The effect of shape, width and slope of a resting platform on resting behaviour and floor cleanliness for housed sheep

Grete Helen Meisfjord Jørgensen & Knut Egil Bøe

Norwegian University of Life Sciences, Department of Animal and Aquacultural Sciences, P.O. Box 5003, 1432 Ås, Norway

Corresponding author: Grete Helen Meisfjord Jørgensen, (grete.meisfjord@umb.no, telephone: +47 64965142, fax: +47 64965101)

Abstract

The aim of this experiment was to investigate how shape (U-shaped, L-shaped or platform both in front and back (FB-shaped) of the pen), width (0.5 or 0.6 m) and slope (0, 5 or 10%) of a solid wooden resting platform together with cleaning frequency (daily or every second day) would affect resting behaviour in ewes and floor cleanliness. The experiment was conducted in three different commercial farms in Norway, within each herd, two of the factors were tested in a 2 x 2 factorial design using four experimental pens, while the effect of cleaning frequency (daily or every other day) was replicated within herd using four additional experimental pens (eight experimental pens within each herd). Ewes were systematically rotated between pens within herds and the ewes' resting behaviour was scored the last six days of each experimental period. The manure on the solid resting platforms was collected and weighed while moisture on the surface of the resting platforms was scored the two last days of each experimental period.

In all herds, significantly more sheep were observed resting in pens with FB-shaped resting platforms than in pens with U- or L-shaped platforms (P<0.0001). A reduced time on resting platforms was mainly compensated by an increase in number of sheep lying on the slatted floor and partly by an increase in the number of sheep standing. An effective perimeter length (EPL) of minimum 0.9 m/ewe was necessary to enable all sheep to rest simultaneously on the resting platform. Increasing the slope of the resting platform had no effect on the resting behaviour, but decreasing the width of the platforms resulted in more ewes resting on the original pen floor (P<0.01). A slope of 5 % resulted in a significantly lower amount of manure (P<0.0001) and a lower moisture score (P<0.0001). In two of the herds, cleaning out every second day increased the amount of manure (P<0.01), but not the moisture score.

In conclusion, FB-shaped resting platforms of solid wood may be a relatively cheap and convenient way of increasing the resting time and comfort of sheep housed in fully slatted floor pens, as long as there is sufficient effective perimeter length available.

Keywords: effective perimeter length; ewes; fully slatted floor; group housing; pen.

Introduction

In Nordic countries (Robinson, 1981), Canada (Canada plan service, 1981) and parts of the USA (Outhouse, 1981) sheep are kept indoors during winter, and then often housed in pens with fully slatted floors and with a space allowance of 0.7 - 0.9 m^2 per animal (Bøe and Simensen, 2003). In contrast to conventional sheep production, regulations for organic sheep farming (Council Regulation (EC) No. 1804/1999) demand a resting area with solid floor. Earlier experiments show that unsheared sheep have no particular preference for floor type for resting (Bøe, 1990; Færevik et al. 2005), but that sheared sheep however, show a very clear preference for resting on flooring materials with low heat conductivity (e.g. straw, solid wood or rubber mattresses) (Færevik et al. 2005). As the availability of bedding material is often scarce in some Nordic countries, installing resting platforms made of solid wood in the slatted floor pens can be a convenient and cheap alternative in order to improve the animals' resting comfort. However, because of the low total space allowance in the pens, the available space for such resting platforms is limited.

Marsden and Wood-Gush (1986) found that next after feed, limited lying space caused most of the displacements in sheep. A reduction in resting space from 1.0 to 0.5 m^2 /ewe not only resulted in increased number of displacements but total resting time and resting synchrony was also reduced (Bøe et al. 2006). Both sheep and goats have shown a clear preference for lying against a wall when resting (sheep: Marsden and Wood-Gush, 1986; Færevik et al. 2005; goats: Andersen and Bøe, 2007). Hence, when considering the lay-out of resting platforms, maximizing the perimeter length is important to ensure attractive lying space for the sheep. Size as well as shape of the pen affects the wall perimeter available (Bøe et al. 2006) and the ratio of perimeter to area decreases as group and pen size increases (Stricklin et al. 1995). In an effort to create not only a visual barrier but also increasing the accessible wall length to lie against when resting, Jørgensen et al. (2009) installed additional walls on the resting area for ewes (actually increasing the perimeter length). However, this measure did not prove to be successful in increasing the resting time, presumably because these walls also gave some individuals the possibility to block off access to the resting area.

As sheep do not seem to have specific dunging areas, the hygiene and cleanliness is a major challenge when introducing solid floor areas. Studies on cattle suggest that the design of the lying area influence the cleanliness of the animals (e.g. Herlin et al. 1994; Zurbrigg et al., 2005), and that the cleanliness again affect claw (e.g. Bergsten & Petterson, 1992) and udder health (e.g. Schreiner & Ruegg, 2003). Although cattle seem to actively avoid surfaces covered with excreta (Phillips & Morris, 2002), we do not know if sheep behave in a similar way. A slope (between 2 and 5 %) on the solid floor is both recommended and used in pens for pigs (e.g. Anonymous, 1993) and stalls for cattle (e.g. Anonymous, 2005) in order to drain off urine. Interestingly, there seem to be few scientific papers supporting these slope recommendations (Ye et al., 2007), and knowledge on how different levels of slope affect floor cleanliness is thus needed.

The aim of this experiment was to investigate how shape (U-shaped, L-shaped or front and back (FB-shaped)), width (0.5 or 0.6 m) and slope (0, 5 or 10%) of a solid resting area together with cleaning frequency (daily or every other day) would affect resting behaviour in ewes and floor cleanliness.

Materials and methods

2.1 Experimental design

This field experiment was conducted in three private farms with organic sheep production in the western region of Norway, from January to March 2004.

The following factors were tested in our study:

1. Shape of the resting area (U-shaped (U), L-shaped (L) or both at the back and the front of the pen (FB-shaped).
2. Width of the resting platform (0.50 m or 0.60 m)
3. Slope of the resting platform (0 % or 5 % slope)
4. Cleaning interval (daily or every second day).

In each herd, two of these factors (1-3) were tested in a 2 x 2 factorial design (Latin square) using four experimental pens (Figures 1-3), and the same set-up was replicated within herd so that the resting areas in the first four experimental pens were cleaned out daily while the resting areas in other four pens were cleaned out every second day. Furthermore, within each herd and cleanliness treatment the ewes were systematically rotated between the four pens so that all groups were observed in each of the four experimental pens. Each experimental period lasted for 14 days, giving a total duration of eight weeks.

2.2 Animals, pens and feeding

Two of the herds consisted of the breed Spælsau, a native light Norwegian breed mainly used for wool production. The last herd consisted of Norwegian white sheep, a relatively heavy breed selected for meat production (Table 1). All sheep were pregnant and unshorn during the experiment. Space allowance varied from 0.85 to 0.98 m^2 per ewe. In two herds the pen floor consisted of expanded metal, whereas the last herd had wooden slatted floors (Table 1).

Table 1. Information on management, sheep breeds and pen treatments.

Herd	**A**	**B**	**C**
Sheep breed	Norwegian white	Spælsheep	Spælsheep
Number of animals per pen	9	9	8
Pen size (m)	3.60 x 2.00	3.60 x 2.45	3.60 x 2.00
Area/animal (m^2)	0.80	0.98	0.90
Pen flooring	Exp. Metal.	Wooden slats	Exp. metal
Roughage type	Predried silage	Hay	Silage

The resting platforms were 5.0 cm high and made of solid wood boards placed directly on top of the existing pen floor. We defined 'effective perimeter length' (EPL) as the length of accessible walls along the resting platform that sheep could lean against when resting.

In herd A the shape (resting platform both in front and in the back of the pen (FB) vs. U-shaped) and slope (5 % vs. 0 %) of the resting platform was investigated (Figure 1), while the width of the platforms were kept at 0.60 m. The perimeter length was 0.80 m and 0.49 m per ewe in pens with FB- and U-shaped resting platforms respectively. An automatic drinking vessel was located in each pen, on the side wall close to the feed barrier.

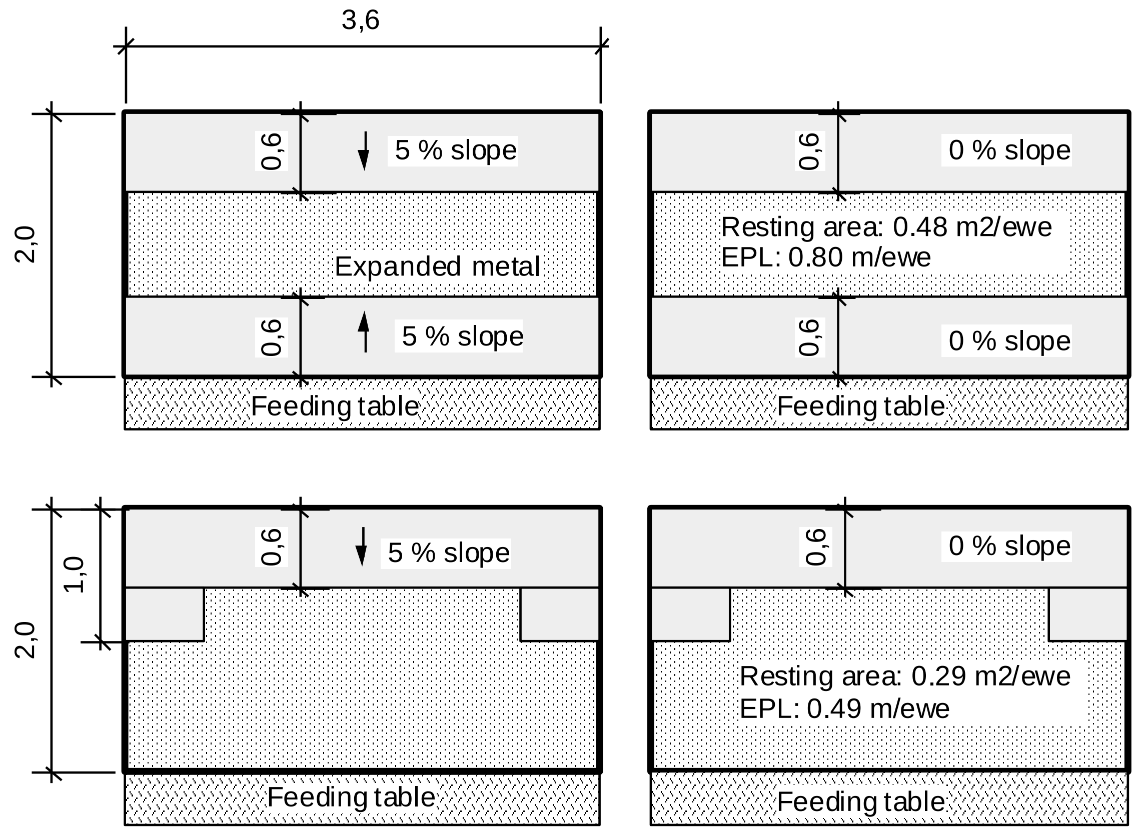

Figure 1. Shape, slope and width of the solid resting area in herd A.

In herd B the shape (FB-shaped vs. U-shaped) and width (0.5 m vs. 0.6 m) of the resting platform was investigated (Figure 2). The slope of the resting area was 5 % in all pens, and the perimeter length was 0.80 and 0.72 m per ewe respectively. Two nipple drinkers were located at the rear pen wall.

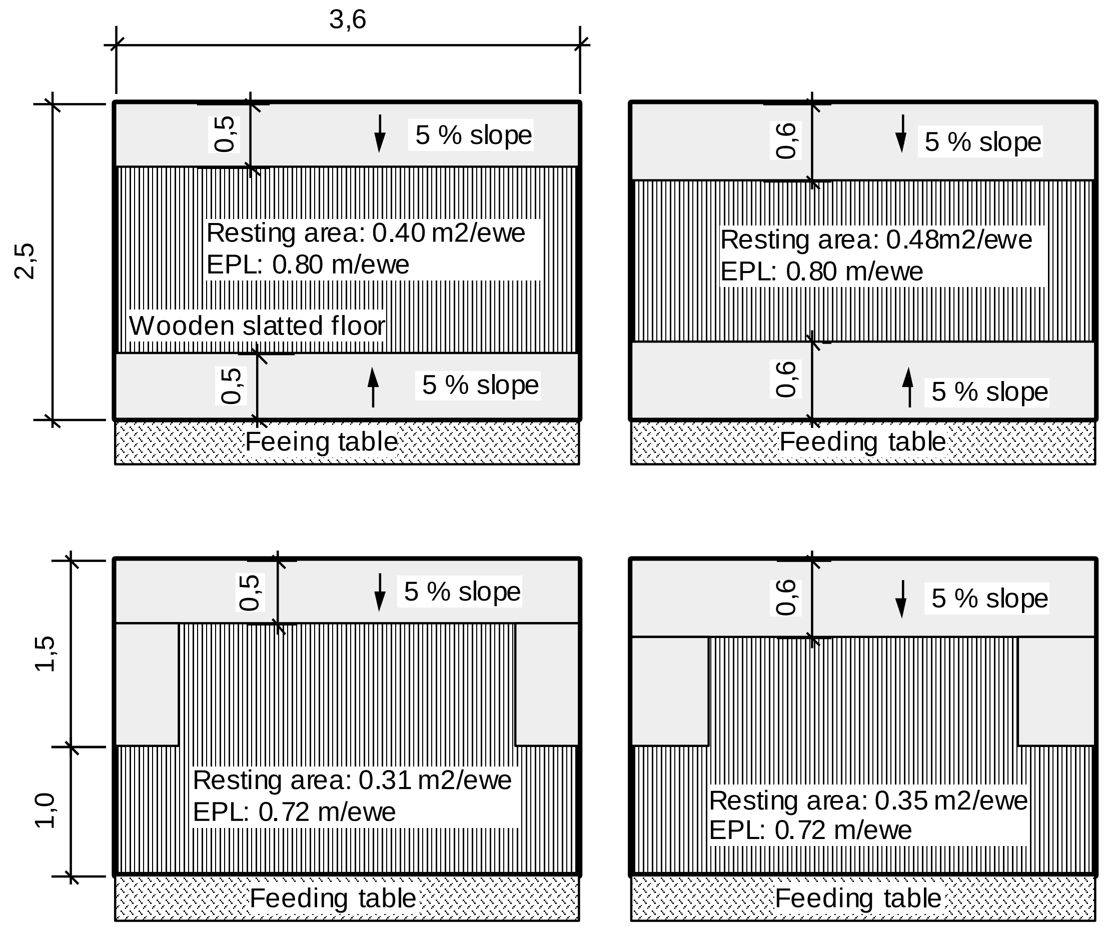

Figure 2. Shape, slope and width of the solid resting area in herd B.

In herd C the shape (FB-shaped vs. L-shaped) and width (0.5 m vs. 0.6 m) of the resting platform was investigated (Figure 3). The slope of the resting areas was 10 % in all pens, and the perimeter length was 0.90 and 0.64 m per ewe respectively. One automatic drinking vessel was located on the side wall of each pen.

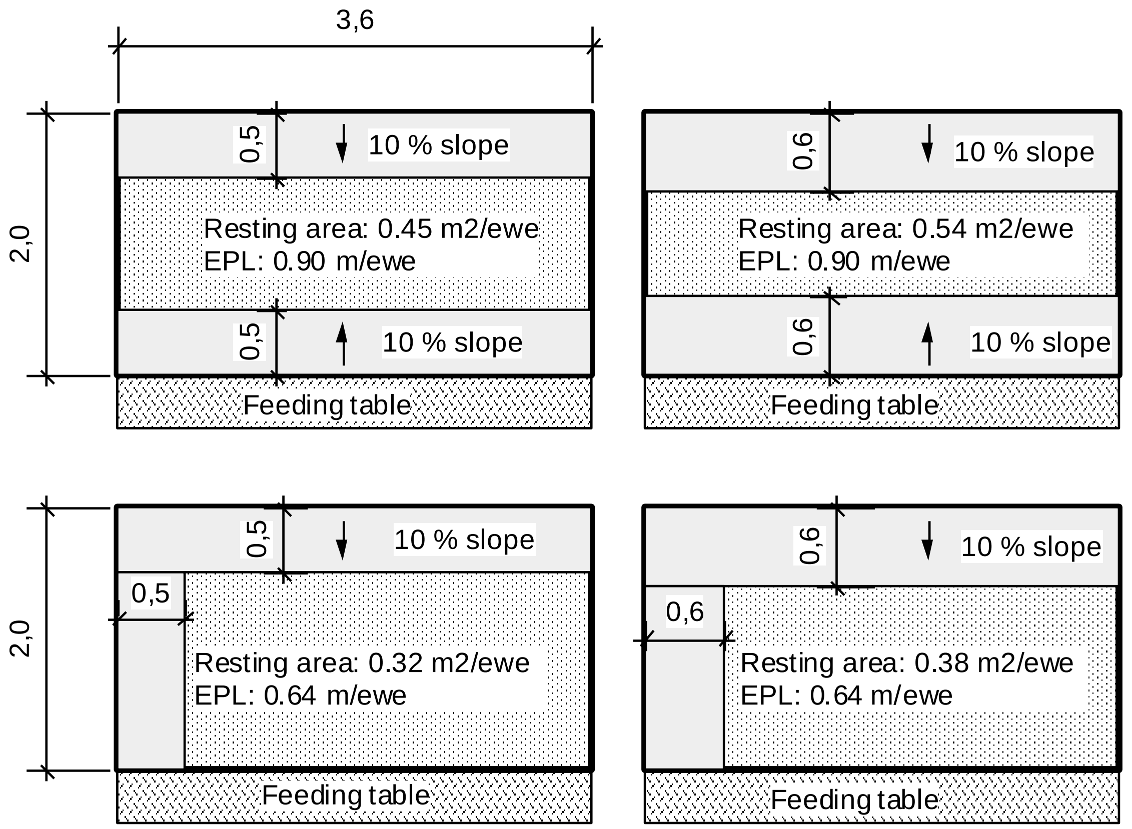

Figure 3. Shape, slope and width of the solid resting area in herd C.

2.3 Behavioural observations

Every day for the six last days of each experimental period, the ewes' resting behaviour within each of the eight experimental pens were scored by the farmer, on a quiet time of the day when the sheep were supposed to be resting (herd A: 1200 hours; herd B: 1200-1300 hours; herd C: 2200-2300 hours). The following parameters were scored:

- Number of sheep resting on the resting area

- Number of sheep resting partially on the resting area

- Number of sheep resting outside the resting area

- Number of sheep standing

2.4 Cleanliness

Every morning for the two last days of each experimental period all manure on the resting area was carefully collected into a container and weighed on an electronic balance. In addition, moisture on the surface of the resting area was scored using the following categories: 1) dry or only small spots are wet, 2) < 1/3 of the resting area is wet, 3) 1/3 ~ 50 % of the resting area is wet and 4) > 50 % of the resting area is wet.

2.5 Statistical analysis

In order to test the effects of resting area treatments on sheep resting behaviour and resting area cleanliness within each herd, we applied a mixed model of analysis of variance with shape of resting area (U-, L- or front and back), slope (0 % or 5 % - only herd A), width (0.5 or 0.6 m – only herd B and C) and cleaning frequency (daily or every other day) as class variables. Since groups of sheep were systematically rotated between treatment pens within herds we specified Group as a random effect (Hatcher and Stephanski, 1994). In addition, we tested for the following interaction effects: shape*width (or slope), cleaning frequency*shape and cleaning frequency*width (or slope).

Differences in resting behaviour and resting area cleanliness between the front and the back resting areas in pens with FB-shape were tested using a two-tailed t-test.

Effects of resting area treatments on moisture scores were analyzed using contingency analysis of moisture scores by shape, slope or cleaning frequencies within herds, with Pearsons Chi-square tests in the JMP® 7.0 software from SAS Inc.

Data are presented in means and standard errors (SE) from eight groups per herd.

3. Results

3.1 Resting behaviour

In all herds, the number of sheep resting on the platforms was significantly higher in pens with the FB-shaped platforms than in the U- or L-shaped platforms (Table 2). A reduced resting time in the other resting platform shapes was mainly compensated by an increase in number of sheep lying on the slatted floor and partly by an increase in the number of sheep standing. In herd B the number of sheep lying partially on the platform and standing was higher in pens with U-shaped platforms than FB-shaped resting platforms, whereas the opposite occurred with L-shaped platforms in herd C. The number of sheep standing was generally much higher in herd C than in herds A and B.

Table 2. Resting behaviour of the sheep in relation to shape of the resting areas.

Means ± S.E. % of total observations	**Herd A**				**Herd B**				**Herd C**			
	U-shape	**FB-shape**	$F_{1,24}$	***P*-value**	**U-shape**	**FB-shape**	$F_{1,24}$	***P*-value**	**L- shape**	**FB-shape**	$F_{1,24}$	***P*-value**
Lying on the resting area	34.0 ± 0.9	56.4 ± 0.8	284.0	<0.0001	29.9 ± 1.1	44.7 ± 1.2	78.1	<0.0001	32.0 ± 1.5	49.0 ± 2.1	54.4	<0.0001
Lying partially on the resting area	7.5 ± 1.2	7.5 ± 1.0	0.0	ns	5.9 ± 1.1	1.4 ± 0.4	16.3	<0.001	0.9 ± 0.4	6.3 ± 1.2	22.8	<0.0001
Lying on the original pen floor	40.3 ± 2.0	20.7 ± 1.6	83.0	<0.0001	53.8 ± 0.8	47.2 ± 1.0	32.8	<0.0001	18.0 ± 1.9	3.2 ± 0.7	47.7	<0.0001
Standing	18.1 ± 2.1	15.2 ± 1.0	1.5	ns	10.3 ± 0.7	6.7 ± 0.9	12.7	<0.01	49.2 ± 3.1	41.3 ± 2.8	5.1	<0.05
*Maximum number of animals observed lying on the resting area	5	8			5	6			5	8		
EPL in % of probable need 0.9 m per animal	54 %	88 %			80 %	88 %			71 %	100 %		
*Theoretical maximal number of animals able to lie in the resting area simultaneously	4.86 **~5**	7.92 **~8**			7.20 **~7**	7.92 **~8**			5.68 **~5**	8.00 **~8**		

*Measure given in number of animals and not in % of total observations. Herd A and B had 9 ewes per group while herd C had 8 ewes per group.

In all herds, the maximum number of sheep observed lying on the resting platforms was higher in the pens with FB-shaped platforms than in pens with U- or L-shaped platforms (Table 2). The only treatment where all group members were observed to lie simultaneously on the resting platforms were in pens with FB-shaped platforms within herd C where the EPL was 0.9 m/ewe. The theoretical maximum number of sheep resting on the platforms was then calculated using the EPL of 0.9 m/ewe for the different treatments of shape of resting area. As can be seen in Table 2, the actual maximum number of sheep resting simultaneously on the resting platforms and the calculated maximum number of sheep being able to lie simultaneously was nearly identical in herds A and C, but somewhat lower in herd B.

In herds A and C, the sheep seemed to distribute themselves evenly between the front and the back platforms in pens with FB-shaped resting areas (herd A, mean ± SE: 28.6 ± 1.4 % vs. 27.9 ± 0.5 %; herd C: 25.4 ± 1.4 % vs. 23.7 ± 1.1 %), whereas in herd B the ewes seemed to have a preference for lying on the resting area in front of the pen (27.8 ± 0.7 % vs. 16.9 ± 0.4 %, T=2.0, P<0.0001).

More ewes rested on the original pen floor in pens with narrow resting areas compared to in pens with 10 cm wider resting areas in herd B (52.1 ± 1.3 vs. 48.9 ± 1.1 %, $F_{1,24}$=7.4, P<0.05), but no such effect was found in herd C.

In herd A, no effects of slope on resting behaviours were discovered, but a significant interaction effect between shape and slope of the resting area was found ($F_{1,24}$=5.6, P<0.05). More sheep were resting partially on the resting area with 5 % slope compared to 0 % slope in pens with FB-shaped resting platforms (10.1 ± 1.0 % vs.5.0 ± 1.8 %,), whereas the opposite occurred in pens with U-shaped platforms (6.9 ± 1.7 % vs. 8.2 ± 1.8 %). No interaction effects of shape and slope were found in any other herds.

More ewes were resting on the original pen floors in herd B in pens where the resting areas were cleaned out daily compared to in pens where the resting areas were cleaned out only every second day (52.8 ± 1.2 % vs. 48.9 ± 1.3 %, $F_{1,24}$=7.4, P<0.05), but cleaning frequency had no effect on resting behaviour in herds A or C.

No significant interaction effects between cleaning frequency and shape, width or slope were discovered for the different resting behaviours.

3.2 Floor cleanliness

The amount of manure per m^2 of resting area was significantly lower on FB-shaped platforms than on the U-shaped and L-shaped platforms in herd B and C, but this effect was not found in herd A (Figure 4). Generally the amount of manure was much higher in herd B, especially on the U-shaped resting area. The manure in all FB-shaped pens was quite evenly distributed between the front and rear resting platforms.

Resting area shape also affected the mean moisture score in herd B, where U-shaped resting platforms had higher moisture scores than FB-shaped resting platforms, but this difference was not significant in herd A and only showed a tendency in herd C (Table 3).

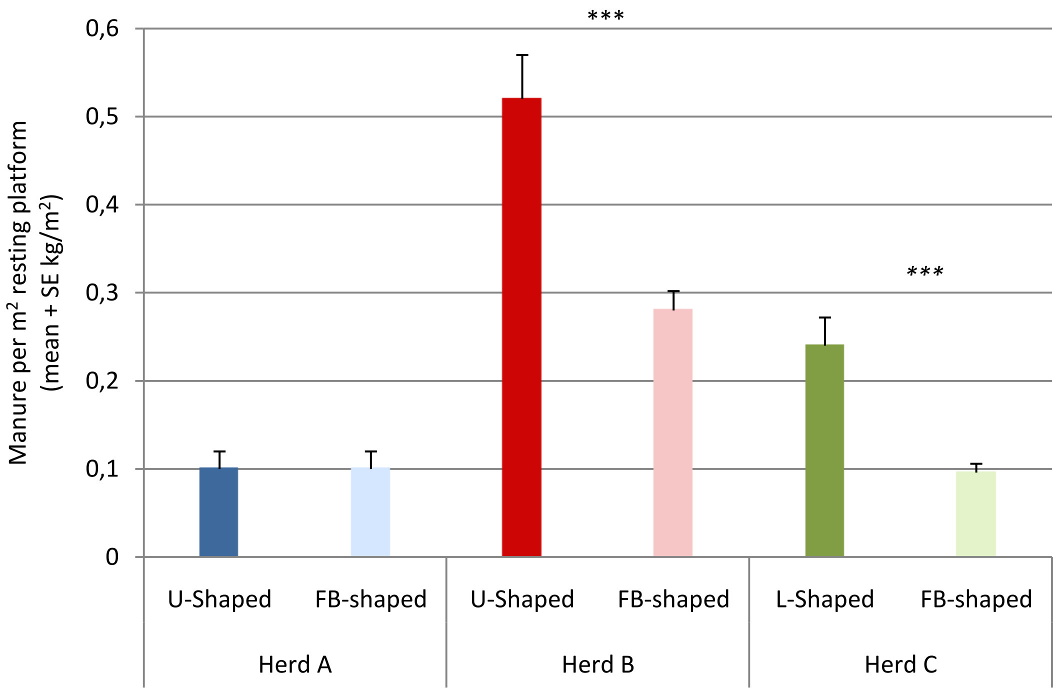

Figure 4. Amount of manure gathered in relation to resting platform shapes ($^{***}P$<0.0001).

In general, most observations were scored using moisture category 1, except in pens with U-shaped resting areas within herd B where category 3 was scored the most (Table 3).

In herd A a floor slope of 5 % resulted in a significantly lower amount of manure than no slope (0.03 ± 0.006 kg/m^2 vs. 0.2 ± 0.02 kg/m^2, $F_{1,24}$= 69.2, P< 0.0001) and a significantly reduced mean moisture score (0 % slope: 1.8 ± 0.2 vs. 5 % slope: 0.8 ± 0.03, $X^2_{1,32}$= , P<0.01). Only in herd B increasing the width of the resting platform resulted in a significantly higher amount of manure gathered (0.5 ± 0.05 kg/m^2 vs. 0.3 ± 0.05 kg/m^2, $F_{1,24}$= 10.2, P< 0.01). Width of the resting platforms did however not affect moisture scores in herds B or C (herd B: 0.50 m: 2.8 ± 0.05 vs. 0.60 m: 2.9 ± 0.2; herd C: 0.50 m: 1.2 ± 0.2 vs. 0.60 m: 1.3 ± 0.2), and no interaction effects between width and slope were discovered. Cleaning every second day increased the amount of manure on the floor compared to cleaning out every day both in herd B (0.5 ± 0.06 vs. 0.3 ± 0.02 kg/m^2, $F_{1,24}$=33.2, P< 0.0001) and in herd C (0.2 ± 0.03 vs. 0.1 ± 0.01 kg/m^2, $F_{1,24}$=22.6, P< 0.0001) but no such effect was found in herd A.

Table 3. Distribution of moisture score and means in relation to resting area shape within herds (frequency in % of total observations).

	Resting area shape	***Moisture score (frequency in % of tot obs)***				***Differences between shapes***		**Mean moisture score ± SE**
Herd		**1**	**2**	**3**	**4**	$\mathbf{X^2_{1,62}}$	***P*-value**	
A	U	71.8	18.7	6.3	3.13	5.0	ns	1.2 ± 0.3
	FB	62.5	25.0	12.5	0.0			1.2 ± 0.3
B	U	0.0	12.5	84.4	3.1	36.3	<0.0001	2.9 ± 0.08
	FB	46.8	12.5	34.9	6.3			2.0 ± 0.1
C	L	68.7	28.1	3.1	0.0	4.9	0.08	0.9 ± 0.5
	FB	95.3	4.7	0.0	0.0			1.1 ± 0.1

In both herds B ($F_{1,24}$=20.7, P<0.0001) and C ($F_{1,24}$=8.4, P<0.01), a significant interaction effect between shape and cleaning frequency of the resting platform was found for the amount of manure gathered. More manure was found on U-shaped (0.7 ± 0.05 vs. 0.3 ± 0.03 kg /m^2) and L-shaped resting platforms (0.33 ± 0.03 vs. 0.1 ± 0.02 kg/m^2) when these pens were cleaned out every second day compared to when they were cleaned on a daily basis. Differences between FB-shaped platforms regarding cleaning frequency were less prominent (herd B, daily vs. every second day: 0.2 ± 0.03 vs. 0.3 ± 0.03 kg/m^2; herd C, 0.07 ± 0.01 vs. 0.1 ± 0.01 kg/m^2). No other interaction effects were found for moisture scores or manure gathered.

Discussion

Both the average and the maximum number of sheep lying on the resting platform were significantly higher in pens with the FB-shaped than in the U- or L-shaped platforms. This was mainly compensated by an increase in the number of sheep lying on the original pen floor, in pens with U- or L-shaped platforms. However, the number of sheep standing also increased in these pens, which suggest that the sheep have a preference for lying on the resting platforms and experiences the platforms as an improvement of the environment. Færevik et al. (2005) on the other hand, found no clear preference for type of flooring in the resting area for unsheared sheep, but sheared sheep had a clear preference for solid flooring over expanded metal. Experiments with dairy goats show corresponding results (Bøe, et al., 2007).

Number of sheep resting on the platform was very closely correlated to the EPL (effective perimeter length) and only when the EPL was 0.9 m/ewe were all sheep in the pen observed to lie simultaneously. Studies on body measurements in sheep confirm that adult ewes with at mean live weight of 80 kg (similar to the Norwegian white breed) have a body length of around 0.8 m from point of the shoulder to the pin bone (e.g Riva et al., 2004). This further supports our assumption that a minimum EPL of 0.9 m/ewe is necessary. This can either be achieved by adding platforms both in the front and in the back of the pen and/or by increasing the space allowance of the pen. Alternative ways of increasing the EPL have been to add additional walls in the pen (Jørgensen et al., 2009) or to organize the resting areas in two levels (Hansen & Lind, 2008), but these measures did neither increase the resting time nor the synchrony of resting.

The width of the resting platform had no effect on resting behaviour in herd C and only a limited effect in herd B, suggesting that the ewes experiences a resting platform width of 0.50 m as sufficient. Because of the strong preference for lying next to a wall as apposed to lying side by side with other sheep (e.g. Færevik et al., 2005, Bøe et al., 2006), a further increase of the width of the platform will probably have no effect on resting behaviour. In earlier experiments with loose-housed dairy cows given moderate slopes (8-10 %) on the resting area, Keck et al. (1992) found that slopes modified the resting pattern but not the time spent resting, whereas another study on fattening bulls reported more incidents of slipping and falling when resting areas sloped more than 5 % (Schulze Westerath et al., 2006). In the present experiment the floor slope of the resting platforms did not seem to have significant effects on the number of ewes resting, but on the other hand the width of the resting platform also restricted ewe's freedom to choose other resting patterns or positions. Phillips & Morris (2002) showed that cattle actively avoid surfaces covered with excreta and thus cleaning frequency might affect resting behaviours, but no such effects were found in the present study. This might be explained by the relatively low amounts of manure gathered in general, and that the manure was quite dry and the moisture scores were low.

Floor cleanliness

The amount of manure was quite low in two of the herds and actually lower on FB-shaped platforms compared to U- and L-shaped platforms which seem strange because the area of the FB-shaped platforms are larger. In pens with FB-shaped platforms the ewes were also standing on the front platform during feeding; hence it is possible that the ewes were shuffling the manure off the platform when backing out of the feed barrier. Only in herd B, the moisture score was higher on U-shaped platforms than on FB-shaped platforms and this could not be explained by difference in water spillage from the drinking nipples since these were mounted on the back wall in all pens regardless of resting platform shape.

Contrary to what has been reported in experiments with cattle (Schulze Westerath et al., 2006) we found that increasing the slope improved the cleanliness of the floor both by reducing the amount of manure and the moisture score. This confirms the positive effect of a floor slope on cleanliness commonly pointed out in recommendations for pigs (e.g. Anonymous, 1993) and cattle (e.g. Anonymous, 2005). A wider resting platform resulted in an increase in the amount of manure, which is reasonable because of the increased area, but there was no increase in moisture score. The latter indicating that a sufficient floor slope will drain off the moisture and that the width of the platform is of minor importance for moisture levels.

Not surprisingly, cleaning out every second day increased the amount of manure on the platform floor. However, since this did not affect lying behaviour, the only negative consequence of the increased amount of manure is a possible long-term effect of fleece, skin and claw contamination.

In conclusion, resting platforms of solid wood might be a relatively cheap and convenient way of increasing the resting comfort of sheep housed in fully slatted floor pens, but it is important that there is sufficient effective perimeter length available. The resting platforms were relatively clean and dry, even when these were cleaned out every second day.

Acknowledgements

The authors would like to thank Dr. Inger Lise Andersen and Professor Bjarne Braastad for valuable comments on earlier versions of this manuscript. We would also like to extend our gratitude to the three farmers participating in the study. The experiment was funded by the project Økosau Hordaland.

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