Forest Landscapes and Global Change

New Frontiers in Management, Conservation and Restoration

Proceedings

Edited by
João Carlos Azevedo
Manuel Feliciano
José Castro
Maria Alice Pinto

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Relationship between small ruminants behaviour and landscape features in Northeast of Portugal

Marina Castro[1,2*], José Ferreira Castro[1] & António Gómez Sal[3]

[1] Escola Superior Agrária - Instituto Politécnico de Bragança, Campus de Santa Apolónia, Apartado 172, 5301-854 Bragança, Portugal
[2] CIMO – Centro de Investigação de Montanha - Instituto Politécnico de Bragança, Portugal
[3] Dpto. Interuniversitario de Ecología, Universidad de Alcalá. Edif. de Ciencias, Campus Universitario, 28871 Alcalá de Henares, Madrid, Spain

Abstract

The small ruminant production systems in Northeastern Portugal are mainly based on the extensive exploitation of the spontaneous plant production. The shepherds direct their flocks on daily grazing itineraries across different patches of land use.
Sheep and goats flocks were monitored monthly for a year. Data collected consists of geographical position and the type of land use crossed. Also, essential livestock activities were monitored.
The corrected frequencies (preference indexes) approach was used for the data analysis.
The principal aims were to examine the relationships between livestock behaviour and land use types, and to check how they change throughout the year and the time of day. Our results showed a strong dependence between land use types and livestock activities and suggested a considerable coherence between human management, the spontaneous behaviour and physiological needs of animals and the agroecosystems capacity to supply the livestock needs.

Keywords: preference indexes, sheep and goat, livestock behaviour, land use types

1. Introduction

The small ruminant production systems in Northeastern Portugal are mainly based on the extensive exploitation of the spontaneous plant production. The shepherds direct their flocks on daily grazing itineraries across different patches of land use (Barbosa and Portela 2000; Castro et al. 2004). These circuits strongly differ throughout the year in duration and design. The places visited and the time spent in each one depends on the natural conditions and nutritional needs of the animals.
The relationship between environmental factors and animal-behavior was studied by various authors (De Miguel et al. 1997; Oom et al. 2004; Horne et al. 2008). Most of them are focus on wild ungulate herbivorous or free-ranging domestic herbivorous. Livestock systems with human control such as itinerant shepherding haven't been to a great extent studied from these point view. However, according (Baumont et al. 2000) shepherding consists in interacting with spontaneous animal's decisions and the herder's interventions could be considered simply as new constraints to the expression of the behavioral trends of the flock. As a result, in this feature,

* Corresponding author. Tel.351 273 303345
Email address: marina.castro@ipb.pt

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a study of livestock activities or movements across the landscape permits understanding the animal's perception of landscape.
Several animal attributes and environmental characteristics affect livestock movements, for instance, species or breed (Bailey et al. 2001), prior experience with a landscape(Bailey et al. 1996), degree of slope (Ganskopp and Vavra 1987), diurnal temperature dynamics of the landscape(George et al. 2007), presence of trails (Ganskopp et al. 2000), resources availability and quality.
Animal activities (grazing, resting and walking) were also affected by landscape attributes (Ganskopp and Bohnert 2009). The research provided an understanding of how to animals use the landscape, what kind of requirements they search when they visit a particular land use type. Having an understanding of animal landscape use could help to develop strategies to better management the landscapes and its temporal changes.
In this paper we show that relationships between animal behavior and environment can be easily highlighted by preference indexes values (Godron 1965). This method produces a general descriptive overview of the environmental factors associated with each type of behavior, and provides information about the importance of each factor in conditioning animal activities.
The principal aims were to examine the relationships between livestock behavior and land use types, and to check how they change throughout the year and the time of day (temperature and vegetation moisture effect). Our results showed a strong dependence between land use types and livestock activities and suggested a considerable coherence between human management, the spontaneous behavior and physiological needs of animals and the agroecosystems capacity to supply the livestock needs.

2. Methodology

The experiment was carried out in Trás-os-Montes region; from May 1999 to May 2000. Fieldwork was conducted over the territory of four villages located near Bragança, northeast Portugal (41°46'N latitude and 6°45'W longitude) at 700 to 1000 meters above sea level. The climate is humid Mediterranean with yearly mean temperature of 11.6°C and precipitation of 972.1 mm, which occurs mainly from October until May (INMG 1991). The dominant soils are umbric leptosols and dystric leptosols, depending on the land use.
Four flocks (two of goat and two of sheep) were monitored every month for a year. Each flock was observed for a complete day by an operator using a GPS. Data collected consists of geographical position and type of land use crossed (annual and perennial crops; meadows, forestlands and scrublands). Also, animal behaviour was monitored.
Behavioural activities (grazing, browsing, resting and walking) and the grazed species were noted every 15 minutes by direct observation (instantly recorded). Within each day, the frequency of animals involved in each activity was calculated for each individual observation of sheep or goat behaviour. The calculation of frequencies involved all the activities sampled, namely grazing, browsing, resting and walking.
The corrected frequencies (preference indexes) approach was used for the data analysis. The frequency of sheep and goats in each activity was computed, in addition to each land use type and part of the day. Also, the seasonal variations were computed of animal frequencies in each land use in each time of the day (table 1).

Table 1: Details of different frequencies considered

Animals observed in each activity	* Land use type
	*Period of the year (cool days, warm days, summer, winter)
Animals observed in each land use type	*Part of day (morning, middle-day, afternoon) in different periods of year (cool days, warm days, winter, summer)

The day was classified into morning, middle-day and afternoon, by dividing the daylight period. The year was classified into four periods; the summer corresponds to the months of June, July, August and September; cool days to the November, January, February, March; warm days to the April. May, October and winter December and January.
Animal-environmental interactions were analysed by comparing the expected and observed frequencies (observed / expected). This approach shows the main patterns of association between animal activities and environmental variables. In addition, the relationship between physical variables and land use types permits the analysis of the landscape organisation and the animals 'perception of the environment'.
Numerical output allows us to identify the level of the relationship between variables: the association is positive or preferred when the quotient is higher than to 1.24; indifferent, when there is a value between 0.75 and 1.24, and negative or not preferred, when the corrected frequency value is lower than 0.75).

3. Result

The animals' perception of the environment are focused on habitat types or land uses types. Table 2 shows the preference index values for the four principal activities and five principal land uses types (annual crops, perennial crops, meadows, scrublands and forestlands). Stables and paths were also considered.

Table 2: Preference index values of activities in different land uses and stable and path

Activities	Annual crops	Perennial	Meadows	Shrubs	Forest	Stable	Path
Sheep							
grazing	1.63	1.03	1.94	0.12	0.10	0.07	0.00
resting	0.22	0.45	0.20	1.97	2.54	2.82	0.08
walking	0.63	1.46	0.25	0.14	0.07	0.05	7.24
browsing	1.35	2.61	0.13	3.66	0.82	0.00	0.37
Goats							
grazing	3.21	0.62	2.36	0.73	0.13	0.00	0.16
resting	0.37	1.23	0.62	0.26	1.69	4.11	0.21
walking	0.48	0.49	0.40	0.88	0.34	0.22	4.05
browsing	0.78	1.25	0.99	1.57	1.24	0.00	0.34

The relationship between animal activities and land use types permits the investigation of the animal habitat preferences and activity patterns.
Grazing activities are positively related to annual crop land use (1.63; 3.21) and meadows (1.94; 2.36) in both kinds of flocks.
Browsing activities are positively related to annual and perennial crop areas and scrublands in the case of sheep, whereas goat flocks concentrate browsing activities on scrublands (3.66).
Resting activities are positively related to patches of forestlands (2.54), scrublands (1.97) and stables (2.82) in sheep flocks. Goat flocks rest in stables or forestlands (1.69).
Sheep and goat flocks use mainly the path to walk; nevertheless perennial crop lands are used by sheep to move into other land use types.
Annual crop land uses are used by sheep for grazing and browsing; activities of resting and walking are not frequent in this land use type. Goats use preferentially annual crops for grazing. These results suggest that some ancient areas of annual crops were converted into long-term fallow or have been abandoned. For that reason, sheep flocks use this land use type for grazing and browsing.

Perennial crop lands are used by sheep, mainly for moving up from some land use types to others (1.46) and browsing (2.61). Goats use them to browse (1.25). There isn't an association between perennial crop areas and resting activity (0.45 and 1.23 for sheep and goats, respectively). It relates to the organisation and specific function of each land use type, for example, the flocks rest in forest lands and not in chestnut orchards, despite their availability and good shade.
Forestlands are used by goats (1.24) for browsing and resting (1.69), whereas sheep use this land use for resting (2.54). Scrublands are used to feed sheep (3.66) and goats (1.57); they are also places for resting by sheep (1.97). Meadows are used only to feed in both species.
Table 3 shows the preference index values from the five principal land use types (also stable and paths) in different periods of the year (cool days, warm days, winter, summer) of sheep and goats flocks.

Table 3: Preference index values of land uses (also stable and path) in different periods of the year.

	Sheep				Goats			
Land uses	cool	warm	winter	summer	cool	warm	winter	summer
annual	1.56	1.46	0.62	0.63	1.63	0.88	0.95	0.77
perennial	1.50	1.44	2.04	0.40	0.23	1.48	3.39	0.36
meadows	1.24	0.83	2.03	0.84	1.08	0.47	1.54	1.20
shrubs	1.00	0.26	0.00	1.63	1.50	1.35	1.11	0.45
forest	0.07	0.20	0.11	1.92	0.13	1.00	0.47	1.60
path	0.97	1.04	1.87	0.83	0.98	0.64	1.49	1.14
stable	0.04	0.96	0.00	1.50	0.04	0.91	0.00	1.85

In the case of sheep flocks, cool days are positively related to annual (1.56) and perennial crops (1.50) and negatively related to forestlands. Goat flocks on cool days prefer to use annual crops (1.63) and scrublands (1.50). On warm days, sheep show the same pattern (annual and perennial crops) and goats replace annual with perennial crops (1.48). In the winter period goats and sheep show the same pattern, using for the most part perennial crop lands and meadows. In summer, itinerant sheep are strongly connected with forest (1.92) and shrub (1.63) land use types. Itinerant goats are positively connected with forest lands (1.60) and negatively related to shrub (0.45) and perennial (0.36) land use types.
The relationship between animal activities and time of day, as well as period of year, permits the investigation of how the animals understand their environmental constraints and opportunities.
There is a general widespread pattern for both species (table 4). In the morning, animals preferentially walk and browse. The mid-day period is used for resting. The afternoon period is used for grazing.
Resting in both species is connected with the higher temperatures of mid day, in all periods of the year. The resting activity in goats in winter is unreliable. Sheep flocks show a stronger reluctance for morning grazing on cool days and in winter. In the case of goats, only in summer periods they are reluctant to graze in the mornings. In summer, all activities excluding repose are negatively connected with mid-day time.

4. Discussion

The relationship between activity preference and time of the day, land use type, and their seasonal variation suggest a complex pattern of use of landscape by the flocks.
During their daily itineraries, the flocks use different land use types for different purposes; they can be used for browsing, grazing, resting, or walking. Also, these uses can change throughout the year and day. The results confirm those found by (Castro 2004) with different methodologies; in particular, using the time spent in each land use type.

The data indicate that flocks move over the landscape with a special perception of benefits and requirements. The displacement is guided by a complex interpretation of land uses type profits (fodder, shade or transit between habitats), environmental constraints like temperature of mid-day, moisture of pasture in the morning, and land use types occurring near villages.

Table 4: Seasonal variation of preference index activity values in different periods of day

	Sheep			Goats		
	warm days					
Activities	morning	mid-day	afternoon	morning	mid-day	afternoon
grazing	1.06	0.76	1.32	0.51	0.78	1.52
resting	0.07	1.80	0.43	0.44	1.61	0.46
walking	1.42	0.82	0.99	1.29	0.75	1.20
browsing	3.20	0.57	0.21	1.23	0.92	1.00
	summer					
grazing	1.17	0.00	1.76	0.90	0.53	1.62
resting	0.63	1.92	0.52	0.09	2.29	0.35
walking	1.91	0.00	0.99	1.20	0.21	1.24
browsing	1.99	0.00	0.91	1.35	0.12	1.02
	cool days					
grazing	0.59	0.73	1.25	0.34	0.91	1.55
resting	0.64	2.09	0.33	0.00	1.90	0.60
walking	1.72	0.86	0.97	1.35	0.60	1.24
browsing	3.36	1.68	0.14	1.48	1.00	0.67
	winter					
grazing	0.33	1.02	1.17	0.37	1.03	1.33
resting	0.00	1.87	0.66	0.81*	0.75*	1.44*
walking	1.81	0.70	0.99	1.34	0.54	1.39
browsing	2.13	0.99	0.70	1.41	1.36	0.30

*not reliable, because only six animals were observed in this activity

The seasonal variation of frequencies in different land use types for sheep and goats suggest that the itineraries vary during the year, regarding different needs of animals and dissimilar opportunities for exploitation of resources. Shepherds recognize these different habits and use them accordingly to manage their production systems (Meuret 1996; Baumont et al. 2000).

The occurrence of resting was markedly associated with the places in which shelter was provided and the period of the year where the temperature increased. Various authors (De Miguel et al. 1997) described the same pattern.

The feed activities (grazing and browsing) are related in the case of sheep to annual and perennial crops, meadows and shrubs. Frequently, the meadows are enclosed by hedgerows or splashed by scattered riparian trees. In the case of goats, they related to annual crops, meadows and scrublands. An interesting aspect is the different value of browsing activity in meadows for sheep and goats. In the first case, they are negatively related. In the case of goats, the value (0.99) shows that browsing activity can take place in meadows (presence of isolated trees or hedges); also interesting is the value of browsing activity on scrublands for sheep (3.66) and goats (1.57), showing goats browsing a bit everywhere while sheep browse specially on scrublands. These results agree with those reported by authors that pointed out the different foraging styles between sheep and goats.

The complex pattern of landscape use by flocks described in this paper, show the importance of each land use type for a particular animal activity. The natural complexity of Mediterranean landscapes has been increased by traditional pastoral activity. Several structures of the

landscape, such us hedgerows, scattered trees on the arable fields, forage trees, have been preserved over time by their functional value. However, part of these structures is threatened by the abandonment of agriculture and rural areas. Also, this specific pastoral system is strongly threatened. As a result, specific measures for its conservation should be taken as soon as possible, in accordance with European Landscape Convention assumptions.

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