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Seasonal variations of herbage yield and quality in Karst pastures for sustainable management: first results from the BioDiNet project

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Abstract. The project Network for the Protection of Biodiversity and Landscape (BioDiNet) started in autumn 2011, pursues the aim of preserving the natural and cultural heritage of the Karst Edge. One of the scheduled activities scheduled was the study of the herbage yield and quality of Karst pastures for defining grazing management guidelines. The preliminary findings obtained in the study area of Polazzo (Gorizia, Italy) are reported here. Four sites were selected as representative of the most common pastures in the area. The daily herbage yield (t ha^{-1} d^{-1} dry matter [DM]) from April to October 2012 was determined using the Corrall and Fenlon (1978) method and described by a Gaussian model. Herbage nutrient concentrations were also determined. The four sites displayed similar trends for daily DM yield, with a maximum in May, followed by a decrease in August, and a slight recovery in September. However, each pasture showed different total annual DM yield, and different Gaussian growth curve parameters. There were also significant differences in herbage quality. In all sites, the highest concentration of crude protein and lowest concentration of acid detergent fibre coincided with the maximum daily DM yield. These results suggest grazing should be managed according to the productivity of each pasture to reduce the risk of excessive grazing, and provide high quality forage to animals.

Keywords. Daily herbage yield – Herbage nutrient concentration – Grazing guidelines – Sustainable management.

Variations saisonnières de la production et de la qualité de l'herbe dans des prairies du Karst dans un but de gestion durable : premiers résultats du projet BioDiNet

Résumé. *Le projet "Réseau pour la protection de la biodiversité et du paysage" (BioDiNet), commencé à l'automne 2011, vise à préserver le patrimoine naturel et culturel du Karst. La production des prairies et la qualité des pâturages karstiques ont été étudiées pour établir des lignes directrices de gestion des pâturages. Les résultats préliminaires de la zone d'étude de Polazzo (Gorizia, Italie) sont rapportés ici. Quatre sites représentant des pâturages les plus courants dans la région ont été choisis. Le rendement quotidien d'herbe (t ha^{-1} j^{-1} de matière sèche [DM]) d'Avril à Octobre 2012 a été déterminé en utilisant la méthode de Corrall et Fenlon (1978) et décrit par un modèle Gaussien. Les concentrations en nutriments de l'herbe ont également été déterminées. Bien que le rendement quotidien en MS des quatre sites fût semblable, les quatre pâturages ont montré des différences dans leurs rendements annuels de DM, ainsi que dans les paramètres de la courbe de croissance de Gauss, et dans la qualité de l'herbe. La plus forte concentration en CP (protéines brutes) et la plus faible concentration en ADF (fibres) ont coïncidé avec le rendement quotidien de MS maximal. Ces résultats suggèrent que chaque pâturage doit être géré en fonction de sa productivité pour réduire le risque de pâturage excessif, et pour fournir un fourrage de haute qualité.*

Mots-clés. *Production journalière d'herbe – Concentration en éléments nutritifs de l'herbe – Lignes directrices de pâturage – Gestion durable.*

I – Introduction

The majority of Karst grasslands were included in the Italian and Slovenian Natura 2000 network for their high environmental value. However, the low production capacity of these grasslands and the changing socio-economic conditions over the last decades led to widespread abandonment in this area (Ivajnšič *et al*., 2013). According to the Slovenian Agri-Environmental Programme, the primary objective of conservation of Karst grasslands is to counter the depopulation of rural regions. In order to preserve the natural and cultural heritage of the Karst Edge region, the project Network for the Protection of Biodiversity and Landscape (BioDiNet) co-financed by the European Regional Development Fund, started in autumn 2011. The sheduled project activities included the study of the productivity of Karst pastures for defining grazing management guidelines. Due to the climatic and topographic characteristics of the Karstic areas, the grassland productivity varies according to very specific spatial and temporal patterns (Škornik *et al*., 2010). Therefore, to meet the project requirements, it is essential to understand the seasonal evolution of herbage yield and quality in these pastures. This paper reports the preliminary findings obtained in the study area of Polazzo (Gorizia, Italy).

II – Materials and methods

The study was carried out in the rural park "Alture di Polazzo" in northeastern Italy (45°86' N, 13°50' E, elevation 114 m a.s.l.) from April to October 2012. Four sites were selected as representative of the most common pastures in the area, based on both botanical and geo-morphological characteristics. Sites chosen were semi-natural calcareous dry grasslands, species-rich ecosystems, and deemed habitats of community interest (92/43/EEC Directive). Botanical surveys were conducted in each site and results showed that the vegetation at all sites is referable to *Danthonio alpinae-Scorzoneretum villosae* (Poldini and Kaligarič, 1997). Three sites were located on a ridge (B, C and D), while the other (A) was in a doline. Soil properties are reported in Table 1.

Table 1. Soil characteristics of four Karstic pastures in the rural park "Alture di Polazzo" northeastern Italy

Properties	A	B	C	D
Sand (%)	18.1	30.1	36.1	36.1
Silt (%)	60	56	50	50
Clay (%)	21.9	13.9	13.9	13.9
Depth (cm)	49	10	41	32
pH	6.8	6.79	6.45	6.88
N content (g kg^{-1})	2.4	4.1	3.2	3.3
C:N (g/100g)	12.23	13.49	17.1	17.99

Four plots (4 m^2) replicated in two blocks were established in each site and harvested in regular rotation once a week to determine daily dry matter (DM) yield (kg DM ha^{-1} d^{-1}) using the Corral and Fenlon (1978) method. At each harvest the entire plot herbage was collected in the field and subsequently dried for 36 h in an oven at 65°C to determine DM yield. Herbage nutrient concentrations were determined using near infrared reflectance spectroscopy (model 5000; NIRSystems, Silver Springs, MD). The following nutrients were determined: ash (ash [% of DM]), neutral detergent fibre (NDF, Van Soest method [% of DM]), acid detergent fibre (ADF, Van Soest method [% of DM]), acid detergent lignin (ADL, Van Soest method [% of DM]), crude protein (CP, Kjeldahl method [% of DM]) and crude lipid (EE, Soxtec method [% of DM]).

The herbage daily growth was then obtained. Gaussian models ($f_{(x)} = a * e - \frac{(b - x)^2}{c^2}$) were were used to fit observed daily DM yield, obtaining a DM yield growth curves for each site. Parameters *a* and *b* were used to describe the fitting curves: *a* is the peak of the curve, *b* is the day of the year (DOY) in which the maximum DM yield occurred; the number of days necessary to reach 90% of the DM yield (ND90) was also calculated and used instead of parameter *c* (distance between curve inflection points). Total DM yield produced throughout the year was estimated in each site calculating the integral of its daily growth curve. Nutrient concentrations were analysed using generalized linear models (GLM). For each site, GLMs were built to analyse the relationship between nutrient concentrations and DOY, including in the models the square of the DOY that represents the curvature of the relationship. Statistical analyses were performed with R software (R Development Core Team, 2013).

III – Results and discussion

The four sites displayed a similar trend for daily DM yield, with a maximum in May, followed by a rest in August, and a slight recovery between 5th September and 22nd October (the trend for site A is shown in Fig. 1). Based on this trend, the seasonal growth was split into two periods (1 and 2) from which the daily growth curves were calculated.

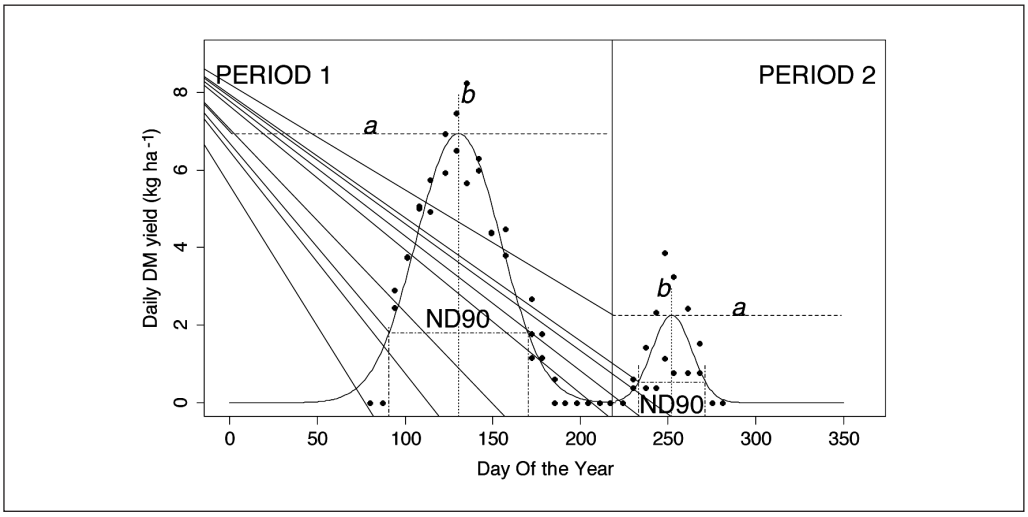

Fig. 1. Seasonal variation of daily dry matter (DM) yield of a Karstic pasture (site A) analysed in two periods. Dots are daily DM yield calculated with Corral-Fenlon method. Curves are the model prediction of DM yield over the periods. The parameters of the curves (*a* and *b*) and number of the days necessary to reach 90% of DM yield (ND90) are reported with letters and lines.

Differences in seasonal yield distribution within sites are shown in Table 2. Sites A and B displayed a low weekly DM yield during period 1, however their DM yield in period 2 was comparable with the others. In period 1, site A reached the maximum production (parameter *a*) on DOY 130 (parameter *b*) and 90% of its production occurred in 80 days (ND90). The other sites reached maximum production in a shorter time and displayed higher ND90. Differences within sites were less pronounced in period 2, with site D reaching a higher daily DM yield value than the other sites (5.83 kg ha^{-1}). In addition, different total DM yields were found, ranging from 0.5 to 1.4 t ha^{-1}.

Significant negative correlations were found between fibre concentrations (NDF, ADF, ADL) and CP (R^2 was 0.43, 0.74 and 0.53 respectively), while correlations between fibre concentrations and EE were not significant. As in the daily yield analysis, the datasets were split into two periods (1 and 2). None of the sites displayed significant changes in NDF over the year. However, models built with ADF and ADL showed a significant effect of DOY and their squares, with positive curvature coefficients, and the squared DOY showed a significant effect on CP content in all sites, with negative curvature coefficients (data not shown). The lower values of ADF and ADL, and higher values of CP, corresponded to the DOY on which the maximum daily DM yield occurred. This could be related to the very short period of high growth rate, in which the new herbage could positively affect the forage quality. Nutrient concentrations in the Karstic pastures studied were in line with other studies of mountain pastures (i.e Isselstein *et al*., 2007). However, this study demonstrates that herbage quality, especially for ADF and CP, increased when pastures were more productive in terms of daily DM.

Table 2. Parameters of the curves (*a* and *b*) and number of days necessary to reach 90% of DM yield (ND90), calculated for periods 1 and 2, and total DM yield of the four Karstic pastures

	PERIOD 1			PERIOD 2			Total DM yield (t ha^{-1})
	a	*b*	ND90	*A*	*b*	ND90	
A	6.94	130	80	2.25	252	38	0.48
B	9.30	120	114	2.26	252	34	0.86
C	13.37	122	104	1.76	258	36	1.11
D	13.42	124	116	5.83	258	42	1.36

IV – Conclusions

The seasonal evolution of herbage yield in the studied Karstic pastures is described by two-phase models, and herbage quality is higher at the maximum DM yield. These results could help optimize grazing management strategies. For a sustainable utilization of these pastures, the differences found within sites suggested that in a morphologically complex landscape like the Karst, morphological aspects have a strong influence on management decisions.

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