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beat.wechsler@fat.admin.ch

Space requirements of horned and hornless goats

B. Wechsler, C. Loretz, R. Hauser and P. Rüsch

Swiss Federal Veterinary Office, Centre for proper housing of ruminants and pigs, Agroscope FAT Tänikon, 8356 Ettenhausen, Switzerland

Abstract
The behaviour of horned and hornless goats was compared to investigate their space requirements at the feed barrier and in the lying area. Two experiments were carried out with eight groups each of ten females, four groups with and four groups without horns. In experiment 1, the number of feeding places (width 35 cm) was restricted stepwise from an initial 20 to 15 and 10. In experiment 2, the size of the lying area was stepwise reduced from 2.0 m^2 to 1.5 m^2 and 1.0 m^2 per animal.
The distance between the animals at the feed barrier was lower in the experimental condition with only 10 feeding places ($p < 0.002$) and in groups with horned goats ($p < 0.05$). The proportion of time the animals spent feeding decreased significantly with increasing animal/feeding place ratio ($p < 0.001$) and was significantly lower in groups with horned goats ($p < 0.02$). The average distance between lying animals was not influenced neither by the presence of horns nor by the size of the lying area. The proportion of time the goats spent lying decreased significantly with decreasing space allowances ($p < 0.05$), but was not influenced by the presence of horns. It is concluded that the space requirements of horned goats at the feed barrier are higher than those of hornless goats, whereas space requirements in the lying area do not differ between horned and hornless goats.

Introduction
Traditionally, dairy goats were housed individually in tie-stalls in central Europe. Nowadays, they are kept increasingly in loose housing systems with feed barriers, straw-bedded lying areas and milking parlours. In this study, we investigated whether horned and hornless goats differ in their space requirements in a loose housing system.
Most dairy cows kept in loose housing systems are dehorned. With goats, the situation is quite different for several reasons. First, many goat farmers consider the horns to be an important aspect of the animals' appearance, especially with organic farming. Second, disbudding of goats is more difficult than disbudding of calves (Mobini, 1991; Koller, 2000). Third, although there are genetically hornless goats, breeding for completely hornless herds is difficult, as hornlessness in goats has negative effects on fertility (Ricordeau and Lauvergne, 1967). For these reasons, it is usual to keep horned goats in loose housing systems (Steiner and Leimbacher, 1987).
In the present study, we carried out two experiments to compare the space requirements of horned and hornless goats. In the first experiment, we varied the number of feeding places available at the feed barrier. In the second experiment, we investigated the effect of different space allowances in the lying area on the behaviour of the goats.

Methods
Animals and housing conditions
The study was carried out from October to December 2000 with a total of 12 groups of ten female goats kept on three commercial farms (Loretz et al., 2004). All females were in late pregnancy and not lactating. The groups were composed of animals of different breeds (farm A: 16 Saanen goats, 8 Toggenburg goats, 8 Chamois Coloured goats, 4 Peacock goats, 1 Vercasca goat and 3 goats rep-

resenting crossings of these breeds; farm B: 7 Saanen goats, 2 Boer goats and 31 goats representing crossings of these breeds; farm C: 30 Nubian goats, 7 Saanen goats and 3 goats representing crossings of these breeds). The goats were between two and four years old. Before the start of the experiments they were group-housed in pens with a straw-bedded lying area. On each farm, the experimental animals were selected randomly from larger herds and assigned to the study groups at the start of the experiments. During the experiments, all animals were marked individually by means of neck collars as well as dyeing of the fur.
The experiments were carried out in deep litter pens (straw bedding). The goats were fed restrictedly with hay twice a day. Water was offered ad libitum in buckets. In each pen, there was a salt lick. The shape of the pens was slightly different on the three farms.

Experiment 1: space requirements at the feed barrier
Experiment 1 was carried out on farms A and B. On each farm, two groups of ten horned and two groups of ten hornless female goats were observed. On a given farm, one group of horned and one group of hornless animals was observed simultaneously, and the experiment was carried out twice. In the course of the observations, one horned and one hornless goat had to be removed due to health problems.
The total floor area in the pens was kept constant at 1.5 m^2 per animal. Food was offered in racks that were divided in feeding places with a width of 35 cm. Neighbouring feeding places were only separated by iron bars positioned in front of these racks. At intervals of one week, the number of feeding places was reduced stepwise from 20 to 15 and 10. A minimum of ten feeding places (width 35 cm) is required for a group of ten goats according to the Swiss animal welfare legislation. The feeding places were numbered. Behavioural observations started on the fourth day after setting up the experimental conditions and lasted for four days. On each day, the goats were observed directly for two hours each in the morning (between 7:00 and 9:00) and in the afternoon (between 16:30 and 18:30). At the beginning of these observation periods, hay was provided in the racks.
At intervals of 2.5 minutes (scan sampling method; Altmann, 1974), it was noted which animal was feeding at which feeding place. From these data, we calculated the percentage of total observation time each goat spent at the feed barrier (feeding time) as well as the average distance (in number of feeding places) between the animals at the feed barrier. The latter was quantified by first counting the numbers of feeding places between a given focal goat and all other goats present at the feeding rack at the same time and then calculating an average value for each goat over all scan samples. For the analysis, these average values were corrected with regard to the number of feeding places available in a given experimental condition (i.e. divided by 2 and 1.5, respectively, for the experimental conditions with 20 and 15 feeding places).
During the observation periods, all aggressive interactions (displacements with and without body contact) between the goats at the feed barrier were recorded continuously. Over the first three days of data collection, the actor and the receiver of these interactions was noted to determine the dominance hierarchy for each group. In the analysis, the two top ranking animals of each group were classified as high ranking and the two goats at the bottom of the dominance hierarchy as low ranking.

Experiment 2: space requirements in the lying area
Experiment 2 was carried out on farms A and C. As with the previous experiment, two groups of ten horned and two groups of ten hornless female goats were observed on each farm. On farm A, the same four groups were used as in experiment 1.
The animals were fed twice a day. During the feeding periods the animals were locked in a self-locking feed barrier for about 60 minutes. At intervals of one week, the total floor area in the pens was stepwise reduced from 2.0 m^2 to 1.5 m^2 and 1.0 m^2 per animal. A minimum floor area of 1.0 m^2 per goat is required according to the Swiss animal welfare legislation. Behavioural observations

started on the fourth day after each change in the experimental conditions and lasted for three days. The behaviour of the goats was recorded continuously with a time-lapse recorder.

In the analysis, the feeding periods in the morning and in the afternoon (four hours each) were left out, which resulted in 16 hours of observation per day. At intervals of 5 minutes (scan sampling method; Altmann, 1974), the number of animals standing and lying was noted. In addition, the place of lying was recorded for each individual at intervals of 20 minutes. To do so, the location of each goat was assigned to one of eight equally sized sectors in the pen in the experimental condition with 2.0 m^2 per animal. In the conditions with 1.5 m^2 and 1.0 m^2 per animal, there were six and four sectors, respectively. From these data, we calculated the percentage of observation time each goat spent lying as well as the average distance between the animals while lying. The latter was quantified by means of a distance index. Goats lying in the same sector were given a score of zero, goats in adjacent sectors a score of one, goats separated by one sector a score of two, and so on. For each scan, these scores were noted for a given focal goat in relation to all other goats in the group. In a second step, an average score was calculated for each goat over all scan samples. For the analysis, these average scores were corrected with regard to the size of the total floor area available in a given experimental condition (i.e. divided by $\sqrt{2}$ and $\sqrt{1.5}$, respectively, for the experimental conditions with 2.0 m^2 and 1.5 m^2 total floor area per animal). Also at intervals of 20 minutes, it was recorded for each individual whether it was lying with body contact to an other goat or not.

From the video recordings, all aggressive interactions (displacements with and without body contact) between the goats in the lying area were recorded continuously. As with the previous experiment, the actor and the receiver of these interactions was noted over the first three days of data collection to determine the dominance hierarchy for each group. The two top ranking animals of each group were classified as high ranking and the two goats at the bottom of the dominance hierarchy as low ranking.

Statistical analyses

Data were analysed by means of ANOVA. Average values per group were treated as independent observational units. The presence of horns, the number of feeding places (experiment 1) and the space allowances in the lying area (experiment 2) were included as explaining variables into the ANOVA models. Data collected in the different experimental conditions was treated as repeated measurements. Before the analysis, data was checked for farm effects. As no such effects were evident, data was pooled for the analysis.

Results

Experiment 1: space requirements at the feed barrier

The distance between the animals at the feed barrier (corrected for the number of feeding places available) was significantly influenced by the presence of horns ($F_{1,6} = 7.27$; $p < 0.05$; Tab. 1) and by the number of feeding places available ($F_{2,12} = 11.44$; $p < 0.002$). The average distance was markedly lower in the experimental condition with only ten feeding places available, because low ranking animals had to share a feeding place whereas high ranking animals occupied several places. As can be seen from Figure 1a, the effect of the reduction in the number of feeding places on the distance between the animals at the feed barrier was most pronounced in horned low ranking goats.

The proportion of time the animals spent feeding was significantly lower in groups with horned goats ($F_{1,6} = 13.60$; $p < 0.02$; Tab.1) and decreased significantly with increasing animal/feeding place ratio ($F_{2,12} = 28.35$; $p < 0.001$). There was also a significant interaction between the presence of horns and the number of feeding places available ($F_{2,12} = 5.07$; $p < 0.03$). Again, the effects were most pronounced in horned low ranking goats (Fig. 1b). With the high ranking goats, the proportion of time spent feeding was constant over the experimental conditions, irrespective of the presence of horns. The rate of aggressive interactions at the feed barrier was not significantly affected by the presence of horns ($F_{1,6} = 0.02$; n.s.) or by the number of feeding places available ($F_{2,12} = 3.11$; n.s.).

Table 1: Effects of the number of feeding places available and the presence of horns on the average distance between the goats at the feed barrier (number of feeding places between the animals), the proportion of observation time spent feeding (%) and the rate of aggressive interactions (per hour and per individual). Average values (n = 8 groups) are presented.

Behavioural parameter	Horned			Hornless			*P*-values		
	Number of feeding places						Presence of horns	Feeding places	Interaction
	20	15	10	20	15	10			
Distance between animals	2.5	2.5	2.0	2.8	2.8	2.6	< 0.05	< 0.002	n.s.
Time spent feeding	76.5	72.8	58.0	84.0	83.5	76.8	< 0.02	< 0.001	< 0.03
Aggressive interactions	2.1	2.4	1.9	1.8	2.3	2.0	n.s.	n.s.	n.s.

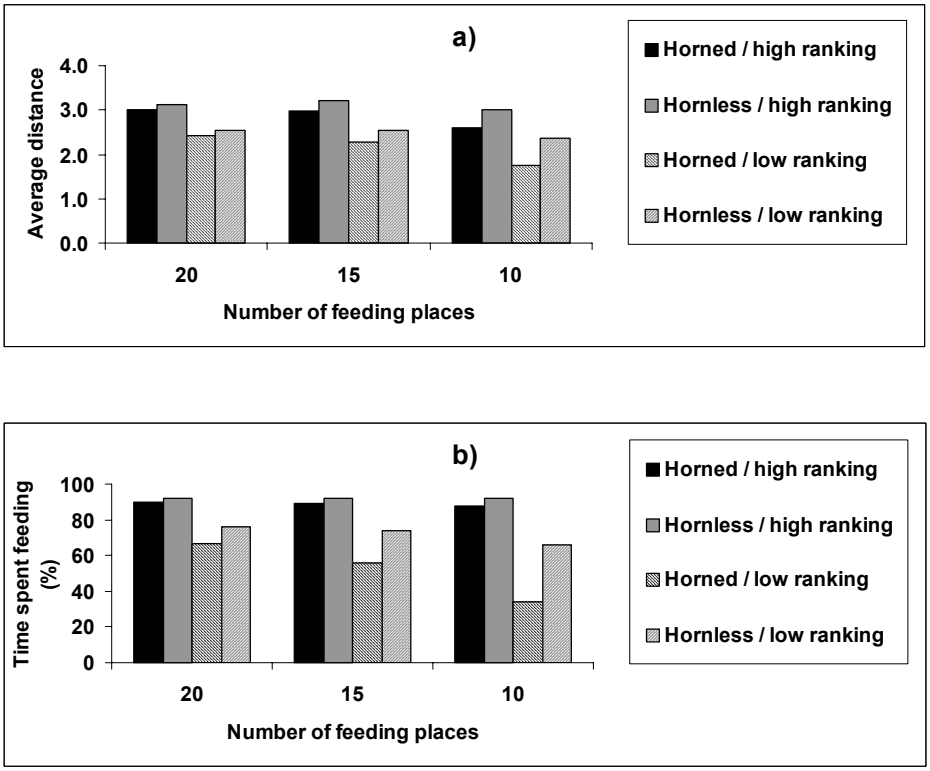

Figure 1: Effects of the number of feeding places available and the presence of horns on (a) the average distance between the animals (number of feeding places between the animals) at the feed barrier and (b) the proportion of observation time spent feeding. Average values (n = 8 groups) are presented for high and low ranking goats.

Experiment 2: space requirements in the lying area

Neither the presence of horns ($F_{1,6}$ = 0.02; n.s.; Tab. 2) nor the size of the total pen area ($F_{2,12}$ = 1.81; n.s.) had significant effects on the distance between the lying animals (corrected for the total floor area available). As can be seen from Figure 2a, the average distance was lowest in hornless low ranking goats kept at a space allowance of 1.0 m^2 per animal.

Table 2: Effects of the size of the total pen floor area (m2 per animal) and the presence of horns on the average distance between lying goats (distance index, see Methods), the proportion of observation time spent lying (%) and the rate of aggressive interactions (per hour and per individual). Average values (n = 8 groups) are presented.

Behavioural parameter	Horned			Hornless			*P*-values		
	Pen floor area per animal						Presence of horns	Floor area	Interaction
	2 m^2	1.5 m^2	1 m^2	2 m^2	1.5 m^2	1 m^2			
Distance between animals	0.8	0.8	0.7	0.8	0.8	0.7	n.s.	n.s.	n.s.
Time spent lying	72.5	79.6	66.8	76.2	74.5	70.5	n.s.	< 0.05	n.s.
Aggressive interactions	0.4	0.4	0.5	0.2	0.3	0.4	n.s.	n.s.	n.s.

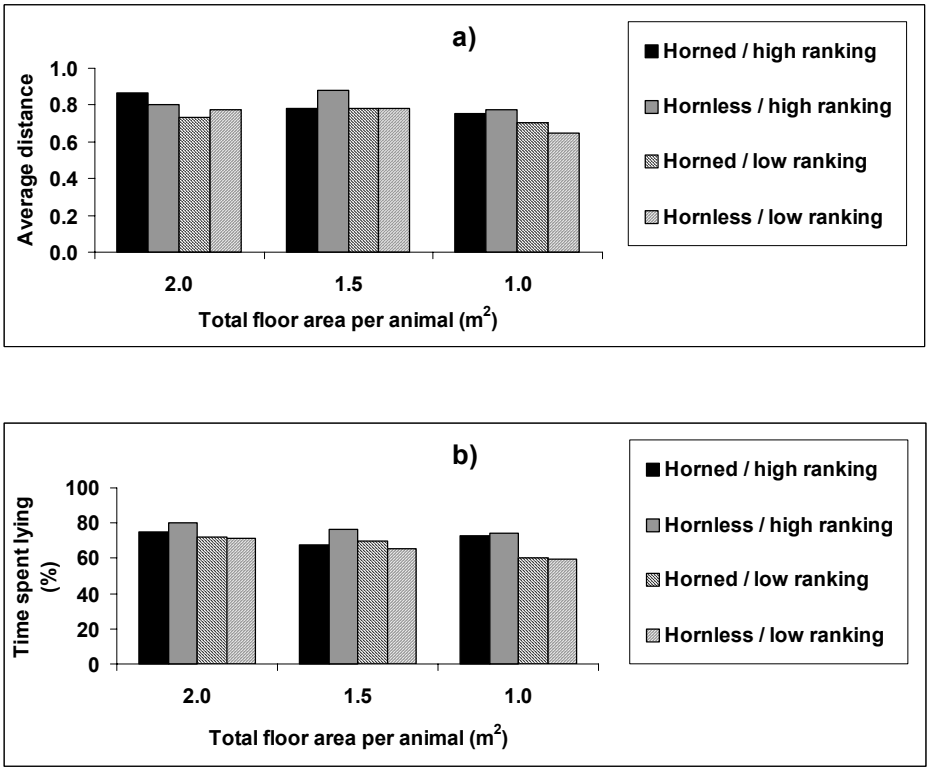

Figure 2: Effects of the size of the total pen floor area (m2 per animal) and the presence of horns on (a) the average distance between lying animals (distance index, see Methods) and (b) the proportion of time spent lying. Average values (n = 8 groups) are presented for high and low ranking goats.

The proportion of time the animals spent lying was not significantly influenced by the presence of horns ($F_{1,6} = 1.79$; n.s.; Tab. 2), but decreased significantly with decreasing space allowances ($F_{2,12} = 4.05$; $p < 0.05$). In the experimental condition with 1.0 m^2 per animal, low ranking goats spent less time lying than high ranking goats, irrespective of the presence of horns (Fig. 2b). Neither the presence of horns ($F_{1,6} = 1.67$; n.s.) nor the space allowances ($F_{2,12} = 1.90$; n.s.) had a statistically significant effect on the percentage of goats lying with body contact to an other goat. On average, 37.0% of the horned and 23.4% of the hornless goats lay with body contact to an other goat. The

rate of aggressive interactions in the lying area was also not significantly affected by the space allowances ($F_{2,12} = 2.30$; n.s.) or by the presence of horns ($F_{1,6} = 0.91$; n.s.).

Discussion

The reduction in the number of feeding places available (experiment 1) had marked effects on the behaviour of the goats, especially in horned low ranking animals. Both the average distance between the animals at the feed barrier (corrected for the number of feeding places available) and the proportion of time spent feeding decreased significantly with the reduction in space at the feed barrier. Low ranking horned animals had to share feeding places, and they may not have had sufficient access to feed in the experimental condition with only ten feeding places (width 35 cm). In the longer term, this could lead to a reduction in body weight and milk production. In the present study, body weight generally increased over the study period as the females observed were in late pregnancy. However, these increases were lowest in low ranking horned goats (Loretz, 2003). Effects of the reduction in feeding places on milk yield could not be assessed because the experimental animals were not lactating. With goats in late pregnancy, insufficient feed intake could also result in hypocalcaemia or ketosis.

Imhof (1988), Toussaint (1997) as well as Gall (2001) recommended a minimum space allowance of 40 cm per animal at the feed barrier, whereas Steiner and Leimbacher (1987) suggested a minimum of 35 to 40 cm per animal. None of these experts made, however, a difference between the space requirements for horned and hornless goats. Given the results of our study, more space should be provided for horned goats to prevent negative effects of high competition for access to the feed in low ranking animals.

Irrespective of the presence of horns, both the average distance between the animals and the proportion of time spent feeding were quite similar in the experimental conditions with 20 and 15 feeding places available, but markedly decreased when the number of feeding places was further reduced to ten. A minimum of 50 cm per animal may thus be adequate for hornless goats, if these are fed restrictedly and not locked in the feed barrier during feeding periods. With horned goats, the space requirements seem to be even higher. In our study, the average proportion of observation time the horned animals spent feeding in the experimental condition with 20 feeding places (70 cm per animal) amounted to 76.5%, which was similar to the average proportion of time the hornless goats spent feeding when only 10 feeding places (35 cm per animal) were available (76.8%).

The reduction in the space allowances in the lying area (experiment 2) resulted in a decrease in the proportion of time spent lying, irrespective of the presence of horns. This effect was most pronounced when the size of the pen floor area was reduced from 1.5 to 1.0 m^2 per animal. Toussaint (1997) recommended a minimum indoor floor area of 1.5 m^2 per animal in open housing with an outside yard, whereas Steiner and Leimbacher (1987) and Imhof (1988) suggested a minimum floor area of 1.0-1.2 m^2 and 1.3-1.7 m^2 per animal, respectively, for deep litter systems without additional feeding area or outside yard. Gall (2001) also recommended a lying area size of 1.5 m^2 per animal, and Toussaint (1985) reported lying area sizes ranging from 1.6 to 1.75 m^2 per animal in his survey of housing conditions on eight dairy goat farms in France. With all these recommendations found in the literature, no difference was made between space requirements of horned and hornless goats.

In both experiments, neither the reduction in space allowances nor the presence of horns had statistically significant effects on the rate of aggressive interactions. Keil and Sambraus (1996) comparing the social behaviour in two dairy goat herds, one with horned and one with hornless animals, reported that horned low ranking animals avoid aggressive interactions involving body contact by making way upon the approach of a higher ranking animal. This may explain why the reduction in space allowances in our experiments did not result in increased rates of aggressive interactions in groups of horned goats.

It should be considered that the study was done with female goats in late pregnancy. It is thus possible that different results would be obtained if the experiments were carried out with young goats

or lactating females. Similarly, the space allowances at the feeding place and in the lying area were reduced over time in both experiments. A different order of the experimental conditions (e.g. increasing the space allowances over time) could have had an influence on the results.

In conclusion, our results show that the space requirements of horned goats at the feed barrier are markedly higher than those of hornless goats. On the other hand, space requirements in the lying area did not differ significantly between horned and hornless goats. It should, however, be considered that our experimental groups were relatively small. Space requirements per animal may be different, both at the feed barrier and in the lying area, if goats are kept in larger groups.

Acknowledgements

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