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Effect of pasture size on behavioural synchronization and spacing in German Blackface ewes (*Ovis aries*)

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ABSTRACT

This study aims to assess plot size related changes in spacing and behavioural synchronization in a herd of 14 German Blackface ewes kept on three different pasture sizes: S (126 m^2), M (1100 m^2), and L (11,200 m^2). In direct field observations, behaviour and nearest neighbour distance were recorded individually. Additionally, interindividual and nearest neighbour distances were derived from aerial photographs of the herd taken on plot sizes S and M. Nearest neighbour distances <1 m accounted for more than 60% of observations, and were more frequent on plot size L than on plot sizes S ($Z = 3.3$; $p < 0.01$) and M ($Z = 3.2$; $p < 0.01$). Average interindividual distances were significantly smaller on S (4.89 ± 2.62 m) than on M plots (5.99 ± 3.06 m; $t = 7.3$; $p < 0.01$). Synchronization tended to increase with plot size ($K_{(S)} = 0.42$; $K_{(M)} = 0.52$; $K_{(L)} = 0.66$), but was not accompanied by a concomitant increase in dispersion. Aerial photography proved a valuable tool in the analysis of spacing behaviour as intraindividual repeatability of the derived distances was highly significant (Kendall's W between 0.32 and 0.58; $p < 0.01$). The sheep kept small distances on all plot sizes, thus the high degree of behavioural synchronization might be mainly attributed to the motivation for close proximity to any conspecific.

1. Introduction

Behavioural synchronization occurs if multiple group members mutually adjust their activities, resulting in simultaneous performance of the same activities. Synchronization is considered essential for group cohesion (Clayton, 1978) because in order to stay together, socially organised animals, like most farm animals, have to synchronize their decisions about direction of movement and behavioural switches (Couzin and Krause, 2003). Behavioural synchronization is even postulated as a behavioural need, which implies that animals may experience suffering if they are prevented from synchronizing their behaviour (see definition by Jensen and Toates, 1993). Synchronization can be triggered by external events like sunrise, time of feed distribution, or by various environmental cues if proximity between individuals leads to shared environmental conditions which stimulate similar behaviour (Engel and Lamprecht, 1997). According to Clayton (1978) environmental stimuli provide gross synchronization, while social factors induce finer-scale synchronization. However, social influences on behavioural synchronization are interwoven with environmental factors and difficult to separate (Favreau et al., 2009). For instance, Stoye et al. (2012) observed in pastured cattle that synchronization of posture (i.e. lying down or standing) was affected by time of day as a collective response, and by synchronization with the posture of near neighbour as an individual response.

Confined in stables, pens or on pastures, farm animals' synchronization might be enhanced and largely shaped by management conditions, like predetermined feeding schedules or limited space. On the other hand, decreased synchronization might reduce competition for limited resources making it more beneficial for the individual not to be behaviourally synchronized. Such a shift in synchronization was found in the study by Brouns and Edwards (1994), where sows fed ad libitum preferred to feed singly. Alternatively, competition for unevenly distributed feed (Vahl et al., 2007: ruddy turnstones) as well as competition for space under high stocking densities (Blanc and Thériez, 1998: farmed red deer hinds) can decrease synchronization in foragers.

Spacing has been found to affect activity synchronisation in sheep (Michelena et al., 2008). Sheep distribution can differ as a result from specific associations between familiar peers (Jørgensen et al., 2011), genetic relatedness (Nituch et al., 2008), forage distribution (Arnold and Dudzinski, 1978) or space allowance (Sibbald et al., 2000). Furthermore, high solar radiation may induce the

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Table 1
Median proportion and 25%/75% percentiles of nearest neighbour distance classes (expressed as proportion of sample points) in ewes ($n = 14$) by sward surface height and plot sizes *S* (126 m²), *M* (1100 m²), and *L* (11,200 m²).

Neighbour distance (class)	Sward	*S*			*M*			*L*		
		25	50	75	25	50	75	25	50	75
<1 m	LS	0.44	0.54[a]	0.61	0.56	0.62	0.66	0.65	0.75[a]	0.78
	TS	0.68	0.71[b]	0.73	0.54	0.62	0.72	0.73	0.77[b]	0.80
1–3 m	LS	0.22	0.28	0.31	0.29	0.33	0.40	0.17	0.20[a]	0.27
	TS	0.22	0.24	0.26	0.27	0.33	0.41	0.13	0.18[b]	0.21
3–10 m	LS	0.12	0.17[a]	0.31	0.03	0.04	0.08	0.04	0.06	0.09
	TS	0.03	0.05[b]	0.10	0.02	0.03	0.06	0.04	0.05	0.10
>10 m	LS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	TS	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03

LS = low mean sward height ≤10 cm; TS = tall mean sward height >10 cm.
[a b]Signify differences between sward height within distance class, $p \leq 0.05$.

phenomenon of "shade grouping", leading to small interindividual distances when sheep seem to search each other's shade (Scott and Sutherland, 1981).

Aerial photographs have been used in studies on sheep spacing measuring neighbour distances (Dudzinski et al., 1969: paddocks; Hutson, 1984: holding pens), interindividual distances (Winfield et al., 1981: open-field-test; Michelena et al., 2008: experimental pen), social distance (Arnold and Maller, 1985: paddocks), or general sheep distribution (Dudzinski and Arnold, 1967: arid rangelands). Under intensive grazing conditions, only Crofton (1958) used aerial photographs to analyse interindividual distances. However, none of these studies distinguished between sheep individuals. The present study involves aerial photographs to complement and validate individual spacing data from direct observations of individuals.

The present study analyses the effect of different space allowances on behavioural synchronization and spacing behaviour in a highly gregarious species, the sheep (*Ovis aries*). In addition, the relation between behavioural synchronization and animal distribution is considered. A herd of 14 German Blackface sheep was used. The same individuals were observed in a stable group constellation. Individual differences and repeatability of spacing behaviour were examined. Forage quantity (grass sward height) was considered as possible external determinant of spacing and behavioural synchronization. The results are expected to give further insight into whether behavioural synchronization in sheep is triggered by social proximity, or rather by environmental constraint.

2. Materials and methods

2.1. Animals, keeping and management

This study was carried out on pastures of the University of Göttingen, Germany (51°N, 9°E), during the summer of 2012 (May to September). The study involved a herd of 14 German Blackface non-pregnant, non-lactating ewes originating from the Experimental Farm of the University of Göttingen in Relliehausen, Germany. The animals were familiar with each other. Before the start of the observations, animals accommodated to the new environment for two weeks. Mean age (mean ± SD) was 5.3 ± 1.6 years and mean body weight was 82.5 ± 11.9 kg at a body condition score (BCS, Russel, 1984: scale from 1 = emaciated to 5 = obese) of 3.9 ± 1.2.

The ewes were kept on pastures of three different sizes: 10 small plots (*S*) of about 126 m² each (9 × 14 m, 9 m²/head), 2 medium plots (*M*) of about 1100 m² each (50 × 22 m, 79 m²/head), and one large plot (*L*) of about 11,200 m² (90 × 125, 800 m²/head). For technical reasons, animals were first kept on plot sizes *M* (10 observation days on plot M1 and 12 observation days on M2; June 2012), then on plot sizes *S* (2 observation days per plot; July 2012), and finally, on plot *L* (20 observation days; August–September 2012). On *M* plots, animals had permanent access to a shelter (3.6 × 4.0 m). On plot *L*, overhanging trees protected from wind and rain. *S* plots were only temporarily grazed during daylight hours and sheep were moved to a pasture with shelter during the night. The experimental plots *S* and *M* were located adjacent in Göttingen (150 m above sea level), while plot *L* (226–384 m above sea level) was situated in Deppoldshausen, at a distance of approximately 5 km. The ewes had permanent access to a mineral lick, and were offered water ad libitum from a trough. For individual identification, animals were marked with coloured symbols on their backs using animal marking spray (Raidex®).

2.2. Data collection

Direct field observations covered 40 h on plot size *S*, 44 h on plot size *M*, and 40 h on plot size *L*. All observations were carried out by the same observer during daylight between 7:00 and 17:00 h. The observations were made from outside the plots on pastures *S* and *M*, and from inside the plots on plot size *L*, keeping a distance of approximately 10 m to the sheep. One observation session lasted 2 h. Observation sessions were evenly distributed among hours of the day. Behavioural patterns, nearest neighbour identity and neighbour distance were individually recorded every 15 min by point sampling (Martin and Bateson, 2007), resulting in 160, 176, and 160 sampling points per animal on plot sizes *S*, *M*, and *L*. Distances to the nearest neighbour were categorized in four classes (≤1 m; 1–3 m; 3–10 m; >10 m). If two neighbours were equally close to the focal ewe, the sheep which was closer to her head was defined as the nearest neighbour. The following mutually excluding behavioural patterns were recorded: grazing (with or without forward movement), standing, locomotion (excluding locomotion associated with grazing) or lying.

Ambient temperature was continuously recorded every 20 min by miniature data loggers (Tiny view TV 1500, resolution: 0.25 °C, West Sussex, UK) and ranged between 3.1 and 33.5 °C. Mean temperatures (across day and night) on observation days were 17.0 ± 2.9 °C (*S*), 14.1 ± 2.8 °C (*M*), and 17.1 ± 2.7 °C (*L*), respectively.

Compressed grass sward surface height was weekly measured by a rising-plate-meter on plot sizes *M* and *L*, and before and after every use of *S* plots according to the method proposed by Castle (1976). On plot sizes *M* and *L*, one sampling point per 100 m² was taken in equal distances of 10 steps, crossing the plot zigzagways, whereas five points were measured on *S* plots, corresponding to one sampling point every 5 steps. Average sward height was: plot size *S* = 12.07 ± 4.64 cm, plot size *M* = 11.60 ± 2.7 cm, and plot size *L* = 12.54 ± 3.46 cm. The sward was homogenous within plots. The botanical composition was dominated by ryegrass (*Lolium perenne*) on plot sizes *S* and *M*, and by tall oatgrass (*Arrhenatherum elatius*) on plot size *L*.