Resting pattern and social interactions in goats - the impact of size and organisation of lying space

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ABSTRACT

The aim of the present experiment was to examine how size and organisation of lying space affected resting pattern and social interactions in female goats. Twenty-four goats of a Norwegian milking breed divided into 6 groups, were systematically rotated between six experimental pens (width x depth: 2.0 x 3.0 m) with resting areas of different size (small: 0.5 m^2, medium: 0.75 m^2 or large: 1.0 m^2) and organisation (one vs. two levels/heights). Resting pattern was analysed using instantaneous sampling with 10 minutes intervals for 24 hours, whereas social interactions were continuously observed in five hours between 09.00 and 14.00 during the last 24 hours of each experimental week. Individuals within each group were ranked from 1 to 4 (1 being the dominant individual) according to how many times they had withdrawn from an interactions and avoided contact with another goat throughout the entire experimental period. By using MatMan (Software for matrix manipulation and analysis), we converted a matrix of withdrawal and avoidance interactions among the goats (based on all treatments) in each group into a matrix of dominance relationships.

The goats spent less time resting ($P<0.01$) and rested less simultaneously ($P<0.001$) when the resting area was small compared to a medium and large resting area. Time spent resting in the activity area also increased with decreasing lying space ($P<0.01$). The goats preferred resting close to a pen wall, and this occurred more seldom when the resting area was small ($P<0.01$). Resting in social contact with pen mates occurred in less than 6 % of the observations lying, and this was not significantly affected by the size of the resting area. When the lying space was organized on two levels, one or two goats resting at the same time on the same level was most the commonly observed. In most pens, the lowest ranked individuals in the groups spent less time resting ($P<0.01$), less time resting against a wall ($P<0.01$), and spent more of their resting time in the low-comfort activity area ($P<0.0001$). The amount of social interactions

was not significantly affected by the size of the resting area, but there were significantly fewer displacements ($P<0.01$) and the overall aggression level was lower ($P<0.05$) when lying space was organised on two levels rather than one. In conclusion, time spent resting and resting pattern was more dependent on size (large, medium, small) than organisation (one vs. two levels) of the lying space, whereas this was the opposite for social interactions.

Key words: goats, lying space, resting pattern, social interactions

1. INTRODUCTION

Aggressive interactions among animals increase when resources become more limited in space (e.g. Milinski and Parker, 1991; Estevez et al., 2006) and for farm animals these resources may be feeding or drinking space, access to litter or straw, attractive resting places and the freedom to move itself if the overall space is limited. Although resting pattern may not appear to be the most important indicator of the welfare status, farm animals tend to show a very synchronous activity and resting pattern if the environmental conditions allow it (Rook and Penning, 1991; Fraser and Broom, 1997). Behaving synchronously is considered to be an important benefit of living in groups, since it may increase the safety of the individual (e.g. Estevez et al., 2006). Decreased space allowance reduces resting time and synchrony in resting, and increases the amount of aggressive interactions in cattle (Zeeb et al., 1988; Fisher et al., 1997; Mogensen et al., 1997; Nielsen et al., 1997; Fregonesi and Leaver, 2002). Similar results are found when decreasing lying space in social groups of sheep (Bøe et al., 2006), and it is the low status individuals that tend to suffer most in terms of a major decrease in resting time. As has been documented theoretically (Milinski and Parker, 1991) and with empirical work on pigs (Andersen et al., 1999), it is not only the average access to resources that are

reduced when resources become more limited in space. The differences between high and low status individuals also increase in a more competitive environment.

In his review of goat housing, Toussaint (1997) recommends a space allowance for adult goats of 1.50 m^2, which corresponds to the requirements in the European regulations for organic farming (Council Regulation (EC) No 1804/1999). However, regulations both in Sweden (1.20 m^2 per goat) and Switzerland (1.0 m^2 per goat) have lower demands for space allowance. In the present study we chose to use a space allowance of 1.5 m^2 since this is both in accordance with European legislations for ecological goat farming and what is recommended by Toussaint (1997). Unfortunately, scientific information about how size and organisation of lying space affects the behaviour and social interactions in goats is scarce. When offering a total floor space of 1.0 m^2, 1.5 m^2 or 2.0 m^2 per animal in social groups of horned and horneless goats, Loretz et al. (2004) documented a lower resting time at the lowest space allowance, but inter-individual distances and the level of aggression remained surprisingly stable across treatments. This is in contrast to several studies in pigs and cattle, showing an increase in the aggression level when the available space is being reduced (pigs: Weng et al., 1998; Turner et al., 2000, cattle: Zeeb et al., 1988; Fisher et al., 1997; Fregonesi and Leaver, 2002). In addition to floor space per se, the different areas of the pen may represent different qualities, and attractive lying places may be a source of competition. For example ewes compete for access to resting places next to a wall, and tend to avoid resting in the centre of the pen even if the flooring material is exactly the same (Marsden and Wood-Gush, 1986; Færevik et al., 2005; Bøe et al., 2006). As lying space decreases, time spent lying in close contact to other ewes increased (Bøe et al., 2006), clearly indicating that the individuals prefer to rest without body contact if the space allowed them to do so.

Female Mountain goats are reported to interact aggressively much more frequent than most other female ungulates (reviewed by Fournier and Festa-Bianchet, 1995). Shank (1972) describes in an elegant way a wide repertoire of social behaviours in goats ranging from the very intensive 'rush association' or 'clash association' to the less risky and intensive threatening movements such as pawing, directing the forehead/horns or one side of the body towards, or rushing towards the opponent. Some claim that dominance is relatively mild and not so clear in wild or feral goats (e.g. Stewart and Scott, 1947; Scott, 1948), whereas others find clear dominance relationships (e.g. Schaller, 1977; Hart, 1985) and a relatively stable hierarchic order within the flock (Barroso et al., 2000; Cote, 2000). Yet, the dominance relationships appear to be less stable in time than what is reported for other female ungulates (Fournier and Festa-Bianchet, 1995).

The aim of the present experiment is to investigate how size and organisation of lying space influence the resting pattern and social interactions in goats kept in small groups.
Since attractive resting places can be considered an important resource that are worthwhile competing for, we predict that the overall time spent resting and resting synchronously will decline with decreasing lying space, that the time spent lying in the less attractive activity area will increase and that the amount of aggression in the groups will increase. We also expect that dividing the lying space into two levels rather than one will increase the possibility for some individuals to avoid each other while resting, and thus more individuals are predicted to rest simultaneously and the level of aggression is predicted to be lower. Finally, we predict to find large individual differences in access to the resting areas within groups, and that the differences between low and high-ranked individuals will increase as the lying space is reduced.

2. MATERIAL AND METHODS

2.1 Experimental set-up and pens

Twenty-four goats divided into six groups of four goats, were systematically rotated between six equally sized experimental pens in a 3 x 2 factorial design with resting areas of different size (small: 0.50 m^2 per goat, medium: 0.75 m^2 per goat or large: 1.00 m^2 per goat; Fig. 1) and organisation (one vs. two levels). Total space allowance for each goat irrespective of the size of lying area was 1.5 m^2. We used the same sizes of lying areas as previously used in a similar study on sheep (Bøe et al., 2006) to be able to compare the results. To get accustomed to the different pen treatments, the groups stayed one week in each pen, and video recordings were made in the last 24 hours of each week.

The pens were located in an insulated, mechanically ventilated room where the ambient air temperature was kept constant around 10 °C. All the pens measured 2.0 x 3.0 m, and the total lying space was exactly the same in the one and two-level pens (Fig. 1). The height between first and second level was 0.80 m, and stairs were provided on the right side in front of the resting area to make an easy access to the second level (pilot studies revealed the need for these stairs). The resting area in both types of pens, including the second level, was made of solid, wooden floor covered with a small amount of sawdust. Pen walls were also made of solid wood. To make it unattractive to lie in the activity/feeding area, wooden beams (1.5” x 2.0”) were placed on the floor at c/c 400 mm, as previously demonstrated in a similar study on sheep (Bøe et al., 2006).

Figure 1 here

2.2 Animals and feeding

Healthy, female, dehorned, dry, pregnant (late gestation) goats (between one and four years old) of a Norwegian milking breed were used in the experiment.

The goats were fed grass silage *ad libitum*, and they had free access to water from buckets placed in the feeding through in front of the pen. A total amount of 0.3 kg per goat of standard concentrates was given in the morning (08.30 hours). Fresh silage was provided, pens were cleaned and new litter was added both in the morning and in the afternoon (14.30 hours).

2.3 Behavioural observations

All the goats were video recorded in the last 24 hours within each experimental week before being rotated. Three video cameras (Panasonic WV – BP 310 G) were suspended over the pens, covering two pens each, and were connected to a multiplexer (Robot MV99P) and a time-lapse video recorder (Panasonic AG 6720).

Resting pattern was analysed using instantaneous sampling with 10 minutes intervals for 24 hours. Percent of total observations of the following behaviours were then calculated:

- Standing in the activity area
- Standing in the resting area
- Moving (walking or running) in the activity area
- Moving (walking or running) in the resting area
- Lying in the resting area:
    a. with or without body contact (<10 cm) with another goat
    b. with or without 50% or more of one side of the body in contact (<10 cm) with a pen wall

- Lying in the activity area:
    a. with or without body contact (<10 cm) with another goat
    b. with or without 50% or more of one side of the body in contact (<10 cm) with a pen wall

From this, % of observations where all four goats within each group were resting simultaneously on the resting area was calculated. Based on the data from the two-level pens, we also calculated % of observations where one, two, three or four goats were resting on the same level in the three two-level pens.

All instances of social interactions were continuously scored for five hours between 09.00 and 14.00 hours during the 24-hour period of video recording in each experimental week. This was the time of the day when the goats were most active. The following ethogram with mutually exclusive behaviours was based on previous studies on social interactions in goats (e.g. Shank, 1972):

- Nosing on/exploring (nose in contact with) another goat
- Frontal clashing (a position where the actor is rearing onto the hind legs with the head and torso twisted followed by descending forcefully onto the front legs delivering a powerful strike forwards and downwards reaching the head of the receiver)
- Butting with the head towards the head or shoulders of another goat
- Butting with the head towards other parts of the body
- Chasing (moving quickly after) another goat that tries to escape
- Threatening (pawing or rushing towards, or directing the forehead towards the opponent but without physical contact)

- Avoiding (moving the head and/or body away from an approaching goat, but with no direct interaction)
- Withdrawing (moving the head and/or body away from another goat after a social interaction)
- Displacing (physically forcing another goat to leave its resting position or feeding place by pushing or butting sideward or from behind)

Frontal clashing, butting, chasing, threatening, and displacing were then summed into total number of aggressive interactions.

Withdrawal and avoidance order was the criteria for determining rank within groups (e.g. Rowell, 1974; Jensen, 1982). Individuals within each group were ranked from 1 to 4 (1 being the dominant individual) according to how many times they had withdrawn from an interactions and avoided contact with another goat throughout the entire experimental period. By using MatMan (Software for matrix manipulation and analysis), we converted a matrix of withdrawal and avoidance interactions among the goats (based on all treatments) in each group into a matrix of dominance relationships. The dominant animal of each pair was given the value '1' whereas a subordinate individual was assigned the value '0'. If the dominance relationship was undecided (either because no dominance interactions occurred or because both animals performed an equal number of interactions to each other), both animals were given the value '0.5'.

2.4 Statistics

To analyse the effects of size and organisation of lying space on social behaviours, a mixed model analysis of variance with the following class variable were used (Hatcher and

Stepanski, 1994): size of resting area (small: 0.5, medium:0.75, large:1.0 m^2 per goat), lying space organisation (1 or 2 levels), the interaction between size and organisation of lying space, group (1 to 6) and experimental period (rotation 1 to 6). Group was specified as a random effect in the model. Mean values per group were used as statistical unit. Differences between means were investigated by using the Student-Newman Keuls` test. Experimental period was included to document the development in social interactions over time in the experiment. Lying/resting pattern was also analysed with a similar mixed model analysis of variance and with the same class variables.

To compare % of observations where 1, 2, 3 or 4 goats were resting simultaneously on the first versus second level of the resting area, a mixed model analysis of variance with number of goats resting simultaneously (1, 2, 3 or 4) and group (random effect) as class variables were used.

The relationship between individual rank and resting pattern within the different pens was investigated by using a one-way analysis of variance with individual rank (1, 2, 3 or 4) as class variable.

3. RESULTS

Experimental period (rotation) did not significantly affect resting pattern or social interactions.

3.1 Resting pattern

Irrespective of whether the lying space was organised on one or two levels, the goats significantly decreased their resting time from 66 % when the resting area was large, to 61 %

when the resting area was small (Table 1). All four goats in each group were lying simultaneously significantly more often when the resting area was large both when lying space was organised on one and two levels (Table 1). However, the mean proportion of observations when this occurred was not more than 21 %, even when the resting area was large. The goats tended to rest at the same time more frequently when lying space was organized on one rather than on two levels. Groups differed significantly in how much time they spent resting simultaneously ($F_{5,25}$=4.7, P<0.01), ranging from 0.6% of the observations in one group to 23% in another, irrespective of treatment. This suggests that resting pattern may also depend on the types of individuals that are grouped together. When decreasing the resting area from large to small, the goats increased their time spent resting in the low-comfort activity area significantly from 4 % to 16 % on average (Table 1), but there was no significant difference between groups. There was a large individual difference within groups in time spent resting and the proportion of time resting in the activity area. When the resting area was large, the individual range in total resting time was from 46 to 77% in the one-level pen, whereas the corresponding range in the two-level pen was from 24 to 81%. At the largest lying space, the proportion of time spent lying in the activity area varied between 0 and 38% in the one-level pen, whereas this range was between 0 and 58% in the two-level pen. These ranges increased when the resting area decreased, and when the resting area was small, the time spent lying in the activity area varied as much as between 0 and 88% when the resting area was on one level compared to a range of 0 to 96% in the two-level pen.

The goats were lying in body contact in less than 7% of the observations lying in all treatments (Table 1). Lying in contact with another goat occurred more frequently in the one-level than in the two-level pens, irrespective of the size of the resting area (Table 1), and there was no significant difference between the groups in this behaviour. Time spent resting in

contact with a pen wall increased from 68 % of observations lying when lying space was small to 82 % when lying space was large (Table 1). There were no significant effects of lying space organisation on how much time the goats spent lying against a wall, but the groups tended to differ in this behaviour ($F_{5,25}$=2.5, P=0.06).

There were no significant interactions between size and organisation of lying space in any of the behaviours related to resting pattern.

3.2 The use of first vs. second floor in the two-level pens

We never observed four goats resting on the same level simultaneously in any of the two-level pens, and three goats resting on the same level rarely occurred even when the resting area was large (Fig. 2). One or two goats resting at the same time on both levels was the most common resting pattern. At a medium resting space, one goat resting on the second level was more frequently observed than two goats (first level: one goat: 37.7±3.8%, two goats: 41.9±8.4%, three goats: 0.9±0.9%, $F_{2,10}$=13.9, P<0.01; second level: one goat: 55.6±6.1%, two goats: 24.0±7.0%, three goats: 0.6±0.5%, $F_{2,10}$=18.2, P<0.001). When the resting area was small, one goat resting on each level occurred in more than 50% of the observations and significantly more often than two goats (17-23%; first level: $F_{2,10}$=30.7, P<0.0001; second level: $F_{2,10}$=15.3, P<0.001). There were no significant differences between groups with respect to how frequent one, two or three goats were resting on each of the two levels.

3.3 Social interactions

There were no significant effects of the size of the resting area on the number of agonistic interactions between the goats, but they tended to displace each other more frequently when lying space was medium than when lying space was small (Table 2). Lying space on two

levels resulted in significantly fewer displacements, and the overall aggression level was lower than when lying space was organised on one level (Table 2). Furthermore, when lying space was on two levels, there were fewer incidents where the goats fled/withdrew from an interaction or avoided interactions with others. There were significant differences between groups in the amount of threats and defensive behaviours (threat: $F_{5, 20} = 5.5$, $P<0.01$; avoidance: $F_{5,20} = 10.4$, $P<0.0001$; withdrawal: $F_{5, 20} = 5.2$, $P<0.01$) made by the goats, but none of the other social behaviours differed significantly between groups. Even within the 'large resting area' treatment, the total number of aggressive interactions within a group varied between 0 and 24 (lying space on one level) and between 2 and 12 (lying space on two levels), suggesting that the amount of aggression was strongly dependent on the individuals that were grouped together. There was a huge individual variation in aggression level within the different groups, ranging from some individuals not initiating any aggressive conflicts at all to one individual initiating more than 50 aggressive interactions within a 6-hour period. On average there was one goat in each group during each treatment that initiated less than two aggressive interactions.

There was a significant interaction between size and organisation of lying space concerning the number of displacements ($F_{2,20} =5.7$, $P<0.05$). When lying space was organised on one level, the number of displacements were highest for the medium lying space whereas this was the case for the large lying space in the two-level pen (Large lying space, one level: 2.1±0.5, Medium lying space, one level: 4.3±0.8, Small lying space, one level: 2.1±0.6; Large lying space, two levels: 2.0±0.3, Medium lying space, two levels: 1.4±0.2, Small lying space, two levels: 1.5±0.2). Concerning the other social behaviours, there were no significant interactions between size and organisation of lying space.

3.4 Dominance relationships and the use of resting areas

Calculated matrixes of dominance relationships showed that the individuals in three of the groups could be ranked from 1 to 4 (1 is the highest rank and 4 is the lowest rank) with respect to the number of times one individual had withdrawn from an interaction or avoided another goat. In another two groups, one individual was dominant over the other three (one received rank 1, and three received rank 2). In the last group, no clear dominance relationship occurred with respect to avoidance and withdrawal, and this group was thus excluded from further analysis.

The lowest ranked (rank 4) goat spent less time resting than the other individuals in most of the pens (One-level: large: $F_{3,19}=0.03$, $P<0.05$, medium: $F_{3,19}=9.1$, $P<0.001$, small: Fig. 3; Two level: large: $F_{3,19}=3.6$, $P< 0.05$, medium: $F_{3,19}=4.2$, $P<0.05$), except for the two level pen with small resting area where there was no significant effect of social rank (Fig. 3).

In the one-level pen with a large resting area all individuals spent more than 90% of their resting time on the resting area. In most of the other pens, the lowest ranked individual in each group spent significantly more time (% of observations lying) resting in the activity area than the other individuals (One-level: large: $F_{3,19}=0.6$, $P=0.65$, medium: $F_{3,19}=6.6$, $P<0.01$, small: Fig. 4; Two level: large: $F_{3,19}=39.2$, $P< 0.0001$, medium: $F_{3,19}=254.7$, $P<0.0001$, small: Fig. 4).

In the one-level pen with large resting area all goats were resting against a pen wall in 64 to 98% of the observations lying, irrespective of social rank. In the other pens, the extent to which the goats were lying against a wall decreased with decreasing rank (One-level: large resting area: $F_{3,19}=1.2$, $P=0.33$, medium resting area: $F_{3,19}=4.0$, $P<0.05$, small resting area:

Fig. 5; Two level: large: $F_{3,19}$=3.5, P< 0.05, medium: $F_{3,19}$=15.4, P<0.0001), except for the two-level pen with small resting area where it was hardly possible to rest without wall contact (Fig. 5).

There was no significant effect of social rank on the use of first vs. second level for resting. In three out of five groups, the highest ranked individual spent 93 to 96% of their resting time on the first level whereas in the other two groups they spent all their resting time on the second floor in the pen with the large resting area. In most of the groups, the first and second ranked individual rested on separate levels, irrespective of the size of the resting area.

4. DISCUSSION

The main results from the present study showed that resting pattern in goats was more dependent on size than organisation (one vs. two levels) of lying space, whereas this was the opposite for social interactions. Loretz et al. (2004) found no effect of space allowance per se on the aggression level in social groups of goats, but when lowering the space allowance from 2.0 to 1.0 m^2, the proportion of time spent lying decreased. In accordance with previous results in sheep (Bøe et al., 2006) and complementary to the results of Loretz et al. (2004), the present experiment documented that the lying time decreased even further when available lying space decreased from 1.0 to 0.5 m^2, reaching a level of 61% of the observations when the smallest resting area was used. In comparison, the proportion of time lying was around 75% of the observations at 2.0 m^2 per goat in the study of Loretz et al. (2004). Comparatively, the goats rested in 66 % at the largest resting space in the present study, which may suggest that the environment was far from being optimal in terms of achieving adequate rest for the goats. This can be due to the larger amount of agonistic interactions in the present study that both had a smaller group size and 0.5 m^2 less floor space per goat than what Loretz et al.

(2004) used in their study. It is important to be aware that while changing the size of the resting area in the present study, the total available floor space was kept constant on 1.5 m^2 per goat. Despite the significant effects of the size of the resting area in the present study, the actual change in percent of observations resting from the largest to the smallest lying area was only 5% and the corresponding increase in percent of observations resting in the activity area was 15%. Furthermore, there was no effect of size of the lying area on the amount of agonistic interactions. Thus, the direct welfare consequences by this decrease in lying space may be considered as minor. Increasing the total space allowance and thereby allowing more personal space may thus be of greater importance to reduce aggression and to increase resting time than changing the size of the lying areas per se. According to Jensen et al. (2005), heifers show an inelastic demand to rest for at least 50% of a 24-H period, which suggests that resting is a strong, basic need for the animals. No such studies have been conducted in goats, and thus we know little about what is the preferred resting time and resting pattern for this species.

In accordance with what was predicted and previously found in sheep (Bøe et al., 2006), the goats were resting less synchronously, and they were lying more in the less comfortable activity area when lying space was decreased. However, in contrast to sheep that also spent more time resting in close proximity of other group members as the lying space declined, the goats strongly avoided this during all treatments. Even in the largest lying space, the goats only spent around 3% of the resting observations lying in body contact with another individual, whereas the corresponding value for sheep was 60% (Bøe et al., 2006). This supports the results of Lyons et al. (1993) who found that sheep spent more time near pen-mates and showed greater adrenocortical responses when separated from pen-mates than did goats, suggesting that goats have a more individualistic nature and prefer a larger distance to

other individuals. They also express separation anxiety differently in that the sheep showed a higher locomotive activity whereas vocal rates were higher in goats (Lyon et al., 1993). When lying space was divided into two levels rather than one, the amount of aggressive conflicts declined as predicted, but in contrast to what was predicted, this did not result in more individuals resting simultaneously. The latter can be explained by the more limited lying space on each level when the resting area is separated on two floors than when all available lying space is concentrated on one level.

Although sheep and goats are both herd-living ungulates that are born into structured social groups (e.g. Shackleton and Shank, 1984), they still differ in their social behaviour. In contrast to sheep mothers and their lambs that keep in close proximity and interact frequently, newborn goat kids can spend much time away from their mother lying hidden at a distance (Lickliter, 1984). Adult sheep also seek close proximity to social companions much more than goats (Hafez et al., 1969), and it is more difficult to separate two sheep when faced with a human handler than a pair of goats (Scott, 1945). This most likely reflects adaptation to different habitats where the species originally evolved, since wild goats tend to live in more competitive environments than do wild sheep.

If goats prefer larger individual distances when resting as suggested by the present study, this may also explain why the amount of aggressive interactions is lower when lying space in divided on two separate levels. Using resting areas on different levels or several separated resting places instead of one large area would thus probably be a good way of reducing the aggression and social stress in groups of goats. The goats appeared to prefer wall space for resting in a similar way as sheep (Bøe et al., 2006) and domestic fowl (e.g. Cornetto and Estevez, 2001). This may be due to increased comfort, but in poultry this has been explained

as an anti-predator strategy suggesting that the animals may feel safer close to a wall than in an open area. Since providing solid partitions between the animals may reduce the likelihood of aggressive interactions (e.g. Andersen et al., 1999), the use of individual resting stalls could be an interesting alternative to increase the overall resting time in goats, especially if lying space is limited. Time spent resting synchronously in the present study (20% of the observations lying) was much lower than what was found in sheep (45% of observations lying) at a lying space of 1.0 m^2. This can be due to interspecies differences in resting pattern, but also that the goats need a larger social space due to a different social motivation and preferences than sheep. Fournier and Festa-Bianchet (1995) states that goats are more frequently involved in aggressive interactions than other ungulates and this should be taken into consideration when designing houses for goats. When legislations concerning space requirements are made, preferred individual distances and individual differences in the use of space in social groups should be emphasized rather than the need for physical space per se.

The most common resting pattern in the two-level pen with the large resting area was that one or two goats were resting simultaneously on each level. However, it was only when the resting area was large that all goats could rest simultaneously in this type of pen. Our experience from the present study indicates that since the preferred distance between resting individuals appears to be high, we would expect more individuals to rest on the same level if the length of the large two-level resting area is increased while the depth is maintained. To be able to document this, we have to study the exact individual distances between goats. The differences in access to the resting area between goats of different social rank appeared to be stronger when lying space was on one rather than two levels, probably because it is easier to monopolize one big resting area. As predicted, low-ranked individuals rested less and spent more time resting in the less attractive activity area than high-ranked goats, and in the one-

level pens this difference was most pronounced when the resting area was medium or small. Thus, low-status individuals are likely to get too little rest in such an environment.

5. CONCLUSION

In conclusion, time spent resting and resting synchronously decreased whereas the time spent resting in the activity area increased as the resting area became smaller irrespective of whether the resting area was organised on one or two levels. Low-status individuals suffered more from a reduced resting time, and were forced to rest more on the low-comfort activity area than high-status goats. The organisation of lying space had little impact on the resting time and the resting pattern of the goats, but the amount of agonistic interactions was lower when the resting are was organised on two levels, which suggest that this may be a recommendable system in commercial herds. In general, the goats preferred to rest against a wall and without body contact with other individuals.

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Tables

Table 1. Resting pattern in relation to size and organisation of lying space. Mean ±SE % of total observations or observations lying are given.

	Size of lying area					Lying area on one or two levels			
	Small	Medium	Large	$F_{2,25}$-value	P-value	One level	Two levels	$F_{1,25}$-value	P-value
Lying (% of total obs.)	61.2±2.1[a]	64.1±2.6[ab]	66.1±2.0[b]	5.8	<0.01	63.8±2.2	63.8±2.1	0.0	0.99
All goats lying simultaneously (% of total obs.)	4.2±1.7[a]	8.5±3.4[a]	21.1±4.3[b]	11.3	<0.001	13.4±3.5	8.4±2.8	3.6	0.07
Lying in lying area (% of obs. lying)	84.2±2.7[a]	87.2±2.7[a]	95.8±1.3[b]	6.5	<0.01	91.1±2.1	87.0±1.8	2.3	0.14
Lying in activity area (% of obs. lying)	15.8±2.7[a]	12.8±2.7[a]	4.2±1.3[b]	6.5	<0.01	8.9±2.2	13.0±1.8	2.3	0.14
Lying in contact with another goat (% of obs. lying)	6.8±1.9	5.2±1.4	2.9±1.4	1.9	0.17	7.2±1.5[a]	2.7±0.8[b]	7.9	<0.01
Lying in contact with wall (% of obs. lying)	67.9±3.3[a]	77.6±3.9[b]	82.3±2.2[b]	6.6	<0.01	74.3±2.7	77.5±2.9	0.9	0.35

Superscripts (a and b) show significant differences between columns within the two treatments.

Table 2. Number of social interactions (mean ± SE) in pens with different size and organisation of lying space.

	Size of lying area, m^2/goat					Lying area on one or two levels			
	0.5	0.75	1.0	$F_{2,20}$-value	P-value	One level	Two levels	$F_{1,20}$-value	P-value
Nose/explore	0.7±0.2	1.2±0.3	1.0±0.3	1.0	0.40	1.2±0.2	0.8±0.2	1.2	0.28
Frontal clashes and butting towards head /shoulders	2.2±0.5	2.8±0.8	3.7±1.1	0.7	0.53	3.6±0.9	2.3±0.4	0.12	0.73
Butting towards rest of the body	1.3±0.3	1.2±0.4	1.8±0.5	1.23	0.31	1.6±0.4	1.3±0.3	1.1	0.30
Displace	1.8±0.3	2.8±0.6	2.1±o.3	2.9	0.08	3.0±0.5	1.6±0.2	11.8	< 0.01
Chase	0.4±0.2	0.4±0.2	0.5±0.2	0.2	0.79	0.6±0.2	0.2±0.1	3.4	0.08
Threat	0.8±0.3	0.7±0.3	0.8±0.4	0.0	1.0	1.0±0.3	0.6±0.1	1.4	0.25
Aggressive Interactions*	6.4±0.8	8.0±1.6	8.9±2.1	0.9	0.4	9.7±1.6	6.0±0.7	4.2	< 0.05
Avoid	0.9±0.3	0.8±0.2	1.1±0.3	1.4	0.28	1.2±0.2	0.7±0.1	5.7	< 0.05
Withdraw/flee	3.7±0.8	3.9±1.3	4.1±1.2	0.1	1.0	5.0±1.2	2.9±0.4	3.5	0.08

*Aggressive interactions include clash, butt, displace, chase and threat.

Figure legends

Figure 1. Experimental pens

Figure 2. Percent of observations (means + SE) where one, two or three goats were simultaneously resting on one of the levels in the large two-level pen. Differences between white bars: $F_{2,10}=6.4$, a,b: $P<0.05$; differences between black bars: $F_{2,10}=12.8$, c,d: $P<0.001$

Figure 3. Percent of observations (means + SE) resting for individuals with different social rank (1 is the highest rank and 4 is the lowest rank) when lying space was small. Differences between white bars: $F_{3,19}=7.7$; a,b: $P<0.01$.

Figure 4. Percent of observations (means +SE) resting in the activity area for individuals with different social rank (1 is the highest rank and 4 is the lowest rank) when lying space was small. Differences between white bars: $F_{3,19}=7.7$; a,b: $P<0.0001$.

Figure 5. Percent of observations (means + SE) resting against a pen wall for individuals with different social rank (1 is the highest rank and 4 is the lowest rank) when lying space was small. Differences between white bars: $F_{3,19}=5.6$; a,b: $P<0.01$.

Lying space:

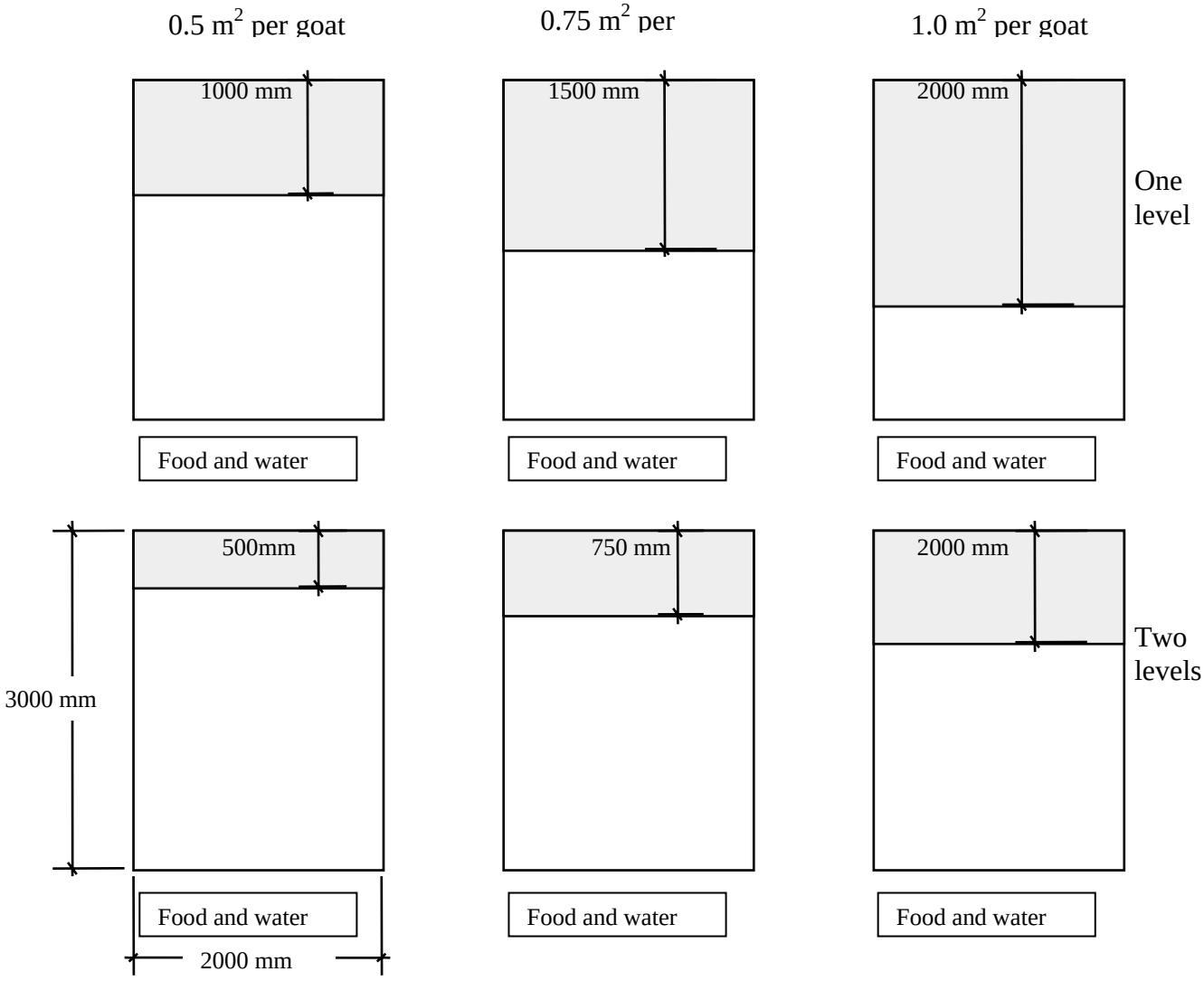

Figure 1.

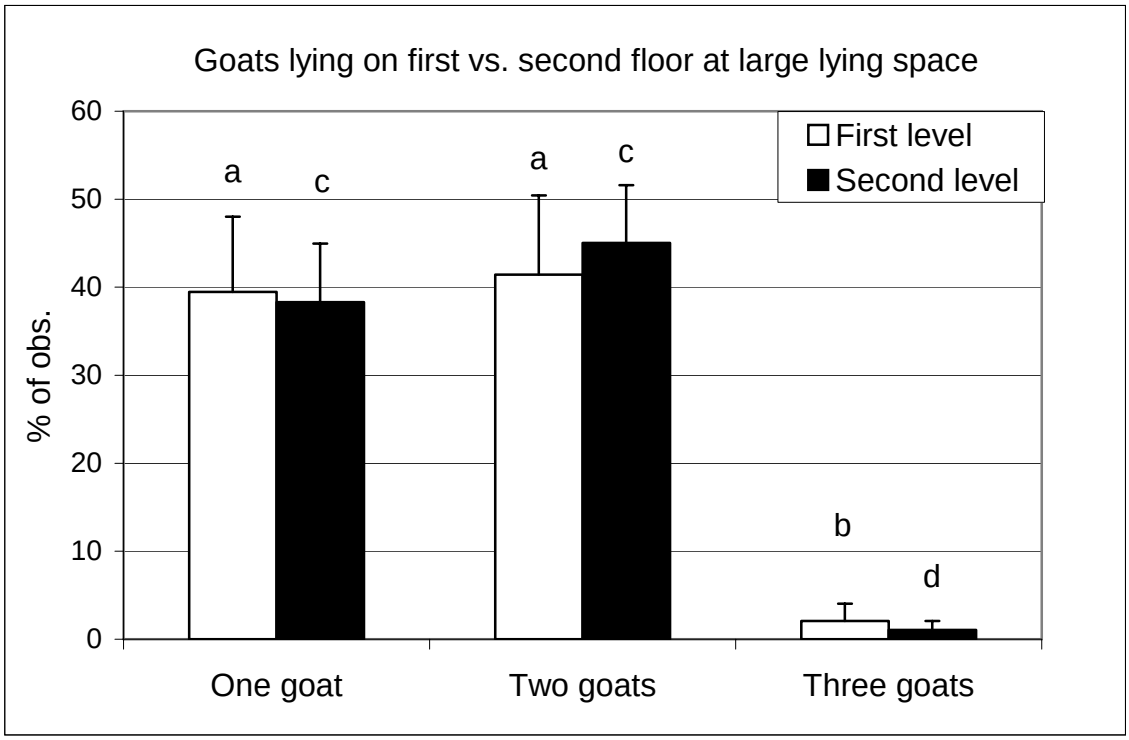
Goats lying on first vs. second floor at large lying space
% of obs.
60
50
40
30
20
10
0
First level
Second level
a
c
a
c
b
d
One goat
Two goats
Three goats

Figure 2.

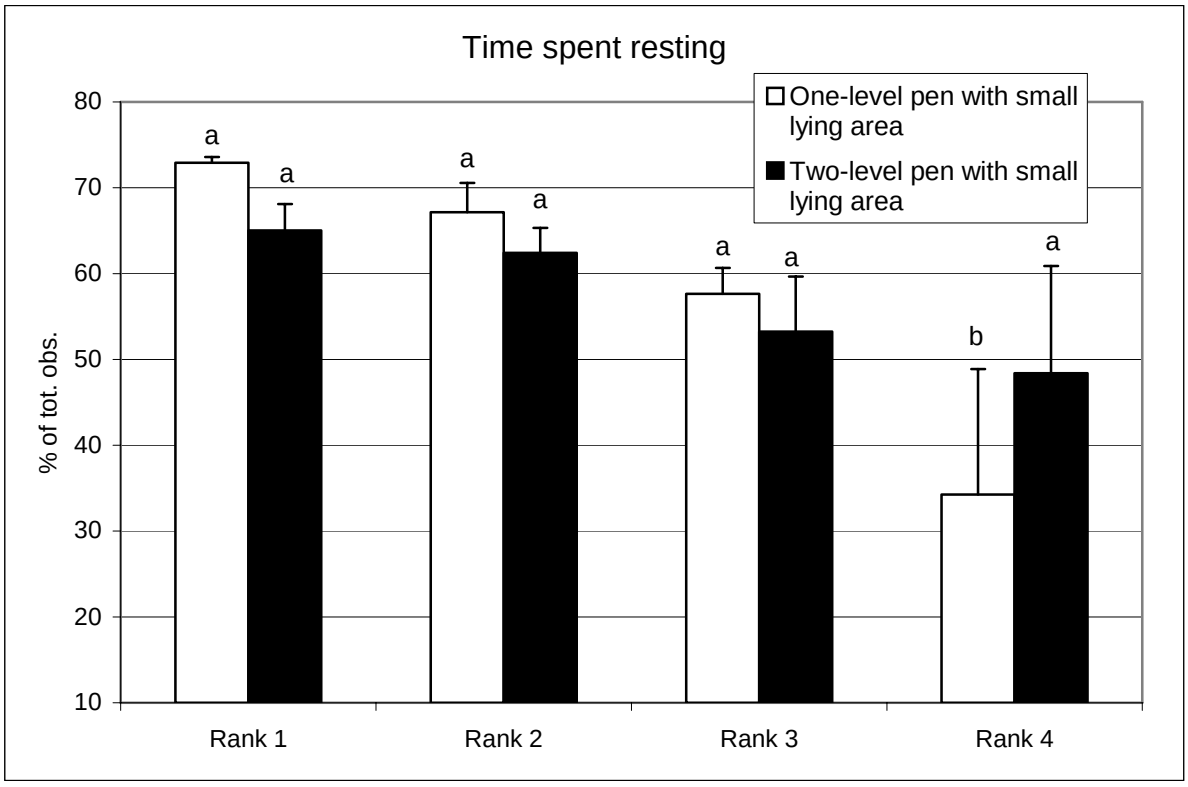
Time spent resting
One-level pen with small lying area
Two-level pen with small lying area
% of tot. obs.
80
70
60
50
40
30
20
10
a
a
a
a
a
a
b
a
Rank 1
Rank 2
Rank 3
Rank 4

Figure 3.

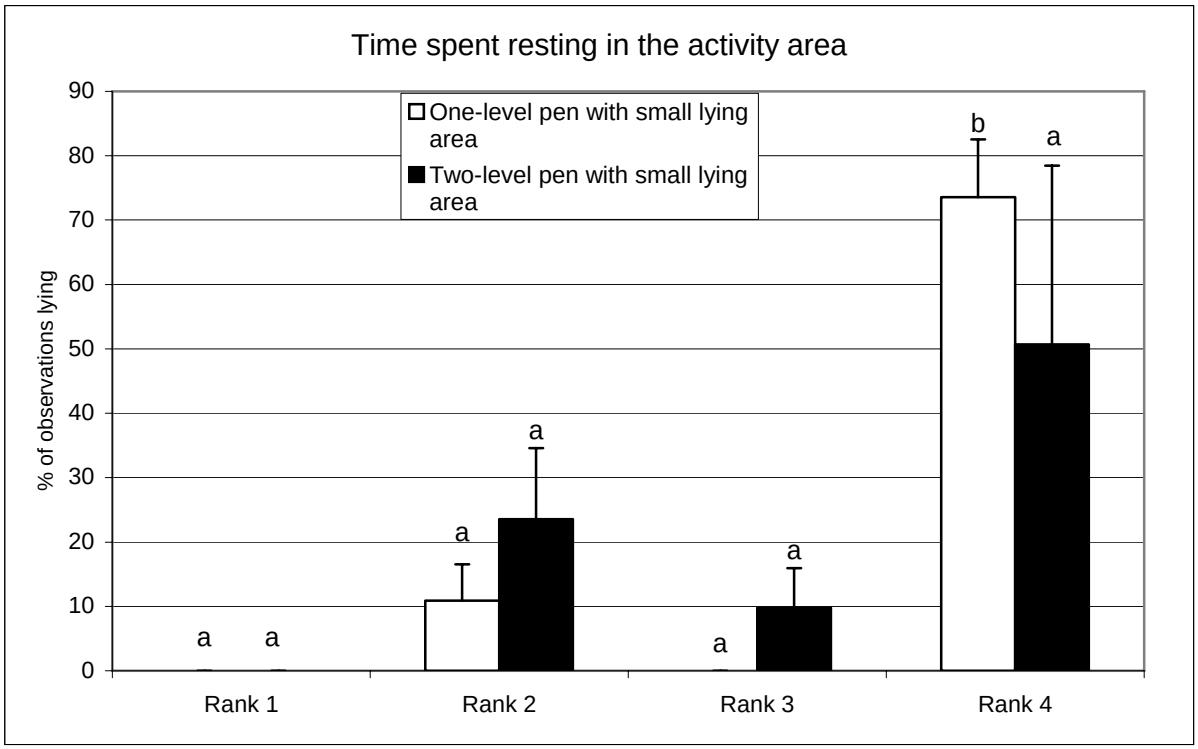
Time spent resting in the activity area
One-level pen with small lying area
Two-level pen with small lying area
% of observations lying
90
80
70
60
50
40
30
20
10
0
a
a
a
a
a
b
a
Rank 1
Rank 2
Rank 3
Rank 4

Figure 4.

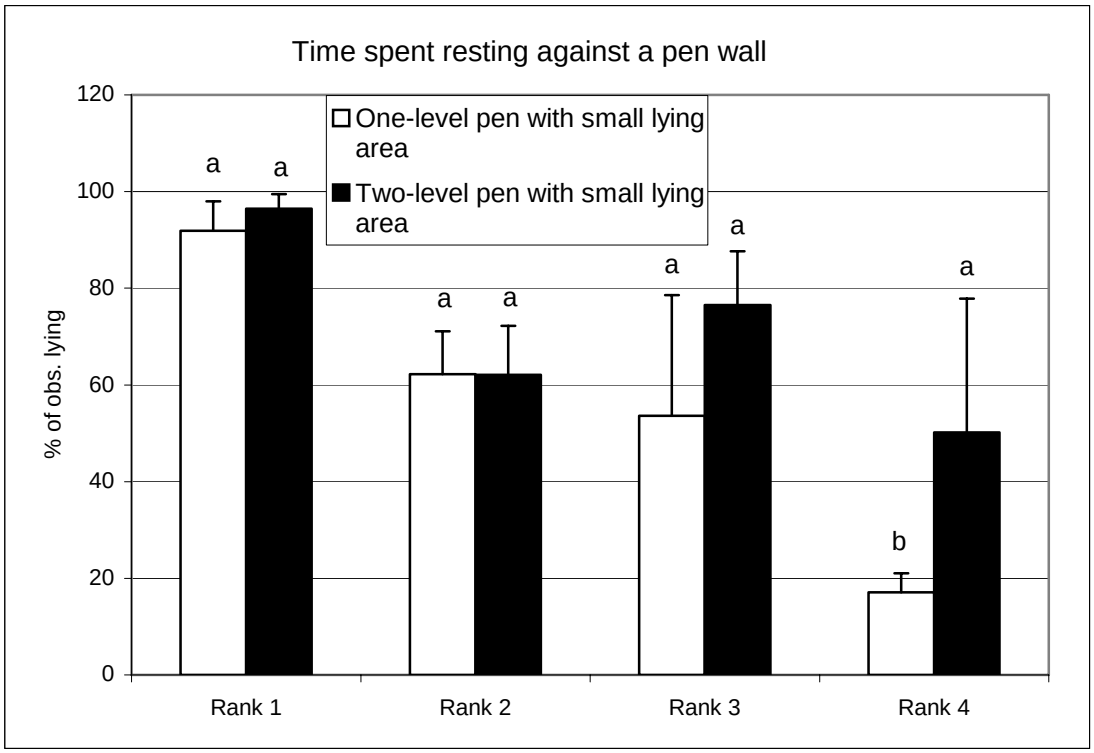
Time spent resting against a pen wall
One-level pen with small lying area
Two-level pen with small lying area
% of obs. lying
120
100
80
60
40
20
0
a
a
a
a
a
a
b
a
Rank 1
Rank 2
Rank 3
Rank 4

Figure 5.