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The spatial distribution and activity of cattle in response to plot size

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ABSTRACT

The behaviour and spatial utilization of beef cows on a Mediterranean foothill rangeland with rich hemicryptophytic vegetation was compared in small (28 ha) and large (146 and 78 ha) plots stocked at similar animal densities. Cow location and activity were monitored during late winter and early and late summer using Global Positioning System collars with motion sensors. The daily horizontal locomotion and time spent grazing ranged from 0.97 to 2.72 km and from 5.6 to 12.0 h d^{-1}, respectively, depending on period and plot size. The larger plots offered a wider herbage and habitat selection. While in the small plot animals visited most of the available area at least once, less than 50% was visited in the larger plots. Accordingly, cows grazed relatively higher slopes in the small plots compared to the larger ones.

KEY WORDS: gazing cattle, animal activity, Global Positioning System

INTRODUCTION

Grazing systems based on beef cattle have a central role in the agricultural economies of many countries around the world. There is also increasing interest in utilizing the grazing animal as a tool for manipulating the bio-diversity and landscape values of rangelands (Seligman, 1996). Methodologies are required to study free-ranging animals and the swards they graze in a spatially explicit way to better understand the

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interrelationships between the landscape and the animals, and to improve management accordingly. The diurnal and seasonal patterns of time allocated by cows to different activities, as well as distance traveled and herbage utilization, were previously measured by Brosh et al. (2006) for two stocking rates in relatively small plots of 28 ha. However, plot size may influence animal behaviour because in larger plots each individual cow has a larger area to explore for herbage selection, and this may affect activity, distances traveled, and energy balance. Hence a similar experiment was conducted to examine cattle behaviour in relatively large plots. The objective of the present study was to compare the time budget of animal activity, distances traveled, and spatial utilization and preference between large and small plots.

MATERIAL AND METHODS

Experimental site and study procedure

The experiment was conducted during the years 2003 and 2004 at the Karei Deshe experimental farm, which is situated in the Lower Galilee (Israel; lat. 32° 55' N, long. 35° 35' E, alt. 80 to 150 m a.s.l.) (Gutman and Seligman, 1979). The topography is hilly, with slopes generally <20°. The site has a Mediterranean climate, characterized by wet and mild winters with mean minimum and maximum temperatures of 7 and 14°C, respectively. The average annual rainfall is 570 mm, falling mostly from November to March. In this study we compared cow behavioural variables characteristic of small plots (SP) of 28 ha (similar to Brosh et al., 2006) to those measured in two large plots (LP), one of 146 ha (plot LPa) and the other of 78 ha (plot LPb) with the same stocking rates used in all plots. Measurements in the different plots were conducted during three periods: late winter (February-March), early summer (May-June) and late summer (August-September) of 2003 (for SP) and of 2004 (for LP). Supplementary feed was given *ad libitum* to all cows during late summer.

Mature, medium-frame-size cows were used in the study. The cows were Simford (Simmental × Hereford) crossbreds, with some blood from local breeds of the eastern Mediterranean region. In the SP, the mean body weight of the cows was 418±37 in late winter, 451±20 in early summer, and 457±16 kg in late summe, and in the LP the mean body weight of the cows was 422±12 in late winter, 477±22 in early summer, and 477±25 kg in late summer.

Measurements

The location and activity of 5-8 randomly selected cows in each plot were monitored continuously in each period using Lotek Global Positioning System

(GPS) collars of the 2200 Series (Lotek Engineering Inc., New Market, Ontario, Canada). Four activities (grazing, lying, standing and walking without grazing) were determined from the collar data (GPS locations and cumulative motion sensor counts in two axes over 5-min intervals) using the calibration equations developed by Ungar et al. (2005). Horizontal locomotion distances during each 5-min interval were computed using the ArcView 9.1 GIS (Geographic Information Systems) software from layers containing the GPS and topographic data. Time ($h \cdot d^{-1}$) devoted by cows to each activity, and horizontal distance covered ($m \cdot d^{-1}$), were calculated for the three periods of the grazing season.

Using the ArcView 9.1 all plots were divided into cells of 25×25 m and the slope for each cow location was defined (using the DTM layer). The proportion of a plot area utilized during each measurement period was defined as the number of different cells visited by the cows divided by the total number of cells in a plot. The number of cells visited per cow per day for all activities and the proportion of cells utilized altogether by cows in the large and small plots of the range was tested. Herbage standing biomass was determined for each of the periods in which animal measurements were conducted. Herbage was sampled by clipping to ground level 10 quadrates of 0.25×0.25 m along each of 4 transects of 100 m, i.e. 40 samples per plot. Samples were dried at 60°C for 48 h prior to weighing.

RESULTS

Herbage biomass in the large and small plots during each period of the study is shown in Table 1. As shown, no significant difference between plots was found.

Table 1. Herbage biomass (kg DM ha^{-1}) in the large (2004) and small (2003) plots during the three periods of the grazing season

Plot size	Late winter	Summer		SE	P, between seasons
		early	late		
Large	1.084	2.415	1.104	149	<0.001
Small	0.963	2.287	1.177	137	<0.001
P, between plots	n.s	n.s	n.s		

The daily time ($h \cdot d^{-1}$) spent by the cows lying, standing, walking and grazing, and the horizontal distances of locomotion are shown in Table 2. The time spent lying in the large and small plots was 5.4 to 7.1 $h \cdot d^{-1}$ and 4.5 to 8.3 $h \cdot d^{-1}$, respectively. More time was spent lying during the hot and dry summers. The time spent grazing during late winter was similar in the large and small plots (11.7 and 12.0 $h \cdot d^{-1}$, respectively), but it was greater compared to early summer (8.3; LP) and 5.8 (SP; $h \cdot d^{-1}$) and late summer (7.4; LP) and 5.6; (SP; $h \cdot d^{-1}$). A significant difference was found between periods ($P<0.05$).

Table 2. Time ($h \cdot d^{-1}$) devoted by cows to each activity, and horizontal distance covered ($m \cdot d^{-1}$), in small and large plots during three periods of the grazing season

Season	Winter		Summer			
	late		early		late	
Plot size	large	small	large	small	large	small
Activity						
lying down	5.4	4.5	6.2	6.3	7.1	8.3
standing	6.6	7.2	9.0	11.4	8.4	9.7
grazing	11.7	12.0	8.3	5.8	7.4	5.6
walking	0.2	0.3	0.4	0.5	1.1	0.4
Locomotion distance						
horizontal total	2.642	3.372	2.509	2.336	3.550	1.659
horizontal while grazing	2.327	2.724	1.832	1.179	1.551	969

The daily horizontal distance traveled (Table 2) while grazing was greatest during late winter and shortest during late summer. The daily horizontal locomotion during grazing reached a maximum of 2.327 and 2.724 m in the large and small plots, respectively, during late winter, but dropped to 1.551 (LP) and 969 (SP) m during late summer.

The average slope of all cells of a plot was 6.9°±3.5 for SP, 7.4°±4.8 for LPa and 5.8°±4.3 for LPb. In all cases, the average slope of the cells visited by the cows was less steep than the average of the whole plot. During late winter and late summer, when herbage biomass was about 1,000 kg DM ha^{-1}, cows in the SP utilized areas of steeper slopes compared to cows in the LPs (Figure 1), but during early summer, when herbage biomass was 2,300-2,400 kg DM ha^{-1}, no difference was found between the plots. As shown in Figure 2a LP cows visited more cells per day at all periods than SP cows, but a greater proportion of the plot was visited by SP compared to LP cows (Figure 2b).

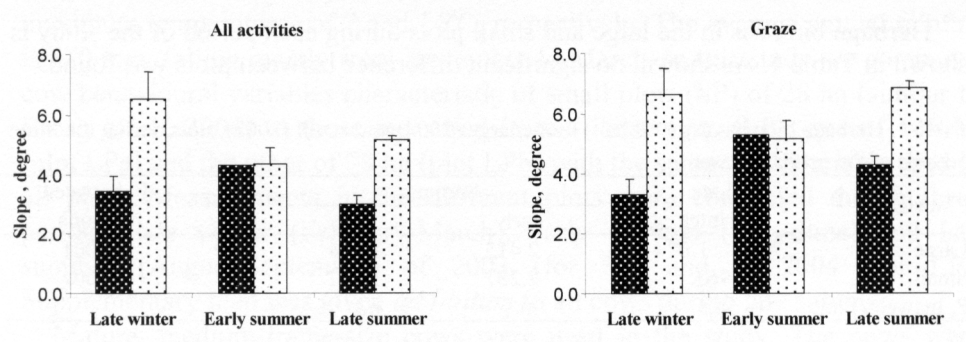

Figure 1. Average slope utilized by cows during three periods of the grazing season during all activities and during grazing only in large and small plots. ▩ large plot, ⁞⁞ small plot

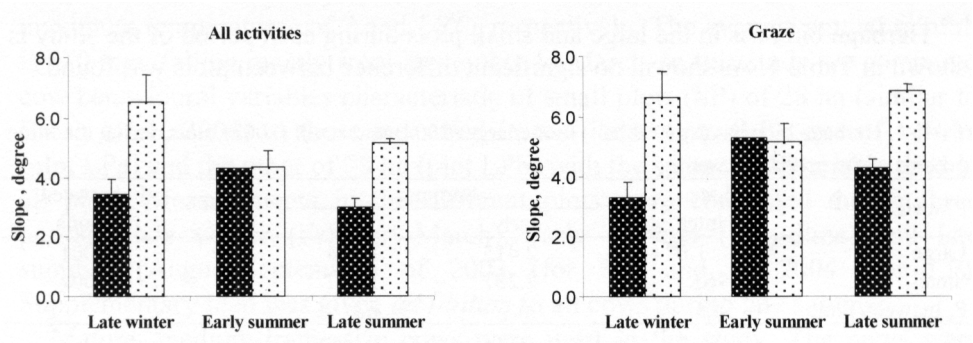

Figure 2. Number of cells visited per cow per day for all activities (a) and the proportion of cells utilized altogether by cows (b) in the large and small plots of the range. ▩ large plot, ⁝⁝ small plot

DISCUSSION

The comparison between cattle behaviour in large and small plots in this study included several criteria: 1. time spent in each activity, 2. locomotion distance, 3. quality of terrain visited as expressed by slope, 4. area utilization rate of the range. The high cost of the GPS collars did not enable us to conduct measurements in all the plots in the same year, and this is no doubt a source of potential confounding. However, the similarity between plots in the dynamics of herbage quality and biomass - which we assume are the primary variables influencing behaviour - was sufficient grounds to compare these cow behavioural variables in the context of an exploratory study. Our results suggest that plot size per se may be an important factor influencing behaviour, and one that merits further investigation with due control for potentially confounding factors.

When the herbage in the plots was green and of high quality, and biomass was approximately 1,000 kg DM ha^{-1} (i.e. in late winter), plot size did not affect the time spent by the cows in each of the activities. The longer time cows spent grazing in the LPs compared to the SP during early and late summer is in accordance with the higher quality of the selected herbage that was grazed. This finding is compatible with Brosh et al. (2006), who showed that grazing time is positively correlated to grazed herbage quality.

The utilization of relatively lower slopes by the cows is in accordance with a higher preference rate (i.e. avoidance of steeper habitats). As shown in this study (Figure 1), during late winter and late summer the average slopes that cows grazed in the LPs were less steep than those grazed in the SP. Accordingly, a higher preference rate was found in the LPs compared to the SP during these periods. However, during early summer no difference was found in utilized slopes between

the plots. An opposite trend manifested itself in the comparison between the periods in each of the plots. While in the LPs the average slopes grazed during late winter and late summer were less steep compared to those grazed in early summer, in the SP the average slopes grazed during late winter and late summer were steeper than those grazed in early summer.

CONCLUSIONS

Under similar conditions of biomass and apparently similar herbage quality, individual cows in large plots are exposed to a larger area to explore for herbage selection than cows in small plots. Consequently, cows grazing small plots with limited rangeland extent and herbage (1,000 kg DM ha^{-1}) will explore rougher areas and, as a result, cattle distribution under these conditions will be more homogeneous.

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