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Space allowance and flooring in ewes

Effect of space allowance and flooring on the behavior of pregnant ewes

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ABSTRACT

Space allowance recommendations for pregnant ewes vary considerably. The aim of this experiment was to investigate the effect of space allowance and floor type on activity, lying position and aggressive interactions in pregnant ewes. A 3 x 2 factorial experiment was conducted with space allowance (0.75, 1.50 and 2.25 m^2/ewe) and type of flooring (straw bedding and expanded metal flooring) as the main factors. A total of 48 pregnant ewes were randomly assigned to 6 groups with 8 ewes in each group. All groups were exposed to each treatment for 7 days. The ewes were video recorded for 24 hours at the end of each treatment period and general activity, lying position in the pen and social lying position were scored every 15 min. Displacements were scored continuously from 10:30 h to 14.30 h. Mean lying time ($P < 0.0001$) and time spent lying simultaneously ($P < 0.0001$) increased whereas time spent eating ($P < 0.001$) and standing ($P < 0.01$) decreased when space allowance increased from 0.75 to 1.50 m^2/ewe. Increasing the space allowance further to 2.25 m^2/ewe however, had no effect on these parameters. Sitting was only observed in the 0.75 m^2/ewe treatment. Type of flooring had no significant effect on general activity. Ewes in the straw bedding treatment spent more time lying in the middle of the pen than ewes on expanded metal ($P < 0.0001$), but space allowance had no significant effect on this parameter. Proportion of time spent lying against side walls increased ($P < 0.0001$) whereas lying against the back wall decreased ($P < 0.0001$) when increasing the space allowance. In general, the distance between the ewes when lying increased significantly when space allowance increased from 0.75 to 1.50 m^2/ewe. Total number of displacements when lying ($P < 0.0001$) and total aggressive interactions when active ($P < 0.01$) decreased when space allowance increased from 0.75 to 1.50 m^2/ewe and decreased further, but not significantly, when

space allowance increased to 2.25 m^2/ewe. In conclusion, increasing space allowance from 0.75 to 1.50 m^2/ewe resulted in increased lying time, more simultaneous lying and fewer displacements and aggressive interactions. There were however, no significant effect of increasing space allowance further to 2.25 m^2/ewe except increased distance between ewes when lying. Type of flooring had no significant effect on general activity, distance between ewes and displacements.

Key words: Ewes, space allowance, slatted floor, straw bedding, behavior

INTRODUCTION

Space allowance recommendations for pregnant ewes in confinement housing varies from 0.65 to 1.50 m^2 (e.g. Agriculture Canada, 1988; Midwest Plan Service, 1994). For ewes in organic production, the European regulations requires 1.50 m^2/ewe (Council Regulation (EC), 1999). Increased space allowance seems to enhance the daily gain in feeder lambs (Gonyou et al., 1985) and increased milk yield in dairy ewes (Caroprese et al., 2009). Averós et al. (2014a) reported that increasing the space allowance from 1 to 2 m^2/ewe resulted in a higher total travelled distance, net to total distance ratio, maximum step length and angular dispersion and a lower movement activity, but increasing the space allowance further to 3 m^2/ewe had no effect. Jørgensen et al. (2011) found that when the space allowance was abundant, the mean individual distance between ewes was 2.2 m during resting and 2.7 m when ewes were feeding. Bøe et al. (2006) found that when the size of the lying area for dry ewes was increased from 0.5 to 1.0 m^2/ewe (the total space allowance was kept constant), the total lying time and synchronization of lying was increased and the number of displacements of lying ewes decreased.

The recommended space allowance is higher on straw bedding than on slatted flooring (Agriculture Canada, 1988; Midwest Plan Service, 1994). This is actually not related to performance and behavior of the ewes, per se, but a high animal density will entail problems of keeping the straw bedding surface acceptably clean and dry. Færevik et al. (2005) found that shorn, but not unshorn ewes showed a clear preference for lying on straw bedding and solid wooden floor over expanded metal flooring. Further, the regulations for organic farming (Council Regulation (EC), 1999) state that there should be solid flooring in the resting area.

The aim of this experiment was to investigate the effect of space allowance and floor type on activity, lying position and aggressive interactions in pregnant ewes.

MATERIALS AND METHODS

Experimental design

A 3 x 2 factorial experiment was conducted with space allowance (0.75, 1.50 and 2.25 m^2/ewe) and type of flooring (straw bedding and expanded metal flooring) as the main factors. A total of 48 pregnant ewes were divided into 6 groups with 8 ewes in each group. All groups were exposed to each treatment. Each treatment lasted for 7 days. The experiment was divided into two periods. During the first period (Period 1), groups 1, 2 and 3 were housed on straw bedding and groups 4, 5 and 6 were housed on expanded metal flooring. The groups were rotated between the three different space allowances within each floor type (straw bedding or expanded metal flooring). In Period 2, the groups were housed on the opposite floor type and rotated between the three different space allowances as in Period 1. Before Period 1 started, and between Periods 1 and 2, the ewes had two days to become habituated to the new floor type.

Experimental pens

The pens were designed so that all ewes in each group could eat simultaneously. Hence, the pen widths equaled the number of animals multiplied with the mean width of the ewes (0.45 m x 8 = 3.60 m). The depths of the pens were: 1.67, 3.30 and 5.00 m, providing 0.75, 1.50 and 2.25 m^2/ewe, respectively (Figure 1). There was one water bowl located on the side wall in each pen. The pens with expanded metal flooring were cleaned twice daily. In the pens with straw bedding, new straw was added as needed. During the habituation days between periods, all straw was

replaced in the pen with 0.75 m^2/ewe as the high density of animals resulted in heavily soiled bedding. The experiment was conducted in an insulated building with mechanical ventilation, where the air temperature varied between 5.8 and 15.3 ºC.

Figure 1 here.

Animals and Feeding

Forty-eight pregnant ewes of the Nor-X breed were randomly selected from the University herd in January and divided into 6 groups with mean age 2.7 ± 0.2 years. At the start of the experiment, the mean body weight of the ewes was 88.5 ± 9.4 kg. From October until the experiment started in January, the ewes were housed in pens with expanded metal flooring and space allowance of approximately 1 m^2/ewe. One ewe was replaced because of listeriosis and therefore all groups had two extra days of habituation in period 2, second rotation.

The ewes were fed hay (671 g/kg TS) *ad libitum* at the feed barrier in the front of the pen, provided at 09:00 and 14:30. Their diet was supplemented with concentrate (0.6 kg/ewe/day), minerals and salt stone.

Behavioral observations

All groups were video recorded for 24 hours at the end of each treatment, starting 09:00 h. Video cameras (Foscam FI9805W) were suspended above each pen and connected to a computer. The ewes were marked individually on their head and the pen walls were marked with lines with one meter distances to easily observe the position of the ewes. Instantaneous sampling at 15 min intervals was used when the video files were analyzed and the following ethogram (based on a

previous study on resting behavior and displacements of each individual ewe by Bøe et al. (2006)):

- activity
    - lying
    - eating (head through feed barrier)
    - standing
    - moving
    - sitting
- lying position
    - next to a pen wall (< 15 cm)
    - in the middle of the pen
- social lying position
    - head-to-head with another ewe (< 15 cm)
    - back-to-back with another ewe (< 15 cm)
    - head-to-back with another ewe (< 15 cm)
    - parallel with another ewe (< 15 cm)
    - 15 – 100 cm away from another ewe
    - > 100 cm away from another ewe

Simultaneously lying time (all 8 ewes lying) were calculated as percent of total observations.

Displacements, attempts to displace another ewe and aggressive interactions were scored continuously between 10:30 h and 14:30 h with the following ethogram (Bøe et al., 2006):

Displacements when lying:

- Ewe stands up and leaves the location because another ewe is approaching her (no physical contact)
- Ewe stands up and leaves the location because another ewe is stomping on her with the front legs or pushing her with the head
- Ewe stands up because another ewe is approaching her (no physical contact), but lies down again in the same position
- Ewe stands up because another ewe is stomping on her with the front legs or pushing her with the head, but lies down again in the same position
- Ewe ignores the attempts of another ewe to displace her

Aggressive interactions when being active (eating, standing and moving):

- butting with the head towards another active ewe's head
- butting with the head towards another active ewe's body
- rushing or directing the forehead towards another active ewe (no physical contact)

Social rank order

A feed competition test at the end of the experiment was used to determine the social rank order in each group. The ewes did not receive any food the morning of the test day. Each group was moved to an unfamiliar pen (3.84 m x 4.73 m). A small bucket containing 200 gram of concentrate was placed in the middle of the pen by a person that normally were feeding the animals. The ewe that first claimed access to the bucket and displaced the others was removed from the pen and given top rank position. The test was repeated until only one ewe remained,

which was given the lowest position in rank (Bøe et al., 2006).

Statistical analysis

To analyze the effect of space allowance and flooring on general activity, lying position, synchronization of lying periods and displacements and other aggressive interactions, a mixed-effects regression model was used including space allowance, floor type and interactions as categorical predictors (using the nlme package in R). Group was specified as a random intercept in the model and mean values per group were used as statistical units. To correct for multiple comparisons comparing the effects of different space allowances on activity, lying behavior and social interactions, Tukey post-hoc tests were used (using the lsmeans package in R). The coefficient of variation (CV) for lying time was calculated for all three different space allowances. Regression analyses were used to analyze the effect of social rank and lying time.

RESULTS

Activity

Mean lying time and time spent lying simultaneously increased significantly when space allowance increased from 0.75 to 1.50 m^2/ewe and increased further, but not significantly, when space allowance increased to 2.25 m^2/ewe (Table 1). The individual variation in time spent lying (CV) decreased successively with increasing space allowance but were only significant between 0.75 and 2.25 m^2/ewe. Even in the 0.75 m^2/ewe treatment, there was no correlation between lying time and social rank ($R = 0.19$, $P = 0.68$).

Time spent eating and standing decreased significantly when space allowance increased from

0.75 to 1.50 m^2/ewe and decreased further, but not significantly, when space allowance increased to 2.25 m^2/ewe (Table 1). There was no significant effect of increasing space allowance on time ewes spent moving or sitting, but it is interesting to note that sitting was only observed in the 0.75 m^2/ewe treatment.

Type of flooring had no significant effect on the ewes' activity and there was no interaction between space allowance and floor type (Table 1).

Table 1 here.

Lying position

Space allowance had no significant effect on proportion of time spent lying in the center of the pen (Table 2). The proportion of time spent lying against side walls increased significantly with increasing space allowance, whereas lying against the back wall decreased. Lying against the feed barrier decreased significantly when space allowance increased from 0.75 to 1.50 m^2/ewe, and decreased further, but not significantly, when space allowance increased to 2.25 m^2/ewe (Table 2).

There was a significant effect of flooring type in that the ewes spent more time lying in the middle of the pen and less time lying against pen walls and the feed barrier when housed on straw compared to expanded metal flooring (Table 2). There was a significant interaction between space allowance and floor type so when space allowance was increased, time spent lying against sidewalls increased more in the expanded metal treatment than in the straw bedding treatment. When comparing the four ewes that were lying the most with the four ewes that were lying the

least in the 0.75 m^2/ewe pen, differences were only found on expanded metal flooring where the ewes that were lying the least, were often the ewes lying in the middle of the pen. There was a correlation between the social rank order and lying in the middle of the pen in the treatment with 0.75 m^2/ewe and expanded metal flooring (R = 0.72, P = 0.04).

Table 2 here.

Social lying position

Lying > 100 cm away from another ewe increased significantly with increasing space allowance (Table 2). Ewes lying with 15 to 100 cm distance increased when space allowance increased from 0.75 to 1.50 m^2/ewe, but there was no significant difference between 1.50 and 2.25 m^2/ewe. Lying head-to-head, head-to-back, back-to-back or parallel decreased significantly when space allowance increased from 0.75 to 1.50 m^2/ewe and decreased further, but not significantly, when space allowance increased to 2.25 m^2/ewe. Regardless of space allowance, head-to-back was the most common of the social lying positions (< 15 cm to another ewe).

When ewes were housed on expanded metal flooring they laid significantly more in the positions head-to-back and back-to-back compared to straw bedding (Table 2). There was a significant interaction between space allowance and floor type on lying parallel. When space allowance was increased, time spent lying parallel increased more in the straw bedding treatment than in the expanded metal treatment. Floor type had no effect on lying 15 – 100 cm and > 100 cm away from another ewe (Table 2).

Aggressive interactions when lying

The most frequent aggressive interaction was displacement with physical contact where the lying ewe stood up and left the location (Table 3). Displacement with physical contact where the ewe stood up and left the location, displacement with physical contact where ewe ignored the attempts and total aggressive interactions decreased significantly when space allowance increased from 0.75 to 1.50 m^2/ewe and decreased further, but not significantly, when space allowance increased to 2.25 m^2/ewe. Floor type had no significant effect on aggressive interactions when lying.

Table 3 here.

There was no effect of the ewes' social rank position on displacements (R = 0.58, P = 0.13) although ewes with the two lowest positions in rank had a tendency to be displaced more often.

Aggressive interactions when being active

In general, there were few displacements when being active. Total aggressive interactions decreased significantly when space allowance increased from 0.75 to 1.50 m^2/ewe and decreased further, but not significantly, when space allowance increased to 2.25 m^2/ewe (Table 3).

There was no correlation between social rank position and aggressive interactions (R = 0.35, P = 0.39).

Floor type had no significant effect on aggressive interactions when being active and there was no significant interaction between space allowance and floor type (Table 3).

DISCUSSION

Gougoulis et al. (2010) state in their review that ewes, compared to other female ungulates, have a relatively low level of aggression but are still sensitive to changes in space allowance. Marsden and Wood-Gush (1986) found that after feed, limited lying space caused the most displacements in sheep. In the current study, ewes were exposed to higher number of displacements from pen mates when lying compared to aggressive interactions when being active. When space allowance increased from 0.75 to 1.50 m^2/ewe, the number of displacements was halved, whereas a further increase in space allowance had a limited effect. Averós et al. (2014b) found that the occurrence of negative, but also positive, interactions were lower at 2 and 3 m^2/ewe than 1 m^2/ewe. A significant reduction in the total number of displacements in ewes was also shown in another study, where lying area increased from 0.50 to 0.75 m^2/ewe (Bøe et al., 2006). Interestingly, in pigs aggressive behavior also decreased with increasing space allowance (Weng et al., 1998; Turner et al., 2000), although in sows Hemsworth et al. (2013) found that space allowance only influenced aggression soon after regrouping rather than later.

The ewes had significantly greater lying time when space allowance increased from 0.75 to 1.50 m^2/ewe, but a further increase in space allowance had no significant effect. Averós et al. (2014b) found no effect on resting behavior in ewes with increasing space allowance. On the other hand, Bøe et al. (2006) found that lying time increased significantly when lying area increased. In addition, in finishing steers (Hickey et al., 2003) and heifers (Fisher et al., 1997) an increase in lying time with increased space allowance has been found. Another important parameter related to resting behavior is lying simultaneously. The ewes in the present experiment were lying simultaneously significantly more when space allowance increased from 0.75 to 1.50 m^2/ewe. While the reduced space allowance has an obvious effect on physical space available for lying,

this finding is in accordance with previous studies where synchronization of lying increased when lying area increased in ewes (Bøe et al., 2006), goats (Loretz et al., 2004; Andersen and Boe, 2007), calves (Færevik et al., 2008) and heifers (Mogensen et al., 1997; Nielsen et al., 1997).

In this study, individual variation in lying times were lower when space allowance was increased. No effect on activity was found when looking at the ewe's social rank order, which is not in accordance with earlier findings where high-ranked individuals spent more time lying in pens with restricted lying space (ewes: Bøe et al., 2006; goats: Loretz et al., 2004; Andersen and Boe, 2007).

In the 0.75 m^2/ewe treatment, ewes spent more time eating and standing which is in accordance with Averós et al. (2014b), who observed that ewes spent less time at the feeder when space allowance increased from 1.0 to 2 .0 m^2/ewe. Averós et al. (2014b) suggest that time at the feeder could be an adaptive strategy to increase individual distance with other pen mates. In the present experiment, aggressive interactions when being active was reduced to the half when increasing space allowance from 0.75 to 1.50 m^2/ewe. This is supported by Kondo et al. (1989), showing that larger space allowance resulted in a lower incidence of agonistic interactions (butting, pushing, threatening, avoiding and fighting) in calves and adult cattle.

Sitting was only observed in the 0.75 m^2/ewe treatments and is most likely an effect of difficulties to lay down in such a restricted area. To our knowledge, sitting behavior in ewes has not been observed and/or mentioned in previous studies. Increased observations of sitting when space allowance decreases is found in sows (Weng et al., 1998) and in a study by Pearce et al.

(1989) pigs that were handled unpleasantly spent more time sitting and standing inactive than pigs handled pleasantly.

Many ruminant species prefer a longer distance to other individuals when lying (e.g., goats: (Andersen and Boe, 2007) calf and adult cattle: (Kondo et al., 1989) bulls: (Gygax et al., 2007)). This is also shown in sheep where Nor-X ewes preferred a distance of more than 3.0 meters to next pen mate during resting (Jørgensen et al., 2011). Preferred individual distance between ewes is also related to breed where the heavy breed Nor-X kept a significantly larger individual distance to their pen mates during resting than the lighter Spæl breed (Jørgensen et al., 2011). Increased distance between resting ewes was also found in this study where ewes were lying significantly more with 15 – 100 cm and over 100 cm away from another ewe in the 1.50 and 2.25 m^2/ewe treatments when compared to 0.75 m^2/ewe. This is in accordance with Averós et al. (2014a) who found increased distance from the neighbor ewe in treatments with 2 and 3 m^2/ewe compared to 1 m^2/ewe space allowance. Further, Bøe et al. (2006) showed that the distance between ewes increased with increasing lying space and, hence, an increased perimeter.

When increasing space allowance, lying close to the back wall decreased whereas lying close to the side walls increased almost correspondingly. The length of the back wall remained constant whereas the length of the side walls increased when increasing space allowance. Generally, the ewes have a clear preference for lying against a pen wall (e.g. Færevik et al., 2005; Jørgensen et al., 2009). They also try to maximize the distance between individuals (e.g. Bøe et al., 2006; Jørgensen et al., 2011) which is exactly what they achieve when moving to the side walls. Lying against the feed barrier decreased slightly when space allowance increased. On the other hand, ewes in the straw bedding treatment laid significantly less against the feed barrier than ewes in

the expanded metal treatment. This can be explained by the ewes in the straw treatments spending much more time lying in the middle of the pen and not having a strong preference for lying against a pen wall. This is in accordance to Færevik et al. (2005) who almost exclusively observed ewes lying in the middle of pens with straw pens but not in pens with other floor types. Space allowance had no significant effect on the time ewes spent lying in the middle of the pen.

As expected, the proportion of time spent lying close to another ewe decreased with increasing space allowance. In all three space allowances, and especially the smallest space allowance, the dominant social lying position was head-to-back. This social lying position is the position in which ewes maximize perceived social distance, but perhaps not the actual physical distance. In addition, Jørgensen et al. (2011) found that this social lying position was dominant when ewes were lying close together.

We conclude that increasing space allowance for pregnant ewes from 0.75 to 1.50 m^2/ewe resulted in increased lying time, more simultaneous lying, less individual variation in time spent lying, and fewer displacements and aggressive interactions. Increasing space allowance further to 2.25 m^2/ewe had no significant effects except from increased distance between ewes when lying. Type of flooring had no significant effect on general activity including resting, distance between ewes, displacements and aggressive interactions, but ewes housed on straw bedding laid more in the center of the pen.

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Table 1. Effect of space allowance and floor type on general activities (mean ± standard error)

	Space allowance (m²/ewe)			Floor type		P-value		
	0.75	1.50	2.25	Straw	Expanded metal	Space allowance	Floor type	Interaction
Lying (% of total observations)	61.1 ± 0.9[a]	66.4 ± 0.9[b]	68.2 ± 1.0[b]	65.1 ± 1.1	65.3 ± 0.9	< 0.0001	0.85	0.36
Eating (% of total observations)	22.9 ± 0.9[a]	20.0 ± 0.7[b]	19.3 ± 0.8[b]	20.7 ± 0.8	20.9 ± 0.7	<0.001	0.54	0.54
Standing (% of total observations)	13.0 ± 0.6[a]	10.5 ± 0.4[b]	10.0 ± 0.7[b]	11.6 ± 0.7	10.9 ± 0.4	<0.01	0.35	0.28
Moving (% of total observations)	2.8 ± 0.2	3.0 ± 0.2	2.4 ± 0.2	2.7 ± 0.2	2.7 ± 0.2	0.14	0.87	0.39
Sitting (% of total observations)	0.2 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.0	0.1 ± 0.1	0.07	0.73	0.75
Variation in lying time (% CV)	3.6 ± 0.3[a]	2.8 ± 0.2[ab]	2.2 ± 0.2[b]	2.3 ± 0.2	3.0 ± 0.3	<0.01	0.42	0.82
Lying simultaneously (% of total observations when lying)	14.4 ± 1.7[a]	33.6 ± 1.9[b]	35.5 ± 1.7[b]	27.3 ± 2.6	28.4 ± 2.8	< 0.0001	0.60	0.69

Means with the letters ‘a’ and ‘b’ differ significantly

1 Table 2. Lying positions (% of total lying time) for ewes in pens with different space allowance and floor type (mean ± standard error)

2

	Space allowance (m²/ewe)			Floor type		P-value		
	0.75	1.50	2.25	Straw	Expanded metal	Space allowance	Floor type	Interactio
Lying position								
Lying < 15 cm to back wall	40.4 ± 1.6[a]	23.9 ± 1.7[b]	19.8 ± 1.2[c]	26.3 ± 2.5[a]	31.2 ± 2.3[b]	< 0.0001	< 0.0001	0.84
Lying < 15 cm to side wall	21.2 ± 1.2[a]	35.5 ± 1.4[b]	48.3 ± 2.5[c]	34.4 ± 3.8[a]	38.5 ± 3.4[b]	< 0.0001	<0.001	< 0.05
Lying < 15 cm to feed barrier	21.3 ± 1.6[a]	16.9 ± 2.3[b]	15.7 ± 1.8[b]	13.6 ± 1.3[a]	23.1 ± 1.0[b]	<0.01	< 0.0001	0.38
Lying in the middle of the pen	17.2 ± 3.1	20.8 ± 4.0	16.5 ± 4.9	26.5 ± 2.8[a]	7.3 ± 1.4[b]	0.41	< 0.0001	0.31
Social lying position								
Lying head-to-head (< 15 cm) with another ewe	9.4 ± 1.1[a]	2.8 ± 0.7[b]	1.9 ± 0.5[b]	4.2 ± 0.9	5.6 ± 1.1	< 0.0001	0.06	0.96

Lying head-to-back (< 15 cm) with another ewe	42.7 ± 3.0[a]	13.6 ± 2.2[b]	8.3 ± 1.0[b]	17.6 ± 3.4[a]	26.0 ± 4.4[b]	< 0.0001	0.0001	0.12
Lying back-to-back (< 15 cm) with another ewe	11.0 ± 1.4[a]	6.1 ± 1.0[b]	3.9 ± 0.8[b]	6.4 ± 1.2[a]	8.3 ± 1.1[b]	<0.001	0.05	0.87
Lying parallel (< 15 cm) with another ewe	17.4 ± 2.9[a]	2.2 ± 0.7[b]	0.4 ± 0.1[b]	9.8 ± 2.8[a]	3.5 ± 1.2[b]	< 0.0001	< 0.0001	< 0.0001
Lying 15 - 100 cm away from another ewe	19.3 ± 1.2[a]	62.7 ± 4.3[b]	56.5 ± 3.2[b]	48.9 ± 5.7	44.0 ± 5.0	< 0.0001	0.14	0.67
Lying > 100 cm away from another ewe	0.2 ± 0.1[a]	9.7 ± 1.2[b]	29.1 ± 2.6[c]	13.9 ± 3.2	12.7 ± 3.3	< 0.0001	0.73	0.88

1

2 Means with the letters ‘a’, ‘b’ and ‘c’ differ significantly

1 Table 3. Number of observations (mean ± standard error) of displacements (when lying) and aggressive interactions when being active

2

	Space allowance (m²/ewe)			Floor type		P-value		
	0.75	1.50	2.25	Straw	Expanded metal	Space allowance	Floor type	Interaction
When lying								
Displacement (no physical contact), ewe stands up, leaves the location	2.6 ± 0.5	1.5 ± 0.4	1.2 ± 0.2	2.1 ± 0.4	1.4 ± 0.3	0.05	0.16	0.86
Displacement (physical contact), ewe stands up, leaves the location	14.5 ± 1.6[a]	7.0 ± 0.6[b]	5.1 ± 0.8[b]	8.4 ± 1.3	9.3 ± 1.3	< 0.0001	0.65	0.89
Displacement (no physical contact), ewe stands up, lies down again	0.3 ± 0.2	0.1 ± 0.1	0.1 ± 0.1	0.1 ± 0.1	0.2 ± 0.1	0.55	0.24	0.14
Displacement (physical contact), ewe stands up, lies down again	0.8 ± 0.3	0.2 ± 0.1	0.3 ± 0.1	0.3 ± 0.2	0.6 ± 0.2	0.10	0.23	0.94
Displacement (physical contact), lying ewe ignore the attempts	2.8 ± 0.5[a]	1.4 ± 0.3[b]	0.5 ± 0.2[b]	1.4 ± 0.2	1.7 ± 0.4	< 0.001	0.50	0.30

Total displacements when lying	20.8 ± 1.4[a]	10.2 ± 0.6[b]	7.2 ± 0.8[b]	12.3 ± 1.6	13.2 ± 1.7	< 0.0001	0.70	0.57
When being active								
Butting with the head towards another active ewes head	2.8 ± 0.5	1.4 ± 0.3	1.5 ± 0.4	2.3 ± 0.4	1.4 ± 0.3	0.06	0.08	0.99
Butting with the head towards another active ewes body	1.7 ± 0.3[a]	0.8 ± 0.2[ab]	0.7 ± 0.3[b]	1.3 ± 0.3	0.8 ± 0.2	< 0.05	0.20	0.89
Rushing or directing forehead towards another active ewe (no physical contact)	2.1 ± 0.4	1.3 ± 0.3	1.0 ± 0.3	1.6 ± 0.3	1.4 ± 0.3	0.08	0.69	0.84
Total aggressive interactions when active	6.5 ± 0.8[a]	3.6 ± 0.5[b]	3.2 ± 0.7[b]	5.2 ± 0.6	3.7 ± 0.7	< 0.01	0.10	0.89

1

2 Means with the letters ‘a’ and ‘b’ differ significantly

LEGENDS TO FIGURES

Figure 1. Experimental pens

Figure 1