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Forage resources and ecosystem services provided by Mountain and Mediterranean grasslands and rangelands

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To what extent do French mountain grasslands provide simultaneously biodiversity and forage services?

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Abstract. The key role of permanent grasslands for the conservation of biodiversity, and more generally for the preservation of environment quality, is clearly established. However, the total area covered by grassland is regularly declining in most EU countries. A way to stop the decline of their surfaces is to underline the economic potential of grasslands for breeders and their value. In this perspective, we studied the links between forage services and biodiversity through the survey of a network of 47 permanent grasslands from Pyrenees, Massif Central, Jura and Vosges. Grasslands were followed during 2 years (2009-10) considering the seasonal dynamic of forage characteristics and botanical and functional composition. Forage services of grasslands were estimated measuring production and quality (digestibility, crude protein content), and biodiversity by indicators of botanical diversity (species richness, percentage of entomophilous species, number of oligotrophic species, botanical families). We showed a strong link between quality of permanent grasslands and biodiversity. The productive grasslands presented a lesser interest for biodiversity. We also showed that permanent grasslands could provide simultaneously biodiversity and forage services or only forage services or biodiversity.

Keywords. Permanent grasslands – Forage services – Biodiversity.

Les prairies permanentes de montagne en France apportent-elles simultanément des services fourragers et de la biodiversité ?

Résumé. *Le rôle des prairies permanentes dans la conservation de la biodiversité, et plus généralement dans la préservation de la qualité environnementale est maintenant bien établi. Cependant, leur surface totale diminue régulièrement dans de nombreux pays européens. Une alternative pour stopper ce déclin est de souligner l'intérêt économique de ces surfaces dans le système fourrager et leur valeur. Dans cette perspective, nous avons étudié les liens entre les services fourragers et la biodiversité à travers l'étude d'un réseau de 47 parcelles de prairies permanentes des Pyrénées, du Massif Central, du Jura et des Vosges. Ces surfaces ont été suivies durant deux années (2009-10) en prenant en compte leur dynamique fourragère saisonnière et leur composition botanique et fonctionnelle. Les services fourragers des prairies ont été estimés à travers la mesure la production et de la qualité de celles-ci (digestibilité et teneur en matières azotés), et la biodiversité par des indicateurs de diversité botanique (richesse spécifique, pourcentage d'espèces entomogames, nombre d'espèces oligotrophes, familles botaniques). Nous avons réalisé une ACP sur les indicateurs de biodiversité. Nous avons montré un lien important entre la qualité des prairies permanentes et la biodiversité. Les prairies productives présentent un intérêt moindre pour la biodiversité. Nous avons également montré que ces surfaces pouvaient rendre simultanément des services fourragers et présenter un intérêt en termes de biodiversité.*

Mots-clés. *Prairies permanents – Services fourragers – Biodiversité.*

I – Introduction

The role of permanent grasslands in the preservation of biodiversity and more widely in the delivery of ecosystemic services (for environmental or economical purposes) is today well established (Leroux *et al.*, 2008). However, these surfaces are decreasing for several years in several European countries. European Union policy tries to maintain permanent grasslands in the landscape, especially because of their environmental interest. A way to stop the decline of their surfaces is to provide evidence about the joint interest of grasslands, in terms of economy and environment. It is thus important to underline the economic potential of grasslands for breeders related to their production and nutritive value (Jeangros and Schmid, 1991; Michaud *et al*., 2012). In this perspective, we studied the links between forage services and biodiversity, with the aim to underline the diversity of services they can return: forage services, ecosystemic services or both. Links between indicators of forage services and these services were established by Michaud *et al.* (2011). To this end, we analyzed data collected in an original set of permanent grasslands distributed along a large mountain gradient in France.

II – Materials and methods

A set of 190 French permanent grasslands was studied on 78 farms (Michaud *et al.*, 2011). We extracted within this network all the plots of land located at more than 600 meters above sea level. Forty-seven permanent grasslands were thus studied from 4 mountainous massifs: Pyrenees, Massif Central, Jura and Vosges. They were studied during 2 years (2009-10) considering the seasonal dynamic of forage characteristics and botanical/functional composition.

Botanical composition was determined in spring 2009 on each grassland in a homogeneous plant community (vegetation structure and floristic composition) of *c.* 1 ha. The list of species was compiled from eight randomly located sampling areas (0.25 m²) and completed by an overview of the global plant community in order to note the presence of other species in the sampled area. In each 0.25 m² sampling area, species dominance was determined by visual estimation of the relative volume of each species in the biomass (Benizri and Amiaud, 2005). The botanical lists were entered into the e-flora-sys software (*http://eflorasys.inpl-nancy.fr,* Plantureux *et al.*, 2010). From the botanical composition, e-flora-sys calculated the proportion of entomophilous species and the number of oligotrophic species.

The seasonal dynamic of forage production and nutritive value was assessed during 2009 and 2010 on the dominant homogeneous plant community of each grassland. In three areas of that plot (1.5×3 m), samples were taken on four occasions each year: two samples in spring (one at the beginning of spring and one at the end of spring), one in summer and one in autumn. At each measurement, two samples were collected to study:

– The proportions of grasses, legumes and forbs, estimated visually, according to volume;
– The biomass production and grass nutritive value of permanent grasslands. By means of the dried sample and the dry matter content, the biomass production of each grassland was calculated for all cutting dates. The nutritive value of the herbage (organic matter digestibility and crude protein content) was estimated using NIRS (Michaud *et al*., 2012).

Relationships between forage services and biodiversity was analyzed by investigating the links between production and nutritive value (organic matter digestibility, crude protein content) on one hand and indicators of botanical diversity (species richness, number of oligotrophic species, proportion of entomophilous species, grasses, legumes and forbs proportion) on the other hand. We studied the distribution of grasslands according biodiversity and forage indicators. For that, a Principal Component Analysis (PCA) was performed on SAS, package 3.0.2. Biodiversity indicators were considered as active variables and forage indicators as illustrative variables.

III – Results and discussion

Grasses, legumes and forbs proportion showed colinearity: we only kept legumes and forbs proportions in the analysis. Only independent variables were kept for the analysis. Axes 1 and 2 take into account about 50 % of the overall variability of data.

1. Links between the indicators of the forage services and the indicators of biodiversity

In Fig. 1, directions of axes are explained for axis 1 by proportion of legumes and number of oligotrophic species, and for axis 2 by forbs proportion, percentage of entomophilous species and species richness at the opposite. The number of oligotrophic species is related with the legumes proportion of grasslands. The percentage of entomophilous species stayed rather related to forbs proportion. In fact most of entomophilous species are forbs.

Moreover Fig. 1 underlined links between indicators of forage production and of biodiversity. Nutritive value was related to legumes proportion and oligotrophic species. The effect of legumes on crude protein content or organic matter digestibility was described by several authors (Bruinenberg *et al.*, 2002; Daccord *et al.*, 2006; Baumont *et al.*, 2008). Moreover forbs proportion and percentage of entomophilous species contributed to explain grasslands nutritive value at the end of spring. Daccord *et al.* (2006) classified forbs into two categories: stemmy and leafy forbs. Leafy forbs could help to improve nutritive value of grassland whereas stemmy forbs would decrease it. In contrast, biomass production of grass was set against the nutritive value indicators and against the indicators of biodiversity as legumes proportion.

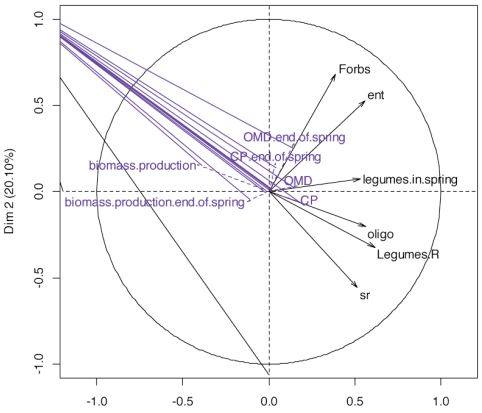

Fig. 1. PCA of active variables and indicators of forage services.

Illustrative variables: ent: entomophilocus species; oligo: oligothophic species; Legumes R: legumes for regrowths; OMD: organic matter digestibility for the rest of the year; CP: crude protein content for the rest of the year.

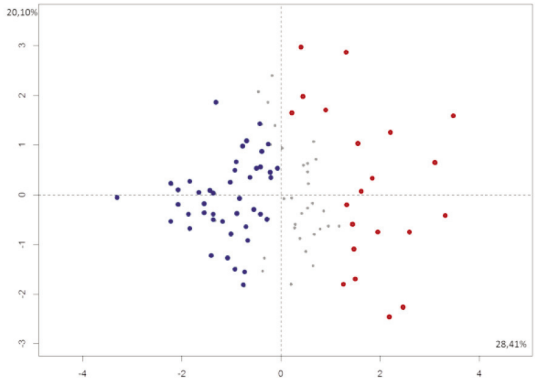

Fig. 2. Distribution of grasslands according to biodiversity indicators. Values of 2 years are represented.

- grasslands presenting and interest for biodiversity
- grassland presenting and interest for forage services
- grassland presenting an interest for biodiversity and forage services.

2. Can the permanent grasslands of mountains return forage services and present an interest in terms of biodiversity?

The distribution of grasslands in the PCA plan showed a group of productive grasslands which deliver forage services linked to production. A more scattered distribution of grasslands was showed for those which present an interest for biodiversity (Fig. 2). Here we find grasslands which only return interest for biodiversity (on the right of Fig. 2) and those which provide both: services linked to quality of grasslands and biodiversity interest (close to center of circle). So we can set a gradient in relation to the services and biodiversity, from left to right: permanent grasslands, which provide only forage services linked to production, to those who consider forage services linked to nutritive value and biodiversity, and those which favor rather the biodiversity.

IV – Conclusions

The study of links between indicators of forage services and biodiversity showed a strong positive relation between quality of permanent grasslands and biodiversity and in contrast a negative relation between biomass production and biodiversity. We also showed a homogeneous distribution of grasslands in the plan of study: we found grasslands which return rather forage services linked to biomass production, others which presented rather an interest for the biodiversity and finally others which reconciled both (quality of the grass and biodiversity, average productivity and biodiversity). Thus, mountain permanent grasslands can provide simultaneously forage services related to nutritive value of grass and environmental services related to biodiversity. Considering that, various strategies could be driven at the level of fodder system management to reconcile biodiversity and forage services. However it depends on the objectives of the breeder and on constraints at farm level.

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