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Networks, Markets & People

Communities, Institutions and Enterprises Towards Post-humanism Epistemologies and AI Challenges, Volume 3

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Methodology for Research and Learning About Mediterranean Pastures

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Abstract. In the field study of Mediterranean grasslands, two types were identified, which from the edaphic point of view are classified as subnitrophilic and nitrophilic. Subnitrophilic grasslands include communities dominated by *Taeniatherum caput-medusae* and to a lesser extent by species of the genus *Medicago* sp. The second group of nitrophilic grasslands includes two subgroups: (1) those with a high percentage of *Hordeum leporinum*, which together with subnitrophilic grasslands have a high value for cattle and horse breeding, and as carbon sinks due to the high absorption of CO_2. To subgroup (2) belong the grasslands of the Spanish dehesas and Portuguese montados, very rich in *Poa bulbosa*, *Trifolium subterraneum*, *Biserrula pelecinus*, considered of interest by the habitats directive and national and regional governments. Grasslands belonging to the *Poetea bulbosae* class are of interest for sheep farming, but not as CO_2 sinks because they have a lower biomass than the subnitrophilous and nitrophilous of the *Sellarietea mediae* class. Considering the jaw system of the three types of livestock and the structure of the different pastures, a close correlation should be established between the type of livestock and the type of pasture. All these aspects should be known by future managers, which will enable them to defend the conservation and use of Mediterranean pastures, hence the need to teach them in Universities and Research Centers.

Keywords: Botany · Grazing · Sustainability · Education · Teaching · Environmental deterioration

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1 Introduction

From a botanical point of view, various types of ecological, phytosociological, agricultural and livestock studies have highlighted the high floristic diversity [1, 2]. This high floristic diversity of plant communities is a key element to differentiate the temperate Mediterranean and Central European biogeographic regions [3–6]. The factors conditioning the diversity of both Mediterranean and Central European grasslands are mainly soil type, bioclimate (thermocline and ombroclimate) and anthropogenic and agricultural action [7–9]. According to Raunkiaer's [10] classification, the dominant biotypes in grasslands and grasslands are: therophytes, hemicryptophytes and geophytes.

Several phytosociological classes have been described considering the dominance of biotypes, substrate and anthropic and livestock activities, among which *Stellarietea mediae, Helianthemetea guttati, Festucetea indigestae, Festuco-Brometea, Poetea bulbosae, Lygeo-Stipetea, Stipo giganteae-Agrostietea castellanae, Molinio-Arrhenatheretea, Nardetea strictaae.* All of them contain a great diversity of plant communities and present a different interest to livestock. The class *Stellarietea mediae* is widespread in ruderal environments due to grassland control mechanisms. The management of the species in these communities is today a subject taught in universities, with studies on malerbology (malherbology is the science and technology dedicated to the study and control of weeds) and their use and conservation. This is also the case of the study and teaching of the *Poetea bulbosae* class grasslands, which are of great socioeconomic interest in the Mediterranean [1]. In this work, methods of utilization and conservation of pasture diversity are recommended, and several strategies are presented, such as the proposal for teaching grazing in universities and the planning livestock for the use of Mediterranean pastures.

The grasslands of the Mediterranean region are habitats of EU interest. According to the Habitats Directive [11], these Mediterranean grasslands are present in the open spaces between holm oaks, cork oaks, gall oaks and oak woods, constituting in the case of the Iberian Peninsula the Spanish dehesas and the Portuguese montados, even being located in agricultural crops. The diversity of substrates in the Mediterranean basin is a triggering factor for the diversity of species, ranging from poor oligotrophic siliceous soils obtained from Paleozoic slates, quartzites, granites and diorites, and rich eutrophic soils of limestone rocks, marbles, dolomites, serpentines and gypsum substrates. This diversity, together with the presence of several ombroclimates (arid to hyper-humid) and thermoclimates (infra-Mediterranean to cryo-Mediterranean in the high mountains), explains the high floristic and phytocenotic diversity.

The classification established by Rivas-Martínez and collaborators in various publications [12–14] has allowed researchers to know these habitats with some precision. Rivas Goday and Rivas-Martínez were pioneers in these studies [15, 16]. The interest in the knowledge of Mediterranean grasslands is due to their high socioeconomic, cultural and educational value, and focuses on the different ecosystem services they provide, the diversity of plant associations of each phytosociological class, their distribution and their agricultural and livestock use. Other topics of study are the conservation status of these associations, and the management of certain plant communities according to

their nutritional value in the case of both extensive and stabled livestock farming [16–23]. Recently, a section of grasslands dominated by *Hordeum murinum* subsp. *Leporinum* (Link) Arcang. in the Mediterranean has been studied, and the floristic differences between the associations studied in Spain, Portugal, Italy and Morocco were determined [2]. These communities were included by Rivas Martínez in the broad cosmopolitan class of *Stellarietea mediae*, is well represented by a large number of grassland and herbaceous communities throughout the Mediterranean. Communities found in both basic and acidic pH soils. The key factors conditioning their presence is the nitrogen and organic matter content of the soil obtained by livestock pressure, and by crop fertilization. They are frequent in agricultural environments, where cultivation techniques such as tillage and fertilization condition the presence of different types of grasslands. However, the *Helianthemetea guttati* class, which thrives on both basic and acidic substrates and does not require organic matter or nitrogen, comprises the pioneer grasslands from which the rest of the therophytic grasslands derive. Several associations of this class belong to EU priority habitats, with codes 6220 and 2230.

The *Festuco-Brometea, Lygeo-Stipetea* and *Poetea bulbosae* classes formed by terophytes and hemicryptophytes include associations included in habitat 6220. The first two are important preventing erosion phenomena and contain rare and endemic species. The *Poetea bulbosae* class, represented in the Mediterranean, but especially in the Iberian Peninsula, where it is of great interest for livestock, is a grassland dominated by grasses and legumes. *Poa bulbosa* L. and *Trifolium subterraneum* L. are included in habitat 6220 [12], widely distributed in the Iberian dehesas, pastures that are fed by sheep farming of high socioeconomic interest.

From the educational point of view, the current focus in the teaching-learning process is on active learning, which moves away from classical methodologies involving mere rote learning.

University education is currently undergoing a challenging transition in its training models. It is necessary to rethink the different elements and actors that give life to education: teacher, student, materials, evaluation, contents, activities, technologies and methodologies. In this scenario, the methodologies and contents to be taught acquire vital importance as a guiding element of training, especially those that favour the active role of the student, meaningful learning, collaboration and autonomy. Through active methodologies, the student becomes responsible for the acquisition of knowledge and the construction of his own thinking, thus increasing his critical-reflective capacity [24–26].

This article presents a proposed model to facilitate the use of active methodologies in Botany higher education, placing the student at the centre of the teaching and learning process. Specific active methodologies such as flipped classroom are presented to achieve this learning. Teaching method through which future professionals acquire a high level of knowledge about Mediterranean grasslands, which will allow them to adequately manage ecosystem services. The flipped classroom consists of turning traditional classes upside down to turn students into active protagonists of their learning [27–29]. Another important issue to consider is the knowledge of local populations about the rich biodiversity of their territories, which is at risk of being gradually lost due to neglect and ignorance [30].

Based on this premise, we proceed to teach the great diversity of Mediterranean grasslands by applying these didactic methodologies. The aim of this work is to review the current status of various Mediterranean grasslands, their diversity, conservation status, exploitation, proposals for sustainability and educational and socioeconomic strategies in Mediterranean countries to promote sustainability and development.

2 Materials and Methods

This work is based on the study of some phytosociological classes located in Mediterranean environments. A review of grassland communities is presented through the application in the classroom of active methodologies, aimed at facilitating the self-construction of knowledge by the students themselves. By means of these methodologies, the groups of grassland and herbaceous communities described by several authors and in our own research are studied. The number of syntaxa per class is reviewed and in particular the class *Stellarietea mediae*, studied in several works by Rivas-Martínez [2, 12–14, 31]. Some of these grasslands are included in their corresponding habitat, and we examined their prioritization by the EU and their conservation status to maintain habitat sustainability. We analyze the greater or lesser diversity of associations in each of the aforementioned classes, and establish which ones require protection measures [26, 32, 33].

We study in the field the vegetation cover of the *Stellarietea mediae* class and propose corrective measures. Management proposals are made through different educational, social and economic strategies that promote sustainable development. We highlight the flipped classroom within the proposed educational strategies.

We transfer learning models outside the classroom and use class time, combined with the teacher's experience, to facilitate and promote other acquisition processes and put this knowledge into practice [34–36]. Next, students (with the theoretical basis incorporated into their previous knowledge in the classroom) carry out phytosociological inventories in the field itself and obtain a series of skills, such as knowing how to select the minimum area in which to determine the maximum floristic diversity, as well as measurting of the different parameters inherent to sampling.

With the field data obtained in the laboratory using the formula Bv = S. hm. Cm (S = minimum area, hm = average height of the dominant species (*Hordeum murinum* subsp. *Leporinum* (Link) Arcang.), Cm = average cover, students calculate the amount of CO2 absorbed by these grass communities according to Mota et al. [37, 38] (Fig. 1).

This methodology consists of transferring teaching outside the classroom, to the field, so that students learn, from their own experience, not only to recognize plant communities, but also their interrelationships and their state of conservation.

Socioeconomic analysis explores ways of valuing ecosystem services [39–43] that consider the value of pastures as CO_2 sinks and in preventing erosion, and the valuation of pastures for sustainable livestock farming.

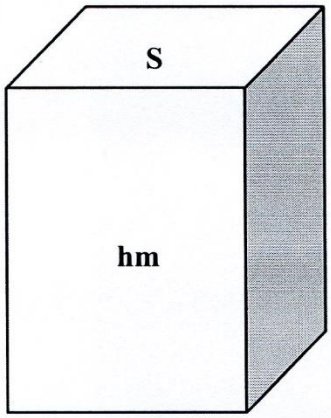

Fig. 1. Formula for calculating the Biovolume of a plant community (Bv = S x hm x Cm)

3 Results

The students observed and interpreted different grassland communities thanks to this teaching through active methodologies. The academic results of the students during several years were highly satisfactory. 100% of the students in these years incorporated the proposed contents to their knowledge. These results were obtained by using active methodologies applied in the field, such as the flipped classroom or the inquiry method.

Regarding the contents studied, we established two groups of plant communities of the *Stellarietea* class distributed throughout the Mediterranean basin that grow on both basic and acid substrates, taking into account the environmental factors that condition their presence: communities on soils whose organic content can be of animal origin and with a dominance of grasses, legumes and composites, and a second group that appears in rural environments due to cultivation techniques, tillage, semi-tillage, no-tillage, fertilization and use of herbicides.

This is a very diverse class with a wide distribution in Holarctic territories, especially the Mediterranean. So far we have detected 15 alliances and 164 plant associations in this class. We highlight the communities of *Taeniatherum caput-medusae* (L.) Nevski and *Hordeum murinum* subsp. *Leporinum* (Link) Arcang. Which are of interest for cattle and horse breeding, and for discerning between sub-nitrophilous and nitrophilous grasslands. During the years of field and laboratory work, the students took more than 100 samples under the supervision of the teacher, which were analysed in the laboratory according to their floristic composition, obtaining the different phytosociological tables representative of the types of grasslands, of which we reflect two tables corresponding respectively to *Taeniathero-Aegylopion geniculatae* and *Hordeion leporini*, these tables present the number of inventions, surface in m2, altitude above sea level, vegetation cover in %, orientation and slope of the plot if any, average height of the vegetation and average height of the dominant species. Each species is assigned an abundance-dominance index according to [44].

Pure non-nitrified grasslands, also known in some places as starvation grasslands, cannot be used by livestock due to their low nutritional value, although some associations are important for conservation. Grasslands of the class *Helianthemetea guttati* are included in 13 alliances and 102 associations, this is the second most diverse class.

Only the alliances *Helianthemion guttati* and *Trachynion distachyae* can be important to obtain through pasture dynamics other alliances of *Stellarietea mediae* (*Taeniathero-Agilopion geniculatae* and *Hordeion leporini*) that are of interest as food for livestock. Although they have little interest as CO_2 sinks due to their low biomass, *Poetea bulbosae* grasslands that grow on acidic and basic substrates have a high value for sheep farming due to their nutritional richness, they are very important socioeconomically since they support sheep farming. Extensive. This class is represented by three alliances in the Iberian Peninsula, of which we highlight *Trifolio subterranei-Periballion* located on siliceous soils and *Poo bulbosae-Astragalion sesamei* on basic substrates, which are the basis of sheep feeding. *Poa bulbosa* L. communities are widespread throughout the Mediterranean, and are very suitable for sheep due to their palatability and nutritional richness, with a percentage of legumes greater than 50%.

4 Discussion

The flipped classroom model and the inquiry methodology are considered an alternative for the achievement of competencies, that is, a set of knowledge, attitudes and skills that students should acquire. Initially, we observed that the students had basic misconceptions, which were later improved thanks to the didactic methodologies applied. These methodologies contributed to the acquisition of competences on sustainability in pastures and their use by livestock [45]. Scientific research confirms the undeniable diversity of Mediterranean grasslands and pastures, both from an ecological and phytosociological point of view. The current state of knowledge is high, especially with regard to the Iberian Peninsula. However, we detected in this study that there is no management at the institutional level, which promotes the sustainable development of these pastures, although there are associations such as the Spanish Society for the Study of Pastures (SEEP) that are dedicated to this end. This is due to the lack of support from government institutions; only universities and research institutes focus their attention on the knowledge of pastures.

Natural pastures provide food for a livestock herd of great importance, since they represent a large part of a country's economy. There are essentially three types of livestock of interest: cattle, horses and sheep. Although the type of pasture should be correlated with the type of livestock, this is not always the case due to the loss of knowledge transmitted from parents to children and the lack of teaching of these concepts. It is essential to know the palatability and nutritional value of the pasture, the structure of the flora that composes it and the type of animal that grazes it. For example, the biodiverse communities of *Hordeion leporini* and *Taeniathero-Agilopion geniculatae* [38], which have an important biovolume, are suitable for cattle and horses, but not for sheep, since the latter community is composed of 50% grasses and 50% legumes.

It is estimated that the implantation of some crops such as cardoon (Cynara cardunculus) has a carbon sequestration close to 3.7 T/ha/year, biomass that compensates up to 70% of the CO2 emissions produced by the use of fossil fuels. Mota et al. [37] study CO_2 absorption by barley, oats and wheat in the region of Murcia, based on this and using the biovolume of the plant community we obtain the incorporation of carbon by some nitrophilic communities of *Stellarietea mediae* [38].

Some authors [23] have estimated the economic cost of sowing grasses and legumes in the afforestation of grasslands, although without specifying which species of grasses, which would aim at carbon sequestration. The Hordeum murinum subsp. Leporinum (Link) Arcang. And Poa bulbosa L. grasslands that the students sampled in the field have a minimum area of 1 m^2, with 60–100% cover abundance of the dominant species. Field data are essential for assessing ecosystem services.

It is therefore necessary to implement a management regime in which each type of pasture corresponds to a particular type of livestock, thus ensuring sustainable development. This type of management is not usually carried out, the most common being rotational grazing and planting of species to provide supplementary feed in unfavorable seasons.

Although *Stellarietea mediae* meadows have a high ecosystem value, they are little or not used by the population, possibly due to lack of knowledge or because they have been taught that they are weeds, this has led to the use of herbicides and inappropriate cultivation techniques in agriculture that damage the flora. However, there are studies on soil and fertilization bioindicators in which sustainable management of *Stellarietea mediae* grasslands is carried out [46–49].

According to the European Commission's 2021 statement, economic losses due to extreme events caused by climate change amount to more than 12,000 million per yers. The Commission is committed to promoting local, individual and equitable resilience, which is the cornerstone of adaptation to climate change, for which the EU has increased the European Structural and Investment Funds. This financing mechanism requires action to be taken at the individual and local level: economically value vegetated land, ensure that farmers receive an economic incentive per hectare covered with grassland, and avoid or reduce spending on herbicides, which increased significantly between 2010–2019.

Mediterranean grasslands are dominated by annual and perennial plants (therophytes and hemicryptophytes), particularly species from the grass, legume, cruciferous and composite families. Given that the nutritional value of grasses is concentrated in the first two botanical families, we propose as a strategy the promotion of extensive grazing and, when this is impossible, a regime of mowing and transformation into hay for stabled livestock. It is essential in this case not to eliminate the plant cover with herbicides. These vegetation covers offer various ecosystem services, since they act as CO_2 sinks.

Another strategy is to raise awareness in society about the usefulness of green roofs. To achieve this, public knowledge of grasslands and grasslands must be promoted. We must promote the transmission of knowledge from parents to children and modify the content in secondary, high school and university centers. In the specific case of Spain, the subject of Malerbology, which aims to teach what was previously known as crop weeds, is only taught in a few higher education centers.

In the case of Spain, BOE No. 5 of January 5, 2007, [50] includes Royal Decree 1631/2006, of December 29, which establishes the minimum curriculum for Compulsory Secondary Education. This Royal Decree refers to content on the environment in terms of pollution and water resources, so that students acquire skills in knowledge and interaction with the physical environment, as well as in mathematics and linguistics (BOE no. 5-January, 2007). These guidelines are clearly insufficient, since linguistic competence refers to the Spanish language and does not cover scientific terminology, and students

do not acquire skills in relation to the far-reaching environmental changes that are currently taking place. More recently, BOE No. 3 of January 3, 2015, [51] establishes the minimum curriculum for Compulsory Secondary Education (ESO) and Baccalaureate studies. Although the contents of Biology and Geology are included in some depth, no reference is made to serious environmental problems such as climate change and the loss of biological diversity (BOE no. 3-January, 2015), which means that students reach the University without prior knowledge in the subject. It is essential that all institutions, public and private, undertake the education and teaching of extreme natural phenomena such as climate change, its causes and consequences, and the loss of biological diversity due to the excessive use of chemicals.

5 Conclusions

This analysis of pastures and meadows allows us to verify their deterioration, the loss of floristic diversity and vegetation cover is a cause of great concern, since it entails loss of soil and water, and causes serious economic damage and unresolvable social conflicts due to low agricultural yields, which ultimately causes an increase in migration from areas most affected by climate change to areas less affected. This triggers a chain of events that begins with environmental pollution, increased CO_2 and the loss of vegetation cover that would potentially act as a CO_2 sink. Climate change could be alleviated by mitigating the lack of water and soil resources and, consequently, maintaining the economic resource.

Mediterranean grasslands represent an undeniable economic resource, since they have a high value as CO_2 sinks, with 32.5 tons/ha-year in the case of the *Hordeum murinum* subsp. *Leporinum* (Link) Arcang. Communities, or a high livestock value, since the grasslands of *Poa bulbosa* L. can maintain 25 lambs per hectare and year. However, there is a lack of training among the population, so it is essential to offer education on up-to-date environmental issues.

The use of active methodologies within the teaching of complex concepts has been shown to generate better assimilation and understanding of the topics, and—when implemented—achieves the proposed objectives in 100% of the students. To do this, the "flipped classroom" and the inquiry process can be used, respecting the learning pace of each student and increasing their interest in what they have learned. All of this allows us to generate well-trained and trained professionals for the management of Mediterranean grasslands.

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