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Seasonal distribution of production of Apennine grasslands described from sward height

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SUMMARY – In the Apennine region, grassland grazing is at the root of the livestock system. It is essential to maintain the current level of biodiversity and to create the conditions for the development of the local rural society. This paper presents a simplified integrated approach between botany and agronomy to characterise the grassland space-time production pattern, based on the grazed sward height (SH) compared to a reference 28-day cutting interval, measured on well characterised pastoral facies. In this context, SH proved to be an effective indicator of herbage productivity, particularly to assess the time-space yield dynamics, which is relevant to rangeland management. SH measurements are quick and allow the estimate of grassland production on more sampling areas than destructive methods. This information can be used to support the space-time organisation of infrastructures and activities in the rangeland, to achieve a sustainable balance between grass production and animal grazing.

Key words: Apennine, grasslands, grazing management, productivity, weighted plate, time-space dynamics.

RESUME – *"Distribution saisonnière de la production des herbages des Apennins décrite à partir de la hauteur de la prairie". Dans les Apennins, le pâturage est au coeur du système d'élevage. Il est essentiel de maintenir le niveau actuel de biodiversité et de créer les conditions d'un développement de la société rurale locale. Cette communication présente une approche intégrée simplifiée entre la botanique et l'agronomie pour caractériser le comportement de l'herbe dans l'espace et le temps, basé sur la hauteur de la prairie pâturée (SH) comparée avec une référence correspondant à un intervalle de fauche de 28 jours, mesuré sur des faciès pastoraux bien connus. Dans ce contexte, SH paraît un indicateur efficace de la productivité de l'herbe, particulièrement pour prendre en compte la dynamique de production dans l'espace et le temps ce qui est en cohérence avec la gestion des parcours. Les mesures de SH sont rapides et permettent d'estimer la production d'herbe avec plus de fiabilité que des méthodes destructives. Cette information peut aider à l'organisation espace-temps des infrastructures et des activités sur les parcours pour atteindre un équilibre durable entre production d'herbe et animal au pâturage.*

Mots-clés : *Apennins, pâturage, gestion du pâturage, productivité, plaque à pression, dynamiques espace-temps.*

Introduction

There is concern about the risk of environmental degradation following abandonment of the secondary grasslands in the Apennines (Italy). The sustainable management of these areas requires new knowledge in the perspective of the assignment of new multifunctional roles, other than forage production, such as the preservation of plant biodiversity and natural resources and the prevention of natural calamities. In the central Apennine, upland grasslands are of secondary origin and are located at the top of the mountains, where slope is relatively low. Grassland grazing is at the roots of the whole livestock system and it is therefore essential to prevent the environmental degradation and to create the conditions for the development of the local rural society. The current grazing systems are based on free range grazing of sheep, cattle and/or horses. Therefore, the pattern of grassland utilisation and productivity is very variable in space and time and requires a number of measurements to identify over and undergrazed areas, where environmental degradation may occur. The agronomic productivity of the Italian grasslands has been assessed in the 80s using a four-weeks repeated cutting scheme on fenced areas (Sarno *et al.*, 1989; Acutis and Reyneri, 1992). However, this method is expensive and then not always suitable to

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evaluate the spatial variability. Sward height (SH), when measured with a sward stick or a weighted plate, proved to be an effective non-destructive indicator of grass production and animal intake of temperate grasslands (Frame, 1993).The objective of this study was to verify the reliability of a non-destructive sampling method based on the use of sward height, to assess Apennine grassland seasonal growth rates, as a support tool to plan their sustainable management.

Materials and methods

The study area is located at the top of the mountains of the calcareous Apennine between Umbria and Marche, at an altitude of 1240-1400 m a.s.l. where secondary grasslands, originated by the forest cut, are currently extensively grazed by sheep, cattle and horses (Bagella, 2001a). The weather station, located at an altitude of 1005 m a.s.l., reports an average annual temperature of 10.4°C and an annual rainfall of 1695 mm. From a bioclimatic point of view, this area is included in the submediterranean oceanic temperate bioclimate. According to Ballelli *et al.* (1976) the potential vegetation is represented by the oak forest (*Polysticho aculeati-Fagetum sylvaticae* Feoli et Lagonegro 1982). The main ecological constraints are represented by low temperatures, strong winds and the shallow soil depth associated to a sandy soil texture, which in dry summers may induce severe water stress (Bagella, 2001c). An integrated phytosociological and phytopastoral analysis made in the study area (Bagella, 2001c) identified as the most relevant grassland the association *Brizo mediae-Brometum erecti* Bruno in Bruno and Covarelli (1968) corr. Biondi and Ballelli (1982), within which several variants (i.e. pastoral *facies*) related to altitude, slope, soil type and grazing management, were distinguished (Daget and Poissonet, 1969; Daget and Godron, 1995; Bagella, 2001c). A phytosociological and phytopastoral georeferenced map was also created to describe the space distribution and assess the surface area of each facies (Bagella, 2001b).

To assess the seasonal growth rate of three different sites, a 4-plots experimental device based on a 28-days repeated cutting scheme (Corrall and Fenlon, 1978) was set up on three fenced areas, corresponding to three different pastoral *facies* (Table 1).

Table 1. Characteristics of the sampling areas

Site	Most represented species of the pastoral facies	Grazed area (ha)
Uomo di Sasso	*Festuca circummediterranea* Patzke, *Thymus longicaulis* Presl, *Carex caryophyllea* La Tourr	125
Cave Macine	*Bromus erectus* Hudson, *Thymus longicaulis*, *Carex caryophyllea*	22
Orneto	*Festuca circummediterranea*, *Bromus erectus*, *Cynosurus cristatus* L.	11

During the growing season (1998-1999), SH was measured with a weighted plate of 30 × 30 cm in size and 430 g in weight (Castle, 1976; Frame, 1993; Daget and Godron, 1995). Dry matter yield (DMY) was measured cutting the aboveground phyto-mass at an average height of 0.5-1.5 cm. The harvested phyto-mass was dried in the lab for 72 hours at 80°C. In the fenced areas SH and DMY were measured at weekly intervals on the to replicate plots corresponding to a 28-days cutting interval (0.5 m^2 each). SH was also measured on the plot that had been cut 7, 14, 21 or 28 days earlier. At weekly intervals, SH was measured over a wide area surrounding the fences, to monitor the pasture production under grazing. DMY was occasionally assessed in the grazing area. All the SH and DMY data pairs were used to calibrate a single linear regression equation between SH and DMY over the two years (Bagella and Roggero, 2003): DMY = 0.201 SH – 0.132; R^2 = 0.86. Growth curves of the fenced areas were calculated both from destructive and non destructive DMY data using the algorythm of Corrall and Fenlon (1978). Furthermore, DMY means were weighted on the basis of the corresponding area of each pastoral *facies*, in order to estimate the productivity of the whole grazed area. SH time dynamic in the fenced and grazed area were also compared, in order to verify if the grazed grassland growth rate were comparable to the fenced grassland using a reference 28-day rotational cutting system. The two years were characterized by contrasting weather conditions: summer 1998 was very dry (only 38 mm in July and 2 mm in August), while water availability was no limiting in 1999.

Results and discussion

In 1998, the grass growth season was restricted to about two months, from early May to the end of June because of the prolonged drought, and there was almost no regrowth after the first cutting round of the four plots at all experimental devices (Fig. 1). In 1999, the growing season was extended from the end of April to the beginning of November. In both years, the maximum herbage growth rate was less than 20 kg/ha/d dry matter (DM), and it occurred between the end of May and the beginning of June, when grasses were at the end of heading and begining of earing. The forage DM content increased from 25% at the start of the growing season to 80% in August 1998 or 50% in September 1999. This indicate that, even without deep water deficits, plants have an average high degree of dehydration at this altitude. The seasonal distribution of production of both years has been well described by both destructive and non destructive measures. However, DMY calculated from SH overestimated the re-growth after the first cutting round of the four plots and, in 1998, underestimated maximum growth rates. These differences were partly attributed to the use of a single regression equation for all the SH data, which was not always suitable to the diversity of canopy structures in relation to time, cutting or grazing. However, SH data are based on a higher number of replicates than DMY data.

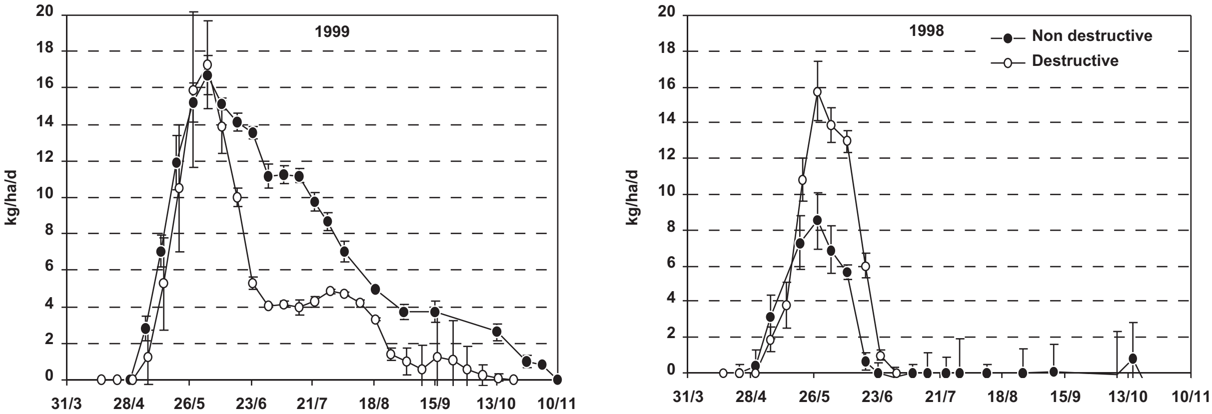

Fig. 1. Mean growth rates of the grassland obtained with destructive methods or derived from SH (non destructive) and weighted according to the surface areas of the pastoral facies.

The total DMY assessed with the destructive method was 0.46 and 0.82 t/ha DM in 1998 and 1999 respectively, while DMY indirectly estimated from SH ranged from 0.30 (1998) to 1.35 t/ha. Despite the relative differences between DMY data obtained with the two methods, SH made a substantially consistent estimate of absolute total DMY and its seasonal distribution. In fact, both methods of estimate of DMY are critical when SH is very short and harvest of destructive samples to be used for the calibrations is not made at ground level. The production data are in agreement to the ones obtained in a four years destructive survey by Santilocchi (1989) under similar ecological conditions. The indirect information obtained by the SH may then be sufficient to contribute to an integrated and grazing management in a perspective of maintenance of the grasslands role and composition. Furthermore, SH allowed an estimate of sward growth rates when the sward was so short that cutting was not possible.

The comparison of the average sward height in the cut (fenced) and grazed areas (Fig. 2) indicates that in 1998 the cutting height of fenced areas was too low, on average 1 cm lower than in the grazed areas, while in 1999 it was substantially similar.

This indicates that, under normal circumstances, the grazing simulation with the 28-days cutting interval scheme was suitable for the description of the growth pattern of these grasslands. It also indicates that the current grazing management can be considered substantially adequate. The figures describe the dynamic of sward production in relation to the grazing management.

Conclusions

The indirect estimate of DMY from SH measurements made with a weighted plate meter, proved to be reliable enough to describe the seasonal distribution of forage production of native Apennine grasslands. However over or underestimates of DMY occurred, particularly when SH was very short and grass growth rates were low.

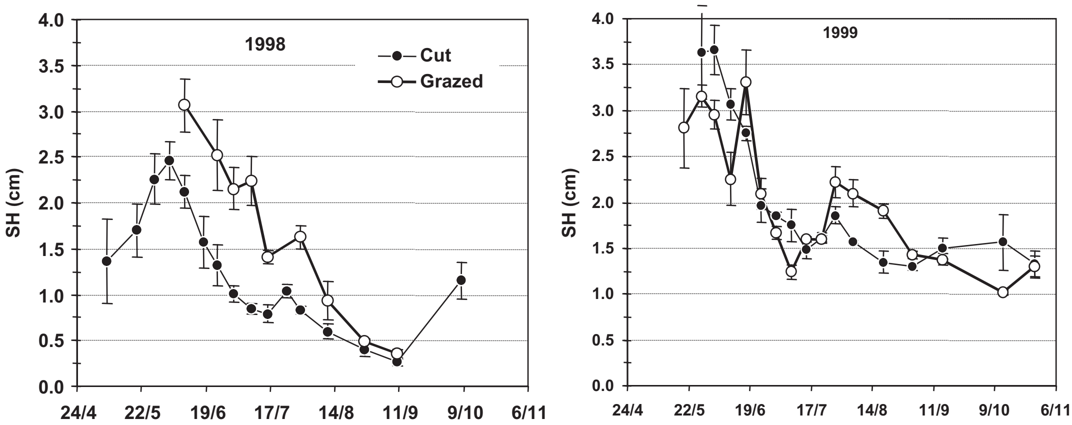

Fig. 2. Comparison of mean SH of grazed and fenced (i.e. 28-days repeated cutting regime) swards.

The measurements of SH could replace the conventional destructive methods to assess pasture productivity, thus increasing the number of sampling areas and hence extending the monitoring to a wider grassland area. However, to achieve a sustainable management system of Apennine grasslands, several other biophysical aspects should be considered (flora, vegetation, agronomic value, livestock management, economic aspects) and linked to the local socio-economic context. The SH data provided sufficient information to describe the space-time growth dynamics of the grassland, which is one of the most relevant indicators to support the grazing management planning, particularly when dealing with secondary grasslands, whose vegetation would rapidly evolve to forest under too low grazing pressures.

The systematic monitoring of SH with rapid methods allows the description of the spatial description of the pasture production, to interpret the grazing behavior and to identify the over- and under-grazed areas in the grassland, which can determine the reduction of the grazing value and the deterioration of the sward botanical composition. These data are also suitable to be included in a GIS (geographic information systems) to integrate other layers of space based information, which could be used to facilitate the participation of different stakeholders to decision making in order to develop sustainable land use systems, following a recent trend on participative approaches to environmental issues (Cinderby, 1999).

The sward plate meter does not require specific skills, but it cannot be effectively used on steep slopes, woody and stony areas. The information obtained from SH data on natural grasslands can be satisfactory in most cases, particularly when time-space sward production dynamics are more relevant than absolute values. The comparison of average SH of grazed vs reference cutting management can help the interpretation of SH data in relationship to grazing pressure: grasslands can be considered overgrazed when average SH of the grazed areas is lower than that in the reference areas, where a simulated 28-days rotational grazing occurs. However, this information should be analyzed for its space and time dimensions to design a sustainable grazing management. For instance, the analysis of SH spatial distribution could guide the infrastructure positioning (e.g. water pools, milking areas, feeding blocks, etc.) to modify the animal grazing paths in order to increase grazing pressure where it is necessary to contrast wood restoration.

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