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Habitat selection of dairy-sheep in Atlantic mountain grasslands

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Abstract. Understanding the implications of habitat selection by dairy sheep for diet quality is essential for an appropriate management of grasslands and dairy production. Here we test whether ewes select grassland patches with high plant diversity or with species of high nutritional quality (i.e. low carbon/nitrogen ratio –C/N ratio–) to meet their physiological needs. We also discuss whether non-lactating and lactating ewes behave alike. Our study was conducted in the Aralar Natural Park (Northern Spain) during the lactating period (2015, May-June). The geographical locations of 40 ewes from 3 different flocks were recorded every 30 minutes using GPS (Global Position System) devices: 7 lactating and 6-7 non-lactating in each flock. Floristic composition was measured and the most abundant plant species were collected to quantify N and C content. Dense and transition pastures were selected by ewes, regardless of their physiological state. The preference order of habitats differed among flocks. The positive correlation between selection index and plant diversity indicated that sheep selected the most diverse habitats, and not the higher N content ones to graze.

Keywords. Ewes – GPS – Physiological state – Plant diversity – Plant nutritional quality.

Sélection des habitats par les ovins laitiers dans les pâturages des montagnes atlantiques

Résumé. *Il est essentiel de comprendre les implications, pour la qualité du régime, de la sélection d'habitat par les ovins laitiers, en vue d'une gestion appropriée des pâturages et de la production laitière. Cet article examine si les brebis sélectionnent des portions de pâturage à forte diversité végétale ou à espèces de haute qualité nutritionnelle (c.a.d. à faible rapport carbone/azote – ratio C/N) pour leurs besoins physiologiques. Nous analysons aussi si les brebis en lactation et non-lactation se comportent de la même façon. Notre étude a été menée dans le Parc Naturel d'Aralar (Nord de l'Espagne) durant la période de lactation (2015, mai-juin). Les localisations géographiques de 40 brebis de 3 troupeaux différents ont été enregistrées toutes les 30 minutes par appareil GPS (Global Position System): 7 brebis en lactation et 6-7 brebis en non-lactation dans chaque troupeau. La composition floristique a été mesurée et les espèces végétales les plus abondantes ont été collectées pour quantifier la teneur en N et C. Des pâturages denses et en transition ont été sélectionnés par les brebis, indépendamment de leur état physiologique. L'ordre de préférence des habitats différait selon les troupeaux. La corrélation positive entre indice de sélection et diversité végétale indiquait que les ovins sélectionnent pour paître les habitats plus divers, et non ceux à plus forte teneur en N.*

Mots-clés. *Brebis – GPS – État physiologique – Diversité végétale – Qualité nutritionnelle des plantes.*

I – Introduction

Grazing by seasonal livestock maintains a mosaic landscape with high spatial heterogeneity in Atlantic mountains. These grasslands have high economical and cultural importance, as they provide high-quality food resources that determine the production and quality of traditional dairy products such as milk and cheese.

Habitat preference is influenced by abiotic and biotic factors that operate at differing spatial scales (Bailey *et al*., 1996). When selecting habitat, herbivores try to reach an equilibrium between the benefit of satisfying their nutritional requirements and the cost of seeking it (Stephens and Krebs, 1986) and these nutritional requirements depend on the morpho-physiological characteristics of the animal (Provenza, 1995). Recent works agreed that lactating ewes tend to select plant species with higher protein content than dry ewes (Allegretti *et al.,* 2012) and also, that plant diversity is a key factor to stimulate food intake (Feng *et al*., 2016).

Understanding the implications of habitat selection by dairy sheep for diet quality is essential for an appropriate management of grasslands and dairy production. This study investigates whether ewes and, in particular, lactating ewes, selected habitats with abundant high nutritional quality species (low C/N ratio) or with high plants diversity. To test this hypothesis, habitat selection by lactating (L) and non-lactating (NL) ewes were first analyzed, and then whether N content (as nutritive quality indicator) and plant diversity could explain the observed selection pattern.

II – Materials and methods

The study was conducted in Atlantic Mountain grasslands located in the Aralar Natural Park (42°59'48''N, 2°06'51''W), Basque Country, Northern Spain. The extensive grazing system of the park from May to November supports about 18,000 dairy sheep, and also beef cattle and horses.

1. Experimental flock

3 flocks of dairy-sheep (*Ovis aries*) of the latxa breed were selected for the study: flock A (485 ewes), B (360 ewes) and C (270 ewes). Ewes are milked twice a day (morning and evening) and finish the lactating period in the park (May-June) after a short transhumance.

2. Vegetation sampling

A vegetation map was created using photointerpretation and verifying defined five habitats *in situ*: H1, stony pasture; H2, transition pasture (transition community between stony and dense pastures); H3, dense pasture; H4, scrubland and H5, other habitats including nitrophylic communities and small areas with scattered trees. H5 was excluded from the analysis, as ewes mainly use nitrophylic communities as resting areas.

Species composition of the grazing areas was measured using 300 random points (100 in each grazing area). Cover percentage of plant species was estimated by direct observation using 50 x 50 cm quadrats and the most abundant species (adding up to 21) were collected for posterior analysis of C and N content.

3. Habitat selection

Habitat selection by 40 ewes from selected flocks was assessed by using GPS (Global Position System) collars to record their spatial location during the lactating period (2015, May-June). In each flock, the GPS devices were divided into two groups: 7 collars in L ewes and 6-7 in NL ones. The location of ewes was registered every 30 minutes (Spot 3, GlobalStar). The original dataset was filtered removing position errors based on previous work, thus keeping 5350 locations. These records were used to define the grazing area of L and NL ewes of each flock with the minimum convex polygon function (Mohr, 1947) and overlaid with DEM (digital elevation model) layers later to exclude natural barriers.

Habitat selection was determined with Selectivity index (W_i), calculated as follows: $(W_i = \frac{o_i}{p_i})$

where o_i is the used proportion of habitat type *i* and p_i is the proportion of area covered by habitat type *i* in the grazing area. Then, Chi-square tests were used to test for statistical significance (Krebs, 1989).

Shannon diversity index (H´) was calculated as follows: $(H' = -\sum_{i=1}^{s} p_i \ln_{pi})$, where, p_i: the proportion of species *i* (abundance divided by the total species found in a given quadrat). Combining species composition and nutritional variables (C and N content and C/N ratio), community weighted means were computed for 300 sampling points. Finally, Spearman rank correlations were used to explore relationships between nutritional and diversity variables and selection indices at habitat level.

III – Results and discussion

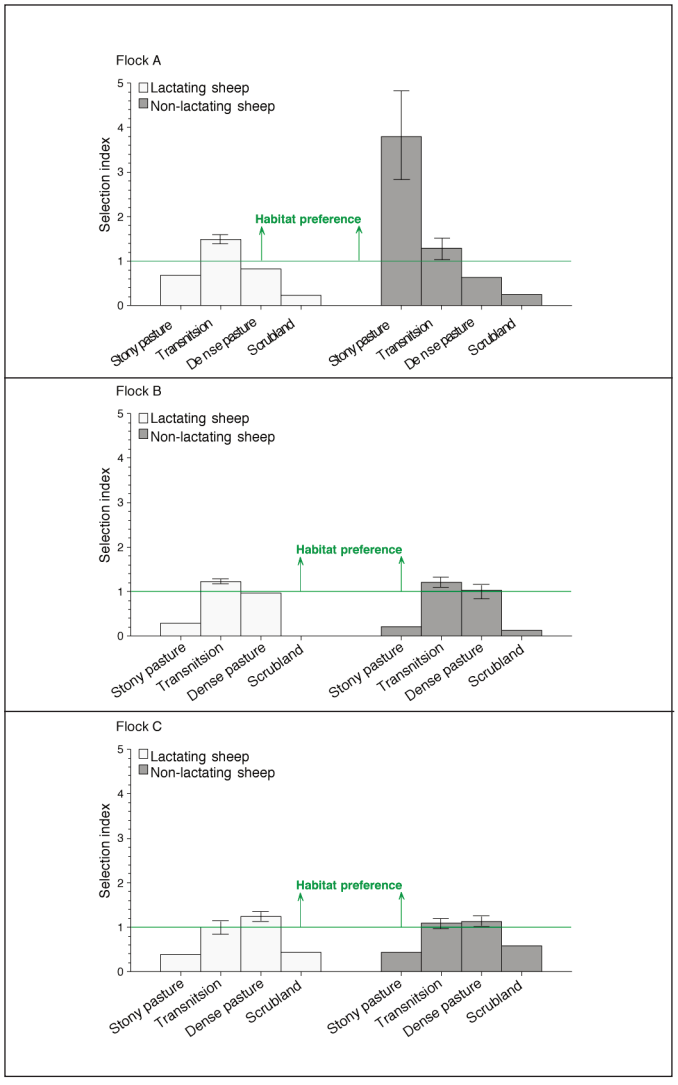

Fig. 1. Selection indices of each habitat and the habitat preference limit for lactating and non-lactating ewes in the three flocks.

Ewes of the three flocks mainly used dense and transition pastures. The sum of the use of both habitat ranges from 0.781 to 0.968 of the total use.

The selection indices (Fig. 1) indicated that ewes of flocks A and B selected positively transition pasture, whereas dense pasture was selected by the ewes of the flock C. L and NL ewes selected the same habitats in the three flocks, with the exception of the NL ewes of flock A. These NL ewes showed a clear preference for the stony pasture. This might be due to the fact that in the first week of May flock A was divided in L and NL ewes and the last ones did not return to shed. Probably, they used the stony pasture to take refuge during the study period. Scrubland was avoided by L and NL ewes of the three flocks (Fig. 1). Chi-square test was significant ($P \leq 0.001$) in all cases, so null hypothesis of random habitat selection was rejected for the three flocks.

These results suggest that ewes clearly preferred to graze in transition and dense pasture and that the flock determines the pattern of habitat selection rather than the physiological state of the animals.

Spearman correlation between N content and the selection index was not significant, but positive correlation was observed with the Shannon diversity index (rho = 0.608; *P* = 0.002). This means that ewes selected the most diverse habitats to graze. Slight differences have been found in the N content among habitats (19.77-20.22%). However, species into the habitats differ more in N content, suggesting that selection for plant quality might occur at fine scale into the habitat (feeding station scale).

Feng *et al*. (2016) demonstrated that plant diversity increases the food intake, modifying the nutrient balance, toxin dilution and taste modulation (Wang *et al*., 2010). Selection of high diversity patches in our study agrees with this hypothesis. Lastly, the social behaviour of ewes could explain the similar habitat selection between physiological states. Recent investigations have reported that group effect overcomes the individual diet requirement at least at habitat level (Sibbald *et al*., 2008).

IV – Conclusions

Ewes, whatever the physiological state, preferred transition and dense pastures to graze. Habitat plant diversity, and not nutritional quality, drove the habitat selection by ewes.

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