergie.*

Mots-clés. Avena sterilis – Bromus inermis – Hordeum bulbosum – Phalaris aquatica – *Biocarburants.*

I – Introduction

Bioenergy is the chemical energy that is stored in organic material and it can be directly converted into useful energy sources by biological, mechanical or thermo-chemical processes (Bessou *et al*., 2011). It refers to renewable energy from agricultural crops, residues, forest products, aquatic plants, manure and waste that can be used either directly or following conversion processes (e.g., liquefaction or gasification) for heating, electricity, fuel as well as their by-products (Haberl *et al*., 2010).

Among the agricultural crops, grass species and especially the perennials are considered to be the future of the bioenergy industry and are the focus of intense research (Sanderson and

Adler, 2008) because of their beneficial attributes over wood feedstocks for bioenergy applications (Lewandowski *et al*., 2003). These species can be harvested once a year minimizing storage requirements, are easily established, require fewer agricultural inputs than other crops and can be grown on agriculturally marginal lands (McLaughlin *et al*., 2002). The aim of the present study was to investigate the potential use of three perennial grasses, (*Bromus inermis*, *Hordeum bulbosum*, *Phalaris aquatica*) and an annual (*Avena sterilis*), as bioenergy crops.

II – Materials and methods

The experiment was conducted at the farm of the Aristotle University of Thessaloniki, Northern Greece (40°32'N, 22°59'E), at an altitude of 10 m a.s.l. The climate is characterized as Mediterranean semiarid with cold winters. The mean annual precipitation is 443 mm and the mean annual temperature is 15.5 °C.

The grass species *Avena sterilis* (A.st), *Bromus inermis* (B.in), *Hordeum bulbosum* (H.bu) and *Phalaris aquatica* (P.aq) were used. The experimental plots of 2 m^2 were established October 2012 in completely randomized design with four replicates. The annual A.st after the first establishment was self-seeded. Four reproductive tillers in order the plant material to be more uniform, were randomly collected from each plot at the inflorescence phenological stage (mid May 2013) and at the fruiting one (mid June 2013). The tillers were bulked and the samples were then oven-dried at 60°C for 48 h and subsequently passed through a 1 mm sieve and disrupted by the method of wet oxidation using triple acid mixture H_2SO_4, HNO_3, $HClO_4$ in a ratio of 5:1:1, (Allen *et al*., 1986). Concentration of total Mg, K, and Na was conducted by atomic absorption spectroscopy (Perkin-Elmer AAnalyst 300). Ash content was determined after burning in a muffle furnace at 540 °C for 5 h.

Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF) and Acid Detergent Lignin (ADL) were measured using the procedure described by Van Soest *et al.* (1991) with the ANKOM fibre analyzer (ANKOM Technology Corporation, Macedon, NY, USA), using sodium sulphite and α-amylase to the solution for the NDF determination. All analyses were carried out on duplicate samples and results are reported on DM basis.

General linear models procedure (IBM SPSS®21 for Windows) was used for ANOVA. The LSD at the 0.05 probability level was used to detect the differences among means (Steel and Torrie, 1980).

III – Results and discussion

Average dry matter production, ADL, Na and Mg content did not significantly differ between the inflorescence and fruiting stage. The period May to July of the experimental year was relatively dry as the mean precipitation was 15 mm while generally for this period is 30 mm. Especially in May it was only 3 mm. Inversely, NDF and ADF content were significantly lower, while K and ash content significantly higher at the inflorescence phenological stage compared to the fruiting one (Table 1). The average higher content of NDF and ADF at the fruiting stage is the result of plants maturity and is expected especially for grass species (Adler *et al*., 2006; Arzani *et al.*, 2004).

P.aq had significantly higher dry matter production and ash content compared to the other species (Table 2). The NDF and ADF content of B.in was significantly lower in comparison to the other species. B.in had the higher K and the lower Na and Mg content compared to the other studied grass species. Significant interaction between phenological stage and species was recorded only for NDF and ADF content (data not shown). According to this, the NDF and ADF content of B.in increased from the inflorescence to the fruiting stage inversely of the main effect.

Table 1. Effect of phenological stage on average dry matter production (DM), ash, NDF, ADF, ADL, K, Na and Mg content (n=16)

Phenological stage	DM ($g*tiller^{-1}$)	Ash (%)	NDF ($g*kg^{-1}$)	ADF ($g*kg^{-1}$)	ADL ($g*kg^{-1}$)	K ($mg*gr^{-1}$)	Na ($mg*gr^{-1}$)	Mg ($mg*gr^{-1}$)
Inflorescence	10 a	7 a	68 b	43 b	7 a	18 a	0.17 a	2.2 a
Fruiting	9 a	6 b	71 a	45 a	7 a	12 b	0.15 a	2.8 a

*Means of each parameter followed by the same letter in the same column are not significantly different (P≥0.05).

Table 2. Dry matter production (DM), ash, NDF, ADF, ADL, K, Na and Mg content of the studied species

Species	DM ($gr*tiller^{-1}$)	Ash (%)	NDF ($g*kg^{-1}$)	ADF ($g*kg^{-1}$)	ADL ($g*kg^{-1}$)	K ($mg*gr^{-1}$)	Na ($mg*gr^{-1}$)	Mg ($mg*gr^{-1}$)
A.st	9 b	8 a	72 a	46 a	7 b	15 b	0.40 a	2.0 b
B.in	7 b	7 b	62 b	37 b	6 b	21 a	0.02 d	1.9 b
H.bu	5 c	5 c	73 a	46 a	9 a	11 b	0.08 c	3.6 a
P.aq	18 a	8 a	72 a	45 a	7 b	14 b	0.20 b	2.6 ab

*Means of each parameter followed by the same letter in the same column are not significantly different (P≥0.05).

High concentration of total fiber (NDF, ADF, ADL) in combination with low concentration of mineral and ash are desirable for bioenergy crops (Trebbi, 1993). All the studied species except B.in had the higher fiber concentration at the fruiting phenological stage. The alkali elements such as potassium (K) and sodium (Na) as well as magnesium (Mg) are decisive factors which determine the behaviour of the biomass under thermal degradation (Fahmi *et al*, 2007). As regards to the above factors, these preliminary results are indicative that B.in could not be used as a bioenergy crop, because of its low concentration in fiber and its high content of K. On the other hand, all the other study species could be potentially bioenergy crops. However, the perennial grass P.au had additionally higher biomass production. These results are in accordance with Sulas *et al.* (2015) that native Mediterranean perennial grasses have a potential for rainfed crops for bioenergy.

IV – Conclusions

The phenological stage affected the chemical characteristics of the grasses but it did not affect their biomass production. At the fruiting stage the plants had higher concentration of total fiber and lower content of K and ash than at the inflorescence one, which are desirable elements for the bionergy crops. *Phalaris aquatica,* among the tested species, showed positive traits for bioenergy as it combined at the fruiting stage high dry matter production and optimal chemical composition for such use. However, these results are preliminary and additional research is needed.

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Is it possible to develop dormancy groups for *Bituminaria bituminosa* L.?

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Abstract. This study was carried out with 86 *Bituminaria bituminosa* genotypes collected from Central Black Sea Region of Northern Anatolia in Samsun in 2012. After seed cleaning, germination tests and scarifying the seeds with sandpaper, seeds were sown in small pots. In November of 2012, the seedlings were transplanted to experimental field. No fertilizer and water applied throughout the study and spring and autumn elongation, hay yield and harvesting number in the second year of the plants (2014) were observed during the study. According to correlation analysis, there was a negative and statistically significant linear correlation between altitude and spring elongation, autumn elongation, harvest number. There was also a negative statistically insignificant correlation between altitude and hay yield. A positive and significant correlation was found between hay yield and spring and autumn elongations, harvest number; between spring and autumn elongations and number of harvest. Some genotypes taken from high altitudes stayed dormant in winter period, furthermore they started elongation later than the others and a slight growth was recorded in autumn. In the light of these results, it is possible to develop dormancy groups for *Bituminaria bituminosa* cultivars in future.

Keywords. *Bituminaria bituminosa* – Altitude - Spring and autumn elongation – Correlation – Dormancy groups.

Est-il possible de développer des groupes de dormance pour* Bituminaria bituminosa L.*, comme pour la luzerne ?

Résumé. *Cette étude a été menée sur 86 génotypes de* Bituminaria bituminosa *collectés dans la région centrale de la mer Noire au nord de l'Anatolie, à Samsun, en 2012. Après nettoyage et tests de germination, et abrasion au papier de verre, on fit germer les semences dans de petits pots. En novembre 2012 les plants furent transplantés aux champs. Pas de fertilisant ni d'eau ne furent appliqués durant l'étude, et on observa l'élongation de printemps et d'automne, le rendement en foin et le nombre de récoltes lors de la deuxième année des plantes (2014). Toutes les données obtenues pour les génotypes telles qu'altitude, élongation de printemps et d'automne, rendement en foin et nombre de récoltes, furent analysées ensemble. Les altitudes originelles de culture des génotypes se situaient entre 3 et 985 m. Le démarrage de l'élongation de printemps variait d'un génotype à l'autre. La hauteur des plantes selon les génotypes était mesurée vers la mi-avril pour le printemps et au début de novembre pour l'automne. En 2014 une récolte double fut effectuée pour 55 génotypes et une récolte simple pour 31. Selon l'analyse de corrélation, il y avait une corrélation linéaire négative et significative entre l'altitude et l'élongation de printemps, l'élongation d'automne, et le nombre de récoltes. Il y avait aussi une corrélation négative mais non significative entre l'altitude et le rendement en foin. Nous avons trouvé une corrélation positive et significative entre le rendement en foin et les élongations de printemps et d'automne, le nombre de récoltes; entre les élongations de printemps et d'automne et le nombre de récoltes. Certains génotypes prélevés à hautes altitudes sont restés dormants pendant la période d'hiver, en outre ils ont commencé l'élongation plus tard que les autres et ils avaient moins ou pas du tout de croissance en automne. À la lumière de ces résultats, nous pouvons dire qu'il est possible de développer des groupes de dormance pour des cultivars de* Bituminaria bituminosa *à l'avenir.*

Mots-clés. Bituminaria bituminosa *– Altitude - Élongation de printemps et d'automne – Corrélation – Groupes de dormance.*

I – Introduction

Bituminaria bituminosa (Bitbit) is a herbaceous deep rooted perennial legume that has been used by farmers in the Canary Islands for hundreds of years where it is grazed in situ or is cut and fed green to dairy goats (Méndez, 2000). It is an extreme drought tolerant species, and produce good quality feed throughout the year. *Bitbit* remains green in summer and autumn in Mediterranean-type climates with minimal loss of leaves (Finlayson *et al*., 2012). The var. *bituminosa* has a wide adaptation across the Canary Islands (300-1000 mm) and is the only one present in the Mediterranean basin. In the Iberian Peninsula it is found in environments ranging from 250-1000 mm of rainfall and up to 1250-1500 m of altitude (Sternberg *et al*., 2006; Méndez *et al.*, 2006). Natural distribution of *Bitbit* in Turkey is in coastal provinces, located in North, West and South of Anatolia (Davis, 1970; Kilinc *et al.,* 1998; Akcin *et al.,* 2010).

The main aim of the study was to determine relationships amongst yield, harvest number, spring and autumn elongation, original altitudes of genotypes. Thus, we could be obtained some information about dormancy characteristics of *Bitbit.*

II – Materials and methods

Seed samples of 86 *Bitbit* genotypes were collected from Central Black Sea Region in 2012. Regarding the altitude, *Bitbit* plants naturally grow from just nearby the sea (3 m) to south-eastern skirts of Mount Dranaz (985 m). After seed cleaning and germination tests, seeds were scarified and sown in small pots. In November of 2012, the seedlings were transplanted to the experimental field with 70 cm*70 cm spaces as 20 plants for each genotype. Measurements were realised on 10 plant samples for all genotypes in 2014. Plant height in spring was measured on 15th of April. Last harvest was performed at the end of September and plant height data about autumn growing before winter were taken at the beginning of November. In 2014, 55 genotypes gave twice harvest but 31 genotypes only once. Linear correlation and regression analysis were performed amongst the traits with SPSS 17.0 program.

III – Results and discussion

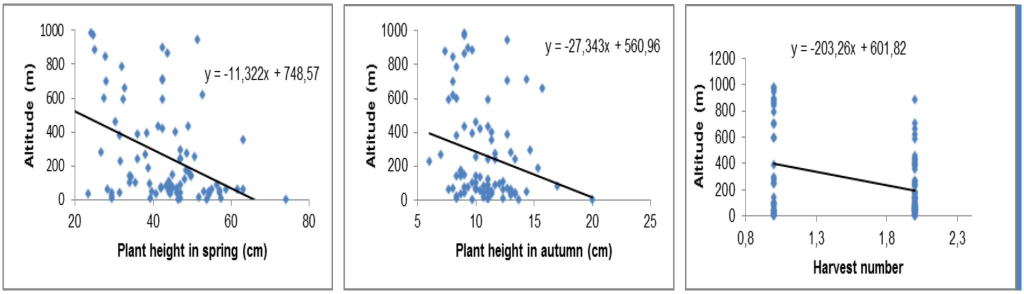
The altitude affected the measured traits negatively. As altitude increased, plant heights in autumn and spring, hay yield and harvest number decreased. While effect of altitude on elongation in autumn was statistically significant (r=-0.224*), elongation in spring and number of harvest were statistically significant affected by altitude at level of ($P \leq 0.01$). More hay yield was obtained from the genotypes when elongations in autumn and spring were high. The genotypes with elongation earlier in spring had higher hay yield and number of harvest (Table 1). Some other factors such as direction affect distribution of plant species. In south and south-eastern skirts and valleys of mountains, plants can survive up to 985 m altitude on the other hand cold winds come from Siberia and Balkans through north and north-western directions, limited the adaptation of *Bitbit* plants to 400-500 m altitudes.

Table 1. Linear correlation values amongst the traits and their significance levels

Traits	Altitude (m)	Plant height in autumn (cm)	Plant height in spring (cm)	Hay yield (g/plant)	Harvest number
Altitude	1				
Plant height in Autumn	-.224*	1			
Plant height in Spring	-.417**	.363**	1		
Hay yield	-.096	.278*	.433**	1	
Harvest number	-.337**	.064	.332**	.345**	1

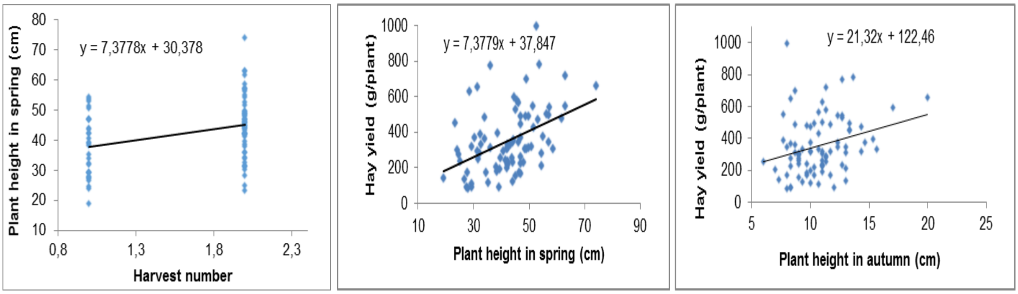
*Indicated values at p ≤ 0.05; **indicated values at p ≤ 0.01 levels are significant.

The genotypes from high altitudes started elongation later than the others (Fig. 1). There was also slight elongation of those genotypes in autumn (Fig. 2). The plants adapted to high altitudes generally have dormancy characteristics and they stay dormant in autumn, winter and early spring period to survive in harsh conditions (Kilinc and Kutbay, 2004). *Bitbit* genotypes adapted to high altitudes had less elongation in autumn and also started to elongate late in spring.



Figs. 1, 2 and 3. Relations between altitude and plant height in (1) spring and (2)autumn; relations between altitude and harvest number (3).

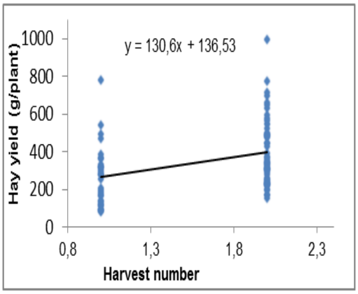
Regarding the altitude, as adaptation limits increased, the number of harvest was decreased (Fig. 3). Unlike Fig. 3, in Fig. 4, the genotypes started elongation earlier in spring had more number of harvests. The genotypes stayed dormant in winter, they started elongation late and natural consequence of this situation, number of harvest decreased. Some researchers determined clear differences amongst *Bitbit* genotypes in terms of cold tolerance, harvest number and hay yield (Correal, 2012; Real *et al*., 2014).

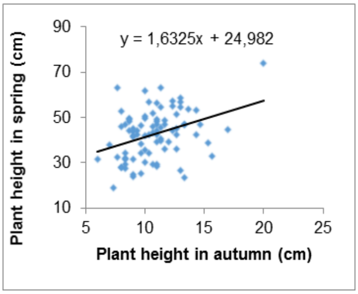


Figs. 4, 5 and 6. Relations between (4) plant height in spring and harvest number; hay yield and plant height in (5) spring and (6) autumn.

There were statistically significant correlation between hay yield and plant height in spring (r= 0.433**) and in autumn (r=0.278*) (Table 1 and Figs 5 and 6). The genotypes started elongation early in spring and continue their growth until autumn with higher hay yield than the others. Probably those genotypes have better regeneration ability of than the others. Furthermore, if a genotype started elongation early it has more time and natural resources for growing. Even if the plants keep growing and greenery in summer period, there are the best environmental conditions in spring, thus earlier genotypes have more advantage compare to the others.

It is not surprised that increasing number of harvest causes increasing hay yield (Fig. 7). Despite the decreasing hay yields through to sequencing harvests, the genotypes had higher number of harvest gave higher hay yield. There was a strong correlation between plant heights in spring and autumn (r= 0.363**) (Table 1 and Fig. 8). The genotypes had more growth in autumn; they also started elongation earlier in spring due to no dormancy period.





Figs 7 and 8. Relations between hay yield and harvest number (7) and relations between plant heights in spring and autumn (8).

IV – Conclusions

There was a strong relation among the altitude, *Bitbit* genotypes, and growing characteristics. The genotypes adapted to high altitudes had a slight growth in autumn and they also started elongation later than the others in spring. They survived in cold period owing to dormancy or semi-dormancy. This behaviour of *Bitbit* plants is similar to alfalfa. In the light of these results, it is possible to develop dormancy groups for *Bitbit* cultivars in future.

Acknowledgment

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Performances of the first registered forage cowpea cultivar of Turkey: Ülkem

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Abstract. Milk production has increased and become intensive in some parts of Turkey. In parallel to the increasing milk production, farmers demand high yielding annual legume forage crops for summer seasons in irrigated lands to grow as mixture with maize and sorghum. Regarding this point, cowpea has been conducted in researches more than 15 years. This study was conducted to determine the effects of row spacing and sowing dates of the Cultivar 'ÜLKEM' and a promising forage cowpea genotype on seed yield and some other characters i such as the number of seeds per pod, pod length, thousand seed weight and seed yield. In this study, It was clear that the Cultivar ÜLKEM was superior to the promising genotype; higher yields were obtained in sowing date 1st May; larger row spacing caused decreasing seed yields however larger row spacing had positive effect on other measured characters. The highest seed yields were determined at 30 cm row spacing (121.18 and 141.14 kg/da) for both sowing times. Average thousand seed weights were determined between 157.14 and 187.50 g at 1st May and 155.85 and 178.59 g at 1st June. In conclusion, for high seed yield, cowpea could be sown in 30 cm row spacing at the earliest possible time in spring.

Keywords. Sowing date – Row spacing – Seed yield – Forage cowpea.

Performances du premier cultivar de dolique fourrager enregistré en Turquie : Ülkem

Résumé. *La production de lait a augmenté et est devenue intensive dans certaines zones de Turquie. En parallèle à cette production laitière accrue, les éleveurs réclament des cultures de légumineuses fourragères annuelles à fort rendement pour la saison estivale en terres irriguées, à cultiver en mélange avec du maïs et du sorgho. Sur ce point, des recherches ont été menées sur le dolique pendant plus de 15 ans. Cette étude a pour but de déterminer les effets de l'espacement des rangs et des dates de semis du cultivar 'ÜLKEM' et d'un génotype prometteur de dolique fourrager sur le rendement en graines et d'autres caractères tels que le nombre de graines par gousse, la longueur des gousses, le poids de mille graines et le rendement en graines. Il ressort de cette étude que le cultivar ÜLKEM est supérieur au génotype prometteur; des rendements plus élevés sont obtenus avec la date de semis du 1er mai; un espacement plus large des rangs entraîna de plus faibles rendements en graines tandis qu'il avait un effet positif sur les autres caractères mesurés. En conclusion, pour un rendement élevé en graines, le dolique pourrait être semé en rangs espacés de 30 cm et le plus tôt possible au printemps.*

Mots-clés. *Date de semis – Espacement des rangs – Rendement en grains – Dolique fourrager.*

I – Introduction

Cowpea (*Vigna unguiculata* L. Walp) is a substantial food and a valuable part of the conventional cropping systems in the drier region tropics of Asia, Africa and Central America (Mortimore *et al*., 1997). This precious tropical and subtropical legume is especially important for the semi-arid regions of the tropics for forage, green pods and grains (Adeyanju *et al*., 2007; Ali *et al*., 2004). Cowpea is one of the super plants among legumes regarding resistance to high temperature and drought. Considering the temperature rise and reduction of water resources due to global climate change, it is emerging as a plant to be worked on.

Cowpea is often used as human and animal nutrition and green manure. Green hay, silage and cowpea seeds are used for animal nutrition. Having a high nutritive value of green forage cowpea, green hay contains 14-21% crude protein, while the seeds have the rate of 18-26% crude protein. Seed yield of forage cowpea ranges between 500 and 3500 kg/ha. It is stated that cowpea is grown alone for green hay yield. However, it could be grown mixed with maize, sorghum and millets for silage (Ismail and Hall, 2000; Saricicek *et al*., 2002; Bilgili, 2009; Basaran *et al*., 2011; Ayan *et al*., 2012).

II – Materials and methods

The study was carried out in 2013 and 2014 for two years and was designed as split split plots with 4 replications in Amasya-Suluova ecological conditions. The experiment was designed as sowing dates at main plots, inter row distances at split plots and cultivars at split-split plots. Throughout the vegetation period (from May to September) of 2013 and 2014 total rainfall were 103.1 mm and 168.6 mm, mean temperature were 19.5ºC and 20.2ºC, average relative humidity were 62.0 % and 67.3 %, respectively. While mean temperature was similar both years, total rainfall and average relative humidity were lower in 2013 than 2014. Released forage cowpea cultivar "ÜLKEM" and a promising cowpea genotype were examined to figure out the effects of different row spacing (30, 45, 60 and 75 cm) and two sowing dates (1st May and 1st June) on number of seed per pod, pod length, thousand seed weight and seed yield. The study was completed in irrigated conditions (three times in 2013, and six times in 2014). Irrigation process was continued until soil humidity comes to field capacity. All data obtained from this study was analysed by using SPSS 17.0 program. The differences amongst the mean values were calculated according to DUNCAN test.

III – Results and discussion

Released forage cowpea cultivar "ÜLKEM" was superior to the promising forage cowpea genotype for all examined characters considering both sowing dates and all row spacing treatments. In both years, higher values were obtained in terms of all the studied characters on sowing date of 1st May. Regardless of sowing time, as row spacing expands, pod length, the number of seeds per pod and 1000-seed weight values increased yet seed yield decreased in both the Cultivar ÜLKEM and the Genotype.

Sowing date affected average pod length (between 12.6 and 10.95 cm) in 2013. In addition to this, average number of seed per pod (10.17 and 8.94 number) and thousand seed weight (169.17 and 168.17 g) were similarly affected by sowing date (Table 1). Average seed yield of both genotypes and cultivar Ülkem were affected by row spacing. The highest seed yields were determined at 30 cm row spacing (121.18 and 141.14 kg/da) for both sowing times (Fig. 1).

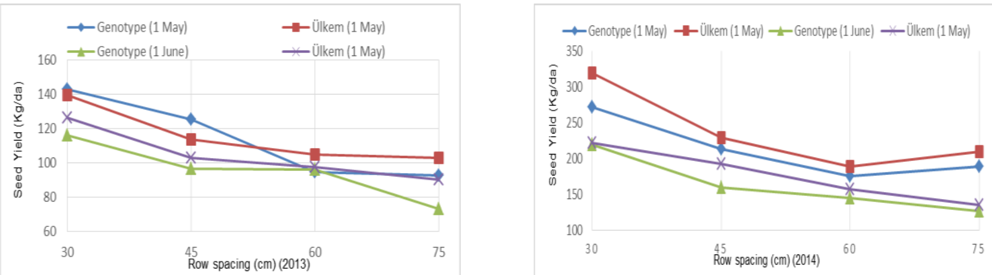

Fig. 1. Seed yields of Cultivar Ülkem and Genotype grown in different row spacings in 2013 – 2014 (sowing dates of 1st May and 1st June).

Table 1. Seed yields and value of some agronomic characters of forage cowpea grown in different row spacings (2013- 2014)*

Row space	2013						2014					
	Sowing date: 1 May			Sowing date: 1June			Sowing date: 1 May			Sowing date: 1 June		
	Genotype	Ulkem	Average	Genotype	Ulkem	Average	Genotype	Ulkem	Average	Genotype	Ulkem	Average
	Pod lenght (cm)											
30 cm	8.27	10.2	**9.23 c**	6.6	8.03	**7.32 d**	13.43	13.3	**13.37 d**	11.07	10.3	**10.68 b**
45 cm	11.7	11.87	**11.78 b**	9.2	9.67	**9.41 c**	15.47	14.07	**14.77 c**	13.27	11.7	**12.48 ab**
60 cm	13.13	13.83	**13.48 a**	12.93	12.57	**12.75 b**	17.57	15.9	**16.73 b**	14.2	12.93	**13.57 a**
75 cm	12.87	15.4	**14.13 a**	13.17	15.4	**14.28 a**	18.17	18.6	**18.38 a**	14.77	14.57	**14.67 a**
Average	11.49	12.83	**12.16 A**	**10.48**	**11.42**	**10.95 B**	16.16	15.47	**15.81 A**	**13.33**	**12.38**	**12.85 B**
	Number of seed per pod (adet)											
30 cm	7.38	9.2	**8.29 c**	5.03	6.17	**5.60 d**	9.12	11.9	**10.51 c**	9.2	8.83	**9.01 c**
45 cm	9.18	10.69	**9.94 b**	7.73	8.86	**8.30 c**	10.46	11.02	**10.74 c**	10.31	10.74	**10.52 b**
60 cm	9.01	10.91	**9.96 b**	8.69	10.29	**9.49 b**	11.63	12.14	**11.88 b**	10.8	12.27	**11.53 a**
75 cm	10.86	14.12	**12.49 a**	11.81	12.89	**12.35 a**	13.74	14.62	**14.18 a**	11.69	13.11	**12.40 a**
Average	**9.11**	**11.23**	**10.17 A**	**8.31**	**9.55**	**8.94 B**	**11.23**	**12.42**	**11.83 A**	**10.50**	**11.23**	**10.87 B**
	Thousand seed weight (g)											
30 cm	156.86	157.41	**157.14 c**	161.69	150.01	**155.85 c**	176.93	189.7	**183.31 d**	176.51	175.63	**176.07 c**
45 cm	158.67	167.49	**163.08 b**	173.98	167.66	**170.82 ab**	185.26	195.03	**190.14 c**	183.94	181.27	**182.61 c**
60 cm	165.18	172.73	**168.96 b**	168.67	169.86	**169.26 b**	200.67	202.34	**201.50 b**	191.84	190.61	**191.22 b**
75 cm	182.69	192.31	**187.50 a**	182.9	174.28	**178.59 a**	209.16	230.31	**219.74 a**	209.61	202.78	**206.19 a**
Average	**165.85**	**172.48**	**169.17 A**	**171.81**	**165.45**	**168.63 B**	**193.01**	**204.34**	**198.67 A**	**190.47**	**187.57**	**189.02 B**

*There are no differences amongst the means indicated same letter at the same line and same column at P≤0.05 probability level.

Row spacing affected the average pod length at both sowing dates in 2014. It was ranged between 9.23-14.13 and 7.32-14.28 cm respectively, for the first and second sowing dates. Number of seed per pod ranged between 8.29 and 12.49 at 1st May, and between 5.60 and 12.35 at 1st June. Average thousand seed weights were determined between 157.14 and 187.50 g at 1st May and 155.85 and 178.59 g at 1st June (Table 1). In parallel with the increase of number of irrigation in 2014, an increase could be seen in all characters except number of seed per pod. It was observed that irrigation during dry periods remarkably increased the yield and yield components although forage cowpea is resistant to drought (Table 1 and Fig. 1).

IV – Conclusions

In future farming system, the importance of cowpea, known as resistant to high temperature and drought, is likely to increase due to changing climatic conditions. In this study, 30 cm distance has emerged as the most suitable the row spacing for seed production. Taking into account the increasing temperature and drought period, the earliest sowing date as possible should be preferred in order to achieve high efficiency.

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Agronomic performance of the selected Turkish grass pea (*Lathyrus sativus* L.) landraces

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Abstract. Eighteen selected Turkish landraces, one registered variety and four ICARDA origin genotypes of grass pea (*Lathyrus sativus* L.) were assessed for seed yield, protein ratio, 1000 seed weight and ODAP content in the Central Anatolian conditions under spring (2015) and autumn (2014) sowing. The effects of the genotype and sowing time were significant on the studied traits. Except protein ratio, investigated traits were higher among genotypes under autumn sowing. Seed yield varied from 101,90 to 187,31 kg/da, with a mean of 149,62 kg/da in spring sowing and was between 129,13 and 310,95 kg/da with a average of 205,85 kg/da in autumn sowing. Mean ODAP content of genotypes was 3.95 and 3.27 mg g^{-1} in autumn and spring sowing respectively. Many of the landraces were superior than registered variety in terms of the all the investigated traits in both sowing time. Especially higher seed yield and low ODAP content in the landraces is promising for developing new cultivars.

Keywords. Grass pea – Landraces – Seed yield – ODAP.

Performances agronomiques de la gesse turque (*Lathyrus sativus *L.) sélectionnée parmi les variétés locales

Résumé. *Dix-huit variétés locales turques sélectionnées, une variété enregistrée et quatre génotypes d'origine ICARDA de gesse (*Lathyrus sativus *L.) ont été évalués pour le rendement grainier, le ratio de protéines, le poids de 1000 graines et la teneur en ODAP pour un semis dans les conditions de l'Anatolie centrale au printemps (2015) et à l'automne (2014). Les effets du génotype et du moment du semis étaient significatifs sur les caractéristiques étudiées. Sauf le ratio de protéines, les caractères étudiés étaient plus élevés chez les génotypes en semis d'automne. Le rendement en graines variait de 101,90 à 187,31 kg/da, avec une moyenne de 149,62 kg/da dans les semis de printemps et était entre 129,13 et 310,95 kg/da avec une moyenne de 205,85 kg/da en semis d'automne. La moyenne de teneur ODAP des génotypes était de 3,95 et 3,27 mg g-1 pour les semis en automne et au printemps respectivement. Beaucoup de variétés locales étaient supérieures aux variétés enregistrées en termes des caractères évalués pour les deux temps de semailles à la fois. En particulier, le haut rendement en graines et la faible teneur en ODAP dans les variétés locales sont prometteurs pour le développement de nouvelles variétés*.

Mots-clés. *Gesse – Variétés locales – Rendement en graines – ODAP.*

I – Introduction

Agricultural point of view, *L. sativus (*grass pea*)* is a most important species of the *Lathyrus* genus in the entire world as food (Jackson and Yunus, 1984) and, lesser as feed and forage. Grass pea is atractive crop with a number of agronomic characters such as drought tolerance; insects and pests resistance; nitrogen fixation; hardy root system; low input requirment, high seed yield and protein content (Campbell, *et al.,* 1994). These features made grass pea an excellent crop in sustainable farming especially in drought-prone and marginal areas. Overconsumption of grass pea more than three months as a staple diet caused motor system disease named lathyrism. The responsible agent for lathyrism is ß-N-oxalyl-L-a,ß-diaminopropionic acid (ODAP). So, reducing the ODAP content is main concern in grass pea breeding (Kumar *et al*., 2011).

Although increasing interest, grass pea has received very little attention in Turkey and, aproximately all the cultivated seeds are landrace types. The new varieties with high yield and low ODAP content can contribute to increase grass pea cultivation. Thus present stuy aim to investigate seed yield and chemical content (protein, ODAP) of selected gass pea genotypes.

II – Materials and methods

Eighteen landraces, previously selected for seed yield within Turkish landraces, one registered variety and four ICARDA lines of *Lathyrus sativus* (Table 1) were investigated for seed yield, 1000 seed weight (TSW), seed protein ratio and ß-N-oxalyl-L-a,ß-diaminopropionic acid (ODAP) content in the Central Anatolian conditions under autumn and spring sowing. Experiments were established on 9 October 2014 and 24 March 2015 and arranged as randomised block design with three replications. Climatic conditions in growing season were given in Fig. 1. Total nitrogen was determined by the Kjeldahl method and protein ratio was estimated using a conversion factor of 6.25. Quantitative estimation of ODAP was done by the method of Rao (1978) with some modifications. Anova was performed by using SPSS 13.0 package program and Duncan's multiple range test was used to separate the means.

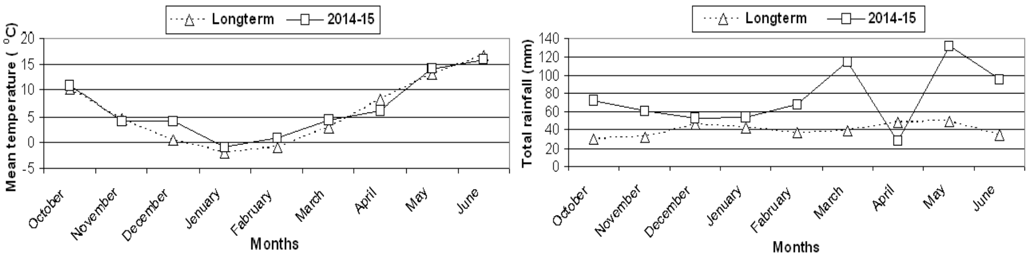

Fig. 1. Climatic condidtions in experimental area during vegetation period.

III – Results and discussion

Seed yield, seed protein ratio, TSW and seed ODAP content of grass pea genotypes under autumn sowing (AS) and spring sowing (SS) were given in Table 1. Over the genotypes, mean seed yield, protein ratio, TSW and ODAP content of grass pea genotypes were different between AS and SS and, except protein content, were higher in AS. In addition, the effect of the genotypes on all the traits was significant ($p<0,05$) in both sowing time. Inter genotype variation (CV%) was also clearly high for all the traits under AS (Table 1). Under AS, mean seed yield of the grass pea genotypes varied from 129.13 kg/da to 310.95 kg/da (average 205. 85 kg/da) an it was higher about 30 percent than SS. High yielding genotypes were landrace 6408 and 5501 in AS while its were landrace 6410, 6402, 2401, 2006 in SS.

Contrary to other traits, protein content was higher in SS and also it was a trait that showed lowest variation among genotypes with 3.00 CV% in AS and 2.43 CV% in SS. Protein content in grass pea seed varied from 24.11% to 27.04% (average 25.67%) in AS and varied from 25.48% to 27.82% (average 26,79%) in SS. The highest protein content was determined in landrace 4401 and 4901 in AS and was determined in landrace 4404, 4403 and 4901 in SS. Average TSW of genotypes was clearly high in AS. It was between 118.93 g and 177.80 g in AS and was between 122.60 g and 148.66 g in SS. Landrace 0201, Sel 564 and Sel 560 had highest TSW. Similarly Sel 560 and 564 had highest TSw under SS.

ODAP content was different between sowing times. It showed high variation among genotypes especially in AS (CV= 31.68%) and was the highest in landrace 4403 (6.15 mg g-1), 4404 (5.85 mg g-1) and 4901(6.41 mg g-1) 5501(5.82 mg g-1). The landrace 4403, 4401 and Sel 566 were highest ODAP content genotypes in SS. ODAP content is highly affected by climatic conditions and shows high genotype × environment interaction (Girma and Korbu, 2012). It can reach up 16 mg g-1 (Tamburino et al., 2012), 2 mg g-1 is critical value (Abd El-Moneim et al., 2010). In terms of the ODAP content, the best genotype seem to be Sel 565 for AS and landrace 5501 for SS, however, its seed yield not high at the same seasons.

Table 1. Origin of the investigated grass pea genotypes

Genotypes	Genotype origins			
	City	**Town**	**Willage**	**Rakım (m)**
Sel 560	ICARDA			
Sel 564	ICARDA			
Sel 566	ICARDA			
Sel 565	ICARDA			
0201	Adıyaman	Merkez	Dardogan	825
1501	Burdur	Bucak	Kızılkaya	787
1603	Bursa	Harmancık	Demirciler	719
1604	Bursa	Local seed market		
1803	Cankırı	Eldivan	Elmacı	957
2006	Denizli	Cal	Baklancakırlar	886
2401	Elazıg	Merkez	Uzuntarla	995
4301	Kutahya	Domaniç	-	
4401	Malatya	Darende	Yenikoy	1600
4403	Malatya	Darende	Basdirek	1445
4404	Malatya	Local seed market		
4901	Mus	Merkez	-	
5001	Nevsehir	Kozaklı	Kalecik	1120
5006	Nevsehir	Acıgol	Tatlarin	1113
5501	Samsun	Kavak	Degirmenci	600
6402	Usak	Merkez	Kasbelen	960
6408	Usak	Ulubey	Kılsa	800
6410	Usak	Ulubey	Kılsa	800
Gurbuz	Registered variety			

These results show that many of the investigated landraces are superior than registered variety in both sowing time, therefore, can be canditate variety. Especially landrace 6408, 4301 and 1803 are promising for AS while landrace 6410, 6402, 2401, 2006 for SS due to their high seed yield and low or moderate ODAP content.

IV – Conclusions

The differences between sowing time indicate that breeding or selection program of grass pea should be carried out for autumn and spring seasons sperately. In general, autumn sowing produced a high seed yield but also high ODAP content. Today ODAP not seem to be a problem and it can be detoxified with some physical of chemical methods. For these reason, autumn sowing seem to be best way. However, grass pea is a plant having spreading growth habit. Therefore, if grass pea will be seeded in autumn, lodging should be taken into account.

Table 2. Seed yield, potein ratio and ODAP content of grass pea genotypes under autumn and spring sowing

Genotype	Seed yield (kg/da)		Protein ratio (%)		TSW (g)		ODAP (mg g-1)	
	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring
Sel 560	177.86 i	142.69 b-f	24.11 j	25.50 i	168.67 ab	148.66 a	3.76 de	3.35 cde
Sel 564	129.13 n	141.53 c-f	24.69 i	25.48 i	172.33 a	148.03 ab	3.29 d-h	3.38 cde
Sel 566	217.37 f	124.44 fg	25.07 h	26.29 fgh	152.07 cde	143.28 abc	3.34 d-g	3.89 ab
Sel 565	211.29 f	161.30 a-d	24.55 i	25.71 hi	145.87 def	130.12 c-i	2.11 j	2.90 efg
0201	147.99 m	145.52 b-f	26.06 d	26.71 c-f	177.80 a	144.31 abc	3.86 cd	3.15 d-g
1401	178.01 i	152.55 b-f	25.59 g	27.13 a-e	131.93 gh	115.34 ij	2.22 ij	2.97 d-g
1603	210.67 f	155.88 b-e	25.52 g	26.88 b-f	158.80 bc	133.02 b-g	3.57 de	3.03 d-g
1604	170.68 jk	139.68 c-f	26.02 de	25.96 ghi	170.87 a	138.58 a-e	2.86 fgh	3.03 d-g
1803	272.10 c	129.12 ef	25.84 de	27.36 abc	141.27 efg	119.43 g-j	3.18 e-h	3.29 c-f
2006	201.28 g	172.36 ab	26.69 b	26.59 d-g	146.83 def	113.28 j	3.47 def	3.17 d-g
2401	167.53 kl	171.67 ab	25.85 de	27.23 a-d	140.30 fg	126.13 d-j	2.76 ghi	3.51 bcd
4301	298.10 b	164.77 abc	25.79 ef	26.49 efg	138.93 fg	137.98 a-f	3.57 de	2.71 gh
4401	161.79 l	134.26 def	27.04 a	27.11 a-e	147.47 c-f	123.59 e-j	5.02 b	4.03 a
4403	152.88 m	101.90 g	25.84 de	27.81 a	139.57 fg	131.13 c-h	6.15 a	4.1 a
4404	190.47 h	133.98 def	26.42 c	27.82 a	155.30 cd	139.66 a- d	5.85 a	3.82 abc
4901	163.91 kl	154.49 b-e	26.85 ab	27.45 ab	139.03 fg	125.17 d-j	6.41 a	3.79 abc
5001	176.53 ij	159.26 a-d	26.00 de	26.76 b-f	150.03 c-f	122.78 f-j	5.00 b	2.95 efg
5006	265.23 d	149.40 b-f	24.49 i	27.09 b-e	148.50 c-f	121.79 g-j	3.17 e-h	2.99 d-g
5501	304.56 ab	153.52 b-f	25.28 h	26.52 d-g	139.13 fg	122.01 g-j	5.82 a	2.39 h
6402	195.98 gh	172.13 ab	25.25 h	26.97 b-f	127.20 hi	125.41 d-j	3.57 de	3.31 cde
6408	310.95 a	157.50 b-e	25.16 h	26.91 b-f	118.93 i	115.79 hij	2.68 hij	3.50 bcd
6410	239.74 e	187.31 a	26.46 c	27.35 abc	122.73 hi	112.60 j	4.68 b	2.75 fgh
Gurbuz	190.45 h	136.00 c-f	25.88 de	26.94 b-f	120.13 i	114.54 ij	4.40 bc	3.25 d-g
Mean	205.85	149.62	25.67	26.79	145.81	128.38	3.95	3.27
Min	129.13	101.90	24.11	25.48	118.93	112.60	2.11	2.39
Max	310.95	187.31	27.04	27.82	177.80	148.66	6.41	4.10
CV%	25.47	12.56	3.00	2.43	11.21	8.90	31.68	13.45

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Nutritional and anti-nutritional characterization of six Tunisian local forage legumes species

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Abstract. Nutritional and anti-nutritional value of six local forage legume species accessions (*Medicago truncatula*, *Medicago ciliaris*, *Hedysarum coronarium* (cultivar Bikra 21), *H. carnosum*, *Lathyrus cicera* and *Scorpiurus muricatus* ssp *muricatus* (cultivar haffouz) was investigated. Dried samples of each accession were analyzed for NDF, organic matter, crude protein (CP), soluble nitrogen contents in pepsin, non-protein nitrogen, soluble nitrogen in the buffer and non-digestible nitrogen (N-ADF), total phenols, total and condensed tannins. Biological parameters were determined using *in vitro* gas production technique. Except from *Hedysarum coronarium*, all species had a CP content ranging between 200 and 230 g kg^{-1} DM. The proteins of all species are of good quality as suggested by low proportion of fiber-bounded and soluble nitrogen. Secondary compounds had no negative effect on nutritive value of the six species, even for the case of *Hedysarum coronarium* which had relatively high level of condensed tannins (37 g kg^{-1} DM). High gas production registered during fermentation and real degradability (superior to 70%) suggest that studied species present an excellent forage quality potential.

Key words. Local forage legume – Proteins quality – Phenols – Tannins – Gas production – Real degradability.

Rendement, caractérisation nutritionnelle et anti-nutritionnelle de six légumineuses fourragères locales tunisiennes

Résumé. *Le rendement et la valeur nutritionnelle et anti-nutritionnelle de six accessions d'espèces de légumineuses fourragères locales (*Medicago truncatula, Medicago ciliaris, Hedysarum coronarium *(cultivar Bikra 21),* H. carnosum, Lathyrus cicera *et* Scorpiurus muricatus *ssp* muricatus *(variété Haffouz) ont été étudiés. Les échantillons séchés et broyés étaient analysés pour leurs teneurs en fibres, matière organique, matières azotées totales (MAT), la qualité des protéines, et les teneurs en phénols totaux et tannins totaux et condensés. Les paramètres biologiques étaient déterminés en utilisant la technique* in vitro *de production de gaz. À part* Hedysarum coronarium*, toutes les espèces ont montré une teneur en CP comprise entre 20 et 23%. La proportion d'azote lié aux fibres est faible pour toutes les espèces ce qui traduit une bonne qualité des protéines de toutes les espèces. Les composés secondaires n'ont pas montré un effet négatif sur la valeur nutritive des six espèces, même dans le cas de* Hedysarum coronarium *qui a montré un niveau relativement élevé de tannins condensés (37 g kg^{-1} DM). La production de gaz enregistrée pendant la fermentation et la dégradabilité réelle (supérieure à 70%) suggèrent que les espèces étudiées présentent une excellente qualité fourragère.*

Mots clés. *Légumineuses – Qualité des protéines – Phénols – Tannins – Production de gaz – Dégradabilité réelle.*

I – Introduction

Forage legumes of Mediterranean pastures play a considerable role as protein source in ruminant diets. They provide grazable material in spring and early summer or silage, hay straw or seeds in period of forage shortage such autumn and winter, while ensuring soil fertility maintenance through symbiotic nitrogen fixation (Cocks and Bennett, 1999; Chatterton and Chatterton, 1996). Tunisia is known by an important phytogenetic diversity of native forage and pasture legumes (Chakroun and Zouaghi, 2000). Several varieties and cultivars have been released by INRAT (National Institute of Agricultural Research) originating from local legume species such as *Medicago* sp., *Hedysarum* sp. and others. However, they still underutilized because of a failing seed production system to provide quality seeds to farmers (Hassen *et al*., 2013). Moreover, few studies investigated the nutritional and anti-nutritional value of released cultivars (Gasmi-Boubaker *et al*., 2012). The objective of this work is to determine the nutritive value of some new released forage legume cultivars according to their chemical composition and *in vitro* gas production.

II – Material and Methods

The trial was carried out in Tunis at the experimental station of the National Institute of Agricultural Research of Tunisia (INRAT). Six local forage legume species accessions (*Medicago truncatula*, *Medicago ciliaris*, *Hedysarum coronarium* (cultivar Bikra 21), *Hedysarum carnosum*, *Lathyrus cicera* and *Scorpiurus muricatus* ssp *muricatus* (cultivar Haffouze) were sown in plots of 8 m² according to completely randomized block design.

Three 1 m² quadrates of each plot were cut at 50% flowering stage, then weighed and a subsample of 0.5 kg is dried at 60°C during 72 h and then milled to pass through a 1mm screen. Ground sampled of each of the six legumes separately were analyzed for dry matter (DM), organic matter (OM), crude protein (CP), Ca, P according to AOAC (1990) and crude fiber (NDF) according to Van Soest *et al.* (1991). Nitrogen profile of the six legumes was investigated (Soluble CP (pepsin), Non-protein nitrogen, Soluble CP (buffer) and N-ADF according to the methods developed by Licitra *et al.*, 1996). They were also analyzed for total phenols, tannins and condensed tannins according to Makkar (2003). A 72 h *in vitro* gas production technique was carried out to determine the extent and rate of gas production as affected by different substrates (Menke and Steingass, 1988). Ruminal juice was collected from ewes fed oaten hay and commercial concentrate. Gas volumes were recorded after 2, 4, 6, 8, 12, 24, 48 and 72 h of incubation. Metabolizable energy was estimated according to equation developed by Menke and Steingass (1988) using the gas produced in 24 h and CP content. Gas production parameters (a, b and c) were generated using the procedure NLIN of SAS software (SAS, 1994).

Data were subjected to an analysis of variance using GLM procedure (SAS, 1994). The LSMEANS procedure was used to compare means of each variable as affected by the species.

III – Results and discussion

Lathyrus cicera has the highest OM (88.4 %) while *Scorpiurus muricatus* (73.1 %) the lowest one (Table 1). There was no significant difference in the CP content of the tested species which was high, expect *Hedysarum carnosum* NDF content was high (Table 1) and without significant difference in the tested species expect *Scorpiurus muricatus*.

Ca content varied significantly among species, and the highest content was noted in *Hedysarum carnosum accession.* There was no significant difference in the P content among the tested species. P content was relatively low which resulted in a high Ca /P ratio. This imbalance could affect negatively, animal growth, feeds digestibility and ruminal fermentation (Underwood and Suttle, 1999). Overall, total phenols and tannins content of the six legumes was relatively low (Table 1). *Hedysarum coronarium* had the significant higher content of these secondary compounds compared to other tested species. According to Makkar (2003), these concentrations of tannins do not have negative effect on the digestion and animal performance. Moreover, tannins can improve performance in sheep through protecting the protein of legume against ruminal degradation and therefore induce an increase in the flow of alimentary proteins that are found in the intestine where they are transformed into amino acids Barry *et al.*, (2001).

Table1. Chemical composition of six local forage legume species accessions

Accession	DM %	OM	CP	NDF	Total phenols	Total tannins	Conden-sed tannins	Ca	P
Medicago truncatula	11.0	86.3 a	22.2 a	68.2 a	6.20 b	3.6 c	1.02 b	1.85 bc	0.32
Lathyrus cicera	13.3	88.4 a	21.5 a	64.1 a	11.22 b	7.48 bc	1.4 b	1.92 bc	0.35
Medicago ciliaris	13.4	85.9 a	22.9 a	66.9 a	10.28 b	7.51 bc	1.42 b	1.72 c	0.34
Hedysarum carnosum	9.7	73.6 b	15.1 b	62.8 ab	10.54 b	7.99 bc	8.04 b	4.79 a	0.15
Hedysarum coronarium	12.3	85.1 a	21.3 a	67.6 a	19.69 a	15.59 a	37.49 a	2.36 bc	0.28
Scorpiurus muricatus	9.5	73.1 b	20.5 a	57.5 b	11.7 b	9.31 b	11.77 b	3.83 ab	0.38
SE	0.9	2.1	0.5	0.9	1.085	0.916	2.247	0.35	0.22
Pr	0.2297	0.0345	0.0004	0.0103	0.0091	0.0048	0.0002	0.016	0.58

SE and Pr are Standard errors and probability of significant difference, respectively.

Nitrogen quality of the six species was investigated on the basis of soluble nitrogen contents in pepsin, non-protein nitrogen, soluble nitrogen in the buffer and non-digestible nitrogen (N-ADF) (Table 2). The proportion of soluble nitrogen in pepsin ranged from 13 to 51% of CP. This proportion varied significantly among species (Pr = 0.0002) with a deviation of 6.87 % between the maximum value observed in *Lathyrus cicera* (20.29 % DM) and the minimum value observed in *Hedysarum carnosum* (13.42 % DM). The proportion of non-protein nitrogen ranged from 3.6 to 5 % of total nitrogen with the minimum observed in both *Scorpiurus muricatus and Hedysarum carnosum.* This type of nitrogen is considered totally degradable in the rumen. All legumes Buffer soluble nitrogen showed no significant differences among species, except *Hedysarum carnosum*. N-ADF, which represents non digestible nitrogen fraction, was low in all species (inferior to 4%).

Table 2. Nitrogen profile of legume species

	Soluble CP (pepsin)	Non-protein nitrogen	Soluble CP (buffer)	N-ADF
Medicago truncatula	19.4 ab	4.95 b	17.8 a	1.36 a
Lathyrus cicera	20.3 ab	4.43 bc	17.03 a	1.3 ab
Medicago ciliaris	21.5 a	5.87 a	17.9 a	3.5 a
Hedysarum carnosum	13.4 c	3.667 c	11.5 b	0.95 b
Hedysarum coronarium	18.5 b	4.82 b	15.7 a	1.45 a
Scorpiurus muricatus	19.0 ab	3.93 c	16.8 a	1.09 ab
SE	0.46	0.16	0.39	0.07
Pr	0.0002	0.0011	0.0002	0.0441

SE and Pr are Standard errors and probability of significant difference, respectively

Gas production parameters obtained through modeling gas volumes and estimated real degradability and metabolizable energy are given in Table 3. According to results, all of the produced gas came from the insoluble fraction potentially degradable. Indeed, the value of 'b' varied between 92 and 100 %. Gas production rate 'c' is considered high for all species. *Medicago ciliaris* and *Hedysarum carnosum* were distinguished from other species by the highest rate 'c' (P = 0.0218). This rate is an indicative of how fast the DM is fermented in the rumen. Estimated real degradability had not significant difference among the species with a range of 72.7 to 80.1 %. However, metabolizable energy (ME) varied significantly between species. ME content seems to be dependent on DM, OM, CP and Fiber contents and to nitrogen quality. The maximum gas production took place during the first 24 hours of incubation, which suggests that nutrients of studied material including nitrogen and energy are easily used by ruminal micro flora. The relatively high levels of CP and the good quality of nitrogen associated with the high content of ME could explain high gas production rates.

Table 3. Gas production parameters, real degradability and estimated metabolizable energy

Species	a (%)	b (%)	c (/h)	Real degradability (%)	ME (MJ/kg DM)
Medicago truncatula	0.6	93.6	0.08 b	73.9	17.7 ab
Lathyrus cicera	0.5	92.7	0.09 ab	72.7	17.4 ab
Medicago ciliaris	0	97.5	0.10 a	74.5	18.5 a
Hedysarum. carnosum	2.3	95.0	0.10 a	80.1	13.8 c
Hedysarum coronarium	0	100	0.08 b	80.0	18.6 ab
Scorpiurus muricatus	0	100	0.076 b	78.8	16.3 b
SE	0.58	1.75	0.003	1.39	0.3
Pr	0.5648	0.1144	0.0218	0.1649	0.0005

SE and Pr are Standard errors and probability of significant difference, respectively.

IV – Conclusion

This study confirms the high nutritional quality of local forage species which were rich in CP and energy. The high content of proteins and the good degradability of dry matter exclude any negative effect of tannins. Despite their presence in a relatively important amount in *Hedysarum coronarium*, tannins seem to have no effect on its nutritive value.

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Yield production of two *Trifolium* species at different habitats of a Mediterranean island

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Abstract: Natural and semi-natural grasslands comprise a major part of Mediterranean ecosystems and they are mainly used for livestock grazing. However, legume species are not usually found there, probably due to poor management practices. The present study aimed to evaluate the capacity for establishment of two introduced legumes (*Trifolium michelianum* and *Trifolium subterraneum*). The two species were introduced at two different habitats, an abandoned field (AF) and an olive grove (OG) on the island of Lesvos, both destined for sheep grazing. The above ground dry matter biomass produced was measured for two years. The above ground dry matter biomass of *T. michelianum* and *T. subterraneum* did not significantly differ at both habitats the first year. On the contrary, the above ground biomass on average (across the species) was significantly higher at the OG compared to the AF the second year. *T. subterraneum* had significantly higher production than *T. michelianum* at the OG, while their production did not significantly differ at the AF. In the second year, biomass production of both species declined at both experimental areas. It seems that *T. michelianum* is more robust in its adaptation to different habitats, while *T. subterraneum* response is more susceptible to habitat characteristics.

Keywords: Legumes – Mixtures - Biomass production - Agropastoral systems.

Rendement productif de deux espèces de* Trifolium *dans différents habitats d'une île de la Méditerranée

Résumé: *Les prairies naturelles et semi-naturelles comprennent une grande partie des écosystèmes méditerranéens et sont principalement utilisées pour le pâturage du bétail. Cependant, on n'y trouve généralement pas les espèces de légumineuses, probablement en raison de mauvaises pratiques de gestion. La présente étude visait à évaluer la capacité d'établissement de deux légumineuses introduites (*Trifolium michelianum *et* Trifolium subterraneum*). Les deux espèces ont été introduites dans deux habitats différents, un champ abandonné (AF) et une oliveraie (OG) sur l'île de Lesbos, tous deux destinés au pâturage des moutons. La matière sèche de la partie aérienne de la biomasse produite a été mesurée pendant deux ans. La matière sèche de la partie aérienne de la biomasse de* T. michelianum *et* T. subterraneum *ne différait pas significativement dans les deux habitats pour la première année. Au contraire, la biomasse au-dessus du sol (en moyenne pour les espèces) était significativement plus élevée dans l'OG par rapport à l'AF pour la deuxième année.* T. subterraneum *avait une production significativement plus élevée que* T. michelianum *dans l'OG, alors que sa production ne différait pas significativement dans l'AF. Dans la deuxième année, la production de biomasse des deux espèces a diminué dans les deux zones expérimentales. Il semble que* T. michelianum *soit plus robuste dans son adaptation aux différents habitats, tandis que la réponse de* T. subterraneum *est plus sensible aux caractéristiques de l'habitat.*

Mots-clés: *Légumineuses – Mélanges – Production de biomasse – Systèmes agropastoraux.*

I – Introduction

Natural and semi-natural grasslands comprise a major part of the Mediterranean habitats and they are mainly used for grazing (Cosentino *et al.*, 2014; Perevolotsky, 2005). At recent decades overexploitation of grasslands has been observed as the demand for animal products increased due to changes in consumers' choices. Forage legumes adapted to a wide range of soil types, climatic conditions and management systems, are expected to become increasingly important components of sustainable agricultural production systems in Europe. In Mediterranean regions, the commercial pasture seed mixtures commonly consist of a small number of annual legume species, few subclover varieties etc (Maltoni *et al.*, 2006).

During the last decades the annual self-reseeding legumes, mainly subclovers and annual medics, have been increasingly utilized in the Mediterranean areas for the improvement of low quality native pastures, in agropastoral systems (Porqueddu and Maltoni, 2006). Farmers usually don't prefer the establishment of pure legume swards. They establish them in mixture with grasses or cereals in order to ensure satisfactory biomass production rich in carbohydrates, but with adequate protein content (Abbas *et al.*, 2014). The introduction of legumes may positively influence the botanical composition of grasslands and nutritive value of produced forage, improve forage quality and add fixed nitrogen (N) to grasslands, which decreases the need for mineral N (Komárek *et al.*, 2007).

Lesvos island in the North-East Aegean has a long tradition in sheep farming towards the production of Protected Designation of Origin cheeses (Hadjigeorgiou *et al*., 1996). However, grasslands of the island are of poor productivity and often in need for restoration (Hadjigeorgiou *et al.*, 2009). The objective of the present study was to evaluate the capacity of two introduced legume species (*Trifolium michelianum* and *Trifolium subterraneum*) to thrive and persist at two different but typical Mediterranean habitats on Lesvos island.

II - Materials and methods

The experiment was conducted at two different habitats on the island of Lesvos, North east of Greece. These were: (i) an abandoned field (AF) for several years (at 76 m. a.s.l.) which has never been irrigated and mainly used for sheep grazing and occasionally for horses; and (ii) a cultivated olive grove (OG) (at 3 m. a.s.l.) as an agropastoral ecosystem. The climate of the study area is classified as subhumid (Mavromatis, 1980): mild and dry autumn, cool and slightly rainy winter, wet spring, hot and dry summer. Region belongs to the Oleo-ceratonion vegetation zone. The average annual rainfall during study period was 907.6 mm, while mean air temperature over the year was 16.3^{o}C.

The two fields were fenced in order to prevent unplanned animal grazing during the experimental period for two consecutive years 2014-15. After the end of the growing season both fields were grazed by sheep. Each experimental field was divided into three plots depending on vegetation distribution in each field. Plot size was of 0.05 ha at the AF and of 0.07 ha at the OG, respectively. Both fields were ploughed in late November 2013, after the first rainfall. Drill seeding was made in the AF on an area of 0.6 ha. In the OG direct sowing has been made by hand on an area of 0.4 ha. The seeds mixture used in the two cases, was: a) at the AF: *T. subterraneum* (cv Seaton Park - 5 kg/ha), *T. subterraneum* (cv Woogenellup - 7.5 Kg/ha) and *T. michelianum* (cv Paradana - 17.5 kg/ha) b) at the OG: *T. subterraneum* (cv Dalkeith - 9.3 kg/ha), *T. subterraneum* (cv Antas - 13.5 kg/ha) and *T. michelianum* (cv Paradana - 37.1 kg/ha).

Forage production was measured by harvesting the above ground biomass when the inflorescence percentage of sowed species was at least at 50-60%. This was made in order to ensure satisfactory combination between biomass production and nutrient contents. Three samplings quadrats of 0.5 m x 0.5 m were used in each of the experimental plots. After that, above ground biomass of *Trifolium* species was separated from the herbage production of native vegetation and oven-dried at 50 ^{o}C for 48 h.

For all measured parameters differences between the biomass productions were calculated using two-way ANOVA (Steel and Torrie, 1980). All statistical analyses were performed using the GenStat v.11 application. The LSD at the 0.05 probability level was used to detect the differences among means (Steel and Torrie, 1980).

III - Results and discussion

The above ground dry matter biomass of *T. michelianum* and *T. subterraneum* did not significantly differ at both habitats the first year (Fig 1). However, *T. michelianum* tended to produce more at the AF than *T. subterraneum* and less at the OG respectively. The above ground biomass on average (across the species) was significantly higher at the OG compared to the abandoned field (Table 1) the second year. The two species responded differently in terms of forage production at the two habitats during the second year. *T. subterraneum* had significantly higher production than *T. michelianum* at the OG, while their production did not significantly differ at the AF (Fig 1).

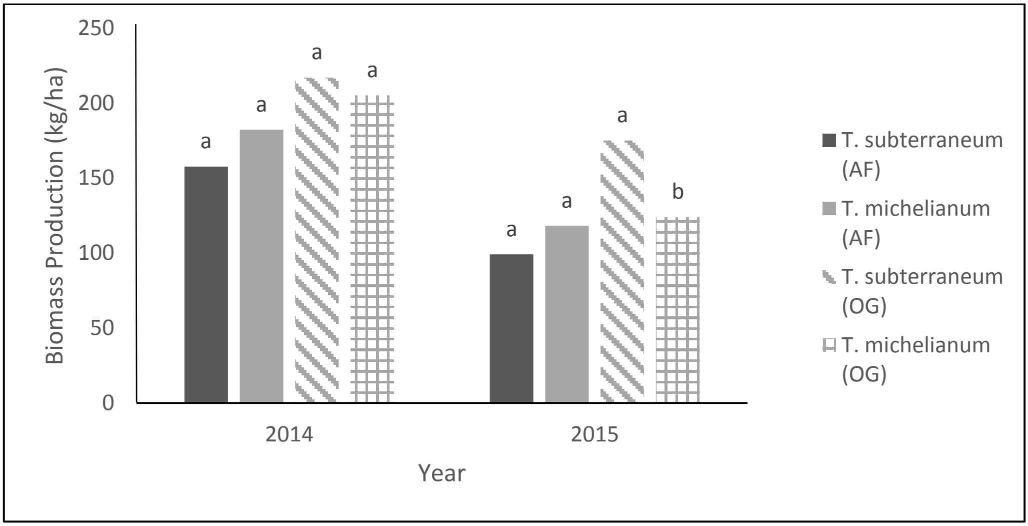

Fig. 1. Above ground dry matter biomass production (kg/ha) of *T. michelianum* and *T. subterraneum* in both habitats for the two experimental years. *Means followed by the same letter in each year and habitat are not significantly different (P≥0.05).

Additionally, there was a general reduction of biomass production from the first year to the second for both species. Yield decline rate was slightly higher at the abandoned field (AF) compared to that at the olive grove (OG) (Table 1).

Table 1. The above ground biomass production of the two habitats (across species) and proportional changes within two years

	2014	2015	Change (kg)	Rate (%)
Abandoned Field (AF)	170a	108b	62	-36.4
Olive Grove (OG)	211a	150a	61	-28.9

*Means of each parameter followed by the same letter in the column are not significantly different (P≥0.05)

Although, the native vegetation density was high in both areas (data not shown) and the climate conditions are expected to have a strong effect at this expansion, the introduced species had a good response to their habitat adaptation. Habitat has the major role in species growth. The main environmental factors affecting growth and herbage production are temperature, light as well as soil nutrients and moisture (Hopkins, 2000). Legumes are strongly influenced in this respect by environmental stress factors (Kadžiulienė and Kadžiulis, 2007). Apart from that, adaptation of each introduced species depends on its special characteristics. For example, it is well known that *T. subterraneum* is a shade tolerant species (Koukoura *et al.*, 2009; Bellon, 1995) therefore it can thrive well under olive trees.

IV – Conclusion

Both introduced species had higher biomass production at the olive grove, although their production was less in the second year. However, it seems that *T. michelianum* is a lesser habitat dependent species, while *T. subterraneum* is much more influenced by its habitat, taking also into account its tolerance to shading. Further monitoring could confirm these responses.

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Production potential of annual meadows in Moroccan coastal region

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Abstract. Harsh soils of the coastal middle region of Morocco are less favorable and over-exploited areas. They are managed as traditional extensive systems, which raise problems of profitability of the production and the durability of the ecological system. Diversification and adaptation of fodder resources is one way to improve and increase forage productions. The aim of this study is to test the performance of production and the adaptation of the some forage species in mixture stands. Four meadows, containing mainly annual species of fodder grasses and legumes were sown in a site located the middle coastal region of Morocco. Meadows were exploited by forage cutting the first year, and by grazing in the beginning of cycle and later mowing for hay on the second year. Dry matter yields ranged from 7 to 12 t ha^{-1} with differences in meadows production. The based fast growth species meadow had exceeded the others by about 5 t/ha of dry matter. Despite some inconveniences of the beginning of cycle, yields were satisfying. There was no elimination of species since all sown species were present in the harvest.

Keywords. Forages – Grasses – Legumes – Annual meadows – Coastal region – Morocco.

Potentiel de production des prairies annuelles dans la région côtière du Maroc

Résumé. *La région côtière de l'ouest du Maroc comprend des sols pauvres et surexploités. Ils sont gérés de manière extensive et traditionnelle ce qui soulève des problèmes de rentabilité et de durabilité du système écologique. La diversification et l'adaptation de ressources fourragères sont une façon d'améliorer et d'augmenter la production de fourrages. Le présent essai est mené dans le but de tester les performances de production et d'adaptation d'un certain nombre d'espèces fourragères conduites en mixture. Quatre prairies de graminées et de légumineuses annuelles ont été semées dans une localité représentative de la région côtière, et ont été exploitées par coupe en première année et par pâturage et coupe en seconde année. La biomasse produite a varié entre 7 à 12 t ha-^{1} avec des différences entre les prairies. La prairie annuelle basée sur les espèces à croissance rapide a présenté de bonnes performances de production et a produit 5 t ha-^{1} de plus. Malgré quelques inconvénients survenus en début de cycle, les rendements ont été satisfaisants. Il n'y a pas eu d'élimination d'espèces à la récolte.*

Mots-clés. *Fourrages – Graminées – Légumineuses – Prairies annuelles – Maroc.*

I – Introduction

Pastures can be considered as one of the ways to improve forage production, quite particularly on the harsh soils of the coastal middle region of Morocco. These less favorable and over-exploited regions are managed as extensive and traditional areas, which raise problems of production profitability and ecological system durability. Furthermore, feeding systems are characterized by the lack of resources diversification coupled with low quality of the available feed resources resulting in unbalanced diets and thus, low animal performance. The diversification and increase of fodder resources in both quantity and quality, in addition to adaptation to soil and climate conditions should be one major key for improving forage production and conserving soils in these areas. In such systems, where crop intensification chances are reduced, it would be better to use a wide range of adapted species than using few high yielding species (NAS, 1979). Furthermore, it is necessary to choose the most profitable grass/legume mixtures under specific soil and climatic conditions (Knoden *et al.,* 2005). Indeed, the use of more diversified seed mixture increases the chances of achieving a productive and a balanced pasture (Crespo, 1997). This study was undertaken for the aim of testing and evaluating the production performance and the adaptation of some annual forage species cropped in mixture stands and based on recent available varieties.

II – Materials and methods

Trials were conducted during two successive years, in 2012-2013 and 2013-2014, in a representative site of the coastal part of the north eastern Morocco, Bouznika (33°74 .N, 7°09'O, 19 m asl). Climate is typical of south Mediterranean region with an average rainfall of 524 mm. Soil is a sandy loam type, moderately deep with pH 6. The study was realized over 4 ha of a divided land into four meadows of 1 ha each during the first year, and on 3 ha of meadow the second year. Four commercial biodiverse mixtures of annual grasses and legumes species by FERTIPRADO Ltd were tested for their adaptation and production (*Fertifeno, Avex, SpeedMix* and *TritiMix*), (Table 1). The proportions of mixture components were not provided for commercial reasons. All mixtures were exploited by unique cutting for hay production during the first year. *Avex* mixture was reconducted in the second year, grazed at vegetative stage and let to produce hay in late spring.

Table 1. Identifiers and species involved in tested mixtureswith their seed weights percentages

Commercial mixture	Mixture species
Fertifeno	Biodiverse mixture of annual rye grass (61.6%), *Trifolium resupinatum* (15%), *Trifolium vesiculosum* (7%), *Trifolium micheli* (4%), *Trifolium incarnatum* (2.4%), hairy vetch (10%)
Avex	Biodiverse mixture composed of *Avena strigosa*, *Lolium miltiflorum, Vicia villosa, Trifolium balansae, Trifolium vesiculosum* and *Trifolium resupinatum*
SpeedMix	Biodiverse mixture composed of alternate rye grass (36.5%), rye grass diploide (36.5%) *Trifolium resupinatum* (14.4%), *Trifolium vesiculosum* (4.6%), *Trifolium micheli* (8%) and *Trifolium incarnatum* (2.4%),
TritiMix	Biodiverse mixture composed of *Triticale secale* (60%), annual rye grass (15%), *Trifolium resupinatum* (10.5%), *Trifolium vesiculosum* (4%), hairy vetch (10.5%)

Sowing was carried out on 28th and 1st November, for 2012 and 2013 respectively, with 35 kg ha^{-1} for each of the mixtures *Avex, Fertifeno and SpeedMix,* and 70 kg ha^{-1} of seeds for the *TritiMix* mixture. Sowing was made using a mechanical seeder with control of seeding depth. Fertilizers were applied at sowing at the rate of 90 and 50 and 40 kg ha^{-1} of phosphorus, potash and nitrogen respectively**.** The observations and the measures concerned stand establishment, visual evaluation of plant covering, weed invasion, diseases scoring, yielded biomass and species proportion at harvest. Meadows were harvested with mechanical mower for hay in early May for *Avex* and *SpeedMix* mixtures and a month later for the *Fertifeno* and the *TritiMix*. Forage yield was assessed through 5 samples harvested from 1 m² each. Forage biomass was weighed and dried in an oven for 72 h at 75°C. During the second year, a herd of 20 dairy cows grazed the meadow when plants height was above 10 cm. Before grazing, cages were placed and served to weight the ungrazed biomass after cows' withdrawal. Pasture was mowed in late May 2014. Statistical analysis was carried out using SAS, software Inc (2007).

During the two years, differences were recorded in rainfall amounts (510 and 305 mm respectively) and distribution through the months. Rainfall came early with near 60% received between October and January. In spring, rains oscillated between 70 and 127 mm. The pattern of rains, even quantity and distribution, did not affect the development and growths of plants for both years. The climatic characteristics of trials location are reported in Fig. 1.

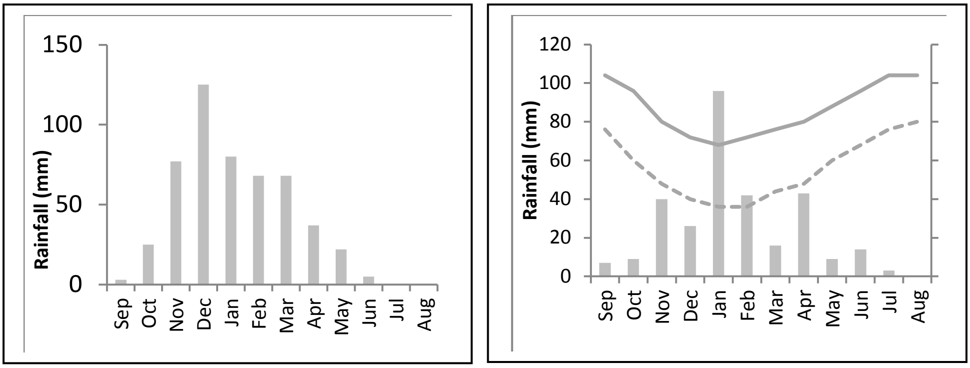

Fig. 1. Rainfall, minimal and maximal temperatures near trial location in 2012/13 and 2013/14 (Bouznika, Morocco).

III – Results and discussion

Stand establishment. All mixtures emerged and established approximately at the same date. Plant densities estimated in December, were 150 to 180 plants m² for all sown species without differences between plots. However, legumes establishment and growth were slower than grasses within all mixtures. Weed invasion occurred, since no defoliation or cutting was performed in early crop season to insure crop's homogeneity and weeds control. During the second year, seedling establishment was accomplished four weeks after sowing. Plant density was between 80 and 100 plant m^{-2}. Grass species had rather good installation than legumes and represented two thirds of canopy composition. The 3 legume species shared the remaining third. Weeds had strongly invaded some naked spots. Main weeds species were *Raphanus raphanustrum*, *Emex spinosa* and *Echium horidum.*

Meadows production. During the first year, forage production differed according to sown mixtures (α<0.01) and average biomass yield varied from 7 to 12 t ha^{-1} (Fig. 2). As mentioned above, harvested biomass results from a single main cutting when the legumes plants were at the end of flowering stage. Forage mixtures *Avex, Fertifeno* and *TritiMix* had rather close yields; however biomass of *SpeedMix* mixture, based on fast growth species exceeded that of the others by 5 t ha^{-1}. During 2014, the meadow was grazed at the end of winter under wet soil conditions, which resulted in plants trampling and soil compaction. The early grazed biomass at vegetative stage was estimated only on a border of the plot, because the established cages for this purpose, were not enough fixed and thus were knocked down by animals when pastured. Therefore, biomass was estimated to 3 t ha^{-1} and four months later, yielded biomass was around 5 t ha^{-1}. The botanical composition at harvest time was rather similar for *Fertifeno* and *SpeedMix* mixtures (Fig. 2). They revealed a dominance of ryegrass, representing almost half biomass yield. Beside this, comparable parts of legumes were found (17 and 14% respectively). Legumes proportion at harvest was higher for *TritiMix* mixture, indeed *Vicia* and *Trifolium* species represented almost one quarter of total yielded biomass. In addition, grasses proportion was lower compared to that of the other mixtures and represented one third of total yielded biomass. Grasses dominated within *Avex* mixture because of the fast development of grasses, especially *Avena strigosa*, apparently well adapted to Moroccan soil and climate conditions. Indeed grass proportion reached 62%, while legume part at harvest decreased to 8%.

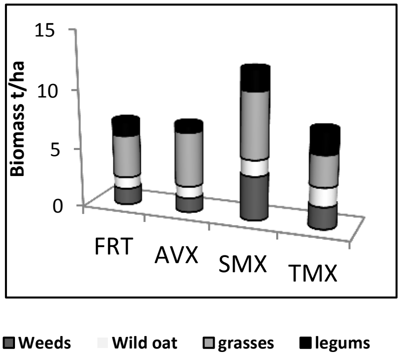

Fig. 2. Annual dry matter yield (T ha^{-1}) from four mixtures (FRT (*Fertifeno*), AVX (*Avex*), SMX (*SpeedMix*) and TMX (*TritiMix*) conducted under Moroccan conditions.

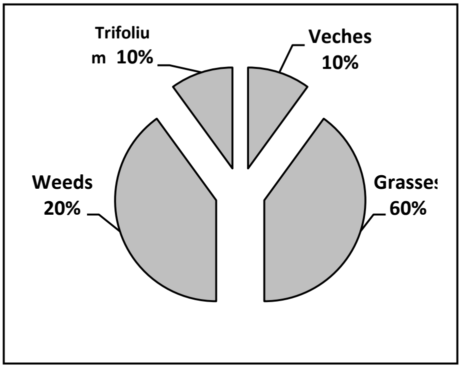

Fig. 3. Botanical composition of *Avex* annual mixture at harvest time at Bouznika site in 2014.

Avena strigosa confirmed its high competitiveness towards weeds. More or less same tends were shown for the second year Nevertheless, the part of legumes is significantly superior in the meadow (20 %), which presents a better balance (Fig. 3). The four meadows had relatively fast establishment, all species had chance to emerge and establish with acceptable rate. With time running, some species such rye grass, oat and triticale, showed some aggressiveness towards the other mixture components, benefiting from their early starting up, their stand habit and their enhanced growth rates. Beside, grass species within each mixture had relatively similar heading periods, which facilitate the later exploitation of the meadow. However some delays in flowering were noticeable in case of legumes. Indeed, it is not recommended to mix varieties with different plant cycle earliness within the same mixture (AFPF, 2014).

IV – Conclusions

Meadows production was satisfactory in the conditions of the region despite some disagreements. The presence of most sown species in the yielded biomass showed that there was no species elimination. Achieved biomass yields with balanced composition confirm that appropriate forage species were used and it should be up to farmers to decide according to their own way of managing meadows and livestock.

Aknowledgments

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The impact of structure and pattern of landscape on grassland ecosystems: the case of Mygdonia basin

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Abstract. The aim of this study was to evaluate the impact of the structure and pattern on grassland ecosystems, using landscape indicators. The research was conducted in five municipal departments in the northwestern part of Mygdonia basin. The spatial allocation of the four different types of landscape structure (grassland, crop fields, tree crops and mountainous crop fields), resulting from the interpretation of satellite image Alos 2008 and indicators of the spatial structure of the landscape were calculated using the Patch Analyst program. The results showed differences between the four types of landscape structure in terms of indicators such as a) class area, the sum of areas of all patches belonging to a given class, b) number of patches for each individual class and c) mean shape index, the average perimeter-to-area ratio for a particular patch type. Most of the area consists of grassland, while the greatest number of patches is found in mountainous crop-fields. Moreover, the patches of these two types of landscape structure have the most irregular shapes, which mean that the inhabitants of each different area have different needs.

Keywords: Patch analysis – Satellite – Physiographic level – Spatial – Indicators.

L'impact de la structure et du modèle de paysage dans les écosystèmes des prairies: le cas du bassin de Mygdonia

Résumé. *Le but de cette étude était l'évaluation de l'effet de la structure du paysage sur la biodiversité des écosystèmes des prairies. La partie nord-ouest du bassin Mygdonia est choisie comme domaine de recherche. La répartition spatiale des différents types de structure du paysage résultant de la transformation de l'image de satellite d'Alos 2008 et les indicateurs de la structure spatiale du paysage ont été calculés en utilisant le programme Patch Analyst. L'analyse des indicateurs a interprété le niveau géomorphologique des cinq départements municipaux de la zone d'étude. Les résultats ont montré des différences entre les quatre types de structure du paysage sur les indicateurs a) CA, b) NUMP et c) MSI. La plupart de la région est constituée de prairies tandis que le plus grand nombre de patches est trouvé dans les cultures en champ montagneux. De plus, les patches de ces deux types de structures du paysage ont la forme la plus irrégulière, ce qui signifie que les habitants de chaque zone différente ont des besoins différents.*

Mots-clés. *Analyse de patch – Satellite – Niveau géomorphologique – Spatial – Indicateurs.*

I – Introduction

Landscape as a general concept is approached from different perspectives. It is the place where mankind developed and organized his life from the beginning of his existence on earth, in various ways and various methods, such as hunting, farming, the cultivation of land, exploitation of forests and the establishment of settlements. Thus, it can be said that today man lives in a landscape which fulfills man's basic and daily needs through a variety of services and goods offered and additionally enables relaxation through the observation of the aesthetic elements (Ispikoudis, 2005).

Traditional agricultural and agroforestry landscapes are characterized by low-intensity systems and land-management activities, providing a high degree of multifunctionality (Jones-Walters, 2008; Pinto-Correia and Vos, 2004; Vos and Klijn, 2000). Such traditional landscapes usually include numerous species of flora and fauna that maintain high biodiversity and represent high aesthetic values and recreational options for people who visit or live within them. These sites allow the harmonious coexistence of man and nature and can be models of sustainable use of land, which is necessary for ensuring the future of man on earth

The study of the structure of landscape and the quantification mosaic stems from landscape indicators, provide information on ecological processes taking place. Specialized indicators, such as indicators on cultural/ rural landscapes and wildlife habitats associated with mosaic, can be very useful in the qualitative and quantitative assessment of the environment (Lausch and Herzog, 2002).

The meaning of each category of indicators of landscape spatial structure is: (a) area measurements: this indicator calculates the area for each patch type (Rutledge, 2003), (b) patch density/patch size: these indicators describe the synthesis of landscapes while considered to be the most basic indicator assessment of their fragmentation (Batistella, 2001; Rutledge, 2003); and (c) shape metrics: these indicators estimate the diversity of patches forms of the landscape, both at class level land use/ land cover. Number of patches (NUMP) describes the ecological processes taking place in a landscape. This indicator characterizes the stability-durability of the landscape in the face of threats. The Mean Shape Index (MSI) captured the shape of patches, which as diverged from value 1 becomes more irregular and calculates the variation of the patches in relation to a perfect geometric shape (Rutledge, 2003).

The aim of this study was to analyze the impact of the structure and pattern of the agricultural landscape of the Northwestern part of Mygdonia basin, Greece, as interpreted by landscape indicators.

II – Materials and methods

The study area consists of five municipal departments located in the northeast part of Mygdonia basin of the prefecture of Thessaloniki where farming is one of the most important economic activities. The total area amounts to 2,059 square kilometers and has a population of 70,000 inhabitants. The main land uses are: grassland: 14,140 ha, forests: 1,820 ha, agricultural crops: 7,760 ha, and other uses: 1,010 ha (NSSG, 1995). It is part of the Para-Mediterranean vegetation zone (*Quercetalia pubescentis*) and belongs to *Ostryo-carpinion* sub-zone in *Coccifera-carpinetum* growth area (Ntafis, 1973). The altitude extends from 80 to 670 meters asl., and according to Mavromatis (1978) the study area has an intense medi-Mediterranean character in low altitudes and as the altitude increases it becomes moderate medi-Mediterranean and sub-Mediterranean up to the highest zone.

According to Zonneveld (1979) the basic structural components of landscape depend on the way they are distributed and create different types of landscape structures, such as: (a) mosaic, (b) grid, (c) dot, (d) dot-grid, and (e) zonation. In our study area we encountered the first four types.

The mosaic structure type corresponds to cultivated land in mountainous areas; the grid structure type corresponds to cultivated land in low areas; the dot structure type corresponds to abandoned areas or grasslands and the dot-grid structure type corresponds to cultivated land with tree crops.

As primary resources in the analysis of the study area characteristics we used satellite image Alos 2008, with panchromatic resolution of 2.5x2.5 meters and the projection system EGSA '87. In the five municipal departments of the study area we applied grids of 1000x1000m with the help of Hawth tools (2010).

The indicators of the spatial structure of the landscape were calculated using the Patch Analyst program and evaluated with level classes modules use/land cover in ArcView 3.2. Of all the available indicators in this study three were calculated and evaluated. These indicators were assessed at the level of class modules use/land cover and classified in relation to the type of patches and their ecological interpretation within three categories, a) area metrics (class area CA), b) patch density/patch size (indicator NUMP) and c) shape metrics (indicator MSI) (McGarigal *et al*., 2004).

III – Results and discussion

The largest percentage of study area included patches of cultivated lands in mountainous parts of these areas (mosaic) and areas for grazing (dot). These two types of landscape structure are the most fragmented and most irregular compared with the other two types, including; cultivated areas in lowland parts of the study area (grid) and tree crops (dot-grid). The class area (CA) indicator presented great diversification for the abandoned area type structure as the NUMP indicator for the cultivated land in mountainous areas. The diversification of the Mean shape index (MSI) between the four types of landscape structure is not so great.

In the study area the three metrics that were used were manifested differentially in the four landscape types. The Class area indicator (Table 1) shows that the grasslands (4287.67 ha) occupied the largest portion of the study area, which also included areas that have been abandoned. These are no longer cultivated and are used as pasturelands. A significant percentage of the patches consist of mountainous crop fields (1478.98 ha), and smaller percentages consist of patches in lowland crop fields (538.67 ha) and tree crops (20.13 ha).

Table 1. Indicator values of structure types in the study area of Mygdonia basin

Structure type	Indicators		
	CA (ha)	NUMP	MSI
MCF	1478.98	252	1.621
LCF	538.67	23	1.47
G	4287.67	109	1.997
TC	20.13	24	1.228

[1]Mountainous crop fields. [2]Lowland crop fields. [3]Grasslands. [4]Tree crops.

The Number of patches indicator (NUMP) (Table 1), which shows the number of patches in each category of landscape structure type found in the study area (Rutledge, 2003), recorded the highest number, 252 patches, for the mountainous crop fields, followed by 109 patches of grasslands, 24 patches of tree crops and the smallest number, 23 patches, recorded for lowland crop fields. The values of the NUMP indicator suggest that in the study area there is differentiation in relation to landscape fragmentation (Rutledge, 2003). The landscape in the study area manifested higher fragmentation in mountainous crop fields and grasslands than in lowland crop fields and tree crops.

On the other hand, the Mean Shape Index indicator (Table 1) presented the lower values for the lowland crop fields and tree crops, which tend to approach the value of 1 (MSI_{grid}=1.47, $MSI_{dot\text{-}grid}$=1.228), while mountainous crop fields and grasslands diverge from the value of 1 (MSI_{mosaic}=1.621, MSI_{dot}=1.997). The above results suggest that in the lowland crop fields and tree crops the shape of patches tend to be regular (Rutledge, 2003; Skouteri, 2005) while in the mountainous crop fields and grasslands have irregular shapes (Rutledge, 2003; Skouteri, 2005). The MSI for the four classes shows a difference of shape complexity between the anthropogenic classes of cultivated land and the grassland/abandoned land. Our results for the MSI indicator are in agreement with the results of O'Neill *et al*. (1988) and De Cola (1989) because mountainous crop fields are not intensively cultivated in contrast with lowland crops fields and tree crops, which reflect the perimeter-conserving tendencies of agricultural development: farmers create rows and consequently blocks (De Cola, 1989) which are also present in grasslands and semi-natural open land.

IV – Conclusions

In the grassland ecosystem of the Mygdonian basin most of the land consists of grasslands (66%). The largest number of patches was found in mountainous crop fields and it shows the extent of the fragmentation in this type of structure of the landscape. Moreover, the patches of these two types of landscape structure have the most irregular shapes.

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Cereals attract wild avian herbivores in wet grasslands – Implications for range management

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Abstract. The aim of this paper was to investigate the effectiveness of the broadcast seeding of common wheat (*Triticum aestivum*) in order to increase the available wintering food for geese species, along the eastern shoreline habitat of the Kerkini Lake, Greece. Seeding wheat increased the total plant cover and subsequently reduced the percentages of the bare soil and the mosses' cover at about 20%. Herbage biomass was also increased (about 30%) compared to the non-seeding sites. Herbage utilization rates by geese species were increased more than 40% in December, i.e. only two months after the implementation of the seeding process. In conclusion, seeding cereals is a promising management practice in order to increase the availability of food for the avian herbivores during the critical wintering period.

Keywords. Broadcast seeding – Geese – Grazing – Food availability.

Les céréales attirent les oiseaux sauvages herbivores dans les prairies humides – Implications pour la gestion des parcours

Résumé. *Le but de cet article était d'étudier l'efficacité du semis à la volée de blé tendre (*Triticum aestivum) *afin d'augmenter la nourriture d'hivernage disponible pour les espèces d'oies, le long de l'habitat sur la rive est du lac Kerkini, en Grèce. Le semis de blé a augmenté la couverture végétale totale et a ainsi réduit les pourcentages de sol nu et la couverture de mousse à environ 20%. La biomasse de l'herbage a également augmenté (environ 30%) par rapport aux sites non ensemencés. Le taux d'utilisation des herbages par les espèces d'oies a augmenté de plus de 40% en décembre, à savoir deux mois seulement après la mise en œuvre du processus d'ensemencement. En conclusion, l'ensemencement avec céréales est une pratique de gestion prometteuse en vue d'accroître la disponibilité de nourriture pour les oiseaux herbivores pendant la période d'hivernage critique.*

Mots-clés. *Semis à la volée – Oies – Broutage – Disponibilité alimentaire.*

I – Introduction

Among many factors capable of shaping the distribution of birds, the availability of winter food supplies is of vital importance (Folmer *et al.*, 2010). It seems that this is also holding for the Asiatic population of the Lesser White-fronted Goose in China, where it heavily uses the heterogeneous recessional grasslands of the East Dongting Lake (Wang *et al.*, 2013). It also plays a major role for bird species in order to withstand the harsh weather conditions during winter and also to be prepared for the trip back to their breeding areas (Owen and Black, 1990). Furthermore, food availability during winter may affect the following breeding success (Morrissette *et al.*, 2010). Cereal crops may constitute a substantial part of geese diet (Vickery and Gill, 1999) and may attract wild herbivores outside of the protected (non hunting) area (Fox *et al.*, 2005). Seeding cereals and generally highly palatable cool-season grasses may be an important benefit for the LWfG because both the availability of forage is expected to be increased and their movements to other areas outside the protected area of the Kerkini Lake National Park are also expected to be further minimized.

The aim of this study was to investigate the effectiveness of seeding cereals in enhancing winter food supplies for goose species in the wet grasslands zone near the shoreline of Kerkini Lake, northern Greece.

II – Materials and methods

The study area was the marshy grassland at the northern and eastern parts of the Kerkini Lake (no more than 300 – 400 m away from the shoreline). Kerkini Lake is a National Park included in the list of the wetlands of international importance for waterbirds (according to Ramsar convention) and is a Special Protection Area (SPA). Due to the lake's operation as an irrigation reservoir, this area is temporarily covered with water six to eight months annually (usually from mid winter to August). As a consequence, the study area is available for grazing by geese usually from August to December – January each year. This marshy freshwater habitat is dominated by *Echinochloa crus-galli*, *Paspalum paspalodes*, *Ranunculus* spp., species of the *Cyperaceae* family, etc. Several geese species, such as the Lesser White-fronted Goose (*Anser erythropus*), the Greater White-fronted Goose (*Anser albifrons*), the Greylag (*Anser anser*) and, occasionally, a few (2 or 3 individuals) escaped Aegyptian Goose (*Alopochen aegyptiacus*) use this habitat for feeding.

Winter wheat (*Triticum aestivum*) was seeded in the marshy habitat, i.e. the main feeding habitat for geese species in order to increase the available food for herbivores during the wintering months. In total, 12 plots at three size levels were seeded (0,5 ha, 0.05 ha and 0.005 ha – 4 plots per level), using the broadcasting method. In addition, 12 plots (3 x 3 m) within three fenced, control (protected from grazing) plots (20 x 20 m) were also seeded with the same method. Seeding was performed at a seeding rate of 250 kg / ha during October of 2014, without any prior preparation of the soil in order not to affect the native vegetation which also constitutes a food resource for geese (Karmiris *et al.*, 2014). During the next two months (November and December), the total plant cover (%) and the average plant height (cm) were estimated in 100 randomly selected plots (0.5 x 0.5 m) in each of the seeded and native sites. In addition, the above ground biomass and the utilization rates of seeded (wheat) and native species were also estimated by clipping the vegetation in 10 randomly selected plots (0.5 x 0.5 m) in each of the free grazing and control sites (Cook and Stubendieck, 1986). Field data were collected twice a month during November and December (at the first and second half of each month). Afterwards, the study area, as well as the wider area including the non-marshy habitat was flooded constituting an unsuitable feeding habitat for geese. This flooding in early winter can be considered as an exception as the whole area is usually flooded in late winter or in early spring (Pyrovetsi and Papastergiadou, 1992). Because no significant differences in any of the vegetation parameters were found among the three size levels of the seeded sites ($P > 0.05$ in all cases) the data were combined for further analysis.

Significant differences in total plant cover in seeded and native sites were evaluated with the Kruskal - Wallis one-way analysis of variance (Siegel and Castellan, 1988). Vegetation (native and seeded) height data, as well as above ground production data were subjected to one-way analysis of variance (ANOVA). Protection from grazing was treated as a fixed factor with two levels (no protection and protection from grazing). Levene's test was performed prior the analysis in order to check the homogeneity of variances (Petrie and Watson, 1999). Differences were considered significant at $P \leq 0.05$.

III – Results and discussion

Plant cover was estimated significantly higher ($\chi^2 = 130.402$, df: 1, $P < 0.001$) in the seeded sites in relation to the native sites (Table 1). As a consequence, cover of bare soil and mosses followed an inversed trend. Height of wheat plants was relatively low in November (3.5 cm); however, one month later their height was almost tripled (9.1 cm), but still significantly lower ($F = 23.563$, df: 1,198, $P < 0.001$) than the height of native vegetation (11.8 cm).

Above ground biomass of the species which potentially constitute food for the herbivores was also almost doubled and significantly higher ($F = 53.771$, df: 1,18, $P < 0.001$) in the seeded sites in comparison to the native sites (Table 1). Wheat above ground biomass was an available food resource for the geese even from November (i.e. only one month after seeding) despite the relatively low height of the wheat plants (just 3.5 cm). This is more profound during early December (i.e. about 40 days after seeding) when geese were used the seeded sites for feeding. By the end of December, all the seeded areas were grazed by geese intensively and the utilization rates of the wheat in December (almost 60%) was even higher than the respective rates (about 44%) of the native vegetation.

Table 1. Vegetation parameters (plant cover, height and above ground biomass) in the seeded and native sites in the marshy habitat at Kerkini Lake in December 2014

Vegetation parameters*	Seeded sites	Native sites
Plant cover (%)	52.7^{a}	26.1^{b}
Height (cm)	9.1^{a}	11.8^{b}
Above ground biomass (g)	29.6^{a}	14.1^{b}

*Different letters within a row indicates significant differences at a = 0.05.

Cereal crops may constitute a substantial part of the diets of geese species (Vickery and Gill 1999) and may modify their usual movement pattern (Fox *et al.*, 2005, Wang *et al.*, 2013). In addition, LWfG have been recorded occasionally in previous years to feed on the non-marshy habitat and in cereal crops outside of the protected area of the Kerkini Lake National Park (Kazantzidis and Naziridis, 1999). Under this perspective, the unusual behavior of LWfG to visit other non-protected feeding areas may be justified by the unavailability of their food. Seeding cereals and generally highly palatable cool-season grasses may be an important benefit for the LWfG because both the availability of forage is expected to be increased and their movements to other areas outside the protected area of the Kerkini Lake National Park are also expected to be further minimized. Consequently, it is expected that such approach will increase the ecosystem's carrying capacity, i.e. to support a higher number of herbivores for a longer period each year. This may further reduce the accidental shooting of LWfG in Europe, which according to Jones *et al.* (2008) constitutes the main threat of the European population of LWfG. At Kerkini Lake, an adult bird was found shot outside the protected area of Kerkini Lake in 2007 (Tsougrakis *et al.*, 2009).

The further and in depth investigation on the movement pattern between/ and within habitats of LWfG (selection of habitats and microhabitats) during the upcoming years should be high in research priority setting. This knowledge is required to assist in prioritizing multiple management actions for the conservation of the European LWfG population and their habitats. Creation of alternative feeding sites for geese, as it was investigated in this study, seems to be a promising, feasible and low cost range management practice which it has been tested successfully for many geese species (Owen and Black, 1990, Percival, 1993, Vickery and Gill, 1999). These sites should be located at the upper parts of the marshy habitat or even more at the boundaries with the non-marshy habitat (i.e. about 400-450 m away from the shoreline), where flooding occurs at a later time in relation to the parts of the marshy habitat near the shoreline. Under this aspect, seeding cereals (e.g. *Triticum aestivum*) in specific sites in the marshy habitat before the arrival of the LWfG (i.e. late September – early October) is a management practice which will enhance the availability of food during the winter.

IV – Conclusions

Seeding winter wheat in the main feeding habitat of goose species at Kerkini Lake increased the total plant cover and the above ground production and subsequently the availability of food for geese. Furthermore, seeding sites attracted geese within 40 days after seeding and herbage utilization of the seeded sites was higher than the sites covered by native vegetation. Seeding winter wheat in the marshy habitat at Kerkini Lake without preparation of the soil is a promising and feasible solution in order to increase the availability of food and to create alternative wintering feeding areas for geese.

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Flowering legumes as pollen and nectar-rich habitats for bees: preference of bee pollinators to different forage species

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Abstract. The intensive use of pesticides in agriculture over the last decades has led to the destruction of a great part of the population of wild bee - pollinators. The objective of the study was to determine the period of flowering and the preference of the bees for different species of flowering leguminous crops. Crops of six (6) species of intensively flowering forage crops were selected: alfalfa (*Medicago sativa*), sainfoin (*Onobrychis viciaefolia*), birdsfoot trefoil (*Lotus corniculatus* L.), forage peas (*Pisum sativum* L.), phacelia (*Phacelia tanacetifolia* Benth) and cocksfoot (*Dactylis glomerata* L). The most prolonged period of flowering was observed in sainfoin (38 days), followed by birdsfoot trefoil, phacelia and cocksfoot. Considerably higher density of bee pollinators was found in sainfoin. The flowering of alfalfa is longer in its first regrowth and shorter in the second. The largest number of wild bees - pollinators appeared in sainfoin and the second largest number in alfalfa. Birdsfoot trefoils are characterized by the lowest attendance of bees. Bees were not found in peas and cocksfoot. The highest density of honeybees (*Apis mellifera)* was found in Phacelia. Their number is influenced by weather conditions.

Keywords. Alfalfa – Sainfoin – Birdsfoot trefoil – Phacelia – Bees pollinators.

Les légumineuses en floraison en tant qu'habitats riches en pollen et nectar pour les abeilles: préférence des abeilles pollinisatrices par rapport aux différentes espèces fourragères

Résumé. *L'utilisation intensive de pesticides dans l'agriculture au cours des dernières décennies a conduit à la destruction d'une grande partie des abeilles sauvages - pollinisatrices. L'objectif de l'étude était de déterminer la période de floraison et la préférence des abeilles vers les différentes espèces de fleurs des légumineuses. Six (6) espèces de cultures fourragères à fleurs intensives ont été sélectionnées - luzerne (*Medicago sativa*), sainfoin (*Onobrychis viciaefolia*), lotier (*Lotus corniculatus *L.), pois fourragers (*Pisum sativum *L.), phacélie (*Phacelia tanacetifolia *Benth) et dactyle (*Dactylis glomerata *L). La plus longue période de floraison a été observée pour le sainfoin (38 jours), suivie par le lotier, la phacélie et le dactyle. Une densité considérablement plus élevée d'abeilles pollinisatrices a été trouvée dans le sainfoin. La floraison pour la luzerne est plus longue au premier cycle et plus courte au deuxième. Le plus grand nombre d'abeilles sauvages pollinisatrices se produit dans le sainfoin et d'autre part dans la luzerne. Le lotier se caractérise par la présence plus faible d'abeilles. Les abeilles sont introuvables dans les pois et le dactyle. La plus forte densité d'abeilles (*Apis mellifera*) a été trouvée dans la phacélie. Leur nombre est influencé par les conditions météorologiques.*

***Mots clés.** Luzerne – Sainfoin – Lotier – Phacélie – Abeilles pollinisatrices.*

I – Introduction

The intensification of crop production and the use of large amounts of fertilizers and plant protection products in recent decades have led to the destruction of a large part of the wild bee pollinators (Carreck and Williams, 2002). The creation of strips of flowering annual and perennial legumes in the field can improve the habitat conditions and increase the biodiversity and abundance of pollinators. The density of the bees is affected by the presence of mass flowering crops (Dochkova *et al.*, 1981, a, b; Westphal *et al.*, 2003). The aim of the experiment was to determine the period of flowering and the preference of the bees for different species of flowering leguminous crops, including sainfoin, birdsfoot trefoil, alfalfa, peas, phacelia, cocksfoot and a mixture of legumes with a view to preserving the biodiversity of pollinators in terms of agricultural production.

II – Materials and methods

The experiments were conducted in 2014 and 2015 in the experimental field of the Institute of Forage Crops – Pleven, Bulgaria. The six flowering fodder crops were subjects of monitoring and comparisons, including three perennial legumes – alfalfa *(Medicago sativa),* sainfoin *(Onobrychis viciaefolia)* and birdsfoot trefoil *(Lotus corniculatus* L.*),* two annual legumes – forage peas (*Pisum sativum* L.) and phacelia (*Phacelia tanacetifolia* Benth), and a single grass – cocksfoot (*Dactylis glomerata* L). A mixed crop included phacelia, alfalfa, sainfoin, red clover and cocksfoot at a ratio of 0.25 of the seeds sown in an area of 600 m^2. The crops were grown without the use of fertilizers and plant protection products.

During the vegetation period each trial on forage crops was marked at the beginning and at the end of the flowering stage and the corresponding length in days was calculated. The bee pollinators were counted during full flowering of the legumes in appropriately sunny (no more than half of the sky is covered with clouds) and warm days (15-20 to 30°C) between 11 am and 15 pm. The number of pollinators was reported by "cutting" with entomological bags. The samples from 1m^2 were taken of the diagonals of the area in four replications.

III – Results and discussion

In meteorological terms the two years are significantly different (Table 1). In 2014 the average daily temperatures during the growing season were lower than those in 2015. The total rainfall in 2014 was about 50 liters more per m^2 compared to that in 2015, which reflected on the humidity, which was higher in 2014 compared to 2015.

Table 1.Temperatures, precipitation and humidity during the period from April to July 2014 and 2015 in the region of Pleven

	Average daily temperature (°C)		Humidity		Rain, mm	
	2014	**2015**	**2014**	**2015**	**2014**	**2015**
April	14.9	12.2	77.0	54	32.3	43.6
May	16.7	18.8	70.0	66	83.0	30.6
June	20.6	21.5	67.0	64	54.3	95.7
July	23.1	25.8	67.0	54	71.8	21.,5
Average	*18.75*	*19.58*	*70.25*	*59.50*	*241.4*	*191.4*

1. Flowering period

The lower daily average temperatures and greater precipitation during the active growing season of the crops are probably the reasons for the long flowering period observed in 2014 (Table 2). It was found that the longest flowering period in 2014 was that of the sainfoin - 38 days, followed by the birdsfoot trefoil, phacelia, cocksfoot and lucerne. This trend continued in 2015, but with a shorter flowering period. Longer flowering was found for the first regrowth of alfalfa in 2015 compared to the second regrowth in 2014.

Table 2. Duration of the phenological stage of flowering

№	Species	Duration of flowering (days)	
		2014	2015
1.	Sainfoin	38	23
2.	Field pea	13	12
3.	Birdsfoot trefoil	21*	20*
4.	Alfalfa	16*	25**
5	Cocksfoot	18	14
6.	Phacelia	21	20

Note: * - second regrowth; ** - first regrowth.

2. Bees density and species composition

The results on the types and numerical composition of the wild bees - pollinators are presented in Table 3 and in Fig. 1. Bees were not observed in the cocksfoot and peas and they were not subject to consideration and discussion. The pollinating insects in the sainfoin are the most numerous and varied. The species composition is represented by seven identified species. The results are consistent with those established by Donchev (1978). The dominant species with the highest representation was *Halictus quadricinctus* (35.5%). High rates were also presented by *E. Longicornis* (19.1%) and *A. falsifica* (18.6%), followed by subdominant types *A. dorsata* (10.6%) and *B. Terrestris* (6.6%). *Bombus sylvarum* has the least representation among the crops.

The results on the number of wild bees in alfalfa have shown that it is also a preferred crop after the sainfoin with seven identified species. A higher number of bees were observed in alfalfa in 2014, when the second regrowth was monitored and lower than the first regrowth in 2015. Probably the different weather conditions in which they formed two saplings had an impact not only on the duration of flowering, but also on the number of bees in both regrowth.

The mixed species treatment was less preferred by the bee pollinators, probably due to the different periods of flowering of legumes and the correspondingly small number of flowers per area unit. Of the six identified species of bees the one with the highest representation was *H. quadricinctus* (34.5%). Dominant types, exceeding 15%, were *A. dorsata* (22.7%) and *A. falsifica* (17.6%), and sub-dominant – *E. Longicornis* and *B. terrestris*.

The number of bees in birdsfoot trefoil was the smallest. Three types of bees were monitored (*A. dorsata*, *B. sylvarum* and *E. longicornis*). Of these, *E. Longicornis* had the highest number.

The frequent rainfall and lower daily average temperatures during the vegetation period in 2014 affected the number of bees' pollinators. Higher air temperatures in 2015 had a favorable impact on the attendance of flowering legumes by pollinators.

Table 3. Number and composition of species of wild bees in legumes of the study, pcs./ 1m^2

Family Apidae	Sainfoin				Alfalfa				Mixed crops		Birdsfoot trefoil	
	2014	2015	Av.	%	2014	2015	Av.	%	2015	%	2014	%
Andrena dorsata	2.4	4.5	3.5	10.6	2.7	2.0	2.4	8.6	2.7	22.7	0.3	15.8
Andrena falsifica	3.1	9.0	6.1	18.6	0.6	4.2	2.4	8.8	2.1	17.6	0.0	0.0
Bombus sylvarum	0.4	1.4	0.9	2.8	1.3	0.7	1.0	3.7	0.3	2.5	0.3	15.8
Bombus terrestris	0.5	3.8	2.2	6.6	0.0	1.1	0.6	2.0	1.0	8.4	0.0	0.0
Eucera longicornis	7.8	4.6	6.2	19.1	13.0	5.5	9.3	33.9	1.7	14.3	1.3	68.4
Halictus maculatus	0.6	3.7	2.2	6.6	11.3	3.6	7.5	27.3	0.0	0.0	0.0	0.0
H.quadricinctus	5.3	17.8	11.6	35.5	2.1	6.4	4.3	15.6	4.1	34.5	0.0	0.0
Total	2062	2094	57		2063	2061	50		2044	127	2024	

3. Density of honeybee *Apis mellifera* L

The honeybee *Apis mellifera* L. is a constant and multiple pollinator of sainfoin, birdsfoot trefoil, alfalfa and phacelia. The highest density of this species was found in phacelia (21.3/m^2), followed by sainfoin (16.4). The smallest representation of honeybees was seen in birdsfoot trefoil (1.7). Alfalfa occupies an intermediate position (13.2). Bees of this type open only from 1.1 to 2.6% of the visited flowers (Dochkova *et al.*, 1981 a, b). During the two years of the experiment the phacelia was visited primarily by the honeybee.

The percentage of bees - pollinators in the forage crops varies primarily as the prevalent type is *Apis mellifera* in sainfoin (33.5%), followed by alfalfa (32.6%) – Fig. 1. Among the phacelia crops we found only honeybees, which absent in birdsfoot trefoil. In the mixed crops the species occupy an intermediate position with 12.5% participation.

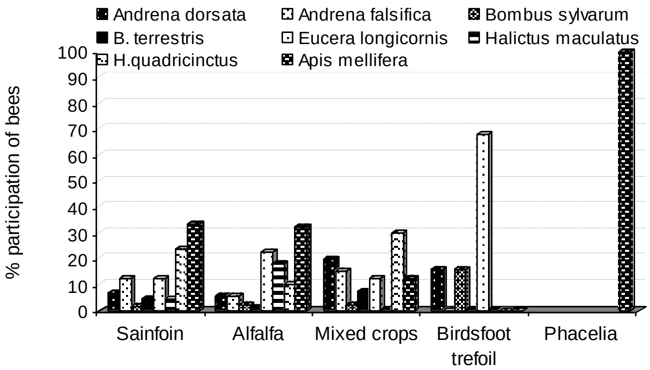

Fig. 1. Ratio of bee pollinators in different forage crops.

IV – Conclusions

The duration of flowering is the longest in sainfoin, followed by birdsfoot trefoil and alfalfa. The period of flowering of alfalfa is longer in the first regrowth and shorter in the second.

The largest number of wild bees occurred in sainfoin and then in alfalfa. The birdsfoot trefoil was characterized by the lowest attendance of bees and the mixed crops occupied an intermediate position. The highest density of *Apis mellifera* was established in phacelia. Their number is influenced by weather conditions. Sainfoin, alfalfa and phacelia are suitable flowering plants to create stripes with a long flowering period as habitats for bees - pollinators.

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Water deficit effect on physiological responses of *Lotus corniculatus* plants of different origin

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Abstract. *Lotus corniculatus* seedlings of two different origins were used to evaluate the effect of water deficit on physiological parameters. Plants from two natural populations of Northern Greece (Kilkis and Taxiarchis) were selected and transplanted to pots. After a period of plant establishment, two water regimes were used: (a) irrigation up to field capacity and (b) limited irrigation in order to maintain water deficit conditions in the soil. The measurements were taken during the growing season at four different phenological stages. Assimilation rate, transpiration rate, stomatal conductance, chlorophyll fluorescence and water potential were measured, while water use efficiency (WUE) was calculated. The results showed that plant origin significantly affected the assimilation rate, stomatal conductance and transpiration rate, with plants of Taxiarchis origin showing higher values. On the other hand, the water treatment used in the present study did not induce any significant changes of the measured physiological parameters, suggesting some degree of drought tolerance of this species.

Keywords. Birdsfoot trefoil – Water stress – Stomatal conductance – Transpiration – Photosynthesis.

Effet du déficit hydrique sur les réponses physiologiques de plants de* Lotus corniculatus *d'origine différente

Résumé. *Des semis de* Lotus corniculatus *provenant de deux régions différentes ont été utilisés pour évaluer l'effet du déficit hydrique sur les paramètres physiologiques. Des plantes de deux populations naturelles du nord de la Grèce (Kilkis et Taxiarchis, respectivement) ont été sélectionnées et transplantées dans des pots. Après une période d'établissement des plantes, deux régimes d'eau ont été appliqués: (a) l'arrosage jusqu'à saturation et (b) l'arrosage limité afin de maintenir des conditions de déficit hydrique dans le sol. Les mesures ont été prises au cours de la saison de croissance à quatre stades phénologiques différents. Le taux net de photosynthèse, le taux de transpiration, la conductance stomatique, la fluorescence de la chlorophylle et le potentiel hydrique ont été mesurés, tandis que l'efficience d'utilisation de l'eau (WUE) a été calculée. Les résultats montrent que le taux net de photosynthèse, ainsi que le taux de conductance stomatique et de transpiration sont significativement influencés par l'origine des plantes ; ceux de* Taxiarchis *montrant des valeurs plus élevées. D'autre part, le traitement de l'eau utilisée dans la présente étude n'a pas induit de changements significatifs des paramètres physiologiques mesurés, ce qui suggère un certain degré de tolérance à la sécheresse de cette espèce.*

Mots-clés. *Conductance stomatique – Lotier corniculé – Photosynthèse – Stress hydrique – Transpiration.*

I – Introduction

Water deficit is one of the most important abiotic factors affecting plant growth in arid and semi-arid regions (Wood, 2005). Plants have developed different strategies to overcome water deficit conditions in the field (Karatassiou *et al.*, 2009). *Lotus corniculatus* L. (birdsfoot trefoil) is a common herbaceous, perennial species, native to areas experiencing dry summers in Greece, and other Mediterranean countries, as well as, in many temperate areas all over the world. Due to its non-bloating features when grazed directly by livestock it is considered as agronomically important. It has also been used for soil remediation and erosion control (Inostroza *et al.*, 2015). Although it is regarded as drought resistant the mechanisms that cause its resistance have not yet been fully understood (Inostroza *et al.*, 2015). This study analyzes the effect of water deficit on the physiological responses of *L. corniculatus* seedlings from two middle elevation grasslands of Northern Greece.

II – Materials and methods

The experiment was conducted in the farm of the Aristotle University of Thessaloniki, Northern Greece (longitude: 40°31'91'', latitude: 23°59'58''), at an altitude of 6 m a.s.l. The climate of the area could be characterized as Mediterranean semiarid with dry summers. The mean annual precipitation of the area is approximately 400 mm and the mean annual air temperature is 15.5°C. During the experimental period, the temperature at the canopy level (T), photosynthetic photon flux density (PPFD) and vapor pressure deficit (VPD), were also acquired using a microclimatic sensor (Novasima MS1, Novatron Scientific Ltd, Horsham, UK). Temperature ranged between 24.3 and 32.6°C, PPFD between 822 and 1304 μmol $m^{-2}s^{-1}$ and VPD between 2.02 and 4.24 kPa.

Lotus corniculatus seedlings were sampled from two semi-arid areas of central Macedonia, Greece, namely Kilkis (K, temperature 12.2ºC; precipitation 585 mm; altitude 570 m a.s.l.) and Taxiarchis (Tax, temperature 11.1ºC; precipitation 767 mm; altitude 645 m a.s.l.) in September and October of 2012 and transplanted in small pots. At the beginning of March 2013, 32 seedlings from each origin were transplanted –one plant per pot– in larger pots (16 cm diameter and 45 cm height), filled with medium texture soil collected from the farm. After a two-month establishment period, a transparent shelter was placed upon plants in order to prevent rainfall intervention. Two drip irrigation regimes were applied: a) irrigation up to field capacity (Full irrigation –FI) and (b) limited irrigation (Limited irrigation –LI) (40% water of that received by FI) in order to maintain water deficit conditions in the soil. The pots were placed in a completely randomized design with four replicates. Measurements were taken during spring 2013 on four different dates corresponding to four phenological stages: early vegetative, vegetative, flowering and start of fruit formation.

In each phenological stage four plants were randomly selected for physiological measurements. The water potential (Ψ) was measured in stems using a pressure chamber (SKPM 1400, Skye Instruments Ltd, Llandrindod Wells, UK). Assimilation rate (A), stomatal conductance (g_s) and transpiration rate (E) were measured with a portable photosynthesis system (LCpro-SD, ADC Bioscientific Ltd, Hoddesdon, UK) on the abaxial leaf surface. Water use efficiency (WUE) was estimated as the ratio of assimilation to transpiration rate. The ratio of variable to maximum chlorophyll fluorescence (F_v/F_m) was measured at 20min dark-adapted leaves using a chlorophyll fluorometer (OS 30p+, OptiSciences Inc, Hudson, USA). All measurements were carried out between 9.30 and 12 a.m. on sunny days.

Analysis of variance (ANOVA) was used to determine the effects of origin, irrigation treatment and plant phenological stage ($P<0.05$) for all measured parameters (Steel and Torrie, 1980). Statistical analysis was performed using the statistical package SPSS (SPSS for Windows, release 22.0; SPSS, Inc., Chicago, USA).

III – Results and discussion

According to the statistical analysis of the data, transpiration rate, stomatal conductance and assimilation rate significantly differed between origins (Table 1), with plants from Taxiarchis presenting higher values of these parameters compared to plants from Kilkis (Table 1). On the other hand, no significant effect of water treatment on *L. corniculatus* physiological responses was found, suggesting some degree of drought tolerance of this species. Water potential, F_v/F_m, E, g_s and A significantly differed among the four phenological stages (Table 1). At the first two phenological stages, Ψ remained at relatively high values, while after the flowering stage it rapidly decreased reaching values about -19 bar. Stomatal conductance and A were higher at the flowering stage, while transpiration rate remained relatively low, leading to high levels of WUE at that particular stage. Even under very low Ψ values, however, plants from both origins continued to photosynthesize at a lower rate. Interestingly, *L. corniculatus* plants showed similar values of F_v/F_m at all phenological stages, which were close to the values reported for non-stressed terrestrial leaves (Bjorkman and Demmig, 1987). Some plants are adapted to photosynthesize even under low water potential, using mechanisms that tend to maintain turgor, in order to protect tissues from dehydration (Jones, 2004). Sanchez *et al.* (2012) and Inostroza *et al.* (2015) working with *L. corniculatus*, found that this species uses osmotic adjustment as a means to overcome water deficit.

Table 1. Main factor effects on *Lotus corniculatus* physiological parameters. Data represent means±S.E

Effect	Ψ (bar)	F_v/F_m	E (mmol $m^{-2}s^{-1}$)	g_s (mol $m^{-2}s^{-1}$)	A (μmol $m^{-2}s^{-1}$)	WUE (μmol $m^{-2}s^{-1}$/ mmol $m^{-2}s^{-1}$)
Origin	NS	NS	*	*	*	NS
Taxiarhis	-6.1±1.8	0.81±0.01	2.3±0.3	0.10±0.01	5.8±0.5	2.89±0.22
Kilkis	-7.0±1.6	0.82±0.01	1.7±0.2	0.06±0.01	4.4±0.6	2.75±0.24
Water treatment	NS	NS	NS	NS	NS	NS
Full	-6.4±1.9	0.82±0.01	1.9±0.2	0.08±0.01	5.2±0.6	2.98±0.25
Limited	-6.7±1.5	0.81±0.01	2.1±0.3	0.08±0.01	5.0±0.6	2.66±0.21
Phenological stage	***	***	***	***	***	***
Early vegetative	-2.4±0.2	0.86±0.01	2.7±0.4	0.09±0.02	5.7±0.9	2.04±0.17
Vegetative	-1.2±0.2	0.79±0.01	2.7±0.4	0.08±0.02	5.5±0.8	2.10±0.18
Flowering	-3.8±1.0	0.82±0.00	1.6±0.2	0.11±0.02	6.8±0.5	4.51±0.19
Fruit formation	-18.9±2.2	0.79±0.01	1.0±0.1	0.03±0.01	2.4±0.3	2.63±0.28

*P<0.05, **P<0.01, ***P<0.001, NS: non significant

Under full irrigation, for the same values of Ψ plants from Taxiarchis had higher values of g_s compared to Kilkis (Fig. 1A). Under limited irrigation and for Ψ>-5 bar, plants from Taxiarchis showed higher g_s values. However, for Ψ<-5 MPa, g_s of plants from Kilkis remained relatively stable and higher than the Taxiarchis one. In addition, in Kilkis origin under both water treatments g_s was less strongly correlated to Ψ (r^2= 0.32 for FI and 0.22 for LI), compared to the Taxiarchis origin (r^2=0.84 for FI and 0.88 for LI), indicating that other factors apart from water potential control the opening of the stomatal apparatus. The changes of g_s in relation to Ψ are expected to also affect the assimilation rate of the species. Indeed, under full irrigation for the same values of Ψ, plants from Taxiarchis showed higher values of A (Fig. 1B). However, A decreased rapidly when Ψ reached very low values. Plants from Kilkis, on the other hand, decreased A more slowly with the decrease in Ψ. Under limited irrigation, for Ψ <-5 bar, plants from Kilkis showed higher assimilation rate compared to Taxiarchis. These differences in the physiological responses indicate that plants of different origin may have developed varying strategies to overcome water deficit conditions. *L. corniculatus* populations obtained from origins of Northern Greece also exhibited different growth parameters in response to water stress (Karatassiou *et al.*, 2015).

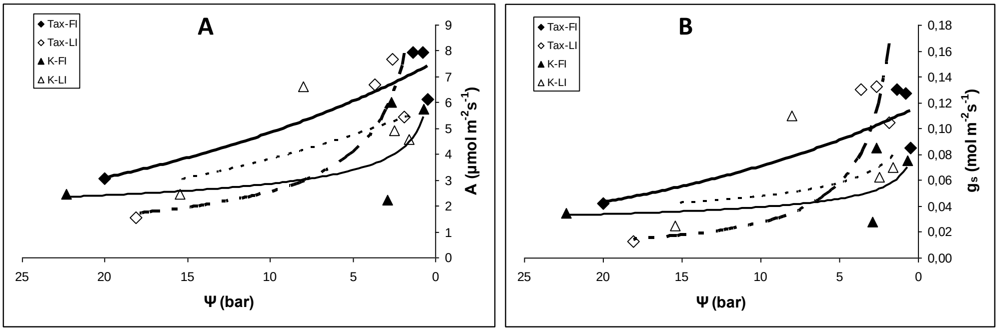

Fig. 1. Changes of stomatal conductance (gs) and assimilation rate (A) in relation to water potential (Ψ). Tax-Taxiarchis, K – Kilkis, FI – Full irrigation, LI – Limited irrigation.

IV – Conclusions

Our results showed that water treatment did not affect *L. corniculatus* physiological responses, indicating some degree of drought tolerance of this species, through the development of strategies that allow photosynthesis even under very low water potential. However, the differences in the physiological responses of the two origins found in the present study may indicate that plants could have employed other plastic and/or adaptive mechanisms to persist and thrive in the environmental conditions of each area.

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Phosphorus use efficiency of *Trifolium subterraneum* as affected by seeding rate under rainfed conditions

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Abstract. Legumes are particularly important feed sources for livestock due to their high nutritive value. The objective of this study was to examine the agronomic phosphorus use efficiency (PUE) of *Trifolium subterraneum* at different seeding rates (13, 17, 20 kg ha^{-1}) and phenological stages (inflorescence, fruiting). The experiment was conducted in Orestiada, northern Greece under rainfed conditions in 2014. Seeds were sown in February and phosphorus fertilization was applied before the seeding. According to the results agronomic PUE was higher at the inflorescence stage compared to the fruiting one. The lowest value of agronomic PUE was observed at the 17 kg ha^{-1} seeding rate, while there was no significant difference between the other seeding rates. However, all the corresponding values were negative. Positive agronomic PUE values were recorded at the seeding rate of 13 kg ha^{-1} during the inflorescence stage and at 20 kg ha^{-1} during the fruiting stage, indicating that phosphorus fertilization is essential to improve forage yield at the specific seeding rates.

Keywords. Forage production – Subterranean clover – Inflorescence – Fruiting – Fertilization.

Efficacité de l'utilisation du phosphore du trèfle souterrain (*Trifolium subterraneum*) influencé par le taux de semis en conditions pluviales

***Résumé**. Les légumineuses sont des sources d'alimentation particulièrement importantes pour le bétail en raison de leur haute valeur nutritive. L'objectif de cette étude était d'examiner l'efficacité agronomique de l'utilisation du phosphore (PUE) du trèfle souterrain à différents taux de semis (20, 17, 13 kg ha^{-1}) et stades phénologiques (inflorescence, fructification). L'expérience a été menée à Orestiada, au nord de la Grèce, dans des conditions pluviales au cours de 2014. Les graines ont été semées en février et la fertilisation phosphatée a été appliquée avant l'ensemencement. Selon les résultats la PUE agronomique était plus élevée au stade de l'inflorescence par rapport à la fructification. La valeur la plus basse de PUE agronomique a été observée au taux de semis 17 kg ha^{-1}, alors qu'il n'y avait pas de différence significative entre les autres taux de semis. Cependant, toutes les valeurs correspondantes ont été négatives. Des valeurs de PUE agronomiques positives ont été enregistrées à 13 kg ha^{-1} lors de l'étape de l'inflorescence et à 20 kg ha^{-1} pendant la phase de fructification, ce qui indique que la fertilisation phosphatée est essentielle pour améliorer le rendement en fourrage dans les taux de semis spécifiques.*

***Mots-clés.** Production de fourrage – Trèfle souterrain – Inflorescence – Fructification – Fertilisation.*

I – Introduction

Legumes are particularly important feed sources for livestock due to their high nutritive value (Porqueddu *et al.*, 2003). They can be sown in pasturelands in order to provide feed for livestock directly or indirectly in various forms (eg. forage, hay, silage) (Gibson, 2009). However, the appropriate choice of the legume forage species will have a significant impact on the success of the pastureland, especially under rainfed conditions in the Mediterranean region.

Trifolium subterraneum L. (*T. subterraneum*) is an annual legume species that grows in all types of soils, with a preference to those of moderate texture, lightly acidic to alkaline and tolerates higher pH values (Rossiter, 1978). It is tolerant to grazing, while it has high feeding value as forage as well as hay and silage (Frame, 2005). However, the seeding rate is an important factor that affects the density, the morphological and productive characteristics of plants, the nutritive value as well as the cost of the seeding (McGuire, 1985; Stefanou, 2015).

Phosphorus (P) fertilization promotes and maintains the production of crops and is an important component in the growth of plants, as its deficiency causes a reduction in the growth rate and the final size of plants (Syers *et al.*, 2008). Low phosphorus (P) availability in many lands is one of the most serious problems worldwide, creating problems both on plant growth and on agricultural productivity (Lynch, 2007). Improving the efficiency of phosphorus (P) fertilizer use for crop growth requires enhanced P acquisition by plants from the soil and enhanced use of P in processes that lead to faster growth and greater allocation of biomass (Veneklaas *et al.*, 2012).

Thus, the objective of the present study was to study the phosphorus use efficiency of *T. subterraneum* at two phenological stages as affected by seeding rate under rainfed conditions.

II – Materials and methods

The research was conducted at the farm of Democritus University of Thrace in Orestiada, northeastern Greece (41°33´N latitude, 26°31´E, 33 m a.s.l.) from February to June 2014. The soil is silty clay with pH 7.5 and P (Olsen) 13.2 mg kg^{-1}. The climate of the study area is classified as Mediterranean type, with mean air temperature of 14^{o}C and average annual rainfall of 507mm (Koutroubas *et al.*, 2012). However, during the experimental period the mean air temperature was 14.2^{o}C and the rainfall was 66 mm (Stefanou, 2015).

T. subterraneum cv Geraldton was seeded in 36 plots of 4m^2 each. The sowing was performed in autumn 2013 but the extremely cold winter resulted in the very low survival rate of *Trifolium subterraneum*. Thus, it was repeated in February 2014. Three seeding rates were tested: 20 kg ha^{-1}, 17 kg ha^{-1} and 13 kg ha^{-1} with six replications per seeding rate. Two levels of fertilization (40 kg ha^{-1} phosphorus and control) were applied before the seeding.

T. subterraneum samples were collected at two phenological stages, early inflorescence in May and fruiting in June. The above-ground biomass production in each plot was determined by using, two 25 x 25 cm quadrats. Plant material was clipped at ground level and placed in individual paper bags. All samples were oven dried at 60°C for 48 h and weighed. Agronomic Phosphorus Use Efficiency (PUE) was calculated by:

$$PUE = \frac{Yhigh - Ylow}{DPapp}$$

were Y_{high} is yield on a high P/fertilized soil, Y_{low} is yield on a low P/unfertilized soil and DP_{app} is difference in amount of P applied as fertilizer between high and low P treatments (Hammond *et al.,* 2009). The results reported on g DM g^{-1} Pf (DM=dry matter; Pf=fertilizer P).

General linear models procedure (SPSS® 18 for Windows) was used for ANOVA. The LSD at the 0.05 probability level was used to detect the differences among means (Steel and Torrie, 1980).

III – Results and discussion

Phosphorus fertilizer application resulted in a negative PUE (Table 1) at both phenological stages (across seeding rates) and at all the tested seeding rates (across phenological stages) indicating that P fertilization depressed the yield of *T. subterraneum*. However, this depression was more intense at the fruiting stage in comparison to the inflorescence one. PUE was significantly lower at the 17 kg ha^{-1} compared to the seeding rates of 20 kg ha^{-1} and 13 kg ha^{-1}, while there were no significant differences between them. The negative response of *T. subterraneum* to P fertilization can be related to the moderate to high availability of phosphorus in the specific soil, as the optimum level of P (Olsen) in the soil for *T. subterraneum* is 15-20 mg kg^{-1} (McLaren *et al.*, 2015). Moreover, the differences among the seeding rates can be attributed to differences in weeds invasion. Indeed, Katsinikas *et al.* (2015) reported that the production of weeds was significantly higher at the seeding rate of 17 kg ha^{-1} in comparison to the other two seeding rates. It is well known that fertilization operated satisfactorily by weeds, thus increasing their competitive ability and decrease the yield of cultivated plants (Eleftherochorinos, 2002).

Table 1. Phosphorus Use Efficiency (g DM g-1 Pf) of *Trifolium subterraneum* at different phenological stages and seeding rates

Effect	PUE (g DM g^{-1} Pf)
Phenological stage	
Inflorescence stage	-0,41$_a$
Fruiting stage	-6,20$_b$
Seeding rate	
20 kg ha^{-1}	-0,29$_a$
17 kg ha^{-1}	-8,24$_b$
13 kg ha^{-1}	-1,38$_a$

*Means of each treatment followed by the same letter in the column are not significantly different (P≥0.05).

A significant interaction between the phenological stage and the seeding rate was recorded (Fig. 1). Phosphorus fertilization at the seeding rate 13 kg ha^{-1} was more efficient at inflorescence stage, while at the seeding rate 20 kg ha^{-1} was more efficient at the fruiting stage. These were the only cases that P fertilization increased the yield of *T. subterraneum*. However, PUE did not significantly differ between the inflorescence and fruiting stage at the seeding rate of 20 kg ha^{-1}. As no significant differences have been recorded among the seeding rates regarding the dry matter production of unfertilized plants in the inflorescence phenological stage (Stefanou *et al.*, 2016), P fertilization can be efficient and improve forage yield only at this low seeding rate.

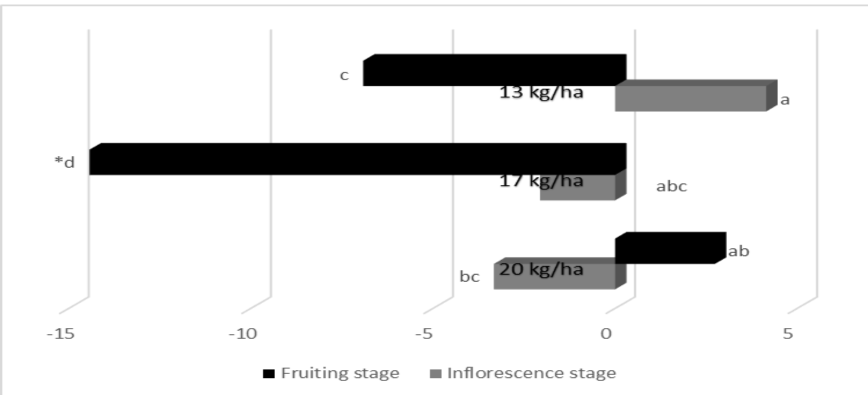

Fig.1. Phosphorus Use Efficiency (g DM g^{-1} Pf) of *Trifolium subterraneum* as affected by phenological stage and seed rate. *Means followed by the same letter are not significantly different (P≥0.05).

IV – Conclusions

Phosphorus fertilizer application had a negative PUE at both phenological stages and at all the tested seeding rates with the exception of inflorescence at the seeding rate 13 kg ha^{-1} and fruiting at the seeding rate 20 kg ha^{-1}. This weak or even negative response of *T. subterraneum* to P fertilization indicates that fertilization is not necessary in soils with moderate to high available phosphorus. Phosphorus fertilization can be applied only in swards established by lower seeding rates that are used for grazing in inflorescence phenological stage.

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Effects of different Nitrogen rates on hay yield and some quality traits of Sudan grass and sorghum x Sudan grass hybrid varieties

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Abstract. This research was conducted to determine the effects of six nitrogen rates (0, 40, 80, 120, 160, 200 kg ha^{-1}) on the hay yield and some quality characteristics of Sudan grass and sorghum x Sudan grass hybrid grown in Yozgat ecological conditions in 2013-2014. As plant material, one Sudan grass and two sorghum x Sudan grass hybrids varieties were used. The experiment was arranged in split plot design with three replications. The average plant height, leaf ratio, hay yield, crude protein ratio, crude protein yield, ADF and NDF ratio were ranged from 200.9 – 205.5 cm, 36.02 – 39.90 %, 1.39 – 2.55 t/da, 8.17 – 11.90 %, 113.5 – 304.9 kg/ha, 37.51 – 40.31 % and 62.59 – 67.34 % in the 2013-2014 respectively. In this study P, K, Ca and Mg content of the varieties were found sufficient in both years. At the end of the two years study, in terms of hay and crude protein yield, Aneto and Bovital varieties which are sorgum x Sudan grass hybrids were superior with 80 kg ha^{-1} N rates under irrigated conditions.

Keywords. Sorghum x Sudan grass hybrids – Hay yield – Crude protein – ADF – NDF.

Effets de différents taux d'azote sur le rendement en foin et sur certaines caractéristiques de qualité chez Sudan grass et chez des variétés hybrides de Sorgho x Sudan grass.

Résumé. *Cette recherche a été menée afin de déterminer les effets de six taux d'azote (0, 40, 80, 120, 160, 200 kg ha^{-1}) sur le rendement en foin et sur certaines caractéristiques de la qualité chez Sudan grass et chez des variétés hybrides de sorgho x Sudan grass cultivées dans Yozgat en conditions écologiques en 2013-2014. Comme matériel végétal, 1 variété de Sudan grass et 2 variétés de sorgho x Sudan grass ont été utilisées. L'expérience a été organisée selon un dispositif split-plot avec trois répétitions. Dans cette étude, la hauteur moyenne des plantes, le nombre de feuilles, le rendement en foin, le ratio de protéine brute, le rendement en protéine brute, les ratios d'ADF et NDF, ont varié entre 200,9 – 205,5 cm, 36,02 – 39,90 %, 1,39 – 2,55 t/da, 8,17 – 11,90 %, 113,5 – 304,9 kg/ha, 37,51 – 40,31 % et 62,59 – 67,34 % en 2013-2014 respectivement. À la fin de l'étude de deux ans, on a compris que, en termes de rendements en foin et en protéines brutes, les variétés Aneto et Bovital, qui sont des hybrides de sorgho x Sudan grass, se sont avérées supérieures avec des taux de 80 kg ha^{-1} N et en conditions irriguées.*

Mots clés. *Hybrides sorgho x Sudan grass – Rendement en foin – Protéine brute – ADF – NDF.*

I – Introduction

Forage sorghum (*Sorghum bicolor* (L.) Moench) is an important crop due to its high yield and drought tolerance. It outperforms other cereals under various environmental stresses and generally is more economical to produce after a winter cereal harvest (Prostko *et al.,* 1998; Diallo, 2012). So, sorghum can be a profitable alternative crop for Türkiye. It is a little-known crop among farmers. Sorghum forage is a basic feed for livestock and especially valuable for feeding in all regions of the world (Afzal *et al.,* 2012). Sorghum is often used to produced silage, hay or pasture during summer. Sudan grass (*Sorghum sudanense* (Piper.) Stapf) has relatively thin stems; tillers cover a large area when conditions permit, and it can regrow rapidly. Thus, it is better suited to pasturing than other types of sorghum. Hybrid Sudan grass crosses usually yield slightly more than true Sudan grass varieties in multiple-cut harvest systems (Anderson and Volesky, 2013).

Nitrogen fertilizer is an expensive but essential input for optimum production of non-leguminous crops on rotation. Despite nitrogen being one of the most abundant elements on earth, nitrogen deficiency is certainly the most common nutritional problem affecting crops worldwide. The application of fertilizer has been known to increase yield of sorghum (Diallo, 2012). Timing is crucial in nitrogen application and plant growth stage, season and leaching must be taken into consideration.

This research was conducted to determine the effects of six nitrogen fertilization rates (0, 40, 80, 120, 160, 200 kg ha^{-1}) on the hay yield and some quality characteristics of Sudan grass and sorghum x Sudan grass hybrids in Yozgat ecological conditions.

II – Materials and methods

This study was conducted in the experimental fields of the Agriculture and Natural Sciences Faculty of Bozok University in Yozgat in 2013 and 2014 growing seasons. The soil taken from 30 cm depth is classified as clay loam with pH: 8.20, $CaCO_3$: 7.93 %, P_2O_5: 8.62 kg da^{-1} and K_2O: 48.47 kg da^{-1}. Organic matter is low in experimental fields. The total rainfall of this area is 111.6 and 371.1 mm, and average temperature of growing season is 16.0 and 16.8^{o}C (2013 and 2014, respectively). The effects of six nitrogen doses (0, 80, 120, 160, 200 kg ha^{-1}) on the hay yield and some quality characteristics of Sudan grass and sorghum x Sudan grass hybrids were investigated. Gözde 80 (a Sudan grass variety registered in Turkey), Aneto and Bovital (hybrid introduced material) were used as plant material. The experiment was arranged in split plot design with three replications. The varieties was the main plots, N doses was the sub plots. The net plot size 3 x 4 m = 12 m^2 and total experimental field size 994 m^2. The seed dose was 30 kg ha^{-1}. Sowing dates were 24.05.2013 (first year) and 13.05.2014 (second year). Recommended dose of phosphorus is 80 kg ha^{-1}. Half dose of nitrogen and full dose of phosphorus were applied at the time of sowing while the remaining nitrogen half was applied at plant high of 40-50 cm. Maturity at harvest was determined using Zadok's scale (Zadok *et al.,* 1974). Harvest was done at late milk stage (Zadok scale 77). Plants were harvested one time in the first year (10.09.2013) and two times in the second year (08.08.2014 and 21.10.2014). Investigated characters were plant height, leaf ratio, hay yield, crude protein ratio, crude protein yield, ADF, NDF, P, K, Ca and Mg ratio. To determine dry weight per plant, plant samples were dried at 60°C until constant weight. After cooling and weighing, the samples were ground to pass through 1 mm screen for quality analyses. Crude protein (CP), Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF) and mineral contents were determined by using Near Reflectance Spectroscopy (NIRS, 'Foss XDS') with the software package program 'IC-0904FE'. Crude protein yield was calculated by multiplying dry matter yield with crude protein content. The data were analyzed using the statistical package program SPSS 11.0 V. (SPSS Inc., Chicago IL, USA). Probabilities lower than 0.05 were considered significant. Duncan's multiple range tests was used to separate the treatment means.

III – Results and discussion

According to the results, the effect of the N rate was significant on the investigated morphological and quality traits (Table 1). Plant height was not influenced by the varieties and N rates. Plant height ranged from 199.4 to 207.9 cm among varieties and 191.7 to 209.3 cm among N rates. Plant height was higher 2014 than 2013 (205.5 and 200.9 cm, respectively). Plant height was higher on the second year because total rainfall in 2014 was higher than 2013. Plant height in previous studies was 194 cm in Sudan grass, and ranged from 60 to 300 cm in hybrids (Karataş, 2011; Nazlı, 2011). Leaf ratio among the varieties was determined between 36.86 and 37.85%. Average hay yield (HY) was significantly ($P<0.01$) affected by genotype, N rates and year and it ranged between 1.89 (Gözde-80) and 2.03 t da^{-1} (Aneto) among genotypes, and 1.92 (Control) and 2.10 t da^{-1} (at 80 kg N ha^{-1}) over the N doses (Table 1).

Aneto and Bovital had better hay yield than Gözde 80. The highest hay yield was measured at 80 kg ha^{-1} N rates, and in 2014 year. Similar results were reported by Balabanlı and Turk (2005), Cecen *et al.,* (2005), Gunes and Acar (2005), Kırbas (2012), and Ozkose *et al.* (2015). The highest crude protein ratio was determined in Aneto with 10.84 %. According to N doses, average crude protein ratio ranged from 9.71 to 10.37%. Crude protein ratio was higher in 2014 compared to 2013 (11.90 *vs* 8.17 %, respectively). Crude protein yield ranged from 190.1 to 233.8; 197.7 to 230.4; and 113.5 to 304.9 t da^{-1} (varieties, N doses and years, respectively).

Table 1. Means of yield and some quality traits Sudan grass and sorghum x Sudan grass hybrids

	PH	LR	HY	CP	CPY	ADF	NDF
Varieties							
Gözde80	202.5	37.85	1.89 *b*	9.65 *b*	190.1 *b*	40.02 *a*	67.44 *a*
Aneto	199.4	36.86	2.03 *a*	10.84 *a*	233.8 *a*	37.65 *b*	62.73 *b*
Bovital	207.9	37.67	2.01 *a*	9.63 *b*	203.7 *b*	39.07 *ab*	64.73 *b*
N Doses (kg ha^{-1})							
0	200.8	36.38	1.92 *b*	10.06	198.8 *b*	40.26	65.79
40	204.8	38.42	1.94 *b*	9.71	202.1 *b*	38.79	64.28
80	209.3	36.01	2.10 *a*	10.34	230.4 *a*	39.37	65.71
120	207.5	40.35	2.00 *b*	9.99	212.2 *ab*	38.09	64.48
160	205.7	37.05	1.95 *b*	10.37	214.2 *ab*	38.89	65.18
200	191.7	36.55	1.93 *b*	9.75	197.7 *b*	38.05	64.34
Year							
2013	200.9	36.02 *B*	1.39 *B*	8.17 *B*	113.5 *B*	37.51 *B*	62.59 *B*
2014	205.5	38.90 *A*	2.55 *A*	11.90 *A*	304.9 *A*	40.31 *A*	67.34 *A*

PH: Plant height (cm); LR: Leaf ratio (%); HY: Hay yield (t da^{-1}); CP: Crude protein (%); CPY: Crude protein yield (t da^{-1}); ADF: Acid detergent fiber (%); NDF: Neutral detergent fiber (%).

There was significant difference in ADF content among varieties and years. ADF content was not affected by nitrogen rates. The highest ADF content was found in Gözde 80 (40.02 %) and Bovital (39.07 %). Aneto had lower ADF content in comparison with other varieties. The highest ADF content was determined in the control fertilization dose and, there was no significant difference between N doses. ADF ratio was higher in 2014 compared to 2013 (35.71 and 40.31%, respectively). NDF content was significantly affected by varieties and year but was not affected by N rates. Sudan grass (Gözde 80) with 67.44% had the highest NDF content. The P, K, Ca and Mg content of varieties were sufficient for sheep and cow requirements in both years. The highest P and K ratio was determined in Aneto variety. Ca and Mg content in this study ranged from 0.50 to 0.67% and 0.15 to 0.22%, respectively (Fig. 1). Gestating or lactating beef cow minerals needs are 1.8–4.4 g kg^{-1} for Ca, 0.4–1 g kg^{-1} for Mg, 6–8 g kg^{-1} for K and 1.8–3.9 g kg^{-1} for P (NRC, 1996). Tejada *et al.* (1985) reported that forage should contain at least 2 g kg^{-1} Mg and 3 g kg^{-1} Ca for the ruminant. For this respect, P, K, Ca and Mg contents of the forage in all the genotypes were higher than animal needs recommended by the previous studies (Ayan *et al*., 2012).

At the end of the two years study, in terms of hay and crude protein yield, Aneto and Bovital varieties and at the dose of 80 kg ha^{-1} N are suggested under irrigated conditions.

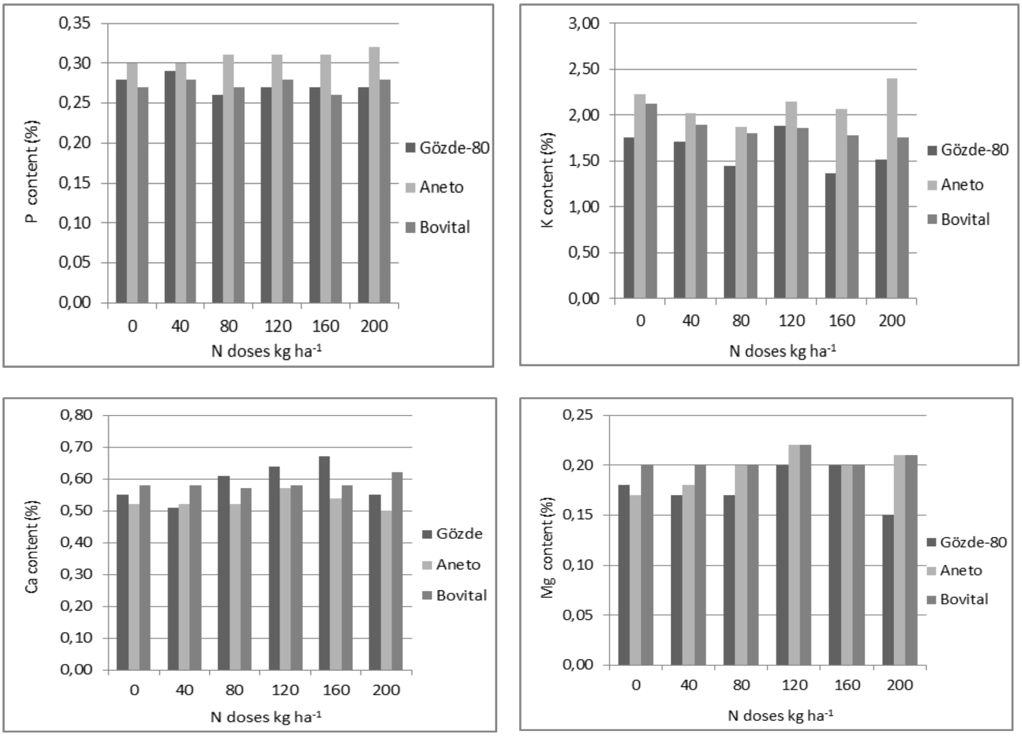

Fig. 1. Mineral content of sudan grass and sorghumxsudan grass hybrids over the mean.

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Hay yield and quality of oat (*Avena sativa* L.) genotypes of worldwide origin

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Abstract. Oat (*Avena sativa* L.) has been traditionally a major crop for feed and forage in Turkey. The objective of this research was to study hay yield and quality of oat genotypes harvested at the late milk stage. One hundred oat varieties of worldwide origin were compared in field experiments in Samsun (northern Turkey) over two growing seasons (2007-2008 and 2008-2009). Significant differences between the tested oat varieties were observed for e plant height, hay yield, crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF) and macro minerals (Ca, K, P and Mg). Plant height varied from 76.2 to 141.2 cm, hay yield varied from 6.03 to 11.83 t ha^{-1}, crude protein varied from 58.8 to 136.4 g kg^{-1} dry matter (DM), acid detergent fiber and neutral detergent fiber varied from 333.2 to 424.8 g kg^{-1} DM and from 522.5 to 652.4 g kg^{-1} DM, respectively. Genotypes such as Sisko, Akiyutaka, Longchamp, Sanova, Flämingslord, Matra and Revisor were identified as the high hay yielding genotypes although their quality s was lower than that of the other genotypes. Furthermore, while some macro minerals were insufficient, others were in excess regarding healthy feeding. Hence, some form of commercial mineral supplement would be required for oat-based ration or oat legumes mixtures should grow for feeding productive livestock.

Keywords. Oat genotypes – Hay yield – Hay quality – Mineral content.

Rendement en foin et qualité de l'avoine (*Avena sativa *L.) de génotypes d'origine mondiale

Résumé. *L'avoine (*Avena sativa *L.) a traditionnellement été une des principales cultures pour l'alimentation et le fourrage en Turquie. L'objectif de cette recherche était d'étudier le rendement en foin et la qualité des génotypes d'avoine récoltés au stade laiteux tardif. Une centaine de variétés d'avoine d'origine mondiale ont été comparées dans des expériences de terrain à Samsun (nord de la Turquie) sur deux saisons de croissance (2007-2008 et 2008-2009). Des différences significatives entre les variétés d'avoine testées ont été observées pour la hauteur des plantes, le rendement en foin, en protéines brutes (CP), en fibres au détergent acide (ADF), en fibres au détergent neutre (NDF) et macrominéraux (Ca, K, P et Mg). La hauteur de la plante varie de 76,2 à 141,2 cm, le rendement en foin varie de 6,03 à 11,83 t ha-1, la protéine brute varie de 58,8 à 136,4 g kg-1 de matière sèche (MS), les fibres au détergent acide et les fibres au détergent neutre varient de 333,2 à 424,8 g kg-1 MS et de 522,5 à 652,4 g kg-1 MS, respectivement. Les génotypes tels que Sisko, Akiyutaka, Longchamp, Sanova, Flämingslord, Matra et Revisor ont été identifiés comme génotypes à rendement en foin plus élevé bien que leur qualité était inférieure à celle des autres génotypes. En outre, alors que certains macrominéraux étaient en quantité insuffisante, d'autres étaient en excès en ce qui concerne une alimentation saine. Par conséquent, une certaine forme de supplément minéral commercial serait nécessaire pour les rations à base d'avoine ou à base de mélange avoine-légumineuses pour la croissance et l'alimentation du bétail productif.*

Mots-clés. *Génotypes d'avoine – Rendement en foin – Qualité du foin – Teneur en minéraux.*

I – Introduction

In Turkey, forage quality is needed for the livestock because the productivity of Turkey's rangeland is very low and the other forage production sources are extremely insufficient. As alternative feed source, uses of small grain cereal forages could partly solve the scarcity of forage (Çelik and Bulur, 1996). Cereals (wheat, barley, oat, rye and triticale) are important forage for livestock feeding. Traditionally, summer grazing and cereal straw feeding in winter are the major sources of ruminants in Turkey. Oats are grown for both grain and forage for livestock feeding over a long time in many parts of the world. In Turkey, oats are grown as both a sole crop and intercropped with annual forage legumes for forage. Oat forage yield and quality are determined by variable factors such as genotype, environment and management practices (Kim *et al*., 2006).

There is a need for continued effort for recent data (agronomic adaptation, hay yield and quality) as new crop genotypes become available for forage cropping systems of the region. Therefore, this research was conducted to investigate hay yield and quality among different oat genotypes.

II – Materials and methods

This study was carried out in experimental field at the Department of Field Crops at the Faculty of Agriculture of Ondokuz Mayis University (41°21´ N, 36°15´ E, and 195 m a.s.l.) during the 2007-2009 growing seasons. Long-term mean precipitation between November and June was 481.3 mm and long-term mean temperature was 11.2°C. Total precipitations in the experimental area were 437.8 and 541.2 mm for 2007-2008 and 2008-2009, respectively. Average temperature was 11.2, 11.9 and 11.2 ºC during 2007-2008, 2008-2009, respectively. The soil texture at the experimental fields was clay. The soil pH and EC were neutral and non-salty, respectively (insert soil data if possible).

One-hundred grain oat genotypes obtained from Europe, North and South America, Asia and Oceania were used in this study. The genotypes were tested in incomplete block design (10x10 alpha lattice) with three replications. Each genotype was sown in 4.8 m^2 (1.2 by 4.0 m) plots consisting of six rows with 20 cm row spacing. The sowing was at the beginning of November 2007 and 2008. Plots were fertilized with 60 kg ha^{-1} N and 60 kg ha^{-1} P at sowing. Maturity at harvest was determined using Zadoks scale. Harvest was done at late milk stage (Zadoks scale 77).

A sub-sample (800 to 1000 g) was randomly selected from each harvested plot to estimate hay yield and provide samples for forage quality analysis. The samples were weighed and dried for 72 h by forced-air drying oven at 65°C. The dried samples were reassembled and ground to pass through a 1 mm screen. Crude protein, acid detergent fiber (ADF), neutral detergent fiber (NDF) and Ca, K, Mg and P contents of samples were determined using near infrared reflectance spectroscopy (NIRS). All data for the two years were combined because of homoscedasticity and adjusted by correction factor and then analyzed with analysis of variance (ANOVA) procedures using the MSTAT-C statistical software. The mean comparison among genotypes was obtained by using the least significant difference (LSD) test.

III – Results and discussion

Analysis of variance combined over two years revealed significant differences among genotypes and years for plant height and hay yield. Plant height in the second year (115.3 cm) was higher than in the first year (95.3 cm). This difference might probably be resulted from the higher cumulative precipitation and other climatic conditions in the second year. The combined data over the two years showed that plant height for all genotypes ranged from 76.2 cm (for CROA 43) to 141.2 cm (for Akiyutaka). Cultivars like Akiyutaka, Yeşilköy 330, Cascade, Sisko, Kolpashevskii, Mantaro 15 and Faikbey were taller (141.2, 132.8, 127.7, 127.2, 124.7, 123.9 and 123.1 cm, respectively) than CROA 43, Lang, Winston, Ebe´ne and Brawn (76.2, 81.3, 82.6, 84,3 and 86.0 cm, respectively).

Data on hay yield showed that hay yield varied significantly among the genotypes. On average, the highest yielding cultivars were Sisko, Akiyutaka, Longchamp, Sanova, Flämingslord, Matra and Revisor (11.83, 11.77, 11.60, 11.53, 11.53, 11.52 and 11.50 t ha^{-1}, respectively). The lowest hay yields were observed for cultivars Lang (6.03 t ha^{-1}), Litoral (6.10 t ha^{-1}) and

IA91400-2-3 (6.37 t ha^{-1}) (Table 1). The high hay yielding genotypes were generally European genotypes. The variation in hay yield among genotypes may be attributed to their genetic characteristics and adaptation to different environmental conditions. Significant variation among oat genotypes for hay yield was reported by Chapko *et al.* (1991), Kim *et al.* (2006), Aydın *et al.* (2010).

Table 1. Means of the traits measured on hundred oat genotypes

Year/traits	PH (cm)	HY (t ha^{-1})	CP (g kg^{-1})	ADF (g kg^{-1})	NDF (g kg^{-1})	Ca (g kg^{-1})	K (g kg^{-1})	P (g kg^{-1})	Mg (g kg^{-1})
2007-2008	95.9	8.84	93.1	375.4	588.7	5.36	19.62	3.16	1.09
2008-2009	115.3	9.92	84.2	397.8	616.0	5.24	18.63	3.13	1.15
$LSD_{0.05}$	4.6	0.2	0.3	9.2	11.0	0.3	2.1	0.7	0.3
Significance	**	**	**	**	**	NS	NS	NS	NS
Overall mean	105.6	9.38	88.6	386.6	602.3	5.30	19.13	3.14	1.12
Minimum	76.2	6.03	58.8	333.2	522.5	2.67	13.32	2.33	0.56
Maximum	141.2	11.83	136.4	424.8	652.4	8.58	25.07	3.67	2.05
CV %	11.4	12.4	7.8	4.7	5.6	4.4	5.1	6.2	3.6

PH: Plant height, HY: hay yield, CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, Ca: Calcium, K: Potassium, P: Phosphor, Mg: Magnesium.
* and **, significant at P<0.05 and P<0.01, respectively. NS, not significant at P<0.05
$LSD_{0.05}$, least significant difference at P<0.05. CV: coefficient of variation.

Significant differences were found among years and genotypes for crude protein, ADF and NDF. Crude protein content of forage is one of the most important criteria for hay quality evaluation (Caballero *et al.,* 1995; Assefa and Ledin, 2001). Crude protein content was higher in the first year than in the second (89.9 g kg^{-1} *vs* 87.4 g kg^{-1}) (Table 1). It ranged from 58.8 to 136.4 g kg^{-1} (Table 1). Bajka (136.4 g kg^{-1}), Aberglen (134,6 g kg^{-1}), Zvolen (132.3 g kg^{-1}), Katri (121.8 g kg^{-1}), Mantaro 15 (121.1 g kg^{-1}), Borowiak (120.7 g kg^{-1}), Pajaz (120.5 g kg^{-1}), Pal (120.1 g kg^{-1}) and Puhti (118.1 g kg^{-1}) had significantly higher crude protein content than the other genotypes. The variation in crude protein of hay between oat cultivars was also reported by other authors (Contreras-Govea and Albrecht, 2006; Kim *et al.,* 2006; Aydın *et al.,* 2010).

Other important quality for forages is the concentration of ADF and NDF (Caballero *et al.,* 1995; Assefa and Ledin, 2001). These fiber contents are strong predictors of forage quality since they represent the poorly-digested portion in the cell wall. In this study, the values for ADF and NDF in first year were lower than those in second year (Table 1). Significant variation was observed between genotypes for ADF and NDF (Table 1). They ranged from 333.2 to 424.8 for ADF and from 522.5 to 652.4 g kg^{-1} for NDF. Cavallo, Belinda, Dukat, Erasmus, Lang, CDC Packer, Boog, IA91400-2-3, Sidabres, Roope, Mara, Flämingsstern, Pharao, Edelprinz ana Yeşilköy 330 had significantly higher ADF than the other genotypes. Similarly, Lang, Flämingsstern, Mara, Boog, IA91400-2-3, Borowiak, Kolpashevskii, Belinda, Dukat, CDC Packer, Cavallo, Rodney, Flämingsplus, Triton, Skakun, Sidabres and Yeşilköy 330 had significantly higher NDF than the other genotypes. For ADF, seven genotypes with the highest hay yield (Sisko, Akiyutaka, Longchamp, Sanova, Flämingslord, Matra and Revisor) were within standard 2 of forage quality (360-400 g kg^{-1} ADF). While for NDF, only five genotypes with the highest hay yield (Longchamp, Sanova, Flämingslord and Matra) met the NDF standard 3 criteria (540-600 g kg^{-1}NDF). Also, significant differences between genotypes were observed for Ca, K, P and Mg contents. Ca contents varied from 3.12 g kg^{-1} DM for Chantilly to 8.58 g kg^{-1} DM for Pharo. According to Tajeda *et al.* (1985) and The American National Research Council (NRC, 2001), forage crops should contain at least 3.0 g kg^{-1} of Ca for ruminants and 3.1 g kg^{-1} Ca for beef cattle, respectively. Results obtained for Ca concentration in this study were more than these recommended values. In the present study, K contents of the genotypes varied from 13.32

g kg^{-1} DM (for CDC Boyer) to 25.07 g kg^{-1} DM (for Riel). The between years difference for K contents was not significant. This result is on line with those of Mut *et al*. (2006), on yield and quality of triticale, barley, rye, and barley varieties and those of Aydın *et al.* (2010), on yield and quality of oat genotypes. The values obtained by our genotypes were higher than those suggested by Tajeda *et al.* (1985) (8.0 g kg^{-1}) although, high K concentration may cause Mg deficiency. Phosphorus contents varied between 2.33 g kg^{-1} DM for Cavallo to 3.67 g kg^{-1} DM for Flämingsplus (Table 1). These values are adequate for ruminants although P concentrations of 1.6-2.6 g kg^{-1} for forage crops are recommended for ruminants (NRC, 2001). Mg concentration in all genotypes was between 0.60 and 2.05 g kg^{-1} (Table 1). The recommended Mg concentrations for forage crops are 2.0 g kg^{-1} for ruminants (Tajeda *et al*.,1985) and 1 g kg^{-1} for beef cattle and 2 g kg^{-1} for lactating cow (NRC, 2001). Magnesium deficiency may lead to a reduction in weight gain, milk production and conception rate (Stuedemann *et al.*, 1983).

IV – Conclusions

Significant differences between the tested oat genotypes were noticed for the following traits: plant height, hay yield, crude protein, acid detergent fiber (ADF), neutral detergent fiber (NDF) and some mineral contents (Ca, K, P and Mg). Generally, the highest yielding genotypes were European origin in this study. Sisko, Akiyutaka, Longchamp, Sanova, Flämingslord, Matra and Revisor were identified as the high hay yielding potential genotypes. Consequently, some forms of commercial mineral supplement would be required to oat-based forage production systems or oat should be grown in mixtures with legumes to fulfill livestock needs in effective feeding. Furthermore, to meet animal needs in oat-based forage systems, crossing high yielding genotypes with genotypes having high forage quality should be suggested for future breeding programs.

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Improving seed production reliability of summer-dormant, drought-tolerant hispanica cocksfoot

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Abstract. Research over the last 20 years has confirmed summer-dormant, hispanica cocksfoots (*Dactylis glomerata* spp *hispanica* Roth.) to be amongst the most drought-tolerant, cool-season, perennial grasses yet commercialised. However, seed supply of this subspecies has failed to meet demand. In Australia farmers successfully grow seed of cultivars (cvv) of the related *Dactylis glomerata* spp *glomerata* and typically use similar management practises to grow *hispanica* cvv but usually obtain low seed yields. Research was therefore initiated to assess whether: (1) there are inherent seed production problems associated with *hispanica* cocksfoot and, if not: (2) focus on issues, e.g. excessively low plant density, previously identified as being possible causes of low yield. This research has demonstrated no inherent seed production limitations associated with *hispanica* cocksfoots. Thus, in the first trial, characterised by a dry period during reproductive growth, the cultivar Kasbah produced commercially viable yields of 450 kg/ha while in the following trial at a different location but with a similar rainfall pattern, a yield of 692 kg/ha was obtained. Another trial showed that the alleviation of moisture deficit between the stages of 75% of inflorescence emergence and 50% anthesis played an important role in maintaining seed yield and quality. These results have implications for those growers with available irrigation. On-going studies are assessing the role plant density might play in seed yield production in older swards.

Keywords. Orchardgrass – Spanish cocksfoot – Plant density – Moisture deficit – Germination.

Amélioration de la fiabilité de production de semences chez le dactyle hispanique, dormant en été et tolérant à la sécheresse

***Résumé**. La recherche sur les 20 dernières années a confirmé que les dactyles hispaniques à dormance en été (*Dactylis glomerata *spp* hispanica *Roth.) étaient parmi les herbacées vivaces de saison froide les plus tolérantes à la sécheresse déjà commercialisées. Toutefois, le stock de semences de cette sous-espèce présente des contraintes pour répondre à la demande. En Australie les agriculteurs font pousser avec succès des semences de cultivars (cvv) d'un apparenté,* Dactylis glomerata *spp* glomerata*, et utilisent typiquement des pratiques de gestion similaires pour cultiver* hispanica *cvv mais généralement n'obtiennent que de faibles rendements en semences. Une recherche a donc été lancée : (1) pour évaluer s'il existe des problèmes inhérents à la production de semences associée au dactyle hispanique et, en cas contraire, (2) pour développer des pratiques de gestion visant à augmenter fiablement la production de semences à des niveaux qui soient commercialement rentables pour les agriculteurs. Le programme expérimental résultant n'a montré aucune limitation inhérente à la production de semences pour les dactyles hispaniques. Ainsi, lors du premier essai, caractérisé par une période sèche lors de la croissance reproductive, le cultivar Kasbah a produit des rendements commercialement viables de 450 kg/ha tandis que lors de l'essai suivant dans un lieu différent mais ayant des précipitations similaires, un rendement de 692 kg/ha a été obtenu. Un autre essai a montré que l'atténuation du manque d'humidité entre les stades 75% d'épiaison et 50% d'anthèses, jouait un rôle important pour le maintien du rendement et de la qualité des semences. Ces résultats ont des implications pour les agriculteurs ayant des disponibilités d'irrigation. Des études sont en cours pour évaluer le rôle que la densité de plantes pourrait jouer dans la production et le rendement de semences dans les prairies plus âgées.*

***Mots-clés**.* Dactylis glomerata – Dactylis glomerata *var.* hispanica – *Densité de plantes – Déficit d'humidité – Germination.*

I – Introduction

Early breeding of *Dactylis glomerata* spp *hispanica* in Australia, led to the release, in the late 1960's of cvv. Kasbah and Berber (Oram, 1990). These cultivars were derived from populations collected in the semi-arid region of southern Morocco and both express high levels of summer dormancy and as a consequence are highly drought tolerant (Norton *et al*., 2006).

However, the delivery of this innovation was thwarted by the unavailability of seed because seed growers were unable to obtain commercially viable yields of these cultivars. Whether this was because of inappropriate agronomic recommendations, e.g. excessively low plant densities, or because hispanica, summer-dormant cultivars such as Kasbah are inherently low seed yielding, needs clarification. Carpenter (1968) also noted that seed yield could be severely restricted if plants experienced moisture deficit during reproductive growth. Thus studies of the role of plant density in seed yield production and to identify that period of reproductive growth when seed development is most reduced by moisture deficit were undertaken.

II – Materials and methods

Two field trials were conducted. The first, sown in September 2012 at Canberra, Australia (35.18 S, 149.06 E) comprised *Dactylis glomerata* spp *glomerata* cv Currie and *Dactylis glomerata* spp *hispanica* cv Kasbah (Oram, 1990). The second was sown in May 2014 at Gerogery, Australia (35.53 S, 146.56 E) and comprised cvv Currie and Kasbah and *Dactylis glomerata* spp *hispanica* cv Uplands. In both trials each cultivar was sown at a rate sufficient to obtain plant densities of 200, 400 and 500 plants/m^2, accounting for variation in seed weight, germination percentage and the likely establishment achieved. Each plot was 4.6 m^2 in area, with rows spaced 20 cm apart. Experimental design was a randomised complete block with 4 replications in the 2012 sown trial and 3 replications in the 2014 trial. Fertiliser was applied at sowing at the rate 22.5 kg N/ha and 19 kg P/ha and N was applied at 50 kg/ha again in early spring of each year in the season before seed harvest. In the 2012 sown trial seed harvest did not occur until early January of the following season, 2013/2014, at which time 2 m of row was randomly selected from each plot and harvested. In the 2014 sown trial seed harvest occurred in January 2015 when 4 m of row was harvested from each plot. In the second trial the number of reproductive tillers harvested together with the length of 20 randomly selected mature inflorescences was also measured.

A third trial to examine the effect of moisture deficit occurring over the period of reproductive growth in cv Kasbah was undertaken in a glasshouse at Canberra, Australia. Three Kasbah plants were grown in 20 cm wide pots each containing approximately 5.5 kg of a freely-draining substrate. The period during which moisture deficit was imposed began on 14 September and continued until 6 November. The pots were divided into seven groups of eight pots. Each group of pots experienced a period of water deficit once (a period of 7 to 8 days) during the reproductive growth period by withholding irrigation. The growth stages was measured on all plants during this trial using the system of Zadoks *et al.* (1974) and all data were analysed by ANOVA in Genstat for Windows 16.

III – Results and discussion

In both the 2012 and 2014 sown trials there were no significant seed yield differences due to plant density and any interactions between cultivar and plant density were also not significant. However, at Canberra the mean seed yield of cv Kasbah across the 3 plant densities was 450 kg ha^{-1}, significantly greater than the yield of cv Currie, 347 kg ha^{-1}. Cv Kasbah was again at Gerogery, as at Canberra, the highest yielding cultivar, producing 692 kg seed ha^{-1}, followed by Currie and Uplands with 452 and 321 kg ha^{-1} respectively. Reproductive growth and thus seed yield, particularly in the later flowering cv Currie, was probably constrained by the low rainfall that Canberra received in October 2013, as only 20 mm of rain fell during that month. This amount is substantially less than the median rainfall of 55 mm for that month. More severe seed yield development constraints would have been experienced in the 2014 sown trial at Gerogery, particularly by both the later flowering cvv Currie and Uplands, as in the 6 week period from 1 October to 15 November only 25 mm of rain was received. The relationship between plant density and seed yield seemed to differ between trials. Results suggested (although statistically not significant) that in the 2012 sown Canberra trial a higher plant density might lead to greater yield in cv Kasbah especially if reproductive growth was not constrained by moisture deficit. In contrast, the results at the 2014 sown Gerogery trial showed that seed yields of Kasbah and Currie declined as plant density increased with 500 plants m^{-2} treatments yielding 384 kg ha^{-1} while the 200 plants m^{-2} treatments had yields of 577 kg ha^{-1}. It is possible that the longer and more severe dry spell during reproductive growth in the 2014 sown trial was the reason why yields in Currie declined so rapidly as plant density increased above 200 plants m^{-2} (Table 1). By contrast this yield decline did not occur in Kasbah as density increased from 200 to 400 plants m^{-2} but was only apparent at 500 plants m^{-2}. The lower yield limit for a commercially viable seed crop of cocksfoot is approximately 400 kg ha^{-1} (N. Phillips, G. Stewart pers. com.). Accordingly the yield of cv Kasbah was high enough in both trials to be commercially viable whereas cv Currie only achieved this seed yield level in the 2014 sown trial while Uplands did not.

Table 1. Seed yield (kg ha^{-1}) of three cocksfoot cultivars at three plant densities in a trial at Gerogery. LSD=253 (P>0.081)

Cultivar\Plant density	200 plants m^{-2}	400 plants m^{-2}	500 plants m^{-2}
Currie	651	361	343
Uplands	302	332	329
Kasbah	777	819	480

Measurements of tiller density and inflorescence length were undertaken to improve understanding of seed yield components in the 2014 sown trial. Across the 3 densities cv Uplands had a higher tiller density (53.5 tillers/m of row) than Currie (30 tillers/m of row). Uplands also had longer inflorescences (66 mm) than either Kasbah (45 mm) or Currie (41 mm). However, while these components might suggest a greater potential seed yield capability of cv Uplands, its later flowering date in the case of this trial and its greater exposure to moisture deficit in the dry spell during October and November caused it to be more adversely affected in seed yield than either cvv Kasbah or Currie. A key factor in explaining seed yield differences between cultivars in both of these trials is their stage of phenological development in relation to the time in the trials when moisture deficit occurred. Cv Kasbah typically flowers in early September in these environments whereas Currie flowers almost one month later in late September/ early October while cv Uplands flowers later still in mid-October (Oram, 1990). Given that the dry period at both sites occurred in October, and at Gerogery continued through until mid-November, it seems likely that cv Kasbah was able to escape from the severest yield reducing effects through its early development whereas this was not possible for cvv Currie and Uplands, with the greater negative effects experienced by the later flowering cv Uplands.

In addition, the results suggest that a positive correlation between plant density and seed yield might exist in cultivar Kasbah under growth conditions where moisture deficit during the reproductive stage is less severe. This is possible because in the Canberra 2012 sown trial a non-significant yield increase of 130 kg ha^{-1}, occurred in Kasbah with 500 plants m^{-2} compared to 200 plants m^{-2}. Moreover, in the second trial, even though the dry period was longer than in the first, Kasbah seed yield did not decline as density increased from 200 to 400 plants m^{-2}. Certainly this possibility deserves ongoing investigation and these studies should also be extended to examine seed yield and plant density interactions with cv Uplands particularly if the possibility of moisture deficit during reproductive growth can be reduced.

In the trial to study the effect of moisture deficit imposed at different plant growth stages on seed yield and germinability, the stage of reproductive growth during which moisture deficit was imposed had a pronounced effect on both seed yield and seedlot germinability (Table 2). Thus moisture deficit imposed at the earliest growth stage tested (Zadoks 55.4, 50% infloresence emergence) had much less effect on both yield and germinability than when the deficit was imposed just 6 days later at Zadoks 56.6. Seed yield and seedlot germinability seemed to be most reduced by moisture deficit when imposed during the period when the growth stages ranged from Zadoks 56.6 (75% inflorescence emerged) to 63.8 (50% anthesis).

Table 2. The effect of moisture deficit imposed at different plant growth stages on seed yield and seedlot germination of cocksfoot cv. Kasbah

Zadoks growth stage	Seed yield (g)	Seedlot germination (%)
55.4	4.846 a	78.3 a
56.6	1.123 c	2.6 c
57.9	2.613 bc	24.7 bc
61.3	2.67 bc	24.2 bc
63.8	2.501 bc	11.6 c
66.2	3.211 b	49.2 b
66.8	4.58 ab	70.6 ab
LSD (P>0.05)	*1.572*	*26.1*

IV – Conclusions

These three trials indicate that moisture deficit during reproductive growth can have a major negative impact on seed yield and germinability of both subspecies of cocksfoot. Irrigation, if available and applied during this period should be able to overcome this yield constraint. Studies of the effect of plant density on seed yield are so far inconclusive but suggest that continued research on this topic is necessary as there is a suggestion that when moisture deficit is absent, seed yield may be positively correlated with plant density. Measurement of the effects of plant density on seed yields in older, mature swards are required as in commerce cocksfoot seed crops must be maintained for several years and it is possible that plant density may change over time.

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Effect of grazing intensity on rangeland productivity in Northern Libyan area of Syrt

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Abstract. Urbanization and irrigation plans that took place in Libya during the last decades have started also to concentrate livestock rearing, consequently for the first time it would now be possible to restrict overgrazing in some areas of the rangeland. Rangeland rehabilitation after long overgrazing by wild animals and nomadic herds should take a start from a preliminary investigation of the present productivity and the effects of grazing limitations. A trial has been done in 2009 in the Syrt rangeland few months before the start of the war, in order to compare forage productivity of the grazed rangeland with that of areas where grazing was avoided. The trial was managed thanks to agreements of the Italian Agronomic Institute for Overseas (Ministry of Foreign Affairs), University of Florence, and University of Syrt now destroyed. The results have shown a very little productivity of the native vegetation, but also the possibility to rise it considerably if grazing can be suspended for a period of time. Further investigation would be needed soon as the area will be secured again for national and international operators. However our results show also that the little productivity of the rangeland cannot be enough to give better lives to rural people and suggest that herding and rangeland uses should be linked to other sectors of the national economy and integrated in a modern scenario.

Keywords. Rangeland productivity – Grazing intensity – Overgrazing – Rehabilitation.

Effet de l'intensité de pâturage sur la productivité des terres de parcours dans la région de Syrte, au nord de la Libye

Résumé. *L'urbanisation et les plans d'irrigation qui ont eu lieu en Libye au cours des dernières décennies ont commencé aussi à concentrer l'élevage, par conséquent et pour la première fois, il sera maintenant possible de restreindre le surpâturage dans certaines zones de pâturages. La réadaptation des parcours après un long surpâturage par les animaux sauvages et les troupeaux nomades, devrait démarrer suite à une enquête préliminaire sur la productivité actuelle et les effets des limitations de broutage. Un essai a été réalisé en 2009 dans les parcours de Syrte quelques mois avant le début de la guerre, afin de comparer la productivité fourragère des parcours pâturés avec celle des régions où le broutage a été évité. Le processus a été géré grâce aux accords de l'Institut Agronomique pour l'Outre-mer d'Italie (ministère des Affaires étrangères), de l'Université de Florence et de l'Université de Syrte maintenant détruite. Les résultats ont montré une très faible productivité de la végétation indigène, mais aussi la possibilité de l'augmenter considérablement si le pâturage était suspendu pour une période de temps. Une enquête plus poussée serait nécessaire dès que le secteur sera de nouveau sécurisé pour les opérateurs nationaux et internationaux. Cependant, nos résultats montrent également que la faible productivité des pâturages ne peut pas être suffisante pour donner une vie meilleure à la population rurale et suggèrent que l'élevage et l'utilisation des pâturages doivent être liés à d'autres secteurs de l'économie nationale et intégrés dans un scénario moderne.*

Mots-clés. *Productivité des terres de parcours – Intensité du pâturage – Surpâturage – Réadaptation.*

I – Introduction

The Libyan Government during the period of Gheddafi conducted a policy of agricultural development supported by the construction of the Great Man made River that would serve 180,000 ha using fossil water. This project was integrated into a wider project of sedentarization and urbanization. The development of intensive irrigated agriculture has already brought a reduced human and livestock pressure on the predesertic environment, but also gradual abandonment of the heritage of rangeland people. Grazing was locally conducted with too low or too high stocking rates, with uncontrolled herds. This caused progressive loss of productivity, increasing percentage of bare soil and biodiversity loss (Pardini *et al.,* 2009). For these reasons we did a preliminary investigation on vegetation productivity and soil cover of the local rangeland in view of changes for its sustainable management. The purpose of the research has been to identify some good management practices that can favour vegetation recover and consequently higher biomass production and soil cover, reducing contemporarily soil erosion.

This research investigated biomass availability at the end of the growing period in the rangeland in Shabiyat of Misurata (area of Bani Walid) and Syrt (areas of Sultan and Al-Gardabia), in representative areas of the transitional region between the narrow strip of coastal vegetation which also includes the new farms irrigated by GMMR project, and the great inland Sahara desert. The area has very poor natural vegetation, characterized by grasses and small shrubs, often with low palatability and nutritional value, the unfavourable condition of the vegetation are due primarily to the harsh physical environment but also to decades of excessive human pressure on the rangeland.

The following research was done within the project “Centre for applied research in animal growing and forage cropping in the Shabiyah of Syrt”, which was assigned by the Directorate General for Development Cooperation of the Italian Ministry of Foreign Affairs to Istituto Agronomico per l’Oltremare of Florence, with Shabiyah of Syrt, local partner, and in collaboration with the School of Agriculture of the University of Florence, and Al Tahadi University of Syrt.

II – Materials and methods

A preliminary investigation and the choice of the sampling areas has been done in February, all data have been collected at the end of March 2009. February - March is the only short period with some rain and plant growth. The quantity of biomass reduces rapidly in the following months due to grazing, drying, and enhanced drought. The livestock grazes in mixed groups of mainly sheep and goat, sometimes also with few dromedaries. The livestock is conducted by shepherds in different parts of the rangeland according to annual planning, so that there is always a part grazed and another normally not grazed and left to periodical rest. Grazing control is sometimes facilitated with fencing.

Three areas of the coastal rangeland of Syrt have been investigated (Bani Walid, As Sultan, Al Gardabya). Each of the three areas had three sub-areas. Each sub-area had one area that normally is grazed and one nearby area that normally is not grazed, for a total 18 sub-areas. Three sampling areas were controlled into each sub-area for a total of 54 sampling areas. Grazing or not grazing is just controlled by shepherds, even if in some areas there is fencing. The following measurements have been done in each area and sub-area:

Soil cover. Linear analysis. Three lines in each of the three sub-areas in grazed and not grazed areas, for a total of 54 lines. Each line 100 m, with analysis points each 1 metre. We considered any plant present as “covered” and every spot without plants as “bare soil”. Consequently the calculation of bare soil percentage has been analytical.

Biomass. Grass mowing and shrubs defoliation in 5 m^2 inside the 54 sampling areas. After mowing and green weighting, samples of 500 grams have been collected, oven dried and weighted again to know the percentage of dry matter.

Rangeland carrying capacity. This calculation has been done by the Ponderal Contribution method (Pardini *et al*., 2002) that integrates biomass measurements and calculations, with esteems of the forage value. The method however has been simplified introducing a coefficient of forage value = 0.4 as it was calculated for the same area in a different study (Pardini *et al.,* 2016). The data of biomass and the coefficient were input in the program Ranger 3.0 (Pardini *et al*, 2011).

III – Results and discussion

1. Soil cover

The soil covered by vegetation was not much (43.3% in the average of all areas and sub-areas), however considering that this is an arid rangeland the cover has been good (Table 1). The difference of grazed and not grazed areas has been notable, only 35.8% of the soil was covered by vegetation in the grazed areas, in comparison to 50.7% in the ungrazed. This difference is important and confirms the utility of resting periods for the vegetation.

Table 1. Percentage of soil covered by vegetation in the three areas investigated

Area	Soil covered by vegetation (%)		
	Grazed	Not grazed	Average
Bani Walid	42.1 a	57.3 a	49.7
As Sultan (Alhnioa)	34.6 b	48.4 b	41.5
Al Gardabya	30.7 b	46.5 b	38.6
Average	35.8	50.7	43.3

Data with different letters in columns are significantly different at P=0.05, ANOVA by Sistat.

2. Biomass available

The quantity of biomass in the rangeland (Table 2) has been very little in all the three areas and in the average (1.13 t ha^{-1}), this quantity will remain almost unchanged through the whole year due to rapid drought, however this small quantity is normal in a predesertic area.

In the three not grazed areas was recorded the highest production in all cases and in the average (1.38 t ha^{-1} in not grazed areas, and only 0.88 t ha^{-1} in grazed areas). This suggests that even an annual period of rest is enough to restore vegetation conditions and productivity. Plants in the not grazed areas were more frequent and bigger than in the grazed areas where clearly some were eaten and also killed before reaching a large size.

Table 2. Biomass in the three areas investigated

Area	Biomass DM (t ha^{-1})		
	Grazed	Not grazed	Average
Bani Walid	0.36 b	0.80 c	0.58
As Sultan (Alhnioa)	1.24 a	1.46 b	1.35
Al Gardabya	1.04 a	1.86 a	1.45
Average	0.88	1.38	1.13

Data with different letters in columns are significantly different at P=0.05, ANOVA by Sistat.

3. Rangeland carrying capacity

The annual carrying capacity per hectare, calculated on the biomass cumulated at the end of March and corrected with Forage Quality coefficient = 0.4, has been within 0.051 and 0.127 Livestock Units (500 kg livestock). Even if the biomass was cumulated only up to the end of

March, this is the data that must be considered because any further production will be extremely little after this period and, on the contrary, livestock will keep on grazing all through the year. The carrying capacity resulted 1.57 times higher in the not grazed areas (0.077 LU per ha per year in the average of three areas) than in grazed areas (0.12 LU in the average).

Conclusions

The biomass availability in the arid rangeland analyzed is very low and will be impossible to rise it conveniently unless there is irrigation, that of course shall not be applied. The productivity of vegetation has been higher in the not grazed than in the grazed areas, thanks to lower percentage of bare soil and because plants were bigger than in other parts.

In conclusion, this preliminary research has shown very poor biomass availability, although higher in not grazed areas. Consequently, we advise longer resting periods for the grazing sectors and a better control on herd movements.

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Irrigated forage productivity in the area of Syrt (Northern Libya)

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Abstract. The construction of the Great Man Made River started and completed by the former Libyan Government, allowed the irrigation of many farms in the northern part of Libya cultivating food and forage crops. A trial has been done in 2009 in the Syrt irrigated area few months before the start of the war, in order to compare the productivity of irrigated forages. The trial was managed thanks to agreements of "The Italian Agronomic Institute for Overseas" (Ministry of Foreign), University of Florence, and University of Syrt. Initial forage crops compared were oats (*Avena sativa*), vetch (*Vica sativa*), intercropping of oats+vetch, Chickpea (*Cicer arietinum*), field bean (*Vicia faba* var. *minor*). Our results suggest interesting potentialities in terms of yield but difficulties due to weeds diffusion. Further research would be needed, as soon as the new social conditions will be secured, especially comparing cool season forages and some tropical species.

Keywords. Irrigated forages – Overgrazing reduction.

Productivité des fourrages irriguées dans la région de Syrte (nord de la Libye)

Résumé. *La construction du Grand Fleuve Artificiel au cours de l'ancien gouvernement libyen, a permis l'irrigation de nombreuses fermes dans la partie nord du pays, pour les cultures alimentaires et la production de fourrage. Un essai a été réalisé en 2009 dans la zone irriguée de Syrte quelques mois avant le début de la guerre, afin de comparer la productivité des cultures fourragères irriguées. Le processus a été géré grâce aux accords de l'Institut Agronomique pour l'Outre-mer d'Italie (ministère des Affaires étrangères), de l'Université de Florence et de l'Université de Syrte. Les plantes fourragères initialement comparées sont l'avoine (*Avena sativa*), la vesce (*Vicia sativa*), l'association avoine+vesce, le pois chiche (*Cicer arietinum*), et la féverole (*Vicia faba *var*. minor*). Nos résultats suggèrent des potentialités intéressantes en termes de rendement, mais des difficultés subsistent dues à la diffusion des mauvaises herbes. D'autres recherches seraient nécessaires dès que les nouvelles conditions sociales seront assurées, en particulier en comparant des fourrages tempérés et certaines espèces tropicales.*

Mots-clés. *Plantes fourragères irriguées – Réduction du surpâturage.*

I – Introduction

Libya imports most of the dairy products consumed, as well as feeds for animals; therefore there is a strong need for establishing a local milk production and transformation industry and also for identifying more suitable crops to support dairy cow farms (Adrawi, 2009; Gamal Ghashut, 2005).

The former Government of Libya had carried out a plan to develop agriculture as part of a wider project of sedentarization and urbanization. As a part of this policy, the "Great Man-made River" project was built over 2.000 km to carry water (Abdelrhem *et al.,* 2008) to each small farm (5 hectares each). Thanks to the water of the "Great Man-made River", the Libyan country had increased considerably the potential of producing foods, forages and animal products.

An important agronomical issue related to the use of water for irrigation is the choice of species to crop. Our research analyzed the productivity of irrigated forages in Syrt coastal area, in the fields of the Experimental Centre for milk production and transformation, established in compliance with the agreements undertaken between Italy and Libya in 1998. The Italian Ministry of Foreign Affairs has entrusted the realization of this program to the Agronomic

Institute for Overseas of Florence, which has worked in partnership with the Shabiyah of Syrt and the Al Tahadi University of Syrt as local institutions, and in cooperation with the University of Florence.

II – Materials and methods

The research was done at the Experimental Research Centre for Livestock and forages in the Syrt region, built on 100 hectares of land at 15 km from Syrt. All experimental plots are surrounded by *Eucalyptus* spp. and *Acacia spinosa*. All data were collected at the end of March 2009 because at that period the arrival of drought is quite fast and large amount of water is necessary to support further production. Seven crops were compared, each repeated three times with random distribution on the field (three randomized blocks with seven plots each). Each forage plot was 10x20 meters (200 m^2). The following plant species were sown after soil harrowing, in December of the year before the collection of data and irrigated by sprinklers for the production of forage biomass and/or legume seeds aiming to enrich livestock diets with high protein content:

Medicago sativa (Ms, alfalfa, for plant biomass)

Hordeum vulgaris (Hv, barley, for plant biomass)

Avena sativa (As, oats, for plant biomass)

Avena sativa + *Vicia sativa* (A+V, oats+vetch, for plant biomass)

Pisum sativum (Ps, field pea, mainly for legume seeds - proteins)

Cicer arietinum (Ca, chickpea, mainly for legume seeds - proteins)

Vicia faba var*. minor* (Vm, broad bean, mainly for legume seeds - proteins)

The measurements done were the following:

1) Weeds and bare soil in the crops. Linear analysis method (Warren Wilson, 1959). Three lines per plot, thus 9 per crop, each line of 20 m length, recorded every 50 cm. We recorded separately weed species, crop plant and bare soil, then we calculated the percentage each plant species contributed to the vegetation and the proportion of bare soil in the plots.

2) Forage biomass. A sampling area of 1 m^2 was mowed completely, that means 9 sample areas per crop. Weeds were removed manually and excluded from this calculation. The green biomass was weighted, then one sample of 500 grams taken from each plot, oven dried and then weighted to calculate the percentage of dry matter.

III - Results and discussion

1. Weeds and bare soil in the crops

The most frequently weed (Table 1) was *Emex spinosa* (17.91% on average for the seven crops). It is an annual plant of the *Polygonaceae* family. It has colonizing characteristics including drought tolerance, rapid growth, abundant seed production, seed dormancy and high dispersal abilities.

The second frequent plant was *Festuca arundinacea* (only 7.90% in the average of all plots), which is a rather drought tolerant grass well adapted also to the warm Mediterranean environment. All other weeds had only very little specific contributions and were occasional in our trial.

The bare soil has not been much anywhere in the trial and it had the minimum value in the combination *Avena sativa* + *Vicia sativa* var*. minor*, probably because of the good relationship and cooperation of the legume with the cereal has favored the development of the association. This suggests that intercropping legumes and grasses can be very useful in the sandy soils of the area.

The three grain legume crops contributed to the total plant biomass less than the others which can be resolved by introducing different *Rhizobium* strains than those naturally present. The most covering crops were *Medicago sativa* that is known to have a rapid growth and good cover, *Hordeum vulgare* and *Avena sativa* that are sown denser than legume pulses, and the association of *Avena*+*Vicia* that probably benefited of the association.

Table 1. Weeds specific contribution (%) in the seven forage crops of the trial, in order of presence. (MS = *Medicago sativa*, HV = H*ordeum vulgare*, As = *Avena sativa*, A+V = Association *Avena sativa* + *Vicia sativa*, Ps = *Pisum sativum*, Ca = *Cicer arietinum*, Vm = *Vicia faba* var*. minor*

Weed species	Specific Contribution (%) in the seven crops							
	Ms	***Hv***	***As***	***A+V***	***Ps***	***Ca***	***Vm***	**Aver.**
Emex spinosa	5.23	14.71	0.00	10.42	26.03	34.02	34.95	17.91
Festuca arundinacea	3.51	0.00	2.86	5.82	10.95	27.75	4,41	7.90
Lolium loliaceum	0.00	0.05	0.10	0.00	12,45	0,00	0,00	1.80
Solanum nigrum	0,00	3.23	3.22	0.00	0.00	0.00	0.05	0.92
Cynara cardunculus	0.00	4.84	0,00	0,00	0.00	0.11	0.12	0.73
Hippocrepis multisiliquosa	0.13	0.00	0.00	0.03	2,59	0,00	0,00	0.39
Hirschfeldia incana	0.00	0.12	0.00	0.00	0,00	0,00	2,38	0.36
Matricaria aurea	0.00	0.00	0.05	0.05	0,00	0,00	2,38	0.35
Chrysanthemum coronarium	0.08	0.00	0.00	0.00	0,00	0,00	1,47	0.22
Bare soil	8,74	5,47	8,93	1,16	4,61	5,96	4,41	5.61
Crop	82.31	71.58	84.84	85.52	43.37	32.16	49.83	63.81

2. Forage biomass

The most productive crop (Table 2) has been *Hordeum vulgare* (5.47 t/ha DM in the average of the replications). However, despite of the lower contribution of legume pulses in total biomass, these gave interesting productions of dry matter. Strangely the association of *Avena*+*Vicia* and that of *Medicago sativa* that had given very high soil covers did not produce much.

The recorded production of dry biomass does not appear great as compared to those in the Northern Mediterranean, however it was considerably higher than expected from native vegetation and without irrigation in a few months. Further production can be supported by irrigation for an estimated growing period of 6-8 months during which the total amount will increase.

IV – Conclusions

The irrigation capacity provided by the Great Man Made River can increase much the productivity of crops in comparison to wild vegetation. However it would be convenient to limit the use of irrigation to produce what is really needed, including crops for food and a limited quantity of forages just to sustain cow milk production that is important especially for children.

A question comes about the choice of the forage species that we tried and that are all C_3 plants, whilst the hot environment and water availability could make convenient to crop C_4 species which are more productive and also more drought tolerant.

Table 2. Forage biomass (dry matter yield t/ha and % on the green biomass) of the seven crops of the trial. Values in column with different letters are significantly different at P=0.05 (ANOVA by Sistat)

Forage crop	Dry matter	
	t / ha	%
Hordeum vulgare	5.47 a	21.6
Pisum sativum	3.71 b	17.3
Cicer arietinum	3.57 bc	20.9
Avena sativa	2.44 bc	15.9
Vicia faba var. *minor*	2.30 bc	14.2
Avena sativa +Vicia sativa	2.02 bc	16.2
Medicago sativa	1.96 c	14.0

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The role of tannins in forage legumes

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Abstract. Plant tannins, polyphenolic secondary compounds, are synthesized to meet ordinary physiological demands of plants and as a response to biotic and abiotic stress. Tannins have been described as having adverse or beneficial effects, depending on their concentration and structure, plant source and the species, physiological state and diet of the animals. Proper concentrations of condensed tannins (20 – 50 g kg^{-1} of DM) are expected to increase the efficiency of protein digestion and to minimize detrimental effects associated with a heavy load of internal parasites, with positive consequences for animal performance and health. Moreover, lower CH_4 emissions by ruminants consuming forages containing low levels of condensed tannins were noticed. This paper reports an update of current use of legume tannins in feedstuff and their effects in animals. It also refers to the implications concerning the improvement of nutrient utilization and the environmental sustainability in meat and dairy farming.

Keywords. Polyphenols – Condensed tannins – Leguminous plants – Fodder – Animal health.

Le rôle des tanins dans les légumineuses fourragères

Résumé. *Les tanins végétaux, composés polyphénoliques secondaires, sont synthétisés pour répondre aux exigences physiologiques ordinaires, mais aussi comme une réponse aux stress biotiques et abiotiques. Les tanins ont été décrits comme ayant des effets néfastes ou bénéfiques, selon la concentration en tanins et la structure, l'origine de la source et les espèces animales, l'état physiologique et l'alimentation. Des concentrations appropriées de tanins condensés (20-50 g kg-1 de MS) augmentent l'efficacité de la digestion des protéines et minimisent les effets néfastes associés à une lourde charge de parasites internes avec des conséquences positives pour les performances et la santé des animaux. En outre, la baisse des émissions de CH_4 par les ruminants consommant des fourrages contenant de faibles niveaux de tanins condensés a été remarquée. Cet article présente une mise à jour sur l'utilisation actuelle des tanins en alimentation et sur leurs effets sur les animaux et discute les implications connexes sur l'amélioration de l'utilisation des nutriments et la durabilité environnementale pour la production de viande et l'élevage laitier.*

Mots-clés. *Polyphénoliques – Tanins condensés – Fourrage – Santé animale.*

I – Introduction

Tannins are polyphenols with various molecular weights and variable complexity and are synthesized in plants not only as a genetically controlled response to physiological demands and evolution-controlled defence needs, but also under the impact of environmental stress (Min *et al.,* 2003). In the past, tannins were often described as antinutritional factors as they can affect negatively on animal production. However, tannins have both adverse and beneficial effects, depending on their concentration and nature, besides other factors such as animal species, physiological state and composition of the diet. Condensed tannins (CT) are expected to bind strongly to proteins and protect them from degradation by rumen microbes. Forage containing CT have been reported to minimize the detrimental effects due to a heavy load of internal parasites (Min *et al.,* 2003). The consumption of forages containing CT may affect gastrointestinal nematode abundance and animal performance in a number of ways that involve direct effects on the parasite and indirect effect through improved protein supply (Piluzza *et al.,* 2014). CT are also thought to be among the plants protective factors evolved to prevent predation by herbivores, and invasion by pathogenic bacteria, fungi and insects (Barry, 1989). CT are found in a number of important forage genera within the family Fabaceae, including

Coronilla, Hedysarum, Lespedeza, Lotus spp., *Onobrychis, and Trifolium* (Piluzza *et al.,* 2014). It is very important to update information on the content and nature of tannins present in the feedstuffs, and on the effects and fate of tannins in animals. This paper deals with the role of tannins in leguminous plants and in animal productivity and focuses on natural products with promising nutritional, animal health and environmental effects.

II – Tannin localization in leguminous species

Tissue-specific localization has been observed in a number of legume species (Table 1). The content of tannins varies with the phenological stage of plants (Häring *et al.,* 2007; Molle *et al.,* 2009; Theodoridou *et al.,* 2010; Guglielmelli *et al.,* 2011), and in the different plant organs (Piluzza and Bullitta, 2010; Theodoridou *et al.,* 2010). The dynamics of CT concentration in growing plants is important for the nutrition and health of ruminants. However, for Mediterranean forage species there are few reports detailing the changes in CT content in different tissues and across different phenological stages.

Young shoots in the vegetative stage of the shrub legumes *Cytisus purgans* (andorra broom), *C. scoparius* (scotch broom), *Genista florida* and *G. occidentalis* had low levels of CT (less than 6.5 g kg^{-1} DM), generally considered unlikely to significantly affect nutrient digestion in ruminants (Frutos *et al.,* 2002). However, high CT content has been detected in the shoots and flowers of *C. scoparius* and *G. florida* samples collected in June. The CT concentration in the leaves of *Chamaecytisus palmensis* (tagasaste) has been found to vary between accessions. Moreover, varietal selection and harvesting management could be used to modulate tannin and alkaloid levels in this perennial leguminous shrub (Assefa *et al.,* 2008).

Considering that CT levels vary widely across plant species, tissues and developmental stage, together with variability arising from adopted method and standard, it is necessary to establish common procedures in order to compare results from different laboratories.

Table 1. Condensed tannin localization in forage, grain and shrub legumes

Species	**Localization**	**Species**	**Localization**
Astragalus cicer	Whole plant	*Trifolium repens*	Flowers
Hedysarum coronarium	Stems,leaves, flowers whole plant, leaf blades, petioles	*Trifolium pratense*	Flowers
Lotus corniculatus	Whole plant, roots, leaves, stems	*Vicia faba*	Seed hull, seed coat
Lotus pedunculatus	Whole plant	*Vicia sativa*	Seed
Lotus tenuis	Shoot	*Ceratonia siliqua*	Fruits
Lotus uliginosus	Leaves, stems, shoots	*Chamaecytisus palmensis*	Buds, leaves, stems, bark
Medicago sativa	Seed coat	*Cytisus purgans*	Shoots
Onobrychis viciifolia	Whole plant, leaf blades, petioles, stems, racemes, leaves, roots	*Genista occidentalis*	Shoots

Modified from Piluzza *et al.*, 2014.

III – Beneficial effects on ruminants

Moderate CT concentrations (20-50 g kg^{-1} DM) enhance forage nutritive value in grazing ruminants by reducing protein degradation by rumen bacteria and increasing protein degradation in the intestine, without depressing rumen fibre digestion or voluntary intake (Min *et al.,* 2003). CT increased live-weight gains in sheep consuming *H. coronarium* compared with those consuming lucerne or perennial pasture (Niezen *et al.,* 1995). This was also confirmed in sheep consuming *L. corniculatus* when compared with those receiving PEG (polyethylene glycol), which deactivates CT (Decandia *et al.,* 2000). Also, increased milk production and wool growth were observed in sheep grazing on *L. corniculatus*, when compared with sheep treated with PEG (Min *et al.,* 2006). Girard *et al.,* (2015), found that forage legumes rich in CT may increase n-3 fatty acid levels and sensory quality of lamb meat. Because of the widespread resistance to synthetic chemical anthelmintics, there is a strong impetus to explore novel approaches for a more integrated management of parasitic infections with gastrointestinal nematodes. Tannin containing legumes are useful as a model for nutraceutical against digestive parasites in livestock (Hoste *et al.,* 2015). However, if present in large quantities (> 50 g kg^{-1}), CT can adversely affect nutrition of grazing herbivores by reducing intake and inhibiting protein digestibility (by inhibiting digestive enzymes or by direct systemic toxicity), leading to a reduction in feed intake and depressing the digestibility of almost all nutrients (Barry, 1989).

IV – Effects of tannins on methane emissions from ruminants

There is public and political concern regarding the need to reduce methane emissions from livestock. For countries that have signed the Kyoto protocol, reduction in CH_4 production from grazing ruminants fed forage diets is an important research area (Ramirez-Rastrepo and Barry, 2005). There have been reports of lower CH_4 emissions by ruminants consuming forages containing low or moderate levels of CT (Piluzza *et al.,* 2014). Methane yields from sheep and cattle fed plant species of varying CT content are presented in Fig. 1 in grazing ruminants. Tavendale *et al.* (2005) found inhibitory effects of polymeric CT fractions from *L. pedunculatus* on the growth of *Methanobrevibacter ruminantium*, a predominant rumen methanogen. The effect of CT fractions on pure cultures of methanogens may be greater than the effect of CT-containing plants in mixed rumen fluid. In another study, it was found that quebracho-supplemented ruminal fluid incubated with minced wheat forage produced less gas and CH_4 *in vitro* (Min *et al.,* 2006). Guglielmelli *et al.* (2011) found that sainfoin forage, at the stage between early and late flowering, could reduce *in vitro* CH_4 production, highlighting the importance of plant phenological stage for CH_4 emission. Bueno *et al.* (2015) found that CT have greater effects in large ruminants than in small ruminants..

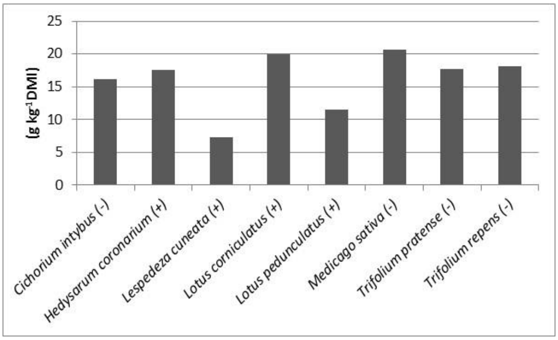

Fig.1. Methane emissions from ruminants fed forages with (+) or without (-) condensed tannins. (Modified, from Piluzza *et al.*, 2014).

V – Conclusions

The mechanisms by which tannins exert their effects on animal health and performance are not completely understood. Therefore, it is important to utilize the appropriate tannin-containing plant species/varieties in ruminant feeding. The finding that CT can reduce ruminant CH_4 emissions has important environmental implications. Future studies are required to evaluate the sustainability of CT supplementation in CH_4 mitigation and rumen methanogenesis, without detrimental effects on productivity or health. As a natural and ecologically friendly tool to improve nutrient utilization for meat and dairy farming, the exploitation of forage legume containing CT has an important role to play in agriculture. Further research is necessary, focused on the definition of appropriate strategies to better exploit tannin-containing plant species and /or varieties in ruminant feeding, thereby improving animal husbandry and contributing to environmental sustainability.

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Sustainable management of intercropped vineyards on sandy acid soils

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Abstract. A two-year experiment was carried out to study alternative systems of soil management and the possible effects on the grapevine. Conventional tillage was compared with legume cover crops based on subterranean clovers. Two different mixtures were utilized: *Trifolium subterraneum* cv Campeda (60%), *T. brachycalycinum* cv Antas (20%) and *T. subterraneum* cv Seaton Park (20%) in the first site and *T. subterraneum* cv Campeda (60%), *T. brachycalycinum* cv Antas (20%) and *T. subterraneum* cv Denmark (20%) in the second one. Data on seedling establishment and re-establishment, soil covering rate, canopy height, phenology of subterranean clover varieties, dry matter production were collected. Regarding grape vine, data on grape production and quality were recorded. The cover crops controlled the growth of weeds and ensured an excellent covering of the soil. No negative effects of cover crops on grape production and quality were observed in comparison with the tillage treatment.

Keywords. Vineyard cover crops – Annual self-reseeding legumes – Subterranean clovers – Grape production.

Gestion durable de vignobles avec cultures intercalaires sur sols sableux acides.

Résumé. *Une expérience de deux ans a été réalisée pour étudier des systèmes alternatifs de gestion des sols et les effets possibles sur la vigne. Dans un essai en champ on a comparé le travail du sol classique avec des cultures de couverture de légumineuses sur la base de trèfles souterrains. Deux mélanges différents ont été utilisés:* Trifolium subterraneum *cv Campeda (60%),* T. brachycalycinum *cv Antas (20%) et* T. subterraneum *cv Seaton Park (20%) dans le premier site et* T. subterraneum *cv Campeda (60%),* T. brachycalycinum *cv Antas (20%) et* T. subterraneum *cv Denmark (20%) dans le second. On a recueilli les données sur l'établissement et le ré-établissement des trèfles, le taux de couverture du sol, la hauteur de la canopée, la phénologie des variétés de trèfle souterrain, la production de matière sèche. En ce qui concerne la vigne, les données sur le nombre de bourgeons, pousses, nombre de grappes par plante et production de raisin ont été enregistrées. Les cultures de couverture ont contrôlé la croissance des mauvaises herbes et ont assuré une excellente couverture du sol. Aucun effet négatif sur la production de raisin n'a été observé mais plutôt une meilleure qualité en utilisant les mélanges de trèfles souterrains par rapport au traitement classique du sol.*

Mots-clés. *Cultures de couverture des vignobles – Légumineuses annuelles en auto-réensemencement – Trèfles souterrains – Production de raisin.*

I – Introduction

Cover cropping in vineyard is an alternative technique to traditional tillage and to chemical weed control and represents also an effective tool to mitigate soil erosion. The use of cover crops remains hampered in Mediterranean areas under rainfed conditions. They compete with grapevine for water in summer, when low rainfall and high evaporative demand usually results in severe summer drought, leading to higher water stress and consequently to lower growth and yield. Nonetheless, in order to gain the potential benefits of cover crops under Mediterranean conditions, annual self-reseeding forage legumes as subterranean clovers may be used. These species have an autumn-spring cycle which allows them to reduce the water requirements to approximately 350 mm per year. Early-senescent and self-reseeding legumes can meet the objectives of improving soil characteristics and reduce the competition for water resources. Moreover, the use of self-reseeding annual cover crops reduces the production costs, avoiding the purchase and the sowing of seeds each year (Porqueddu *et al*., 2000). With this research, the authors aimed to provide useful information for an alternative soil management of a vineyard grown in a hilly area characterized by acid sandy soils and low fertility.

II – Materials and methods

The experiment was carried out in the years 2008-2010 in two private vineyards located in Enas-Loiri (site A, N 40.5, E 9.2 and 50 m a.s.l.) and Luogosanto (site B, N 41.0, E 9.1 and 200 m a.s.l.), in north-eastern Sardinia. The climate of the sites was typical of central Mediterranean area with a mild winter and rainfall concentrated between autumn and spring. The average total annual rainfall was 526 mm and 591 mm in site A and site B, respectively. In both sites, the soil was granitic-sandy type with pH (water) = 5.8 (A) and 5.6 (B) with low fertility (0.07 and 0.12 N%; 6.0 and 6.5 ppm P). The vineyards were planted in 1998 using the local white variety Vermentino grafted on 1103 Paulsen. Vine stocks were spaced 1.00 X 2.50 m in site A and 1.30 X 2.30 m in site B and trained by a cordon spur pruned. Both vineyards were under drip irrigation. Two different soil managements were tested at both sites: conventional tillage (CT), performed with mechanical tools, and legume cover crop (LCC), where legumes were subterranean clover varieties used in the inter-rows. In site A, a mixture of *Trifolium subterraneum* cv Campeda (60%), *T. brachycalycinum* cv Antas (20%) and *T. subterraneum* cv Seaton Park (20%) was used. In site B, *T. subterraneum* Campeda (60%), *T. brachycalycinum* Antas (20%) and *T. subterraneum* Denmark (20%) were used. The seeding rate was 34 kg ha^{-1} and 42 kg ha^{-1} in site A and in site B, respectively. Plot size was 1 ha for each treatment.

The sowing of the inter-rows was done in November 2008, using a rotary tiller with seed drill and packed roller. The following data on the cover crop were collected: establishment and re-establishment (on 80 quadrats of 0.12 m^2), soil covering (seasonal visual score), sward height before chopping, main phenological phases of sown species (seedlings emergence, flowering, fruit set and senescence), dry matter yield (on 12 quadrats of 0.5 m^2) and its botanical composition. Seeds were hand harvested in July on 12 quadrats of 0.12 m^2. On the vine, the following observations were carried out: grape production and characteristics of the cluster, berries and must quality.

III – Result and discussion

During the two years of the experiment, the dynamics of soil covering was similar in both sites. Nonetheless, soil covering due to subterranean clovers was slightly higher in site B than site A (Fig.1). In both sites the seedlings emergence and the sward establishment was slow, especially in A where winter soil covering was only 20%. Similar observations were reported by Pou *et al.* (2011). In the spring of the establishment year, soil covering increased up to 64% and 88% in site A and site B, respectively. In the second year, soil covering was quite high in both sites, ranging from 50% in winter (site A) to 93% in spring (site B). The contribution of spontaneous species to soil covering ranged from 24% (winter) to 16% (spring) in site B in the first year, but it did not exceed 3% in the second year. In site A, the contribution of spontaneous species was always less than 5%. The most frequent spontaneous species identified were: *Echium vulgare* L., *Vulpia ligustica* All., *Bromus hordeaceus* L., *Avena sterilis* L., *Lolium rigidum* Gaudin, *Anagallis arvensis* L., *Sonchus arvensis* L., *Fumaria officinalis* L., *Galactites tomentosa* M., *Parentucellia viscosa* L., *Inula viscosa* L. Subterranean clovers flowered in late February. Full plant senescence took place in mid-June. The high self-reseeding ability of subclovers guaranteed a high natural re-establishment in autumn 2009 with an average of 1,200 seedlings m^2 in both sites (Table 1). In the second year, despite a higher seed production than in the previous year, there was a sharp decrease in the number of seedlings per m^2 at site B. As a consequence of the abundant rainfall in autumn in both years, subterranean clovers showed a fast vegetative growth, controlling weed development. Among subclovers varieties, cv Antas increased its contribution to soil covering in both mixtures along time. In spring 2010, cv Antas reached 51%, cv Campeda 33% and cv Seaton Park 16% in site A while cv Antas dominated (93%) on cvs Campeda (5%) and Denmark (2%) in site B. In the first year, only one chopping after seed ripening was done, with the aim to allow a good self-reseeding. In the second year, due to a favourable meteorological pattern, two chopping were necessary. Two-year total dry matter yield was higher in site B than in site A: 6.3 t ha^{-1} and 2.6 t ha^{-1}, respectively (Table 2).

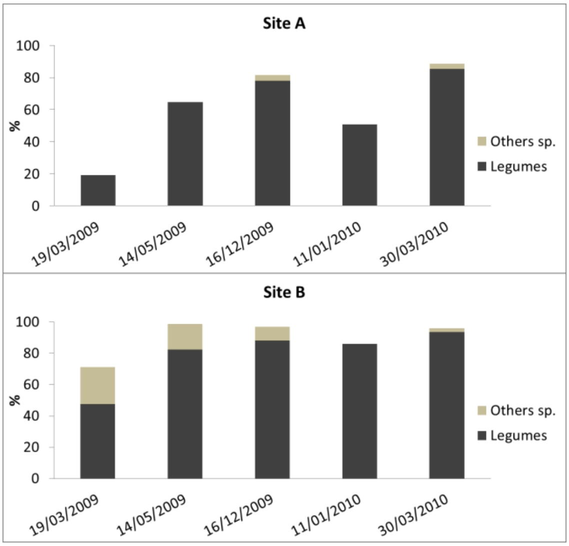

Fig. 1. Seasonal pattern of soil cover in site A (above) and B (below) during 2009 and 2010.

Table 1. Number of seeds in July and seedlings at autumn re-establishment in the two sites

Variable	Site A		Site B	
	2009	2010	2009	2010
Seeds m^{-2}	8755 (±5119)	12581 (±4872)	12040 (±3955)	15282 (±3365)
Seedlings m^{-2}	1215 (±260)	2520 (±816)	1221 (±402)	516 (±131)

The standard deviation is reported in brackets.

Table 2. Dry matter yield for each cut (t ha-1) in the two sites

Site	26/05/2009	11/01/2010	30/03/2010
A	0.21 (± 0.16)	0.58 (± 0.35)	1.87 (± 1.19)
B	1.45 (± 0.54)	1.31 (± 0.22)	3.57 (± 0.69)

The standard deviation is reported in brackets.

The yield of vine plants and its components widely varied between sites and years. In 2010, grape production was significantly higher than the previous year. In both years and sites, CT showed higher production than LCC, but with no significant differences, as found by Porqueddu *et al*. (2000). The number of clusters was influenced by the year and site but not by the treatment. Moreover, the use of legumes as a cover crop did not modify the fertility of the vines but it caused a production drops due to competition for water that induced a lower weight of berries, as previously reported by Mercenaro *et al*. (2014). Regarding fruit quality, in the first year sugar content of the berries in LCC was statistically higher than CT in all three sampling dates in site A. In site B, despite the higher amount of total soluble solids in LCC than CT in all sampling dates, no significant differences for sugar content was found between treatments

(Fig. 2). In the second year, no statistical differences between treatments for sugar content were found in both sites except for one sampling date, although in site B berry sugar content in LCC tended to be higher than in CT. In general, LCC seemed to favour the accumulation of sugars, probably because legume cover crops have the potential to supply nitrogen to grapevines, especially during the times of N-peak demand in early spring and fruit set (Patrick *et al*., 2004). Regarding the acidity, in both sites and years, the malic acid content measured in the berries of CT was higher than in LCC. No differences were observed on tartaric acid and the pH of must.

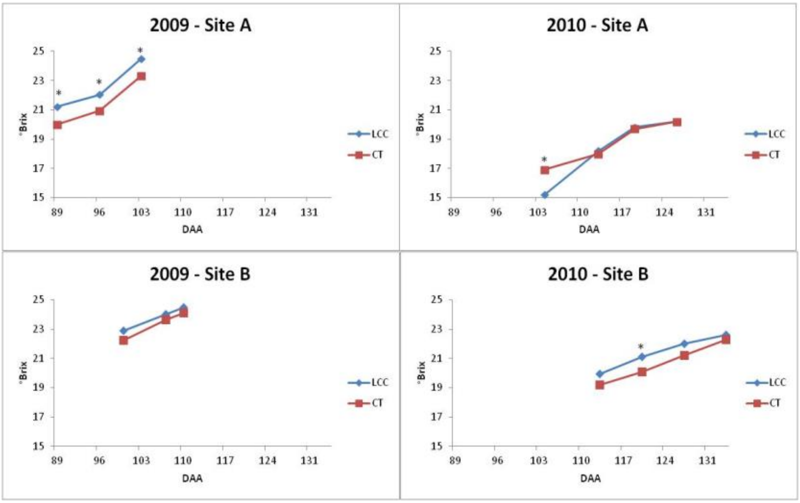

Fig. 2. Pattern of total soluble solids (Brix) in the berries during ripening stage (DAA= day after anthesis).

IV – Conclusions

The outcome of this study confirmed that appropriate varieties of subterranean clovers can be used for intercropping in vineyards located on acid sandy soils. Despite a slow winter sward establishment, subterranean clovers assured a high soil covering from the first spring along the two years, allowing to achieve the two main objectives of the vine grower: weed control and limitation of soil erosion. Moreover, summer mulch produced by senescent legume plants limited seed germination and growth of weeds. Yet, subterranean clover did not have negative effects on grape production and must quality. Cover cropping, as alternative technique of soil management, can be a useful tool to improve the sustainability and multi-functionality of wine farms. In fact, it can be used to improve the ecosystem services with positive effects on carbon sequestration, biodiversity, landscape and, last but not least, as a source of fodder for livestock during winter.

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Chemical composition, fatty acid content and phenolics (bioactive) compound on linseed (*Linum usitatissimum* L.) harvested at six phenological stages of growth

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Abstract. *Linum usitatissimum* L. is an annual dicotyledonous multipurpose crop grown either for fibre (fibre flax) or seed (linseed, oil seed flax or flax seed). Linseed straw can be exploited as source of roughage and although at the late stages is very fibrous, at the early stages, can be very nutritious, comparable to canola hay. Linseed and grass are the most important n-3 fatty acid sources for ruminants. Linoleic acid (LA, 18:2n-6) and α-linolenic acid (ALA, 18:2n-3) are both available in linseed. Plant secondary metabolites have attracted interest as potential antioxidants for both inhibiting deterioration of foodstuffs and for providing beneficial metabolic effects in animals. Evaluation of quality of linseed biomass, as an important source of precursors of fatty acids, and its chemical composition (total polyphenols, flavonoids and condensed tannins) at different morphological stages, was the first aim of this work.

Keywords. Fatty acid – Bioactive compound – Phenological stages.

Composition chimique, teneur en acides gras et composés phénoliques (bioactifs) du lin (**Linum usitatissimum*** **L.) récolté à six stades phénologiques de croissance***

Résumé. Linum usitatissimum *L. est une plante annuelle polyvalente de la famille des dicotylédones, produite soit pour les fibres (lin textile) ou les graines (lin oléagineux). La paille de lin peut être exploitée en tant que source de fourrage grossier et bien que très fibreuse lors des derniers stades, elle peut être très nutritive aux premiers stades phénologiques, comparable au foin de canola. Les graines et l'herbe de lin sont les sources les plus importantes d'acides gras n-3 pour les ruminants. L'acide linoléique (LA, 18:2n-6) et l'acide α-linolénique (ALA, 18:2n-3) sont tous deux disponibles dans les graines de lin. Les métabolites secondaires végétaux ont suscité de l'intérêt comme antioxydants potentiels à la fois pour l'inhibition de la détérioration des denrées alimentaires et pour fournir des effets métaboliques bénéfiques chez les animaux. L'évaluation de la qualité de la biomasse de lin, comme importante source de précurseurs d'acides gras, et de sa composition chimique (polyphénols totaux, flavonoïdes et tanins condensés) à différents stades morphologiques, était le premier objectif de ce travail.*

Mots-clés. *Acide gras – Composé bioactif – Stade phénologique.*

I – Introduction

Linseed (*Linum usitatissimum* L.) is an herbaceous annual dual-purpose crop plant grown worldwide, with wide range of industrial uses due to its main products, fibre and seed (Jankauskiené and Grudeviené, 2015). Belonging to Linaceae family, it is native to West Asia and has been cultivated since 5,000 BC. Moreover, linseed is an important nutraceutical crop as a rich source of omega-3 fatty acid and antioxidant compounds. Polyphenols are among the most significant compounds related to the antioxidant properties of plant materials. Flavonoids have also been shown to act as scavengers of various oxidizing species. Linseed straw can be ammoniated and made adequate forage base for wintering beef cows (Mann *et al.*, 1988) and used safely as the only source of roughage for cattle (Peiretti and Meineri, 2008). The main objective of this work was to assess the effects of the stage of maturity on total plant chemical composition for crude protein, fibrous fractions, fatty acids and phenolic compounds.

II – Materials and methods

The experiment was conducted during 2014 at the experimental station of Leccari, Sassari (40°45'12" N, 8°25'17" E; 27 m a.s.l.), in Sardinia (Italy). The climate of the area is typically Mediterranean with mild winter, characterized by a long-term average annual rainfall of 554 mm, prevailingly distributed in autumn and winter months, and a mean annual air temperature of 16.2 °C. Soil has been classified as *Eutric*, *Calcaric* and *Mollic Fluvisol* according to FAO (2006) and is sandy-clay-loam, alkaline with a scarce average nitrogen content (0.96‰) and adequate contents of phosphorous (20.33 ppm), organic matter (1.46%) and organic carbon (0.85%). The morphological stages of linseed were evaluated on a sample of 50 stems randomly clipped to ground level and classified according to a BBCH scale (Smith and Froment, 1998). The six morphological stages were: **Stage 3** – Stem extension; **Stage 5** – Inflorescence development and emergence; **Stage 6** – Flowering and capsule formation; **Stage 7** – Development of the seed and capsule; **Stage 8** – Capsule and seed ripening; and **Stage 9** – Stem senescence. Forage quality was evaluated by drying samples of biomass in oven at 80°C for 48 h, then milling the samples for chemical traits determination. Total N was determined using Kjeldahl method and crude protein (CP) was calculated by multiplying the N content by 6.25. Neutral, acid detergent fibres and lignin (NDF, ADF and ADL), were determined according to Van Soest (1994) procedure. Secondary plant metabolites were evaluated in samples kept on ice during harvesting, freeze dried and ground to a fine powder for the chemical analysis. The powdered material was then used for extract preparations as reported by Piluzza *et al.*, (2014). Total phenolic content (TotP) of extracts was determined using the Folin–Ciocalteau reagent according to Singleton and Rossi (1965), with some modifications by Piluzza and Bullitta (2010). Results were expressed as g gallic acid equivalent kg^{-1} dry weight of plant material (g GAE kg^{-1} DW). The butanol assay of Porter *et al*. (1986) was adapted (Piluzza and Bullitta, 2010) for quantification of extractable condensed tannins content from our samples. The condensed tannins content was expressed as g delphinidin equivalent kg^{-1} dry matter (g DE kg^{-1} DM). Total flavonoids (TotF) were quantified by colorimetric assay with the $AlCl_3$ method (Kim *et al*., 2003). Catechin was used as a standard and the flavonoid content was expressed as g catechin equivalent kg^{-1} dry weight of plant material (g CE kg^{-1} DW). Fatty acids were determined in an external laboratory (Agriecobio, Pomezia, Rome). Chemical composition and secondary metabolites were correlated by regression with morphological stages.

III – Results and discussion

CP was negatively related to the phenological stages whereas NDF, ADF lignin contents, were positively related to the phenological stages, respectively (Fig. 1 a,b,c and d); R^2 ranged from 0.85 to 0.97. Concentration of CP ranged from 150 at early stages to 90 (g kg^{-1} DM) at maturity, according to Peiretti and Meineri (2008). The highest protein level (about 150 g kg^{-1} DM) was found at stem extension (stage 3). On later stages, seeds formation and changes in cell wall components occurred, resulting in NDF, ADF and lignin increases. The lowest NDF and ADF contents (Fig. 1 b and c) were found at the same stage (stage 3), but later for ADL (stage 5) (Fig.1 d). Levels of NDF, ADF and ADL were 480, 330 and 90 (g kg^{-1} DM) at early stages, while they increased to 650, 460 and 170 (g kg^{-1} DM) at seed ripening, confirming the fibrous characteristics of linseed.

Total phenolic and total flavonoid contents were negatively related with morphological stages (Fig. 2 a, b). Moreover, total phenolic showed the highest values (16.7 g GAE kg^{-1} DW) at stage 2, whereas total flavonoid at stage 5 (16.5 CE kg^{-1} DW).

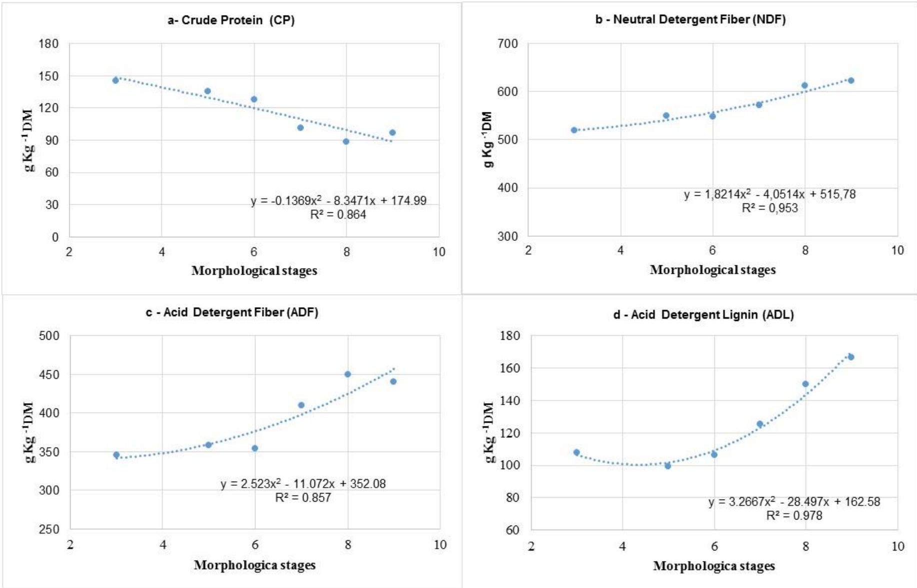

Fig. 1. Relationship between chemical composition (CP, NDF, ADF, ADL) and morphological stages in linseed biomass.

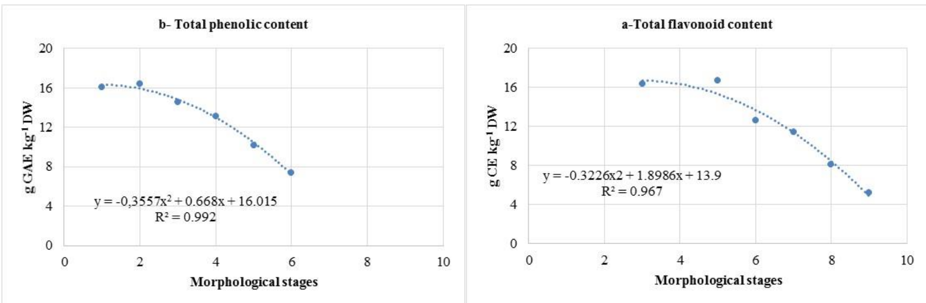

Fig. 2. Relationship between total phenolic (g GAE kg^{-1} DW) and total flavonoid content (g CE kg^{-1} DW) content in relation to linseed morphological stages.

The lowest values were reached at stage 9 (5.2 g GAE kg^{-1} DW) and 7.4 (g CE kg^{-1} DW), respectively. El-Lethy *et al*. (2010) found in linseed plant harvested at vegetative growth stage, a total phenolic content of 0.88% in the control and 1.81% and 1.64% in leaves treated using the antioxidants stigmasterol and putrescine, respectively. No condensed tannins were detected in linseed under study. Fatty acids (Fig. 3) were not affected by the different morphological stages, α-linolenic acid (ALA) ranging from 33.5 % to 40.6% and linoleic acid (LA) from 8.1% to 10.5%. El-Lethy *et al*. (2010), found similar levels of LA but lower levels of ALA, 5.5% and 12.2% respectively, in linseed grown in Egypt. In contrast with our study, Peiretti and Meineri (2008) found higher values for both fatty acid (LA and ALA) and evidenced that LA and ALA were affected by phenological stages of linseed. This was probably caused by the different environment and sowing date: late autumn in Sardinia (40°45'N. 8°25'E) and June in Piedmont (44°41'N. 7°11'E).

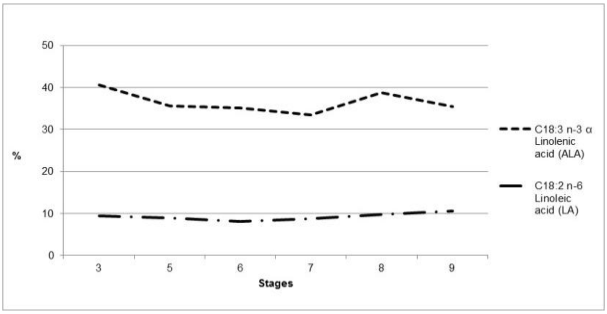

Fig. 3. Concentrations of Linoleic acid (LA) and α-Linolenic (ALA) acid at different morphological stages in linseed.

IV – Conclusions

As many studies were mainly referred to the seed chemical composition of *L. usitatissimum*, our research contribute to give new insights into the chemical composition of linseed biomass. In particular, our results highlight that the levels of NDF, ADF and ADL were positively related to the phenological stages, whereas CP level was negatively affected, as it was expected. A similar trend was recorded for the contents of phenolic and flavonoid. On the contrary, the levels of fatty acids proved to be not affected by the morphological stages. The obtained information is useful for a complete exploitation of linseed plant biomass as a forage source.

Acknowledgements

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Quantification of N_2-fixation from *Medicago polymorpha* L. grown as cover crop in vineyard

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Abstract. Cover crops in vineyards help the reduction of chemical inputs and soil erosion risk as well as the improvement of soil fertility. In a two-year experiment carried out in Sardinia (Italy), the nitrogen (N) fixed by burr medic (*Medicago polymorpha* L.) grown as cover crop in a vineyard was quantified. The potential of N fixation in burr medic was estimated by the ^{15}N isotopic dilution method. In late spring, dry matter legume forage mass ranged from 3.7 to 4.0 t ha^{-1}, in 2012-13 and 2013-14, respectively. On average, the aerial fixed N was 120 kg ha^{-1} year^{-1} and represented about twice of the total N in grapevine organs (leaves, fruits and canes). If burr medic below-ground N is also taken into account, legume contribution to the total N of grapevine could be even higher. Results indicated that the N requirements from the annual organs of the grapevine could be potentially covered by atmospheric N via legume cover crop, compared to soil tillage treatment in vineyards.

Keywords. Burr medic – ^{15}N – Fixed N – Vine organs – Vineyard.

Quantification de la fixation de N_2 de* Medicago polymorpha *L. cultivé comme plante de couverture dans les vignobles

Résumé. *Les cultures de couverture dans les vignobles permettent la réduction des intrants chimiques et des risques d'érosion des sols et l'amélioration de la fertilité des sols. Dans une expérience de deux ans menée en Sardaigne (Italie), l'azote fixé par la luzerne polymorphe (*Medicago polymorpha *L.) cultivée comme plante de couverture dans un vignoble a été quantifié. Le potentiel de fixation de l'azote par la luzerne polymorphe a été estimé par la méthode de dilution isotopique ^{15}N. À la fin du printemps, la masse de MS des légumineuses fourragères se situait de 3,7 à 4,0 t ha-1, respectivement pour la première et la deuxième année. En moyenne, l'estimation de l'azote fixé aérien était de 120 kg ha^{-1} an^{-1}, ce qui représente deux fois l'azote total dans les organes de la vigne (feuilles, branches et grappes). Si l'azote en dessous du sol pour la luzerne polymorphe est également pris en compte, la contribution des légumineuses à l'azote total de la vigne pourrait être encore plus élevée. Les résultats indiquent que les besoins en azote des organes annuels de la vigne pourraient être potentiellement couverts par l'azote atmosphérique à travers la couverture de légumineuses, par rapport à un traitement des sols avec un travail traditionnel.*

Mots-clés. *Luzerne polymorphe – ^{15}N – N fixé – Organes de la vigne – Vignes.*

I – Introduction

Within the multifunctional agriculture, the use of annual self-reseeding legumes as cover crop is an important tool in order to support sustainable agroecosystems. The promotion of the environmental sustainability in viticulture requires increasing in the knowledge of all the issues related to vineyard ecosystems (Mercenaro *et al.*, 2014). In addition to the several well-known advantages arising from the cover crops in vineyards (Piano, 1999), the use of annual self reseeding legumes could allow to avoid the need of nitrogenous chemical fertilizers for their ability to fix biologically the atmospheric N (Unkovich and Pate, 2000). Legume plants are the only cover crop species able to produce net N inputs for the agroecosystem. Patrick *et al.* (2004), using a mix of different legumes species, showed that leguminous cover crops have the potentiality to supply N to grapevines during the times of peak nitrogen demand in early spring and fruit set. However, the amount of fixed N depends on several factors such as legume species, management and environmental conditions (pH, soil N content and humidity), inoculation with selected strains of rhizobia, etc. Therefore, the estimation of legume N fixation is highly variable within the same species. For this reason, the quantification of the N fixation carried out at local level is preferable. The objective of this work is to quantify the N fixation ability of a legume in an intercropped Mediterranean vineyard and the potential benefit that vines could receive from the N produced by legume cover crops.

II – Materials and methods

The experiment was carried out over two agronomical seasons in 2012-13 and 2013-14, in a private vineyard located in North Sardinia (Italy). Carignano vines, trained by VSP, were grafted onto 779 Paulsen and spaced 2.7 x 1 m. The climate is Mediterranean with an average annual rainfall of 540 mm and an average temperature of 16.2 °C. The soil in the site is calcareous, with sand-clay-silt texture and pH 7.4. Within three adjacent rows, each plot consisted of a central row along 10 vines, under a randomized block design with four replications. In order to quantify the legume N fixation, the following inter-row treatments were compared: (*i*) a legume cover crop by burr medic (*Medicago polymorpha* cv Anglona); (*ii*) a grass cover crop by a summer semi-dormant perennial grass, cocksfoot (*Dactylis glomerata* cv Currie), used as non-fixing reference plant (NFS).

A rate of 4 kg N ha^{-1} of enriched ^{15}N fertilizer (10 atom %^{15}N enriched ammonium sulfate) was applied on the sampling areas of both NFS and burr medic. At maturity, dry matter (DM) production was determined by cutting the aerial biomass at 5 cm above ground level over the ^{15}N-enriched area within each experimental plot, and drying the material at 65°C in a forced-air oven until it reached a constant weight. Dry samples ground finely enough to pass through a 1 mm mesh were subjected to elemental analyser isotope ratio mass spectrometry (Cheshire, United Kingdom) to determine both N and the atom%^{15}N content. The proportion of burr medic N derived from the atmosphere (%Ndfa) was calculated by the ^{15}N dilution method (Warembourg, 1993). The amount of N fixed was calculated by multiplying burr medic N yield (kg ha^{-1}) per %Ndfa/100.

Another inter-row treatment, (*iii*) based on the traditional soil tillage was used as a baseline for comparing the potential N benefits from legume cover crop to vines. Therefore, on the vines, either intercropped with burr medic either managed under the soil tillage, subsamples of leaves, fruits (at maturity) and canes (in winter) were collected and their DM and N contents were determined.

Data were analysed by ANOVA and separation of mean values by the least significance difference (LSD) test at 5% of probability.

III – Results and discussion

Aerial biomass in burr medic ranged from 3.7 to 4.0 t ha^{-1} over the two years, whereas it was, on average, 1.2 t ha^{-1} in cocksfoot, due to its slow establishment (Table 1). Nitrogen concentration was remarkably higher in the legume biomass as well as the N yield that was affected by both DM yield and N concentration. On the contrary, compared to NFS, the isotopic excess values were lower in the legume with ^{15}N amounts diluted by atmospheric N. The Ndfa values of burr medic ranged from 90 to 92%.

The amount of fixed N in aerial phytomass of burr medic was, on average, 120 kg ha^{-1} $year^{-1}$. This was close to the values previously recorded for the same annual medic cultivar in a near site (Sulas and Sitzia, 2004) and for other Mediterranean forage legumes (Sulas *et al.*, 2009). In spite of the additional N supplied by burr medic via biological N fixation was remarkable, no significant effects on yield and berry quality were recorded in the vines during the study period. Our findings are in agreement with Bair *et al.* (2008), who carried out an experiment aimed at providing N to organically produced Concord grape through legume used as cover crops. These authors found that, although legume treatments resulted in increase of the N availability from grape bloom until the onset of ripening (veraison), no differences were detected between legume treatments and control for yield and sugar content. When comparing vine intercropped with burr medic vs. vine managed by using the traditional soil tillage treatment, the N concentration of the annual organs of vine (i.e., leaves, fruits and canes) where similar or slightly higher in the legume cover crop treatment (Fig. 1), suggesting a possible positive effect in N levels of vine annual organs.

Table 1. Dry matter yield (DMY), N concentration and yield, isotopic excess of species used as cover crops. Proportion of N derived from the atmosphere (%Ndfa) and amount of fixed N in the aerial phytomass of burr medic

Species	Year	DM t ha^{-1}	N g kg^{-1}	N yield kg ha^{-1}	Atom % ^{15}N %	Ndfa %	Fixed N kg ha^{-1}
Burr medic	2012-2013	4.0a	34.3a	132.7a	0.0033a	92.1	123.0
	2013-2014	3.7a	26.6a	131.1a	0.0222a	90.0	117.0
Cocksfoot	2012-2013	1.2b	13.1b	15.8b	0.0440b	-	-
	2013-2014	1.2b	10.7b	13.5b	0.2228b	-	-

Means followed by the same letter within each column are not significant different at P≤0.05.

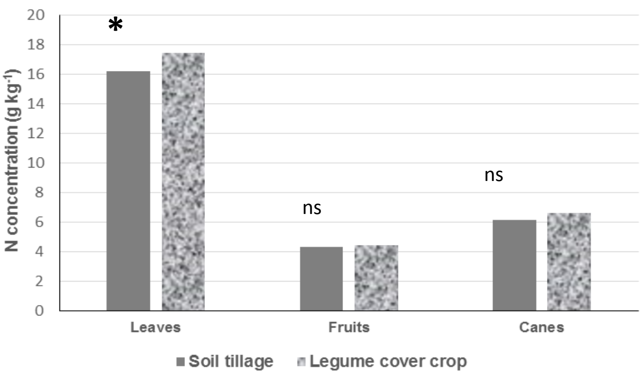

Fig. 1. Nitrogen concentration in the annual organs of vines (* = P<0.05).

On the opposite, the absolute values of N yields from the annual organs of vines revealed low values in fruits and canes of vines intercropped with burr medic (Table 2), and wider variations of N yields compared to those of N concentrations, as shown in figure 1. However, it is important to point out that the fixed N in the aerial biomass of burr medic was twice as high as the total N production of vine annual organs. This means that the amount of the fixed N by the legume cover crops is, presumably, able to cover the N requirements of leaves, clusters and canes annually produced by vines and, consequently, represents an important N contribution to the system represented by the soil – vine – cover crop.

Table 2. Nitrogen yield in annual organs and total per vine on hectare basis. Fixed N in the aerial biomass of the legume and ratio Fixed/Total nitrogen

Treatment	Year	Leaves	Grapes	Canes	Total	Fixed N	Fixed/Total
		------------------------ N kg ha^{-1} ------------------------					%
Soil tillage	2012-2013	30.6	19.9	15.7	66.2	0	-
Burr medic	2012-2013	28.9	14.9	14.9	58.7	123.0	2.0
Soil tillage	2013-2014	26.5	18.1	11.0	55.6	0	-
Burr medic	2013-2014	32.8	10.5	10.6	53.9	117.1	2.2

However, our estimation of burr medic N fixation can be considered conservative because legume below ground N and N rhizodeposition were not taken into account in this experiment. On the other hand, the N content of vine trunk and roots, which are capable of storing large amounts of N for later use, needs to be measured for better understanding of the N fluxes in vine plants. Moreover, two year of experiment are not enough to determine differences in yield and must quality of the vines subjected to different soil management. For future, it is also important to evaluate the size of the legume contributions to the nitrogen in each organ of vine plants.

IV – Conclusions

The present research has highlighted the important role of annual self reseeding legumes used as cover crops in a Mediterranean vineyard, in fixing the atmospheric N biologically. Aerial biomass of the legume fixed about 120 kg ha^{-1} year^{-1} of N, representing an important N net input to the system, soil – vine – cover crop. This can potentially meet about twice the N needs for the nutrition of leaves, branches and clusters annually produced by the vine plant. Therefore, burr medic proved to be a valuable component in the soil – vine – cover crop system.

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Tetragonolobus purpureus Moench: a legume species to be exploited as a forage and other uses

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Abstract. In a multi-year project aiming to valorize the flora of Sardinian pastures, some native species were collected and evaluated. Among these, an ecotype of *Tetragonolobus purpureus* Moench proved to be particularly interesting. This species is a Mediterranean legume growing in hilly pastures up to 1200 m a.s.l., but it is not properly exploited. In this preliminary study, the species has performed interestingly in every growth stage: in winter for grazing, in early spring for hay and in late spring for grain. Moreover it is appreciable for its gastronomic value, especially because of its immature pods which can be either cooked whole or shelled. Other uses of potential interest are related to soil fertility improvement and landscape enhancement due to its velvety purple flowers. The seeds, compared to those of classic self-reseeding legume species, have the considerable advantage of being able to be harvested with the cereals threshers. All these features, together with the good organoleptic characteristics and its versatility of use, make this species very interesting for the Mediterranean areas. This paper aims to set up a study group in order to ensure its successful widespread in the Mediterranean environment.

Keywords. *Tetragonolobus purpureus* Moench – Biodiversity – Multiuse.

Tetragonolobus purpureus *Moench: une légumineuse à exploiter comme fourrage et à usages multiples*

Résumé. *Dans un projet pluriannuel visant la valorisation de la flore des pâturages sardes, plusieurs espèces indigènes ont été recueillies et évaluées. Parmi ces espèces, un écotype de* Tetragonolobus purpureus *Moench semble être particulièrement intéressant. Il s'agit d'une légumineuse méditerranéenne qui pousse dans les pâturages vallonnés à une altitude allant jusqu'à 1200 m mais elle n'est pas encore adéquatement exploitée. Dans cette étude préliminaire, des résultats intéressants ont été obtenus à tous les stades de croissance: en hiver comme pâturage, au début du printemps pour le foin et à la fin du printemps pour le grain. Par ailleurs, cette espèce est appréciable d'un point de vue gastronomique, surtout pour ses gousses immatures qui peuvent être cuites entières ou décortiquées. D'autres utilisations comme l'amélioration de la fertilité des sols et l'amélioration du paysage en raison de ses fleurs violettes veloutées sont d'un intérêt potentiel. Les graines, par rapport à celles des légumineuses classiques à auto-régénération, ont l'avantage considérable d'être récoltées avec les moissonneuses-batteuses pour céréales. Toutes ces caractéristiques en plus de ses bonnes qualités organoleptiques et de son usage multiple, font d'elle une espèce très intéressante pour les régions méditerranéennes. Ce travail vise à mettre en place un ensemble d'études dans le but d'assurer la réussite de sa large répartition dans les environnements méditerranéens.*

Mots-clés. Tetragonolobus purpureus *Moench – Biodiversité – Multi-usage.*

I – Introduction

In Sardinia within a multi-year study aiming to enhance the floristic knowledge of pastures, some native pastoral species have been collected and evaluated. The first evaluation, carried out in different environmental conditions, focused on the traditional self-reseeding legumes (subterranean clovers and annual medics) because of their productive aspects, both quantitative and qualitative, as well as their constancy of production.

The main obstacle for the commercial deployment of these species lies on the difficulty of seed harvest that is performed by suction because the ripe pods fall down to the ground. The seeds of these Mediterranean genotypes are exclusively produced in Australia where large-scale economies can be easily achieved.

To overcome the difficulties of seed production, the interest was focused on species that can be easily harvested with cereals threshers. Our attention was addressed to an ecotype of *Tetragonolobus purpureus* Moench. Its solitary or paired flowers are very showy in spring due to their velvety and intense red-purple colour related to its botanical name. Likewise, the genus name refers to the characteristic pods.

This strictly Mediterranean species grows in hilly pastures up to 1200 m a.s.l. (Pignatti, 1982) and up to date it is not properly evaluated and valorized for forage purpose (Martyniak *et al.,* 1998). Moreover it can be used for environmental purposes, both to improve soil fertility and to increase the amenity of landscape thanks to its outstanding red-purple flowers. It is also interesting for its gastronomic characteristics, especially with regards to the unripe pods that can be cooked whole or shelled (Świąder, 2011). Therefore, this species shows a high versatile use for food as it has a good value for livestock and humans and for its remarkable environmental benefits.

This paper reports the preliminary results on the biological cycle in our environment and the potential productivity and quality of herbage and seed of an ecotype of *Tetragonolobus purpureus* Moench, and aims to set up a study group in order to ensure its successful widespread in the Mediterranean basin.

II – Materials and methods

In 1995, a *Tetragonolobus purpureus* Moench ecotype was collected nearby Collinas, a small village in central Sardinia. In the following years it was evaluated and multiplied.

This study was carried out in an experimental farm located in southern Sardinia (39°10’ N, 3°20’ E, 150 m a.s.l.). The site is characterized by typical Mediterranean climatic conditions. Long term rainfall of 460 mm is distributed from October to May with a large annual and seasonal variation. Winter temperatures seldom reach 0°C, while maximum temperature average is 32°C in July.

The observations regarded: biological cycle, disease susceptibility, forage potential productivity, herbage and seed quality. Herbage production was sampled with cutting and chemically analysed for protein and fibre content.

In the year 1995-1996, the assessment started on three benches containing soil of different origins: basalt, schist and granite. In the year 1996-1997, the ecotype was planted only in the most adapted bench of schistose soil. In the year 2005-2006, the evaluation on bench restarted. Herbage was sampled at the end of February and analysed for macro and microelements. In the year 2006-2007, the seed previously collected from bench was sown in 10 m^2 plot to evaluate the ecotype under field conditions. From 2006-2007 up to date, the ecotype was sown in order to produce more seeds for the evaluation in open field in different seasonal and annual weather conditions.

III – Results and discussion

Biological cycle. In the first year after sowing (1995-96), the ecotype showed a remarkable speed of emergence and establishment, allowing a late winter pasture. The growing rate was affected by soil types: in granitic soil, forage production was about 20 days later than in the other soils (cutting date: March 22 *vs* February 27). On schistose soil, before the flowering stage (April 24), the herbage was sampled at both previous dates. Oppositely flowering date (April 24) was not affected by soil types.

In 1996-97, the previous results were confirmed, reaching the suitable height for grazing (15-20 cm) in February. Its potential production was confirmed in 2012 with a record DM yield of 3 t/ha.

Flowering date was constant over years; it occurred at the end of March until early April if not grazed and 20 days later if grazed. Moreover the ecotype showed a long flowering period.

The first pods appeared in the second part of April. Seed development started at the beginning of May in the advanced flowering stage. So, it is possible to observe at the same time, flowers, immature pods and ripe pods.

Seed yield and harvest. The annual seed yield ranged from 0.25 to 1.87 t/ha with an average of 1 t/ha. The 1000 seed weight was 23.6 g on average and ranged from 16.7 to 31.2 g.

For all years, seeds were collected using a cereal harvester with an adequate setting for thresher, fan and sieves. Each year, a serious attack to the grain by a *coleopteran* was observed.

Quality. Forage production contains 25% of protein and 14% of crude fibre on average. Tables 1 and 2 show some analytical results with regards to forage quality.

Table 1. Chemical analyses (% DM) of herbage in 1996

Protein (%)	NDF (%)	ADF (%)	ADL (%)
24.2	24.9	12.6	5.2

Table 2. Content of macro (%) and micro (ppm) elements in forage in 2006

Ca (%)	Mg (%)	Na (%)	K (%)	P (%)	S (%)	B (ppm)	Zn (ppm)	Cu (ppm)	Mn (ppm)	Fe (ppm)
1.12	0.41	0.39	2.54	0.48	0.38	51.8	41.6	3.3	66	104

Table 3 shows the most important parameters on seed quality to be used for concentrate.

Table 3. Chemical composition (% DM) of seeds collected in 2011

Ashes	6.53	**Raw lipid**	3.24
Organic matter	93.47	**Raw protein**	23.38
NDF	38.47	***In vitro* digestibility**	77.64
ADF	24.88	**WSC**	5.78
ADL	2.90	**Amides**	12.49

IV – Conclusions

Compared to the traditional self-reseeding legumes, the considerable advantage of this species is its easy harvest with the cereal thresher. The following crop models could be identified:

1. As a forage, the crop can be grazed at the end of winter, and provide a later cut for hay production at the flowering period.

2. After the initial grazing, the crop can be used for seed production. Moreover, the seeds could serve as protein feeding, while the straw residues could be usefully baled or grazed.

This species could be very interesting for the Mediterranean environment for its rapid emergence, its early grazing, its organoleptic characteristics and the versatility of its use. It could be used for both human food and animal feeding, as well as for environmental purposes in order to increase soil fertility, landscape enhancement, gardening, etc.

Based on all these features, we suggest constituting a working group on *Tetragonolobus purpureus* Moench in order to ensure the success of its cultivation through the Mediterranean countries.

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The use of in vitro techniques in routine ruminant feed evaluation

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Abstract. This study determined the nutritive value of some browse assessed bythe in vitro dry matter digestibility and kinetics of gas production at several incubation times (till 144 h) with or without the addition of polyethylene glycol (PEG 6000). Species varied widely in their *in vitro* dry matter digestibility (IVD, 33-61%), asymtotic gas production (A, 187-291 ml/g DM) and fractional rate of gas production (c, 0.030-0.047/h). Addition of PEG to the incubation medium increased the asymptotic gas production (A) by 51% for *P. lentiscus* and the parameter c by 60% for *M. communis*. Effect of PEG on the volume of gas produced was generally greater at 6 and 12 h of incubation. Irrespective of the incubation time, the greatest increase was observed with *A. unedo, E. arborea, M. communis* and *P. lentiscus.* Based on their *in vitro* digestibility and gas production characteristics, *P. angustifolia*, *M. communis* and *C. villosa* were superior in quality to *P. lentiscus*, *Q. suber*, *A. unedo* and *E. arborea.* The results suggest that the *in vitro* gas production may be appropriate to assess browse with relatively high phenolic concentrations, such as *P. lentiscus*, *E. arborea* and *A. unedo*.

Key words: Shrubs – Gas production – Antinutritional factors – Tannins.

Utilisation des techniques* in vitro *dans l'évaluation de routine des aliments des ruminants

Résumé. *Cette étude détermine la valeur nutritionnelle de certains arbustes fourragers en déterminant la digestibilité de la matière sèche et la cinétique de production de gaz* in vitro *(jusqu'à 144 h) et ce en présence et en absence de polyéthylène glycol 6000 (PEG 6000). Les espèces étudiées ont montré une large variabilité pour la digestibilité* in vitro *de la matière sèche (DIMS, 33-61%), le potentiel de production de gaz (A, 187-291 ml/g MS) et le rythme fractionnel de la production de gaz (c, 0,03-0,047/h). L'addition du PEG au milieu d'incubation s'est traduite par une augmentation du potentiel de production de gaz (A) de 51% (*P. lentiscus*) et du paramètre c de 60% (*M. communis*). Dans le cas de* C. villosa *et* Q. suber *l'addition du PEG s'est accompagnée par une réduction du paramètre c. L'effet du PEG sur le volume de gaz produit a été généralement élevé après 6 et 12h d'incubation. Indépendamment du temps d'incubation l'effet du PEG a montré la plus forte augmentation chez* A. unedo, E. arborea, M. communis *et* P. lentiscus*. Sur la base des données sur la DIMS et des caractéristiques de production de gaz,* P. angustifolia, M. communis *et* C. villosa *sont de bonne qualité nutritionnelle par rapport à* P. lentiscus, Q. suber, A. unedo *et* E. arborea*. Ces résultats suggèrent que la technique de production de gaz* in vitro *pourrait être appropriée pour les arbustes fourragers relativement riches en composés phénoliques tels que* P. lentiscus, E. arborea *et* A. unedo*.*

Mots-clés. *Arbustes – Production de gaz –* In vitro *– Tannins.*

I – Introduction

Despite their abundance in the Tunisian rangelands and their evergreen foliage throughout the year, many browse species, such as *Erica* spp., *Quercus* spp. and others, have been undervalued. The prejudice against these species is attributed mainly to the insufficient knowledge about their potential feeding value. *In vitro* incubation techniques are valuable tools to estimate digestibility and kinetics of ruminal fermentation of roughages. Moreover, quantification of tannins seems to be an important factor in the process of evaluating true nutritive value of shrubs and their suitability as feed sources in the feeding systems (Kumar and

D'Mello, 1995). Recently, it has been suggested that occurrence of tannins and their effect on the kinetics of *in vitro* fermentation can be assessed using the gas production technique coupled with the use of a tannin-binding agent such as polyethylene glycol 6000 (PEG 6000). The objectives of the present study were to estimate the nutritive value of some Tunisian shrubs using *in vitro* techniques and determine the biological activity of tannins with the gas production technique in presence of PEG.

II – Material and methods

Leaves and stems of seven browse species namely *Arbutus unedo* L., *Calicotome villosa* (Poir) Link, *Erica arborea* L., *Pistacia lentiscus* L., *Myrtus communis* L., *Phillyrea angustifolia* L. and *Quercus suber* L., were collected in spring from the uplands in the province of Taaref in the delegation of Nefza (northwest of Tunisia). The selection of the species was based in the available information about their palatability and preference by small ruminants and on their relative abundance in the studied area. In the laboratory, leaves, twigs and small stems (Ø< 2 mm) were separated by hand, oven-dried at 40°C and finely ground (1 mm screen). Chemical composition and phenolic compounds were studied previously (Ammar *et al.,* 2005).

For the *in vitro* studies rumen fluid was obtained from four rumen cannulated Merino sheep fed 1 kg alfalfa hay daily and with free access to water and mineral/vitamin licks. A sample of rumen content was collected before the morning meal in thermos flasks and taken immediately to the laboratory where it was strained through four layers of cheesecloth and kept at 39°C under a CO_2 atmosphere.

1. In vitro digestibility

A culture medium containing macro- and micro-mineral solutions, a bicarbonate buffer solution and resazurin was prepared as described by Goering and Van Soest (1970). Rumen fluid was then diluted into the medium in the proportion 1:4 (v/v). Samples (250 mg) were weighed out into polyester bags (two bags per sample), 5-L glass recipients with a plastic lid provided with a single-way valve which avoids the accumulation of fermentation gases. Then the buffered rumen fluid was anaerobically transferred into the incubation jars (2-L per jar). The jars were placed in incubator (DAISY, ANKOM) at 39°C, with continuous rotation. After 48 h of incubation, bags were rinsed under cold tap water and in a washing machine (short washing cycle with cold water), dried at 60°C for 48 h and weighed to determine *in vitro* dry matter Digestibility (IVD)

2. In vitro gas production

For the assessment of the kinetics of gas production and the biological activity of tannins (using PEG 6000), the technique proposed by Theodorou *et al.* (1994) was followed. A sample (300 mg) of each browse species was weighed in triplicate into serum. Buffer solutions and rumen liquor/buffer (1:4) were prepared as described above, and 50 ml of rumen/buffer mixture were anaerobically dispensed into each bottle, with the addition of either 2 ml of distilled water or 2 ml of an aqueous solution of PEG (25 g/ 100 ml, for an intended addition of 500 mg PEG per bottle). All the bottles were crimped and placed in the incubator at 39°C and the volume of fermentation gas released was measured at 3, 6, 9, 12, 16, 21, 26, 31, 36, 48, 60, 72, 96, 120 and 144 h post-inoculation using a pressure transducer (Theodorou *et al.,* 1994). In order to estimate the kinetics of gas production, data of the cumulative gas volume produced were fitted to the exponential model proposed by France *et al*. (2000) **¡Error! No se pueden crear objetos modificando códigos de campo.**, where *G* (ml/g) denotes the cumulative gas production at time *t*; *A* (ml/g) is the asymptotic gas production; c (h^{-1}) is the fractional fermentation rate and L (h) is the lag time.

One-way ANOVA was performed on with browse species as the only source of variation. The Bonferroni test was used for the multiple comparison of means.

III – Results and discussion

The foliage of *Ph. angustifolia* had the highest values of IVD (0.613) and rate of gas production (0.047 h^{-1}) and *C. villosa* had the highest value of G24 (211 ml/g DM) and asymptotic of gas production, A (343 ml/g DM) (Table 2). However, *M. communis* had the slowest fermentation rate (0.030 h^{-1}). The volume of gas produced at 6 h of incubation (G06) was higher (>70 ml/g DM) only for *C. villosa* and *Ph. angustifolia* (Table 1). This was expected since gas volume measured after a few hours of fermentation mainly reflect the fermentation of highly soluble feed fractions. However, further increase of the gas production in relation to the incubation time, maybe is due to the decrease of the release of tannins (Makkar *et al.*, 1995) and consequently increase the volume of gas produced. When compared with *P. lentiscus*, a tannin-rich shrub, all parameters of gas production were generally higher in *C. villosa* and *M. communis* (Table 1). Nonetheless, fractional fermentation rate suggests that tannins and indigestible components of the cell wall affect the rate of gas production to a littler extent than the others parameters.

Table 1. In vitro digestibility (IVD) and parameters of gas production kinetics of browse foliage

Species	IVD g/g DM	G06h ml/g DM	G24h ml/g DM	A ml/g DM	c /h
A. unedo	0.468bc	53b	156c	263c	0.037b
C. villosa	0.609a	73a	211a	343a	0.040b
E. arborea	0.381de	42d	126d	217d	0.036b
M. communis	0.525b	49c	151c	292b	0.030c
Ph. angustifolia	0.613a	71a	197b	291b	0.047a
P. lentiscus	0.330e	46cd	127d	190e	0.046a
Q. suber	0.422cd	44d	122d	187e	0.044a
SEM	0.0126	0.8	1.9	3.0	0.0007
P-value	<0.001	<0.001	<0.001	<0.001	<0.001

SEM Standard error of the mean.

a,b,c,d,e Means with different letter within the same column are significantly different (P<0.05).

It is well established that condensed tannins at high levels may depress ruminal fermentation of feed, reducing microbial activity and digestibility. In the current study the higher levels of tannins present in *A. unedo* were accompanied generally by higher kinetics of fermentation than *Q. suber*, which revealed lower tannin content (Ammar *et al.*, 2005). This finding may indicate that *Q. suber* possess a mechanism for reducing microbial degradation in the rumen which is independent of tannins. Up to date, few studies have studied the effect of tannins on plant palatability. *E. arborea*, for example, an evergreen species, is preferred by sheep and goats through the year in spite of its high tannin content. The percentage increase in gas production represents the effect of tannins, the higher the biological activity of tannins on rumen microbes, the higher the increase in gas production in presence of PEG. The largest increment was observed to *P. lentiscus* (86, 80, 71, 60 and 51% for G06, G12, G24, G48 and asymptotic of gas production respectively) (Table 2). *M. communis* presented the highest increase in the fermentation rate (60%). Irrespective of the browse species, the magnitude of the increase of the volume of gas produced peaked at 6 h and decreased progressively with the incubation time. The effect of PEG on the volume of gas produced decreased progressively with the incubation time. Such findings indicate that microbes can adapt or counteract some of the antinutritive effects.

Addition of PEG to tannin-free plants (i.e., *C. villosa* and *Ph. angustifolia*) did not increase the *in vitro* gas production and may result in negative effects by decreasing the efficiency of microbial synthesis. Our results strongly indicate that addition of PEG is advantageous if the tannin content of the feed is high to the extent that it depresses microbial activity and digestibility of feeds drastically. Although total condensed tannin content was higher in *E. arborea* than in *M. communis* and *A. unedo* (Ammar *et al.,* 2005), effect of PEG on kinetics of gas production from these two latter species was larger than that from *E. arborea*.

Table 2. Increase (%) of the in vitro gas production parameters with the PEG presence

Species	∆G06	∆G12	∆G24	∆G48	∆A	∆c
A. unedo	66b	58b	44b	29b	14b	55a
C. villosa	-4c#	-3d#	-2d#	0d#	3c#	-7e
E. arborea	57b	51b	40b	27b	14b	44b
M. communis	64b	56b	44b	27b	8bc	60a
Ph. angustifolia	6c#	6cd#	5cd#	4cd#	3c#	4d#
P. lentiscus	86a	80a	71a	60a	51a	27c
Q. suber	12c	13c	13c	14c	15b	-2de
SEM	3.1	2.9	2.5	2.1	1.8	1.4
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

SEM Standard error of the mean.
a,b,c,d,e Means with different letter within the same column are significantly different (P<0.05).
Effect of PEG not significant (P>0.05).

IV – Conclusion

Based on the data of kinetics of *in vitro* fermentation, the browse species had the following ranking: *C. villosa>P. angustifolia>M. communis>A. unedo>Q. suber>E. arborea>P. lentiscus.* However, although methods used here for screening the nutritional potential of browse plant species have some advantages, the practical feeding experiment with the target ruminant species is the most suitable method. Further studies are therefore recommended to determine whether the observed superiority in the nutritional value of *C. villosa*, *P. angustifolia* and *M. communis* could be translated into improved animal performance. The apparently low nutritive value of *A. unedo*, *E. arborea* and *P. lentiscus* makes them less suitable as an alternative feeding stuff in ruminant diets.

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Session 3
Socio-economic benefits of sustainable grassland management

Overlooked benefits and services of grasslands to support policy reform

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Abstract. Despite their ecological, economic and social importance, Mediterranean grasslands continue to receive limited scientific, political and media attention. Grasslands are typically viewed as underutilized space, able to be transformed into more "valuable" land by placing it under cultivation, transforming it into forest land and/or privatizing it. This paper synthesizes a number of pertinent issues in relation to social and economic systems on grasslands within the southern Mediterranean region. One effective avenue for drawing more attention to the need for preserving grasslands is to emphasize the economic aspects and benefits of grasslands, relative to the costs of degradation and the cost of inaction. This paper defines marketable and non-marketable goods that are not clearly defined in the literature of sustainable grassland management. When goods are clearly defined payment for environmental services is feasible. Providing an enabling environment for community-based land use and decision-making may foster an acceptance of schemes for community-based payment for ecosystem services on grasslands. There is a need for policies which provide security in property rights, risk reducing strategies, and that take into account both technical and socioeconomic constraints to ensure adequate incentives for participation in grassland management. This is important as mismanagement and climate change have led to further degradation. Land tenure practices and improper policies can also act as indirect drivers of grassland degradation. When farmers and herders lose control or long-term security over the land they use, the incentives for maintain environmentally sustainable practices are lost.

Keywords. Mediterranean grasslands – Community-based land management – Payment for environmental services – Marketable goods.

Des avantages et services inconnus pour soutenir la réforme politique des prairies

Résumé. *Malgré leur importance écologique, économique et sociale, les prairies méditerranéennes continuent de recevoir une attention scientifique, politique et médiatique limitée. Les prairies sont généralement considérées comme des espaces sous-utilisés, capables de se transformer en terres "précieuses" comme les forêts et/ou soumises à la propriété privée. Cette étude fait la synthèse d'un certain nombre de questions pertinentes liées aux systèmes sociaux et économiques sur les prairies dans la région du sud de la Méditerranée. Un moyen efficace pour attirer davantage l'attention sur la nécessité de préserver les prairies est de souligner les aspects et les avantages économiques de ces prairies, par rapport aux coûts de la dégradation et au coût de ne rien faire. Cet article détermine les biens commercialisables qui ne sont pas clairement définis dans la littérature sur la gestion durable des prairies. Uniquement si les biens et les services sont clairement définis, le paiement de ces services environnementaux sera faisable. Fournir un environnement propice pour l'utilisation des terres communautaires et la prise de décision liée aux prairies peut favoriser l'acceptation des systèmes de paiement à base communautaire pour les services de cet écosystème. Il y a un besoin de politiques qui assurent la sécurité des droits de propriété, les stratégies de réduction des risques, et qui tiennent compte des contraintes techniques et socio-économiques pour constituer des incitations adéquates pour la participation à la gestion des prairies. Ceci est important car la mauvaise gestion et le changement climatique ont conduit à une dégradation avancée. Une gestion du foncier et des politiques inappropriées peuvent également agir en tant que facteurs clés indirects qui contribuent à la dégradation des prairies. Lorsque les agriculteurs et les éleveurs perdent le contrôle ou la sécurité de longue durée liés aux terres qu'ils utilisent, les incitations à maintenir des pratiques de gestion environnementale durable sont également perdues.*

Mots-clés. *Prairies méditerranéennes – Gestion communautaire des terres – Paiement pour les services environnementaux – Biens commerciaux.*

I – Introduction

Worldwide, there is estimated to be 50 to 200 million pastoralists, who secure a living through the benefits provided by a range of ecosystem services and public goods which are produced by grasslands (IFAD and FAO, 2014). While this paper discusses grasslands in the Mediterranean region, much of the literature often refers to grasslands as rangelands, as well as parts of the Mediterranean region as MENA (Middle East and North Africa). Literature citations which are relevant to grasslands in the Mediterranean are used, however reference to rangelands and MENA are largely left unchanged in order to maintain citation integrity and inclusivity. Within the MENA region, grasslands are home to ecosystems which have historically played a vital role in the evolution of human societies (Jouven *et al.,* 2010); with the nature of uncertainty and an intermingling of environmental, social and political concerns shaping the makeup of rural society. Not surprisingly, unsustainable management of grassland resources, influenced and exacerbated by climate change (recurrent drought), is leading to concerns over degradation; thereby diminishing potential agro ecological, environmental, social and economic roles in maintaining both community identity and a vibrant rural society. To be sure, in regions which exhibit significant geo-political sensitivity, arid grasslands are prone to the enactment of regulatory mechanisms, targeted at shaping the makeup of rural society, and with limited attention accorded to the potential benefits and impacts from a leveraging of social, cultural, aesthetic and economic values. This is particularly true for much of the MENA where the pan-Arabism movement of the 1950's and 1960's, exacerbated by recent strife within the region ("Arabic Spring") is leading to increased vigilance on border areas. One aspect of regional political economy in this regard was, and continues to be, a felt need for national policies aimed at incentivizing the settlement of communities on large swathes of grasslands as a vehicle for monitoring movements and developments on border areas (Chatty, 2006).

For a variety of reasons therefore, grasslands continue to face immense pressure for landscape change, but are generally of low priority when discussed in the context of conservation (Veldman *et al.*, 2015). Often misclassified and identified as potential areas for reforestation (ibid), many have been targeted for forest expansion (Fig. 1), which is particularly true for areas within the 'European' Mediterranean. The existence of both grassy biomes and desert grasslands is clearly visible for the MENA region, where limited potential for agro-silvopastoral exists. Within this region, increasing population pressure, urbanization and elevated food consumption, above its production capacity, is leading to costly and unsustainable production systems (El Kharraz *et al.,* 2012). As a result, there are concerns regarding environmental degradation. A natural inclination, therefore, is to seek out avenues for reducing the pressure on grasslands through restrictions on mobility or free access on grasslands (Nori *et al.*, 2009). Given that mobility of herds within the region is a traditional strategy for dealing with drought and uncertainty, addressing rangeland degradation through regulatory measures for restricting access is not clear cut and complicated because of a number of thorny issues (Nori *et al.*, 2009).

Linkages between access to pastures, grassland degradation and conflicts are complex. There is evidence to suggest that severe grassland degradation is a trigger for conflicts locally, which can potentially spill over into broader conflicts at a national or regional level (Meier *et al*., 2007). Some have therefore argued that grassland degradation can be both a cause and a consequence of such conflicts and can be preventable with sound land management practices (Suliman, 2011; Bedunah and Angerer, 2012). In light of these issues, an integrated analysis of grassland systems is complex and requires a multidisciplinary approach to fully understand synergies and trade-offs between competing public, private, social, economic, cultural and environmental interests.

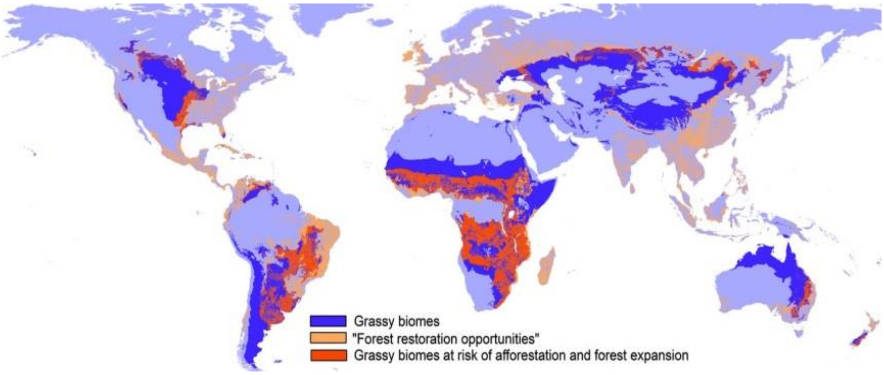

Fig. 1. Forest restoration opportunities targeted in grassy biomes (Veldman et *al.*, 2015)

Recent research suggests that under the right environment, grazing management can potentially sequester 148 Tg CO_2 yr^{-1} and legume sowing/cultivation could sequester 203 Tg CO_2 yr^{-1} with a 28% offset in N_2O emissions (Henderson *et al.*, 2015). Achieving tangible outcomes in this area however requires a more detailed understanding of social systems within rangelands. This is particularly important in terms of understanding the value of 'place' and tradition, as well as in terms of concerns related to political economy in areas where vast expanses of barren land render surveillance of sensitive border areas difficult. Ascribing economic values to ecosystem services of rangelands has the potential to provide incentives for better rangeland management, reduce externalities, improve national GDPs (Mirzabaev *et al.*, 2016), and mitigate conflict. Yet, social systems are just as crucial as ecological and environmental systems (Cousins, 1999), but are often not accorded the same attention in policy discourse as economic and environmental systems and particularly in relation to uncovering avenues for mitigating degradation.

The socio-economic benefits of sustainable grassland management have not been comprehensively assessed. As pastoralists are increasingly urged to manage their lands in a more sustainable manner it is not often clear what the benefits are regarding this change in management. Sustainable management derives benefits principally through ecosystem services and economic impact. To have a sustainable impact it is pertinent to work within the socio-economic framework. In this paper, we endeavor to synthesize valued and unvalued rangeland benefits and a number of pertinent issues in relation to social and economic systems on rangelands within the southern Mediterranean region.

II – Economic values

When looking at the socio-economic benefits of sustainable grassland management marketable and non-marketable goods are not often clearly defined. In building on Nábrádi (2007), we identify a range of marketable and non-marketable goods and services for discussion (Table 1) and attempt to break down the attributes of value from both economic and social perspectives. Some of these goods exhibit both economic and social attributes and are discussed in more detail within relevant sections with supportive literature. Marketable services are defined here as services that either receive compensation or replace a household cost. Non-marketable services are defined as services that are provided from grasslands that do not offset household costs and there is no willingness to pay for these services. As a result, some services can be both marketable and non-marketable, depending on the producers' offsetting of cost of the services and the willingness to pay of others. When services become marketable it is easier to manage and preserve them. While value can be attributed to use, non-use, and indirect use, use does not always represent a willingness to pay or cost offsetting and can assume economic value where there is not any. As a result use is not used in the definition of marketable and non-marketable services. .Many of the defined services are often overlooked or deemed non-marketable, causing rangelands to be undervalued and further undermine the economic case for sustainable grassland management.

Table 1. Services provided from grasslands

Product/Name	Marketable	Non-marketable	Marketable and Non-marketable
*Forage Production	+		
*Livestock Product/Sales	+		
*Recreation	+		
Extractive Industries (mining & oil)	+		
*Energy (wood, charcoal, biofuel, solar power, wind power)	+		
*Non Forage Rangeland Products (oils, honey, syrups, sweeteners)	+		
*Medicinal Plants			+
Wildlife			+
Climate Mitigation/ Soil Carbon			+
Water Infiltration			+
Cultural value			+
Soil Fertility (legumes, organic matter)			+
Plant Biodiversity		+	
Erosion Control		+	
Water Purification		+	

*Any product that is used for household consumption and offsets costs is considered marketable

1. Marketable services

Marketable grassland services are: forage production, livestock production and sales, recreation, extractive industries such as mining and oil, and non-forage rangeland products (such as oils, honey, syrups and sweeteners among others). These services either receive compensation or replace a household cost. Some services can be both marketable and non–marketable depending on whether others are willing to pay for the service. When people are willing to pay for medicinal plants, wildlife, soil carbon for climate mitigation, soil fertility for increased production, water infiltration, and cultural values from tourism become marketable services. Sustainable grassland management enables the longevity of many of these services.

One of the principle services from grasslands is forage production, which supports livestock product and sales. The EU provides subsidies to promote the development of sustainable farming systems with an emphasis on the conservation of natural resources. In many European countries within the Northern Mediterranean basin, flock sizes are being reduced (Toro Mujica *et al.*, 2015). In stark contrast, livestock production in the southern Mediterranean basin is witnessing a steady increase. It is not clear whether the increase in flock size in the south is substituting the reduction in supply to meet demand in the north and should be explored further. Regardless, reducing feed costs on both sides of the Mediterranean is an important economic issue which can be accomplished in a sustainable manner. Greater reliance on livestock grazing relative to purchased forages is an effective avenue for reducing feed costs. This is particularly the case given that winter feeding costs are the single largest expense for many livestock operations (Prevatt *et al.,* 2001). Even when grazed directly, grasslands have an implicit market value in so far as they replace the need for the purchase of feed. The ability to maintain animal weight (or at least minimize weight loss) is equally an aspect of marketable gain, which is an environmental service provided by grasslands. This service is not charged to livestock herders in open access systems and as a result is more sustainable in closed communal and individual tenure.

Often missed in research aimed at mitigating rangeland degradation is the marketable and non-marketable value which medicinal plants provide. They provide value in terms of both income and cultural attachment, and in their role in providing environmental services such as water infiltration or purification. While values are typically location specific (Brown and MacLeod, 2011; Louhaichi *et al.,* 2011), we argue that the value of medicinal plants are not properly valued in terms of indigenous knowledge, with both economic (in terms of offsetting medicinal costs) and cultural values not appreciated. This is shown by a questionnaire survey conducted in Egypt which documented uses for plants which were unknown within the scientific literature prior to the study. Of the 322 native plants which were compiled, direct benefits in the form of food, medicine, and energy were documented as well as indirect (environmental) services such as biodiversity, water storage, and soil fertility (Table 4 in Bidak *et al., 2015)*. Wetlands have been disappearing globally despite the ecosystem services they provide. It is recommended to use multiple research approaches to highlight their importance, one of them is to document the uses of local plants as well as their economic importance (Turner *et al.,* 2000). Including local benefits in opportunity costs has been influential in preserving them (Barbier, 1993)

Payment for water has been implemented in many forested areas (Muñoz-Piña *et al.,* 2008), and has potential in grasslands. Reductions in grasslands in arid areas reduces water infiltration to a level that is insufficient for grass growth and can lead to a stabilized desertified state (Castellano and Vallone, 2007). In some grasslands brush management may be a way to increase water yield as well as bird habitats for species that require grasslands (Olenick *et al.,* 2004). There are many management practices that can be implemented to increase water infiltration and saving, however they need to be verified in different locations to avoid estimation errors (Havstad *et al.*, 2007). While this may sound overwhelming for large programs, smaller scale user financed programs could be better targeted, more closely tailored to local conditions and needs, with better monitoring and also exhibiting a greater willingness to enforce conditionality (Wunder *et al.*, 2008). Small scale projects that implement PES for water have been implemented in Latin America and South Africa (Turpie *et al.*, 2008; and would be strategic for the region as many areas have water stress with growing populations (Kliot, 2005). As large research programs can be costly and time consuming to implement, community based research that allows users to document water changes with management could be immensely beneficial. Such small scale projects can build greatly needed momentum for local payment for environmental services around water in grasslands.

Grasslands in the MENA region provide natural beauty, diversity of wildlife, and recreational opportunities such as hunting, hiking, and camping, as well as economic opportunities such as, ranching and mining (Louhaichi, 2011). This is particularly the case in areas where degradation has limited the ability for sustainable livelihoods. Cultural tourism, which allows for sharing of lifestyles and experiences with tribal pastoralists such as the Bedouin community in Jordan, is a source of revenue for many pastoralist groups (Chatelard, 2006). In some MENA countries tourism represents an important income source and income diversification strategy for nomadic pastoralists. In Southern Morocco for example, it is a common strategy for poorer pastoralists to rent their dromedaries to tourism agencies accompanied by one family member employed as a tourist guide. Tourism often provides more income than traditional livestock rearing. Relatively well-off pastoralists have opened their own tourism agencies and combine touristic desert trips with herding their dromedaries on desert pastures (Werner, 2007). They also provide tourism opportunities for those imbued with feelings of attachment to nature and natural lifestyles. In seizing opportunity from this growing trend and demand, ecotourism is generally found to exist in those areas which exhibit fragility in ecological, social and cultural systems. It is an important tool for the creation of additional income for farmers, especially in protected and mountainous areas. Day hunting and season leases provide considerable amount of income to ranchers in some locations (Olea and San Miguel-Ayanz, 2006).Yet, the management of rangeland resources which are suitable for recreational use requires contextually relevant institutions and governance mechanisms in order to promote sustainable use. For example; motorized recreation is on the rise in many rangelands. While it can provide an important revenue source it can also cause damage (White *et al.,* 2000; Wulfhorst *et al.*, 2006), namely soil disturbance and vegetative destruction, which can further exacerbate erosion and degrade water quality. As a result it is pertinent that extension is fully equipped to advise how to manage motorized recreation sustainably.

2. Non-marketable services

Sustainably managed grasslands produce positive externalities, public goods and environmental services. Services are considered non-marketable when there is not a willingness to pay and costs are not offset by the service. The non-marketable services that sustainably managed grasslands can provide are: plant bio-diversity, erosion control, water purification, soil fertility, medicinal plants, wildlife, and climate mitigation from soil carbon, water infiltration, and cultural value. Sustainably managed grasslands can play a major role in providing ecosystem services such as; carbon sequestration and biodiversity enhancement but also on landscape and nature conservation, mitigation of soil erosion, water protection, cultural heritage, or wildfire prevention. However since there is often not a willingness to pay, these services are listed here as non-marketable services. The new Paris climate agreement changes the wording from permanent vegetation to long term vegetation opening up the potential for carbon sequestration from some rangeland plants. If local payment for environmental services are set up, some of these ecosystem services can become marketable. Grazing has been shown to increase soil organic carbon and nitrogen contents with light grazing compared to no grazing or heavy grazing (Ganjegunte *et al.,* 2005). Efforts to integrate grasslands into the carbon market could help eliminate/internalize this positive externality and promote sustainable grassland management. However, many of the other public goods are difficult to disaggregate and to measure in terms of cultural, intrinsic and economic value given dynamic interrelationships which can be both supporting/complementary as well as competing. Efforts that assist in generating monetary economic values for non-marketable services from grasslands should be encouraged in order to prevent degradation or inequitable use of these services.

A large number of goods and services found on rangelands and grasslands are non-marketable unless small niche markets have been set up (Bohlen *et al,* 2009), which can be difficult to do.). The main challenges in setting up payment for environmental services are; low cost estimation of ecosystem service flows, difficulty in attaching flows and cost estimates in a low cost way, and the public good nature and often non-exclusiveness of these services (Kroeger and Casey, 2007). Open space is a service which rangelands provide but is seldom accorded economic value other than in formal real estate markets even though open lands provide various ecosystem services (Fausold and Lelieholm, 1999) and a range of benefits which are often difficult to quantify and rarely priced. Due to the ecological, economic and political marginality of rangelands, “higher value” more intensive land uses are impinging on rangelands around the world (Sayre *et al.,* 2013). Efforts to create low cost methods to quantify ecosystem services and assign values as well as provide excludability are needed to advance payment for environmental services further on grasslands.

Large scale cost estimates of grasslands provide an impetus to find low cost ways to measure ecosystem services and make theme excludable. In a study on the valuation of rangeland ecosystem services in China, rangelands generated a value of 149.79 million USD annually in China based on the valuation of biomass alone (Xie *et al.*, 2000). Providing value to ecosystem services can strengthen economies and community resilience. There is often an economic payoff by improving rangelands and internalizing market externalities. Incentives for sustainable grassland management will promote improved practices and make them more economically viable. There is the potential to mitigate land degradation if the correct incentives for investment and regulatory oversight allow.

3. Social

While marketable and non-marketable services are important for the valuation of rangelands, they occur in contextual social environments. Understanding and valuing the social component of rangelands is essential for sustainable management. Sustainably managed rangelands produce a myriad of social goods and provide a place for landless people to live (Sbeita, 1999). When tribal lands are divided, pastoralists face the risk of landlessness and migrate to the city in search of low-paid manual jobs (Graham, 1989). Where opportunities for settlement in peri-urban areas within the periphery of rangelands exist, maintenance of a limited number of small ruminants provide labor opportunities for the youth in terms of shepherding, but more importantly, a sense of attachment to community, identity and place.

Bedouin culture has historically played an important role in the development of the notion of a national identity in the Kingdom of Jordan (Layne, 1994), more generally within the Middle East, and continues so today despite pressures for sedentarization. Within the region, a commonly held understanding of the term ‘Bedouin’ (or ‘Bedu’) is a person or tribe who lives in the open, on rangelands, and is generally associated with a nomadic lifestyle. In antiquity, ‘Bedouins and their camels lived a harmonious, symbiotic relationship with their environment’ (UNESCO, 2007). Through the development of the *Hema* system – moratorium on grazing within defined areas of common tribal pastures – the Bedouins were able to maintain a balance between the needs for maintaining a system of nomadic husbandry with the environmental services provided by rangelands, such that only a slight negative influence on ecosystems existed (ibid, pp. 10). With agricultural mechanization and greater urban demand for animal sourced food products, a movement from traditional husbandry to production for market led to a shift in livestock portfolios from camels to small ruminants (predominantly sheep) in the late 1960’s. Volatile conditions in the availability of feed resources given recurring drought phenomena have thereafter led to a more contemporary shift towards semi-nomadic and settled operations, which brought about deterioration of grasslands and rangelands (Leybourne et al. 1993; UNESCO, 2007). Yet, quite apart from the role of markets in influencing the decision to settle, the southern Mediterranean region exhibits a unique case study in the role that politics has played in settling nomadic (Bedouin) populations.

Unique to other areas, the MENA region has focused on settling pastoral people by physical force or economic incentives to control and integrate marginal and at times problematic populations. This movement provided conformism to aspired nation-states, republics and kingdoms of the region. Accordingly the region has never been the focus of mass international pastoral development assistance (Chatty, 2006), in supporting the view that settlement schemes have largely failed in the southern Mediterranean in terms of limiting the extent of pastoralism through forced or induced settlement within the region. Although settlement efforts have been considered successful in countries like Greece (Hadjigeorgiou, 2011). Bequest or symbolic values for lifestyle choices would appear, therefore, to weigh heavily for the Bedouin, given a continued attachment to rangelands. While official figures are difficult to obtain, anecdotal evidence would suggest that the number of Bedouins who maintain livelihoods on rangelands within the region has declined over the past half-century, yet the number of livestock (per inhabitant) grazed on rangelands may not have declined accordingly and has likely increased. Livestock number have increased in other locations in the Mediterranean while the number of pastoralists declined along with the sedentarization of pastoralists (Hadjigeorgiou, 2011). One reason why policies related to mitigating degradation of rangelands have been of limited effectiveness lies in the deficiency in respecting the role that traditional institutions play in fostering contemporary approaches to grassland management. Innovation in institutional options for common property management within the southern Mediterranean is likely to become more successful when embedded in participatory processes, rather than mandatory and enforced options which are regulated by the state and markets. Governments will inevitably play different and varying roles regarding pastoral management. The question governments will have to address is twofold: should they play a role in managing grasslands through enforced regulations, within a region characterized by historical attachment to open space and kinship ties? Or, should they foster an environment for social values to guide environmentally sound activities (economic, recreational, aesthetic) through incentives and regulatory oversight/supervision/monitoring which are consistent with the local political economy, that include the provision of public goods and services, as well as preserving heritage, culture and national identity?

III – Discussion and conclusion

The analysis of the benefits and services of grasslands highlights a number of marketable and non-marketable goods and services of grasslands. Questions remain as to why their values continue to remain overlooked and why grassland policies seem to continuously not take them into account? Why do governments design grassland policies which exacerbate degradation in lieu of policies which leverage and utilize values found therein (Bedunah and Angerer 2012). One important reason for this dilemma lies in the cultural and economic perceptions of grasslands. This predominant perception sees grasslands as an underused space that would have to be transformed into a more "valuable" land through cultivation, transformation into forest land and/or privatizing it (IFAD and FAO, 2014). Unfortunately polices often see intensification as the only way to produce value as non-marketable services are not seen as having value. This view often does not take into consideration the cost of degradation from overuse. This perspective sees grasslands through a sedentary farmers' perspective and views all communal use as open access – in close parallel with Hardin's tragedy of the commons (Turner, 1999). It does not take into consideration the possibility of defined user groups with management rules and grazing permits. For example, the "hima" system was used in Jordan by the Bedouin that restricted and regularized the use of rangelands with accountability for sustainable land management and ownership by the local people (Haddad, 2014). Furthermore, discounting local knowledge and land use systems seems to reflect the perception of the colonialist's attitudes toward North African Dryland rangelands as "useless". For example, Morocco was divided into "useful Morocco", the areas that can be cultivated and "useless Morocco" ascribed to dry rangelands by the colonists (Planel, 2009). While having overcome this fatal policy, these attitudes continue to persist within present pastoral laws and perceptions of policy makers within the Southern Mediterranean countries. In some of these countries pastoral laws that clearly define the pastoral space as an entity do not even exist. The share of overseas direct investments into grassland-related development, governance and/or tenure activities is insignificant. The focus as a result is on controlling the movement of pastoralists. Regardless the fact that there are many existing examples of successful communal natural resource governance, there is a lack of willingness to invest and to transfer the control of natural resources management and governance to the local level (IFAD and FAO 2014). This can be difficult as local government support has been shown to be essential in reestablishing the "*hima*" system (Haddad, 2014).

The most efficient way to draw more attention to the benefits of grasslands is to emphasize the economic aspects of grasslands, to clarify the consequences of not taking grasslands benefits into account, and the costs of inaction. The latter can be achieved through calculating the costs of grassland degradation. In Uzbekistan it is estimated that the costs of land degradation have a three percent reduction of the national GDP and that most of these costs are related to shifts from grasslands to lower value lands (Mirzabaev *et al.,* 2016). If these costs of shifts from grasslands to degraded land or deserts, would be calculated for all Mediterranean countries with important grassland surfaces, it would create strong arguments for a policy change regarding grasslands. Estimations of social costs are also important but do not always receive adequate attention from all stakeholders. Often social costs and the costs of eliminating non-marketable services can be linked to economic costs indirectly and should be included in economic calculations where possible.

The other step that should be undertaken to realize the benefits of grasslands is to promote community-based payments for ecosystem services schemes for grasslands. First steps in research to transfer lesson learned from payment for environmental services schemes of forest areas to grasslands have received little attention thus far (Dougill *et al.,* 2012) but would be helpful in order to ensure that PES efforts for grasslands are more sustainable.

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Investigation of socio-economic factors affecting sustainable rangeland use

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Abstract. This study was carried out in 11 provinces which have more range improvement projects than others in Turkey. The population of this study was the total of the households (producers) in the villages were the study was implemented between 1998-2013. Sampling volume was determined as 719 according to stratified sampling methods, taking into consideration the number of households in the villages. The data obtained were analysed by the methods of Chi-square and Multinomial Logistic Regression and interpretations were made according to the analysis results. It was determined that age and education level of the producers do not have a significant effect on the sustainability of the rangelands. It was found that the effects of the total land ($p<0.05$) and the aim for ranching on sustainability ($p<0.01$) were statistically significant. The participation rate in the rangeland improvement works was sufficient (51.5%).In respect to socio-economic factors, it was found that rangeland improvement works were not successful, the sustainability of rangelands could not be continued, rangeland improvement works were not adopted and sustainable rangeland use was not realized by the current rangeland improvement works.

Keywords. Rangeland improvement and management works – Sustainability of rangelands – Turkey.

Enquête sur les facteurs socio-économiques influant sur la gestion durable des parcours naturels

Resume. *Cette étude a été réalisée dans 11 provinces qui ont plus de projets d'amélioration des parcours que les autres. Trois régions ont été formées avec les provinces, ayant chacune les mêmes caractéristiques. La population de cette étude était l'ensemble des ménages (producteurs) dans les villages où l'étude a été mise en œuvre entre 1998-2013. Le volume d'échantillonnage a été déterminé comme 719 selon les méthodes d'échantillonnage stratifié, en prenant en considération le nombre de ménages dans les villages. Les données obtenues sont analysées par les méthodes de Chi-carré et la régression logistique multinomiale, et les interprétations sont faites selon les résultats d'analyse. Il est établi que l'âge et le niveau d'éducation des producteurs n'avaient pas d'effet significatif sur la durabilité des pâturages dans les analyses réalisées. On constate que les effets de la quantité totale de terres ($p <0,05$) et le but de l'élevage sur la durabilité ($p <0,01$) sont statistiquement significatifs. Le taux de participation aux travaux d'amélioration des pâturages est de niveau suffisant (51,5 pour cent). Concernant les facteurs socio-économiques, il a été constaté que les travaux d'amélioration des pâturages n'ont pas réussi, la durabilité des parcours ne pouvait pas être poursuivie, les travaux d'amélioration des parcours n'ont pas été adoptés et l'utilisation durable des parcours n'a pas été réalisée par les travaux d'amélioration des parcours actuels.*

Mots clés. *Amélioration des parcours et travaux de gestion – Durabilité des pâturages – Turquie.*

I – Introduction

Rangelands in Turkey are fully owned by the state and the right to use them is allocated to villages and municipalities. Rangelands are not subject to private ownership, they cannot be misused (the proper use of rangelands are to obtain forage according to legislation in Turkey), prescription is not applied for them and their boundary lines are not restricted.

The source of roughages in Turkey is meadows by means of mowing 5 percent of natural vegetation and 95 percent of the rangelands and summer pastures by means of grazing. Meadows and rangelands in every country are the cheapest feed sources. However, rangelands have not been regarded as areas that meet the growing and improving needs of plants and feed needs of animals. Therefore, they have been used in a way that has degraded them, destroying vegetation and making them unproductive. It affects not only livestock production but other agricultural activities, general economy and the future of Turkey. There are six main reasons for degradation of rangelands: over grazing, early grazing, drought, uncontrolled grazing, burning and weed invasion (Ekiz *et al.*, 2001).

Nearly all the producers of the villages in which the rangelands improvement and management works are carried out are of the last subgroup in respect to income and education level. The Ministry of Food, Agriculture and Livestock (MFAL) that is responsible for the management of the rangelands should undertake extension activities for producers about gaining income from ranching which can be possible if rangelands are used in optimum way. To protect the rangelands from negative uses and to increase forage yield, 1,032 range improvement and management projects covering 4,715,396 decares have been implemented between 1998 and 2013. Not only the ranchers but also the views and conditions of other individuals living in the villages should be paid attention for the sustainable rangelands use. For this aim, 11 improvement and management works in three regions of Turkey were implemented, the current uses of rangelands are presented and the effects these works on producers are tried to determine.

II – Materials and methods

The scope of the study is the villages of 11 provinces that have the highest areas of rangeland improvement works. The statistics belonging to the villages were obtained from the Plant Production General Directorate of MFAL. Sample unit was the farms in those villages. Data come from the face to face interviews with the 719 producers who were chosen randomly from those villages. The provinces in the study were divided into three regions according to their similarity in terms of production. Region 1 comprised the provinces of Bursa and Edirne, Region 2 Afyonkarahisar, Aksaray, Niğde and Uşak and Region 3 Ardahan, Artvin, Çorum, Erzurum and Kars. Multinomial Logistic Regression based on likelihood ratio test was used to determine the effect of socio-economic characteristics on sustainability. Moreover, logistic regression assumptions such as normality, linearity and homogeneity of variance were examined and it was found that the assumptions were proved. IBM SPSS v20 statistical program was used in the analyses.

III – Results and discussion

The ages of producers are between 23 and 81, with an average of 50.4 years. 71.6 %of the producers graduated from primary school and they are the most abundant in Region 2 (75.2%). It was found that there is a statistically significant relationship between education levels and regions ($p<0.05$). Majority (97.9%) of the producers live in a rural area. Moreover 29.2% of them have an off-farm income and a big part of them are pensioners from BAĞ-KUR, an insurance directorate of Turkey. Other off-farm incomes come from shop keeping and workmanship.

The Multinomial Logistic Regression was used to determine which socio-economic variables have been effective on sustainability. The compliance test of the model was done using the method of stepwise backward elimination. In step 1, except the region, it was found that the other socio-economic characteristics have no significant effect on sustainability view ($p>0.05$). After omitting these variables, the model passed through step 2. According to this model it can be said the region has a significant effect on the sustainability view ($p<0.001$). The examination related to the variable classes that are effective on sustainability view is given in Table 1. “Region” variable was the only statistically significant (Table 1). As it is seen in Table 1, the probability that a producer says “rangelands is sustainable” varies among regions ($p<0.001$). The producers saying probability of “rangelands can be sustainable” instead of saying not in first region is exp(B)=11.162 times more than the ones in third region. The probability of producers saying “rangelands cannot be sustainable” instead of “sustainable” in Region 2 is 4.853 times more than in third region.

Table 1. Results of the Multinomial Logistic Regression for the “Region” variable

Sustainability†	Region	B	SE	Wald	df♥	Exp(B)
I haven’t decided yet	1	1.659	0.250	43.932***	1	5.252
	2	1.093	0.292	14.065***	1	2.984
	3	0.000♣	-	-	0	-
Sustainable	1	2.413	0.366	43.442***	1	11.162
	2	1.580	0.412	14.671***	1	4.853
	3	0.000♣	-	-	0	-

†Reference Class: Unsustainable, ♣This parameter is set to zero because it is redundant (The standard error cannot be calculated for this, of course, since the parameter is set to zero).
♥Degrees of Freedom, *p<0.05, **p<0.01, ***p<0.001 SE: Standard Error

The variables of producers’ land and animals tenure were examined, too. Average land size is 99.2 decares. Average land size in Region 1 is 91.2, 111.3 in Region 2, and 108.6 in Region 3. According to the chi-square analysis, there is a statistically significant relationship between the total land of producers and regions ($p<0.01$). 6.1%t of the producers has no land, 53.4% of the producers less than 61 decares, 22.9% has from 62-150 decares and 17.5% over 150 decares. The highest percentage of producers who have no land was observed in Region 2 (6.7%). Region 1 has the highest percentage of producers (62.8%) with less than 61 decares land. Animal numbers were investigated to see the effects of farm structure on sustainability. 87.6 of the producers have no sheep and goats in terms of animal numbers. 2.1 percent of them have 1-3 animal units, 2.6% have 4-10 animal units and 7.6% have more than 10 animal units. The producers who have not sheep and goats are mostly with 92.1% in Region 3. According to the chi-square test, it was found that there is a statistically significant relationship between sheep and goats numbers and regions ($p<0.001$). In terms of cattle’s numbers, 43.8% of the producers have no cattle, 7.9% of them have 1-5 animal units, 21.7% have 6-15 animal units and 26.6% over 15 animal units. It was found that there is a statistically significant relationship between cattle numbers and regions ($p<0.001$). In terms of total animal numbers, 38% of the producers have no animals, 7% of them have 1-5 animal units, 22.1% have 6-20 animal units, 14.5% have 21-40 animal units and 18.6% have over 40 cattle unit. It can be said there is statistically significant relationship between total animal numbers and regions ($p<0.001$).

Moreover, it is thought that the aim of ranching can have effects on sustainability. It was found that 60.4% of the producers produce for market, 30% of them for environmental factors (geographical factors-altitude, climate, topography etc.) and 9.6% for family consumption.

The effects of land, animal numbers and aim for ranching on sustainability thoughts were analysed. It was implemented a Multinomial Logistic Regression to determine which farm profile variables had an effect on sustainability. In step 1, animal numbers did not show a significant effect on sustainability views. The model after extracting this variable is given in step 2. According to the model, total land and aim for ranching were statistically significant on the sustainability views of farmers ($p<0.05$). The examination related to the variable classes that are effective on sustainability views is given in Table 2 with Multinomial Logistic Regression, where total land is the ordinal and the aim for ranching is the nominal variable. The probability of producers who ranch for family consumption saying “rangeland use is sustainable” against “not” is significantly different than that of the producers who ranch for environmental factors and the difference is 22.105 times for the producers who ranch for family consumption. Similarly, the probability of the producers who ranch for market saying “rangelands use is sustainable” against "not" is significantly different than that of the producers who ranch for environmental factors and the difference is 23.826 times for the producers who ranch for market.

Table 2. Results of Multinomial Logistic Regression for the effects of the farm profile on sustainability views

Sustainability†	Factor	Level	B	SE	Wald	df♥	Exp(B)
I haven't decided yet	Total land	None	-1.697	1.093	2.410	1	0.183
		≤61	-0.545	0.295	3.417	1	0.580
		62-150	-0.028	0.337	0.007	1	0.972
		>150	0.000♣	-	-	0	-
	Aim for ranching/grazing?	Family consumption	0.603	0.448	1.812	1	1.828
		Producing for market	0.773	0.263	8.624**	1	2.167
		Environmental factors	0.000	-	-	0	-
Sustainable	Total land	None	0.661	0.663	0.992	1	1.936
		≤61	-0.079	0.363	0.047	1	0.624
		62-150	0.633	0.412	2.359	1	1.884
		>150	0.000♣	-	-	0	-
	Aim for ranching	Family consumption	3.092	0.699	19.583***	1	22.015
		Producing for market	3.171	0.608	27.155***	1	23.826
		Environmental factors	0.000♣	-	-	0	-

†Reference Class: Unsustainable, ♣This parameter is set to zero because it is redundant (The standard error cannot be calculated for this, of course, since the parameter is set to zero). ♥Degrees of Freedom. *p<0.05, **p<0.01, ***p<0.001 SE: Standard Error.

IV – Conclusions

According the results, age and educational level and animal numbers have no effect on farmers' thoughts on sustainable rangeland use. Because of the environmental factors, 74.8% of the ranchers stated that sustainability of rangelands cannot be possible. The probability of ranchers who produce for market saying "rangelands use can be sustainable" is 23.826 times more than the producers who ranch for environmental factors. It was found that in order to sustain rangelands, animal numbers should be increased so that the number of ranchers will increase. 51.5% of the producers participated in improvement works and 48.5% of them not. The producers who participated to improvement works took the agricultural equipment and labor as support. The producer's participation is enough for sustainable rangelands use. If other conditions are provided, it can be said that participation in the works can have positive effect for sustainable rangelands use. The factors that affect the most the sustainability of rangelands are the producers changing their old habits, acquiring technical support and applying the rules provided by rangeland law and its regulations. If these conditions are met sustainable rangeland use will be much more. As a result, it was determined that socio-economic variables have no effect on rangelands improvement works and sustainable rangeland use but the animals in farm and the aim for ranching have an effect on rangelands improvement and management works. Therefore, to sustain rangelands use, training activities about rangeland importance and use should be carried out, animal numbers increase and the improvement works have to be determined considering rangeland structure.

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Mapping the diachronic changes of stocking rates in a Mediterranean rural area of North Greece

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Abstract. Livestock husbandry has rapidly changed over the last 50 years in the Mediterranean region. The main changes are the continuous processes of (i) land abandonment in the less accessible areas at a high altitude, and (ii) population transfer to more favourable areas, mainly plains. The study of the temporal spatial evolution of stocking rates is a useful tool for monitoring and analyses of sustainable rangelands management. This tool was used in the 32 Municipal Districts (MDs) of Lagadas Municipality for a period of fifty years (1961-2011). Inventory data were collected for the study area and GIS software (ArcGIS) techniques were implemented in order to produce temporal maps and tables of stocking rates (1961, 1971, 1991, 2001 and 2011). The general stocking rate decreased since 1961 in the study area. However, at low elevation, stocking rate remained higher (characterised as extreme overgrazed) than in zones of intermediate and high elevation. Interestingly the stocking rate was correlated to both proximity of settlements and population status. What is a necessity for the study area is the development of a medium and long term sustainable management plan for grazing which will deal with the issue of livestock distribution which will be developed under a serious public consultation. This consultation can ensure the involvement of the local society to the plan's local adaptation and implementation in a long term basis.

Keywords. ArcGIS – Socioeconomic conditions – Land abandonment – History of grazing animals.

Cartographier les changements diachroniques du taux de chargement dans une zone rurale méditerranéenne au Nord de la Grèce

Résumé. *L'élevage a changé rapidement au cours des 50 dernières années dans les régions méditerranéennes. Les principaux changements sont le processus continu d'abandon des terres dans les zones d'altitude moins accessibles et le transfert de la population vers des zones plus favorables, principalement en plaine. L'étude de l'évolution spatio-temporelle du taux de chargement est un outil utile pour le suivi et l'analyse de la gestion durable des parcours. Cet outil a été utilisé dans les 32 districts municipaux (MDS) de Lagadas sur une période de cinquante ans (1961-2011). Les données d'inventaire ont été recueillies pour la zone d'étude et des logiciels techniques de SIG (ArcGIS) ont été appliqués afin de produire des cartes et des tableaux de chargement temporels (1961, 1971, 1991, 2001 et 2011). Le chargement global a diminué depuis 1961 dans la zone d'étude. Cependant, dans la zone de basse altitude, le chargement est resté plus élevé que dans les zones intermédiaires et d'altitude. Ce qui résultait intéressant était que le taux de chargement était en rapport à la fois avec la proximité des peuplements et le statut de la population. Il est nécessaire pour la zone d'étude d'élaborer un plan de gestion durable du pâturage à moyen et long terme qui traitera de la question de la répartition spatiale du bétail, et qui sera développé dans le cadre d'une consultation publique sérieuse. Cette consultation peut assurer l'implication de la société locale à l'adaptation et la mise en œuvre du plan d'action sur le long terme.*

Mots-clés. *ArcGIS – Conditions socio-économiques – Abandon des terres – Historique du pâturage.*

I – Introduction

Livestock husbandry in Greece basically relies on communally state-owned rangelands. These rangelands are parts of the typical Mediterranean pastoral landscapes that have been shaped by grazing activities for many centuries (Papanastasis and Chouvardas, 2005). During the last 50 years, important changes occurred in the livestock sector, following the general trend of land abandonment in rural areas of the Mediterranean region. This trend was more severe in high altitude rural areas with diverse terrain (Farina, 1998). A consequence is the decline of the number of young people engaged in the primary sector resulting in a direct effect on agriculture forestry and traditional animal husbandry (Ispikoudis and Chouvardas, 2005). Nomadic livestock flocks, which were the main element of traditional husbandry, have decreased in number. On the other hand household livestock and use of conserved feeds have increased, as a result of the difficulty of old people to shepherd their animals far away from their villages. Therefore, grazing pressure is concentrated near the villages, while the most remote parts of rural areas are less grazed (Ispikoudis and Chouvardas, 2005). These changes have contributed to the gradual degradation of rangelands.

The study of the stocking rates, meaning the number of livestock that graze on a particular area at a specific period of time divided by the surface area (Society for Range Management, 1989) is a useful tool to record and examine the progress of livestock husbandry but also to plan management policies for rangelands. This paper aims at studying and mapping the diachronic changes of stocking rates in a rural area of North Greece.

II – Materials and methods

The study was conducted in the municipality of Lagadas, in central Macedonia, Northern Greece. The climate is characterized as semi-arid to sub-humid Mediterranean conditions. Soils are shallow, sandy and acid mainly derived from metamorphic rocks. The study area includes 32 Municipalities Districts (MDs) and covers a surface area of 122,193 ha. The dominant vegetation is rangeland from which the most typical type is the *Quercus coccifera* (kermes oak) shrubland.

The first phases of the study consisted in collecting a large number of inventory data (number of livestock animals). These data were mainly collected from diachronic census reports of the National Statistical Service of Greece (NSSG) and the Direction of Agriculture of Lagadas County. The following phase included the analysis of the raw census data by using MS Office Excel sheets and GIS Software (ArcGIS v10). The final phase combined all these data and resulted in the development of analytical diachronic digital maps and databases of datasets regarding the number of livestock animals (cows, sheep and goats) and their stocking rates for the years 1961, 1971, 1991, 2001 and 2011. These datasets were analysed both temporally and spatially by dividing the study area into three elevation zones: low zone (average altitude bellow 200m), intermediate zone (average altitude between 200-600m) and high zone (average altitude over 600m).

Stocking rate was expressed in animal units per unit area, i.e. by dividing the number of free grazing animal units of each MDs with the area of rangelands registered in the NSSG land use reports. In the communal management system of the state-owned rangelands of Greece, livestock usually graze at the rangelands of the MDs where the farmer is officially registered. Stocking rate calculation included the total numbers of sheep and goats and the free grazing cows. The grazing units were expressed in sheep equivalents (5 sheep for each cow). The 32 MDs were classified into five stocking rate categories: Lightly Grazed (0-0.5 animal units/ha), Properly Grazed (0.5-2.0 au/ha), Heavily Grazed (2.0-3.0 au/ha), Very Heavily Grazed (3.0-5.0 au/ha) and Extremely Overgrazed (over 5.0 au/ha).

III – Results and discussion

The results from the diachronic census reports revealed that the number of livestock animals of the Municipality of Lagadas decreased by 27% during the time period from 1961 to 2011 in all altitude zones (low, intermediate, high). During the same time period cows and sheep were reduced by 21%, and 44% respectively, while the number of goats was on average increased by 2%, probably as a result of shrub encroachment in the area (Papanastasis and Chouvardas, 2005). For the period 1999 to 2009, Toro-Mujica *et al.* (2015) reported a decrease in sheep numbers in Andalusia region, Spain, mainly due to the uncoupling of EU CAP sheep subsidies.

A temporal reduction of the stocking rates from 1961 to 2011 (from darker to lighter colours) was recorded to the mountainous MDs of Lagadas (located mainly to the northern part of the study area, Fig. 1) due to social changes that related with land abandonment.

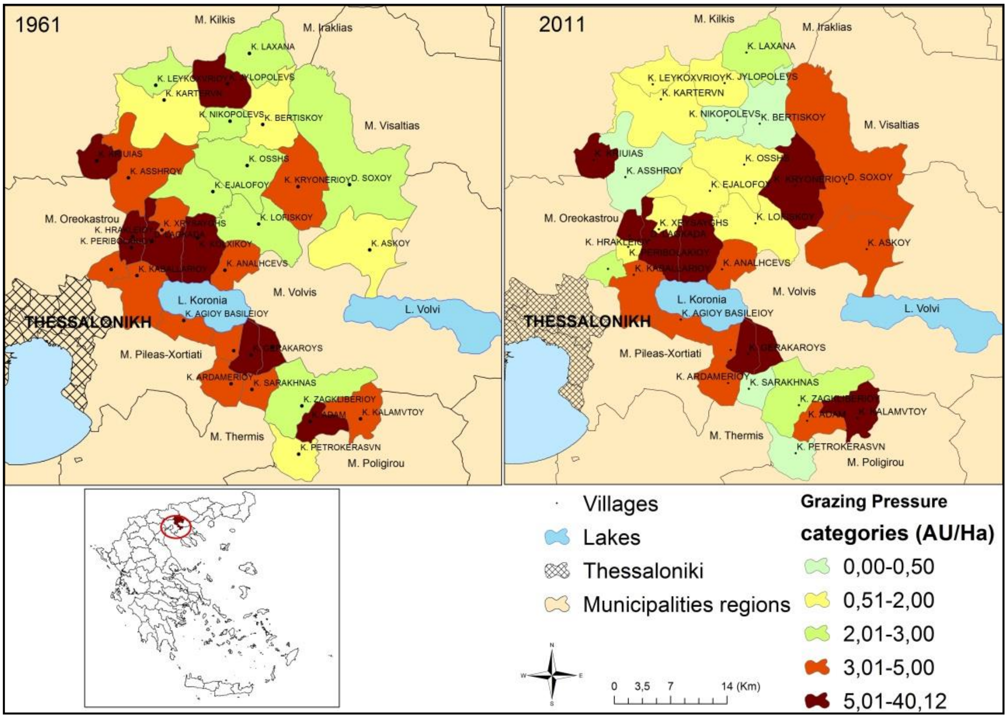

Fig. 1. Stocking rate maps of Lagadas Municipality Districts (MDs) from 1961 to 2011.

Land abandonment in these MDs contributed to an extended diachronic decrease of young people engaged to primary sector and to a reduction of livestock (unpublished data from Lagadas Municipality). Exception of this trend was the three MDs of Sochos, Askos and Kryoneri located in the eastern part of the study area (Fig. 1). The stocking rates diachronically tend to increase at these MDs, although they are mountainous and with harsh environment, mainly due to the fact that their social structure (high rate of young people engaging to primary sector) was maintained unchanged over the years (unpublished data from Lagadas Municipality). Similarly, the stocking rates were temporally increased and/or were stable from 1961 to 2011 at the MDs of low elevation zones (plain areas) located mainly around Lake Koronia and in the southern parts of the study area. This was also as a result of no important socioeconomic changes in the MDs of low elevation (unpublished data from Lagadas Municipality).

The stocking rate was diachronically decreased by 46.2% and 28.4% (Table 1) at the MDs of the low and intermediate elevation zones respectively. However, the rangelands of the low altitude zone were still highly overgrazed (6.1 au/ha) while the ones of the middle altitude zone were still heavily grazed (2.8 au/ha) (Table 1). Finally, the stocking rates at the MDs of the high zone was slightly increased by 4% maintaining at a rather satisfactory rate of 2.3 au/ha (Table 1).

Table 1. Evolution of stocking rate (au/ha) in the elevation zones of Lagadas County and its changes from 1961 to 2011 in percentage (%)

Elevation zones	1961	1971	1991	2001	2011	(%) change
Low zone	11.4	15.9	9.9	8.9	6.1	46.2
Middle zone	3.9	2.9	3.4	2.6	2.8	28.4
High zone	2.2	1.6	2.0	2.5	2.3	4.1

Despite the fact that the total number of livestock animals in the Municipality of Lagadas has been continuously reducing from 1961 to 2011, the unbalanced distribution of the grazing animals in the rangelands has produced high stocking rates mainly at the low zone around Lake Koronia and at the east part of the study area (mountainous area). Moreover, the under-grazed rangelands were in MDs that located at the north part of the study area. However, on overall the sum of heavily grazing rangelands in the study area is being diachronically decreased which is consider as a positive trend.

This research has put forward the necessity of a sustainable grazing management plan for the area which will take into consideration the different rangelands, their available grazing production, the current livestock, the socioeconomic conditions and the possible limitations. The key factor of this plan should be the rearrangement of the livestock in a way that all the available sources are used sustainably.

IV – Conclusions

The sum of the livestock census in the Municipality of Lagadas has been continuously reducing from 1961 to 2011. There is an unbalanced distribution of the grazing animals in the rangelands of the study areas since there are high stocking rates at the low altitude zone around Lake Koronia and at a part of the high elevation zones and low rates to the less accessible and lower density population areas. What is a necessity for the study area is the development of a medium and long term sustainable management plan for grazing which will deal with the issue of livestock distribution which will be developed under a serious public consultation. This consultation can ensure the involvement of the local society to the plan's local adaptation and implementation in a long term basis.

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Characteristics of lowland grasslands used in transhumant sheep systems of Marche region (Central Italy)

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Abstract. The paper aims to analyse botanical composition, DM (dry matter) yield and chemical composition of lowland grasslands to evaluate their effect on growth performances of lambs of three breeds (Bergamasca, Sopravissana and Merinizzata) in Marche region. An experimental flock (lambs and ewes of all monitored breeds) grazed four plots differing in site conditions, management and forage characteristics. In each plot, the following grassland characteristics were assessed: botanical composition (at the beginning of grazing), forage DM yield and chemical composition (at the beginning and at the end). To calculate average daily gain (ADG), lambs of each breed were weighed at birth and every 20 days until the slaughter, performed at 60 days of age. Plot 1 was dominated by grasses (mainly, *Lolium multiflorum*), plots 2 and 3 by legumes (mainly, *Medicago sativa*), while plot 4 was mainly dominated by forbs (among all, *Veronica hederifolia*). The comparison of DM yield and chemical composition at the beginning and at the end of the grazing period within each plot revealed significant differences regarding some of the parameters. No statistical differences in live weight and ADG were observed among breeds. ADG during the whole period amounted to 323, 324 and 234 g d^{-1} for Bergamasca, Sopravissana and Merinizzata, respectively.

Keywords. Forage yield – Forage quality – Lamb performance – Average daily gain.

Caractéristiques des prairies de plaine utilisées dans les systèmes de moutons transhumants de la région des Marches (Italie centrale)

Résumé. *Ce travail vise à analyser la production et la composition chimique et botanique des prairies de plaine pour l'évaluation de leur effet sur les performances d'agneaux de trois races (Bergamasca, Sopravissana et Merinizzata) dans la région des Marches. Le troupeau expérimental (brebis et agneaux) a utilisé quatre parcelles différentes en termes de conditions de site, gestion et caractéristiques fourragères. Dans chaque parcelle, la composition botanique a été évaluée en début de pâturage, tandis que la production de fourrages et la composition chimique l'étaient au début et à la fin. Pour calculer le gain moyen quotidien (GMQ), les agneaux de chaque race ont été pondérés à la naissance et tous les 20 jours jusqu'à l'abattage, effectué à 60 jours d'âge. Le terrain 1 a été dominé par des graminées (principalement, Lolium multiflorum), les terrains 2 et 3 par les légumineuses (principalement, Medicago sativa), tandis que le terrain 4 a été principalement dominé par diverses autres plantes herbacées (entre elles, Veronica hederifolia). La comparaison de la production et de la composition chimique au début et à la fin de la période de pâturage à l'intérieur de chaque parcelle a montré des différences significatives pour certains des paramètres. Aucune différence statistique du poids vif et du GMQ n'a été observée parmi les races. Les GMQ durant toute la période étaient de 323, 324 et 234 g* j^{-1} *pour Bergamasca, Sopravissana et Merinizzata, respectivement.*

Mots-clés. *Production fourragère – Qualité du fourrage – Performances comparées des agneaux - Gain moyen quotidien.*

I – Introduction

In Central Italy, lamb production is mainly based on extensive grazing systems (Caballero *et al.*, 2009). Most of the flocks (up to 4000-5000 sheep) graze different grazing blocks throughout the year. During summer time, they use upland pastures and in autumn-winter period sheep are progressively transferred to lowlands. In Marche region itinerant and vertical grazing, continuous stocking and permanent shepherding are common. Lucerne meadows are the main resource used, but the forage balance can include green cereals, crop residues, marginal lands and riverbanks itinerantly grazed (D'Ottavio and Santilocchi, 2014).

Taking the characteristics of the system into account, the study aims to analyse the botanical composition, forage yield and quality of lowland grasslands to evaluate their effect on growth performances of lambs of three breeds (Bergamasca, Sopravissana and Merinizzata) produced for Easter market under the PGI label "Agnello del Centro Italia".

II – Materials and methods

The study was carried out on four plots located at the surrounding of Macerata characterised by clay soils with different morphology, slope and altitude (150-300 m a.s.l.). The climate of the studied area is characterised by mean annual temperature of 13.7°C and mean annual precipitation of 792 mm. The plots were progressively grazed by an experimental flock (ewes and lambs of all the monitored breeds) from mid-February to mid-April 2015. Botanical composition of the grasslands was assessed before grazing, employing the abundance-dominance method by 3 surveys per each plot. Dry matter (DM) yield was estimated on three 1.0 m^2-sampling areas (1.0x1.0 m), randomly chosen on each plot at the beginning and at the end of grazing (Frame, 1981). Pre- and post-grazing herbage samples were dried at 60°C for 48 h and separately analysed to determine: Crude Protein (CP, Kjeldahl method), Ether extract (EE), Crude Fibre (CF, Weende method), NDF (Neutral Detergent Fibre), ADF (Acid Detergent Fibre), ADL (Acid Detergent Lignin) (Van Soest method, according to Martillotti *et al.*, 1987) and Ash. Net Energy for Lactation (NEL) of the herbage samples was assessed according to I.N.R.A. (1980).

Total of 11 male lambs (born as singles) per each breed (Bergamasca, Sopravissana and Merinizzata) was used to assess the growth performances. At birth, all the lambs were weighed and gathered with their mothers into an experimental flock. Individual lamb weights were recorded each 20 days until the slaughter and average daily gain was calculated. Dams had free access to hay and were supplemented by corn grain (0.5 kg DM $head^{-1}$ day^{-1}); lambs were given concentrate (50% corn, 50% barley) *ad libitum* in creep feeders from 20 days of age.

The data analysis was performed by SAS/Studio® software (version 3.4, SAS Institute, Cary, NC, USA). Within each plot, means comparison of DM yield and chemical composition between the beginning and the end of the grazing periods was performed by using t test. The effect of breed on live weight and average daily gain (ADG) was analysed by means of one-way analysis of variance using the GLM procedure.

III – Results and discussion

During 60 days, from mid-February, flock was moved to four different plots for grazing periods which length depended on the forage availability and quality.

1. Botanical composition, DM yield and chemical composition of the grasslands

The used grasslands differ in terms of site conditions, management and forage characteristics (Table 1). In Plot 1-3 they were meadows dominated by different species: in plot 1 by grasses (mainly, *Lolium multiflorum*), while in plots 2 and 3 by legumes (mainly, *Medicago sativa*). Plot 4, a post-harvested field used for a short period just before the sowing of corn, was mainly dominated by forbs (among all, *Veronica hederifolia*).

DM yield of the samples harvested in the plots (Table 2) is comparable with those reported in relevant literature (e.g. Stavarache *et al.*, 2015) and can be attributed to the late winter (plots 1 and 2) or early spring (plot 3) utilisation. The chemical composition of the forage (Table 2) is in accordance with the relevant literature. In particular, the high CP content in plots 2 and 3 (18.8

and 28.1%, respectively) is in accordance with Popovic *et al.* (2001) and can be explained by a high contribution of legumes (81.7 and 87.3%, respectively) at early stages of growth. The levels of CF and fiber fractions reflect the botanical composition of the grasslands and the vegetative stage of the dominant species. Higher values of ash, in particular in plots 2 and 3 (26.1 and 23.1%, respectively), are probably due to high soil pollution of the forage samples caused by rainfall and trampling that occurred at the end of the grazing period. The calculated values of NEL are in line with the forage quality and its good nutritional characteristics

Table 1. Characteristics and botanical composition of the grasslands in the grazed plots (mean % abundance of the most abundant species)

Plot	1	2	3	4
Altitude (m a.s.l.)	190	234	300	148
Exposure	NW	E	NW	S
Slope (%)	1	8	65	1
Grazing beginning (date)	17/2	27/2	18/3	30/3
Vegetation cover (%)	100	97	97	96
Grasses % abundance	71.9	17.1	2.9	12.8
Legumes % abundance	27.5	81.7	87.3	0.0
Forbs % abundance	0.6	1.2	9.9	87.2
Trifolium pratense L.	3.1			
Medicago sativa L.	24.4	80.6	87.3	
Lolium multiflorum Lam.	71.3	15.1	2.1	12.8
Veronica agrestis L.	0.2		8.2	
Fumaria officinalis L.			0.2	7.8
Diplotaxis erucoides (L.) DC.			0.2	3.1
Veronica hederifolia L.				52.6
Senecio vulgaris L.				14.1
Other species	1.0	4.2	2.1	9.6

Table 2. DM yield (t ha^{-1}), chemical composition (% DM) and NEL (MJ kg^{-1} DM) of the plots grasslands at the beginning (B) and at the end (E) of the grazing period

Plot	Grazing period	DM yield	% CP	% EE	% CF	% NDF	% ADF	% ADL	% Ash	NEL
1	B (17/2)	2.69^{A}	13.65	1.88	18.10^{b}	38.16^{b}	28.57^{b}	5.49	15.13	8.08^{a}
	E (27/2)	1.23^{B}	13.74	1.73	21.35^{a}	43.35^{a}	31.42^{a}	6.64	13.44	7.44^{b}
2	B (27/2)	2.88	18.85	1.23	28.31^{a}	48.26^{a}	40.99^{a}	11.10^{a}	14.76	6.09^{b}
	E (18/3)	1.63	20.03	1.37	18.39^{b}	34.68^{b}	30.82^{b}	6.96^{b}	26.15	7.92^{a}
3	B (18/3)	3.51	28.11^{a}	1.81	17.32	33.99	26.25	6.86	12.41	8.28
	E (30/3)	1.73	22.51^{b}	1.28	14.77	29.29	25.88	5.73	23.07	8.68
4	B (30/3)	4.16	10.92	1.91	24.78	47.13	37.71	6.91	15.84	6.74
	E (14/4)	3.84	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Within the plots, superscript letters indicate significant differences: A, B ($p<0.01$), a, b ($p<0.05$); n/a: not assessed.

The comparison of the forage yield and quality at the beginning and at the end of the grazing period within each plot showed significant differences ($P<0.01$) for DM yield (plot 1) and at $P<0.05$ level for CP (plot 3), CF, NDF and ADF (plot 1 and 1), ADL (plot 2) and NEL (plot 1 and 2). As expected, forage DM yield was reduced at the end of grazing of each plot, even though it significantly ($P<0.01$) decreased just for the plot 1 (-54%). Within plot 3, a significant decrease of the CP content was recorded at end of the grazing period, indicating that animals consumed components with higher CP content. In terms of CF and fiber fractions, statistical analysis showed significant differences according to expectation only in the plot 1 where CF, NDF and ADF increased as a result of grazing. The opposing results observed in plot 2 seem to be attributed to vegetative regrowth that occurred at the end of the winter. As expected, NEL is lower after grazing in plot 1, while opposing results were recorded in plot 2 (significant increase) and plot 3, due to lower fiber content at the end of the grazing period.

2. Growth performances of the lambs

Birth and final live weight (LW), as well as average daily gain (ADG) of the lambs of the three breeds are presented in Table 3. No differences in lambs LW and ADG were observed among breeds, although ADG tended to be greater for Merinizzata during the last 20 days of growing period.

Lambs of all the breeds had higher birth weight, as well as LW and ADG than those reported to be the standard breed characteristics by ASSONAPA (2015).

Table 3. Growth performances of Bergamasca, Sopravissana and Merinizzata lambs

	Bergamasca	Sopravissana	Merinizzata	SEM	P
Live Weight (kg)					
Birth	6.30	5.90	5.50	0.18	0.1939
20 days	13.32	12.70	11.80	0.37	0.2689
40 days	19.47	18.55	16.91	0.61	0.2279
60 days	26.07	25.22	24.71	0.71	0.7508
Average Daily Gain (g d^{-1})					
0-20 days	336	366	345	13.06	0.6523
20-40 days	293	292	255	14.76	0.5025
40-60 days	314	318	371	12.34	0.0977
0-60 days	323	324	324	10.36	0.9997

SEM: standard error of the mean; P: probability of the differences.

IV – Conclusions

The present study demonstrates that the system adopted in Marche region, in which the most diverse grasslands, in terms of botanical composition and availability of high quality forage, are used, allowing the production of the lambs of different breeds with high growth performances.

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The multifunctional pastoral systems in the Mediterranean EU and impact on the workforce

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Abstract. Pastoralism constitutes a multifunctional system of animal production; the system is endowed with a range of values, which, nonetheless, are not captured in the prices of products. Indeed, pastoralism protects rural livelihoods – especially in marginal and remote areas which, in the absence of inhabitants, would become abandoned or nurturing illegal activities –, is endowed with important cultural features, produces high-quality dairy products and plays an irreplaceable role in preserving and maintaining ecosystem functioning. An important function of the system lays in the provision of income and employment to communities inhabiting mountainous or remote areas, for whom productive opportunities are limited. The purpose of this study is to present the main functions of pastoralism, alongside with the main pre-conditions for the protection and development of its various forms in the Mediterranean (transhumance, island animal production, grassland-based livestock farming). The study focuses on necessary political, social and regulatory adjustments to formulate a favorable operational environment, which should accommodate its unique multifunctional features and differentiate it from conventional intensive or semi-extensive systems. The discussion is extended to the role of immigrant farm workers in the reproduction of pastoralism.

Keywords. Extensive livestock farming – Externalities – Rural development policy.

La multifonctionnalité des systèmes pastoraux dans l'UE méditerranéenne et l'impact sur la main-d'œuvre

Résumé. *Le pastoralisme constitue un système multifonctionnel de production animale; le système est doté d'une plage de valeurs, qui, néanmoins, ne sont pas prises en compte dans les prix des produits. En effet, le pastoralisme protège les moyens de subsistance ruraux – en particulier dans les zones marginales et isolées qui, en l'absence d'habitants, deviendraient des secteurs abandonnés ou entretiendraient des activités illégales –, est doté de caractéristiques culturelles importantes, crée des produits laitiers de haute qualité et joue un rôle environnemental irremplaçable. Une fonction importante du système réside dans la fourniture de revenus et d'emplois pour les populations ayant un accès limité à d'autres ressources dans les zones montagneuses ou éloignées, en particulier pour les jeunes "victimes" de la crise économique à la recherche d'un emploi. Le but de cette étude est de présenter les principales fonctions du pastoralisme, à côté des principales conditions préalables pour la protection et le développement de ses diverses formes dans la Méditerranée (transhumance, production animale de l'île, élevage basé sur les prairies). L'étude se concentre sur les ajustements politiques, sociaux et réglementaires nécessaires pour formuler un environnement opérationnel favorable, qui devrait accueillir ses caractéristiques multifonctionnelles uniques et le différencier des systèmes intensifs ou semi-extensifs classiques. La discussion est élargie au rôle des ouvriers agricoles immigrés dans la reproduction temporelle du pastoralisme.*

Mots-clés. Production animale extensive – Externalités – Politique de développement rural.

I – Introduction

The debate concerning the benefits and disadvantages of extensive and intensive animal production systems has been ongoing and is now highly relevant in Southern Europe, as it not only concerns food production, but also relates to environmental, climate change as well as socio-cultural dimensions. Indeed, the shift of consumer preferences towards quality, healthy and safe food products, awareness of animal welfare, genetic diversity, biodiversity and environmental issues, the acknowledgement of increasingly tight links between food and territory by the public, interest in culture and tradition and the inter-temporal support of the European Model of Agriculture constitute only a few of the paradigms comprising the “big picture” in the primary sector. This seems especially true for livestock products and extensive systems, which are endowed with unique features enabling them to come up to these expectations. Pastoralism constitutes a particular category of extensive livestock production, manifesting itself through a broad range of systems throughout Europe. Especially in the Mediterranean, pastoralism plays numerous roles which shape its multifunctionality. Multifunctionality is defined as the entire range of environmental, social and economic functions of the primary sector, as, in addition to tradable goods (food and fibre), agriculture produces a range of non-market outputs (OECD, 2001). These outflows are externalities, positive or negative, and fall into three categories (Lankoski and Ollikainen, 2003), depending on whether they affect the environment, rural development (rural viability) and food safety.

The purpose of this study is to present the formidable functions of pastoralism, alongside with the main socio-political adjustments and regulations necessary to recognize the diversity of its societal contributions and to accommodate this multifunctional role. An integral part of the discussion concerns the potential contribution of pastoralism in the provision of employment to youths in countries suffering financial crisis and the – rival or complementary – role of family and hired labour in these farms, mainly considering that the latter is supplied by immigrants.

II – Materials and methods

In order to examine the multifunctional character of pastoral systems, it is necessary to briefly present the current regulatory framework within which pastoralism in Europe operates and its part in the larger picture of the Common Agriculture Policy (CAP). Following the previous financial support schemes (Reg. EC/1782/2003 and EC/73/2009) income support for the EU primary sector is now regulated by Reg. EC/1307/2013. Except for a particular reference to extensive grazing systems, the new support schemes do not make actual distinctions between intensive and extensive livestock farming, implying that they have the same needs to be addressed by legislative acts. Rural development/Second pillar policies (Reg. EC/1305/2013), much the same, target livestock farmers as a homogenous group; pastoral farmers are eligible for financial support for modernizing their farms or for counterbalancing losses from natural handicaps and/or for the introduction of environmental-friendly measures, but structural and system-specific problems are not addressed or are disregarded. Out of a number of declarations and slogans addressing a ‘smart, sustainable and inclusive’ growth and an agricultural sector aiming at 'not only delivering high quality food but also helping to manage environment and fight climate change' (EC, 2010), the reality is that the recent reform of the CAP has provided little improvements – if any – to extensive livestock systems. Pastoral farmers seem excluded from the decision-making process (Koblenz Declaration, 2015); they face increasing difficulties in maintaining their multifunctional production system, and they are rather directed towards intensification and the adoption of a different production pattern which is, nonetheless, not always compatible with their culture, values and lifestyles. In addition, they are subject to particular strict regulatory constraints: sanitary barriers, food safety rules, etc.

III – Results and discussion

The agricultural cultural heritage of pastoralism and the heterogeneity of its socio-cultural contributions is one of its multifunctional features that characterize pastoral territories up to now: music and dances, habits and customs, traditions and norms, natural and man-made landscapes. Flock and farm family mobilities also involve the dispersion of cultural elements among territories. The reproduction of pastoral farms essentially involves passing not only the farm to future generations but also the whole range of cultural and traditional aspects characterizing the life of pastoralists and the operation of their farms.

The socio-economic role of pastoralism is of utmost importance. Especially in EU Less Favoured Areas, where economic activity is not adequately diversified, pastoralism provides employment and income and sometimes it is the sole economic activity. Even in mountainous communities, in which other sectors have emerged – such as tourism and manufacturing – pastoralism is still an important source of income and has induced a form of development "from within", based on inherent regional advantages and cultural features. Therefore, pastoralism supplies all sectors of the economy (primary, secondary, tertiary) through positive multiplicative effects. In addition, pastoralism protects rural livelihoods, especially of marginal and remote areas which, in the absence of inhabitants, would become abandoned, encroached by wild species and animals and thus inaccessible to humans, or areas nurturing illegal activities.

In this context, the systematic production and marketing of pastoral dairy products is a potentially profitable economic activity, as these products often have extremely high quality characteristics. However, conventional marketing channels and methods are suitable for industrial mass production but not ideal for these products. Reg EC/1305/2013 favours short supply chains linking territorial actors with pastoral farmers, thus generating added value for local actors. Note that traditional cheese-making methods are cultural heritage and their certification could contribute to the improvement of the marketing of pastoral quality products.

The environmental functions of pastoralism are two-fold. First, flocks play an essential role in the management of natural rangelands, especially the mountainous ones, thus contributing to the protection of biodiversity and to the natural renewal of vegetation and providing a most effective way to store CO_2 and therefore support climate change mitigation measures (McGahey *et al*., 2014). Third, by rearing autochthonous animal breeds, pastoral farmers contribute to the protection of genetic diversity in the European continent, which constitutes a major challenge for sustainability, food security, human nutrition and rural development (FAO, 2007).

The multifunctional character of pastoralism stems from its particularities in the use of resources. Pastoralism is tightly linked to and highly dependent on land uses, more than every other system of livestock farming. The operation of pastoral systems depends on the successful management of rangelands, as they base animal nutrition on grazing. This dependence presupposes a fair system of land allocation, among alternative uses and among pastoralists. However, this is seldom the case, as several activities are now rival to pastoralism (protected areas, alternative energy sources, intensive crop production, tourism, etc.) thus altering a land allocation system – empirical or official – in use for centuries. Hence, pastoralists are deprived of their land and even from access to it, when alternative land uses hinder the mobility of flocks – for instance, passing through lowland cropland is necessary for transhumant farmers to reach their summer domiciles. The alteration of the competitive relationships between intensive and extensive land uses also impacts adversely the production of forage – used to supplement grazing animals -, as farmers turn to crops with higher profitability.

Considering labor, highly skilled specialized labor is more and more substituted by unskilled employment, following a generalized world-wide trend. However, a job as a pastoral farmer requires many skills: a very extensive practical background, knowledge of climate, natural resources, new technologies, herd management and manufacturing as well as a clear understanding of economic operations and market conditions. In Mediterranean countries, as France (4) and Spain (5), schools addressing the training needs of herders and shepherds have been established with interesting degrees of success. The availability of such high specialized labor is not always a given, as it is less remunerated under the current conditions; so, even though pastoral families have elaborated an effective way of farm reproduction through time, there have been times in history, including this one, that younger family members leave farms. This phenomenon and the related generational gap that pastoral territories are facing is much the outcome of recent political and commercial dynamics that have restructured the livestock sector throughout the EU; this has brought major changes in the size of the flocks and the nature of labor. The growing presence of wage labor signals the loss of a workforce generated through family relations and the fact that the overwhelming majority of these workers are foreign immigrants indicates that, with the current wages, it remains difficult to find local workforce.

Pastoral systems are less dependent on capital. The use of purchased feedstuff is substituted by grazing and fixed capital requirements are relatively low, as milking machines are not very usual and modern buildings are not needed. Rearing autochthonous breeds also constitutes an advantage as these animals are not costly and are characterized by high adaptability and remarkable endurance. This low dependence on capital is the main asset of pastoral systems shaping their resilience over time and explaining their resilience under harsh socio political and economic conditions (Davies and Nori, 2008).

IV – Conclusions

The characteristics of pastoralism outlined in this paper partially determine the cost effectiveness and competitiveness of the system. It can be supported that pastoralism can further improve its position in the market economy and provide income and employment to mountainous and disadvantaged areas through appropriate structural interventions. Political, social and regulatory adjustments are necessary to formulate a favourable operational environment, which should accommodate the unique multifunctional features of pastoralism and differentiate it from conventional systems. The most important prerequisite is to incorporate particular adjustments in the EU legislation; it cannot be expected that the restrictions imposed to intensive systems can be equally applied on pastoral systems. Also, particular arrangements should be made in land uses: access to mountainous rangelands should be enabled by designating routes for flocks and these areas should be protected against competitive uses (e.g. environmental protection areas, alternative energy establishments etc). The systematic production of dairy products at the farm level could be supported through the introduction of a simpler bureaucratic system and the products from pastoral farms could be circulated through alternative and innovative marketing channels and short supply chains, with the participation of local actors (hotels, restaurants, retailers), in order to reach consumers willing to pay higher prices for high quality. When it comes to education and information, “pastoral schools” would be very important for the temporal continuation of the system, as they would be in charge not only of the provision of technical knowledge but also of the transfer of traditional practical knowledge. In this aspect, EU legislation provides incentives for the communication between producer groups throughout Europe in order to disseminate good practices.

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The legislative framework of environmental impact assessments for establishment of ski resorts in mountainous areas

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Abstract. A strategy for the sustainable development of mountainous areas necessarily involves the development of the natural environment. Any intervention in the natural environment has to comply with the basic established principles of forestry and environmental law (sustainable management of forests).The absence of a comprehensive legal framework in Greece, which would describe with clarity, sufficient detail and accuracy the technical specifications for developing environmental impact assessments (EIA) lead researchers to form general conclusions according to the environmental compatibility of projects. Therefore, the improvement of legislation with objective, scientific criteria to be taken into account by researchers carrying out environmental impact assessments is essential. The aim of the present study is the examination and evaluation of the objectivity, coherence and completeness of the legal framework of developing environmental impact assessments for establishment of ski resorts in mountain grasslands in comparison with European standards.

Keywords. Environmental impact assessments (EIA) – Ski resorts – Mountain grasslands.

Le cadre juridique de l'évaluation d'impact environnemental (EIE) à propos de l'installation de centres de ski dans des régions montagneuses

Résumé. *Le développement durable généralisé/total des zones forestières montagneuses et semi-montagneuses présuppose additionnellement l'exploitation simultanée de leur environnement naturel. Cependant, n'importe quelle intervention sur l'environnement naturel devrait être conduite sur la base des principes institués fondamentaux de la Sylviculture et de la Loi de l'environnement (gestion durable des forêts). Le manque d'un cadre juridique décrivant avec clarté, exactitude et en détail les spécifications techniques de la réalisation de l'évaluation d'impact environnemental (EIE) conduisent les chercheurs à la formulation de conclusions accumulées et généralisées à propos de la compatibilité environnementale d'un projet de construction/d'un chantier. L'enrichissement de la législation avec des critères objectifs et scientifiques sur la réalisation de l'évaluation d'impact environnemental devient nécessaire. Le but de l'étude est la recherche et l'évaluation de l'objectivité - plénitude du cadre juridique de la réalisation de l'évaluation d'impact environnemental à propos de l'installation de centres de ski sur des pâturages montagneux en comparaison avec les normes européennes.*

Mots-clés. *Évaluation d'impact environnemental (EIE) - Centres de ski - Pâturages montagneux*

I – Introduction

The subject of this study is the presentation of the current legislative framework in Greece regarding the development of environmental impact studies for establishment of ski resorts in mountain grasslands, the identification of its deficiencies and the determination of the scientific environmental criteria, which need to be taken into consideration by researchers. A comparative overview of the Swiss model was considered essential for the determination of specific and not general environmental criteria. The Swiss model was specifically chosen, because Switzerland, as a country out of the European Union, is not bound by the legislative framework of EIA regulated by the Council Directive 2011/92, which is common for all Member States.

II – Materials and methods

The protection against the alterations caused to the natural environment by the establishment of ski resorts in mountain grasslands is regulated by a) land planning legislation, b) environmental law and c) forest protection law.

1. Land planning legislation

Spatial planning necessarily precedes any development of a significant work/activity, in order to avoid uncoordinated development which would lead to environmental degradation, destruction and to undermining of rational land planning (Ste, Full court, 3396/2010 NOMOS Legal Database). Therefore, spatial plans must delimit a priori the areas where ski runs and all essential facilities for the operation of ski centers may be constructed (Papapetropoulos, 2002).

The establishment of ski resorts and the construction of accompanying facilities take place in an area called Area of Integrated Touristic Development. These specific areas are described precisely by the art. 29 of Law 2545/1997 on industrial and investment areas (as amended and supplemented by Law 4179/2013) and they are mandatorily subject to spatial planning (Ste, Full court, 3396/2010 and 3397/2010 NOMOS Legal Database). The Areas of Integrated Touristic Development are now incorporated in the specific spatial plan for tourism (art. 8 of Law 4269/2014). This particularly means that they are now subject to the primary land planning, they are parts of the overall comprehensive spatial planning of the country and that the important lack of the previous legislation has been covered (Giannakourou, 2015). However, the new specific spatial plan for tourism foresees many exceptions in its environmentally friendly regulations and this means that the protection of the environment is again being sacrificed on the altar of economic development (Mathioudakis, 2013).

2. Environmental law

According to the Greek environmental law, certain types of projects have significant effects on the environment and, as a rule, they should be subject to systematic assessment. Projects followed by significant environmental implications, such as the establishment of ski resorts, belong to the first category of projects and they are mandatorily subject to an environmental impact assessment, which imposes specific conditions and limitations aimed at the protection of the environment (art. 3 part. 1 of Law 1650/1986 on environmental protection, as amended by the Law 4014/2011). The EIA needs furthermore to be approved by the Minister of Environment, Energy and Climate Change (art. 4 of Law 1650/1986, as amended by the provisions 2 – 10 of the Law 4014/2011).

3. Forest protection law

Grasslands with specific features can be characterized as forest areas and they may also benefit from the protective provisions of Law 998/1979 on forest protection. According to art. 3 par. 3 of Law 998/1979, as amended by the Law 4280/2014, grasslands enclosed by forests or forest areas are considered as forest and forest areas respectively.

4. Evaluation of the Greek legal framework of EIA in comparison to the Swiss model

The aforesaid decisions of the Minister of Environment, Energy and Climate Change which grant or refuse development consent, are subject to judicial review. The Greek Council of State is required to examine if EIAs review and evaluate on the basis of environmental criteria all alternative solutions of the establishment of the project (involving the zero solution) and if they ultimately select the low-environmental - cost solution (Ste 551/2015 and Ste 1492/2013 NOMOS Legal Database). It is noteworthy that the Greek Council of State (STE) appears in the last years very hesitant about the annulment of those decisions. Straight evaluation of EIAs as well as their opposition to the principle of sustainable development, as pointed out by the Greek Council of State, are excluded from the Court' s limits of control (Ste 4491/2009 ,Ste 613/2002,Ste 3478/2000 NOMOS Legal Database). This is a usual manoeuvre of Greek Council of State anchored in its inviolable limits of control. The judge of the Council of State is not competent to examine if the facts presented in an EIA respond to reality. The evaluation of facts is only exhausted at an administrative level. In particular, if the environmental compatibility of a project/activity is concluded from an EIA or from opinions of the competent authorities, Greek Council of State dismisses applications for annulment of approval decisions of development consents, even if they foresee complementary measures aimed at the restoration of the provoked environmental damage (Ste 1492/2013, notes Mathioudakis).

The attitude of the Greek Council of State is undoubtedly encouraged by the absence of precise, analytical, identified and concrete environmental criteria, which should be taken into consideration by the EIA developer. From a scientific perspective, the EIAs are developed on the basis of descriptive criteria and therefore they involve the risk of presentation of environmental criteria without objectivity. The primary, immediately noticeable and measurable effects are detected by the EIA developer. However, there are also negative spill - over effects, which are not easily noticeable or measurable and as a result not assessed (Doukas, 2004).

For these particular reasons, practicable and objective assessment methods of environmental impacts have to be established, in order to define the accurate position of the construction of the project, which ensures its environmental compatibility (Becker, 1995; Giannoulas *et.al*., 2004). At this point, the contribution of a forest expert is crucial. A forest expert, who is responsible for the natural environment, has to examine before the construction of the foreseen project if there is an environmentally compatible area available and provide the relevant instructions. (Drosos *et.al*, 2014). Moreover, the implications of the implementation not only of an individual, but of a whole development project have to be assessed by the EIA as an environmental cost *(*Giannoulas *et.al*, 2007).

The proper evaluation of the environmental impacts of the establishment of ski resorts in mountain areas prerequisites the objective answer to a number of specific questions by the researcher. Common questions, proposed by the canton of Berne (Koordinationsstelle für Umweltschutz des Kantons Bern, Hilfsmittel für Untersuchungen zur Umweltverträglichkeit von Anlagen, 1991) refer to the following issues: a) purpose of the project, b) features of the installation and geological conformation, c) operational concept and number of visitors foreseen and d) works during construction phase. From this point of view and according to the Swiss model, the establishment of ski resorts in mountain areas, often arises conflicts regarding a) soil and green cover, b) corrosion, snowslides, c) landscape and recreation, d) fauna, e) agriculture and forestry and f) traffic.

III – Results and conclusions

Due to the fact that the legislative framework of the development of touristic ski resorts in mountainous areas is governed by three different pillars (land planning law, environment law and forest law), it is not integrated, coherent and complete and as a result the protection of the environment turns out to be insufficient. A prerequisite for the sustainable tourist development of mountain areas is to take into account the carrying capacity of mountain areas as sensitive ecosystems. For this reason, a rational spatial planning based on sustainable development appears to be determinative (Papapetropoulos, 2002).

As far as environmental law is concerned, the terms "environmental criteria" and "low environmental cost" have to be redefined and specified. Ministerial decisions should therefore target more safe, analytical and accurate environmental criteria, similar to those implemented in Switzerland. In this context, it is noteworthy that the new Council Directive 2014/52 amends the provisions regarding the criteria of environmental licensing of Council Directive 2011/92. The criteria become more specific, precise, qualitative - instead of descriptive -, objective and resistant to violations (Schmidt *et al.*, 2014). Moreover, the decisions which grant or refuse development consent should not be issued by the Minister of Environment, Energy and Climate Change, who serves the political interests of the government in force, but by an independent expert authority, which guarantees objectivity and impartiality.

It follows from the above that the establishment of ski resorts is connected with two conflicting interests: economical growth and protection of the environment. The balance of these interests involves the examination of alternative solutions. If any project changes can't avoid important and disproportionate damage to the environment, the project must inevitably not be implemented (Bütler, 2010).

Acknowledgments

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Pastures valorisation: Tools and effects

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Abstract. Pastures in Greece, as a public good, contributed through the ages to the development of efficient small ruminants farming systems and the formation and preservation of the local ecosystems. The shift of this type of livestock farming towards specialization in milk production was based on the abundant use of concentrate feedstuff. This increased milk productivity also contributed to the degradation of traditional pastures. The new Common Agricultural Policy period raises again the importance of pastoral resources. In this paper the methodological chain (advanced technological tools – innovated methods) that we have developed in order to response to the issues of land pastures' degradation and management are presented. The results of a research in the Region of Thessaly demonstrated that pastures renovation should be based both in the involvement of all stakeholders, as well as on the use of modern technology which will contribute to rational valorisation. Improving grazing capacity of pastureland helps to increase farm productivity and improve farm income through reducing animal feeding costs and adding value through an environmental friendly system of production. The existence of a favourable political framework and appropriate tools provides guarantees to the local rural communities for negotiate and decide the appropriate management of their pastureland aimed their sustainability.

Keywords: Pastures – Valorisation - Region of Thessaly - Technological tools.

La valorisation des pâturages: Outils et effets

Résumé. *Les pâturages en Grèce, comme bien public, ont contribué à travers le temps au développement de systèmes efficaces de petits ruminants et à la formation et la préservation des écosystèmes locaux. Le changement de l'orientation d'élevage vers la spécialisation de la production de lait a été basé sur l'utilisation abondante de nourritures concentrées. Cette augmentation de la productivité de lait a aussi contribué à la dégradation des pâturages traditionnels. La nouvelle période de la Politique Agricole Commune soulève à nouveau l'importance des ressources pastorales. Dans cet article, il est présenté la chaîne méthodologique (outils technologiques avancés - méthodes innovantes) que nous avons développée visant à répondre aux questions de dégradation et de gestion des pâturages. Les résultats d'un projet de recherche dans la région de Thessalie ont démontré que la rénovation des pâturages devrait être basée à la fois sur l'implication de toutes les parties prenantes, ainsi que sur l'utilisation de la technologie moderne qui contribuera à leur valorisation rationnelle. L'amélioration de la capacité d'un pâturage contribue à augmenter la productivité agricole et à améliorer les revenus agricoles en réduisant les coûts de la nourriture, mais en ajoutant aussi de la valeur à travers un système respectueux de l'environnement. L'existence d'un cadre politique favorable et d'outils appropriés fournissent des garanties aux communautés rurales locales pour négocier et prendre la décision concernant la gestion de leurs pâturages visant à leur durabilité.*

Mots-clés. *Pâturages – Valorisation – Région de Thessalie – Outils technologiques.*

I – Overview of current situation

Pastoral land in Greece, as a common good, contributed, through rational management, to the development of an efficient extensive livestock farming sector through the ages (Gidarakou and Apostolopoulos, 1995). The rich and varied flora of pastures contributed, and still does, to covering the nutritional requirements of animals and formulated the composition of high natural value ecosystems (Dover *et al.*, 2011). Although at country level pastoral land corresponds to about half (47.9%) of the Utilized Agricultural Area (UAA), lack of proper management and the absence of any intervention to reverse degradation, contribute to reducing their productivity in both volume and quality of biomass, hence their failure to sustainably support self-sufficiency in livestock feeding (Hadjigeorgiou, 2011; Goussios *et al.*, 2014).

The public ownership character and the widespread adoption of a high productivity model in animal husbandry, as it was in other sectors of Greek agriculture in recent decades, resulted in replacing this resource with harvested feedstuff in animal nutrition (Hadjigeorgiou, 2011). The abandonment and the non-proper use of this resource contributed to its deterioration (quantitative and qualitative) and thus the diminution of its contribution to livestock production. At the same time, changes in land use of large areas in the lowlands from pastoral to arable farming and the absence of an official grazing land registry (grazing areas are not delimited relative to forestry areas) prevent the application of effective long-term management actions and often discourage establishment of new livestock farmers (Hadjigeorgiou *et al.*, 2002; Goussios *et al.,* 2014).

The rational management of those lands, in order to protect the landscape as well as the environment is of high priority and constitutes the means to obtain the balance between environmental concerns and farming. Rational and planed grazing contributes positively to maintain the established characteristics of these lands, functioning as a management tool and acting favourably in maintaining protected and endangered species (Hadjigeorgiou, 2011). It is now well documented that pastures in Greece are home to thousands of flora and fauna species, which are rings of a complex food chain. Grazing affects positively vegetation and plant species diversity, and in particular the "mosaic" of the landscape (Goussios *et al.,* 2014). In Mediterranean areas, grazing maintains the desired balance of vegetation and prevents invasion and dominance of some/several woody species, leading to the "green desert", thus achieving the conservation and protection of rare and endangered habitat types; also it functions as a tool to remove the flammable material from the understory of forests thus preventing wildfires.

This paper aims to present the methodological chain applied in the Region of Thessaly, Greece (Fig. 1) to resolve degradation and management issues of pastoral lands. Innovative approaches together with modern technology tools (GIS, satellite data, 3D-representation) as well as techniques-methods of pasture improvement were applied in order to: (a) facilitate the participation procedure in pastures' management, (b) raise the pastures' productivity.

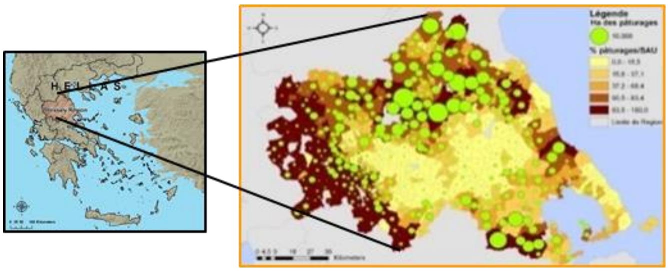

Fig. 1. Map of Greece showing the location of the Region of Thessaly and on the enlarged part the position and size (ha) of pastoral land.

II – Tools to confront the problem

The dominance of extensive and semi-extensive livestock farming in the Region of Thessaly, with significant presence of semi-nomadic farming, helps to preserve the extensive nature of the activity and relies heavily on abundant pastoral resources (Goussios *et al.,* 2014). In order to increase the productivity of these areas and improve the nutritional condition of extensive flocks, especially of sheep and goats, pilot interventions for pasture rehabilitation were undertaken.

Utilizing the innovation action to organize the dairy sector in Thessaly (the LACTIMED research program), the research cooperation of the University of Thessaly, the Agricultural University of Athens and the local authorities was established to reverse the degradation of pastures (Fig. 2). Pilot projects were run in Thessaly and specifically in the Municipality of Sofades aiming: (i) to increase nutritional and economic value of herbage biomass, that can be produced at low cost, by introducing selected forage plants, (ii) to increase the productivity of pastures as well as that of grazing animals. The choice of the selected legume forage plants was based on the abiotic characteristics of the micro-area and on the plants' capacity to react positively to management interventions. Challenging abiotic characteristics considered include: low winter temperatures, long drought periods and high summer temperatures, low fertility and productivity of soils, increased soil salinity etc. Researchers, local authorities' executives and farmers contributed to the monitoring and management of the pilot projects.

Fig. 2. Diagram of the research cooperation project in Thessaly - Visual presentation of the results.

III – Results and discussion

This pilot project brought results at: (a) *the technical level*: based on the analyses of herbage biomass and soils, the nutritional composition of plant biomass and of soil productivity increased twice or three-fold depending on the site; b) *the organizational level*: based on the results at the technical level (biomass volume, soil productivity) it was understood by farmers and by the municipality that is necessary: (i) the formulation of a pasture's management plan in order to pasturelands becoming productive and contributing to animal nutrition and productivity, as well as (ii) the cooperation between breeders and Municipal authorities to implement the management plan; and (c) *the technological tools* which were elaborated in this aspect and were of two types:

1. Participation Tools

With a view to increase participation into land management a methodological chain was developed, in order to allow the various groups operating in the area to gradually describe their relevant actions and practices, to formulate their own strategies and socio-economic objectives, and finally to really/actively involve with researchers in the process of understanding and processing a spatial development program. The success of the above methodology is based on the realistic depiction of the landscape, achieved with digital three-dimensional maps, the virtual flight tool and the integration of other technological tools comprising of geographic information systems (GIS) and remote sensing (using aerial and satellite images). Thus, virtual flight tool (3D-GIS) is a 3D interactive representation of case study area. This tool gives the ability of the 3D realistic representations and movements over the virtual world. The steps of creation of this methodological chain are (Faraslis, 2012):

- creation of the basic three-dimensional digital background,
- enrichment of the background using information by local residents,
- spatial processing and control of the collected qualitative - quantitative information,

- presentation of the current situation of the study area through 3-dimensional “virtual worlds”,
- creation of scenarios-proposals through the construction, presentation and evaluation of "virtual worlds".

The above methodology creates/generates an interactive tool that offers the possibility of a "common language" between researchers and residents/local actors in the region, strengthening dialogue, easing contradictions/conflicts and leading to consensus on effective remedies (Faraslis and Perakis, 2008).

2. Tools to manage pastures

For the efficient management of pastures a specific methodology was developed using geoinformatics technological tools such as remote sensing, pattern recognition and geographical information systems. In particular, to record the current state of pastoral lands (grazing capacity) and to monitor their evolution, the following were used: (i) Satellite data at different wavelengths and at successive time periods, and (ii) High resolution aerial images taken by Unmanned Flight Vehicles (UAV). This methodology involves the combination of field studies with image processing techniques (classifications-automatic image analysis techniques). Spectral signatures of the different vegetation types are connected, as they are associated on the multispectral images after the corresponding field measurements. Thus, the development of a tracking model of the amount of biomass according to the characteristics of pastures is made. Final products are maps of grazing capacity of the study area readily usable by stakeholders.

IV – Conclusions

In the new CAP programming period 2014-2020 the management and improvement of pasturelands across the country has been foreseen. At the same time, local authorities of the Thessaly Region have declared intention to undertake rational pasture management, in order to support livestock farming and to strengthen the connection of the product to the territory. The pastures’ valorisation is based on the involvement of all local stakeholders (local authority (owner), farmer (user), etc.) in their use and management with the use of technological and organizational tools. This contributes to their rational valorisation and conservation –enrichment of biodiversity of natural pastoral resources. Therefore, this contributes to the increase of productivity, the reduction of production’ costs and finally the maintenance of extensive farming.

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Internet promotion of agroforestry networks within regional development planning

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Abstract. Agroforestry is the combination of trees, crops and livestock on the same area and it applies to all agricultural systems. Agroforestry activities can have a positive socio-economic impact to regional sustainable development and planning, especially in the Mediterranean where it constitutes a traditional practice. Internet promotion can play a critical role in planning strategies for regional development. The aim of this paper is to identify and retrieve Internet websites that promote agroforestry issues and to study their content characteristics. Additionally we propose a model website structure with a user-friendly environment aiming to promote agroforestry for Mediterranean areas supporting all the necessary information concerning socio-economic benefits. Through the proposed website structure, local populations can be motivated as to the preservation of agroforest ecosystems and their services and contribute to local socio-economic activities.

Keywords. Agroforest ecosystems – Regional Development – Sustainable development – Internet – Website.

La promotion via l'Internet des réseaux d'agroforesterie dans la planification du développement régional

Résumé. *L'agroforesterie est la combinaison entre les arbres, les cultures agricoles et le bétail sur la même zone de terre et peut être appliquée à tous les systèmes. Les activités agroforestières peuvent avoir un impact socio-économique positif sur le développement régional durable et la planification, particulièrement dans la Méditerranée où elles constituent une pratique traditionnelle. L'Internet et la promotion via l'Internet peuvent jouer un rôle essentiel dans la stratégie en ce qui concerne la perspective du développement régional. L'objectif de cet article est d'isoler et de récupérer dans les sites Internet des sujets relatifs à l'agroforesterie et d'étudier les caractéristiques de leur contenu. En plus nous proposons un modèle structurel pour un site dans un environnement convivial qui vise à promouvoir l'agroforesterie pour les zones méditerranéennes apportant toutes les informations nécessaires concernant les avantages socio-économiques. Grâce à la structure du site proposé, la population locale peut être motivée pour la préservation des écosystèmes agroforestiers et de leurs services et pour contribuer à des activités locales socio-économiques.*

Mots-clés*. Écosystèmes agroforestiers – Développement régional – Développement durable – Internet – Site web.*

I – Introduction

Agroforestry systems are traditional land use practices that can be found both in Greece and around the world. In Greece they can be found throughout the country and are considered as an integral part of the rural landscape (ICRAF, 2011).

Information and Communication Technologies play a fundamental role in environmental protection, sustainability, education as well as in rural sustainable development (Andreopoulou, 2013); Furthermore, Internet, digital, online services and innovative applications can be used as means to achieve regional sustainable development. A business website can become a storefront and if is operated can attract and retain customers (Andreopoulou *et al.*, 2013).

The aim of this paper was to identify websites of agroforestry networks, to study their characteristics and to propose a regional website aiming to promote agroforestry in Northern Greece supporting all the necessary information.

II – Materials and methods

Internet research was done to identify websites with information on agroforestry ecosystems and networks that promote activities related to agroforestry. An online survey was conducted using "Google", which provides acceptable results in comparison with other engines (Langville and Meyer, 2006). The retrieved websites were studied (characteristics - services) (Table 1).

Table 1. Description of characteristics and services studied in research

Characteristic/ Service	Description	Characteristic/ Service	Description
A1	Appearance (Badre, 2002)	A10	Browser Consistency (Ginige & Murugesan, 2001)
A2	Content (Karvonen, 2000)	A11	Effective Navigation (Ginige & Murugesan, 2001)
A3	Functionality (Duyne *et al.*, 2002)	A12	Good Error Handling (Nielsen, 1999)
A4	Website Usability (Duyne *et al.*, 2002)	A13	Usable Forms (Nielsen, 1999)
A5	Mobile Compatibility (Brinck *et al.*, 2001).	A14	Original, Fresh Content (Nielsen, 1999
A6	Accessible to All Users (Brinck *et al.*, 2001)	A15	Target Audience (Nielsen and Loranger, 2006)
A7	Well Planed Information Architecture (Karvonen, 2000)	A16	Tracking (Nielsen and Loranger, 2006)
A8	Well – informed/Easy to Scan Content (Karvonen, 2000)	A17	Get on Board With Social Media
A9	Fast Load Times (Ginige and Murugesan, 2001)	A18	Unique (Kelly, 2000)

The following webpages studied: Greek Agroforestry Network (W1), European Agroforestry Federation (W2), AWAF (W3), REBRAF (W4), AGFORWARD (W5), Otway Agroforestry Network (W6), Center of International Forestry Research (W7), Agroforestry Research Trust (W8), World Agroforestry Center (W9) and Anafe (W10). Nonetheless a 2-dimentional Table was developed (Table 2).

Further, a model website structure developed of regional interest aiming to promote agroforestry in N. Greece. The proposed website will support information for training purposes and as a reference for environmental issues. Through the website users will be informed of agroforestry ecosystems in N. Greece, there will be career opportunities and integration programs in agroforestry unit network and information related to agroforestry ecosystems.

III – Results and discussion

Many websites were retrieved in Internet concerning agroforestry. The 10 most visited websites were selected. In Table 2 the characteristics and services they provide are presented.

The proposed page is easy to use that allows navigating back and forth as it relies on the graphics and the text. Its use is web-friendly and the in-depth knowledge of informatics is not necessary, so that can be used from anyone, and is taking into account people with disabilities in reading (can listen the structure and the parts by opening each page of the website). Also, the opportunity to share the content through social media is given. The site consists of a fixed part (logo - name of the web site) and just below a variable part in which portrayed keywords that separate categories and open sections exists (Fig.1). More specifically, modules begin with the following: Home – News – Media – Events – Projects – Links – Forum – Contact - Sign

On the topside, at the left, there are 3 buttons that allow users to hear the content of each page and to enlarge/minimize letters. On the left side and under the portable part there are two bottoms: “career offers” and “volunteers”. While on the right side the flags of Greece and UK can change the language. After each article a palette is appearing; through that users can share the content of pages to common social media networks.

Table 2. Description of websites concerning characteristics and services

	Characteristics & services																	
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18
W1	*	*	*	*			*	*	*	*	*		*		*	*		*
W2	*	*	*	*			*	*	*	*	*	*	*	*	*	*		*
W3		*	*						*	*				*		*		
W4									*	*						*		
W5	*	*	*	*			*	*	*	*	*	*	*	*	*			*
W6	*	*	*	*			*	*	*	*	*	*	*	*	*			*
W7	*	*	*	*			*	*	*	*	*	*	*	*	*	*	*	*
W8		*	*						*	*				*		*		
W9	*	*	*	*			*	*	*	*	*	*	*	*	*	*	*	*
W10	*	*	*	*			*	*	*	*	*	*	*	*	*	*		*

Also, at the bottom part there is a fixed part with the heading “who we are” that includes portable parts with the following words: Partners and Stakeholders – Consortium – Independent Evaluation arrangement – Funds – Independent Science and Partnership Council. These five words open new pages. They can be found in every page of this web site.

News. By putting the mouse pad above two words appear; “Press releases” (articles related to agroforestry ecosystems) and “newsletters” (issues of the “agroforestry in Northern Greece” magazine that will include crucial subjects of agroforestry).

Media. By putting the mouse pad above this word, two new words appear downside; “library” (articles published in scientific magazines) and “reports” (reports of the government and new laws).

Events. At this part events that have to do with agroforestry are mentioned or related topics such us symposiums, summer schools, seminars etc.

Projects. The “project” part will have to do with projects that are running or that they are about to run in the near future. Also, by the end of a project final reports for that will be uploaded there.

Links. At this part of the site some useful links for navigation will be mentioned.

Forum. This link opens a new page. Here everyone can become a member and exchange his ideas with the others.

Contact. By clicking at this word a platform is uploading. The user can express his questions to the administrator of the web page by putting into cells his personal data (name and surname / email account) and then there will be a bigger cell with empty space to write the text.

Sign. Through that users can be connected and receive emails. Each time something new is added to the website an email will be delivered to their personal email accounts.

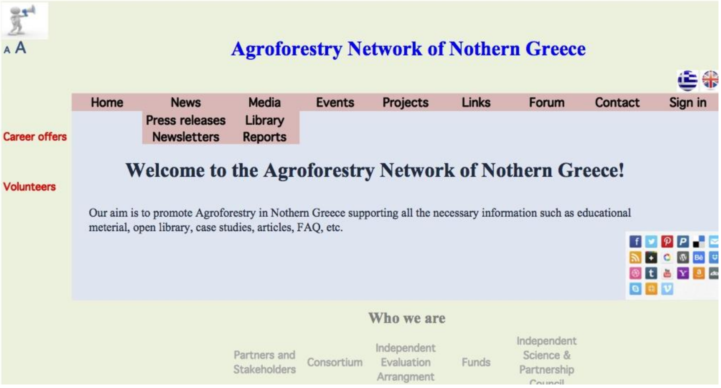

Fig. 1. Description of proposed website. Home page.

IV – Conclusions

There are many websites attempting to support agroforestry activities. 10 of the most viewed were examined as to their content characteristics. Thus, we proposed a structure of a model website with a regional development interest that will promote agroforestry as a technique that respects the environment and has a strong tradition worldwide. It will give all the necessary information in a friendly environment such as audio-visual educational material, open library, case studies, articles, forum, social media, FAQ, etc.

The proposed structure has to be designed in a user-friendly style so that farmers and regional stakeholders, teachers and students and even researchers, can use it as it presents a large volume of agroforestry data in a simple way. Moreover, it can become a model for the improvement of similar websites. Through the website, local population can be motivated as to the preservation of agroforestry ecosystems. It can contribute to the local economy actions as it provides advices/successful examples for agroforestry activities and job opportunities.

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The livestock production system of the Muslim minority in Northern Evros, Greece

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Abstract. The Greek Region of Thrace is the main center of the Greek Muslim minority. Apart from their religion, these people are distinguished by language, attire and customs. In Evros Prefecture, the Muslim minority inhabits the North-western part and mainly consists of Pomaks, a historical highland population who has always lived isolated in mountainous villages. Because of their constant interactions with the natural environment they are used to a frugal living earned by cultivating infertile and unproductive land, timber production and sheep and goat farming. This study provides a description of the operation of the sheep and goat farming system in the Muslim villages of Evros. According to the results of a questionnaire survey, farms are of small size and operate under a very extensive pattern, keeping traditional management practices, rearing autochthonous animal breeds fed upon the natural vegetation of mountainous rangelands almost throughout the year. Labor is offered exclusively by family members and women play a central role, as male members choose to work in timber production or to migrate. Farm households are highly self-sufficient, as a part of the raw products of the farm (milk, meat, wool) is manufactured and consumed by family members.

Keywords. Livestock production system – Pomaks – Female labor.

Le système d'élevage de la minorité musulmane au nord d'Evros, Grèce

Résumé. *La région grecque de Thrace est le principal centre de la minorité musulmane grecque. À part leur religion, ces personnes se distinguent par la langue, l'habillement et les coutumes. Dans la préfecture d'Evros, la minorité musulmane habite dans la partie nord-ouest et se compose principalement de Pomaks, une population qui a toujours vécu dans des villages isolés de montagne. Grâce à leurs interactions constantes avec l'environnement naturel, ils sont habitués à une vie frugale basée principalement sur l'élevage ovin et caprin, l'exploitation forestière et l'agriculture. Le but de cette étude est la description du fonctionnement du système d'élevage ovin et caprin dans les villages musulmans d'Evros. Selon les résultats d'une enquête par questionnaire, les exploitations sont de petite taille et fonctionnent sur un mode très extensif, en gardant des pratiques de gestion traditionnelles, en élevant des races d'animaux autochtones et en utilisant la végétation naturelle des parcours de montagne presque toute l'année. Le travail est fait exclusivement par les membres de la famille et les femmes jouent un rôle central, étant donné que les hommes s'orientent vers la production forestière ou l'émigration. Les ménages sont très autonomes et une partie de la production agricole familiale (lait, viande, laine) est transformée et consommée au sein du ménage.*

Mots-clés. *Système d'élevage – Pomaks – Travail des femmes*

I – Introduction

The Greek Region of Thrace, comprising of the Prefectures of Xanthi, Rhodope and Evros, is the main center of the Greek Muslim minority, since the Lausanne Treaty in 1923. This is the only explicitly recognized minority of about 100,000 people in Greece - almost 1% of the total population. Pomaks constitute a significant part of this minority; in total there are 36,000 Pomaks in the Region, of whom almost 2,000 live in the Prefecture of Evros (ELSTAT, 2011). These people are characterized by their language, traditional attire, customs, way of living and even their physical characteristics. Their language is classified as a dialect of the Bulgarian language and existed before the emergence of the modern nation-states (Ghodsee, 2010).

Pomaks have historically been a highland population who has always lived isolated in mountainous villages. These communities, being isolated in their territory, did not experience the transformations that occurred in the rural communities in the lowlands of Greece. As an imminent result, their rural economy is poorly diversified and employment opportunities are limited for those who do not decide to migrate. Local people are used to a simple way of life, mainly based on self-consumption and the primary sector provides them almost all the employment opportunities. Crop production in the area is restricted due to poor soil quality and low productivity; the main crop is tobacco of excellent quality, which is sold to manufacturers (Greek or international), but also many Pomaks are engaged in forestry.

The livestock production pattern in northern Evros is dual. In the lowlands, intensive farms prevail, which are actually striving for survival in an uncertain environment of financial stress (Koutsou *et al.*, 2013), due to their high dependence on capital. These farms have followed an expansion path common for the whole Greek primary sector, aiming at increasing size and competitiveness by simultaneously minimizing production costs (Karanikolas and Martinos, 2012). On the other hand, the mountainous areas inhabited by Pomaks are endowed with unexploited resources, including history, the sustainable utilization of the natural resources (land, forests and pastures) and technical skills in the manufacture of the agricultural products. Nowadays, livestock farming is the most important economic activity of Pomaks in Evros; they rear sheep and goats and, to a lesser extent, cattle, under a strictly family pattern which did not adopt many modern and/or innovative features. Tradition essentially outlines the resilience of the production system, which enables Pomak livestock farms to survive the economic crisis with minimum losses.

A key feature of the Pomak way of life is that women play a decisive role not only in the rural household, but also in the rural society. The wife is involved in farm operation, providing mainly manual labor; however, in many circumstances she takes the control of the farm. It is usual that the husband often migrates either outside or inside the country in search of work and usually he is employed as a sailor or worker, thus leaving the rural community for long periods. Simultaneously, women, apart from their daily involvement in the farm work, possess the know-how in the production of crop and livestock manufactured products.

This study provides a description of the operation of the sheep and goat farming system in the Muslim villages of Evros. Based on a questionnaire survey, the main dimensions of the operation of the system are presented. Particular attention is paid on the features that shape the resilience of the system. We discuss the possibilities of “good practices” transfer to other Greek production sectors and systems, as remedies against the economic crisis.

II – Materials and methods

The data for the analysis were gathered through a questionnaire survey during the summer of 2011 in Northern Evros, which is situated in northeastern Greece, on the border with Bulgaria and Turkey. The sample included 41 farms and the interviews were all conducted with the wives by women enumerators, because it was easier to approach them and to get sincere and reliable responses. Interviewers were invited to the rural households.

III – Results and discussion

Table 1 presents the profile of the human labor requirements in the Pomak farms. In all cases, labor is offered exclusively by family members. It is verified that Pomak women constitute a primary pillar in the operation of the farm. It can be seen that almost half of the total labor in the farm comes from female members while other family members (children, grandparents) play a rather auxiliary role. Discussions with locals have revealed that in the past few years males worked even less in the farm; it was the crisis that compelled them to return to the rural community and undertake some duties.

Table 1. Labour availability and requirements

	Family labor	Husband labor	Wife labor	Other members	Wives' chores				
					Milking	Feeding	Cleaning	Grazing	Other
Hours	6230	2402	2865	964					
h/ewe	18.8	7.3	8.7	2.9					
h/day					3.2	1.7	1.7	0.4	0.8

Pomak women spend 7.8 hours per day on average working on the farm and performing all types of everyday manual tasks. Most of this labor concerns milking, followed by feeding and cleaning. This profile of labor is not compatible with the role of women in other types of farms; as Herron and Skinner (2012) point out, women's labor is endowed with particular emotional elements "... crucial for the sustainability of rural people and places". This means that women in other systems usually undertake more specific tasks – for instance during the birth season. It is also very interesting to notice that the vast majority of respondents revealed to take decisions for the farm commonly with their husbands (83%), and only a small part claimed not to be a part of the decision making process (10%).

The profile of the production system is depicted in Table 2. Farms are of small size and operate under a very extensive pattern, keeping traditional management practices, rearing autochthonous animal breeds and using the natural vegetation of mountainous rangelands almost throughout the year. Considering the former, most farms rear sheep and goats, with an average size of 247.6 and 287.2 animals respectively, while half of the farms keep a few cows mainly to cover their household needs in meat and milk. As for the latter, the survey revealed that almost all of the 41 farms applied grazing, but they also used purchased feedstuff. As the area is deprived of fertile land, it is unusual to produce feedstuff. The average farm cultivates only 0.9 ha of arid land with cereal and 1.2 ha for the production of forage (lucerne or cultivated grasslands), while almost half of the farms are not engaged in any crop production activity.

Table 2. Farm profile, size and infrastructure of the average farm. Number of farms.

	Crops		Animals			Others					
	Cereal (ha)	Cultivated grassland/ lucerne (ha)	Cattle (av. number)	Sheep (av. number)	Goats (av. number)	Applying grazing	Purchased feedstuff	Use of tractor	Own a farmers' car	Own milking machine	Own modern buildings
Yes	16 (0.9)	24 (1.2)	21 (10.6)	17 (247.6)	12 (287.2)	40	33	29	36	1	6
No	25	17	20	24	29	1	8	12	5	40	35

The results in Table 2 also ascertain that the Pomak production system is not dependent on capital. Tractors and farmers' cars are the only types of machinery available in 70% and 88% of the farms respectively. Only one farm rearing dairy cattle has invested on machine milking. Buildings are mostly of the traditional type, makeshift and of cheap materials; only 14% of respondents reported to have modernized their buildings in the past 10 years.

Table 3 illustrates the main products and their marketing. Milk is the most important product, produced in 39 farms. It can be seen that a considerable part of milk production in channeled to markets through conventional supply chains, namely a local Cooperative (46%) and local dairies (12%). However, farm households are fairly self-sufficient, as more than one third of the milk remains in the farm, either for raw consumption or for manufacturing. Only three women do not produce cheese, while almost 60% also produce other dairy products (yoghurt and local “ariani”). Unlike raw milk, most of these products are consumed within the household, like all the manufactured meat products (local “kavourmas” and sausages). Despite the fact that some of these products are endowed with special characteristics, they are not appreciated by women themselves, as only three of them claimed otherwise.

Table 3. Production, manufacturing and product sales (number of farms)

	Milk	Home manufacturing		
		Cheese	Other dairy	Meat
Cooperative	19	0	0	0
Dairy industry	5	0	0	0
Local market	1	4	4	0
Home consumption	14	36	24	10
No production	2	3	17	31

IV – Conclusions

The Pomak society is a closed one, as a result of its historical isolation. The data presented in this paper revealed that the elements of its resilience can be traced back to this fact: Pomaks only opened up to markets, hired labor and investments at a very low degree and under the economic crisis they safeguarded their family character and did not suffer intense repercussions. It can be supported, then, that the adoption of an extensive production pattern and the operation of farms away from markets constitutes a reliable alternative ensuring the temporal reproduction of farms. But then the question is raised: is the future of sheep-goat farming related to an “Extensive” lifestyle – even in isolation - which has been abandoned for decades? What about the entrepreneurial forms of livestock production which are being supported by agricultural policies in the EU?

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A traditional route of transhumant flocks in Northern Greece: Cultural aspects and economic implications

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Abstract. Transhumance is still practiced in Greece, however a general trend of intensification of production often compels transhumant farmers to adopt innovations and modern standards. Within this context, only vertical flock movements are done by foot, while for longer distances trucks are generally used. This study presents the traditional route which was followed in the past by Sarakatsans – an ethnic group inextricably woven with the transhumant system in Greece, who spent winter in the plains of Chalkidiki (Central Macedonia) and moved to the mountain Kaimaktsalan in Western Macedonia in the summer (almost 250 km). Drawing from personal interviews of families who experienced these movements, we detect aspects of the everyday life of these people. Each stop ("konaki") in this 24-day movement was linked with a particular chore: cheese making and selling, raw milk sales, shearing etc. The economic implications from the potential use of these traditional routes nowadays are two-fold. First, using partial budgeting, we conclude that considerable savings occur if farmers avoid the costly use of trucks; second, the costs of re-establishment and maintenance of these routes could be counterbalanced by alternative uses or the generation of environmental services.

Keywords. Extensive livestock farming – Mountainous rangelands – Sarakatsanoi.

Une route traditionnelle des troupeaux transhumants dans le nord de la Grèce : Culture et économie

Résumé. *La transhumance est encore pratiquée en Grèce, mais une tendance générale d'intensification de la production oblige souvent les éleveurs transhumants à adopter des innovations et des normes modernes. Dans ce contexte, seulement les mouvements "verticaux" sont faits à pied, tandis que pour les longues distances les camions sont généralement utilisés. Cette étude présente la route traditionnelle qui a été suivie dans le passé par les Sarakatsans - un groupe ethnique pratiquant traditionnellement la transhumance en Grèce -, qui passaient l'hiver dans les plaines de la Chalcidique (Macédoine Centrale) et se déplaçaient à la montagne Kaimaktsalan en Macédoine occidentale pendant l'été (près de 250 km). En menant des entretiens personnels avec des familles qui ont vécu ces mouvements, nous détectons les aspects de la vie quotidienne de ces personnes. Chaque arrêt ("Konaki") de ce mouvement de 24 jours a été lié à une corvée notamment: fabrication et vente du fromage, vente de lait, tonte des animaux, etc. Il y a deux types de conséquences économiques pour la réutilisation potentielle de ces routes traditionnelles. Tout d'abord, en utilisant la budgétisation partielle, nous concluons à des économies considérables si les éleveurs évitent l'utilisation coûteuse de camions. Deuxièmement, les coûts de re-création et l'entretien de ces routes pourraient être contrebalancés par d'autres utilisations ou par la génération de services environnementaux.*

Mots-clés. Production animale extensive – Prairies montagneuses – *Sarakatsans.*

I – Introduction

Transhumance constitutes a particular system of livestock production, endowed with a highly multifunctional character. One of its most unique features is its high dependence on land use, unlike other livestock production systems, which are attached to land at a lower degree. These relationships are formidable. First, transhumant farmers cultivate land, either for the production of forage (lucerne) and concentrates (maize and winter cereal) or for the formulation of pasturelands. Second, transhumant flocks base their nutrition on the use of rangelands and particularly on mountainous ones, in order to achieve costs savings from nutrition which can reach up to 47% according to Ragkos *et al*. (2014), thus an integrated regulatory framework for these areas is of the utmost importance. Third, land use design is also important in order to facilitate flock mobilities from winter to summer rangelands because, in numerous cases, flocks and farm families are obliged to pass through cultivated areas, towns, villages and protected areas and the lack of designated routes does not permit them to arrive to their destination.

In Europe, safekeeping transhumances and the routes of flocks receives much interest. In France, multiple efforts are now in force in order to protect and develop the traditional routes of transhumant farmers (www.larouto.eu), aiming at revitalizing the old paths also for other uses (Gilles, 2002). In Spain, the routes of transhumance have been protected by law since 1974; the law of "Vias pecuarias" of 1995 further protected and recognized these routes as public domain areas with regulated uses, while the report "La trashumancia en España: Libro Blanco**"** (AA.VV., 2012) recognized 128,543 km of routes covering almost 1% of the total area of Spain. A very interesting example is provided by the City of Madrid (www. viaspecuariasdemadrid.org), where an extensive network of over 600 km of paths is available for flocks but also for recreational activities. In Italy, on the other hand, the routes of transhumant sheep and goat flocks could be found in the central and southern Apennines in the past, but now these movements have been transformed to vertical movements ("transterminance") of a few kilometers from the lowlands to mountainous rangelands of the same area (Pardini and Nori, 2011).

In Greece nowadays there are more than 3,500 transhumant flocks. In the past all flocks were moved on foot but, due to several reasons, most of these movements are now performed with trucks and only local, "vertical" and a very small proportion of long-distance (more than 100 km) movements are still moved on foot throughout the country. This is due to several reasons including a general trend of transhumant farmers to adopt innovations and modern standards, restrictions in land uses, changes in the living standards of farmers as transhumance on foot is demanding, often difficult and time-consuming.

This study presents the traditional route which was followed in the past by Sarakatsans, an ethnic group historically involved in the transhumant system in Greece, who spent winter in the plains of Chalkidiki (Central Macedonia) and moved to the Mount Voras (Prefecture of Florina, Western Macedonia) in the summer. Lately, efforts are made to record these traditional routes, either through personal communications or using old publications (e.g. Loukopoulos, 1930). There are also applications of new technologies in the graphical representation of routes using GIS and multimedia and/or providing useful practical information for potential users (Ntassiou *et al.*, 2015). The implications of the revitalization of these routes, possible alternative uses and policy measures to fund such initiatives were also investigated.

II – Materials and methods

In order to examine the route followed by Sarakatsans, personal interviews with members of three families who experienced these movements were conducted in 2014. Respondents, who were all over 70 years of age, described the itinerary, the stops ("konakia", singular "konaki") and the tasks performed by farm families everyday during the movement. Through their descriptions important cultural features and historic details were detected.

Almost the whole movement of the flocks took place within the boundaries of the Region of Central Macedonia (RCM). The most important feature of RCM is the high level of agricultural development; there, the largest plain of Greece is situated which, combined with the favourable soil and climate conditions, formulated intensive crop and livestock production systems. The co-existence of transhumance with these systems is very interesting in itself. Nowadays there are

195 transhumant flocks in Central Macedonia rearing more than 71,000 sheep and goats. Most of these flocks perform transterminance within a range of 20-30 km in most cases, thus performing an important environmental role in preserving and maintaining mountainous rangelands. Farms are generally of low productivity, ensuring their survival through milk and lamb meat sales, EU income support policies and cost savings from the limited use of purchased feedstuff. Many farmers produce their own cheese, either for the farm household or for markets.

III – Results and discussion

The traditional route is presented in Table 1. The whole route is 256 km through the modern road network and the distance can be covered in 3 hours and 53 minutes using trucks. However, the situation was different in the old times, as flocks were able to use mountainous roads, which were more direct. Note that the movements were ceased and abandoned during the 1970s. Each stop ("konaki") in the 24-day movement from Chalkidiki to the final destination in Mount Voras was linked with a particular task: cheese making and selling, raw milk sales, shearing, etc. The distance covered each day was determined by the particular chores undertaken at that specific day and also by the type of land uses prevailing at that area. For example, they remained around the city of Thessaloniki for several days in order to sell milk and cheese and to buy supplies. Then, from 13 to day 20 they only moved for a few kilometres per day, because they had to pass through fertile agricultural areas, which were cultivated during spring time, therefore they had to be very careful. After day 21, when the route passed through the mountains dividing Western Macedonia from Central Macedonia (Voras), flocks were able to move at a longer distance within a day, because these areas were mountainous with no agricultural uses, which permitted flocks to move faster, and also farmers only manufactured cheese for self-consumption.

Table 1. The route from Chalkidiki to Mount Voras (Western Macedonia)

Stops ("Konakia")	Chores/Tasks	Stops ("Konakia")	Chores/Tasks
1. Poligyros		13. Gefyra	Milk sales
2. Chalbouki		14. Chalkidona	Milk sales
3. Vatonia (Olinthios river)		15. Giannitsa	Cheese sales
4. Agios Prodromos	Lamb sales	16. Melissi	Milk sales
5. Galatista	Milk sales	17. Kallipoli	Milk sales
6. Vasilika	Cheese sales	18. Lipochori	Milk sales
7. Redestos	Milk sales	19. Rizari	Milk sales
8. Panorama	Milk sales	20. Edessa	Milk sales
9. Thessaloniki ("Seich Sou")	Milk sales	21. Xanthogia	Cheese making
10. Thessaloniki ("Papafio")	Milk sales	22. Kelli ("Mpegna")	Cheese making
11. Diavata	Shearing	23. Skopos	Cheese making
12. Agios Athanasios	Milk sales	24. Koryfi	

This route is not used by flocks nowadays, as the movement is performed with trucks. However, the economic implications from the potential revitalization of these traditional routes nowadays are two-fold. First, using partial budgeting, we conclude that considerable savings occur if farmers avoid the costly use of trucks, because the opportunity costs of human labour are very low. According to survey data (Ragkos *et al*., 2014) leasing a truck for a distance of 200 km costs 700€- 900€ on average, the price being subject to the fluctuation of petrol prices, which is twice this sum if the size of the flock exceeds 500 animals, which means that two or more itineraries would be needed. Consequently, medium-sized transhumant farms could avoid up to 1800€ annually if they were able to move their flocks by foot.

The above consideration is a purely economic one, but there are also non-economic benefits from the use of these routes, including the provision of ecosystem services (for example maintenance and protection of biodiversity, reduction in CO_2 emissions etc) and the protection of cultural identities. There is strong evidence that the public attach monetary values to such services (Bernués *et al.*, 2014; Villanueva *et al.*, 2015), which, are nonetheless, not reflected at the prices of products. Therefore, it is logical to expect that significant values would emerge from the revitalization of these routes. For this to happen at an inter-temporal basis, there are several necessary structural adjustments, such as the effective design of land uses, the assurance of cooperation of transhumant livestock farmers with crop farmers cultivating nearby areas with mutual respect to their activities and the revision of the managerial framework of designated protected areas (for instance, NATURA 2000 network).

IV – Conclusions

The revitalization of this traditional route, also like many more in Greece, could be proven costly, as several highly productive agricultural plots would be needed to remain uncultivated. However, the choice of the correct policies and strategies would help increase the added value of these routes by internalizing externalities, through the development of activities that would bring income and employment to farmers and other involved actors. This way, the costs of re-establishment and maintenance of these routes could be counterbalanced by alternative uses including hiking, eco-tourism and the promotion of the cultural background of these movements. The new Rural Development Program of Greece 2014-2020 provides funding opportunities to interested municipalities through targeted sub-measures of the Measure 07 aiming at the restoration of cultural features in rural areas, the development of local landmarks and the protection of forest roads in mountainous areas.

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The mountainous pastoral livestock farming in Tzoumerka, Epirus: The economic dimension of activity and the sustainable management of pasturelands

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Abstract. The aim of this paper is to depict the structural characteristics of livestock farms in the area of the Pindos Mountain. A questionnaire survey held in June 2013 was used to examine 75 out of a total of 441 heads of livestock farms, mainly pastoral, in order to identify their attitudes and perceptions about their income, professional satisfaction, as well as their practices that ensure the sustainability of mountainous pasturelands. The results show that most of the farmers are not satisfied by the subsidies they receive through the Common Agricultural Policy; even more, they are not familiar with the regulatory requirements of the cross compliance, while the majority of them believe that the current payment system (decoupling) is not fair and is not conducive to livestock farming. Thus, they seem to be dissatisfied with their income. Finally, the participants claim that they are not satisfied with the low forage production as a result of overgrazing of mountainous pasturelands. Moreover, they are willing to pay a higher rent for the pasturelands in case of improved technical infrastructure and increased forage production.

Keywords. Pastoral farmers – Mountainous and sub-alpine pasturelands – Cross compliance – Overgrazing.

Le système d'élevage montagneux pastoral de Tzoumerka, Épire: La dimension économique de l'activité et la gestion durable des pâturages

Résumé. *Le but de cet article est de décrire les caractéristiques structurelles des exploitations d'élevage dans la chaîne de montagnes du Pinde. Cet article utilise une enquête par questionnaires, qui a eu lieu en juin 2013, pour examiner 75 sur un total de 441 éleveurs, essentiellement pastoraux, pour identifier leurs attitudes et perceptions concernant leurs revenus, leur satisfaction professionnelle, ainsi que leurs pratiques assurant la durabilité des pâturages mantagneux. Les résultats démontrent que la plupart des producteurs ne sont pas satisfaits par les paiements qu'ils reçoivent à travers la Politique Agricole Commune; en plus ils sont encore moins familiers avec les exigences réglementaires de l'écoconditionnalité, alors que la majorité estime que le système de paiements actuel (découplage) n'est ni juste ni propice à l'élevage. Ainsi, ils semblent ne pas être satisfaits de leur revenu. Enfin, les participants affirment qu'ils ne sont pas satisfaits de la faible production de fourrage à la suite de la surutilisation des pâturages montagneux. En outre, ils sont prêts à payer un loyer plus élevé pour les pâturages si l'infrastructure technique est améliorée et la production de fourrage est augmentée.*

Mots-clés. *Éleveurs pastoraux – Pâturages montagneux et sous-alpins – Ecoconditionnalité – Surpâturage.*

I – Introduction

In Epirus, mountainous pasturelands are considered to be important feed resources for pastoral livestock farming (Roukos *et al.*, 2011) and they play a key role both in cost-effective production of safe animal origin quality products, and for the pastureland sustainability (Chatzitheodoridis *et al.*, 2007; Papachristou *et al.*, 2005). Even when the pasturelands provide vital ecosystem services, it seems that they continue to be abandoned because of limited economic viability and from the unintended consequences of the Common Agricultural Policy (CAP). In this frame, the examination of the work satisfaction and income of livestock farmers constitutes a useful determinant of their overall satisfaction (Kalleberg and Loscocco, 1983). This factor is also associated with farmers' perceptions about the economic and the non-economic rewards of farming (Coughenour and Swanson, 1988). Molnar (1985) affirmed that net farm income is a more important determinant of farmers' satisfaction. According to Flores and Sarandon (2004), farmer's satisfaction is considered an important indicator of sustainability. The purpose of this study is to identify farmers' satisfaction about their income from livestock activities and to record their perceptions on the techniques they apply ensuring the sustainability of mountainous pasturelands in a Greek mountainous area (Tzoumerka - Pindos).

II – Materials and methods

This survey is based on primary data, collected on field with a questionnaire survey in June 2013 among 75 heads of livestock farms in the area of the Pindos mountain range (Fig. 1). In the study area the natural grasslands and the shrublands cover 68.4% of the total area – with a maximum altitude of 2429 m, and are utilized by 441 livestock farms with 68,000 sheep, 5,800 goats, and 3,600 cattle mainly under a pastoralist system. Descriptive statistics were used to illustrate environmental management practices and economic opinions and logistic regression was applied to depict the characteristics that affect farmers' income satisfaction (Field, 2005).

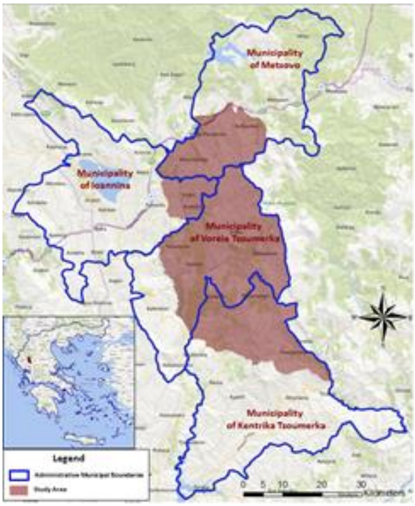

Fig. 1. The study area.

III – Results and discussion

The vast majority (94.7%) of livestock farmers are transhumant (Table 1) utilizing the mountain pastures only for a certain period of the year. In addition, a negative relation between farm size and farmers age was found: the smaller farm size the greater farmer's age and vice versa.

With regard to the EU subsidies, 72% of the respondents stated that their income is not satisfactory even with the subsidies. However, the majority of farmers (81.3%) said that they keep their livestock farm only due to the income they earn. On the other hand, 85.3% of the respondents believe that the financial assistance provided through subsidies is not enough. Additionally, 65.3% of the respondents claimed that the EU subsidies and their requirements affect their farm size and the number of the animals they rear. Subsequently, farmers chose their flock/herd size according to the amount of subsidies. Finally, 78.7% of the participants claimed that without the EU subsidies their farm is not viable (Table 2).

Table 3 presents livestock farmers' perceptions about sustainability management in the examined area. It is important to note that the majority of farmers claim that the pasturelands in the examined mountainous areas are overgrazed without sufficient forage production and, even more, that the existing infrastructure (such as roads, watering places and stabling facilities) is insufficient. However, farmers are willing to pay higher rents for pastureland in case there are improvements in the aforementioned infrastructure.

Table 1. Farm size, farmers' categories and ages in the examined area

Livestock Units*	Categories	Frequency	Age
	Transhumant farmers	9	65.11
0.1 - 7.50	Permanent farmers	3	73.00
	Sub-group total	***12***	***67.08***
	Transhumant farmers	9	53.67
7.51 - 15.00	Permanent farmers	1	52.00
	Sub-group total	**10**	**53.50**
	Nomads	27	46.26
15.01 - 30.00	Farmers	--	--
	Sub-group total	**27**	**46.26**
	Transhumant farmers	22	41.36
30.01 - 60.00	Permanent farmers	--	--
	Sub-group total	**22**	**41.36**
	Transhumant farmers	4	41.25
60	Permanent farmers	--	--
	Sub-group total	**4**	**41.25**
	Transhumant farmers	71	47.79
Total	Permanent farmers	4	67.75
	Total	**75**	**48.85**

*: 1 Livestock Unit = 6.67 sheep = 1 mature cattle.

Table 2. Farmers' Perceptions about Subsidies and Common Agricultural Policy

	Yes (%)	No (%)
Awareness of the Cross – Compliance scheme	47 (62.7%)	28 (37.3%)
Decoupling is a Fair system	52 (69.3%)	23 (30.7%)
Decoupling promotes livestock faming	16 (21.3%)	59 (78.7%)
Subsidies affect your livestock farm size	26 (34.7%)	49 (65.3%)
The amount of European Union Subsidies is sufficient?	11 (14.7%)	64 (85.3%)
Is your farm viable without EU Subsidies?	16 (21.3%)	59 (78.7%)
Being a livestock farmer depends on EU subsidies	61 (81.3%)	14 (18.7%)

Table 3. Farmers' Perceptions about Pastureland Sustainability Management

	Yes (%)	No (%)
Sufficient Forage production	17 (22.7%)	58 (77.3%)
Mountainous areas are overgrazed	58 (77.3%)	17 (22.7%)
There is sufficient infrastructure	26 (34.7%)	49 (65.3%)
Willingness to pay higher rents for improved infrastructure	70 (93.3%)	5 (6.7%)

The next step in the analysis was to determine the characteristics that formulate farmers' decision to express satisfaction or dissatisfaction with their income. According to Table 4, the estimated model correctly predicts 4 out of 5 cases (with a cut value of 0.45 based on the examination of the ROC curve between the observed and the predicted values for satisfied and dissatisfied farmers). The classification table and the different types of goodness-of-fit measures suggest that the estimated model adequately fits the data. The statistically significant variables that determine livestock farmers' income satisfaction are presented below:

Livestock Farm Size has a strong impact with the income satisfaction: the largest the farm the more satisfied the livestock farmers are. In general, for the logistic regression results when Exp (B) is more than 1, increasing values of the variable correspond to increasing odds of the event's occurrence. Thus, when farm size is increasing then the probability that a farmer is "satisfied" increases. The farmers' answers on the questions "*Is the amount of European Union Subsidies sufficient?" and "Is your farm viable without European Union Subsidies"* affect positively the income satisfaction. Having in mind the values of Exp (B) which are greater than 1, then an increase in the values of the variable correspond to increasing odds of the event's occurrence. Thus, when come is quite higher than the average then the satisfaction from the income is higher. However, bearing also in mind that the majority of the livestock farmers state that the amount of subsidies is not enough, we can conclude that the livestock farming in the examined area is based largely on European Union subsidies. To summarize, it must be mentioned that it is possible to determine farmers' satisfaction based on: their farm size and their perceptions about the amount of European Union's Subsidies.

Table 4. Logistic regression analysis for the livestock farmers' income satisfaction

Variables (characteristics affecting income satisfaction)	B	S.E.	Wald Statistic	Wald Sig.	Exp(B)
Age	Finally, omitted from the examined model				
Nomadic	Finally, omitted from the examined model				
Stable owner (yes/no)	Finally, omitted from the examined model				
Livestock Farming is a way of living	Finally, omitted from the examined model				
Is your farm viable without EU Subsidies	2.001	0.751	7.097	0.008*	7.397
Livestock Farm Size (in livestock units)	0.772	0.308	6.261	0.000*	2.164
The amount of European Union Subsidies is sufficient enough?	2.048	0.826	6.152	0.013**	7.752
Constant Term	4.144	0.957	18.740	0.000*	0.016

Estimation Method = Forward Stepwise (Likelihood Ratio).
R^2 = 0,216 (Chi2 4,5, df = 8 - Hosmer & Lemeshow), 0.295 (Cox & Snell), 0,426, (Nagelkerke).
Significance: * p<0.01, ** p<0.05, *** p<0.1

IV – Conclusions

The livestock farmers in mountainous area of Tzoumerka understand the problems associated with low forage production and overgrazing of grasslands. It seems that the continuation of the mountain livestock farming is strongly associated with the changes to the Common Agricultural Policy as the viability of the sector is based mainly in European Union subsidies. It is very likely that livestock farming will be abandoned by a significant number of livestock farmers in the future mainly by those with small size farms, as they claim that EU subsidies are not sufficient and so their incomes are not satisfactory. In this case, there will be a serious impact in the economy, the society and the environment of these mountainous and less favourable areas (LFAs).

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Buffalo farming in Greece: Present and future

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Abstract. Buffalo livestock farming (*Bubalus bubalis*) in Greece has been demonstrating a stable increase during the past 30 years, from only 312 animals in 1984 to 3,563 animals in 2014. This development occurred simultaneously with considerable developments in Greek markets with the emergence of modern enterprises with export orientation, increased demand for buffalo meat by Greeks – nonetheless not for dairy products – and public awareness concerning the two-fold environmental role played by buffalo farming: protection of indigenous genetic resources and development of wetland rangelands. This study presents the current situation in the sector, through the processing of reproduction and technical/economic data describing the operation of the system, provided by the Greek Buffalo Farmers' Cooperative. These farms operate under an extensive or semi-intensive pattern, with low investments in infrastructure and high use of rangelands, as concentrates and forage are provided only during harsh winter periods. It is estimated that a farm of an average size of 40-70 females is viable under the extensive and semi-intensive system respectively. Based on the data, a set of structural measures is proposed to favor the sector.

Keywords. Extensive livestock farming – Meadow management – Wetlands – Genetic diversity.

L'élevage du buffle d'eau en Grèce: Présent et avenir

Résumé. *L'élevage du buffle d'eau (*Bubalus bubalis*) en Grèce a montré une augmentation stable au cours des 30 dernières années, à partir de seulement 312 animaux en 1984 à 3.563 animaux en 2014. Cette évolution a eu lieu en même temps que des développements considérables dans les marchés grecs avec l'émergence d'entreprises modernes d'exportation, la demande accrue de viande de buffle par les Grecs - néanmoins pas pour les produits laitiers - et l'intérêt public concernant le rôle environnemental double joué par l'élevage de buffles: la protection des ressources génétiques et le développement des pâturages humides. Cette étude présente la situation actuelle dans le secteur, à travers la gestion de la reproduction des animaux et des données techniques/économiques décrivant le fonctionnement du système, fournies par la Coopérative des Éleveurs de Buffles d'Eau. Ces fermes fonctionnent sous un modèle extensif ou semi-intensif, basé sur de faibles investissements dans l'infrastructure et sur l'utilisation des pâturages humides; des concentrés et des fourrages sont fournis uniquement pendant les périodes hivernales rigoureuses. On estime qu'une ferme d'une taille moyenne de 40-70 buffles est viable sous le système extensif et semi-intensif, respectivement. Des mesures structurelles sont proposées pour le secteur.*

Mots-clés. *Production animale extensive – Gestion des prés – Terres humides – Diversité génétique.*

I – Introduction

Buffalo livestock farming (*Bubalus bubalis*) in Greece has been demonstrating a stable increase during the past 30 years, from only 312 animals in 1984 to 3,563 animals in 2014 (ELSTAT, 2015).This development occurred simultaneously with considerable developments in Greek markets. First, it was the emergence of modern enterprises with export orientation that boosted the sector; taking advantage of funding opportunities from the Common Agricultural Policy (CAP) and other EU funds, people from areas where buffaloes are traditionally raised in Greece invested on manufacturing, predominantly of meat and much less on milk. The development from the supply/production side also came as an answer to the increasing demand for buffalo meat by Greeks – nonetheless not for dairy products. A recent study revealed that the addition of buffalo meat in sausages influences the quality and organoleptic characteristics of the products (Petridis *et al.,* 2015), thus creating additional opportunities for manufacturers. However, milk production is not as developed as meat processing; according to Borghese (2013) Greek buffalo farms lack the equipment, know-how and genetic improvement techniques (e.g. artificial insemination) to support this development. Also, there is evidence that the consumption of milk products from buffaloes is increasing, depending on the provision of knowledge and the high nutritional value of these products (Cazacu *et al.*, 2014).

Public awareness concerning the two-fold environmental role of buffalo farming was also an important driver in the development of the sector. First, water buffalo farming can be used for the management of meadows and was proven an important tool not only in controlling the expansion of reeds, but also in the formulation of habitats for wild species in a Greek wetland (Kazoglou, 2011). In general, buffalo is an integral component in the operation of silvo-pastoral systems in environmentally sensitive areas, such as wetlands. In Greece they are reared in RAMSAR sites (Prespes, Kerkini, Porto Lagos, Etoloakarnania) where they utilize in an efficient way the available vegetation, without pressuring the fragile ecosystems (Georgoudis *et al.,* 1999). In addition, the extensive and semi-extensive system has got an almost insignificant carbon footprint, contrary to more intensive systems such as the Italian one, which is more based on the provision of feedstuff and the production of milk and poses the same pressure as conventional dairy cattle production systems (Pirlo *et al.,* 2013). However, the protection and continuation of buffalo farming concerns the protection of indigenous genetic resources. Implementing EU legislation, buffalo farmers are eligible for financial support under the Measure 2.1.4 (Action 3.1) of the Rural Development Program of Greece 2007-2013, as a compensation for the protection of endangered animal genetic resources. Under the forthcoming Rural Development Program 2014-2020, income support will still be provided (Measure 10).

This study presents some aspects of the operation of the system, based on data provided by the Greek Buffalo Farmers' Cooperative. The implications of their managerial decisions are described by comparing them with the findings of relevant studies and based on such data, proposals regarding interventions which would improve the future prospects of buffalo farming in Greece are discussed.

II – Materials and methods

The data presented in this paper were gathered by the Greek Buffalo Farmers' Cooperative (GBFC).These data cover a period of 17 months (January 2014 - May 2015) and include the whole population of buffaloes in country, as members of the GBFC are all the Greek buffalo farmers eligible for financial support under the CAP. The GBFC operates under the supervision of the Centre for Livestock Genetic Improvement (CLGI), a governmental body in charge of the conservation of genetic resources and biodiversity. The CLGI verifies that all the requirements of the Measure 2.1.4 are kept in order for farmers to receive the income support. The two Organizations (CLGI and GBFC) collaborate in keeping herd books and genetic records of all buffaloes protected under EU legislation. Drawing from these data, we present quantitative indicators concerning the reproduction management of buffalo farms and their basic operational and economic profile.

III – Results and discussion

Table 1 presents basic reproduction parameters of the buffalo population. The average duration of the reproductive life of females is 12.2 $\pm$ 4.09 years. During this period a female gives birth 4.8 $\pm$ 1.92 times on average. The first calving takes place at the age of 3.4- 4.0 years (40.3 $\pm$ 8.69 months) and the average duration of pregnancy was calculated to 310-320 days. Borghese

(2013) reported similar results for the age of first calving (36-48 months). These indicators are important for dairy farms, as it was found that the environmental temperature in each lactation period influences milk quality (Zotos and Bampidis, 2014). The calving interval is 18.4 $\pm$ 8 months, while the number of calves dying during the weaning period does not exceed 3% and only 2% of calves do not make it to adult age. The annual replacement rate is considerably low (only 6%), which partly explains the expansion of the buffalo population in the country.

Table 1. Reproduction parameters of the population of Greek buffaloes

Parameters	Results
Age at first calving (months)	40.3 $\pm$ 8.69
Number of calving during productive life	4.8 $\pm$ 1.92
Duration of pregnancy (days)	310-320
Average age at the end of reproductive live (years)	12.2 $\pm$ 4.09
Calving Interval (months)	18.4$\pm$8
Percentage of buffalo calves dead before weaning	3.23%
Percentage of buffalo calves dead before adult age	2%
Percentage of annual replacement of buffaloes	6%

Table 2 presents technical and economic indicators describing the operation of buffalo farms. The findings indicate the extensive or semi-extensive pattern of production, which confirms that the water buffalo has got very low treatment requirements (Georgoudis *et al.,* 1999). The semi-extensive system mainly differs from the extensive one concerning animal nutrition, as extensive farms do not provide any concentrates to animals, while the former resort to concentrates and forages during winter. Ligda *et al.* (2015) argued against this type of intensification, because it is more costly for farmers, and emphasize that intensification is a result of inadequate management of meadows, which reduces the availability of natural forage for buffaloes. Nonetheless, both systems play important environmental roles in the management of meadows. Females kept under the semi-extensive system gain more weight because of the different nutritional management, thus often reaching 400 kg of weight. Furthermore, additional feedstuff results in higher carcass weights for heifers (60 kg on average) at the age of 24 months. Borghese (2013) reported animal slaughter at a younger age (15-17 months) but almost the same live weight for females (350-400 kg).

Table 2. Basic technical and economic data of Greek buffalo farms

	Farming system	
	Extensive	Semi-extensive
Average live weight (female) (kg)	250-300	350-400
Carcass weight (2 y.o.) (kg)	150-180	220-240
Price of barn establishment (€)	10,000-20,000	30,000-50,000
Meat price (€/kg)	4.5	4.5
Average milk yield (kg)*	-	700-1000
Milk price (€/kg)*	-	1.4-1.5
Income payment (€/cow)	312-335	

A major advantage of buffalo farming lies in its low cost of initial establishment, as presented in Table 2. Even under the semi-extensive pattern the value of buildings do not exceed 50,000€, while intensive livestock farming systems require much more costly infrastructure; these buildings are makeshift, constructed with wood and iron plates. Also, no machinery is needed for extensive farms which do not produce milk and even in cases where milk is produced, milking is performed by hand. Meat prices are higher than the prices of bovine meat, while milk prices are 3-4 times higher than the price of cow milk prevailing in the country; nonetheless, there are not enough data to make comparisons, since milk production is an unorganized and not systematic activity. Note that apart from meat and milk production, the income payment constitutes a vital element of the income of these farms (312-335€/cow).

IV – Conclusions

Buffalo farming, as depicted in this study, constitutes an example of an environmentally and economically sustainable livestock production sector. Especially its economic element of sustainability has become evident during the past few years, as the sector has reacted positively to the increased market demand and started to develop after a long period of decline. The income support is a very important motive for extensive and semi-extensive buffalo farms, however it generates a false image of economic prosperity, which disorients interest from the true economic performance of these farms. The extensive ones profit from the income payment, as their productivity is low and their earnings are based entirely on meat sales and on the availability natural vegetation. On the other hand, the income of semi-extensive farms is more diversified, but their operational costs are burdened by the provision of feedstuff, so the income payment constitutes a tool for covering these expenses and becoming more market-oriented. Both types of farms perform environmental and social functions, but their roles are different when it comes to the future of the sector. Extensive farms will keep on playing an important role in the management of meadows, safeguarding environmental benefits. Nonetheless, the semi-extensive ones will be able to support the systematic development of milk production, through genetic improvement programs. Despite the inevitable intensification of their production pattern, they will be able to expand their market orientation, become less dependent on EU funds and support the overall development of the sector in the following years.

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Utilization of grazing in different small ruminant management systems on Crete Island, Greece

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Abstract. Two major small ruminant management systems exist on Crete, the semi-intensive (SI) and the extensive (EX). For the establishment of these systems the availability of pasture has a major impact. A project lasted from 2009 until 2012 aimed to study the characteristics of these systems and the impact on productivity, product quality and animal health. Twenty farms were selected, based on criteria established by an earlier survey, and were monitored for two milking seasons. At the extensive systems, located at the slope of the mountains, the animals graze almost exclusively on marginal communal pastures, where transhumant practices are still in place. The farmers use concentrate feeds and hay to increase productivity, mainly during milking period and during critical time-periods when grazing is scarce. The semi-intensive systems, are located at lower altitudes, where the animals graze mainly on fenced cultivated pastures and rotational grazing is applied. The use of concentrate feeds and hay is significant throughout the year. Between the two systems, the semi-intensive achieve higher production rates, but significant differences were also found for product quality, where extensive systems had in general a more preferable fatty acid profile.

Keywords. Small ruminant – Grazing – Management system – Crete.

Utilisation du pâturage dans les différents systèmes de production de petits ruminants en Crète

Résumé. *Deux systèmes de production de petits ruminants existent en Crète, le système semi-intensif et l'extensif. Pour la mise en place de ces systèmes, la disponibilité des pâturages a eu un impact majeur. Un projet qui s'est déroulé de 2009 jusqu'en 2012 a étudié les caractéristiques de ces systèmes et l'impact sur la productivité, la qualité des produits et la santé animale. 20 fermes ont été choisies, selon les critères établis par une enquête antérieure, et ont été suivies pendant deux saisons. Dans les systèmes extensifs, situés sur le versant des montagnes, les animaux se nourrissent presque exclusivement sur des pâturages marginaux et les pratiques transhumantes sont encore en place. Les agriculteurs utilisent des aliments concentrés et du foin, pour augmenter la productivité, principalement durant la période de traite et les périodes critiques où le pâturage est rare. Comme pour les systèmes semi-intensifs, qui sont situés à des altitudes plus basses, les animaux paissent sur des pâturages clôturés cultivés et le pâturage en rotation est appliqué. L'utilisation d'aliments concentrés et de foin est importante tout au long de l'année. Entre les deux systèmes, le système semi-intensif atteint des taux plus élevés de production, mais il y a des différences significatives sur la qualité des produits, et les systèmes extensifs ont généralement un profil d'acides gras préférable.*

Mots-clés. *Petits ruminants – Pâturage – Système de production – Crète.*

I – Introduction

Grazing is a practice closely related to most ruminant rearing systems. Especially, the ability of small ruminants to utilise low quality forage on marginal areas, gave the population of such areas a suitable economic activity and a source of high quality protein. Although this capacity is exploited by most small ruminant rearing systems there is a high variation among regions, associated with different management systems.

In Greece grazing practices have been studied to some extent (Zervas, 1998), but there is a large variation between regions (e.g. continental areas and the islands), due to differences in landscape, socioeconomics and climatic conditions. However, it has been noted that poor grazing practices have a significant impact on landscape, desertification, and on farms sustainability (Kosmas, 2015). A deeper understanding of the use of grazing by the different management systems is essential in order to indentify mistakes and provide viable solutions.

II – Management systems in Crete

Two are the predominant small ruminant management systems on Crete, the **semi-intensive (SI)** and the **extensive (EX)** (de Rancourt *et al*., 2006). The specific characteristics of these systems as found on Crete have been previously studied. In the SI management systems the overall invested capital on housing, machinery and land is high. There is a considerable use of supplementary concentrate and conserved forage especially during critical time-periods (by "critical" we refer either to climate i.e. winter or to production cycle phase i.e. mating, lambing, suckling, early lactation). The animals graze on pastures for some hours on a daily basis, with the exception of winter when animals are kept mostly indoors (Stefanakis *et al*., 2007). In the EX management systems animals are kept outdoors most of the year and grazing is a primary source of energy and nutrients. The overall invested capital in infrastructures is limited and the use of supplementary concentrate and conserved forage is low and targeted at critical time-periods (Volanis and Tzerakis, 1997). The grazed pastures are mainly marginal lands, private or communal where the area grazed by individual flocks is not clearly defined (Fig. 1). Transhumance practices are still present with flocks switching to highland pastures from early summer until late autumn. Productivity is lower in the extensive systems (Volanis *et al.*, 2007). The natural pastures in the area consist mostly of phryganic and orophryganic vegetation and a high variety of endemic taxa. Between the shrubs several herbaceous species, of the *Leguminosae*, *Compositae* and *Gramineae* families, grow. Pure grasslands are limited and found mostly on high altitudes, where several annual herbaceous species and dwarf shrubs grow (Caballero *et al*., 2009).

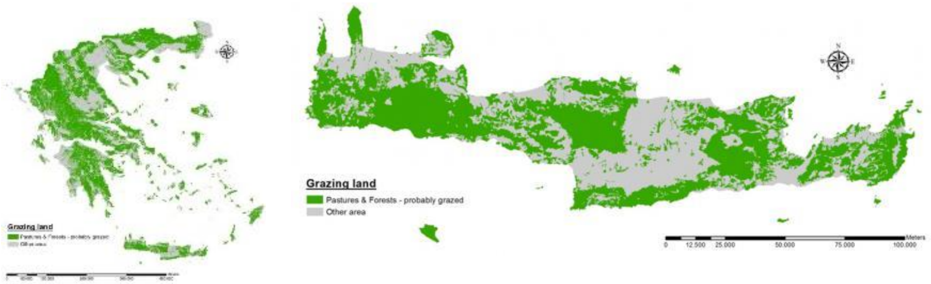

Fig.1. Geographical distribution of natural pastures in Greece and Crete. (CORINE 2000 data).

In both systems lambing takes place mainly in late autumn, with a second lambing period existing in late winter involving mainly the yearlings (around ~30% of the flock). At the EX systems lambs are kept with their mothers for around 60-70 days and slaughtered at 13 to 16 kg live weight. Milking starts after weaning and ewes are milked twice a day until June. At the SI systems lambs suckle their mothers for around 30-55 days and slaughtered at 13 to 16 kg live weight or fattened on concentrates until 30 kg. Milking starts 30-50 days after lambing, depending on the farm, and lasts until the end of summer. The main sheep breed reared is the local "Sfakiano", because it has good production traits (average body weight ~40 kg, lambs per ewe per birth: 1.2 -1.5, average annual milk production: 180 kg) but also is well adapted to the harsh Mediterranean environment (Volanis and Tzerakis, 1997).

III – Grazing practices and feeding regimes

In general the extensively managed flocks spend more time grazing (Fig. 2), compared to the semi-intensively managed flocks, especially on natural pastures. On the other hand the SI farms invest on crop growing and rotational grazing of cultivated fenced pastures is applied during winter and spring. Therefore, the SI farms own more land suitable for cultivation than the EX farms, who mainly use private or communal unimproved pastures for grazing. The average grazing land in the extensive systems has been reported to be 0.477±0.012 ha×animal^{-1}, with only 0.020 ha×animal^{-1} being cultivated grains or forages (Volanis *et al*., 2007). Contrary, the SI farms were reported to have an average of 0.206 ±0.005 ha×animal^{-1} grazing land, with 0.095 ha×animal^{-1} being cultivated with grains or forages (Stefanakis *et al.*, 2007). When we investigated these characteristics in areas of Crete where ruminant rearing is the main agricultural activity similar differences were found. The EX farms had an average of 0.743 ±0.033 ha×animal^{-1} of natural pastures available for grazing and the SI farms an average of 0.096±0.001 ha×animal^{-1} (p-value<0.001). The cultivated pastures were 0.008±0.001 ha×animal^{-1} and 0.062±0.009 ha×animal^{-1} respectively (p-value<0.001). The dominant cultivated fodder plant is oat and though grazing starts primarily in December, it is not systematic due to weather conditions and the availability of forage. It is introduced as a daily practice in February and lasts until early summer with a peak for both systems in March.

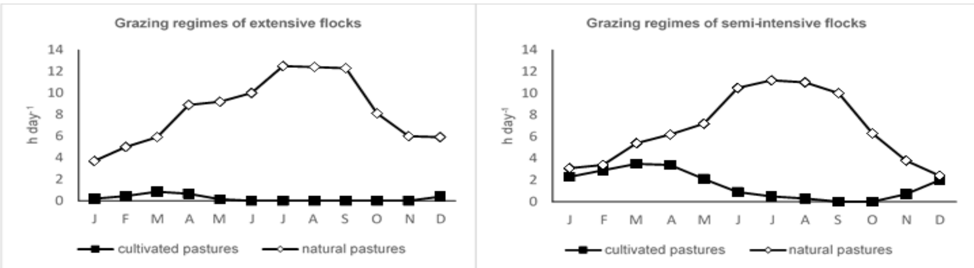

Fig. 2. Grazing regimes of the two management systems within a year (Stefanakis *et al*., 2007, Volanis *et al*., 2007, Voutzourakis *et al*., unpublished data).

While both systems exploited mainly natural pastures during summer, in June the extensive flocks are moved to new pastures at higher elevations, where animals are not always shepherded and graze unattended until September. On the contrary, the semi-intensive flocks are sedentary and grazing time (around 11 h×day^{-1}) remains stable until September. When lambing starts, animals are kept indoors especially in the semi-intensive systems.

Since grazing is closely linked to the climatic conditions the daily grazing time may vary between lactation periods, but these changes are limited. The farmers make use of supplementary feeds (mainly pelleted compound feeds or raw grains) in order to compensate for the shortage of high quality fresh forage. The EX farmers feed on average lower amounts of supplementary feeds, compared to the SI farmers. According to this survey the average amount used annually is 596±31 in the EX flocks and 831±45 g×head^{-1}×day^{-1} in the SI flocks (p-value<0.001); similar amounts have been reported in other studies (Stefanakis *et al.,* 2007; Volanis *et al.,* 2007). During winter the quantities fed are similar between the two systems when grazing is impractical due to weather conditions and lack of good quality fodder. Afterwards, the amount decreases more rapidly in the extensive farms and small amounts of concentrate feed are provided during dry season in the SI farms and in some EX farms. The portion of concentrates in the rations increases again during lambing at similar rates. In cases when the portion of concentrate is high (>70%) or replaced by cereal grains in similar amounts, overgrazing of pasture is observed (Stefanakis A., 2006).

Conserved forage is provided at the beginning September until spring and the amounts are similar between the two systems. This study recorded the amount of 191±5 g×head^{-1}×day^{-1} for the EX farms and 184±5 g×head^{-1}×day^{-1} for the SI farms. Nonetheless, there are seasonal differentiations. During lambing and till winter, higher amounts of hay are used by the SI farms. In contrast, more hay is fed by the EX farmers during milking, in order to compensate for the need of high value forage. As for the hay fed, the farmers used mostly alfalfa hay and secondly self-produced wholecrop oat.

The higher amounts of compound feeds and high quality forage fed, is most likely the reason for the higher milk yield observed in the SI farms. As it has been reported the introduction of supplementary concentrates in a grazing based farming system will increase productivity and may later affect milk composition of small ruminants (Marques and Belo, 2001; Min *et al.,* 2005), thus the most common difference found in milk composition is a higher fat content in the milk of EX ewes, possible due to the dilution effect (Morand-Fehr *et al.*, 2007). Moreover, differences that have been found in milk fat fatty acids concentrations between these two systems (Voutzourakis, unpublished data), with milk from the extensive system exhibiting in general a more preferable fatty acid profile, may be attributed to the aforementioned differences in feeding regimes, as it has been found from previous studies on other ruminants (Chilliard *et a*l., 2007).

IV – Conclusions

Both systems centre their feeding regimes on grazing. However, the semi-intensive managed farms exploit cultivated pastures of annual forages and feed supplementary concentrate and hay to increase productivity. On the other hand the extensive farmers exploit mainly natural pastures. Because of the seasonal availability of these pastures the extensive farmers are forced to apply transhumance practices and use supplementary feed as a mean to meet the nutritional needs of the ewes and boost productivity. If these practices are rationally applied, farmers may be provided with high quality end products, of added value, while utilizing cost-free natural resources and protecting the local environment.

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Rangeland management in Tunisia: Inventory and perspectives under a climate change context

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Abstract. Tunisia rangelands, 25% of the total land area, play an important role in contributing to people's livelihood. Natural rangeland ecosystems decreased in area and production. This is due to the increase of population, its needs in milk, meat and other agricultural products as well as the increase in livestock numbers and needs of fodder units. Current Tunisian rangeland ecosystems consisted of forest and steppe ecosystems, suffer great pressure with an average overgrazing rates that exceed 75%. Projections of climate change in Tunisia for 2030-2050 horizons predict a rise in annual and seasonal temperature and decreased rainfall, with increased frequency of extreme events including the succession of dry years that can have significant impacts on perspectives and developments of the production systems and in particular the rangeland and extensive farming systems which depends largely on livestock feeds. It is concluded that current management of rangelands should be improved to reach more rational management. So, efforts are needed for rangeland management and development of their resources. It is also important to adopt a method of periodic grazing in plots limited, an integrated approach and adaptive management is required to respond to climate change.

Keywords. Rangeland – Management – Climate change – Perspective – Tunisia.

La gestion des pâturages en Tunisie: État des lieux et perspectives sous un contexte de changement climatique

Résumé. *Les parcours en Tunisie représentent 25% de la superficie totale des terres. Ils jouent un rôle important en contribuant à la subsistance des populations. Les parcours naturels ont diminué, ces dernières années, en superficie et en production. Cela est dû à l'augmentation de la population, à ses besoins en lait, en viandes. Les parcours tunisiens actuels, qui se composent principalement des écosystèmes forestiers et steppiques, souffrent une grande pression avec un taux de surpâturage moyen qui dépasse 75%. Les projections climatiques en Tunisie pour les horizons 2030-2050 prévoient une hausse de la température annuelle et saisonnière et une diminution des précipitations, avec une augmentation de la fréquence des événements extrêmes y compris la succession d'années sèches qui peuvent avoir des impacts significatifs sur les perspectives et les évolutions des systèmes de production et en particulier les parcours et l'agriculture extensive dont dépend en grande partie l'alimentation du bétail. La gestion actuelle des parcours devrait être améliorée pour atteindre une gestion plus rationnelle. Ainsi, des efforts sont nécessaires pour la gestion des parcours et le développement de leurs ressources. Il est également important d'adopter une méthode de pâturage périodique dans des parcelles limitées, ainsi qu'une approche intégrée et une gestion adaptative pour répondre aux changements climatiques futurs.*

Mots-clés. *Parcours – Gestion – Changement climatique – Perspective – Tunisie.*

I – Introduction

Tunisia is located in the north of Africa. It has a land area of 16.2 million hectares and has a privileged geographical position at the crossroads of the eastern and western basins of Mediterranean sea, between. Tunisian topography is very varied and landscapes are considerably different from north to south. Mountainous areas are in north and west, steppe is in the centre, vast plains to the north east (Sahel) as well as in the center, and a desert area in the south. Tunisian climate is characterised by rainfall scarcity and a wide variability of rainfall within the year and through the country. The climate is humid (between 1000 and 1200 mm yr^{-1}) at the extreme north, sub-humid in the north and along the coast, and semi-arid and arid in the centre and the south and desertic in the south (between 100 and 150 mm yr^{-1}). According to the latest demographic survey the population in 2014 was estimated as 10,983 million. Between 1960 and 2013 the population increased by 6,665.799 inhabitants (INS, 2014). As in most countries, the greatest challenge facing the management of rangelands is deforestation and degradation, the main causes of which being human activities, including land clearing for agricultural expansion, excessive collection of firewood, production of charcoal and the uncontrolled exploitation of wood. Forest and rangelands development remains lagging behind and the sector suffers because the development of Tunisian agriculture is focused in priority on the development and intensification of agricultural production. climatic projection models available for Tunisia predict an average rise in annual temperatures that could reach by 1.1 to 2.1°C in 2030 and 2050 respectively. The models projection indicate a decrease in annual precipitation by 5-9% in 2030 and 2050 respectively (MARH and GTZ, 2007). Tunisia would be particularly affected by droughts that would be more frequent, more intense and longer-lasting. Drought and wet periods should be more variable between seasonal and intra-seasonal. The main issues of this study concern the rangeland management in Tunisia under a climate change context.

II – Rangelands management in Tunisia

Rangeland management in Tunisia is under one institution, namely General Directorate of Forests (DGF) under the Ministry of Agriculture and Environment. In Tunisia rangelands include different formations like as natural rangelands, Alfa steppe, pastoral plantations, riparian plants and other ranges with forest pastoral land (Fig. 1a). Rangelands cover 27.5 percent of total national area that means 4.5 million ha. This area is distributed in: (1.30 million ha of private area, 2.75 million ha correspond to collective ranges which represent 65 percent of total rangelands, and 0.45 million ha of steppe). Rangelands are important because of their contribution and their forage value for grazing herds composed by sheep, goats, cows and camels (Fig.1b). Rangeland production varies from 1 200 million of UF/year during rainy years and to 450 million in dry years while the needs of the flock are about 4,400 million of UF/year. Rangelands therefore provide about 10 to 25 percent of the needs of the herd.

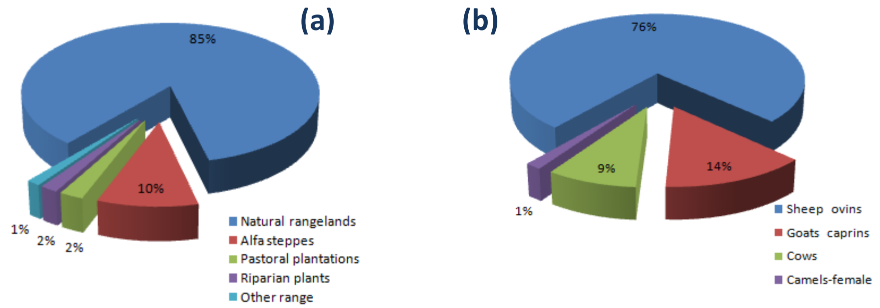

Fig. 1. (a) Area of different kinds of range; and (b) Composition of the herd in Tunisia. Adapted from OEP (2015).

III – Climate change impacts

For most parts of Tunisia, small changes in mean annual precipitation are expected, and under most of the future “emissions scenarios” these are within the range of natural variability. However, shifts towards a higher proportion of the annual rainfall in winter and less rain in summer, have the potential to increase the frequency of years with summer drought stress, leading to reduced security of crop yields on non-irrigated land. An increase in atmospheric CO_2

concentration is one of the most certain outcomes and the one that may have both positive and negative consequences. Elevated CO_2 is likely to affect feed quality for grazing, both in terms of fine-scale and coarse-scale changes. At the farm scale, the consequences for feed budgeting are increased under situations of uncertainty, requiring a greater area allocated for conserved feed to support livestock during periods with limited or no forage production. Heat stress affecting livestock is another serious potential impact affecting the livestock sector, as this can lead to reduced intake liveweight gain and milk production. Climate changes also presents risks of increased spread of vectors of livestock diseases. These are important impacts in the context of seasonally hot, dry regions, like the Mediterranean (Bindi and Olesen, 2011).

IV – Adaptations to climate change

Global climate change is becoming a substantial reality. Tunisia is one of the most susceptible countries to the risks of these alterations particularly on the rangelands level. Indeed, the involvement of natural pasture and rangelands in the feed calendar is declining noticeably because of frequent droughts and over-grazing. The management and the improvement of the existing rangelands, their enrichment by natural regeneration and planting off odder species and pastoral crops may help to alleviate the negative effects related to drought. Planting of woody species adapted to drought would provide not only fodder but also shading and fire wood, as well as environment-related services such as soil improvement, erosion control and soil carbon sequestration. Grazing management techniques intended to increase forage production through increased perennial species have the potential to increase above and below ground soil carbon stocks, and to restore degraded drylands. Rangelands store 30% of the world's soil carbon (Grace *et al*., 2006). Smith *et al*. (2007) estimated that improved rangeland management could globally sequester 0.35–0.55 Gt $C.yr^{-1}$up to 2030. Batjes (2004) estimated that improved management of 10% of the African grazing lands could increase soil carbon stocks by 13-28 $MtC.yr^{-1}$. Rangelands degradation is related principally to agricultural expansion, fuel wood gathering, and overgrazing. Tunisia has prepared and adopted a strategy and national action plan of natural resources (Pastoral plan, soil and water conservation plan, desertification plan, and climate change plan) to address this situation. Strategies adopted have a common basis of perspectives and appreciation of natural resources. Sustainable management of rangelands should be considered as an integral part of national strategies reconciling economic growth, social equity in development and environmental protection. Moreover, in most cases, government institutions responsible for rangelands have policies and programs require better coordination, harmonization, and better integration and improved linkages in land management (Fig. 2).

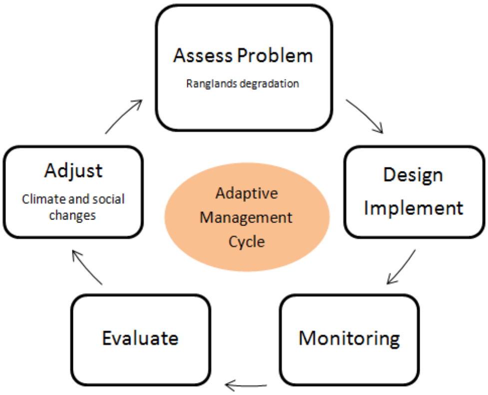

Fig. 2. Adaptive management cycle. Adapted from Williams *et al*. (2007).

V – Conclusions

Maintaining a balance between Tunisian grazed areas remains an important issue, although it does not arise as acutely. Therefore the current management of Tunisia rangelands should be improved to reach more rational management. So, efforts are needed for range management and development of their resources to contribute to climate change mitigation and adaptation. It is also important to adopt a method of periodic grazing in plots limited, so as to control the load exerted by animal on rangeland and preserve resources.

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Grazing land management and sheep farm viability in semi-arid areas: evidence from Western Lesvos, Greece

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Abstract. In semi-arid areas of the Mediterranean basin, sheep and goat herding has been a land management activity for millennia. In the last decades, intensification of grazing has resulted in grazing land degradation. Today, many sheep farms face growing dependence from feed to cover the dietary needs of animals, as grazing land productivity covers only a fraction of these needs and decreasing economic outputs. In this paper, we present a conceptual framework for linking grazing lands management practices and economic viability of sheep farms in Agra, a village in Western Lesvos. The framework required data from grazing lands (biomass production in four periods of the year, plant diversity and plant composition), production and quality of milk and economic viability of four sheep farms. Some insights and initial results of the first year of the research are presented and discussed.

Keywords. Grazing land – Sheep farming – Grazing pressure – Lesvos.

Gestion des pâturages et viabilité des exploitations agricoles ovines dans les zones semi-arides: constats dans l'ouest de Lesbos, Grèce

Résumé. *Dans les zones semi-arides du bassin de la Méditerranée, l'élevage ovin-caprin contribue à la gestion des terres depuis toujours. Dans les dernières décennies l'intensification de l'utilisation des pâturages a entraîné leur dégradation : actuellement de nombreuses exploitations ovines affrontent une dépendance croissante pour couvrir les besoins alimentaires des animaux du fait que la productivité des pâturages ne couvre qu'une proportion de ces besoins, ce qui contribue à la diminution de leurs résultats économiques. Dans cet article, nous présentons un cadre conceptuel pour relier les pratiques de gestion des pâturages et la viabilité économique des exploitations ovines à Agra, un village dans l'ouest de Lesbos. Ce cadre était alimenté par les données nécessaires provenant de pâturages (production de biomasse dans quatre périodes de l'année, diversité végétale et composition de la flore), de la production et de la qualité du lait, et de la viabilité économique de quatre exploitations ovines. Certaines idées ainsi que les résultats de la première année de la recherche sont présentés et discutés.*

Mots-clés. *Pâturages – Élevage de moutons – Pression de pâturage – Lesbos.*

I – Introduction

Grazing of small ruminants (sheep and goats) has always been an integral part of the ecology of many areas of the Mediterranean, especially in semi-arid regions (Kıfi *et al*., 2007). In the past, these systems were integrated with agriculture, involving practices such as mixed farming, fallow and rotational grazing. Intensification of agriculture, the gradual stop of many of the mixed practices and the widespread rural exodus, separated animal husbandry from other agriculture sectors (Kizos *et al*., 2013). For sheep farming, these developments were expressed by the decrease of the number of sheep farms and the increase of sheep per farm, while supplementary feeding was made dominant practice. The recent increase of input costs (especially feeding costs) was not coupled by an equivalent increase of milk prices and this has squeezed profit margins for most sheep farms in semi-arid and/or marginal regions. Moreover, intensification is associated with high grazing pressure, caused by either high densities and/or continuous grazing, which result in the reduction of grazable species in vegetation. In areas of unfavorable pedo-climatic conditions, this leads to severe soil degradation (Kıfi, *et al*., 2007; Papanastasis *et al*., 2015; Symeonakis *et al*., 2014; Kizos *et al*., 2013). Any effort to overcome this dead-end that sheep farmers in such areas seem to face should be based on research on environmental, economic and social aspects of sheep farming systems and their operation, such as the viability of farms, the quantity and quality of its outputs, the volume and cost of inputs, the grazing practices, the productivity and use of grazing lands. So far, the relevant bodies of literature tend to focus on some of these aspects only (e.g. Kıfi, *et al*., 2007; Thornes, 2007; Noguıs-Bravo, 2006).

In this paper, we explore social, economic and environmental impacts of sheep farms in a semi-arid location, on Lesvos Island, Greece. Lesvos Island has a long tradition in sheep farming, but in recent decades farmed sheep increased sharply and pasture lands became insufficient (Hadjigeorgiou *et al*., 2010). The main objectives of the study were to combine grazing lands management, with the actual feeding patterns of the farm, its economic results, the quality of its products and its future. They also call for a combination of research approaches at the farm and the grazing land level. The farm level is vital for understanding and recording grazing and feeding practices, but also for estimating the viability of farms, while the grazing land level is necessary for measuring grazing related attributes of plant communities.

II – Materials and methods

The objectives of our approach were: (a) To measure primary productivity of grazing lands throughout the grazing period; (b) To estimate plant cover throughout the grazing period; (c) To estimate plant diversity in grazing lands; (d) To record supplementary feed provided throughout the grazing period; (e) To record prices and volumes of inputs (feeds) and outputs (milk, meat, etc.) of the sheep farms; (f) To collect data on quality of produced milk produced; (g) To record opinions and attitudes of sheep farmers towards the viability of their farms and their future. These objectives combine grazing lands management, with the actual feeding patterns of the farm, its economic results, the quality of its products and its future. They also call for a combination of research approaches at the farm and the grazing land level. The farm level is vital for understanding and recording grazing and feeding practices, but also for estimating the viability of farms, while the grazing land level is necessary for measuring grazing related attributes of plant communities.

The area selected was Western Lesvos (Agra). Western Lesvos is a typical semi-arid Mediterranean area with very high grazing densities, high dependence on sheep farming for livelihoods and incomes and soil degradation (Kizos *et al.*, 2013). Agra is a settlement of approximately 1000 people, located in the southwestern part of Lesvos (Table 1). It has lost a significant part of its population in the last decades and sheep farming is an important part of local livelihoods. It has been intensified recently with a fourfold increase of the number of sheep between 1961 and 2010 (Table 1).

Table 1. Data from the livestock census of the study area (Agra)

Date	Pasture area (ha)	Sheep farms	Sheep heads	Sheep / farm	Permanent residents
1961	2750.3	224	7733	34.5	1572
2010	4958.2	213	30741	144.3	1013
1961-2010 %	80.2%	-2.3%	297.5%	418.2%	-35.5%

The selection of the four farms with 16 grazing parcels was made considering sizes and locations. We chose to select closely located farms to eliminate differences attributed to soil and micro climate, but care was also taken to include lowland and more uphill grazing lands. Size of farms (assessed by the number of sheep and not the area of land) was selected to be medium to high for both Agra and Lesvos standards, as we aimed to avoid small and part-time farmers and the few very big farms with animals housed indoors. Another important aspect for the selection of farms was the availability of their owners to participate. Their cooperation was also of significant importance for recording grazing and feeding practices, including aspects such as the number of days and the season they graze each particular parcel, inputs and outputs, etc. Finally, we preferred farms with Lesvos sheep.

Measurements of biomass production were conducted in all grazing lands with the use of 0.25 m^2 cylinder shaped metal cages (made of galvanized grid of 1x1.2 cm openings) and 0.7 m height anchored on the ground. We used four cages in each sampling location for each grazing parcel: two were placed at the beginning of the grazing season (September), one of them left unharvested for the entire season, the second one harvested in the 1st sampling period (December) when a third cage was added. In March (2nd sampling period) the third cage was harvested and a fourth added, which was harvested in May (3rd sampling period). Finally in June all the four cages were harvested. In each sampling we also collected above ground biomass of a grazed space area of equal size with the cage and were able to monitor the impact of grazing throughout the year against the productivity of the grazing land (Singh *et al.,* 1975).

Measurements of land cover were conducted by recording the cover of 50 continuous steps along a line, representative of the grazing parcel and repeated the recordings for each parcel several times to cover habitat heterogeneity. Land cover categories used were: herbaceous vegetation, bare soil, rocks, thorny burnet (*Sarcopoterium spinosum*), branched asphodel (*Asphodelus ramosus*) and other shrubs. We repeated these measurements in each sampling period. This provided us with a very good image of the cover and its changes throughout the season. Plant diversity assessment was made at the end of the grazing period. We collected and dried samples of all cages during the last sampling and classified plants at the family, genuses and species levels when this was feasible. Data on feeding and grazing practices were recorded from farmers in a number of personal interviews, along with prices and volumes of inputs and outputs. Finally, quality parameters of the milk produced by these farms, were obtained through analyses conducted by the Greek National Milk and Meat Organization.

III – Results and discussion

The four selected farmers are young (the older 43 year old, the younger 33), all of them of secondary education at the most. Their farms are 50 ha of grazing lands (three also use common pasturage for small periods of time) and 335 sheep on average and are quite large compared to local averages. Only one farm is smaller in size or 210 sheep and 5.6 ha of grazing lands. The larger three farms own automatic milking machines. They all report moderately satisfied with sheep farming incomes (including subsidies: all receive the Single Farm Payment and the compensatory payment from the Less Favored Areas scheme), but stress rising costs, including feed.

Although the second year of the experiment is on the way, some preliminary results demonstrate the relevance of the approach. We were able to monitor seasonal changes of biomass production, with more important differences in autumn and winter when plant growth is slow and less differences between grazed and ungrazed areas in the spring. This is also reflected in the differences between biomass production of grazed areas (Fig. 2B, the differences of means are statistically significant, ANOVA F = 7,045, P <0,001).

All farms provided supplementary feed at least to the producing (high dietary requirements) animals (milking females and replacement lambs) during the recording periods, which indicates that the grazable biomass production was either not sufficient for covering dietary needs or farmers considered that it was not sufficient. Land cover is dominated by herbaceous (56.3% of total cover, while rock covered 19.2% of total, *S. spinosum* 12.3%, *Aspodelus spp.* 9.2% and bare soil 3.1%), with 12.7 / 0.25m^2 annual species on average for ungrazed areas for the whole season, compared to 7.4 / 0.25m^2 species for grazed areas in June (these differences of means are statistically significant, ANOVA F=20,43, p<0.001), which are comparable with those reported in similar semi-arid locations (e.g. Noor Alhamad, 2006).

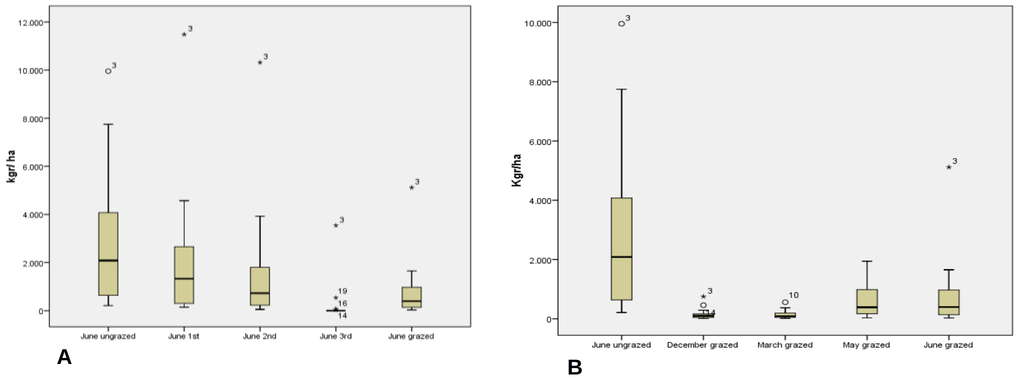

Fig. 1. Boxplots of biomass production (kgr/ha) for: (A) control cage, all cages and grazed area in June; (B) control cages and grazed areas in all sampling periods.

IV – Conclusions

These first results demonstrate the high dependence of sheep farming on imported feeds, but also the strong connection with available land although it can only highlight some aspects of the research objectives. The second year of sampling, the analysis of the data with the use of grazing densities as well, is expected to provide more insights.

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Session 4
Rehabilitation of Mediterranean grasslands

Rehabilitation of Mediterranean grasslands

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Abstract. The grasslands in the different Mediterranean zones around the world are an important component of the landscape. In the past, the central goal of managing these grasslands was to maximize the utilization of the forage resource for animal production. Nowadays the ecological point of view plays an important role as well. During the last several thousands of years the open lands around the Mediterranean Sea were often under heavy human utilization. Therefore these grasslands are mostly anthropogenic ecosystems maintained in dynamic equilibrium by cultivation, fire and intensive grazing. Consequently, a large part of these areas are considered degraded and their productivity is low. Human interventions are required in order to repair these degraded lands. Where degradation is very heavy and the land has no capacity to reach a high productive level, different interventions are essential. Rehabilitation or restoration of grasslands, which is the conversion of the degraded land into a functional ecosystem suitable for high forage production, is one of the options. This strategy can include a range of different eco-technological activities such as: controlled grazing, introducing annual and/or perennial legumes and grass species, controlled fire, input of exogenous nutrients (particularly phosphorus or nitrogen) and herbicide application. The goal of this paper is to present a short overview of rehabilitation measures that can be applied to increase forage production of degraded Meiterranean forage ecosystems.

Keywords. Degradation – Exogenous nutrients – Grazing – Restoration – Sown pasture.

Réhabilitation des pâturages méditerranéens.

Résumé. *Les pâturages dans les différentes zones méditerranéennes du monde sont une importante composante du paysage. Dans le passé, la finalité centrale de gestion de ces pâturages était de maximiser l'utilisation des ressources fourragères pour la production animale. De nos jours, le point de vue écologique joue aussi un rôle important. Pendant les derniers milliers d'années, les terres défrichées autour de la mer Méditerranée étaient souvent soumises à une lourde utilisation humaine. Toutefois ces pâturages sont principalement des écosystèmes anthropogéniques maintenus en équilibre dynamique par les cultures, le feu et le pâturage intensif. Par conséquent, une grande partie de ces zones sont considérées dégradées et leur productivité est faible. Les interventions humaines sont nécessaires afin d'améliorer ces terres dégradées. Là où la dégradation est très lourde et la terre n'a pas la capacité d'atteindre un niveau productif élevé, différentes interventions sont essentielles. La réhabilitation ou la restauration des pâturages, qui est la conversion des terres dégradées en un écosystème fonctionnel convenant à une forte production de fourrage, est une des options. Cette stratégie peut inclure une gamme de différentes activités éco-technologiques telles que: pâturage contrôlé, introduction d'espèces de légumineuses et de graminées annuelles et/ou vivaces, brûlage contrôlé, intrants de nutriments exogènes (en particulier phosphore ou azote) et application d'herbicides. Le propos de cet article est de présenter une courte révision des mesures de réhabilitation pouvant être appliquées pour augmenter la production de fourrage des écosystèmes fourragers méditerranéens dégradés.*

Mots-clés. *Dégradation – Nutriments exogènes – Pâturage – Restauration – Pâturage semé.*

I – Introduction

Grassland is defined as pastureland when referring to an imposed grazing-land ecosystem. The vegetation of grassland in this context includes grasses, legumes and other forbs, and at times woody species may be present (Allen *et al*., 2011). As for the Mediterranean grasslands, which are characterized by broadleaved, sclerophyllous, evergreen trees and shrubs (Raven, 1973), this definition can be expanded and also include these vegetation types. According to Le Houerou (1992), in the Mediterranean basin most native stands are depleted either by woodcutting or by overgrazing or both, and many of them have been cleared for cereal cultivation with poor results in the long run. The annual Mediterranean grasslands are an important component of these areas mainly for animal production. In many cases they are considered to be in an extreme state of degradation or mostly an artifact maintained by cultivation, fire, and grazing against the continuing pressures of the invasion and regeneration of woody species (Seligman, 1996). In all cases, they are anthropogenic ecosystems (Tansley, 1935).

Generally, land use and with it the status and role of Mediterranean grasslands have undergone change during the last millennia (Nave and Dan, 1973). In countries around the Mediterranean basin, deep, fertile valley soils have been cultivated since the dawn of agriculture and have supported one of the more stable, sustainable systems of land use in the world (Seligman, 1996). In other Mediterranean zones in the new world agricultural land use is also intensive but its history is related to the relatively recent colonization of these countries. As fertile cultivated valley soils were finite, along the years people also cleared and cultivated shallower, rockier and more fragmented land areas (Nave and Dan, 1973). With time many of these marginal sites were abandoned and much of the land reverted to sclerophyllous woodland, dwarf shrub formations interspersed with grassland species such as annuals, but also hemicriptophytes (Nave and Dan, 1973; Noy-Meir and Seligman, 1979; Shmida, 1981).

Traditionally, the central goal of grassland management was maximizing the utilization of the forage resource for animal production. Forage utilization of the Mediterranean system depends on the type and seasonality of the vegetation, scale of enterprise, class of livestock, stocking rate, grazing management system, infrastructure, land tenure and socioeconomic context (Seligman, 1996). The annual cyclic change that is of greatest significance for animal production in Mediterranean pastoral systems is the cycle of forage availability and quality. The cool, wet Mediterranean winter and hot and dry summer impose strong seasonality that favors annual species and drought-resistant perennials (Seligman, 1996). It is therefore common to find in Mediterranean grasslands many species well adapted to long dry spells and grazing (Perevolotsky and Seligman, 1998). But as shown by Jackson (1985), where summer conditions are milder, perennial grasses and forbs are more prominent. The perennial grass species were found to be rare on productive soils of Californian rangeland (Wester**,** 1981), while more common on poorer sites with shallow soils, where competition with annuals is less severe (Edwards, 1992).

Systems with an herbaceous layer dominated by annuals were found to be more prone to ecosystem degradation under future global change regimes (Ruppert *et al*., 2015). Grasslands, like the *dehesa* of Spain, are found mostly on soils with fertility constraints that preclude the continuous cultivation practiced in the more fertile and usually deeper and heavier valley soils (Seligman, 1996). So, where traction (by animal or by machine) is feasible, grasslands have been maintained by periodic cultivation. In addition, it was shown (Ruppert *et al*., 2015) that increasing drought intensity reduced ecosystem resistance, and that annual systems were less resistant than perennial herbaceous systems. In contrast, annuals were found to recover faster after droughts than perennials (i.e., they are more resilient), especially under grazing. Coiffait-Gombault *et al*. (2012) showed low resilience of an old dry herbaceous Mediterranean ecosystem after human disturbance. Sternberg *et al*. (2015), on the other hand, showed high resistance of Mediterranean grassland in north-eastern Israel to grazing intensity and inter-annual fluctuations in climatic conditions.

In general, disturbance is an important factor in many ecosystems. Variations among disturbance regimes can affect ecosystem and community structure and their functioning (Hobbs and Huenneke, 1992). As mentioned, many of the open lands of the Mediterranean climate zone were under heavy human utilization during the last several thousands of years; this includes grazing at high stocking densities, which sometimes lead to degradation of the land. Grazing is the most degrading type of land use in the world (Papanastasis, 2009), particularly in arid and semiarid areas. According to Ghassali *et al*. (1999), the land degradation in north Syria was caused by greatly increased populations of people and livestock which led to overgrazing, the uprooting of shrubs and trees for fuel and the encroachment of cultivation. As a result, the original perennial vegetation has been replaced by low densities of annuals and unpalatable spiny species. Also, in China it was shown that large parts of the rangelands have recently become degraded and desertification is a widespread problem, while the cause of degradation is over-grazing and over-cultivation (Han *et al*., 2008).

Human interventions are required in order to repair these degraded lands for increased forage production. In some cases, where degradation is light, the system is capable of returning to the lands' basic state, but in other cases, where degradation is severe there is no capacity of the land to reach a high productive level. According to Aronson *et al*. (1993a), rehabilitation of grasslands is the conversion of degraded land into a functional ecosystem suitable for forage production by a range of intervention strategies. Attempts to rehabilitate former ecosystem structure and functioning, both above- and below-ground, are the best ways to conserve biodiversity and ensure sustainable long-tern productivity in ecosystems subjected to continuous use by people in arid and semi-arid lands (Aronson *et al*., 1993b). However, in addition to the need for repairing the degraded landscapes, in many cases the basic production state of the natural grasslands in the Mediterranean zone is very low and a high cover of un-palatable shrubs is found. The improvement of these low productive areas can be facilitated by applying different interventions in order to increase significantly utilization and forage production of the land.

The goal of this paper is to give a short overview into the rehabilitation of degraded/low productive Mediterranean grasslands and the strategies that can be used in order to achieve this aim. Aronson *et al*. (1993a) have argued that for ecosystems subjected to long periods of human disturbance, three alternatives to continued degradation can be defined: restoration, rehabilitation and reallocation. Reallocation, which is assigning a new use to the landscape that does not necessarily bear an intrinsic relationship with the pre-disturbance ecosystem's structure or functioning (Aronson *et al*., 1993a)**,** will not be discussed in this paper.

II – Sown pastures for grassland rehabilitation

In order to achieve significant improvement in forage production in degraded and/or poor natural grasslands, the question to be decided on, in order to enhance this goal, is which activities should be included in the rehabilitation process. Accordingly, it will be possible to apply different intervention actions, while first of all focusing mainly on the functioning of the land and repairing it by recovering its compatibility for grazing. For this purpose lengthening the green season and improving the quality of dry-season pasture has been an ongoing research objective, while examining the possibility of introducing annual legumes (Ewing 1999), annual grass species and perennial grasses (Menke, 1988).

As soil degradation limits the potential of the re-establishment of native plants, biological nitrogen fixation can play an important role in land remediation (Perez-Fernandes *et al*., 2004). Sown pastures that are relatively recent newcomers to the agricultural scene, particularly in the Mediterranean region (Davis, 1952), can serve as one of the more effective strategies for improvement of the landscape for forage. In Australia, the introduction of sown annual pasture legumes and also annual grass in rotation with wheat were already common during the 1930s on drier and more basic soils (Seligman, 1996). By 1970 much of the wheat-sheep belt in Australia was under sown self-seeding legumes and mixed annual species pasture. This strategy of sowing pastures for rehabilitation of grasslands has become more common during the last few decades and is applied in many grazed landscapes of the different Mediterranean zones.

1. Introducing annual and perennial legumes and grasses

Productivity can be enhanced by a range of interventions that favor annual forage legumes, as they are essential components of the Mediterranean grazing resources for ensuring balanced feeds to ruminants (Papanastasis and Papachristou, 2000). Accordingly, the efforts to introduce annual pasture legumes in the different Mediterranean regions of the world are continuing (van Heerden and Tainton, 1987; Ovalle *et al*., 1993). It is important to establish the annual legumes' ability to grow widely, while being a productive element of systems nitrogen fixation, and to be part of the anticipated land-use system (Ewing, 1999). As such, these species have the attributes required to be useful in practical programs to rehabilitate degraded ecosystems (Ewing, 1999). The main mechanisms of germination control in the reproductive regeneration of annual legumes are seed bank dynamics, hard seededness and its breakdown pattern (Sulas *et al*., 1999; 2000).

The possibility of improving pastures in marginal lands by sowing wild Lucerne (*Medicago sativa* L.) and annual medics (*M. polymorpha* L., *M. truncatula* Gaerten and *M. rigidula* All.) was studied on uncultivated land at Ballobar, Spain (Delgado *et al*., 2000). In the "Espinal" – Mediterranean agroforestry system of dryland in Chile, experiment results confirm that legumes adapted to dryland conditions for ecological and economic rehabilitation showed rapid beneficial effects on productivity, soil, biodiversity and total value (Ovalle *et al*., 2008).

The southern Australian Mediterranean agriculture system depends heavily on annual pasture legumes grown in rotation with cereals and subterranean clover, and annual medics as the dominant species (Loi *et al*., 2000). In the more humid regions of South Australia, the perennial Mediterranean grass, *Phalaris maritima*, generally with *Trifolium sub-terranean* is the basis of intensive pasture. Annual legume pastures such as those of the dryland farming system of southern Australia have shown the potential to increase productivity in most of the Mediterranean-type environments (Puckridge and French, 1983). The value of legumes as nutritious food and forage crops and for soil rehabilitation has been recognized for thousands of years, but the use of self-regenerating annual species of *Trifolium* and *Medicago* in rotations with cereal crops is a southern Australian development (Puckridge and French, 1983). Therefore, a broad range of annual pasture legume species have been evaluated in Australia, with a particular focus on the needs of emerging farming systems. The development of new pasture legumes should consider traits that confer ease of domestication, as well as those of high productivity and persistence (Loi *et al*., 2008). Historically, *Trifolium* and *Medicago* have been the dominant genera, but in addition, many other species were tested. One of the additional options is the agronomic adaptation of *biserrula*, whose ease of seed harvesting and processing were compared with those of current pasture species with highly desirable attributes (Carr *et al*., 1999).

In addition, the introduction of annual and perennial legumes and grasses for sown pastures was tested in different countries around the Mediterranean basin. A series of experiments on communally-owned grasslands in the barley-livestock zone of north Syria were conducted to test the hypothesis that introduction of Mediterranean annual legumes will increase productivity. In those studies a response in biomass was shown to be limited to the seeding of the legume component, although total biomass increased (Ghassali *et al*., 1999). In Algeria**,** Sulla *(Hedysarum coronarium)*, a perennial legume, was examined. The results showed that this species should be developed, particularly in isolated and disadvantaged areas to which it could be adapted (Issolah and Yahiaoui, 2008). In addition, Chebouti and Abdelguerfi (1999) evaluated 48 populations of *Medicago orbicularis* (L.) Bart, for flowering time and for winter and spring growth. In Tunisia, Lucern (alfalfa) is known to be the most important sown perennial fodder as well (Loumerem *et al*., 2008).

In Chile, South America, Del Pozo and Aronson (2000) presented examples of inter-and intra-specific differences that can be useful when introducing or disseminating annual legumes for pasture improvement, rehabilitation, erosion control and/or long term soil restoration programs.

They showed range managers that the development of appropriate mixtures of species and accessions for combined use is a promising strategy.

In addition, annual and perennial grass species were tested for rehabilitation of the land in different Mediterranean zones around the world. This included *Dactylis glomerata*, followed by *Lolium perene* and *Phalaris aquatica*, which were introduced in the *Montado* areas of Portugal and showed high persistence (Carneiro *et al*., 2008). Some spontaneous populations of tall fescue originating from five different countries were also studied in Algeria (Mohguen and Abdelguerfi, 1999). In addition, variability and productivity of 13 autochthonous populations of *Lolium rigidum* from Aragon, Spain, were also studied in order to use this species as a self-reseeding annual grass (Delgado and Andres, 1999).

2. Introducing perennial nutritious shrubs and trees

Using forage shrubs to improve the quality of dry-season pasture has been an ongoing research objective for some time (Le Houerou, 1980). *Atriplex* spp. were tested (Le Houerou, 1992) in addition to different herbaceous legume and grass species in the Mediterranean basin as a means of arid land rehabilitation, since huge areas in the region had undergone processes of severe degradation or had been subjected to desertification, particularly over the past four decades. Planting *Atriplex* spp. was found to be one of the most efficient ways to reclaim these lands, as its planting can achieve spectacular results in two to three years, with higher productivity than the range under pristine conditions (Le Houerou, 1992).

Using leguminous shrubs could improve pastoral value. Introduction of inoculated shrubby legumes as a pioneer species is important and was found to ameliorate the characteristics of the soil (Perez-Fernandes *et al*., 2004). Some native legumes typical of semi-arid Mediterranean areas, such as *Coronilla minima* ssp., *Lotoides* (Kock) Nyman and *Anthyllis cytisoides* L. or *A. terniflora* (Lag.) Pau, are abundant at intermediate stages of succession and were shown to have potential as fodder shrubs (Ibanez and Passera, 1997; Robles *et al*., 2002). Some of the legume shrubs provide highly palatable forage and the protein content of their foliage is often regarded as an important nutritional supplement for the low quality dry summer pastures. Outstanding species among these are the trees medick (*Medicado arborea*) and tagasaste (*Chamaecytisus palmensis*) (Seligman 1996). Introducing *Bituminaria bituminosa*, which is a widespread Mediterranean perennial leguminous bush species, may potentially serve as a fodder crop in Mediterranean grasslands (Sternberg *et al*., 2006) as well. In this case, preliminary results indicate that there is enough variability in *Bituminaria bituminosa* to select lines with high rates of seed production, retention and germination (Correal *et al*., 2008). Growing this plant in dense stands in rotational paddocks may provide alternative sources for natural fodder protein and for reducing the potential costs of artificial feed supplements (Sternberg *et al*., 2006). Nevertheless, the lack of proved benefits for livestock production from forage shrubs has restricted the large scale development of these plantation projects (Seligman, 1996).

3. Mixed species grassland for pasture

At the landscape level, legumes can be combined with other herbaceous or woody species as part of the agro-pastoral or silvo-pastoral systems (Papanastasis and Papachristou, 2000). As so, the best model to optimize both livestock nutrition and environmental impacts was shown to be the perennial grass-legume mixture (Lelievre *et al*., 2008). In an experiment conducted in Sardinia, Italy it was suggested that mixtures are important for pasture improvement. It was found that sowing a simple mixture of 4 or 5 species is probably the most cost-effective way for farmers to improve or establish a balanced mixed pasture (Franca *et al*., 2008). In another case, a 4-species mixture of grass/legume and fast/slow establishing species (*Lolium rigidum, Dactylis glomerata, Medicago polymorpha and Medicago sativa*) were examined. The results suggest that the use of mixtures of different functional types may increase productivity and its seasonal distribution and decrease the growth of unsown species (Porqueddu *et al*., 2008). However, to date only few adapted perennial cultivars have been registered and only seeds from French and Australian cultivars are available. As a result, there is insufficient use of these grasses (Lelievre *et al*., 2008).

III – Ecotechnologies for improving forage production

Rehabilitation of the land is required in degraded Mediterranean grasslands after long periods of continuous disturbances, including heavy grazing, as well as other human activities. Many of these Mediterranean lands are usually characterized by soils that are deficient in one or more plant nutrients (Seligman, 1996) and the productivity of the herbaceous vegetation is very low. Therefore, without any additional treatment to the land, a high cover of the unpalatable shrubby component is a common phenomenon. In order for the competition of herbaceous vegetation to be effective against shrub encroachment, soil fertility should be high enough to allow vigorous seasonal growth of the herb species (Zohary, 1973). In such a shrubby vegetation state, with no additional treatments, the natural succession process will not lead towards the recovery of the vegetation to a highly productive state of forage for grazing. A large part of these lands are characterized by a dense cover of unpalatable plants, mostly shrubs with low value for animal grazing. Therefore, in order to achieve significant improvement it is necessary to apply different artificial interventions.

Effective rehabilitation requires technologically appropriate inputs for the prevailing socioeconomic circumstances (Ewing, 1999). As shown by Sternberg *et al*. (2015), grazing pressure influences the species composition of the grasslands. Accordingly, modifying grazing management on degraded grazing land can very well contribute to its recovery process. But this can be achieved where only the grassland's biotic functions have been damaged. In this case, an appropriate grazing management regime should include a stocking rate adjusted to the grazing capacity of the restored land, the right kind of animal species, and an appropriate grazing system (Papanastasis, 2009). In other cases, where the physical environment has been damaged too, an appropriate grazing management by itself is not enough in order to restore the degraded grazing lands (Papanastasis, 2009). Accordingly, effective strategies are required for the rehabilitation of the grassland and for the improvement and establishment of the forage. These strategies should include combined treatments in addition to control of grazing (intensity and timing), such as fire, input of exogenous nutrients (particularly phosphorus), herbicide application (Henkin *et al*., 1996,1998), and the addition of legume seeds (Ewing, 1999).

In the Aegean island of Lesvos, Greece most of the grazed areas were invaded by the dwarf shrub *Sarcopoterium spinosum*; a rehabilitation trail was designed therefor increasing forage production. The strategy included removal of plant cover by mechanical means, fertilization, reseeding with a mixture of *Dactylis Glomerata*, *Medicago sativa* and *Trifolium subterraneum* and protection from grazing. In that study it was shown that rangeland rehabilitation in semi-arid islands, including removal of undesirable plants, is feasible through a combination of mechanical treatment, reseeding and animal grazing (Hadjigeorgiou *et al*., 2008). In another study conducted in the Western Galilee, Israel, on lands that were dominated by the dwarf shrub *Sarcopoterium spinosum*, it was shown that under an appropriate management system including: grazing, periodic control of the shrub component, and occasional soil nutrient amelioration can lead to the development of attractive open woodland with a productive herbaceous understory (Henkin, 2013).

In different studies it was shown that productivity of herbaceous vegetation on P deficient soils is very low and consequently vegetation highly responds to P enrichment of the soil. It was shown that phosphorus fertilizer alone increased herbage growth, while inducing dominance of annual legumes (Rossiter, 1966; Ofer and Seligman, 1969; Osman *et al*., 1991; Osman and Cocks, 1993; Henkin *et al*., 1996, 1998, 2000, 2010). The above-ground biomass of herbaceous sward patches increased not only as a consequence of nutrient amelioration, but also because of reduced competition with the lower shrub cover following fire and/or herbicide application (Henkin *et al*., 1998). On the other hand, it was shown that shrub recovery, which was dependent on its residual cover in the first year following fire and/or herbicide treatment, was further retarded by competition with the vigorous herbaceous vegetation that benefited from nutrient amelioration (Henkin *et al*., 1998). Moreover, a long-term shift in productivity of the herbaceous component of the grazed ecosystem was found to be triggered by a P nutritional pulse that induced a feedback loop based on changes in the botanical composition of the herbaceous vegetation, the animal- vegetation interaction, grazing and supplementary feeding regimen of the cattle (Henkin *et al*., 2010). But although legumes dominated the botanical composition of the sward for more than ten years as a response to a single P application (Henkin and Seligman, 2000), in order to maintain the dominance of the herbaceous vegetation in the long-term, it may be necessary to repeat the treatments after 10 years (Henkin, 2013). Application of N fertilizer is also important for rehabilitation as it can stimulate early growth and shorten the period of early-season pasture scarcity even in the semiarid margins of the Mediterranean zone (van Keulen and Seligman, 1992).

The Australian agro-ecological context is also characterized by severe phosphorus deficiency in many of the soils. Vegetative growth, especially of annual N-fixing leguminous species, is found to be very responsive to the application of phosphorus fertilizer and provides high-quality forage and a modest but significant and cheap source of N (Cock, 1980). In addition, the legumes were found to boost the yield of wheat in the rotation and the growth of other nitrophilous annuals. Thus, the use of subterranean clover *(Trifolium subterraneum* L.) and various *Medicago* species, together with applications of superphosphate is common in Australia in order to improve soil fertility and increase cereal yields, and consequently with the result of greater sheep and cattle production (Puckridge and French, 1983). In Australia, because of the severe phosphorus deficiency in many soils, fertilizers have been applied for a long period to annual Mediterranean-type pasture as a routine practice (Wild, 1958).

Papanastasis and Papachristou (2000), in Greece, also showed that the presence of forage legumes can be enhanced by appropriate management including proper grazing combined with balanced fertilization, seeding, planting and prescribed burning. In Lebanon, Osman *et al*. (1999) showed that significant improvement of pasture productivity was found in degraded Mediterranean pasture after sowing with native legumes, fertilization and exclusion of grazing during April-May. This raise was followed by an additional increase in economic benefits for the users.

The methods of improving the pastures in the Exdtremadura "dehesa" in Spain are based also on a combined treatment strategy including: sowing of legumes, phosphorus application and grazing (Viguera *et al*., 2000). The improvement and exploitation of the "dehesa" agro-silvopastoral systems in Spain must be founded on the principles of preservation of the environment and the idea of creating systems that can be maintained by correct usage of natural resources. Fertilization of the natural pastures, the introduction of new pasture species and varieties, the favoring of the bush species that are of high forage value and the preservation of the arboreous stratum are methods which allow to preserve that ecosystem (Olea and Viguera, 1999). But, one obvious interpretation is that plantations carried out on harsh sites would require higher technological inputs and investments to achieve a given target than those on less harsh sites (Vallejo *et al*., 2012).

IV – Restoration and conservation for biodiversity and amenity

In general, rehabilitation will not lead to a change in land functioning but to a different and improved vegetation composition and land structure. Restoration is the conversion of degraded ecosystems to the pre-disturbance status of the land, which means recovery of what was lost, while the main target is not improvement of production. According to Aronson *et al*. (1993a), ecological restoration is a complete or near-complete return of a site to its pre-existing state and it takes in account structure, functioning and composition of vegetation. Resilience, which is the ability of the ecosystem to recover after a disturbance, and stability, which is largely determined by the dominant herbaceous life history, plays an important role in this process. Where the return to pre-disturbance status is possible, restoration of the land is a feasible aim; if conversion to a pre-disturbance/pre-degraded status is no longer possible and the target is increasing productivity, rehabilitation must be achieved.

As defined, restoration of ecological communities is important to counteract the global losses in biodiversity (Bullock *et al*., 2001) and in species-richness (Pywell and Putwain, 1996; Young, 2000). An increase in richness could be a restoration management target in degraded ecosystems (Bonet, 2004); in some cases it suggests maximizing high quality herbage production in re-sown grasslands by maximizing biodiversity (Bullock *et al*., 2001). In a study conducted by Bullock *et al*. (2001), they restored biodiversity, not only achieving a higher species number in a species-rich treatment, but also establishing plant communities which resemble their semi-natural target communities. In any case, it is the fragmentation and degradation of the landscape that both restorers and rehabilitators must combat with. Restoring a degraded landscape can be achieved by different interventions. It was shown that endozoochory, cattle dung application, also has a potential to be a highly effective mechanism for the dispersal of viable seeds in Mediterranean grasslands, but this is important particularly for restoration of species-richness in abandoned pastures (Traba *et al*., 2003).

In terms of conservation, there are two processes that have dominated the Mediterranean ecological scene for a long period of time. One is the successional process that in many cases ends with the dominance of woody vegetation and the strong continuous involvement of humans in affecting the local landscape and ecosystem. Conservation, which is defined as the preservation of an existing ecosystem, as restoration does not aim to improve the production system, and can include few external interventions. Consequently, the problem is that nature conservation practices within such a context should start with a decision concerning what the natural state to be preserved is (Perevolotsky, 2004). If the Mediterranean annual grassland is the pioneer stage after a short or long-term disturbance, the question will be, to what stage of plant formation along the successional trend, the conservationists are aiming.

One of the options for conservation is complete abandonment of the land. It was shown that areas at different abandonment stages and under different moderate grazing regimes will contribute to higher diversity (Bonet *et al.,* 2001). However, intensification or abandonment of grazing could both lead to land degradation (Bonet, 2004). Land use previous to abandonment effects vegetation patterns, and recognition of these patterns could be an essential tool for the prediction of changes in Mediterranean landscapes (Pausas, 1999). Bonet (2004) attempted to describe and analyze patterns in vegetation dynamics during the land abandonment process in a Mediterranean semi-arid area, emphasizing the effect of land use history. He showed that species richness on loam soils quickly increased during the first decade of abandonment and decreased later during the rest of the recorded periods, allowing maximum species richness to develop during a relatively early stage of the succession process. As mentioned by Bonet (2004), protocols for conservation and restoration could consider the following aspects:

(i) Introduction of ''late successional shrubs'' in early stages of the succession.

(ii) Restoring old fields by using natural succession if a seed bank or adjacent seed source is present in remnant patches of natural vegetation.

(iii) Maintaining moderate grazing levels during the grassland stage.

In addition to biodiversity aspects, the aim of restoration or conservation of Mediterranean grasslands could also rise from an aesthetic point of view. Recreation activities that include hiking, picnicking, and enjoyment of the scenery require the access provided by open woodlands. Accordingly, it was shown that the most preferred landscape for all uses was found to be an open woodland formation with productive herbaceous patches (Henkin 2011).

Considerable conservation efforts have been invested in attempting to protect the dense shrub forest (maquis), since this vegetation formation is important as the habitat of specific flora and fauna. Therefore the main conclusion is that open landscapes, as shaped by the grazing of goats or cattle, presented greater structural diversity and were preferred over other open or very dense landscapes (Henkin *et al.,* 2007). From that aspect, restoration and conservation of these land types are highly valuable.

V – Conclusions

As many of the grasslands in the Mediterranean zones were under heavy human utilization, including intensive grazing, a large part of them have been degraded. Some of these lands can be rehabilitated in order to improve utilization of the forage resource for animal production. The rehabilitation strategy includes a range of different agro-technological activities such as control of grazing, introducing annual and/or perennial legume and grass species, introducing forage bushes and trees, fire, inputs of phosphorus and nitrogen and herbicide application. This paper presents some insight into these rehabilitation activities as a means of increasing forage production in degraded and low productive Mediterranean grasslands. These activities were examined during the last few decades in all Mediterranean zones around the world. In many of the studies the results show a significant improvement of the ecosystem in terms of forage production, but in many cases the improvement in animal production is too low to justify the cost of rehabilitation.

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Effect of microtopography on the early plant community dynamics following overseeding for the rehabilitation of a Mediterranean silvopastoral system

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Abstract. The sowing of selected seeds is often applied as post-fire rehabilitation practice in Mediterranean silvopastoral systems. Often, the topography of these silvopastoral systems is irregular, requiring low input and easy pasture rehabilitation practices, such as no tillage, low seed and fertilizer rates. In this paper, we studied the vegetation changes over four years, after a low-input overseeding (broadcasting) of non-native pasture species, within a post-fire rehabilitation program of a silvopastoral system in Sardinia (Italy). The main objective was to assess the relationship between topography, soil pH, and soil nitrogen content on the spatial and temporal dynamics of the grassland composition. The spatial patterns of the functional classes were only weakly influenced by nitrogen content, with a higher impact on introduced species in the first two years after overseeding, while the topographic variables had a desultory influence over the four years.

Keywords. Oversown grasslands – Silvopastoral systems rehabilitation – Topography – Vegetation dynamics – Wildfire.

Effet de la microtopographie sur la dynamique des communautés végétales, suivant le sur-semis pour la réhabilitation d'un système sylvo-pastoral méditerranéen

Résumé*. Dans les systèmes sylvo-pastoraux méditerranéens le semis de semences sélectionnées est souvent appliqué comme une pratique de restauration post-incendie. Souvent, la topographie de ces systèmes sylvo-pastoraux est irrégulière, nécessitant de faibles intrants et des pratiques simples de réhabilitation des pâturages, comme le sur-semis direct et de faibles niveaux de semences et de fertilisation. Dans cet article, nous avons étudié pendant quatre ans la dynamique de la végétation, après un sur-semis manuel à faibles intrants avec des espèces fourragères non indigènes, dans un programme de réhabilitation après incendie dans un système sylvo-pastoral en Sardaigne (Italie). L'objectif principal était d'évaluer la relation entre la topographie, le pH du sol et la teneur en azote du sol, sur la dynamique spatiale et temporelle de la composition de la prairie. Les modèles spatiaux des classes fonctionnelles n'ont été que faiblement influencés par le contenu en azote, avec un impact plus important sur les espèces introduites, dans les deux premières années après le sur-semis, alors que les variables topographiques ont eu une influence irrégulière sur les quatre années.*

***Mots-clés.** Sur-semis de prairies – Réhabilitation de systèmes sylvo-pastoraux – Topographie – Dynamique de végétation – Incendie.*

I – Introduction

In silvopastoral systems, the rehabilitation through overseeding of pasture species is a suitable strategy for producing biomass palatable for grazers and for controlling invasive shrubs and spiny forbs (De Luis et al. 2003; Peppin *et al.* 2010). In the topographic irregularity of rangelands, microsite environmental variables play a key role in shaping the vegetation distribution patterns (Pueyo and Alados 2007; Gusmeroli *et al*. 2013). In this paper, we studied the early vegetational changes after overseeding of a grassland degraded by a post-fire shrub encroachment in a Mediterranean silvopastoral system. We tested the hypotheses that micro-site environmental (microtopography, soil N content and pH) variations could influence the spatial plant community dynamics after overseeding.

II – Materials and methods

The study was conducted over four years (1997–2001) at the Campu Massidda public forest located in Usellus, Western Sardinia, Italy (latitude 39°50′N, longitude 8°49′E). The topography of the study area is hilly and the dominant vegetation is characterised by both the association of holm oaks (Quercus ilex) with several Mediterranean shrubs and cork oak (Q. suber). The soil is clay-sandy sub-acid (pH = 6.1), with 1 g N kg−1 dry soil (Kjeldahl) and 0.05 g P2O5 kg−1 dry soil (Bray and Kuntz). The climate of the area is Mediterranean semi-arid with an average annual rainfall of 610 mm. In 1992, the forest was destroyed by a wild-fire. In the following years, shrub encroachment of Cistus spp. occurred. Thus, with the aim of establishing an improved pasture, an area of 4.8 ha was cleared and manually oversown in October 1997, using an annual grass/legume mixture composed of two commercial varieties Trifolium yanninicum var. 'Trikkala' and T. brachycalycinum var. 'Clare', and local cultivars of Medicago polymorpha var. 'Anglona' and Lolium rigidum var. 'Nurra'. The seed mixture was composed of 9 kg ha–1 of 'Anglona', 10 kg ha–1 of 'Trikkala', 5 kg ha–1 of 'Clare' and 1.5 kg ha–1 of 'Nurra'. At the seeding, 80 kg ha–1 of P2O5 and 20 kg ha–1 of N were applied as diammonium phosphate (18% N, 46% P2O5, 0% K2O). During the 4 years of the study, the area was lightly grazed by a flock of 120 Sarda bred dairy sheep, for 2 weeks in winter and 2 weeks in spring. In the first year, winter grazing was avoided in order to facilitate the initial establishment of the oversown species. The oversown area of 4.8 ha was divided into 192 units of 20 × 12.5 m (Fig. 1).

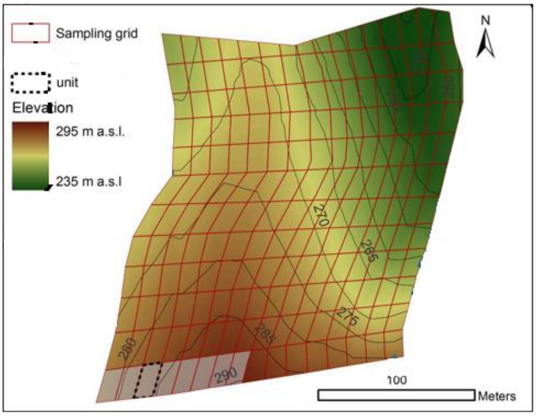

Fig. 1. Study area and sampling design representation.

The floristic composition of the vegetation in spring over 4 years was estimated by recording contacts with a sward stick (Barthram 1986) at the four vertices of a 30x30 cm quadrat placed 6 times randomly within each of the 192 units. Nine "functional classes" (FCs) were identified: subclovers (T), burr medic (T), annual ryegrass (L), grasses (G), autochthonous legumes (AL), Cistus spp. (CI), spiny Carduaceae (CA), spiny Rubus spp (Ro) and other species (A). The following topographic variables were considered: aspect, slope, Topographic Position Index (TPI), Topographic Weatness Index (TWI) and Heat Index (HI). TPI classifies the soil morphology: positive TPI values indicate hummocks, negative TPI values indicate depressions. TWI describes the tendency of the soil to accumulate sediment: the greater degree of accumulation is assigned to the areas with greater concavity and lesser slope. HI is used as a proxy for heat load. At the center of each sampling unit, soil samples were collected and the total N content (Kjeldahl method) and pH (H2O) were determined. The effect of topographic and soil variables on the spatial variability of FC's was studied performing a Redundancy Analysis (RDA) with the package Canoco ver. 4.5 (ter Braak, 1995).

III – Results and discussion

The environmental variables explained the 5.0%, 7.9%, 4.6% and 5.5% of the total variance, respectively from the first to the fourth year of the study. The effect of total N and, at a lesser extent, TWI, pH and slope, was significant on spatial variability of pasture composition. In the sowing year, a significant impact of soil N content on the spatial pattern of FCs was observed (P-value ≤ 0.004), with a slight effect on the distribution of oversown species (Fig. 2A).

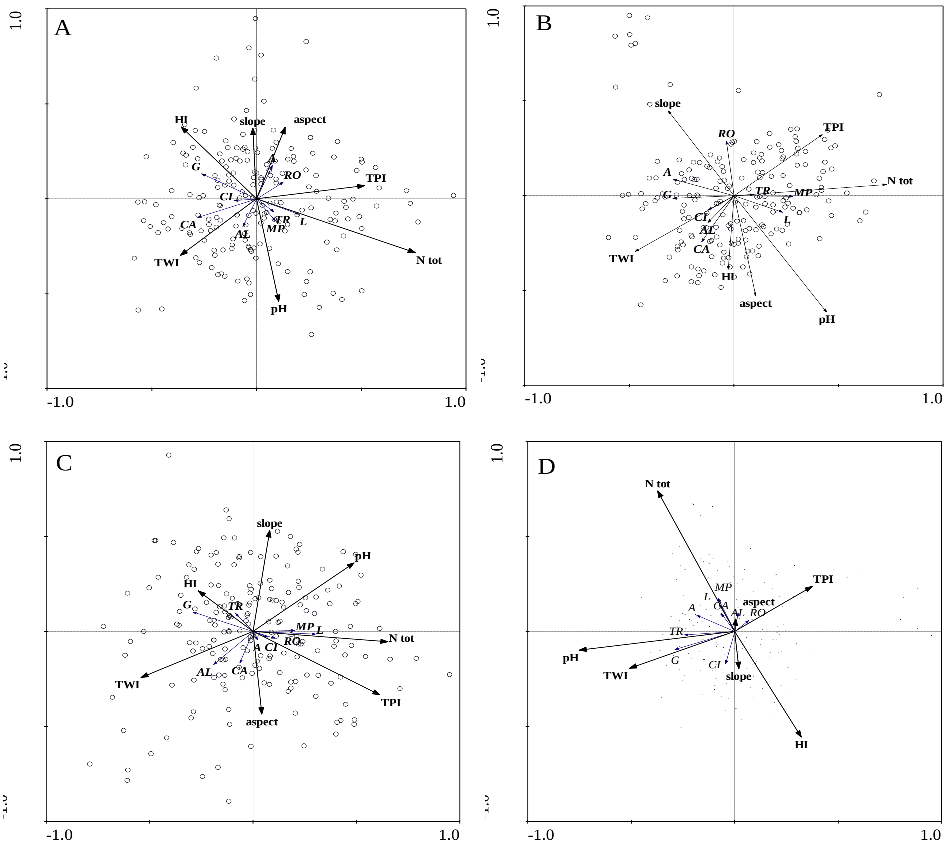

Fig. 2. Biplot between the functional classes and the environmental variables from Redundancy Analysis (RDA) for the first (A), second (B), third (C) and fourth (D) year of the trial.

In the second year (Figure 2B), the results showed a significant effect of soil N content, TWI and slope (respectively with P-values of 0.0002, 0.006 and 0.048).

M, G and T were positively correlated with soil N content; all native FCs, except Ro, resulted positively correlated with TWI. In the third year (Figure 2C), soil N and TPI significantly influenced the presence of M, G, RO and CI (P-value = 0.016 and 0.014, respectively). In the fourth year (Figure 2D), spatial distributions of G, A and T were positively correlated with pH (P-value = 0.0040) and TWI (P-value = 0.045). In our study, sown burr medic and annual ryegrass were facilitated in locations rich in total nitrogen and, to a lesser extent, in potentially drier and sunny convexities. Native grasses and, at least in the second year, other native FCs as CA and AL, tended to be more abundant in concavities where sediments and water flows more likely accumulated. Sown subclovers, in contrast with the other two oversown mixture components, initially did not show any response to topography, but at the end of the study occupied the same concavities of native grasses, in potentially less dry and deep soil conditions.

IV – Conclusions

Soil N and some topographic variables seemed to slightly influence the grassland composition patterns, with oversown species mainly concentrated in the nitrogen-rich convexities of the hillslope, while native grasses in concavities, where sediments and soil moisture were likely higher. At the small scale and relatively low variation of environmental variables of our study, topography is not an essential factor to be taken into account for the design and implementation of rehabilitation programs for improving pastures.

Acknowledgments

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The effect of grazing exclusion on vegetation characteristics and plant community structure in arid lowland pastures

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Abstract. Rangelands are the mainstay of pastoral livelihoods worldwide. Within rangelands, there are landscape depressions or lowlands characterized by high production potentials with their unique edaphic and hydrologic properties. The purpose of this ongoing research is to evaluate the effect of grazing exclusion on the vegetation characteristics and plant community structure in the arid lowland pastoral ecosystems. Plots were randomly identified within two distinct lowlands in Majidya and Sabha, in the Jordanian Badia. Preliminary results indicate that the total biomass and plant density widely differed between the open grazed and protected areas (P<0.001) in both sites. Total annual dry matter production was 954 kg ha-1 for protected and 151 kg ha-1 for open grazed areas in Majidya and 1749 kg ha-1 for protected and 20 kg ha-1 for open grazed areas in Sabha. The average plant densities in open grazed areas were 29 and 16 plants/m2, compared to 83 and 612 plants/m2 in protected areas in Majidya and Sabha, respectively. These results indicate that plant community structure is greatly affected by livestock grazing and that a site's ability to recover from disturbance over time may be limited. Therefore, carefully planned grazing management is needed to achieve greater rangeland productivity and diversity.

Keywords. Badia – Grazing management – Pasture production – Plant diversity.

Effet de l'exclusion de pâturage sur les caractéristiques de la végétation et la structure de la communauté végétale dans les parcours des zones arides

Résumé. *Les parcours représentent un pilier important des moyens de subsistance pour les communautés pastorales à travers le monde. Au sein des parcours, il existe des zones de dépression ou des terres basses qui ont des propriétés édaphiques et hydrologiques spécifiques. L'objectif de la recherche en cours est d'évaluer l'effet de la protection contre le pâturage sur les caractéristiques de la végétation et la structure de la communauté végétale dans les écosystèmes pastoraux des dépressions dans les zones arides. Des parcelles ont été identifiées au hasard dans deux plaines à Majidya et Sabha, dans la Badia Jordanienne. Les résultats préliminaires montrent que la biomasse totale et la densité des plantes étaient différentes entre les zones protégées et les zones pâturées (P<0.001) au niveau des deux sites. La matière sèche totale produite annuellement a atteint respectivement 954 kg ha^{-1} et 151 kg ha^{-1} pour les zones protégées et les zones pâturées au site de Majidya et les valeurs correspondantes étaient de 1749 kg ha^{-1} et 20 kg ha^{-1} pour le site de Sabha. La densité moyenne des plantes dans les zones pâturées était de 29 et 16 plants/m^2 respectivement à Mjidya et Sabha en comparaison à 83 et 612 plants/m^2 dans les parcelles protégées pour les mêmes sites. Ces résultats montrent que la structure communautaire de la végétation est très affectée par le pâturage et que la capacité des écosystèmes à se remettre des grandes perturbations est limitée dans le temps. Par conséquent, une gestion raisonnée des pâturages est indispensable pour garantir une plus grande productivité et diversité dans les parcours.*

Mots-clés. Badia – Gestion du pâturage – Production pastorale – Diversité des plantes.

I – Introduction

Rangelands cover almost a half of the Earth's land surface (Schimel, 2010). Traditionally, rangelands are a major source of feed for the pastoral livestock production system (Kassahun *et al.*, 2008). Rangelands also provide vital ecological resources that include; nutrient cycling, filtering of pollution, medicinal herbs, and the preservation of biodiversity for millions of resource-poor agro-pastoral farmers (Louhaichi *et al.,* 2009). However, these rangelands are suffering from the encroachment of cultivations, overgrazing and harsh climatic conditions particularly recurrent droughts. Within these vast areas, lowlands which are broad dry basins exhibit localized high vegetation productivity and unique edaphic and hydrologic properties.

The purpose of this research is to evaluate the effect of short-term grazing on vegetation characteristics and plant community structure within two different lowlands located in the Jordanian Badia, and to provide other options for sustainable development of these key areas.

II – Materials and methods

Two lowland pastures were randomly selected. The sites are located in Majidya (latitude 31° 43′ 48″ longitude 36° 07′ 25.03″ altitude 835 m, long term average annual rainfall = 100 mm, Rainfall of the growing season “begins in November and ends in May” = 134 mm) and Sabha (latitude 32° 17′ 04.2″, longitude 36° 27′ 53.28″ altitude 754.5 m, average annual rainfall = 130 mm, growing season rainfall = 119 mm). Both sites are located in the Jordanian Badia. The main grazing system is the semi-nomadic. In most cases the number of livestock is much higher than the available feed. Grazing periods start usually in late winter and early spring, this leads to reduced cover, resulting in loss of plant reproduction in the next season.

Vegetation sampling took place during the peak standing crop in the spring of 2015. Each lowland pasture site (5 ha total area) had an open grazing and a protected section. In each site ten 1 m × 1 m quadrats were randomly placed to estimate plant biomass, density, and species diversity. Above-ground biomass was harvested by manually clipping plants 2.5 cm above the soil surface within each quadrat. In the lab, clipped plants were oven dried for 72 h at 70°C and then weighed in order to estimate the total dry weight. The percentage of total biomass for above-ground plant parts was estimated on an individual species basis for all species sampled. Plant density was calculated as the number of individuals for each species that were found within a placed quadrat (m^2).

Cover and density were compared among the locations using one-way ANOVA, followed by Duncan test. Differences between means were considered significant if P values were <0.05. Comparison of means for vegetation characteristics under grazing and protected treatments was undertaken using a t-test. Means and standard error values were calculated for all comparisons. All computations were carried out in SAS (SAS, 2004).

III – Results and discussion

The optimal use of rangeland resources depends on many factors such as understanding of the changes of seasonal biomass production as affected by climate, grazing management, and proper use management. Productivity (kg ha^{-1}) is a measure of the available herbaceous plant species biomass per surface unit. While, plant density is the number of individuals of each taxon per surface unit. Both measurements represent key indicators for understanding the condition and trend of rangeland resources at the local scale. A proper management scheme is required for the sustainability of these natural resource base. Previous studies have reported that short term protection from grazing have positive effects on productivity (biomass) and biodiversity (species richness) of rangeland ecosystems (Mengistu *et al.,* 2005, Louhaichi *et al.,* 2012).

The total biomass and plant density widely differed between the open grazed and protected areas (P<0.001) in both sites. Total annual dry matter production in Majidya was 954 kg ha^{-1} for protected and 151 kg ha^{-1} for open grazed areas (Fig. 1). In Sabha total annual dry matter production was 1,749 kg ha^{-1} for protected and 20 kg ha^{-1} for open grazed areas. Similar results have been reported within similar landscapes by Louhaichi *et al.* (2012). This is due to the fact that overgrazing has negative impact on biomass production (Abdulatife and Ebro, 2015).

Our results show that the main effect of protection from grazing, the site and their interaction significantly affected the plant density (plant /m^2), total biomass (kg ha^{-1}) and the percent (%) of *Anabasis syriaca* (unpalatable shrub species that invades disturbed land). Plant cover (%) was affected only by protection from grazing and its interaction with the site treatment (P<0.05).

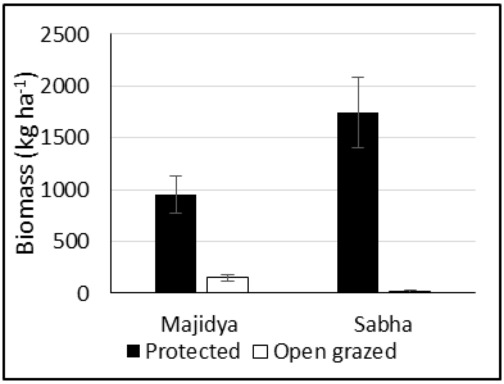

Fig. 1. Total biomass production (kg ha^{-1}) in protected and open grazed sites of two lowland pastures.

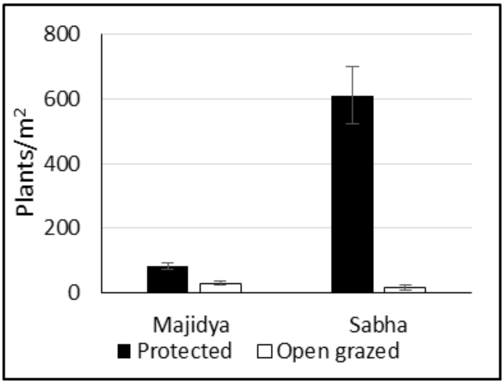

Fig. 2. Plant density (plants/m2) in protected and open grazed sites of two lowland pastures.

The average plant densities in open grazed areas were 29 plants/m^2 in Majidya and 16 plants/m^2 in Sabha. Plant densities increased in protected areas with 83 plants/m^2 in Majidya and 612 plants/m^2 in Sabha (Fig. 2). In the Majidya site, the protection treatment had a significant effect on reducing the percentage (%) of *A. syriaca* from 27% of the total plant cover in open grazed areas to 14% in protected areas.

Table 1. Main family names of species recorded in protected and open grazed areas of Jordan (%)

Family	Protected		Open grazed	
	Annual	Perennial	Annual	Perennial
Poaceae	22	5	13	0
Asteraceae	15	0	7	13
Brassicaceae	10	2	13	0
Caryophyllaceae	0	7	0	13
Fabaceae	5	0	13	0
Amaranthaceae	0	7	0	7
Capparaceae	0	0	0	7
Malvaceae	0	5	0	7
Plantaginaceae	2	5	0	0
Resedaceae	0	0	7	0
Other	8	7	0	0

The plant species composition found in the two lowland pastures represent 15 families mainly (*Poaceae, Asteraceae, Brassicaceae, Caryophyllaceae, and Fabaceae*). Differences between the number of plants that belong to each family in the protected areas and the open grazed areas were observed. In the protected areas, 25% of the species are members of *Poaceae* family compared to 13% in the open grazed areas. Some species were more abundant in the open grazed areas than the protected areas. Species from *Asteraceae, Brassicaceae*, *Caryophyllaceae*, and *Fabaceae* had respectively 20, 13, 13 and 13% in open grazed areas and 15, 12, 7 and 7% in the protected areas. However, a greater availability of the other species in the protected areas was found (Table 1). Grazing exclusion increased herbaceous species richness mainly that related to annual grasses due to the fact that when overgrazing occur during spring annuals are not able to re-seed. These results showed significant variations in terms of plant biodiversity between protected and open grazed areas. Furthermore, the changes in plant composition resulted from overgrazing can involve the replacement of desirable and palatable plants by unpalatable species such as *A. syriaca* which is an unpalatable invasive shrub. This is illustrated through the state and transition models which explain how rangeland ecosystems response to natural and/or management-induced disturbances (Knapp *et al.,* 2011).

The density of perennials in the open grazing treatments found to be higher than annuals, this may indicate that grazing and reduced perennial biomass is important for perennial establishment.

IV – Conclusions

Lowland pastures have the potential to play an important role in the intensification and diversification of pastoral production system and provide a favorable environment for biodiversity conservation. Results of this research suggest that proper grazing is a potential tool for enhance pasture biodiversity, improve biomass availability and vegetation structure not only to maintain but also to improve range sustainability and enhance productivity. Particularly, lowland pastures, could represent a valuable source of feed for livestock, mainly during the dry season when resources are often limited.

Acknowledgements

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Rangeland rehabilitation using rainwater harvesting and rosemary (*Rosmarinus officinalis L.*) transplantation in the Southeast of Morocco

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Abstract. Common grazing lands in the south east of Morocco have provided for centuries forage for livestock, but they are now highly degraded essentially due to the continuous high grazing pressure. The Moroccan government and IFAD implemented in this area an integrated project since 2008. One of the goals of this project was to demonstrate promising rehabilitation methods of rangeland. Assoul, an arid region located in the southeast of Morocco, was one of the communes in which these actions were set. Accordingly, we tried in 2012 to rehabilitate 10 ha of a degraded rangeland using micro-catchment water harvesting in contour ridges lines combined to small trapezoidal bund to establish rosemary seedlings. Over four years, results showed that mortality was of 20% ± 11.6. Rosemary production estimated in the fourth year after the transplantation is of 429 g DM/plant (density 1333 plants/ha). This transplantation permitted also the regeneration of local vegetation. Thus, the Shannon-Weaver diversity index increased from 2.6 in 2013 to 4.3 in 2015. In addition, the rangeland production was improved from 51.3 ± 37.8 kg DM in 2012 to 82.9 ± 53.6 kg DM in 2015. Plant density and cover increased significantly compared to the baseline situation.

Keywords. Steppe – Degradation – Rehabilitation – Rainwater-harvesting – *Rosmarinus officinalis* – Transplantation.

La réhabilitation des parcours en utilisant la collecte des eaux de pluie et la transplantation du romarin (*Rosmarinus officinalis ***L.) dans le sud-est du Maroc (Assoul)

Résumé. *Les parcours collectifs dans le sud-est du Maroc ont assuré pendant des siècles l'alimentation du bétail, mais ils sont aujourd'hui en état de dégradation avancée principalement en raison du surpâturage. Le gouvernement marocain et le FIDA ont mis en œuvre un projet intégré en 2008 dans cette région. L'un des objectifs assignés à ce projet était de démontrer les bonnes pratiques de la réhabilitation des parcours. Assoul, situé dans le sud-est du Maroc, est l'une des communes arides choisies pour mener ces actions. Ainsi, nous avons essayé depuis 2012 de réhabiliter 15 ha d'un parcours dégradé en utilisant les techniques de collecte des eaux de pluie. La technique utilisée combine des cuvettes en trapèze installées sur des contours qui suivent les courbes de niveau pour réussir l'établissement des plantules de romarin. Après quatre ans, les résultats ont montré que la mortalité a été de 20% ± 11,6. La production du romarin estimée dans la quatrième année est de 429 g de MS/plante (densité 1333 plants/ha). Cette transplantation a permis aussi le retour de la végétation autochtone. Ainsi, l'indice de diversité de Shannon-Weaver a augmenté de 2,6 en 2013 à 4,3 en 2015. En outre, la production des pâturages a été améliorée de 51,3 ± 37,8 kg MS en 2012 à 82,9 ± 53,6 kg MS en 2015. La densité et le recouvrement de la végétation ont augmenté significativement par rapport à la situation de référence.*

Mots-clés. *Steppe – Dégradation – Réhabilitation – Collecte des eaux de pluie –* Rosmarinus officinalis *– Transplantation.*

I – Introduction

In Morocco, rangelands are overgrazed and are subject to impoverishment of their vegetation cover and plant diversity. In this regard, approximately 8.3 million ha of rangelands are heavily degraded (MADR, 2003). The estimated annual cost of rangeland degradation stands at 133.6

million MAD (Dahan *et al.,* 2012). This degradation is located in several regions of Morocco between them the Pre-Sahara.

In this context, the Regional Office of Agricultural Development of Tafilalet (ORMVA-TF) with the International Fund for Agricultural Development (IFAD) implemented a Rural Development Project in the Mountain Zones of Errachidia Province (PDRME) in 2008. The main objective of the project was to provide support to poor and vulnerable populations, in order to increase their income and improve the level of their livelihood. Among the component of this project was the demonstration of good practices for rangeland rehabilitation. National Institute for Agricultural Research (NIAR) was responsible to accomplish these actions.

One of the practices concerned the rehabilitation of Assoul rangeland by using rainwater harvesting techniques in combination with rosemary (*Rosmarinus officinalis* L.) transplantation. The main goal of this action was to conserve biodiversity and to improve forage production. In this paper are the main results of this successful action.

II – Material and methods

Study Area. The study was conducted from 2012-2015 (from March 2012) in Agouray village that belongs to Assoul rural community. It is located in the southeast of Morocco at 1690 m a. s. l. (34°51'08.4"N and 08°15'05.3"E). Soils are skeletal, with loamy-sand texture and poor in organic matter. Long-term climatic data (1989–2015) revealed that the Mediterranean climate of this region is arid-type with cold dry winters and hot dry summers. The region receives an average of 188 mm of rain per year (SD= 104 mm; n = 32). Average annual temperature is about 16.4 °C with a minimum of 7.65 °C in January and a maximum of 27.5 °C in July.

Plant material and plantation. The rosemary seedlings (*Rosmarinus officinalis* L.). were raised in 25 cm plastic bags. Nearly one month before the transplantation, seedlings were stressed in the perimeter of plantation under natural solar radiation (open nursery). Seedlings were transplanted at the age of six months, the height was about 25 cm.

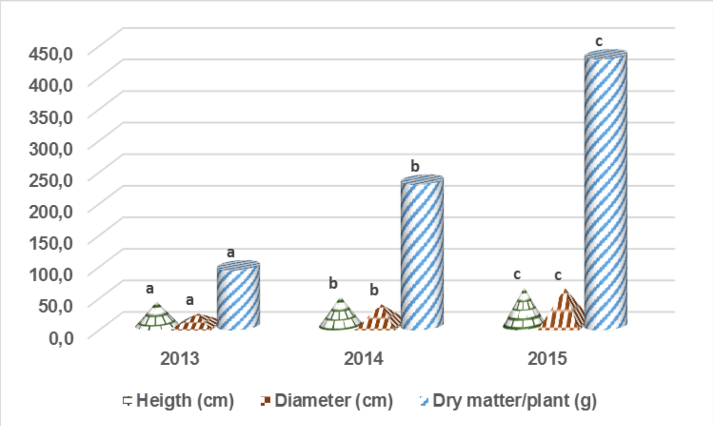
Prior to planting rosemary in trapezoidal bunds, contour ridges lines were traced and distance between lines was defined based on the slope. The ration of catchment to cultivated area (C: CA) was four to seven meters. Seedlings were planted inside trapezoidal bunds combined with natural gravel mulch (diameter 2 to 5 cm) beside the contour lines. Irrigation of 5 L/plant has been assured immediately at the establishment of the plants.

Data collection. Plant mortality rate was calculated during the first summer period and at the last time point of measurement. Then, height, diameter and dry matter were measured for each rosemary plant every year after the establishment. Dry matter was measured according the reference unit method. To study rangeland vegetation, the experimental site was divided into three parts. First, vegetation was inventoried along the site. Then, phytosociological surveys were made within plots of 16 m² (obtained from the minimum area). Hence, 10 records (quadrat) were taken along the diagonal (four quadrats in the median part) every year at the peak of plant's growth. We adopted The Braun-Blanquet system (Braun-Blanquet, 1932) to estimate cover-abundance. Additionally, the plant cover was measured by using the line point intercept method. Density was also counted in the quadrat and dry matter production was estimated indirectly by harvesting some quadrats and estimating others. Harvested biomass was dried (70°C, 48 h) and weighed. The quantitative approach involved also the calculation of some species diversity indices such as Shannon-Weaver's diversity index H'; Simpson's dominance index D and Pielou's evenness E (Hubalek, 2000).

Statistical analysis. Statistical analysis were performed using Microsoft Excel and SPSS software (18 version). The experimental data of rosemary mortality, growth and production were submitted to analysis of variance. Differences between treatments were compared using the Student-Newman-Keuls (SNK) test at $P \geq 0.05$. A Student's t-test was done to assess whether the diversity indices were statistically different from each other. The phytosociological abundance/dominance scores for vegetation were converted into cover percentages before doing an ANOVA between years.

III – Result and discussion

Rosemary transplantation. Mortality rate of rosemary plants was only of 20%±11.6 four years after their establishment even under unfavourable climatic conditions. In fact, the average annual rainfall from 2012 to 2014 was about 130 mm highly lower compared to the mean annual precipitation of 180 mm. The height, diameter and dry matter production of rosemary plants have significantly increased since their establishment in 2012 (Fig. 1). As a consequence, the dry matter production of rosemary was about 457 Kg DM/ha (calculated for a density of 1333/ha) in 2015.



Values in columns followed by different letters for the same parameter are statistically significant according to SNK test.

Fig. 1. Growth dynamics and average dry matter per rosemary plant in the Agouray.

Richness and diversity of Agouray site. The study of floral composition revealed the presence of 69 species. They were divided into 56 genera belonging to 21 botanical families. Five families (Fabaceae, Poaceae, Caryophyllaceae, Cistaceae and Lamiaceae) represented the 40% of the total flora. It seems that the diversity was improved by the rehabilitation action, since 40% of these species appeared after the intervention. The species belongs to five different life forms (Raunkiær, 1934), the most common were: therophytes and hemicryptophytes. The existence of chamaephytes and some nanophanerophytes in the site are of great importance, indicating that this steppe remains resilient, and could be improved. The Shannon- Weaver diversity index for the whole site was increased significantly from 2.6 to 4.3 (Table 1). First, this higher index indicates that vegetation is diversified and not dominated by a specified species. Indeed, this was also indicated by the very low value of Simpson's dominance index. The increase of diversity index values indicates the positive effect of the rehabilitation action. Finally, the high value of Pielou's Evenness indicates similarity or equitability in species relative abundance of this community (no dominant species). This diversity confers resilience and stability within this steppe (Tilmane *et al.,* 1998). As a result, resting and rehabilitation actions increased significantly diversity indices.

Table 1. Floristic diversity for the studied vegetation

	2013	2014	2015	Signifiance[1]
Shannon-Weaver's Index H'	2.6	3.5	4.3	**
Species Evenness E (Pielou's E evenness)	0.8	0.9	0.9	**
Simpson's dominance index D	0.2	0.1	0.05	*

[1] ns: not significant; * P < 0.05 significant; P < 0.01 highly significant

Cover density and production. The intervention generated as well a positive impact on the global vegetation cover. This cover estimated from the Braun-Blaquet method (sub-estimated) increased from 2.1% in 2013 to 8.6% in 2015. On the other hand, the cover estimated according to the line point intercept method revealed that vegetation cover was about 19%, dominated essentially by ephemeral (14%) while perennials remained very low 5%. The density of natural vegetation quadrupled in three years (from 21857 to 52375 per hectare). In addition, some palatable species increased relatively in number like *Artemisia herba-alba* asso. (2018/ha in 2013 to 2938/ha in 2015) and *Thymus satureioides* Cosson. (2875/ha in 2013 to 3125/ha in 2015). The total average production of the entire site, although modest, was variable according to the precipitation received every year. The rangeland production was improved from 51.3 ± 37.8 kg DM in 2012 to 82.9 ± 53.6 kg DM in 2015 assuring forage of better nutritive value.

IV – Conclusion

The purpose of this study was to demonstrate good practices for degraded rangeland rehabilitation through simple action such as water harvesting techniques accompanied by rosemary transplantation. Although the natural environment constraints (recurrent droughts, aridity, poor soil, low plant cover, stoniness, etc.), this intervention generated a positive impact in terms of the success of the rosemary transplantation, the increase of rangeland floral diversity, vegetation cover, density of vegetation and pastoral production. Therefore, the local population was highly satisfied. After the presentation of the results of the action, they claimed to pursue the extension of this action.

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Floristic diversity of the understory in *Pinus brutia* plantations as affected by elevation and grazing intensity

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Abstract. Floristic diversity of the understory vegetation in *Pinus brutia* plantations in Serres, Northern Greece, was studied in order to accurately assess the effect of grazing intensity. Two southern neighboring slopes of different elevation at mountain Vrodou were selected: ''Elaionas'' (on average 200 m a.s.l.) and ''Chrysopigi'' (on average 400 m a.s.l.) and three sampling sites at each slope were selected, representing, three grazing intensities: ungrazed, moderate and heavy. Each sampling site consisted of two plots of similar canopy cover conditions. Plant cover was measured, therefore species composition, and plant diversity indices (Species Richness, Shannon's Index, Evenness, Berger-Parker's index of Dominance and Morisita's Index of Similarity) were calculated for each plot. Number of species and Shannon index was lower at low elevation slope (Elaionas) and at ungrazed sites, while there was no significant difference at sites of moderate and heavy grazing intensity. The diversity of the vegetation followed the same trend in terms of evenness and dominance. Generally, floristic diversity was higher at the slope (Chrysopigi) of higher elevation. Furthermore, the lower value of Morisita's Index of Similarity was recorded between the heavy grazing intensity site of high elevation slope (Chrysopigi) and the ungrazed sites of low elevation slope (Elaionas).

Keywords. Grazing pressure – Diversity indices – Eastern Mediterranean region - Calabrian pine

Diversité floristique du sous-étage de plantations de* Pinus brutia *Ten. affectées par l'élévation et l'intensité du pâturage

Résumé. *La diversité floristique de la végétation du sous-étage dans les plantations de* Pinus brutia *à Serres, nord de la Grèce, a été étudiée afin d'évaluer avec précision l'effet de l'intensité du pâturage. Deux pentes voisines orientées au sud, d'altitude différente, dans la montagne Vrodou, ont été sélectionnées: " Elaionas " (en moyenne 200 m d'altitude) et " Chrysopigi " (en moyenne 400 m d'altitude) et trois sites d'échantillonnage pour chaque pente ont été sélectionnés, représentant trois intensités de pâturage: non pâturées, modérées et fortes. Chaque site d'échantillonnage se composait de deux parcelles de conditions similaires de couverture de la canopée. La couverture végétale a été mesurée, la composition des espèces, et les indices de diversité végétale (richesse, indice de Shannon, équitabilité, indice de Berger-Parker de position dominante et indice Morisita de similarité) ont été calculés pour chaque parcelle. Le nombre d'espèces et l'indice de Shannon étaient inférieurs sur la pente à basse altitude (Elaionas) et sur les sites non pâturés, alors qu'il n'y avait pas de différence significative dans les sites à intensité de pâturage modérée et forte. La diversité de la végétation a suivi la même tendance en termes de régularité et de domination. Généralement, la diversité floristique était plus grande sur la pente (Chrysopigi) d'altitude plus élevée. En outre, la valeur inférieure de l'Indice Morisita de similitude a été enregistrée entre le site à forte intensité de pâturage et pente à haute altitude (Chrysopigi) et les sites non pâturés sur pente à faible élévation (Elaionas).*

Mots-clés. *Pression de pâturage – Indices de diversité – Méditerranée orientale – Pin de Calabre*

I – Introduction

Calabrian pine (*Pinus brutia* Ten.) is a warm Mediterranean coniferous species, which has been used in large scale reforestation projects for catchment protection (Vallejo *et al*., 2006). Moreover, Calabrian pine forests are classified as silvopastoral systems because they provide forest products as well as forage (Papanastasis *et al*., 2009).

Natural disturbances, such as grazing, influence compositional, structural and functional diversity in forested ecosystems (Roberts and Gilliam, 1995). Usually, grazing reduces the abundance of palatable species which are replaced by less palatable ones (Vallentine, 1990). According to Alados *et al*. (2004) woodland and dense shrublands are more resistant to species loss than middle and low dense shrublands, or grasslands. Furthermore, species composition and diversity can be affected differently by various management restoration practices of degraded Mediterranean rangelands (Papadimitriou *et al*. 2013).

Given the fact that species composition and diversity of the plant community must be carefully examined in order to accurately assess the effect of a certain disturbance (Onaindia *et al*. 2004), it is important to determine the floristic diversity in *Pinus brutia* plantations in order to accurately assess the effect of grazing intensity in these silvopastoral systems.

II – Materials and methods

The study was carried out in the area of Elaionas in Serres, Northern Greece (41^{o}13´N, 23^{o}55´E), in *Pinus brutia* plantations, aged between 60 and 70 years. Altitude varies between 200 and 600 m a.s.l., with a mean air temperature of 14.1 ^{o}C and an annual rainfall of 438.9 mm. The study area is part of emanation basins of two neighboring torrents (Ag. Anargyron and Ag. Georgiou) located at the southern slopes of mountain Vrodou. Thus, Forestry Service has applied extensive reforestation projects to protect from soil erosion (Caballero *et al*. 2009). As a result Calabrian pine plantations, shrublands dominated by evergreen (*Quercus coccifera, Juniperus oxycedrus*, etc) as well as deciduous (*Fraxinus ornus, Carpinus orientalis*, etc) species and fields constitute a silvopastoral system. The area is grazed mainly by goats and sheep. Forested areas at two southern neighboring slopes of different elevation were selected: ''Elaionas'' (on average 200 m a.s.l.) and ''Chrysopigi'' (on average 400 m a.s.l.) and three sampling sites at each slope were established, representing three grazing intensities: ungrazed, moderate and heavy grazing. Each sampling site consisted of two 0.05 ha (20 m by 25 m) plots of similar canopy cover conditions.

Plant cover measurements were made in May 2015 using the line-point method (Cook and Stubbendieck, 1986). Within each plot five 25 m transects were placed and the contacts were obtained every 25 cm (100 contacts per transect). Species composition and plant diversity indices [Species Richness (N), Shannon-Wiener diversity index (H´), Evenness (J), Berger-Parker's index of Dominance (d) and Morisita's Index of Similarity (C_λ)] were calculated for each plot. The formulae of the indices are given below (Shannon and Weaver, 1949; Morisita, 1959; Pielou, 1966; Henderson, 2003):

$$H' = -\sum_{i=1}^{S} p_i \ln p_i \qquad J = \frac{H}{H_{max}} \qquad d = \frac{N_{max}}{N_T} \qquad C_\lambda = \frac{2\sum n_{i1} n_{i2}}{(\lambda_1 + \lambda_2) N_1 N_2}$$

where S is the maximum recorded number of taxa, p_i is the proportional abundance of the i-th taxa, H is the observed species diversity, H_{max} is the diversity when the individuals are divided among the species as evenly as possible, N_{max} is the number of records of the dominant taxon, N_T is the total number of records, n_{i1} is the number of individuals of species i in sample 1, n_{i2} is the number of individuals of species i in sample 2, N_1= the number of individuals in sample 1, N_2= the number of individuals in sample 2, and:

$$\lambda_j = \frac{\sum n_{ji}(n_{ji}-1)}{N_j(N_j-1)}$$

where n_{ij} is the number of individuals of species i in sample j and Nj is the number of individuals in sample j.

General linear models procedure (SPSS 19 for Windows) was used for ANOVA. The LSD at the 0.05 probability level was used to detect the differences among means (Steel and Torrie, 1980).

III – Results and discussion

Species diversity, in terms of the number of species and Shannon's diversity index, were lower at ungrazed sites (Table 1). Although this result agrees with previous evidence that moderate grazing intensity contributes to improve diversity (Klimek *et al*. 2007), there was no significant difference between sites of moderate and heavy grazing intensity. However, the number of species and Shannon's index reached their maximum values at the moderate grazing intensity site at the high elevation slope (Chrysopigi) and at the heavy grazing intensity site at the low elevation slope (Elaionas) (Data not shown). Number of species and Shannon's index were also lower at the low elevation slope (Elaionas) (Table 1). This result is in accordance with Prodofikas *et al*. (2013), who found that the elevation slope position (belt) is a factor that affects richness, density, abundance – cover and diversity of woody species.

The floristic diversity followed the same trend in terms of evenness and of dominance. Evenness index was lower at ungrazed sites and at the low elevation slope (Elaionas) (Table 1). Respectively, dominance (Berger-Parker's index) was higher at ungrazed sites and at the low elevation slope (Elaionas) (Table 1). There was no statistical significant difference due to the interaction of grazing intensity and elevation slope to either Evenness or Berger-Parker's index of dominance (Data not shown).

Table 1. Species diversity indices (N, H´, J, d) of the different grazing intensities and elevation slopes

	Grazing intensities			Elevation slope	
	Ungrazed	**Moderate**	**Heavy**	**"Elaionas"**	**"Chrysopigi"**
Species richness (N)	5.46b	13.95a	12.83a	5.53b	15.97a
Shannon's index (H´)	0.93b	2.12a	2.25a	1.16b	2.37a
Evenness (J)	0.58b	0.77a	0.85a	0.66b	0.80a
Berger-Parker's index (d)	0.73a	0.38b	0.29b	0.60a	0.33b

Means in the same row and for the same parameter followed by the same letter are not significantly different (P ≤ 0.05).

The lower values of Morisita's Index of Similarity (0.15, 0.16) were recorded between the heavy grazing intensity site of high elevation slope (Chrysopigi) and the low grazing intensity sites of low elevation slope (Elaionas). The higher value of Morisita's Index of Similarity (0.99) was recorded between the low grazing intensity sites of low elevation slope (Elaionas).

IV – Conclusions

The floristic diversity of the understory in Calabrian pine plantations was altered by different elevation and grazing intensity. It was recorded reduced at the low elevation slope and under low grazing intensity. Regarding the similarity of floristic composition, low grazing intensity sites of low elevation slope were the most similar and both of them were found more dissimilar to the heavy grazing intensity sites of high elevation slope. It seems that, both grazing and elevation were important drivers affecting species composition. However, as other factors could probably shaped the floristic diversity in the area further research is needed.

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Effects of over-seeding and fertilization on yield and quality of pasture

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Abstract. This research was conducted at a pasture in Ondokuz Mayis town of Samsun between 2013-2015 (41° 21'N 36° 15'E, elevation 10 m). Main plots were the two treatments (non over-seeding and over-seeding) and sub-plots were the 18 fertilization combinations. Nitrogen was applied as ammonium nitrate with rates of 0, 6 and 12 kg N da^{-1}. Phosphorus was applied as triple superphosphate with rates of 0, 6 and 12 kg P da^{-1}. Potassium was applied as potassium sulphate with rates of 0 and 8 kg K da^{-1}. Alfalfa (*Medicago sativa* L.), white clover (*Trifolium repens* L.), cocks foot (*Dactylis glomerata* L.), wheatgrass (*Agropyron intermedium* (Host.) Beauv.) and perennial ryegrass (*Lolium perenne* L.) seeds were used for over-seeding in the experiment. Dry matter production in rangeland can be increased with fertilization and over-seeding. In the study, N fertilization stimulated the growth of grasses, P and K fertilizations promoted the growth of legumes. The concentration of Mg and Ca in forages were stimulated with P and K fertilization, but they were decreased with N fertilization.

Keywords. Top seeding – Rangeland – Forage Yield – Hay Quality.

Les effets du sursemis et de la fertilisation sur le rendement et la qualité des pâturages

Résumé. *Cette recherche a été menée, en 2013-2015, près d'une ville nommée Ondokuz Mayis, à Samsun, dans un pâturage naturel (41°21'N 36°15'E, altitude 10m). On a utilisé le dispositif suivant: deux traitements sur les parcelles principales (sans sursemis et avec sursemis) et 18 combinaisons de fertilisation sur les sous-parcelles. L'azote a été appliqué sous forme de nitrate d'ammonium aux doses de 0,6 et 12 kg par décare. Le phospore a été appliqué sous forme de triple superphospate aux doses de 0,6 et 12 kg par décare. Quant au potassium, il a été appliqué sous forme de sulphate de potassium aux doses de 0 et 8 kg par décare. On a utilisé des graines de* Medicago sativa *L.*, Trifolium repens *L.*, Dactylis glomerata *L.*, Agropyron intermedium *(Host.) Beauv. et* Lolium perenne *L. Le rendement de matière sèche dans les pâturages a montré une augmentation grâce à ces pratiques de fertilisation et de sursemis. Dans ce travail, on a remarqué que d'une part, la croissance des graminées s'est élevée avec la fertilisation en N et d'autre part, celle de légumineuses avec la fertilisation en P et K. La concentration en Ca et Mg des fourrages était stimulée avec la fertilisation en P et K, mais diminuait avec la fertilisation en N.*

Mots-clés. *Sursemis – Pâturage - Rendement en fourrage – Qualité du foin.*

I – Introduction

Pastures should contain nearly 20-30% legumes for attaining high quality and sustainable yield (Aydin and Uzun, 2005). Excessive nitrogen application (above 5-6 kg da^{-1}) without regarding its negative affect on botanical composition led to vicious circle in terms of productivity. It is not possible to attain sustainability with present fertilization practices at pastures with destroyed botanical compositions found in Black-Sea region (Alp *et al.,* 2001).

Fertilization with N stimulates growth of grasses, but depresses the legumes growth (Lee and Lee, 2000). K and P fertilizers promote legumes (Snyman, 2002; Mosquera-Losada *et al.,* 2004; Aydin and Uzun, 2008) at pastures. But, generally it is not possible to improve the imbalance in favor of grasses cereals, which occurred due to the use of high amounts of nitrogenous fertilizers, by using other fertilizers (Aydin and Uzun, 2005). New approaches are needed to attain sustainable productivity at pastures found in Turkey. The aim of this study was to determine the effects of over-seeding and fertilization with different levels of N, P and K on hay yield, botanical composition and some mineral contents of rangeland.

II – Materials and methods

This research was conducted at a pasture in Ondokuz Mayis town of Samsun during 2013-2015. (41° 21'N 36° 15'E, elevation 10 m). In the region, the 50-year mean precipitation was 705.4 mm, the annual precipitations were 614.2 and 956.1 mm for 2014 and 2015 (Fig. 1.). Soil characteristics of experimental area were as follows; soil texture is loamy; organic matter is 2.0%; extractable P is 2.6 mg kg^{-1}; K extraction is 43.0 mg kg^{-1}; pH is 7.1 saturation extract.

Main plots were the two treatments (non over-seeding and over-seeding) and sub-plots were the 18 fertilization combinations. Treatments were $N_0P_0K_0$, $N_0P_0K_8$, $N_0P_6K_0$, $N_0P_6K_8$, $N_0P_{12}K_0$, $N_0P_{12}K_8$, $N_6P_0K_0$, $N_6P_0K_8$, $N_6P_6K_0$, $N_6P_6K_8$, $N_6P_{12}K_0$, $N_6P_{12}K_8$, $N_{12}P_0K_0$, $N_{12}P_0K_8$, $N_{12}P_6K_0$, $N_{12}P_6K_8$, $N_{12}P_{12}K_0$, $N_{12}P_{12}K_8$. Nitrogen was applied as ammonium nitrate with rates of 0, 6 and 12 kg N da^{-1}. Phosphorus was applied as triple superphosphate with rates of 0, 6 and 12 kg P da^{-1}. Potassium was applied as potassium sulphate with rates of 0 and 8 kg K da$^{-1.}$ Half of the N, all of P and K were applied at the end of October**.** Before the experiment started, botanical composition of the experimental area based on dry weight was determined in eight squares (1 m^2 each) in May 2013. Botanical composition of the experimental area consisted of, 20% legumes, 35% grasses and 45% plants of other families. Legumes in the botanical composition were mostly alfalfa (*Medicago sativa* L.). Grasses were kentucky bluegrass (*Poa pratensis* L.), perennial ryegrass (*Lolium perenne* L.) and orchardgrass (*Dactylis glomerata* L.). Other plants were star-of-bethlehem (*Ornithogalum orthophyllum* Ten.), daisy (*Bellis perennis* L.), dandelion (*Taraxacum scaturiginosum* G. Hagl), ribwort plantain (*Plantago lanceolata* L.) red stem filaree (*Erodium cicutarium* (L.) Her.), buttercup (*Ranunculus* sp.) and shepherd's purse (*Capsella bursa-pastoris* (L.) Medik.). Alfalfa (*Medicago sativa* L.), white clover (*Trifolium repens* L.), cocks foot (*Dactylis glomerata* L.), wheatgrass (*Agropyron intermedium* (Host.) Beauv.) and perennial ryegrass (*Lolium perenne* L.) seeds were used for over-seeding in the experiment. Seeds are supplied from the seed company. In over seeding application total 3 kg seed/da, alfalfa and white clover (legumes) and cocks foot, wheatgrass and perennial ryegrass (grasses) in equal amounts spreaded seed in October. Herbaceous vegetation was annually harvested within 6 m^2 area when grass plants reached full flowering stage in May. Plants within 1 m^2 quadrate in each plot were classified as legumes, grasses and the others as well as determining the dry weight ratio of each group. All the data were pooled across 2014 and 2015 years because variance was homogeneous. Data were analyzed by using SPSS 17.0.V packet programme (SPSS Inc., 2008).

III – Results and discussion

1. Hay yield (kg da^{-1})

The effects of over-seeding and fertilization on dry matter (DM) production were significant (Table 1). The DM increased 7.8% by the over-seeding. The DM production increased 57.4%, 33.0% and 11.3% with N, P and K fertilization, respectively. This situation can be resulted in to the changes in botanical composition of rangeland depending on fertilization and including new forage species.

Table 1. Dry matter (DM, kg da^{-1}), botanical composition (%) and contents of crude protein (CP) and some mineral (g kg^{-1}) of in rangeland with (OS) and without (NOS) over-seeding and fertilization

	DM	Botanical composition			CP	Minerals			
		Legum.	Grass.	Oth.		Ca	Mg	K	K/(Ca+Mg)
NOS	307 **b**	30.2	45.5	24.3	159	10.3	3.1	24.3	0.80
OS	331 **a**	31.0	45.2	23.8	157	10.2	3.2	24.2	0.80
N_0	258 **c**	48.1 **a**	29.7 **c**	22.2	166	11.5 **a**	3.4 **a**	24.3	0.68
N_6	293 **b**	29.0 **b**	46.0 **b**	25.0	155	10.3 **b**	3.1 **b**	24.3	0.82
N_{12}	406 **a**	14.6 **c**	60.4 **a**	25.0	153	9.0 **c**	2.9 **c**	24.3	0.90
P_0	276 **c**	20.0 **c**	54.3	25.7	154	9.8 **b**	3.1	24.3	0.77
P_6	314 **b**	31.7 **b**	46.9	21.4	160	10.3 **a**	3.1	24.5	0.80
P_{12}	367 **a**	40.1 **a**	34.9	25.0	160	10.6 **a**	3.2	24.0	0.83
K_0	302 **b**	27.5 **b**	47.2	25.3	156	9.8 **b**	3.1	24.3	0.77
K_8	336 **a**	33.7 **a**	43.5	22.8	161	10.7 **a**	3.2	24.3	0.83

$^{a, b,}$ Values within columns with different letters differ significantly (p< 0.01).

2. Botanical composition (%)

N application decreased the ratio of legumes (33.5 point) and increased the ratio of grasses (30.7 point) in vegetation, but it did not change the other families (Table 1). The ratios of legumes and grasses increased approximataly 20.1 point and decreased 19.4 poind due to P application, respectively. Similarly, K fertilization increased the ratio of legumes (6.2 point). As raported by Aydin and Uzun (2005), these findings show that while N fertilization stimulates the growth of grasses, P and K fertilizations promote the growth of legumes.

3. Crude Protein (CP) Ratio (g kg^{-1})

The CP ratios in samples from all treatments were ranged from 153 to 166 g kg^{-1}. Although the studied factors affected the botanical composition of rangeland, the values were not affected by any treatment (Table 1). This indicate that the ratio of grasses with high protein in rangeland may increased.

4. Mineral concentration (g kg^{-1})

The Mg and Ca contents of hays were decreased (21.7 and 14.7%, respectively) with N applications (Table 1). The P and K aplications increased Ca concentration (8.2 and 9.2 respectively). Mineral contents and having the correct ratios of minerals (e.g. Ca/P, Ca/Mg, K/(Ca+Mg) and K/Mg ratios) in the forage as well as DM and CP contents of feeds play important role in animal development and growth. The Ca and Mg contents pasture forages in the present study were enough to meet the requirements in terms of these minerals of livestock, but the content of K was higher than value reported by NRC (2000; 2001).

5. K/(Ca+Mg) ratio

The K/(Ca+Mg) ratios ranged from 0.68 to 0.90 (Table 1). The K/(Ca+Mg) ratio in all treatments were lower than the critical value of 2.2 for tetany (Grunes and Welch, 1989).

IV – Conclusions

Dry matter production in rangeland can be increased with fertilization and over-seeding. In the study, N fertilization stimulated the growth of grasses, P and K fertilizations promoted the growth of legumes. The concentrations of Mg and Ca in forages were stimulated with P and K fertilizations, but they were decreased with N fertilization.

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Landscape evaluation of the “Sheikh Sou” suburban park created in an old Mediterranean rangeland

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Abstract. Rangelands in the Mediterranean region are diverse ecosystems holding great recreation potentials. Landscape evaluation is recognized as a powerful and interdisciplinary research method for evaluating diverse landscape systems such as natural parks and suburban recreation areas. The “Sheikh Sou” suburban park, which is located on the northern edge of the Thessaloniki metropolitan area in North Greece, was chosen as the study area. Sheikh Sou, originally a typical Mediterranean rangeland, was partially restored by planting pine trees in the mid 30’s as an erosion prevention strategy. Following a long history of disturbances, today the park contains six vegetation types: old pine groves, shrublands, grasslands, mixed shrublands with pines that have emerged after a fire due to natural revegetation and several riparian zones. All these vegetation types form a rich mosaic of landscape units that this paper aimed to evaluate. For this purpose, twenty landscape evaluation criteria were applied and graded by experts and a visual management goal was set. The analysis showed that mixed shrublands and riparian areas were visually attractive landscapes receiving higher grades, followed by grasslands. As opposed to this, shrublands and old pine groves received lower grades and became less sensitive to management interventions. Our results suggest that pine groves and ungrazed shrublands had a negative effect on total landscape value.

Keywords. Pine grove – Unmanaged shrublands – Evaluation criteria – Visual management goal.

Evaluation du paysage du "Cheikh Sou", parc périurbain créé dans une ancienne zone de pâturage méditerranéen.

Résumé. *L'évaluation des paysages est reconnue comme une méthode de recherche puissante et interdisciplinaire, pour évaluer les divers systèmes paysagers tels que les parcs naturels et aires de loisirs suburbaines. Les pâturages dans la région méditerranéenne sont des écosystèmes variés détenteurs de grands potentiels de loisirs. Le parc suburbain "Cheikh Sou", situé au-dessus du centre de la ville de Thessalonique dans le nord de la Grèce, a été choisi comme zone d'étude. À l’origine, Cheikh Sou était un parcours typique de la Méditerranée, partiellement restauré par la plantation de pins au milieu des années trente pour la protection des sols. Après de nombreuses difficultés, le parc comprend aujourd'hui six types de végétation: les pins, anciennement plantés, des arbustes, des prairies, une zone arbustive mixte mélangée à des pins apparue par régénération naturelle suite à un incendie et plusieurs zones riveraines. Tous ces types de végétation forment une riche mosaïque d’unités paysagères que cet article vise à évaluer. À cet effet, 20 critères d'évaluation du paysage ont été appliqués et classés par des experts et un objectif de gestion visuelle a été créé. L'analyse a montré que les zones arbustives et riveraines mixtes étaient visuellement attrayantes recevant des notes supérieures suivies par les prairies. Au contraire, les zones arbustives et l’ancienne plantation de pins ont obtenu des notes inférieures et sont devenues moins sensibles aux interventions de gestion. Il a été conclu que la plantation de pins et les zones arbustives non pâturées ont eu un effet négatif sur la valeur totale du paysage.*

Mots-clés. *Plantation de pins – Zones arbustives non pâturées – Critères d'évaluation – Objectif de gestion visuelle.*

I – Introduction

Landscape evaluation is widely recognized as a powerful and interdisciplinary research method suitable for evaluating diverse and traditional landscape systems (Otero *et al.,* 2007), such as rangelands. Rangelands provide a multitude of goods and services not only to rural populations, but also to large urban areas located within or among them (Havstad *et al.,* 2007), including recreational areas such as suburban green parks. Mediterranean rangelands are man-made pastoral landscapes of great variety and value (Papanastasis and Chouvardas 2005) suitable also for recreational use. In North Greece, three vegetation types of Mediterranean rangelands can be found, namely grasslands, shrublands and open forests. The management activities on these pastoral landscapes may be grouped into three main actions: grazing, reforestation followed by prohibition of livestock grazing and abandonment (Papanastasis *et al.,* 2015). The establishment of a suburban green park in previously managed rangelands usually includes reforestation and prohibition of livestock grazing and has a significant impact on landscape value. The aim of this study was to evaluate the landscape of suburban Mediterranean rangelands as they are formed through management activities.

II – Materials and methods

"Sheikh Sou" suburban park, located on the northern edge of the Thessaloniki metropolitan area in northern Greece, was chosen as the study area. Historical records suggest that since the 16th century "Sheikh Sou" was a typical Mediterranean rangeland (a mixture of grasslands and shrublands), where unmanaged wood cuttings and overgrazing activities occurred (Kallidromitou, 2015). During the 20th century, the area was partially reforested with pine trees for soil protection, firstly from the Ottoman municipality of Thessaloniki (1908) and later on from the Greek municipality and the Forestry School of Aristotle University of Thessaloniki (1929). From the mid-30's until the mid-80's, 5.000.000 pine trees were systematically planted in the park, transforming the previously established Mediterranean rangeland into a monocultural pine grove (Kallidromitou, 2015). During that time the park had a long history of disturbances, most important of which was the great wild fire of 1997, which destroyed more than 50% of the pine plantation (Kallidromitou, 2015). The park today is protected as a wildlife refuge area, where livestock grazing and wood cutting are forbidden. It includes six vegetation types: old pine groves that were never burned, mixed shrublands with pines that emerged after the fire due to natural revegetation, shrublands, grasslands, and several riparian zones. All these vegetation types form a rich mosaic of landscape units.

In order to evaluate the six landscape units, 20 evaluation criteria were applied (Table1) (Ispikoudis *et al.,* 2001). These kinds of criteria are based on the physical, aesthetical and psychological attributes of the landscapes and need to be evaluated by a panel of experts (Otero *et al.,* 2007). In the present study, five experts visited all six landscape units and graded each one on a scale from 1 to 4 (Ispikoudis *et al.,* 2001).

The final score of each landscape was the mean of the cumulative grade of each expert. Based on the final grades (ranging from 20 to 80), a value scale and a visual management goal was set for each landscape, namely: Low value/ Maximum Modification (20-35/ MM), Moderate value/ Modification (35-50/ M), High value/ Partial Retention to Retention (51-65/ PR – R,) or Very High value/ Preservation (65-80/ P) (Bacon, 1979, Ispikoudis *et al.,* 2001).

III – Results and discussion

The research showed that the vegetation types of mixed shrublands with pines and riparian zones received higher grades, constituting highly valued landscapes, and retention was set as their visual management goal (Table 2). Grasslands also constituted highly valued landscapes, but were less attractive than the former ones, and their visual management goal was partial retention. Similarly, shrublands scored a high landscape grade but with a marginal value of 51.2. On the other hand, old pine groves received lower grades, suggesting that planting pines in a former shrubland creates moderately valued landscapes, where modification can be set as the visual management goal.

Table 1. Landscape evaluation criteria and their grading system (adapted from Ispikoudis *et. al.*, 2001)

Criteria	Grading							
Scale	Limited	1	Small	2	Big	3	Huge	4
Enclosure	Tight	1	Enclosed	2	Open	3	Exposed	4
Variety	Exposed	1	Small	2	Big	3	Huge	4
Harmony	Chaotic	1	Discordant	2	Balanced	3	Harmonious	4
Movement	Dead	1	Calm	2	Busy	3	Frantic	4
Texture	Smooth	1	Managed	2	Rough	3	Wild	4
Coloring	Monochrome	1	Muted	2	Colorful	3	Garish	4
Rarity	Ordinary	1	Unusual	2	Rare	3	Unique	4
Security	Threatening	1	Unsetting	2	Safe	3	Comfortable	4
Stimulus	Boring	1	Bland	2	Interesting	3	Invigorating	4
Impression	Offensive	1	Unpleasant	2	Pleasant	3	Beautiful	4
Type of view	Far	1	Enclosed	2	Interrupted	3	Panoramique	4
Fragility	Big	1	Moderate	2	Small	3	Not at all	4
Naturalness, Typicalness, Size, Importance, Authenticity, Symbolic value, Potential value	Minimum	1	Small	2	Moderate	3	Big	4

Table 2. Landscape value grades for each landscape unit in the "Sheikh Sou" suburban park

	Old pine groves	Mixed shrublands with pines	Shrublands	Riparian zones	Grasslands
Total Landscape Value	49.20	63.00	51.20	59.60	54.40

Analyzing the grades for each landscape unit and taking into consideration the physical, aesthetical and psychological attributes of landscapes showed that aesthetic criteria (e.g. coloring, variety, harmony, texture) and also psychological ones (e.g. security, impression, enclosure, stimulus) received higher grades in the mixed shrublands and in the riparian zones and partially in the grasslands. This can be attributed to the fact that these vegetation types, especially the mixed shrublands and the riparian zones, sustain a great variety of vegetation species in number, color, shape and size in comparison to the old pine groves and the old ungrazed shrublands. This variety of species promotes the aesthetic value of the landscape and the feeling of relaxation and enjoyment. The fire that created the mixed shrublands transformed the monotonous dark monocultural pine groves to a diverse landscape with a variety of plant species such as *Cistus* sp., *Quercus coccifera* etc. The riparian zones, due to the presence of water, also created diverse systems, but these are much smaller in size and practically embedded in between the old pine groves. The ungrazed old shrublands received lower grades due to the fact that grazing prohibition reduced plant diversity and created a monotonous landscape of old Kermes oak (*Quercus coccifera*) shrubland. It is well documented that ungrazed shrublands tend to reduce their diversity, productivity, ecological values and their ecosystem services in general (Papadimitriou *et al.* 2004).

No significant differences were found while analyzing the physical criteria for the six landscape units. Physical criteria such as scale, naturalness and typicalness gave similar values to all units, with the exception of fragility, which, especially for the old pine groves, scored a very low grade of 1.2 (max 4). The latter datum was probably due to the fact that the old pine groves are very sensitive to disturbances such as wild fires, insect-induced diseases etc.

The visual management goal of retention for the mixed shrublands and the riparian zones of the Sheikh Sou park suggests that management activities suitable for a suburban park, such as recreation activities, should not be visually evident, in order to protect the significantly high landscape value of these two units. Partial retention, on the other hand, allows these kinds of activities to be visually noticeable to some extent. This is the case for the grasslands and the shrublands of the park, but only on condition that they repeat the form, line, color and texture of the surrounding landscape. Finally, the management goal of modification allows structures and recreation activities in the old pine groves to be more visually dominant as this landscape unit is considered less sensitive.

Our landscape evaluation results suggest that pine groves and old shrublands had a negative effect on the landscape value of the "Sheikh Sou" suburban park, thus reducing its recreational value.

IV – Conclusions

Landscape evaluation analysis of the six landscape units of the "Sheikh Sou" suburban park revealed that mixed shrublands with pines and riparian areas were visually attractive landscapes, very sensitive to management activities. Shrublands and old pine groves, received lower grades and became less sensitive to management interventions. It was concluded that pine groves and ungrazed shrublands had a negative impact on the total landscape and recreation value.

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Floristic composition and plant cover in Yozgat rangelands, central Turkey

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Abstract. This research was conducted to determine floristic compositions and plant cover area in four different rangelands of Yozgat province located in central Turkey. The observations and measurements were carried out in Koccagiz village of Sarikaya district, Taspinar village of Sorgun district, Hacilar and Kordeve district of Yerkoy in May 2014. Investigated rangelands are open to graze. Vegetation measurements sampling in rangelands were performed by using Loop method. Total 34 different plant species were determined in vegetation survey. Plant cover area in Koccagiz, Taspinar, Hacilar and Kordeve district was determined 60.6%, 66.5%, 55.0% and 44.9%, respectively. Over the rangelends, the ratio of legumes, grasses and other families in floristic composition respectively varied between 6.4 and 22.0%, 41.0 and 79.1%, 14.5 and 49.1%. In addition the ratio of decreaser, increaser and invader plant in floristic composition varied from 2.9 to 18.2%, 41.0 to 65.4%, 16.4 – 55.0%, respectively in the investigated rangelands. Koccagiz rangeland was in poor class, other rangelands were in medium class.

Keywords. Floristic composition – Plant covered area – Rangeland – Turkey.

Détermination de la composition botanique et de la surface couverte de plantes dans certaines terres de pâturage à Yozgat, centre de la Turquie

***Résumé**. Cette recherche a été menée pour déterminer les compositions botaniques et la surface couverte de plantes en quatre différents pâturages de Yozgat. Cette étude a été réalisée dans le village de Koccagiz à Sarikaya, le village de Taspinar à Sorgun, et les villages Hacilar et Kordeve à Yerkoy en mai 2014. Les pâturages étudiés sont ouverts à brouter. Les mesures de la végétation dans les pâturages ont été effectuées en utilisant la méthode Loop. Un total de 34 espèces de plantes différentes ont été déterminées dans l' étude de la végétation. On a déterminé que les surfaces couvertes de plantes aux villages de Koccagiz, de Taspinar, de Hacilar et de Kordeve étaient de 60,6%, 66,5%, 55,0% et 44,9% respectivement. Les ratios des légumineuses, des graminées et des autres familles dans la composition botanique ont varié entre 6,4 et 22,0%, 41,0 et 79,1%, 14,5 et 49,1%, respectivement, dans les pâturages étudiés. Les pourcentages de plantes « increasers », « decreasers », et envahissantes variaient de 2,9 à 18,2%, de 41,0 à 65,4%, de 16,4 à 55,0%, respectivement. Le pâturage de Koccagiz était en classe faible, d'autres pâturages étaient dans la classe moyenne.*

***Mots clés.** Composition botanique – Surface couverte de plantes – Pâturage – Turquie.*

I – Introduction

Grasslands are important as a feed source for livestock (Aydin and Uzun, 2002), as a habitat for wildlife, for environmental protection and for the *in situ* conservation of plant genetic resources (Acikgoz, 2001). It is well known that the grasslands in Turkey have lost productivity and also their quality due to long-term overgrazing; therefore urgent rehabilitation is needed. For this purpose, floristic composition and plant-covered area of pastures should be known. In fact, improving process includes two steps; firstly to determine qualitative and quantitative characters of grassland and secondly, application of rehabilitation methods and then monitoring its effect (Cerit and Altin, 1999).

In earlier studies conducted in different regions of Turkey, plant covered area was 11.1% consisting of 14% legumes, 38.9% grasses and 47.1% others (Alan and Ekiz, 2001). Similarly, ratio of legumes, grasses and other families were 14.36%, 34.17% and 51.47% respectively in

Bartin pastures (Sengonul *et al.*, 2009). In Cankiri pastures plant covered area was 65.19% (Unal *et al.*, 2012). Cinar *et al*. (2014), reported that plant covered area in a rangeland of Hatay including 41 different species was between 84.4 and 99.0%, and the ratio of legumes, grasses and other families varied from 8.9 to 22.1%, from 48.8 to 58.6% and from 25.6 to 45.0% respectively.

In Yozgat Province there is need to improve feed source for economical animal production. For this reason, it is necessary to improve the pasture yield and quality with suitable improvement methods and appropriate management, as the forage needs for animals are largely covered from pastures. The present study was conducted on four pastures located in Yozgat, Turkey, with the aim of determining plant covered area and floristic composition, thereby shedding light to future rehabilitation studies on these rangelands.

II – Materials and methods

This study was conducted to determine floristic composition and plant covered area of four different rangelands of Yozgat Province in May 2014. These rangelands are grazed uncontrolled during the year and are located in the villages of Koccagiz village (Sarikaya district), Taspinar (Sorgun district), Hacilar and Kordeve (Yerkoy). Vegetation measurements were performed by using Loop Method. Loop measurements were made throughout four directions from center (Sen, 2010) in each rangeland. The ratio of each family in floristic composition was determined by dividing the number of plants belonging to that family to the total number of plants. For plant covered area, the number of the points of interception with the plant species was divided to the number of total measurement points. Rangeland classification was determined according to Bakir (1987) based on the proportions of ground cover of species and their distribution patterns. Range plants are grouped as follows: (i) decreasers: highly productive and palatable species that will decrease on a range when exposed to heavy grazing pressures; (ii) increasers: these species are native plants but they increase in site and number to take the place of decreasers that have been weakened or reduced because of heavy grazing or other range abuse. The increaser plants are normally shorter, lower producing and less palatable to livestock; and (iii) invaders; these are plants that invade and replace the plants that have been reduced or become seriously weakened. They may be annuals, perennials, or shrubs and have little or no grazing value (Wroe *et al*., 2016).

III – Results and discussion

At the end of this study, 34 different species were determined, and plant covered area ranged from 44.9 to 66.5% in the rangelands of Yozgat.

Koccagiz rangeland included 16 different species and was determined in poor class with 60.6% plant covered area (legumes 9.9 %, grasses 41 % and other family plants species 49.1%) (Table 1). Percentage of decreaser plants in Koccagiz was 4%, increaser plants were 41%, and invader plant was 55%. *Bromus tectorum*, *Satureja parnassica* and *Thymus praecox* (36.0%) were dominant species in this rangeland.

Twenty different species were determined in Taspinar rangeland, and plant covered area in this rangeland was 66.5%. Percentage of legumes, grasses and other family plants in the total plant covered area was 19.1, 58.3 and 22.6%, respectively.Ratio of decreaser plants was 6.0%, increaser plants (*Festuca ovina*) 60.4 % and invader plants (*Thymus praecox*) 33.6 %. Rangeland of Taspinar was in medium class (29.5%) (Table 1). In Hacilar rangeland plant covered area 55.0 % with a ratio of legumes (6.4%), grasses (79.1%) and other family plants species (14.5%). Percentage of decreaser plant was 18.2%, increaser plants was 65.4% and invader plant was 16.4% and, dominant species in Haciar were *Festuca ovina*, *Dactylis glomerata* and *Elymus hispidus*. Hacilar Rangeland was in poor class (42.7%) (Table 1).

Table 1. Determined plant species and percentage of plants in experimental lands

Species	Koccagiz		Taspinar		Hacilar		Kordeve	
	PCA	FC	PCA	FC	PCA	FC	PCA	FC
Legumes								
Astragalus angustifolius	-	-	1.5	2.3	-	-	-	-
Astragalus argaeus	2.3	3.8	0.8	1.2	-	-	-	-
Astragalus bicolor	0.8	1.3	3.8	5.7	-	-	1.3	2.9
Astragalus lineatus	0.5	0.8	-	-	0.5	0.9	2.3	5.1
Coronilla varia	-	-	0.8	1.2	1.5	2.7	1.0	2.2
Medicago minima	-	-	3.8	5.7	1.0	1.8	4.0	8.9
Onobrychis cana	2.4	4.0	2.0	3.0	0.5	0.9	1.3	2.9
Total Legumes	***6.0***	***9.9***	***12.7***	***19.1***	***3.5***	***6.4***	***9.9***	***22.0***
Grasses								
Bromus tectorum	21.8	36.0	4.3	6.5	3.5	6.4	19.7	43.9
Cynodon dactylon	-	-	-	-	11.0	20.0	2.3	5.1
Dactylis glomerata	-	-	-	-	0.5	0.9	-	-
Elymus hispidus	-	-	-	-	8.5	15.5	-	-
Festuca ovina	3.0	5.0	34.5	51.9	19.0	34.5	0.7	1.6
Poa bulbosa	-	-	-	-	0.5	0.9	-	-
Stipa holosericea	-	-	-	-	0.5	0.9	3.0	6.7
Total Grasses	***24.8***	***41.0***	***38.8***	***58.3***	***43.5***	***79.1***	***25.7***	***57.3***
Other Family Plants								
Adonis aestivalis	-	-	0.5	0.8	-	-	0.3	0.7
Allium atroviolaceum	-	-	-	-	0.5	0.9	1.3	2.9
Anthemis austriaca	0.5	0.8	0.3	0.5	2.0	3.6	-	-
Artemisia splendens	2.3	3.8	0.3	0.5	-	-	0.7	1.6
Carduus nutans	0.8	1.3	-	-	-	-	-	-
*Convolvus betonicifoliu*s							0.3	0.7
Eryginum campestre	0.5	0.8	0.5	0.8	1.0	1.8	1.0	2.2
Euphorbia sp.	-	-	0.5	0.8	-	-	-	-
Helianthemum nummularium	-	-	2.3	3.5	-	-	3.7	8.2
Noanea mucronata	0.8	1.3	-	-	-	-	-	-
Phlomis sieheana	3.3	5.4	-	-	3.0	5.5	-	-
Plantago maritima	-	-	0.5	0.8	-	-	1.3	2.9
Potentilla recta	-	-	0.5	0.8	-	-	-	-
Sanguisorba minor	-	-	2.0	3.0	0.5	0.9	-	-
Satureja parnassica	10.3	17.0	0.5	0.8	-	-	-	-
Scorzonera hieraciifolia	-	-	0.3	0.5	-	-	-	-
Scutellaria orientalis	1.5	2.5	-	-	-	-	-	-
Taraxacum officinalis	-	-	-	-	1.0	1.8	0.7	1.6
Thymus praecox	8.8	14.5	6.8	10.2	-	-	-	-
Verbascum lasianthum	1.0	1.7	-	-	-	-	-	-
Total Other Family Plants	***29.8***	***49.1***	***15.0***	***22.6***	***8.0***	***14.5***	***9.3***	***20.7***
Plant Covered Area	***60.6***		***66.5***		***55.0***		***44.9***	

PCA: Plant Covered Area (%), **FC**: Floristic composition (%).

Kordeve rangeland was classified as medium (36.4) (Table 1) with a total of 17 different species and 44.9% of plant covered area. The ratioa of legumes, grasses and other family plants in the total plant covered area were 22.0, 57.3 and 2.7%, respectively. Percentages of decreaser plants, increaser plants (*Bromus tectorum*), and invader plants (*Medicago minima*), were 2.9%, 62.4% and 34.7% respectively.

In three rangelands (Taspinar, Hacilar Kordeve), grasses have the highest portion in floristic composition, and then comes other families and legumes. However, in Koccagız, other family plants were dominant in the vegetation and grasses and legumes were lesser; therefore, it was classified as a poor rangeland. Our findings are consistent with earlier studies showing that grass species are generally dominant in rangelands (Gokkus *et al.* 1993; Koc and Gokkus, 1994; Kendir, 1999; Ipek Gergin, 2001; Oner, 2006; Babalik, 2008; Mut, 2009; Sen, 2010; Tasdemir, 2015). In most areas in Turkey, grasses which were generally invader plants are the dominant species in the climax plant community of rangelands (Oztas *et al.*, 2003).

IV – Conclusions

The results of this study indicated that the rangelands around Yozgat Province are under overgrazing pressure. Consequently, in these rangelands suitable improvement methods and management principles should be implemented.

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Rangeland rehabilitation in the southern part of the Mediterranean basin

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Abstract. Rangelands of the southern part of the Mediterranean basin have for centuries provided forage for livestock and wildlife. Now their role as providers of ecosystem services and goods is being widely recognized by local governments and international organizations. But the widespread degraded ecological status of rangelands is causing increasing concern. Over-exploitation of rangeland resources, land tenure issues, conversion of rangelands into rainfed cropping systems, and climate change including drought are the main drivers for this degradation. Several governments are becoming increasingly aware of the magnitude of the problem and have begun to address the root causes through holistic approaches. However, there are major challenges in tackling the issue: the importance of rangelands is generally marginalized, conservation measures are incomplete and often ineffective for the sustainable restoration of degraded rangeland resources. In addition, given the low and slow return on investment, governments are not able to finance large-scale projects to effectively restore and develop rangeland natural resources. Nonetheless, there are ways to improve the situation. In this paper, we propose how to go about this. Not least, we outline how understanding and managing the constraints to widespread adoption of sustainable practices is key to the successful out-scaling of interventions with known potential.

Keywords. Drylands – Climate change – Regeneration – Resting – Participatory approach.

Réhabilitation des parcours dans la partie sud du bassin méditerranéen

Résumé. *Les parcours situés au sud du bassin méditerranéen ont fourni pendant des siècles du fourrage pour l'élevage et la faune. Récemment, leur rôle en tant que fournisseurs de biens et services écosystémiques est largement reconnu par les autorités locales et les organisations internationales. Toutefois, leur statut écologique très dégradé est de plus en plus alarmant. Surexploitation, problèmes fonciers, conversion des terres de parcours les plus riches en culture pluviale et les changements climatiques, y compris la sécheresse, sont les facteurs les plus importants responsables de leur dégradation. Plusieurs gouvernements sont de plus en plus conscients du problème et ont commencé à traiter les causes en utilisant des approches holistiques. Néanmoins, il existe des obstacles majeurs; l'importance des parcours est marginalisée, les mesures de conservation sont incomplètes et souvent inefficaces, et peu d'attention est attribué à la connaissance scientifique pour la restauration durable de ces ressources. Étant donné le faible et lent retour sur l'investissement, les gouvernements ne sont pas en mesure de financer des projets de grande envergure pour restaurer et développer les ressources pastorales d'une manière efficace. Dans ce contexte, nous proposons des solutions pour améliorer la situation. En effet, comprendre les causes de dégradation nous permet de surmonter les obstacles et atteindre une adoption à grande échelle des mesures durables et prometteuse.*

Mots-clés. *Zones arides – Changement climatiques – Régénération – Repos – Approche participative.*

I – Introduction

Rangelands of the southern part of the Mediterranean basin are very important ecologically, economically, and socially. They provide a range of ecological services, including nutrient cycling, pollutant filtering, and biodiversity preservation. They also serve as a resource base for livestock production – a key source of income and livelihoods. Additionally, they hold special cultural and heritage value for pastoral and agro-pastoral communities (Sincich, 2002).

Much of the southern part of the Mediterranean region is arid or semi-arid with shallow and low-fertility soils and poor plant cover. Over time, various human activities have altered the natural vegetation cover, which mainly comprises very sparse steppe species (Louhaichi *et al*., 2012a). During the last few decades, complex political, social, and environmental factors and management practices have degraded large areas of rangeland; this calls into question rangelands' long-term sustainability under current usage practices. The major causes of rangelands degradation, habitat change, and biodiversity loss are conversion of natural ecosystems to farmland, exploitation through selective grazing, fuel wood removal, charcoal production, and livestock overgrazing (Reyers, 2004). Disturbances caused by these activities and, by climate change, influence ecosystem dynamics, structure, and composition. This occurs at both local and regional scales (Hubbell *et al*., 1999).

II – Challenges and constraints

1. Weak institutional and policy arrangements

Communication and coordination between the various institutions servicing and supporting grasslands in rangeland regions has tended to be weak, with agro-pastoral communities rarely being consulted when projects are first formulated. As a result, the majority of past efforts directed to the development of grasslands have been mostly technical with no consideration for social aspects such as tribal rules and land tenure. Nowadays, as decentralization and local empowerment gain momentum, community participation can no longer be ignored. Further, land tenure in rangeland regions is a major issue in the management and restoration of degraded, extensive communal rangelands (Louhaichi and Johnson, 2008). Uncertainties of land tenure and land-use rights cause agro-pastoralists to feel insecure, with little incentive for adopting stewardship responsibilities of protecting resources within the local ecosystem.

2. Climate change

Grassland ecosystems in the southern part of the Mediterranean basin are sensitive to changes in climate and land use. Such changes have meant that, over the last three decades, permanent grassland areas have reduced by 5% in North Africa, while in West Asia they have increased by 18%. Climate change increases the negative impacts of drought on rangeland vegetation. These impacts include low levels of emergence of annual species, changes in phenology and the timing of reproduction, reduced biodiversity, low levels of plant cover, and a decline in productive capacity in pastoral systems (Ouled Belgacem and Louhaichi, 2013). Climatic changes could also lead to a shortage of water resources, widespread land degradation, and increased desertification. These threats would impact negatively rangeland biodiversity, the life cycle of plants, and crop/livestock productivity. Overall, climate change may greatly reduce the resilience of rangeland ecosystems.

III – Sustainable practices

1. Monitoring and assessment

Any rangeland rehabilitation and management activity should be preceded by an inventory, an assessment, and appropriate mapping of the condition and use of the rangeland. To ensure that these lands can provide sustainable products for future generations, their ecological condition should be monitored against specific standards. Both short- and long-term monitoring are necessary – in order to account for the dynamic nature of plant community responses to climate fluctuations (drought and wet conditions) and manmade disturbance. Advances in technology such as GIS and remote sensing enable large areas to be rapidly mapped and monitored if appropriate technologies are used (Louhaichi *et al*., 2012b).

2. A participatory approach

Sustainable rehabilitation of degraded rangelands that are dominated by collective and/or tribal ownership is a challenging task for the southern part of the Mediterranean region. The policy responses to this complex issue have been sectorial and fragmented. Previously, the 'top–down' approach, which puts forward technical solutions and neglects the social context, was the more common form of intervention. But in response to frequent failures of the top-down approach, international development turned during the 1970s towards 'participatory development' as an alternative approach. National governments have been slow to adopt this participatory approach, but recent experiences suggest that integrated and participatory approaches may lead to more sustainable resource management. This kind of development aims to organize people on a decentralized basis and to apply participatory tools in order to effectively empower local people (Nefzaoui *et al*., 2014).

3. Water harvesting

Water is an important resource in arid and semi-arid rangelands, but often it is wasted or allowed to erode the landscape. One way to address this is through simple, cost-effective water harvesting techniques (WHT) that can be easily adopted by pastoral and agro-pastoral communities. This practice has been used for thousands of years in arid and semi-arid regions of the world to supplement scarce water resources. In general, the interventions are used to increase soil moisture content, vegetation cover, and productivity can improve the productivity of rainwater, and maintain productive and sustainable agro-pastoral systems in marginal environments (Van Wesemael *et al*., 1998). WHT can also control soil erosion and reduce the impact of drought. Experience of the last two decades provides increasing evidence that WHT can mitigate the increasing variability of rainfall.

4. Grazing management

For centuries, pastoral nomads were the main users of land in arid and semi-arid parts of the southern Mediterranean region. The basic management problem for most pastoralists is that there is rarely enough forage and water in one place to sustain the pastoral community and their livestock year-round; becoming mobile was the only way for these communities to meet their livestock feeding needs (Abu-Zanat *et al.,* 2005). More recently, the nomadic system has been disappearing in most of the region due to changes in agricultural practices and climatic factors. In addition, there has been a major shift in the attitudes of pastoralists towards an increasing interest in educating their children and in benefiting from social services. Under appropriate management, livestock grazing can be manipulated to enhance not only natural vegetation productivity, but also other rangeland resources such as soil and water.

Furthermore, there are several efficient techniques for rangeland improvement such as using herbaceous annual and perennial species, shrubs, and trees are continually being developed. Techniques with great potential but requiring fine-tuning are deferred grazing, soil surface preparation (e.g. scarification and pitting), and direct seeding (Louhaichi *et al*., 2014).

IV – Conclusions

Reversing the trend of rangeland degradation, and increasing forage production in a sustainable manner, requires better management. If management and rehabilitation are to be sustainable in the long term they must also be conducted in a participatory manner. Using this approach, developments that improve the productivity of rangelands involve a set of policies to assure pastoral communities that they will benefit from the improvements made. Ownership, whether in legal terms or in practice, needs to be cultivated and respected so that pastoralists become guardians of their resource base, thus encouraging long-term sustainable management. Further research on land tenure arrangements is required to encourage best management practices throughout the rangelands. Pastoral communities and governments need to clearly identify the rights and responsibilities of all rangeland users. This can ensure that those with the right to manage land are aware of their management responsibilities.

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Plant diversity in suburban Mediterranean ecosystems: The case of "Sheikh Sou", Thessaloniki, Greece

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Abstract. Mediterranean ecosystems have traditionally developed through human intervention. Especially the ones located near urban areas, have been imposed to various changes resulting from restoration practices such as reforestation, land use change, fire etc. effecting vegetation structure and diversity. The aim of this paper was to study the effects of various human-caused perturbations on plant cover and species diversity and composition in suburban Mediterranean ecosystems. The research was conducted in the "Sheikh Sou" suburban park of Thessaloniki, North Greece. Three different human-caused perturbations have occurred in the suburban ecosystem of "Sheikh Sou" represented by: i) abandoned arable field ii) postfire natural revegetation and iii) pine plantation. Plant cover was recorded on three experimental sites using the line point method and species richness, Shannon-Wiener diversity index and evenness were calculated. The three experimental sites had high plant cover; however the dominant plant group differed among the experimental sites. Abandoned arable field appeared higher plant diversity and evenness, while postfire natural revegetation and pine plantation had vertical plant stratification. Our results suggest that human-caused perturbations in suburban Mediterranean ecosystems affect differently the structure of the plant community and species diversity. In suburban Mediterranean ecosystems proper management actions should be taken in order to preserve a diverse mosaic of vegetation types.

Keywords. Pine plantation – Fire – Field abandonment – Plant cover – Shannon-Wiener index.

La diversité végétale dans les écosystèmes méditerranéens de banlieue: Le cas de "Cheikh Sou" Thessalonique, Grèce

Résumé. *Les écosystèmes méditerranéens se sont traditionnellement développés sous l'influence de l'intervention humaine. Ceux situés à proximité des zones urbaines ont particulièrement subi des modifications résultant de pratiques de restauration, du changement d'utilisation des terres, ainsi que d'incendies, etc. affectant la structure et la diversité de la végétation. Le but de cette étude était d'étudier les effets des diverses perturbations d'origine humaine sur le couvert végétal, sur la diversité des espèces et sur la composition des écosystèmes méditerranéens de banlieue. La recherche a été menée dans le "Cheikh Sou" parc naturel de Thessalonique, au nord de la Grèce. Trois différentes perturbations d'origine humaine ont eu lieu dans l'écosystème suburbain de "Cheikh Sou": i) abandon de terres arables, ii) repousse naturelle de la végétation et iii) plantations de pins, suite à un incendie. La couverture végétale a été enregistrée sur chaque site expérimental en utilisant la méthode ligne-point. La diversité des espèces, l'indice de diversité de Shannon-Wiener ainsi que la régularité ont été calculés. Les trois sites expérimentaux avaient une importante couverture végétale, mais le groupe végétal dominant différait selon les sites expérimentaux. Les champs arables abandonnés ont montré une plus grande diversité et régularité végétale, tandis que la revégétalisation naturelle et les plantations de pins post-incendie faisaient apparaître une stratification végétale verticale. Il est conclu que les perturbations causées par l'homme dans les écosystèmes méditerranéens de banlieue affectent différemment la structure des plantes et la diversité des espèces. Dans les écosystèmes méditerranéens suburbains, des mesures de gestion appropriées devraient être prises afin de préserver les diverses mosaïques de types de végétation.*

Mots-clés. *Plantations de pins – Incendies – Abandon des terres – Couverture végétale – Indice de Shannon-Wiener.*

I – Introduction

Mediterranean ecosystems have traditionally developed through human intervention (Naveh and Lieberman, 1984). This is especially true as far as the suburban Mediterranean ecosystems are concerned. The later are of great importance as they offer multiple ecosystem services such as protection from air and water pollution, human recreation, aesthetic value of the landscape and enhanced natural biodiversity (Mckinney, 2008). None the less, suburban environments have been imposed to various changes resulting from restoration practices such as reforestation, land use changes, fire etc. affecting their vegetation structure and diversity (Papanastasis and Chouvardas, 2005; Papanastasis *et al.*, 2015).

“Sheikh Sou” is a suburban ecosystem forming a park that is surrounding the city of Thessaloniki, North Greece. It was originally a typical Mediterranean rangeland that was reforested in the mid 30’s with pine plantation for protection purposes. After a destructive fire in 1997 (18 years ago), almost the 60% of the area was burned (Kallidromitou, 2015). Furthermore, many arable fields have been abandoned, due to socio-economic changes, following the general trend of land use changes in Greece (Papanastasis, 2007). The aim of this paper was to study the effects of the various human-caused perturbations on plant cover and species diversity and composition in suburban Mediterranean ecosystems.

II – Materials and methods

The research was conducted in the “Sheikh Sou” suburban park of Thessaloniki located at the uphill part of the city of Thessaloniki, North Greece. Three different human-caused perturbations have occurred in the suburban ecosystem of “Sheikh Sou” (arable field abandonment, fire and reforestation with pine plantation) represented by: (i) abandoned arable field more than 10 years ago, (ii) postfire natural revegetation after the 1997 fire and (iii) pine plantation that was never burned. On each experimental site, three transects (20 m long each) were established. Plant cover was recorded along each transect using the line-point method (Cook and Stubbendieck, 1986). Species overlapping in each point were also recorded (multiple contacts) and species composition was calculated. The recorded species were classified into five a priori groups: trees, shrubs, grasses, legumes, forbs and their contribution in each transect was calculated. Furthermore, species richness, Shannon-Wiener diversity index and evenness (Magurran, 2004) were calculated for each transect. Data were analysed using one way ANOVA. Duncan multiple range test was applied to detect the differences among the means at a 0.05 level of significance. All analyses were carried out using the software package SPSS (SPSS for Windows, release 22.0; SPSS, Inc., Chicago, USA).

III – Results and discussion

High plant cover, reaching more than 80%, was recorded for all the experimental sites (Table 1). Pine plantation had the highest tree cover, while postfire natural revegetation the highest shrub cover. Shrubs were absent from the canopy cover of the abandoned field and covered a very small area in the pine plantation but no significant differences were found. Furthermore, herbaceous species cover was significantly higher in the abandoned field, followed by postfire natural revegetation and lowest in the pine plantation. On the other hand, litter and bare soil had a mean cover of 8% and 7.9% respectively in all sites and did not differ significantly among them. Similar results have been reported by Chirino *et al.* (2006) and Papadimitriou *et al.* (2013).

The contribution of the five a priori groups in each experimental site is shown in Table 2. Grasses and legumes had significantly higher representation in the abandoned field. They have been found to be also reduced in the case of pine plantations by other researchers (Chirino *et al.*, 2006; Papadimitriou *et al.* 2013), though Papadimitriou *et al.* (2004) reported grasses as a persistent group among abandoned fields and shrublands. In addition, forbs contributed by a mean of 15% of species composition in all sites without significant differences. Shrubs and trees representation was higher in the postfire natural revegetation and the pine plantation respectively, following the same trend as in the case of plant cover (Table 2). On the contrary, shrubs contribution was almost absent in the abandoned field and the pine plantation and trees totally absent in the abandoned field and the postfire natural revegetation.

Table 1. Mean plant cover (%) of the three experimental sites in the "Sheikh Sou" suburban park

Experimental site	Trees	Shrubs	Herbaceous species	Litter	Bare soil
Abandoned arable field	0.00b[1]	0.00b	86.33a	3.00a	10.67a
Postfire natural revegetation	0.00b	69.00a	11.00b	11.00a	9.00a
Pine plantation	78.33a	0.67b	7.00c	10.00a	4.00a

[1]Different letters in the same column indicate significant differences ($p \leq 0.05$).

Table 2. Mean contribution (%) of the various a-priori groups to the three experimental sites in the "Sheikh Sou" suburban park

Experimental site	Grasses	Legumes	Forbs	Shrubs	Trees
Abandoned arable field	53.24a[1]	23.45a	23.31a	0.00b	0.00b
Postfire natural revegetation	7.66b	0.40b	8.01a	83.93a	0.00b
Pine plantation	11.35b	0.69b	13.81a	2.29b	71.86a

[1]Different letters in the same column indicate significant differences ($p \leq 0.05$).

All three diversity indices followed the same trend (Table 3). Species richness, Shannon-Wiener diversity index and evenness were higher in the abandoned field and lower in the other two sites. These results indicate that abandoned field was more diverse and abundance was evenly distributed among the species. On the other hand, postfire natural revegetation and pine plantation appeared vertical plant stratification due to the presence of shrub and tree stratum respectively. These results come in agreement with other researchers that found higher species diversity in abandoned fields (Papadimitriou *et al.*, 2004) and lower in pine plantations (Chirino *et al.*, 2006; Alrababah *et al.,* 2007).

Table 3. Mean values of species richness, Shannon-Wiener diversity index and evenness of the three experimental sites in the "Sheikh Sou" suburban park

Experimental site	Species richness	Shannon-Wiener (H)	Evenness (J)
Abandoned arable field	16.33a[1]	2.27a	0.81a
Postfire natural revegetation	9.33b	1.24b	0.55b
Pine plantation	10.33b	1.08b	0.46b

[1]Different letters in the same column indicate significant differences ($p \leq 0.05$).

IV – Conclusions

Our results suggest that human-caused perturbations in suburban Mediterranean ecosystems affect differently plant community structure and diversity. Arable field abandonment results in high plant diversity, while natural revegetation with shrubs and pine plantation leads in a vertical vegetation structure. In suburban Mediterranean ecosystems proper management actions should be taken in order to preserve a diverse mosaic of vegetation types.

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The use of native pasture species in the rehabilitation of a limestone quarry

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Abstract. In high environmental value areas, the rehabilitation of quarries requires the use of native well-adapted plant material. The use of forage species could perform the dual function of rehabilitation and production, where livestock breeding is a key aspect. With the aim of evaluating the establishment and persistence of a mixture of native pasture species selected by CNR-ISPAAM from Sardinian populations, a trial for the rehabilitation of a limestone quarry located in a Site of Community Importance (SCI) was carried out. The mixture components were: *Medicago polymorpha* L., *Psoralea bituminosa* L., *Psoralea morisiana* (Pignatti & Metlesics) Greuter, *Melilotus indica* (L.) All., *Lolium rigidum* Gaudin and *Plantago lanceolata* L.. Moreover, an amount of commercial seeds of Mediterranean origin of *Trifolium subterraneum* L. and *Dactylis glomerata* L. was added. The mixture was distributed by hydro seeding in autumn 2011. Two sowing rate, 12 and 21 g m^{-2} seeds, were compared. The mixture showed an excellent establishment with the dominance of native annual species and a high soil cover rate from spring of the establishment year. The autumn re-establishment of self-reseeding annual species in the second year was excellent and then it has gradually reduced. Perennial species showed a slow establishment, reaching a satisfactory presence only from third year. Similar results in terms of soil covering and persistence for the two seeding treatments were observed.

Keywords. Rehabilitation – Native species – Mixtures – High environmental value areas.

L'utilisation d'espèces indigènes de pâturage dans la réhabilitation d'une carrière de calcaire

Résumé. *La réhabilitation des carrières situées dans des zones de haute valeur environnementale nécessite l'utilisation de matériel végétal natif bien adapté. L'utilisation d'espèces fourragères là où l'élevage est un aspect important, pourrait avoir le double objectif à la fois de la réhabilitation et de la production. Dans un essai en Sardaigne, certaines espèces indigènes annuelles et vivaces de pâturages, choisies parmi les populations locales par le CNR-ISPAAM, ont été utilisées dans un mélange, dans le but d'évaluer leur mise en place et la persistance dans la réhabilitation d'une carrière de calcaire située dans une zone spéciale de conservation (ZSC). Les composants du mélange étaient :* Medicago polymorpha *L.,* Psoralea bituminosa *L.,* Psoralea morisiana *(Pignatti & Metlesics) Greuter,* Melilotus indica *(L.) All.*, Lolium rigidum *Gaudin et* Plantago lanceolata L. *En outre, une quantité de semences commerciales d'origine méditerranéenne, de* Trifolium subterraneum *L. et* Dactylis glomerata *L. a été ajoutée. Le mélange a été distribué à l'automne 2011 par hydro-ensemencement. Deux densités de semis ont été comparées. Le mélange a montré une excellente mise en place avec la dominance des espèces indigènes annuelles et un taux de couverture élevé du sol au printemps. Le rétablissement des espèces annuelles à auto-ensemencement dans la deuxième année a été excellent, diminuant ensuite progressivement. Les espèces vivaces ont montré une lente mise en place, pour n'atteindre une présence satisfaisante que dans la deuxième année. Les deux taux de semis ont montré des résultats satisfaisants.*

Mots clés. *Réhabilitation – Espèces indigènes – Mélanges – Haute valeur environnementale.*

I – Introduction

The disused areas exploited for raw material extraction are usually recovered from decay with environmental engineering practices, aimed at achieving the main objectives to preserve the soil from erosion and to include these areas in the surrounding landscape. Conrad and Tischew

(2011) strongly recommended avoiding the use of standardized commercial non-local seed mixtures for grasslands restorations. The use of native species offers a greater probability of adaptation and, in the case of native forage species, it could perform the dual function of rehabilitation and production (Porqueddu *et al.,* 2013).

As a general rule, the rehabilitation of degraded sites should be always made according to the environmental characteristics of the area (i.e. potential vegetation). Nonetheless, in the Sites of Community Importance (SCI) the application of this principle is compulsory, since the European environmental policy imposes strict guidelines especially concerning the plant material suitable to be employed for the rehabilitation. Unfortunately, the application of the European rules is often difficult, as the correct realization of re-vegetation plans requires the market availability of adequate seed amounts of well adapted species to the target substrates and to the local conditions. Our research concerned the environmental quarry rehabilitation program provided by Italian law for the mining sector. The aim of the present study was to evaluate a native-based pasture mixture, including species of different functional groups, for the rehabilitation of a limestone quarry located in Sardinia (Italy).

II – Materials and methods

Study Site. The study was carried out over four years (2011–2015) at the quarry “Sas Funtanas”, located in North East Sardinia (latitude 40° 33' N, longitude 9° 39' E) at an altitude of 560 m a.s.l.. The quarry has been exploited for limestone extraction from 1977 and in 1995 it was included in the perimeter of a Site of Community Importance (SCI - ITB021107 – Monte Albo) defined by the ‘Habitat’ Directive 1992/43/EU. The extraction method currently used was a subvertical steps. The area is characterized by a typical Mediterranean climate, with an average annual rainfall of 900 mm concentrated in autumn and spring, with mild winters and severe drought from late May to early October. The vegetation surrounding the quarry consisted of a degraded garrigue, Sheep, cattle, goats and wild animals (such as wild boars) grazed the surrounding area during the year.

Plant materials. Six native species (selected by CNR-ISPAAM) and two commercial varieties of annual and perennial species belonging to the botanical families Fabaceae, Poaceae and Plantaginaceae were sown in mixture (Table 1). The mixture components were chosen on the basis of their functional features: (i) fast or slow establishing species, namely annual and perennial species, (ii) N-fixing or no N-fixing species, namely legumes, grasses and forbs. According to the SCI management plan, all species used were native and present in the surrounding environment. Restoration activities have also included the planting of autochthonous woody species such as *Quercus ilex*, *Juniperus* sp., *Arbutus unedo*, *Phyllirea* sp. (planting distance 1,5 x 1,5 m).

Table 1. List of species and sowing rate. Life form: T = therophyte; H = hemicryptophyte; SR = seed rate in the mixture (in weight)

Plant materials	Provenance	Common name	Family	Life form	SR (%)
Medicago polymorpha L.	Sardinia	Burr medic	Fabaceae	T	40.0
Lolium rigidum Gaudin	Sardinia	Annual ryegrass	Poaceae	T	26.4
Psoralea bituminosa L.	Sardinia	Arabian pea	Fabaceae	H	2.1
Psoralea morisiana (Pignatti & Metlesics) Greuter	Sardinia	Arabian pea	Fabaceae	H	0.4
Melilotus indica L.	Sardinia	Sweet clover	Fabaceae	T	0.6
Plantago lanceolate L.	Sardinia	Narrowleaf plantain	Plantaginaceae	H	4.7
Trifolium subterraneum L.	Commercial	Subterranean clover	Fabaceae	T	13.4
Dactylis glomerata L.	Commercial	Orchardgrass	Poaceae	H	12.4

Plot Management. The trial was carried out in a slope (average slope = 85%). A layer (12 cm) of soil added with compost (14%) was distributed on the slope surface. The soil was sandy-clay-loam (53.6% sand, 22.8% silt and 23.6% clay), sub-alkaline with pH 7.8 (in water), containing 3.5‰ N (Kjeldhal method), 9.77 ppm P_2O_5 (Olsen) and 5.0% organic matter. The slope area was divided into two plots: (i) A1, equivalent to 900 m^2; and (ii) A2, equivalent to 1800 m^2. Two different sowing rates of the mixture were used in the plots: 12 and 21 g m^{-2} viable seeds, respectively in A1 and A2. Mixtures were sown in November 2011 by hydro-seeding. The hydro-seeding contained a blend of water, green-dyed short fiber, soil improvers and fertilizers appropriately selected. The mixtures were sown after the plantation of native woody species.

Measurements. In the first year, forty days from sowing, plant establishment was assessed by counting the seedlings on eight and twenty-two sample areas of 1/16 m^{-2} in A1 and A2, respectively. Sampling areas were chosen randomly. In spring and winter, vegetation data were collected by applying a point intercept method (Daget & Poissonet, 1969) on 50 m line intersect transects (total counts per transect = 200) to evaluate the species contribution to soil cover.

III – Results and discussion

A satisfactory establishment of seedlings was found in both plots. No statistical differences between the two seeding rates for the establishment (2810 ± 568 SD and 3593 ±1027 SD seedlings m^{-2} in A1 and A2, respectively) were observed. In the different seasons and years, no remarkable variations were recorded for total soil covering (Fig. 1).

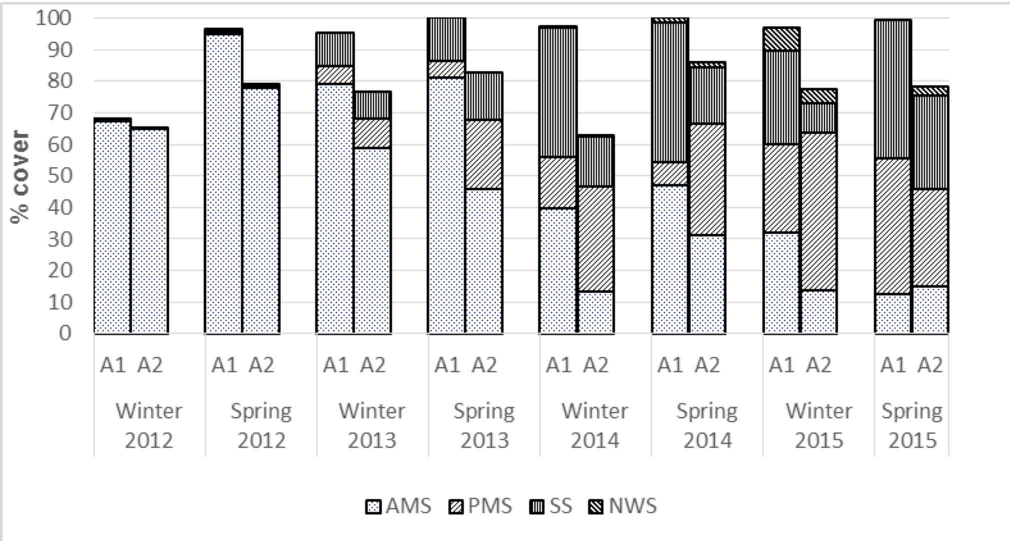

Fig. 1. Soil covering (%) of natural and introduced species during the 4 years for the two seeding rates A1 (12 g m^{-2}) and A2 (21 g m^{-2}). AMS: Annual Mixture Species, PMS: Perennial Mixture Species, SS: Spontaneous Species, NWS: Native Woody Species (planted).

Its level always exceeded 65%, the minimum level registered in the winter of the establishing year. This soil covering rate is the minimum cover level below which increases the risk of erosion (Thornes, 1988). The soil covering rate was slightly higher in A1 than A2. In spring 2015, at the end of the observation period, soil covering was high both in A1 (98%) and A2 (78%). As expected, the annual species of the mixture provided the higher contribution to soil covering in the first two years, especially in A2. The perennial species contribution was initially negligible but tended to increase their importance gradually, reaching rates of 30-40% and more in the last years. In spring 2015, *Psoralea* spp. contributed to soil covering for 14% in A2 and 28% in A1, while the contribution of *P. lanceolata* and *D. glomerata* was similar in both plots (around 10%). Along the years, the spontaneous species also showed an increasing contribution, ensuring a higher plant biodiversity and a better inclusion of these areas in the surrounding landscape. *Onopordum illyricum* L., *Helminthotheca echioides* (L.) Holub, *Sonchus asper* (L.) Hill, *Convolvus* spp. and *Chrysanthemum coronarium* L., were the most abundant species among spontaneous one, accounting for 7% the first three and 5% and 4% the last ones. The growth of woody native species was very slow and their contribution to soil covering was always below 5% in the different years and treatments.

IV – Conclusions

The study highlighted the good performances of the mixture based on native species of different functional groups, even at low sowing rates. The main objective of the rehabilitation was to control soil erosion and the excellent soil coverages recorded in the 4-year trial allowed to meet it. The good performance of species employed, in particular the native ones, encourages the research aimed at promoting the use of local germplasm for the re-naturalization, especially when the seed market does not offer well adapted plant materials. The mixture shown to be not too aggressive, allowing for the spontaneous species growth. Moreover, in degraded areas where slope is not a limiting factor, the introduced forage species ensure, over the years, a high quality pasture for potential pastoral activities. In this case, the creation of areas with high forage production, especially in high natural value areas, could reduce the pressure from grazing areas more susceptible to degradation. Finally, the rehabilitation of abandoned areas by extraction processes generates environmental and landscape benefit, playing an important role for the socio-economic subsistence of rural populations.

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Peroxidase responses of two contrasting *Medicago ciliaris* populations to cold stress in aerial and root systems

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Abstract. Effect of cold on antioxidant responses in aerial (shoots and leaves) and roots tissues of two contrasting accessions of *Medicago ciliaris* Krockers (Cil 126, tolerant and Cil 123, sensible) seedling were investigated. Ten-day-old grown seedlings were subjected at different periods of cold acclimation (4 °C) 2, 4, and 6 days. Peroxidase (EC 1.11.1.7) (POD) activities and isoenzymes expression of plantlets treated and control (23 °C) of the aerial (shoot + leaves) and root systems were carried. Global peroxidase activity under low temperature stress was higher in tolerant ecotype than sensible one. The same trend was also observed at expressed isoenzymes. On the other hand, whether in tolerant or sensitive, activity and isoenzymes peroxidase was more pronounced at the root than in aerial system.

Keywords. Peroxidase activity – Isoenzymes – Cold stress – *M. ciliaris.*

Activité antioxydante des peroxydases sous stress de froid au niveau du système aérien et racinaire chez deux populations de* M. ciliaris *Krockers

Résumé. *L'étude a porté sur l'activité antioxydante sous stress de froid au niveau des tissus aérien (feuille et tige) et racinaire chez deux populations de* M. ciliaris *Krockers (Cil 126, tolérant et Cil 123, sensible au froid). Des plantules âgées de 10 jours sont soumises à différentes périodes de stress de froid (4°C) de 2, 4, et 6 jours. L'activité des peroxydases ainsi que l'expression isoenzymatique au niveau des parties aériennes et racinaires des jeunes plantes traitées et de leurs témoins respectifs ont été analysées. L'activité globale sous basse température est plus prononcée chez l'écotype tolérant Cil 126 que chez le sensible. L'expression isoenzymatique est plus importante au niveau du sytème racinaire qu'au niveau aérien (feuille + tige).*

Mots-clés. *Activité des peroxydases – Isoenzymes – Stress de froid –* M. ciliaris.

I – Introduction

Cold stress is an environmental factor limiting the geographic distribution of plants and crop production. Cold also leads to excessive production of reactive oxygen species (ROS), such as hydrogen peroxide (H_2O_2) and other dangerous derivatives oxygen, which cause progressive oxidative damage and as consequence cell death (Mohammadian *et al.,* 2012). During cold acclimation, increases of enzymatic changes were associated with cold tolerance by a significant capture of these harmful molecules. Antioxidant enzyme activities in plants are accepted as a good indicator of tolerance under stress conditions (Öklen *et al.,* 2008). Wang *et al.* (2009) suggested that peroxidase (POD) activity in normal conditions in two alfalfa cultivars was higher in root than in shoots. However, POD activities in shoot and root tissues of both cultivars showed similar level of under chilling stress. Keshavkant and Naithani (2001) reported that aerial parts of the chilling sensitive young sal (*Shorea robusta*) seedlings showed overproduction of reactive oxygen species. In order to determine the peroxidase response under cold stress during germination, we measured the enzymatic activity and peroxidase isoenzymatique pattern in aerial and root system of two *Medicago ciliaris* accessions contrasting in their cold tolerance.

II – Materials and methods

The study was carried on two annual *Medicago ciliaris* Krockers (Cil 126, tolerant and Cil 123, sensible) (Table 1). Ten seeds for each accession were germinated after scarification and disinfected by dipping in 70% (v/v) ethanol, at temperature room in Petri dishes containing universal compost imbibed with distiller water. At three days growth stage, seedlings were divided into two lots. Cold treated lot at 4 °C for three durations 2, 4 and 6 days (T2, T4 and T6) and control lot kept at 23 °C (T02, T04 and T06). The experimental layout was a completely randomized block design with 3 replications.

Aerial (shoot and leaves) and root tissues from control and treated plants were homogenized in homogenization buffer [10 mM Tris-KCl, pH 6.8, 10 % (w/v) saccharose and 1 mM PMSF]. Tissues were frozen in liquid nitrogen and ground in mortar on ice using homogenization buffer.

Peroxidase activity (EC 1.11.1.7) was assayed in reaction solution (3 ml) containing 0.2 M sodium acetate buffer pH 4.6, 1% o-dianizidine, 10 % H_2O_2 (Mac Adam *et a*l., 1992) modified. The reaction was started by adding 10 µl crude extract, and the enzyme activity is monitored for every 15 seconds for 3 minutes using a spectrophotometer at 460 as o-dianizidine oxidation, with 3 replications. Enzyme activity was expressed as µmol. of o-dianizidine oxidation. min^{-1}. g^{-1} of fresh matter.

The aerial (shoot and leaves) and root tissues peroxidase pattern were resolved by native in 10% separating polyacrylamide gel electrophoresis on vertical slab gel (Hoffer, USA) using the procedure of Laemmli (1970). Equal amounts of proteins (15 µl) were loaded on to each lane. The gel electrophoresis experiment was repeated tree times. To determine the pattern of peroxidase isoforms gels were staining and visualized by immersing the gels in 100 ml 0.2 M acetate buffer pH 4.6 added with 1% o-dianizidine (Sigma), dissolved in 2 ml 95% ethanol, and 200 µl 3% H_2O_2 at room temperature until the brown color appeared. Scanned Isozymes profiles gels were analyzed by Software GELANALYZER (Istvan Lazar Hungary Copyright 2010) to determine Rfs bands.

Table 1. Accessions analyzed for peroxidase antioxidant under cold stress with their origin and ecological description

Species	Accessions	Origin	Latitude	Longitude
M. ciliaris Krocker.	Cil 123	Algeria	36°46'02''N	8° 18' 9.57'' E
	Cil 126	Algeria	36° 28' 0'' N	7° 26' 0'' E

III – Results and discussion

Chilling tolerance or sensitivity in plants is well correlated with inherent antioxidant responses. Tolerant plant species generally have a better capacity to protect themselves from chilling-induced oxidative stress, via the enhancement of antioxidant enzyme activity. Liu *et al*. (2013) have observed an enhancement in activities peroxidase synthesis pathway during cold acclimation. In this study, we observed Increasing of patterns of antioxidant enzyme activities in both aerial and root system under cold stress comparing with control in tolerant and sensible ecotypes. Whereas, under these activities were more pronounced in root than in aerial (leaves and shoots) tissues (Fig. 1). The result was in accordance with study of Wang *et al*. (2009). Under cold stress the activities was better in root than in aerial tissues. In contrast, at 6 days treatment, Cil 126 exhibit slightly increased activity aerial system (Fig. 1B) than in root tissue (Fig. 1A).

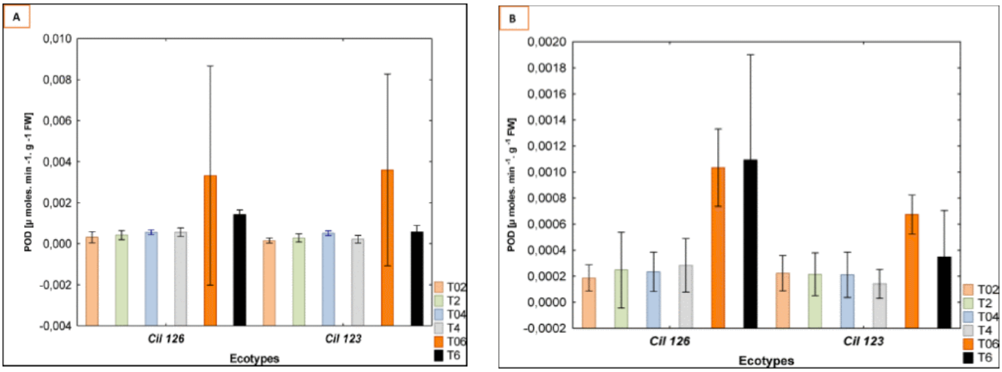

Fig 1. Peroxidase activity in *M. ciliaris* Krockers. (Cil 126 and Cil 123) seedlings untreated (controls: T02, T04, and T06) and treated with different durations (T2, T4, and T6) under cold stress. A: Root system. B: aerial system (shoot and leafs). Data are shown as mean ± SD of three independent measurement.

Comparing the peroxidase profiles between control plants and those treated under cold stress using native-page, the pattern of isoenzyme showed that cold treatment induced a high peroxidase activity. This activity increase slightly in aerial tissues (Fig. 1B) than in root system (Fig. 1A) in both ecotypes. The peroxidase activities were more pronounced when cold stress is maintained in the time. This trend was observed in tolerant accession Cil 126 when plantlets were subjected at 6 days of stress. In contrast, in sensible accession Cil 123 peroxidase activities were slightly maintained (Fig 1A and B). The same results were observed in chickpea (*Cicer orientum* L.) (Nazari *et al.,* 2012). It was found that the number of bands (named POD – Rfs) was higher (five) in tolerant than in sensible (four) ecotype in sensible population. Our results revealed that under cold treatment the intensity of bands were more pronounced in roots than in aerial tissues. As showed in Fig. 2 A the intensity of POD 5-Rf_0.89 of Cil 126 and in Fig. 3 A POD 4-Rf_0.69 of Cil 123 in root was increased in cold treated plants in comparison of aerial tissues in both tolerant and sensible accession.

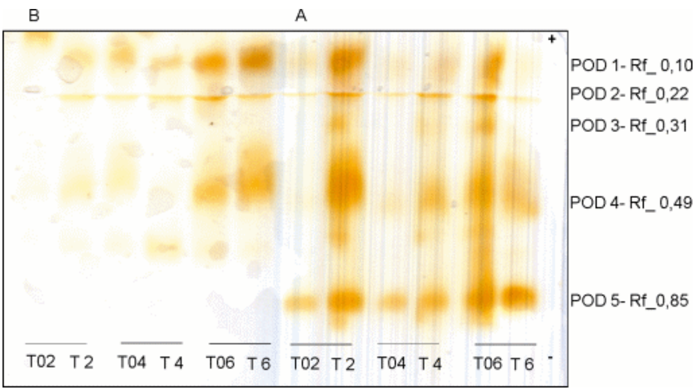

Fig 2. Peroxidase isoenzyme patterns in *M. ciliaris* Krockers. (Cil 126) seedlings untreated (controls: T02, T04, and T06) and treated with different durations (T2, T4, and T6) under cold stress. A: Root system. B: shoot system.

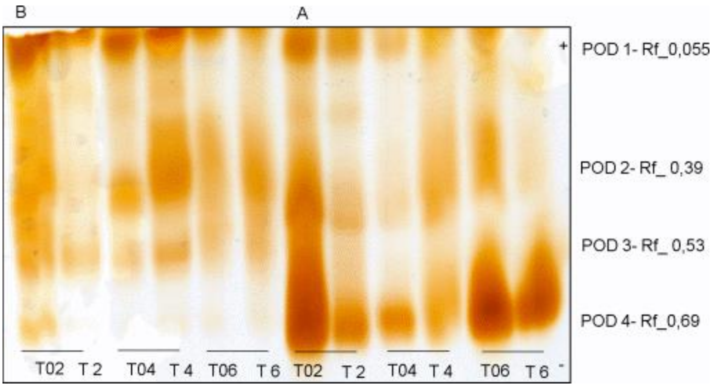

Fig 3. Peroxidase isoenzyme patterns in *M. ciliaris* Krockers. (Cil 123) seedlings untreated (controls: T02, T04, and T06) and treated with different durations (T2, T4, and T6) under cold stress. A: Root system. B: shoot system.

IV- Conclusion

Based on obtained results, it could be concluded that activities of peroxidase had different change trends with tolerant and sensible accession. The enhanced of scavening ability for H_2O_2 in tolerant was better than in sensible accession. Two accessions Cil 126 and Cil 123 has potentially better antioxidant potential in root tissues than in aerial tissues.

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Round Table
Connecting research, policy and stakeholders challenges for the sustainability of grasslands

The role of governance in sustainable rangeland management

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Abstract. The management and rehabilitation of degraded rangelands are inherently complex in south Mediterranean where state and tribal owned pastures are grazed commonly by the agro-pastoralists. The prospect for increased degradation primarily caused by overgrazing and recurrent droughts is currently at alarming levels. Reversing the negative trends primarily requires insightful management practices, institutional and policy support, and ultimately sound governance. Historically, the emphasis on rangeland management and improvement has been placed on the agronomic and ecological techniques but the efforts to restore the health and biodiversity of rangelands have achieved little impact. Low adoption of the technical and agronomic packages indicates that the imperative role of the governance and well-established sustainable communal land management cannot be ignored. Governance practices that are in conformity with socio-organizational arrangements are essential for sustainable management in particular for common rangeland grazing regimes. These practices should be set up in a participatory manner, involving the agro-pastoralists and building social networking to achieve environmental, social and economic sustainability in agropastoral production systems. This brief paper aims to highlight the role of governance of rangelands in sustainable pastoralism in the south Mediterranean region.

Keywords. Agro pastoralism – Degradation – Communal land management.

Le rôle de la gouvernance dans la gestion durable des parcours

Résumé. *La gestion et la réhabilitation des parcours dégradés sont très complexes, dans le sud de la Méditerranée où les pâturages appartenant à l'État ainsi qu'à la communauté sont pâturés collectivement par les agro-pastoralistes. La dégradation causée principalement par le surpâturage et par des sécheresses récurrentes est actuellement à des niveaux alarmants. Inverser les tendances négatives exige principalement des pratiques pertinentes de gestion, l'appui institutionnel et politique, et une bonne gouvernance. Historiquement, l'accent pour la gestion et l'amélioration des parcours a été mis sur les techniques agronomiques et écologiques, mais les efforts visant à rétablir la biodiversité des terres de parcours ont montré peu d'impact. La faible adoption des solutions techniques et agronomiques indique que le rôle essentiel de la gouvernance et d'une gestion durable des terres communales ne peut pas être ignoré. Les pratiques de gouvernance qui tiennent compte des aspects socio-organisationnels sont surtout indispensables pour la gestion durable des parcours communs. Ces pratiques devraient être mises en place de manière participative en impliquant les agro-pasteurs et en ciblant la construction des réseaux sociaux pour atteindre la durabilité environnementale, sociale et économique des systèmes de production agropastoraux. Cette étude vise à mettre en évidence le rôle de la gouvernance des terres de parcours pour le pastoralisme dans les régions du sud de la Méditerranée.*

Mots-clés. *Agropastoralisme – Dégradation – Gestion des parcours communs.*

I – Introduction

Despite advances in rangeland restoration, rehabilitation, and forages degradation of rangelands in the Southern Mediterranean basin persists. This is largely due to the fact that rangelands are either subject to open access or receive limited institutional support from their governments. Technical interventions to improve rangelands will continue to be unsuccessful despite technological advances without addressing this underlying problem of governance and tenure. The objective of this article is to highlight and define the problem of governance and tenure, proven solutions, and provide policy recommendations that will eliminate this negative externality within the cultural and political context of the region.

II – Rangeland governance

Governance in the context of natural resources can be defined as "local people's participation in managing the natural resources that they themselves use, in a sustainable manner, partnership with other key stakeholders (government departments, NGOs, the private sector, etc.) (Acosta 2010; Rist *et al.*, 2007). The type of partnership entailed may vary, but decision-making should be equitable, transparent and accountable. Often, there is a close link between rangeland degradation, failed rangeland policies and lack of rangeland governance. While local conditions for governance may vary there have been "three comprehensive attempts to produce theoretically informed generalizations about the conditions under which groups of self-organized users are successful in managing their common dilemmas," (Agrawal, 2001). The indicators that were identified by these authors have been shown to be robust from findings from a larger set of studies from the commons (Agrawal, 2001). Table 1 synthesis these studies and compares them. There is a little overlap and a few slight differences.

While many opponents to communal tenure look for privatization of rangelands as a solution to degradation, mobility over large tracks of areas is necessary in arid lands as rainfall can be erratic making private tenure not feasible (Miehi *et al.*, 2010). Private tenure of such areas would inevitably make a large group of people "landless". A closed communal tenure with government institutions that provide legislation support in times of conflict with transparently elected officials has proven to reduce degradation compared to open access. Without elected leaders and transparent structures, the minority elite can inequitably benefit at the cost of other pastoralists (Bennett and Barret, 2007).

Currently there are multiple limiting factors in the Southern Mediterranean basin that are contributing to its degradation that is a result of weak governance. In most dryland countries of the basin, the traditional mobility system has been dismantled and replaced by an unsustainable system of supplementary feeding (with state-subsidized barley) of mainly sedentary herds. This subsidized system leads to overgrazing as it reduces herders' incentives to adapt herd sizes to biomass availability and so leads to overstocking and ongoing degradation of the rangelands (Hazell *et al.*, 2001). In North Africa, land rights and civil legislation is complex as there is pluralism of French civil law overlapping with Islamic law and tribal systems. Land rights include registered lands, *melk* lands (private lands), habous lands (or *waaf*) and pre-Islamic collective lands. One of the main causes of land disputes is the pluralism in legislation (UNECA, 2010). The makeup of tenure and which lands laws are followed varies often by locality and is not well defined. As a result, rangeland degradation is exacerbated by the absence of rangeland governance schemes which empower the local pastoral communities to responsibly manage their rangelands and exclude non-permitted users from other communities. Institutional overlap in ministries and agencies that manage land makes it difficult for the local administration to attain comprehensive and integrated land management activities. A tremendous amount of coordination is required as a result (UNECA, 2010). Legal pluralism, institutional overlap and the resulting lack of integrated land management activities has often created a vacuum for power grabbing by various local actors. Resulting conflicts related to rangelands are associated with a failure of governmental rangeland policies (Bedunah and Angerer, 2012). National policies in Southern Mediterranean as a result call for a decrease in rangeland in favor of sedentary crop production, further limiting the movement of pastoralists (Sivanpillai and Shroder, 2015).

Money that is lost through the degradation of rangelands and spent on policies that promote sedentary agriculture could better reduce rangeland degradation if directed elsewhere. The state not only has to cover the costs of the barley subsidies, but also has to cover the indirect costs of rangeland degradation. The annual costs of land degradation in Jordan are estimated at about US$ 280 million (about 3% of annual GDP) (World Bank 2008). There is an urgent need for policy and legislation refinement to achieve a more sustainable rangeland management approach. Such money would be better spent on tenure reform and institutional restructuring. Creating a defined set of rangelands users makes it possible to exclude rogue grazers that can exacerbate overgrazing. Communal land size needs to be large enough to support semi-nomadic grazing (Miehe *et al.,* 2010). Communities need to define their internal communal governing structure such that conflicts can be taken to external authorities if needed. Furthermore governmental institutions that can assist in conflict abatement are essential in supporting such institutions, with clear operating procedures and processes. Eliminating overlapping roles between institutes is essential to fulfill this process. Studies have shown that rangeland rehabilitation and improvement measures are not sustainable on the long run if they are not encompassed by a concept of rangeland governance (Niamir - Fuller, 1999). Reforms are essential if technical efforts to improve rangeland management are to be successful.

Table 1. Summarized concepts from Baland and Platteau (1996), Wade (1988; 1994), and Ostrom (1990) from (Clifton, 2014)

Author	**Wade** **Facilitating conditions**	**Ostrom** **Design Principles**	**Baland and Platteau** **Facilitating successful governance**
Resource system Characteristics	Small size and well defined boundaries	Well defined boundaries	None presented as important
Group Characteristics	Small size Well defined boundaries Past successful experiences Interdependence among group members	Clearly defined boundaries	Small size and shared norms Past successful experiences Appropriate leadership Interdependence among group members Heterogeneity of endowments, homogeneity of identities
Relationship between resource system Characteristics and group Characteristics	Overlap between user group residential location and resource location High level of dependence on resource location	None presented as important	Overlap between user group residential location and resource location Fairness in allocation of benefits from common resources
Institutional arrangements	Locally devised access and management rules Ease in enforcement of rules Graduated sanctions	Locally devised access and management rules Ease in enforcement of rules Graduated sanctions Availability of low cost adjudication	Rules are easy and simple to understand Locally devised access and management rules Ease in enforcement of rules Accountability of monitors and other officials to users
Relationship between resource system and Institutional arrangements	Match restrictions on harvest to generation of resources	Match restrictions on harvest to generation of resources	None presented as important
External Environments	Technology: low cost exclusion technology State: Central government should not undermine local authority	Technology: None presented as important State: Central government should not undermine local authority Nested levels of appropriation, provision, enforcement and governance	Technology: None presented as important State: Supportive external sanctioning institutions Appropriate level of aid to compensate local user of conservation activities

Conclusions

Application of more insightful agronomic and ecological management techniques can substantially improve the conditions of rangelands and present potential for increased livestock production. However, the sustainability can only be achieved through more holistic and sound governance of rangelands. Without them the authors have often found for project interventions to be short lived or even jeopardized due to the short sighted economic incentives for overharvesting that open access tenure provides. Closed communal tenure with grazing permits and rest have shown to have substantial ecological and economic impacts in Southern Mediterranean.

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Livestock grazing, openings and raptors conservation in the Dadia-Lefkimi-Soufli Forest National Park

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Abstract. Livestock grazing regimes may influence indirectly wildlife populations and particularly species such as raptors that depend mainly on open areas for hunting their prey. In the Dadia-Lefkimi-Soufli forest National Park (DLS NP), which supports a valuable number of wildlife species and densities, including mammals, birds, reptiles and amphibians, socio-economic reasons as well as zoonoses have resulted in declining livestock numbers over the last six decades. Its consequence was evident in the gradual increase of forested areas and the decrease of openings. This canopy closure of the area through shrub and tree encroachment may influence raptor distribution and abundance within the DLS NP, but this should be studied in more detail.

Keywords. Grazing – Openings – Raptors – Management – Protected areas.

Pâturage du bétail, zones ouvertes et conservation des oiseaux de proie dans le parc national de la forêt de Lefkimi-Dadia Soufli

Résumé. *Les régimes de pâturage du bétail peuvent influencer indirectement les populations fauniques et en particulier des espèces telles que les oiseaux de proie qui dépendent principalement de zones ouvertes pour chasser leurs proies. Dans le parc national de la forêt de Dadia-Lefkimi-Soufli (DLS NP), qui prend en charge un nombre important d'espèces sauvages et de densités, y compris des mammifères, des oiseaux, des reptiles et des amphibiens, les raisons socio-économiques ainsi que les zoonoses ont entraîné la diminution du nombre d'animaux sur les six dernières décennies. Sa conséquence est évidente dans l'augmentation progressive des zones forestières et la diminution des zones ouvertes. Cette fermeture de la canopée de la zone par empiètement des arbustes et des arbres peut influer sur la répartition et l'abondance des oiseaux de proie dans le DLS NP, mais cela doit être étudié plus en détail.*

Mots-clés. *Pâturage – Zones ouvertes – Rapaces – Aires protégées – Gestion.*

I – Introduction

Habitat degradation and land use change are referred as the most important factors contributing for biodiversity loss worldwide as well as in the Mediterranean basin over the last decades (Cuttelod *et al*., 2008). Among direct drivers of land use changes, which alter the extent, pattern and quality of native vegetation, is the global increase in lands assigned to agriculture and grazing (Alkemade *et al*., 2013). Therefore, the type, timing and intensity of livestock grazing may influence wildlife populations in different ways (Kochert, 1989; Peterjohn, 2003; La Morgia *et al.*, 2015), by modifying nesting substrate availability (Ammon and Stacey, 1997), by changing prey species abundance (Taylor, 1986; Torre *et al.,* 2007), and by influencing prey vulnerability (Bakaloudis, 2009). On the other hand, livestock grazing has been recognized as an easy and cheap management tool in natural habitats for maintaining open structure and suitable plant composition upon which a variety of wildlife species depend for their survival (du Toit *et al.,* 2010; Beemster and Vulink, 2013). In addition, grazing intensity may influence natural habitats, such as grasslands and/or shrublands, on different directions and thus change vegetation composition and density, which may benefit or not some open land raptors, such as eagles, vultures and buzzards (Bakaloudis *et al*., 1998a,b; Sanchez-Zapata *et al*., 2003). The aim of this study was twofold: firstly to highlight temporal changes in both livestock numbers and human population in a protected area, and secondly to assess their consequences on raptors in the Dadia-Lefkimi-Soufli forest National Park.

II – Livestock grazing, openings and raptors

The Dadia-Lefkimi-Soufli forest National Park (hereafter DLS NP) is important for wildlife because it offers the only extensively wooded area along the Evros valley. However, due to long term human activities, including agriculture, logging, livestock grazing and small-scale wildfires, a mosaic of different habitat types has been created in the area.

The DLS NP is located in the central part of Evros Province in north-eastern Greece and covers approximately 427 km^2. Its elevation ranges between 20 and 700 m above sea level, and it is criss-crossed with steep valleys. Most of the area is forested, but agricultural land and shrublands are also occurring. The DLS NP has been established in 2003, but has been designated as a protected area since 1980. This year two cores were established as strictly protected areas for birds of prey, and they cover 75 km^2. The position of the DLS NP, lying at the junction of three continents, as well as the varied geology, the variety of climatic conditions, the diverse structure and vegetation composition and the low human disturbance appoint the area a complicated ecosystem supporting a valuable number of wildlife species and densities, including at least 12 amphibians, 27 reptiles, 46 mammals and more than 173 birds. In particular, it supports one of the richest diurnal raptorial fauna in Europe (Poirazidis *et al.*, 2011). In total, 31 species are present out of the 38 that occur in Europe, and most of them are considered to be of specific conservation concern, as they are endangered or vulnerable in Europe. Most of these raptorial birds are using the forest for nesting and open areas for foraging and hunting their prey (Bakaloudis *et al*., 1998a; 1998b) (Table 1).

Table 1. Different succession stages of forests used by raptors

Species	Common name	Edge, openings	Forest stages			
			regeneration	thicket	pole	mature
Falco tinnunculus	kestrel					
Buteo buteo	buzzard					
Milvus migrans	black kite					
Circaetus gallicus	snake eagle					
Aquila chrysaetos	golden eagle					
Aegypius monachus	black vulture					
Accipiter gentilis	goshawk					

Dark grey indicates ideal nesting habitat, bright grey indicates ideal foraging habitats and white indicates unsuitable habitats.

Grazing occurs inside the DLS NP in nomadic flocks. Numbers of livestock have declined during the sixties due to socio-economic changes in the region, although numbers have stabilized at low levels over the last few decades (Fig. 1). In particular, most of the livestock has been killed due to zoonoses during a two-year period (2014 and 2015), and now only a few flocks remain in the DLS NP.

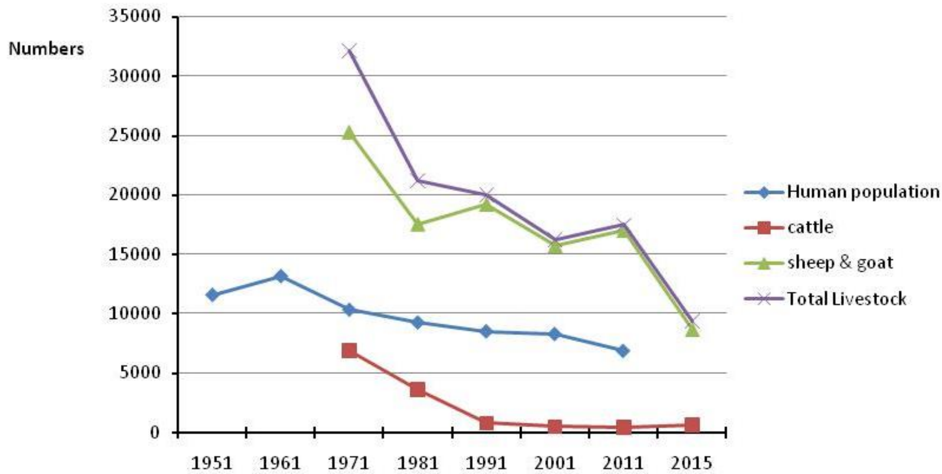

Fig. 1. Numbers of livestock and human population of seven villages in DLS NP in different years.

Similarly, a long-term population declining trend has occurred in villages and towns of DLS NP (Fig. 1). As a result the demand for woods from DLS NP which is used as fuel in the surrounding villages was reduced.

Although grazing by goats and sheep has been noted to have a degrading and/or devastating influence on Mediterranean ecosystems (Dafis, 1991), in the DLS NP had an opposite, positive effect on wildlife through by maintaining an open vegetation structure and by creating a patchwork of different habitat types (Bakaloudis *et al*., 1998b). Following the decline in both livestock numbers and human population, many openings have regenerated with Calabrian pines (*Pinus brutia*), and open shrublands and partially forested areas have experienced a progressive canopy closure. According to Triantakonstantis *et al*. (2006), in DLS NP the forested area (areas covered by >40% by trees) increased steadily from 46% (1945), to 54% (1973) and to 72% (2001). On the other hand, the openings (areas covered by <40% by trees), as a result of their gradual encroachment by trees and shrubs, decreased in numbers and area from 35%, to 25% and to 9% for the time periods 1945, 1973 and 2001, respectively. Agricultural land remained more or less stable, between 18%, 20% and 16% for the above time periods respectively. Those trends are followed both in the buffer zone and the two cores. These changes may have resulted in a greater abundance of small raptors that are able to utilize closed canopy habitats (i.e. goshawk *Accipter gentilis*, sparrowhawk *A. nisus*) over large raptors that require open areas for hunting (i.e. snake eagle *Circaetus gallicus*, golden eagle *Aquila chrysaetos* etc.) (Bakaloudis *et al.*, 1998b). However, more research is needed to clarify the association of raptor species and densities with grazing regimes and vegetation structure.

III – Conclusions

The gradual decline of livestock grazing numbers as well as the changing style of life of local people and the changing of livestock regimes from extensive and pastoral to intensive farming has caused an increase in forested area and a dramatic reduction of open areas, such as small openings and forest gaps in the DLS NP over the last six decades. The closure of the area through shrub and tree encroachment and its consequences on different wildlife species and particularly on raptors has to be studied more in-depth. Reverting to a more open landscape both in buffer zone and protected cores across DLS NP is not realistic in short-term. However, effective long-term management practices, including timber harvesting in conjunction with proper livestock grazing, may lead to an appropriate ratio of forest-open area. This would be based on the conservation goal of the area, and will require more research on what kind of practices is needed to benefit the greatest diversity (multiple-species management) of wildlife in the area while to help single species with high conservation concern.

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Conservation status and management challenges of sub-Mediterranean grasslands in Bulgaria

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Abstract. Semi-natural grasslands are a key component of the EU Natura 2000 network and its second most threatened habitat group after wetlands. The tools available to ensure their sustainable management are placed within the EU Common Agricultural Policy. A new mechanism designating and supporting environmentally sensitive grasslands was introduced in the 2014-2020 period. The paper reviews the conservation status of the traditionally used for grazing Eastern sub-Mediterranean dry grasslands (code 62A0) in Bulgaria. In the 38 Natura 2000 sites where they are found, the combinations of the conservation status per parameter vary but the national conservation status is unfavourable-inadequate. Three sites are selected for an assessment of the CAP support eligibility of their permanent grasslands. The management challenges for ensuring favourable conservation status of semi-natural grasslands in the selected sites are: (i) overall declining levels of grazing; (ii) unresolved issues with permanent pastures definition and eligibility; (iii) lack of information on the habitat types in the agriculture datasets (iv) high share of municipal grasslands, which also have lower eligibility; (v) each municipality has its own pastures management rules and procedures, which complicates the situation in larger Natura 2000 sites.

Keywords. Grasslands – Conservation status – CAP eligibility – Official datasets.

État de conservation et défis de gestion des prairies sub-méditerranéennes en Bulgarie

Résumé. *Les prairies semi-naturelles sont un élément clé du réseau européen Natura 2000 et constituent son deuxième groupe d'habitats les plus menacés après les zones humides. Les outils disponibles pour assurer leur gestion durable résident dans la Politique agricole commune de l'UE. Un nouveau mécanisme de classement et de soutien des prairies écologiquement sensibles a été introduit pour la période 2014-2020. Le document passe en revue l'état de conservation des prairies sèches traditionnellement utilisées pour le pâturage en sub-Méditerranée orientale (Code 62A0) en Bulgarie. Dans les 38 sites Natura 2000 où elles se trouvent, les combinaisons de l'état de conservation par paramètre varient, mais le statut national de conservation est défavorable-inadéquat. Trois sites sont sélectionnés pour une évaluation de la PAC visant à l'éligibilité de leurs prairies permanentes. Les défis de gestion pour assurer un état de conservation favorable des prairies semi-naturelles dans les sites sélectionnés sont: (i) la baisse globale des niveaux de pâturage; (ii) les questions en suspens avec la définition des pâturages permanents et l'éligibilité; (iii) le manque d'information sur les types d'habitats dans les ensembles de données de l'agriculture (iv) la forte proportion de prairies municipales, qui ont également une admissibilité inférieure; (v) chaque municipalité a ses propres règles et procédures de gestion des pâturages, ce qui complique la situation dans les plus grands sites Natura 2000.*

Mots-clés. *Pâturages – État de conservation – Éligibilité PAC – Ensembles de données officielles.*

I – Introduction

Semi-natural grasslands are a key component of the EU Natura 2000 network representing 100% of Habitats Directive farmland habitats and 20% of all Habitats Directive habitats (Collins and Beaufoy, 2012). Yet 86.3% of them are in unfavourable conservation status, making them the second most threatened habitat after wetlands (EEA, 2015). The tools available to ensure their sustainable management are placed within the EU Common Agricultural Policy (CAP), where a new mechanism was introduced in the 2014-2020 programming period. It requires member states to designate and protect “environmentally sensitive grasslands” in areas covered by the Habitats Directive 92/43/EEC (article 45 of EU Regulation No 1307/2013). Farmers are not allowed to convert or plough the permanent grasslands in those designated areas. Furthermore, member states are required to prevent an overall decline (limited to not more than 5% at national level) in the extent of permanent grasslands declared by farmers (article 72 of EU Regulation No 1306/2013). This is closely linked to member state's approach to the design of the eligibility rules for pastures with landscape features and trees. The new EU guidance document allows pastures with more than 50% trees and/or shrubs used for grazing to be classified as "permanent grasslands with established local practices" (LPIS Guidance, 2014). The 50-tree rule is now increased to 100-tree rule, but a recent study in six countries on the CAP and permanent pastures reveals that overall the eligibility of permanent pastures remains a major issue of concern (EFNCP, 2016).

The aim of this paper is to review the conservation status of Eastern sub-Mediterranean dry grasslands (code 62A0) in Bulgaria, which are traditionally used for grazing and assess their eligibility for CAP support in selected Natura 2000 sites. This is used as a basis for drawing on some management challenges for ensuring their favourable conservation status.

II – Materials and methods

Two major national datasets are used for the analysis in this paper. One is related to the mapping, assessment and reporting of the species and habitats in Natura 2000 zones in Bulgaria. The datasets and reports are publicly available via the online information system for protected sites in the Natura 2000 network, set up and maintained by the Ministry of Environment and Waters (MoEW, 2016). The national synthesis report for the Eastern sub-Mediterranean dry grasslands (code 62A0) in Bulgaria is used for the assessment of the changes in the total area coverage per site and the conservation status of habitat 62A0 per site.

Three main parameters define the conservation status per site: area (P1), structure and functions (P2), and future prospects (P3). The lowest score on any of the parameters forms the final conservation status of the site; however, the combinations between them are multiple. Thus, the selected sites represent two of the most common combinations: (1) a site in favourable conservation status on all three parameters (9 sites out of 38); and (2) a site in favourable status on P1 and P3, and unfavourable-inadequate in P2 (14 sites out of 38). A third site is added because it is the only one in unfavourable status on all three parameters. The permanent pastures eligibility for CAP support in the three sites are then assessed.

Permanent grasslands eligible for support are the second national dataset that is used in the analysis. A part of the Bulgarian Land Parcel Identification System (LPIS) related to permanent pastures is publicly available online. It is set up and maintained by the Ministry of Agriculture and Food (MoAF, 2015), and used by the Paying Agency for the land eligibility assessment and payment calculations of CAP support to farmers. The datasets are available at district level and contain information on the land use and ownership, permanent grasslands in Natura 2000 sites under the Bird Directive and/or Habitats Directive, as well as share and area of eligible parcels. One significant deficiency in this dataset is that there is no information on habitat types per parcel. Therefore, for the needs of the current analysis all permanent grasslands in the respective Natura 2000 site are analysed, which usually comprise more habitat types than 62A0. The derived management challenges are therefore applicable to more habitat types.

III – Results and discussion

Bulgaria hosts an important share (45%) of the Eastern sub-Mediterranean dry grasslands (code 62A0). The rest are found in Italy (50%), Slovenia (4.5%) and Greece (no information is available) spreading across four biogeographic regions (EEA, 2015). They are in unfavourable-inadequate status in the Mediterranean and Black Sea biogeographic regions and in unfavourable-bad status in the Continental and Alpine regions (EEA, 2015).

In Bulgaria, habitat 62A0 covers a total area of 25,369 ha. Around 92% of them are located in 38 proposed Sites of Community Interest (pSCIs) (MoEW, 2013). The summary of habitat 62A0 conservation status per parameter (Table 1) reveals that the "area" parameter is favourable in 30 sites. Despite the recorded decreasing area in 18 sites, only 8 are in unfavourable status by this parameter. The weakest parameter is "structure and functions" which is favourable only in 14 sites, and unfavourable-inadequate in 22. The "future prospects" are favourable in 31 sites. There are 10 existing combinations of conservation status per parameter per pSCIs (Table 2). Nine sites are in favourable status per all parameters. Parameter "structure and functions" is the reason for unfavourable-inadequate status in 14 sites. One site scores unfavourable-inadequate status on all three parameters. The selected sites are from these three groups.

Table 1. Conservation status (CS) of habitat 62A0 per parameter (no of sites)

Conservation status (CS)	Area	Structure & functions	Future prospects
FV	30	14	31
U1	5	22	7
U2	3	2	0
Total		38 sites	

FV - Favourable, U1 - Unfavourable-Inadequate,
U2 - Unfavourable-Bad.
Source: MoEW,2015

Table 2. Combinations of CS of habitat 62A0 per pSCI (no of sites)

Sites in respective combination	Area	Structure & functions	Future prospects
14	FV	U1	FV
9	FV	FV	FV
4	FV	U1	U1
3	U1	U1	FV
2	FV	FV	U1
1	U1	U1	U1
5		other combinations	

Site BG00000322 Dragoman (CS FV-FV-FV) is located on the territories of four municipalities (LAU2) and hosts 6,273 ha of habitat 62A0. The habitat covers 29% of the site's area and is one of its most important habitats (Gyurova, 2013). This is a site with a reported increasing area of habitat 62A0. Gyurova (2013) documents that trees and shrubs cover less than 10% of the habitat territory, with no specific issues related to grazing intensity. Site BG0001032 Rodopi-East (CS FV-U1-FV) stretches on the territories of 11 municipalities (LAU2). Habitats 62A0 covers 4,222 ha which is a decrease from previous periods. The unfavourable-inadequate status is due to the presence of three dominating species spread on 30% of the habitats territory (Apostolova, 2012). Trees and shrubs cover less than 10% of the habitat but there is an observed increasing trend. Grazing intensity is very low, which is another condition for shrubs growth in the habitat (Apostolova, 2012). Site BG0000624 Lyubash (CS U1-U1-U1) is located on the territories of two municipalities. Habitat 62A0 covers 265 ha, a recorded decrease from 460ha. The key reasons for the overall unfavourable-inadequate CS of the site are related to the progressive coverage of the habitat by shrubs and trees because of the drastic reduction in grazing (Petrova, 2012).

The analysed permanent pastures in the selected sites are not limited to habitat 62A0 because there is no such information in the LPIS dataset. Nevertheless, permanent pastures eligibility per parcel is highest (94%) in Dragoman (CS FV-FV-FV), and lowest (79%) in Lyubash (CS U1-U1-U1). Stating a link between the CS and eligibility will be speculative at this stage, since eligibility is not limited to habitat 62A0, but requires additional studies. In all sites, the majority of permanent pastures are owned by the municipalities, with a generally lower level of parcels eligibility for CAP support. In Rodopi-East, municipal pastures represent 72% of all permanent pastures, governed by 11 different municipal plans. In general, national legislation requires municipalities to develop annual plans for the management of pastures and meadows as well as procedures for their allocation to farmers and other land users. Each municipality develops its own regulations on the basis of its experience and practice, but often this is insufficient especially in view of the Natura 2000 habitats needs. This makes municipal authorities a key player for ensuring favourable conservation status across the sites.

Table 3. Permanent pastures area, parcels, and eligibility per selected pSCIs

Permanent pastures per site	BG0000322 Dragoman			BG0001032 Rodopi-East			BG0000624 Lyubash		
	Area (ha)	Parcels (no)	Eligibility per parcel (%)	Area (ha)	Parcels (no)	Eligibility per parcel (%)	Area (ha))	Parcels (no)	Eligibility per parcel (%)
Total area	6439	4823	94	25182	17043	83	48	47	79
Private	1309	3790	95	825	3529	92	9	37	81
Municipal	3247	926	88	18148	11057	80	39	10	68
State	1746	68	82	5832	2184	79	0	0	
Others	137	39	89	377	273	88	0	0	

Source: Permanent pastures datasets for districts Kurdzhali, Haskovo, Pernik, Smolyan, and Sofia-district. Ministry of Agriculture and Food, 2015.

In Lyubash, the LPIS for the area does not even include all grasslands as agricultural land. Only 48 ha of permanent pastures are found in the dataset, while only habitat 62A0 covers 265 ha. This illustrates the problem with the eligibility of permanent pastures with trees and shrubs, which is not unique for this site. The national figure for permanent pastures in LPIS is 881,895ha in 2015, while the permanent grasslands in the national agriculture statistics (BANCIK) is 1,368,665ha. There is a “loss” of almost half a million hectares in LPIS, mainly due to the eligibility criteria for CAP support and the different classifications used in the LPIS and BANCIK systems (Stefanova and Kazakova, 2015).

IV – Conclusions

The management challenges for ensuring favourable conservation status of semi-natural grasslands in the selected sites are summarized as: (i) Overall declining levels of grazing; (ii) Unresolved issues with permanent pastures definition and eligibility (in one of the sites, they are not even included in the agriculture land dataset); (iii) Lack of information on the habitat types in the agriculture datasets, which would allow better identification of the land ownership, land use status, and as a result better management measures; (iv) High share of municipal grasslands, which also have lower eligibility, thus the CAP tools aimed at permanent pastures have limited use in addressing the problems; and (v) Each municipality has its own pastures management rules and procedures, which complicates the situation in larger Natura 2000 sites.

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Sheep and goat farming and grasslands conservation: in need of proper policies

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Abstract. Mediterranean landscapes have been formed through human activity for millennia, which resulted in a particularly rich and rare biodiversity. Among these activities grazing is the most beneficial on biodiversity. However, the sheep and goat sector is rapidly transforming into sedentary-housed types and pastoral land is abandoned. The Greek example is presented and a range of policies are suggested to halt this trend and conserve pastoral land biodiversity in Mediterranean.

Keywords. Sheep and goats – Pastoral land – Biodiversity – Policies – Greece.

La conservation de l'élevage ovin et caprine et des prairies: besoin de politiques appropriées

Résumé. *Paysages méditerranéens ont été formés par l'activité humaine depuis des millénaires, ce qui a entraîné une biodiversité particulièrement riche et rare. Parmi ces activités, le pâturage est le plus bénéfique sur la biodiversité. Toutefois, le secteur ovin et caprin transforme rapidement en types sédentaires-logés et des terres pastorales est abandonné. L'exemple grec est présenté et un éventail de politiques sont proposées pour freiner cette tendance et préserver la biodiversité des terres pastorales en Méditerranée.*

Mots-clés. *Ovins et caprins – Terre pastorale – La biodiversité – Politiques – Grèce.*

I – Current situation

Landscapes surrounding Mediterranean Basin have experienced human impact since millennia. In fact indigenous agriculture and animal husbandry have been practiced there for more than 10,000 years (Le Houerou, 1981). The long history of integration of agriculture and animal husbandry with the natural environment has created a rich and endemic biodiversity. This biodiversity is at risk at present for a variety of reasons, among which most important is the abandonment of traditional practices. Grazed areas present the richest variety of flora and fauna species among other land uses.

Pastoral farming of sheep and goats has been an element of the Greek landscape since ancient times and contributed, through rational management, to the development of an efficient extensive livestock farming sector surviving until today (Hadjigeorgiou, 2011). Evidently, pastoralism, as a socio-economic production system, lies deep in Greek history and survived, mainly as part of the national identity, despite not being at present a competitive production system (Vallerand *et al*., 2001; Hadjigeorgiou *et al.,* 2002). However, as in other parts of the Mediterranean, pastures have lost their importance in animal farming therefore conservation of grasslands is at danger which subsequently threatens the conservation of biodiversity (Beaufoy and Poux, 2014). This trend is the result of several facts among which some are pragmatic (i.e. the availability of purchased feed and other inputs, the infrastructures available etc) and the other societal preferences (i.e. the modernization mentality, the food hygiene sensitivities and the devaluation of the related profession) (Dover *et al*., 2011).

To illustrate this trend the example of Greece will be offered, where pastures were a fundamental natural resource of rural areas, supporting the majority of farmed animals until recently. A report of the Hellenic Ministry of Agriculture, dated in 1958 and titled "Pasture and Grazing Animals", calculated the area of permanent pastures "lowland and mountainous" at 56.5% of the Greek land, while stating that "almost all the land of the country is used to pasture animals". At this time 9,195,000 sheep and 5,010,000 goats were farmed in 502,110 and 387,607 farms respectively. When Greece joined the then E.U., in 1981, sheep farms were down by 57.5% and those of goats by 16.5%, although the respective heads were reduced only by 9.5% and 7.7% respectively (N.S.S.G., 1994). At this time pastoral land, according to the official statistics, was representing 39.5% of the land (i.e. a 31.3% decline). Nevertheless, in the following thirty-five years these figures changed considerably since sheep farms were further reduced by 60.3% and those of goats by 78.5%, while sheep populations increased slightly (about 9.1%) and those of goats decreased slightly (7.8%), due to the intense evolution towards specialization and reorganization of this sector (Hadjigeorgiou, 2011). In addition to that, officially registered pastures were reduced by a further 72.1% following the trend of sheep and goat farms (N.S.S.G., 2009).

The decline in farm numbers was accompanied by a respective increase to the average number of sheep and goat heads per farm, guided by the high productivity model in the development of animal husbandry, as it was in most sectors of agriculture in recent decades. However, bigger farms were easier managed when animals were housed, particularly on the Greek terrain. Furthermore, there was relocation from higher altitude areas (mountainous and semi-mountainous) to the lowland areas and closer to the civil centres (Dover *et al.*, 2011). At the same time, the conversion of pastoral land to arable farming in the lowlands,the general absence of an official grazing land registry (the grazing areas are not delimited relative to forest areas) and the use of pastoral land as opportunity land for other activities, prevent the application of effective long-term management actions. All the above changes brought abandonment of pastures and have tremendous effects on the status of rural societies and on the environment as well (Beaufoy and Poux, 2014).

II – Policies to remediate the trend

Pastoral systems around the world are facing demographic, economic, socio-political and climatic pressures which are driving many pastoralists into non-livestock based livelihood strategies or housed systems (de Rancourt *et al.,* 2006; Ayantunde *et al.,* 2011). Since sustainability of a system is not static, its conformation depends on the present and future needs of society, which are constantly changing. The continuity of pastoral and livestock farming activity does not seem to be threatened purely by product devaluation, high input prices and farm structural or economic restrictions. It is very clear that social factors, related to the absence of farmer successors, social devaluation of the pastoral profession, institutional obstacles, absence of interest for the sector by the State and the high opportunity cost of labour are certainly obstacles to pastoral farming in the future (Tzanopoulos *et al*., 2011). Some policies at the State level and that of EU, to reverse this trend or slow down this evolution might be:

Support and progress toward enhanced technical, economic and environmental efficiency in sheep and goat farms

- A ewe and goat premium conditional upon commitments towards enhanced production efficiency and product quality such as:
- Commitment to training and follow-up by peer groups of the technical and economic performances in the farm.
- Better use of genetics (use of adapted highly performing indigenous breeds, artificial insemination or rams registered as improvers, subscription to performance recording and audit systems).

- Improvement of the flock sanitary management (use of genotypes resistant to genetically controlled diseases, prevention plans for zoonoses, global application of vaccination, specific training, etc.).
- Participation to a cluster involving animal farmers, inputs suppliers and raw product processors and proper use of communal resources.
- Securing a minimum of infrastructures, for S&G farmers in the more vulnerable LFAs, to prevent abandonment of these areas due to primitive conditions, etc.

Support to the organisation of the industry and rationalizing its functioning

- Legal support and simplification of the process leading to the merger of commercial structures.
- Set up an Agency at European level for proper use of grazing resources for «small ruminants», with human resources and a centre for documentation and exchange of experiences.
- Develop communication campaigns that will inform on the occupation as sheep farmer and butcher (both meat processing plants and retailers), targeting the youth, and insisting on the possibilities of evolution and income.

Support to the promotion of the EU S&G standards of production and a labelling for that

- Introduction of a mandatory labelling for all the different types of distribution, in both sheep and goat production industries.
- PGI/DOP (and other prime line products like “organic”, “mountain” or “island” product) common promotion campaigns from different EU countries in targeted markets.
- A pluriannual generic promotion campaign for sheep and goat products produced in the EU, insisting both on their production standards and on their intrinsic qualities.
- Local promotion of farm products both from individual farms and small farm groups. A European resource centre could be set up specifically dedicated to supporting local projects and support exchanges between producers with similar experiences.
- Support on research of qualitative properties of sheep and goat products (dairy and meat) and their association to human health issues.
- Support research on laboratory verification of product geographical origin.

Support for innovation

- A European Agency for innovation in the « small ruminant » industry could be set up, with human resources and a centre for documentation and exchange of experiences. This agency would work both on technical innovation for farms and product innovation regarding meat and cheese and also the fifth quarter.
- A specific support for genetic improvement and performance recording and audit.

Better efficiency in the management of sanitary risks

- Provide assistance for the creation of regional peer observatories of small ruminants’ diseases (alert-vigilance and prioritization of risks), throughout Europe.
- Encourage the creation of sanitary defence associations, specialized in the training of producers and prevention.
- A working group including the national veterinary authorities, the veterinary industry (IFAH) and the European experts of the sector, could determine rapidly the procedures allowing simplified marketing authorizations at a European level, for medicinal products for small ruminants.

- Mobilization of R&D funds through the European platform for animal health (ETPGAH) to design and circulate kits for rapid detection of pathogens in raw milk and thus reduce the sanitary risks and the costs of rejection of milk that is not in conformity.
- Work on the re-opening of certain markets closed to EU exportations for sanitary reasons.

III – Conclusions

The sheep and goat farming sector is transforming rapidly into forms independent of grazing, thus leading to abandonment of pastoral land with an immediate threat to biodiversity. Proper policies are required to be designed and implemented in order to halt this trend and some examples are proposed.

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Towards bridging the gap between Common Agriculture Policy implementation and pastures sustainable management: A case study from Tzoumerka, Greece

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Abstract. The CAP reform 2014 – 2020 maintains the two pillars and introduces a new architecture of direct payments; better targeted, more equitable and greener, an enhanced safety net and strengthened rural development. In order to highlight the gap between CAP implementation and pastures sustainable management, a case study was done in the area of Tzoumerka Mountain. The present paper, studies the national and European legal frame concerning pastures eligibility criteria for Pillar I payments, the current grasslands management and the main points of agricultural subsidies system relating with grassland management in Greece. The study points out the legal and technical complexity and the partial application of European regulations in pastures sustainable management. It seems that CAP is more an agriculture parcel-oriented policy rather than an intergraded policy sustainable pasture management. Finally, the adoption of a new policy bridging the gap between CAP implementation rules and pasture sustainable management is necessary.

Keywords. Permanent grasslands – Common Agricultural Policy – Sustainable management.

Vers la réduction de l'écart entre la mise en œuvre de la Politique agricole commune et la gestion durable des pâturages: Une étude de cas à Tzoumerka, Grèce.

Résumé. *La réforme de la PAC 2014-2020 maintient les deux piliers et introduit une nouvelle architecture des paiements directs; mieux ciblée, plus équitable et plus verte, avec un filet de sécurité amélioré et renforcé pour le développement rural. Afin de mettre en évidence l'écart entre la mise en œuvre de la PAC et la gestion durable des pâturages, une étude de cas a été faite dans la région des montagnes de Tzoumerka. Le présent document étudie le cadre juridique national et européen concernant les critères d'éligibilité des pâturages pour les paiements du pilier I, la gestion actuelle des prairies et les principaux points du système de subventions agricoles liées à la gestion des prairies en Grèce. L'étude souligne la complexité juridique et technique et l'application partielle de la réglementation européenne dans les pâturages de gestion durable. Il semble que la PAC soit plus orientée vers une politique d'agriculture de parcelles plutôt qu'une politique de gestion intégrée durable des pâturages. Enfin, l'adoption d'une nouvelle politique visant à combler le fossé entre les règles de mise en œuvre de la PAC et la gestion durable des pâturages est nécessaire.*

Mots-clés. *Prairies permanentes – Politique agricole commune – Gestion durable.*

I – Introduction

One of the main aims of Common Agricultural Policy (CAP) 2015 – 2020 is to promote the sustainable development management of natural resources, such as pastures. This policy is achieved by four main Regulations implementation that define the rules should be met by Member States and farmers in order to receive European Communities subsidies. The new CAP maintains the two pillars and both are aimed at meeting all CAP objectives more effectively, with better targeted instruments of the first pillar complemented by regionally tailor-made and voluntary measures of the second pillar.

In case of pastures, direct payments include the Basic Payment, the green direct payment (an extra payment account for 30% of the basic payment) and possible additional support for Areas of Natural Constraints (ANC). The Greening payment is compulsory and failure to respect the Greening requirements will result in penalties which go beyond the Greening payment. Also, National governments must designate environmentally sensitive permanent grasslands inside or outside Natura 2000 areas. With regard to Greek National decision on greening, only permanent grassland inside Natura 2000 zones is designated as Environmentally Sensitive Permanent Grassland.

The eligibility rules define whether an agriculture area characterized as “permanent grassland” is eligible for Pillar I payments or not. These rules should be designed by Member States. Since 2014, woody vegetation can be eligible for direct payments and should be classified as PG-ELP (permanent grassland with established local practices) on national Land Parcel Identification System (LPIS). But there is a debate about eligibility rules of such areas. In case of arbitrary pasture eligibility system, financial corrections imposed by the Commission on Member States.

The study aims to highlight the gap between CAP implementation and pasture management using data from a representative mountainous and less favorable area (LFA) of Greece.

II – Materials and methods

For the needs of this study, the area of Tzoumerka mountain range in Epirus was selected (Fig. 1). The study area includes 3 Natura 2000 sites and 17 habitat types of Annex I Habitat Directives. The area is important for species associated with alpine and subalpine pastures and due to its characteristic vegetation communities above the timber line in which many Greek endemics as well as rare and threatened plant taxa exist. Although the Tzoumerka mountain range area is known for its traditional extensive livestock raising, it seems that is intensively grazed suffering from high stocking rate values (Roukos *et al.,* 2011). Indeed, the natural grasslands and the shrublands cover 68.4% of the total area and are utilized from 441 livestock farms with 68,000 sheep, 5,800 goats, and 3,600 cattle mainly under pastoralism system.

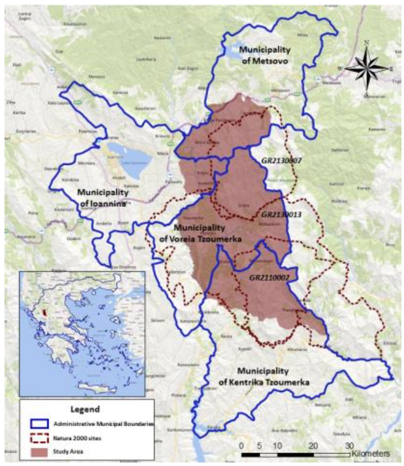

Fig. 1. The study area.

National and European legal frame

The European and Greek Legal Frame concerning Pillar I payments were studied. The main legal framework obtained from the Commission Regulations (EU) No 1307/2013 and (EU) 1306/2013, the Delegated Regulations (EU) 639/2014 and (EU) 640/2014, the Implementing Regulations (EU) 641/2014 and (EU) 804/2014, the Council 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora and EC Directive 79/409 on the Conservation of Wild Birds, theirs latest modifications and theirs incorporation into Greek legislation.

Calculations

Stocking density (the number of grazing animals per unit of land) was calculated according to Holechek *et al.* (2004) taking into account that different kinds of animals utilize different pasture types. Grazing livestock population of the selected area was taken from data provided by Municipalities, in which producers pay for rangeland utilization (graze right) to receive European Communities subsidies. Basic data layers were available from geodata.gov.gr and Ministry of

Rural Development and Food. Grid layers were generated by performing a spatial analysis using the raster calculator of spatial analyst tool of ArcMap software. A digital elevation model based on 50 m contours for the region was available generated for 50 m resolution. Estimated usable area was calculated from total area applying a reduction coefficient in relation to slope as suggested by Holechek *et al.* (2004). The cell size resolution of all interpolated layers was 50 m. The GIS platform used was ArcGIS version 10.

III – Results and discussion

According to the current eligibility system, last updated November 2015, less than one fourth (22%) of total pasture area is considered as eligible for Pilar I payments (Table 1). It is estimated that only 33% of grasslands meet the eligibility rules for Pillar I payments. Although woody pastures, known as permanent grassland under established local practices (PG-ELP), have not yet introduced in the LPIS, 12% of shrublands is currently considering as eligible area.

Table 1. Estimation of eligible area for Pillar I payments and estimated usable area per pasture type in the study area

Pasture type	CORINE Land Cover description		Total Area (ha)	Eligible Area (ha)	Usable Area (ha)	% eligible area to total	% eligible area to usable
	321	Natural Grassland	11,983	4,857	6,447	41%	75%
Grasslands	332	Bare rock	539	12	191	2%	6%
	333	Sparsely vegetated areas	5,620	1,103	2,804	20%	39%
	Total grasslands		**18,142**	**5,972**	9,442	33%	63%
	322	Moors and heathland	2,399	321	1.743	13%	18%
Shrublands	323	Sclerophyllous Vegetation	4,885	925	4.631	19%	20%
	324	Transitional Woodland/Shrub	12,220	1.002	11.535	8%	9%
	Total shrublands		**19,504**	**2,248**	17,908	12%	13%
Grasslands & Shrublands Total			**37,646**	**8,220**	**27,350**	**22%**	30%

Table 2. Stocking densities per pasture type in the study area

Pasture type	Animal Units (AUs)	Stocking density (AU/ha)		
		Total Area (ha)	**Eligible for direct payments Area (ha)**	**Usable Area (ha)**
Grasslands	13,536	0.746	2.267	1.434
Shrublands	853	0.044	0.379	0.048
Total	14,389	0.382	1.750	0.526

Grasslands and shrublands are utilized by 13.526 and 853 AUs, respectively (Table 2). Stocking density values reflect the number of animals per unit of area. As a result, stocking density shows great variations in relation to base – area it's calculated. In grasslands, stocking densities exceed the minimum requirement of 0.7 AU/ha set by the Greek Ministry (1584/66059/2015 Ministerial Decision) as the minimum activity for pastures that are currently grazed and can be kept suitable for grazing. More intensively managed grazing systems are typically correlated with higher stocking densities. Increased stocking density coupled with a five-months grazing period length is possible to result in over-grazing (Holechek *et al.,* 2004). On the other hand, stocking density values in shrublands are lower than required threshold (Table 2). As a result, a gradual spread of shrub vegetation is expected at lower zones and a high risk of pastures degradation occurs at the area above the timber line due to high stocking density and lack of a proper grazing system (Holechek *et al.,* 2004). Furthermore, there is another point of concern: farmers receive direct payments under the Pillar I, should fulfil the obligation to maintain the herbaceous vegetation at a maximum height of 70 cm by cutting and removal of vegetation. They can activate their payment entitlements with eligible pasture area even if it does not grazed by animals.

Additionally, without direct payment, ineligible pasture areas will be abandoned. The absence of grazing both in eligible and ineligible pasture areas leads to shrub encroachment in grasslands (Zarovali *et al.,* 2007). As dense shrubs and trees considered as ineligible elements for Pillar I payments, eligible area will be decreased as a result of the new policy implementation. Although grazing exclusion can temporally have beneficial effect as a restoration technique in degraded mountainous grasslands (Yan and Lu, 2015), grazing plays a key-role in long-term pasture restoration program and its sustainability (Lunt *et al.,* 2007). In mountainous areas where pastures include priority grasslands habitat types, a more intergraded approach of the sustainable grasslands utilization is essential to be applied (Roukos *et al.,* 2013). Fig. 2 shows the areas that are estimated to be eligible for Pillar I payments. A spatial mosaic of eligible areas inside ineligible areas, and vice versa, is formulated. Given the evidence, the pasture sustainability keeps policymakers puzzled.

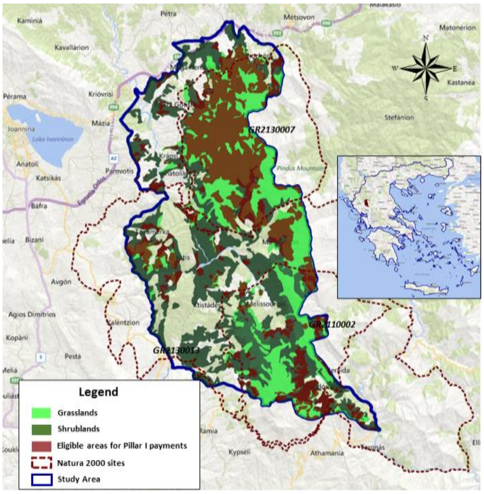

Fig. 2. Estimated eligible areas for Pillar I payments of grasslands and shrublands of the study area.

IV – Conclusions

It seems that the current CAP implementation for pastures is an agricultural parcel-oriented policy paying attention entirely to eligibility rules, as another bureaucratic layer. In the case of maintain pasture sustainability, it can be claimed that CAP “cannot see the wood for the trees”. In order to promote pastures sustainability in mountainous areas, a new policy should be applied based on an intergraded approach of pastures management ensuring efficient and targeted use of CAP funds.

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Meeting Programme
and
List of participants

15th International Meeting of the FAO-CIHEAM Subnetwork on Mediterranean Pastures and Fodder Crops

"Ecosystem services and socio-economic benefits of Mediterranean grasslands"

(Orestiada, Greece, 12-14 April 2016)

Meeting Programme

Day 1 - 12 April 2016

08:30 – 09:00 Registration

09:00 – 09:30 Opening ceremony

09:30 – 10:45 Introductory Session

Chairperson: *Alain Peeters,* Coordinator FAO-CIHEAM Network on Pastures and Fodder Crops, Belgium

09:30 – 10:00 Greece's grazing/ forage resources for livestock production - *T.G. Papachristou,* Forest Research Institute (Greece)

10:00 – 10:15 Overview on grassland and farming systems in Evros regional unit - *A.P. Kyriazopoulos,* Democritus University of Thrace (Greece)

10:15 – 10:45 Ecosystem services and socio-economic benefits of Mediterranean grasslands - *E. Varela,* CREDA (Spain)

10:45 – 11:15 Coffee break

11:15 – 13:30 Session 1. Managing ecosystem services and livestock production in the Mediterranean region

Chairperson: *Carlos Ovalle,* Instituto de investigaciones Agropecuaria, CRI-La Cuz, La Cruz (Chile)

11:15 – 11:45 Guest presentation

Methods and approaches used for assessing ecosystem services provided by grazing systems - *P. D'Ottavio,* Università Politecnica delle Marche (Italy)

Short oral presentations

11:45 – 12:00 The use of cattle grazing as a management tool for sustainable Mediterranean woodlands - *I. Schoenbaum,* Hebrew University of Jerusalem (Israel)

12:00 – 12:15 Functional classification by NIRS of plant parts selected by sheep on a shrubby rangeland - *M. Jouven,* Montpellier SupAgro (France)

12:15 – 12:30 Historical development and future perspective of conservation agriculture practices in crop-pasture rotation systems in the Mediterranean region of South Africa - *P.A. Swanepoel,* Stellenbosch University (South Africa)

12:30 – 12:45 Diet selection of grazing goats in an oak silvopastoral system in Northern Greece using a Markov Chain Monte Carlo simulation - *T. Manousidis,* Democritus University of Thrace (Greece)

12:45 – 13:00 The rates of desirable grazing plant species in rangelands: the effect of different animal species and grazing pressures - *F. Uzun,* Ondokuz Mayis University (Turkey)

13:00 – 13:30 Session 1. Discussion and synthesis

13:30 – 15:00 ***Lunch***

15:00 – 18:00 **Session 2. Improvement of range, pasture and forage species including alternative uses**

Chairperson: *Eleni M. Abraham,* Aristotle University of Thessaloniki (Greece)

15:00 – 15:30 Guest presentation

Improvement of pasture and forage legumes and grasses for Mediterranean climate zones - *P. Nichols,* Western Australia Dep. of Agriculture and Food, Australia

Short oral presentations

15:30 – 15:45 Effects of plant development phases on some morphological, agronomical and chemical traits of *Bituminaria bituminosa* genotypes - *Z. Acar,* Ondokuz Mayis University (Turkey)

15:45 – 16:00 Annual clovers performance in a dairy cows grazing system compared to perennial ryegrass - *A. Botana,* Instituto da Calidade Agroalimentaria (Spain)

16:00 – 16:30 *Coffee break*

16:30 – 16:45 Study of Productivity pattern over 3 years of some annual grass and legume fodders carried as pure and as mixture in rainfed cereal based system in Algerian semiarid area - *K. Abbas,* INRAA (Algeria)

16:45 – 17:00 Antioxidant compounds and nutritional quality of eight Tunisian populations of echinus medic (*Medicago ciliaris* L.) - *A. Zoghlami Khélil,* INRAT (Tunisia)

17:00 – 17:15 Forage potential of *Piptatherum miliaceum* (L.) Coss (smilo grass) - *C. Porqueddu,* ISPAAM-CNR (Italy)

17:15 – 17:30 Productivity of alfalfa cultivars in dryland Mediterranean environments of central Chile - *C. Ovalle,* Instituto de investigaciones Agropecuaria (Chile)

17:30 – 18:00 Session 2. Discussion and synthesis

18:00 - 19:30 ***A Thracian evening (taste of wine, local cheese and Kavourmas - cured meat)***

Day 2 - 13 April 2016

08:00 – 18:00 *Mid-Meeting technical tour, to visit three contrasted areas in the Evros region: (i) the Dadia-Lefkimi-Soufli Forest National Park, one of the most important Greek protected areas at national and international scale in terms of floristic and faunistic biodiversity. The landscape mosaic is formed by pine and oak forests, grasslands and fields and is the ideal habitat for birds of prey; (ii) the semi mountainous area of Megalo Dereio, with traditional livestock farming systems (goats mainly) based on grazing at grasslands and woodlands; and (iii) an artificial pasture grazed by sheep.*

Day 3 - 14 April 2016

09:00 – 11:00 **Session 3. Socio-economic benefits of sustainable grassland management**

Chairperson: *Magali Jouven,* Montpellier SupAgro (France)

09:00 – 09:30 Guest presentation

Overlooked benefits and services of grasslands to support policy reform - *M. Louhaichi,* ICARDA (Jordan)

Short oral presentations

09:30 – 09:45 Investigation of socio-economic factors affecting sustainable rangeland use - *C. Cevher,* Field Crops Central Research Institute (Turkey)

09:45 – 10:00 Mapping the diachronic changes of stocking rates in a Mediterranean rural area of North Greece - *D. Chouvardas,* Aristotle University of Thessaloniki (Greece)

10:00 – 10:15 Characteristics of lowland grasslands used in transhumant sheep systems of Marche region (Central Italy) - *K. Budimir,* Università Politecnica delle Marche (Italy)

10:15 - 10:30 The multifunctional pastoral systems in the Mediterranean EU and impact on the workforce - *A. Ragkos,* Alexander Technological Educational Institute of Thessaloniki (Greece)

10:30 – 11:00 Session 3. Discussion and synthesis

11:00 – 11:30 Coffee break

11:30 – 13:30 Session 4. Rehabilitation of Mediterranean grasslands

Chairperson: *Pieter Swanepoel*, Stellenbosch University, SOUTH AFRICA

11:30 – 12:00 Guest presentation

Rehabilitation of Mediterranean grasslands - *Z. Henkin,* Agricultural Research Organization, ISRAEL

Short oral presentations

12:00 – 12:15 Effect of microtopography on the early plant community dynamics following overseeding for the rehabilitation of a Mediterranean silvopastoral system - *A. Franca,* ISPAAM-CNR (Italy)

12:15 - 12:30 The effect of grazing exclusion on vegetation characteristics and plant community structure in arid lowland pastures - *S. Hassan,* ICARDA (Jordan)

12:30 – 12:45 Rangeland rehabilitation using rainwater harvesting and rosemary (*Rosmarinus officinalis* L.) transplantation in the Southeast of Morocco - *A. Homrani Bakali,* National Institute for Agricultural Research (Morocco)

12:45 – 13:00 Floristic diversity of the understory in *Pinus brutia* plantations as affected by elevation and grazing intensity - *K.A. Margioula,* Aristotle University of Thessaloniki (Greece)

13:00 – 13:30 Session 4. Discussion and synthesis

13:30 – 15:00 Lunch

15:00 – 17:30 Round Table – Connecting research, policy and stakeholders challenges for the sustainability of grasslands

Chairperson: Antonio Lopez-Francos, CIHEAM (Spain)

Panellists:

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C. Paraschoudis, Sheep and goat farmer union of Evros, Greece

C. Roukos, Ministry of Rural Development and Food, Regional Department of Epirus, Greece

D. Skartsi, WWF, Greece

16:00 – 16:30 *Coffee break*

16:30 – 17:30 Round table discussion

17:30 – 18:30 **Business meeting of the Subnetwork and poster awards**

Chairperson: *Claudio Porqueddu,* CNR-ISPAAM, Coordinator of the FAO-CIHEAM Sub-Network on Mediterranean Forage Resources, ITALY

18:30 **Close of the meeting**

21:00 – ? ***Official Dinner***

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CIHEAM

Centre International de Hautes Etudes Agronomiques Méditerranéennes

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Le Centre International de Hautes Etudes Agronomiques Méditerranéennes (CIHEAM) a été créé, à l'initiative conjointe de l'OCDE et du Conseil de l'Europe, le 21 mai 1962. C'est une organisation intergouvernementale qui réunit aujourd'hui treize Etats membres du bassin méditerranéen (Albanie, Algérie, Egypte, Espagne, France, Grèce, Italie, Liban, Malte, Maroc, Portugal, Tunisie et Turquie).

Le CIHEAM se structure autour d'un Secrétariat général situé à Paris et de quatre Instituts Agronomiques Méditerranéens (IAM), localisés à Bari (Italie), Chania (Grèce), Montpellier (France) et Saragosse (Espagne).

Avec au cœur de son action trois missions fondamentales (formation, recherche, coopération), le CIHEAM s'est progressivement imposé comme une référence dans ses domaines d'activité : l'agriculture, l'alimentation et le développement rural durable en Méditerranée.

Founded in 1962 at the joint initiative of the OECD and the Council of Europe, the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM) is an intergovernmental organisation comprising thirteen member countries from the Mediterranean Basin (Albania, Algeria, Egypt, France, Greece, Italy, Lebanon, Malta, Morocco, Portugal, Spain, Tunisia and Turkey).

CIHEAM is made up of a General Secretariat based in Paris and four Mediterranean Agronomic Institutes (MAI) located in Bari (Italy), Chania (Greece), Montpellier (France) and Zaragoza (Spain).

In pursuing its three central missions (education, research and cooperation), CIHEAM has become a reference in its fields of activity: Mediterranean agriculture, food and sustainable rural development.

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Ecosystem services and socio-economic benefits of Mediterranean grasslands

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Mediterranean grasslands (including rangelands, pastures, meadows, and fodder crops) are important resources covering up to 48% of the whole region. Although these ecosystems are a key element in the production of high quality animal products and in the livelihoods of producers, they also provide a range of ecosystem services besides forage production, such as biodiversity conservation, habitat for wildlife, carbon fixation, prevention of erosion and nutrient storage.

There are socio-economic and environmental differences between the different Mediterranean regions, but they share common issues on grasslands sustainability and research. Multidisciplinary investigations are needed to identify the best-adapted and most productive grassland species and mixtures along with the most appropriate grazing management to produce high-quality livestock products. Multidisciplinary research is also needed to monitor the pastoral resources, environmental outputs and ecological services associated with Mediterranean grasslands, to ensure a better understanding of their complexity and to make informed management decisions and take measures for climate change mitigation. More on-farm experimentation and participatory knowledge transfer to farmers are also required.

This publication is an outcome of the 15th Meeting of the FAO-CIHEAM Inter-regional Cooperative Research and Development Sub-Network on Mediterranean Pastures and Fodder Crops titled **"Ecosystem services and socio-economic benefits of Mediterranean grasslands"**, organised in Orestiada (Greece) from 12 to 14 April 2014, by the Mediterranean Agronomic Institute of Zaragoza/International Centre for Advanced Mediterranean Agronomic Studies, the Democritus University of Thrace, the Aristotle University of Thessaloniki and the Hellenic Range and Pasture Society. These Proceedings include 90 papers presented at the Meeting, covering a range of topics allocated into four sessions: (1) Managing ecosystem services and livestock production in the Mediterranean region; (2) Improvement of range, pasture and forage species including alternative uses; (3) Socio-economic benefits of sustainable grassland management; (4) Rehabilitation of Mediterranean grasslands; and a Round Table on "Connecting research, policy and stakeholders challenges for the sustainability of grasslands".

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