Short-term impacts of goat stocking rate on arthropod fauna in upland improved pastures

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Short-term impacts of goat stocking rate on arthropod fauna in upland improved pastures

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Abstract. The reduction in grazing intensity is usually recommended to meet biodiversity goals, frequently at the expense of productive objectives. This statement is mostly based on vegetation data, whereas local fauna responses are unclear, especially under goat grazing. The study aimed at comparing the ground-dwelling arthropod communities of upland improved pastures managed with three different goat stocking rates (10, 15 and 20 goats/ha). Two replicates per treatment were established in six plots at a northern Spanish mountain area. Fauna was collected with pitfall traps (10 per paddock) operating continuously from May to August 2010. A total of 20,672 arthropods from 5 classes, 15 orders and 67 families were collected. Coleoptera (46% of all catches), Aranei (29%) and Hymenoptera (15%) dominated, and within each, the families Staphylinidae (55% of all Coleoptera), Linyphiidae (76%) and Formicidae (99%) stood out. The total abundance and family richness varied among periods (*P*<0.01), the highest records occurring in June, but not between treatments. Although most families were indifferent to the treatments, some responses occurred. Ground beetles (Carabidae) were more abundant at the lowest stocking rate (*P*<0.01), whereas Lathridiidae were at the highest one (*P* = 0.06). Community composition was similar between treatments but it changed through time. The reduction in goat grazing intensity promoted subtle responses of the arthropod fauna after the first experimental year, which should be confirmed with further research at a longer term.

Keywords. Ground-dwelling arthropods – Biodiversity – Grazing impact – Stocking rate.

Impacts à court terme de taux de charge de chèvre sur la faune d'arthropodes dans les hautes terres de pâturages améliorés

Résumé. *La réduction de l'intensité du pâturage est habituellement recommandé pour atteindre les objectifs de la biodiversité, souvent au détriment des objectifs de production. L'étude a comparé les communautés d'arthropodes fouisseurs dans les pâturages améliorés gérés avec trois taux de chèvre de stockage (10, 15 et 20 chèvres/ha). Deux répétitions par traitement dans six parcelles ont été réglées dans un zone montagneuse du nord de l'Espagne. Faune a été recueilli avec des pièges à fosse (10 par parcelle) fonctionnant en continu de Mai à Octobre 2010. Un total de 20 672 arthropodes de 5 classes, 15 ordres et 67 familles ont été recueillis. Coleoptera (46% des captures), Aranei (29%) et Hymenoptera (15%) a dominé, et au sein de chacune, les familles Staphylinidae (55% de l'ensemble Coleoptera), Linyphiidae (76%) et formicidés (99%) se démarquent. L'abondance et la richesse familiale totale variait périodes (P<0,01), tous les records survenant en Juin, mais pas entre les traitements. Un groupe réduit de familles varié entre les traitements. Carabidae étaient plus abondants au taux de chargement plus bas (P<0,01), alors que Lathridiidae étaient au plus haut d'un (P = 0,06). Composition de la communauté était similaire entre les traitements, mais il a changé à travers le temps. Étaient faune réponses subtiles à l'intensification après un an. Études à long terme sont nécessaires pour clarifier ces résultats.*

Mots-clés. *Fouisseurs arthropodes – Biodiversité – Impact du pâturage – Chargement animal.*

I – Introduction

The reduction in grazing intensity has been recommended to meet biodiversity goals, frequently at the expense of productive objectives. By contrast, the sustainable intensification of the livestock production systems is acquiring increasing importance in recent years to contribute to improving the livelihoods of rural households, and as a response to the challenges confronting global food security. Nevertheless, producing more food from the same area of land while reducing the environmental impacts is still a major handicap in many regions (Jordan and Davis, 2015). In fact, most of the conclusions about the environmental impact of altering livestock stocking rates are based on vegetation data, whereas local fauna responses are unclear, especially under goat grazing (Rosa García *et al*., 2012).

In marginal mountain areas livestock production systems are frequently limited by the poor nutritional quality of the vegetation, so the addition of improved pastures is one of the alternatives to compensate such deficits (Rosa García *et al.*, 2013). Previous studies in northern Spain tested the impact of goat grazing on the local fauna in natural heathlands, either alone or with partially improved grasslands (Rosa García *et al.*, 2009, 2010, 2011), but an experimental test where goats had only improved pastures available was lacking. The present study aimed at comparing the ground-dwelling arthropod communities of upland improved grasslands managed with three different goat grazing stocking rates.

II – Material and methods

The experimental farm is located in the San Isidro mountain range (43º 20' N, 6º 53' W), Illano, Asturias (northern Spain), at an altitude of 800–1000 m a.s.l. The climate is typically oceanic, with annual mean temperatures of 9.7 ºC and average rainfalls of 1565 mm/year. Soils are acid and nutrient poor. The improved pasture was established by means of soil ploughing, fertilization with lime and NPK, and sown with perennial ryegrass and white clover. The experimental design consisted of three goat stocking rates (10, 15 and 20 goats/ha) with two replicates randomly allocated in a total of six contiguous plots. Dewormed Cashmere goats grazed the plots continuously from late April to October. Ground-dwelling arthropods were collected from May to October with pitfall traps placed in rows of 10 traps 5 m apart in each plot. The rows were allocated in the middle of each plot to avoid possible border effects. Each trap was 1/3 filled with a mixture of water and ethyleneglycol. They operated continuously and their content was emptied fortnightly.

Proc Mixed ANOVA was used to examine fauna abundance and diversity (family richness) in a model including stocking rate (T), sampling period (P) and T*P as fixed factors. Each period consisted of the pooled catches during each month, totalling six repeated measures. Data were log (x+1) transformed when necessary to meet ANOVA assumptions. Redundancy analyses (RDA) were also performed on log (x+1) transformed data of arthropod families to test the differences in community composition between treatments and periods and the interaction T*P following the appropriate Monte Carlo permutation schemes.

III – Results and discussion

A total of 20,672 arthropods from 5 classes, 15 orders and 67 families were collected. The order Coleoptera was the most abundant one (46% of all catches), followed by Araneae (29%) and Hymenoptera (15%). The total abundance and family richness varied between periods (P<0.01) but not among treatments (Table 1). The highest global abundances occurred during the first two months and especially in June. The majority of the groups followed this pattern, but the phylum Arthropoda includes taxa with remarkable variety of life strategies and environmental needs, so taxa-specific responses were observed.

The responses of the groups to different stocking rates were subtle and heterogeneous. About three quarters (76%) of the captures of Araneae belonged to the family Linyphiidae which differed between periods (P<0.001) but did not respond to the treatments. Around half (55%) of the Coleoptera belonged to the family Staphylinidae which tended (P = 0.08) to be more abundant at the lowest stocking rate compared to the highest one. The interaction between treatment and time (*P*<0.01) reflected seasonal fluctuations in abundances within each treatment. Carabidae were more abundant under the lowest stocking rate (*P*<0.01) whereas Lathridiidae peaked under the highest one (*P* = 0.06). The majority of Hymenoptera belonged to the family Formicidae which was indifferent to the treatments but fluctuated along time (*P*<0.01).

Table 1. Abundance (counts/trap) and family richness of arthropod taxa in Cantabrian upland improved pastures under three goat stocking rates (Low, 10 goats/ha; Medium, 15 goats/ha; High: 20 goats/ha) during the grazing period (May to October). Least square means per treatment are shown together with standard error of means (SEM). Results of repeated-measures ANOVA for the effects of stocking rate treatment (T), period (P) and the interaction on the fauna (ns, not significant; ** *P*<0.01; * *P*<0.001)**

	Low	Medium	High	SEM	Treat (T)	Period (P)	T*P
Total abundance	35.95	33.01	30.25	3.39	ns	***	ns
Aphididae	0.30	0.56	0.22	0.14	ns	**	0.054
Carabidae	2.37	1.34	1.36	0.21	**	***	ns
Cicadellidae	0.77	0.71	1.09	0.18	ns	***	ns
Histeridae	2.69	1.65	1.49	0.35	ns	***	ns
Lathridiidae	0.50	1.11	2.38	0.30	0.063	***	ns
Linyphiidae	8.83	7.21	8.24	0.81	ns	***	ns
Lycosidae	1.66	1.57	1.48	0.19	ns	***	ns
Formicidae	49.50	70.55	22.11	20.88	ns	**	ns
Staphylinidae	9.26	7.67	5.50	0.41	0.070	***	**
Tetragnathidae	0.19	0.24	0.68	0.13	ns	**	ns
Family richness	22.92	22.58	25.00	0.91	ns	***	ns

The multivariate RDA analyses revealed that community composition was similar between treatments. By contrast, it changed through time (*F* = 27.94; *P*<0.001 for the test of significance of first canonical axis and *F* = 9.37; *P*<0.001 for the test of significance of all canonical axes). No significant interaction between treatment and time was observed. The axes 1 and 2 of the RDA analysis testing the differences between periods accounted for 50.0% and 56.3% of the cummulative variance in the taxa abundance, respectively. The taxa environment correlations were 0.96 and 0.86 for both axes respectively. Figure 1 reflects a higher diversity of groups linked to the first and second periods (May and June) compared to the rest. This reflects that the majority of the taxa were already detected at the beginning of the grazing season. The first two periods were separated from the rest on the right side of the axis 1. The most distant periods from them were the last two ones, reflecting the appearance of taxa with delayed phenology such as some Linyphiidae species which peaked during the last two months, some Tetragnatidae which did it in October, or Cicadellidae which flourished by September.

IV – Conclusions

The composition of ground-dwelling arthropod communities evolved along the grazing season with a global peak in total abundance in June. The alteration in goat grazing intensity promoted subtle responses of the fauna after the first experimental year, although some groups responded to the treatments. The low and high stocking rates associated to contrasting arthropod communities and the medium was more similar to the low than to the high stocking rate treatment. Longer-term studies are required to deep on the responses of the groups to the different grazing intensities. The integration of this information together with the knowledge on plant dynamics and animal performance and health would provide a global dataset for the sustainable management of these upland improved pastures.

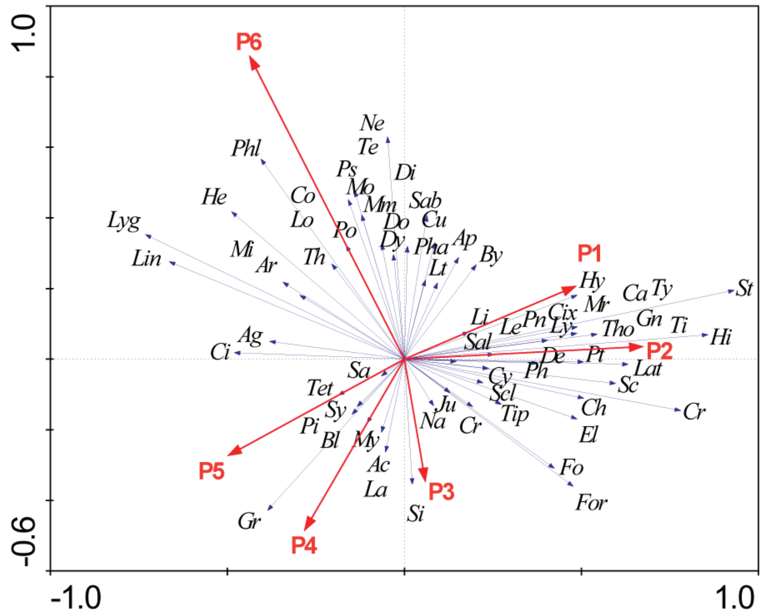

Fig. 1. Biplot ordination diagram of non-standardized RDA analysis testing the effect of period (P1 to P6, May to October) on arthropod fauna assemblages. First and second eigenvalues of 0.46 and 0.06 respectively. Abbreviations of the arthropod groups: Ac-Acrididae; Ag-Agelenidae; Ap-Aphididae; Ar-Armadillidiidae; Bl-Blatellidae; By-Byrrhidae; Ca-Cantharidae; Ch-Chrysomelidae; Ci-Cicadellidae; Cix-Cixiidae; Co-Cholevidae; Cr-Carabidae; Cr-Cryptophagidae; Cu-Curculionidae; Cy-Cydnidae; De-Dermestidae; Di-Dictynidae; Dy-Dysderidae; El-Elateridae; Fo-Forficulidae; For-Formicidae; Gn-Gnaphosidae; Gr-Gryllidae; He-Helophoridae; Hi-Histeridae; Hy-Hydrophilidae; Ju-Julidae; La-Lampyridae; Lat-Lathridiidae; Le-Leioidae; Li-Limnichidae; Lin-Linyphiidae; Lo-Liocranidae; Lt-Lithobiidae; Ly-Lycosidae; Lyg-Lygaeidae; Mi-Microcoryphia; Mm-Mimetidae; Mo-Mordellidae; Mr-Miridae; My-Mycetophagidae; Na-Nabidae; Ne-Nemastomatidae; On-Oniscidae; Ph-Phalacridae; Pha-Phalangidae; Phl-Philosciidae; Pi-Philodromidae; Pn-Ptnidae; Po-Porcellionidae; Ps-Pselaphidae; Pt-Ptliidae; Sa-Saldidae; Sab-Sabaconidae; Sal-Salticidae; Sc-Scarabaeidae; Scl-Sclerosomatidae; Si-Silphidae; St-Staphylinidae; Sy-Scydmaenidae; Te-Tetragnathidae; Tet-Tettigoniidae; Th-Theridiidae; Tho-Thomisidae; Ti-Tingidae; Tip-Tipulidae; Ty-Thysanoptera.

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