Flooring preferences in dairy goats at moderate at low ambient temperature

Applied Animal Behaviour Science 108, 45-57
Flooring preferences in dairy goats at moderate and low ambient temperature

Bøe, K.E.1, Andersen, I.L.1, Buisson, Laëtitia2, Simensen, E.3 and Jeksrud, W.K.4

1 Norwegian University of Life Sciences, Department of Animal and Aquacultural Sciences
2 Institut national agronomique Paris-Grignon,
3 Norwegian School of Veterinary Science
4 Norwegian University of Life Sciences, Department of Mathematical Sciences and Technology

ABSTRACT

Compared to other species, thermoregulatory strategies and lower critical temperature is not well documented in goats. While cattle and sheep prefer soft floors with low thermal conductivity when the ambient temperature is low, such scientific data does presently not exist in goats. The aim of this experiment was to investigate goats’ preference for different types of flooring at moderate and low ambient temperature. In each of two experiments 9 dry dairy goats was selected to a modified 2 x 3 factorial design with ambient air temperature (moderate = +10 to +12 and cold = - 8 to -12 °C) and type of flooring in the lying area (three treatments with the choice between two different flooring materials) was used. Within each temperature treatment the goats were individually subjected to three different flooring treatments where the goats could choose between two lying areas with different flooring materials, and the order of flooring treatments was rotated systematically. The goats were video recorded for 48 hours in the end of each experimental period and the behaviour and
position in the pen were scored using instantaneous sampling at 15 minutes intervals. In addition blood samples were collected from all the goats at two days in the moderate temperature period and at day 0, 1, 2, 7 and 14 in the cold temperature period.

The lying time was reduced from 73.2 % and 73.7 % in the moderate temperature period to 63.8 % and 65.4 % in the cold period in experiment 1 and 2 respectively. In the moderate temperature period, straw was the least preferred flooring. Expanded metal was preferred to solid wood, but there was no significant difference between solid wood and mattress or expanded metal and mattress. Mattress and solid wood were most preferred in the cold period, but no difference between mattress and expanded metal. Surprisingly, straw was not perceived as an attractive flooring material in any of the temperature periods. The concentration of free fatty acids was elevated the first day of cold exposure and thyroxine (T4) was elevated the three first days of cold exposure.

In conclusion, the goats responded to the low temperature by reducing the lying time while increasing the time spent active and eating. A short-term physiological response in the cold period may indicate an increased metabolism, but more data is needed to reach a reliable conclusion on this matter. In the moderate temperature period, straw was the least and expanded metal the most preferred flooring, whereas solid wood and mattress was most preferred in the cold period.

Key words: Goat, Flooring, Preference, Cold exposure
In parts of Europe where the winter is mild, dairy goats are usually kept in simple uninsulated buildings whereas insulated buildings are most common in countries with a cold winter climate, such as Norway (Simensen and Bøe, 2003). However, there are examples of Swedish farmers using uninsulated buildings for goats in areas where the winter temperatures can be as low as – 40 °C and Eik (1991) obtained good performance results for goat kids in uninsulated housing. Sheep and cattle tolerate low temperatures, and the thermal requirements and the lower critical temperatures are well documented (sheep: Webster, 1976; cattle: Hamada, 1971; Webster, 1974). These species also perform well in simple, uninsulated buildings under commercial conditions (sheep: Bøe et al., 1991; cattle: Schnier, 2003). While pigs huddle and lie more on their belly to reduce heat loss when cold (Mount, 1967; Andersen et al., 2000), sheep and cattle appear to stand more and increase their activity to increase heat production (Bøe, 1990; Færevik et al., 2005b).

Toussaint (1997) recommend that air temperature in the goat-house should be between 6 and 27°C (optimal: 10 to 18°C), but presents no data to support this. Except from a small study on goat kids (Sanz Sampelayo et al. 2000), thermoregulatory strategies and lower critical temperature have not to our knowledge been documented in goats. Secretion of thyroid hormones will increase mobilisation of metabolic fuels, such as glucose and free fatty acids, resulting in increased heat production, which is part of the body’s long-term adaptation to low environmental temperatures (Sjaastad et al., 2003). Increased levels of thyroid hormones at low air temperatures are found in sheep (Sano et al., 1995), cattle (eg. Christopherson et al., 1979) and sows (eg. Andersen et al., 2000).
Goats are usually housed on deep straw bedding (Toussaint, 1997), but the advantage with slatted floor pens is that animals are kept relatively clean without any bedding material, at a low space allowance and with a minimum of work input. Because the majority of Norwegian dairy goat production are located in areas where straw is limited, the goats are usually kept in fully slatted floor pens, often with expanded metal and no separate lying area (Simensen and Bøe, 2003). Important characteristics of pen flooring for farm animals are considered to be thermal conductivity, softness, cleanliness and slipperiness. These characteristics will affect both animal preferences and thermoregulatory behaviour. Thermal conductivity and softness of the floor will often be correlated, as soft floors usually will be well insulated (Nilsson, 1988). At low temperatures, animals generally prefer a floor that minimizes heat loss, with a low thermal conductivity, such as straw bedding or mattresses (pigs: Fraser, 1985; Andersen et al., 2000; cattle: Natzke et al., 1982; Manninen et al., 2002). For sheep, the situation is different because of the fleece. Sheared sheep prefer straw and solid wood, but fully coated sheep show no specific preference at temperatures of around 8-10°C (Bøe, 1990; Færevik et al., 2005a).

Softness plays an important role in physical comfort and several studies have found that softer floors like straw bedding, sawdust or rubber mattresses are preferred to harder floors like concrete or other draining materials (cattle: Irps, 1987; Nilsson, 1988; Manninen et al., 2002; sheep: Gordon and Cockram., 1995; Færevik et al., 2005a). Goats in natural environments are often resting directly on the rocks in steep cliff areas (reviewed by Shackleton and Shank, 1984), which apparently do not indicate a preference for soft bedding. Unfortunately, no scientific data on flooring preference in goats is available. Synthetic mattresses made of rubber or plastic are new materials that are often used in dairy cows cubicles to replace bare concrete. They seem to be a good compromise between hard floors and straw bedded floors.
since they are often preferred to bare concrete (Natzke et al., 1982; Nilsson, 1988). The individual preference will strongly depend on previous experience, which is one of the main objections of preference tests in general (e.g. Duncan, 1992; Fraser and Matthews, 1997; Dawkins, 2004). In dairy cows Tucker et al. (2003) found that animals that was previously housed in sawdust-bedded stalls, preferred sawdust to sand and mattresses, but some individuals changed their preference after a period of forced experience with the other floors.

The cleanliness of the floor may influence animal preferences among others because the different types of floors do not have the same degree of absorption (Panagakis et al., 2004): the wetter and dirtier the floor, the less comfortable it is to lie on (Herlin, 1997; Stefanowska et al., 2002) and animals generally do not rest on wet floors (Hutson et al., 1993).

Cattle and sheep prefer soft floors with low thermal conductivity when the ambient temperature is low, but such scientific data does presently not exist in goats. The aim of this experiment was to investigate goats’ preference for different types of flooring at moderate and low ambient temperature.
2. MATERIALS AND METHODS

2.1 Experimental design

Two experiments were conducted in February 2004 (experiment 1) and February 2005 (experiment 2) respectively. In each experiment a modified 2 x 3 factorial design with ambient air temperature (moderate = +10 to +12 and cold = -8 to -12 °C) and type of flooring in the lying area (three treatments with the choice between two different flooring materials) was used.

In each experiment nine dairy goats were first exposed to an ambient air temperature around +10 to 12°C (moderate temperature period, 19 days) and then to an ambient air temperature of -10 to -12 °C in experiment 1 and -6 to -8°C in experiment 2 (cold temperature period, 19 days). In experiment 2 the temperature in the cold temperature period was higher than in experiment 1 because the refrigeration system was not working efficiently enough. Within each temperature treatment the goats were individually subjected to three different flooring treatments where the goats could choose between two lying areas with different flooring materials (Table 1). All the nine goats were exposed to all three flooring treatments and the order of flooring treatments was rotated systematically (three rotations). Each flooring treatment period lasted for four days. The goats were allowed for seven days to be accustomed to each of the two air temperature treatments. In this period the goats were kept in the pens where they were set up to be for their first flooring treatment.

2.2 Experimental facilities
Both experiments were conducted in a specially insulated test room (4.5 x 9.0 m) with mechanical ventilation and with a refrigeration system that made it possible to maintain both low and high ambient air temperatures.

A total of nine individual experimental pens (one goat in each), three pens for each of the three flooring treatments, were located in the test room. Each of the nine experimental pens consisted of two separate lying areas (A and B) measuring 0.60 m x 1.00 m and an activity area (C) measuring 0.90 x 2.00 m (Figure 1). To make it uncomfortable to lie in the feeding area, beams (1.5” x 2.0”) were installed at c/c 0.40 m.

Figure 1 here.

The layer with straw bedding was 0.25 m thick, and new straw was added when necessary to maintain a constant amount. The solid wooden floor was covered with a thin layer of sawdust. It was cleaned twice a day and new sawdust was added. The mattress was a Erri Comfort, originally designed and used for dairy cows, approximately 100 mm thick and filled with granulous rubber and covered with a fibre-cloth (see DLG, Prüfbericht 4891). The mattress was also cleaned daily. The fourth flooring material was standard expanded metal commercially used for sheep and goat, without any bedding.

**2.3 Animals and feeding**

In each experiment, nine, non-lactating, pregnant dairy goats (> 1.5 year; 57.2 ± 8.3 kg) of a Norwegian milking breed were randomly chosen from the resident herd at the Norwegian University of Life Sciences. All the goats were in the same stage of pregnancy in gave birth within two weeks in March. The Norwegian University of Life Sciences is located at , mean
air temperature range is from -4.8 °C in January to 16.1 °C in July and annual precipitation is
785 mm. The goats were normally kept in an insulated, mechanically ventilated building in
pens with expanded metal flooring at an ambient air temperature of around +10 °C during
wintertime, but with frequent access to an outside yard during daytime. Lactation period
ended in December and kidding started in the beginning of March. Normally the goats are
kept on pasture from May to September.

In the experimental room, the goats were fed, the lying area cleaned and new bedding material
was provided at 08:00 a.m. and 03:00 p.m. every day. Each goat was given a ration of 0.2 kg
concentrate and hay was fed *ad libitum*. Water was available in buckets close to the feed.

### 2.4 Behavioural observations

The goats were video recorded continuously for 48 hours in the end of each experimental
period. Video cameras (Panasonic WV – BP 310 G) were suspended over the pens, and were
connected to a multiplexer (MV 16) and a time-lapse video recorder (Panasonic AG 6720).
When analysing the videotapes, the behaviour and position in the pen were scored using
instantaneous sampling at 15 minutes intervals using the following ethogram:

1. Lying in area A
2. Standing in area A
3. Moving in area A
4. Lying in area B
5. Standing in area B
6. Moving in area B
7. Lying in area C
8. Standing in area C
9. Moving in area C
10. Eating (head over feed)

From this we calculated % of total observations lying on the different flooring materials and other behavioural variables.

2.5 Blood samples – pilot study

In experiment 1, blood samples were drawn from the jugular vein of all the nine animals between 10:00 and 11:00 at day –6 and –3 (in the moderate temperature period 6 days before the first day with constant low temperatures). The temperature was gradually lowered at day –1, and blood samples were drawn on day 0, about 18 hours after a constant low temperature was reached. Blood samples were also obtained on day 1, 2, 7 and 14 in the period of cold exposure. Serum samples for hormone analysis were stored at -20 °C until they were analysed by means of time resolved fluoroimmunoassay (AutoDELFA™ kits for cortisol, thyroxine (T4) and triiodothyronine (T3), PerkinElmer™). Serum samples were also analysed by using a standard clinical chemical profile including 18 different parameters (Advia® 1650 System, Bayer, USA). Of these parameters, free fatty acids and glucose were analysed. Because of technical problems, this profile was not conducted on samples from day –3.

2.6 Statistics

To analyse the effect of air temperature and flooring treatment on lying, standing, moving and eating, a mixed model analysis of variance including the class variables flooring treatment (1 to 3), temperature period (moderate vs. cold) and rotation was used (Hatcher and Stephanski,
1994). Individual goat was specified as a random effect in the model. Paired t-tests were conducted to analyse time spent lying (% of observations) on the two different flooring materials within flooring and temperature treatments.

To analyse the effect of cold on different blood parameters a mixed model analysis of variance was used with sample day as fixed effect and animal as a random effect.

3. RESULTS

3.1 General activity

Lying time (% of observations) decreased significantly in both experiments when the goats were exposed to low air temperature and the time spent eating increased (Table 2). In experiment 1, the time spent moving (% of observations) was significantly longer in the cold than in the moderate temperature period, whereas in experiment 2, time spent standing (% of observations) was significantly longer in the cold period. In experiment 1, the lying time (% of observations) remained at a low level during the entire cold period (rotation 1, day 10 and 11: 69.1 ± 1.2 %; rotation 2, day 14 and 15: 67.6 ± 1.1 %; rotation 3, day 18 and 19: 68.9 ± 1.8 %; F=0.81, ns), but in experiment 2 the lying time was back to a normal level in the last days of cold exposure (rotation 1, day 10 and 11: 67.5 ± 1.5 %; rotation 2, day 14 and 15: 68.9 ± 1.7 %; rotation 3, day 18 and 19: 72.3 ± 1.3 %; F=5.08, P < 0.05). Time spent eating in experiment 2 significantly decreased in the same time period (rotation 1, day 10 and 11: 23.0 ± 1.0; rotation 2, day 14 and 15: 21.4 ± 1.0; rotation 3, day 18 and 19: 19.0 ± 0.8; F=14.77, P < 0.0001).

Flooring treatment had no significant effects on variables related to activity pattern (Table 2).
3.2 Flooring preference

In experiment 1, the goats preferred lying on expanded metal to solid wooden floor during the moderate temperature period (Fig. 2 a). Five of the 9 goats showed a preference for expanded metal, one preferred solid wood and three showed no clear preference (Table 3). However, in the cold period the goats changed their preference towards solid wood (Fig. 2 b), but still two goats made a clear preference for expanded metal (Table 3). One goat spent 24% of observations lying in the activity area.

Figure 2 a and b here.

Solid wood and mattress were strongly preferred to straw bedding (Fig. 2 a). In fact, all the nine goats preferred these two flooring materials to straw bedding in the moderate temperature period (Table 3). In the cold period, the preference for solid wood and mattress was still significant but the difference was not so large (Fig. 2 b). Six goats preferred solid wood whereas 7 goats preferred mattress. Two goats were lying part of the time in the activity area in the cold period, 20% and 18% of the observations respectively.

Table 2 here.

The goats showed a strong preference for expanded metal to straw bedding in experiment 2 (Fig. 3 a), and this was the case for all the 9 goats (Table 3). In fact, six of the goats never lay
on straw bedding. During the cold period, the lying time was almost evenly distributed between these two optional floor surfaces (Fig. 3 b) and four of the goats switched their preference towards straw bedding.

When comparing solid wood and mattress in the moderate temperature period, the goats tended to prefer mattress, and 6 of the goats showed this preference (Fig. 3 a; Table 3). This tendency was enhanced in the cold period and now significant, but still only chosen by six of the goats (Fig. 3 b; Table 3). It is interesting to notice that one of the goats that chose solid wood in the moderate temperature period switched to mattress in the cold period whereas another that preferred mattress in the moderate temperature period had no clear choice in the cold period, suggesting individual variation in preferences.

The goats spent on average more time lying on expanded metal than on mattress in both temperature periods (Fig. 3 a and b). Individual shifts in preference from expanded metal to mattress or the opposite occurred in four of the goats.

3.3 Blood samples – pilot study

The concentration of free fatty acids had a significant peak on day 1 (Fig. 4), but then went back to normal. The levels of thyroxine (T4) were elevated the first three days of cold exposure, being significantly higher on day 0 and 2, but declined to normal on day 7 and 14 (Fig. 5). For triiodothyronine (T3), no significant response was found in relation to cold exposure. The mean serum concentration of cortisol varied between sample days, but this variation could not be explained by changes in temperature.
4. DISCUSSION

The goats spent less time lying and more time being active and eating in the cold than in the moderate temperature period, which indicates that the goats are using behavioural strategies to cope with the low temperature in a similar way as sheep (Bøe, 1990) and cattle (e.g. Broucek et al., 1995; Færevik et al., 2005b). The peak in free fatty acids on day 1 may indicate a mobilization of body fat to produce more heat in a similar way as shown in newly shorn sheep (Aulie et al., 1971). The transient increase in free fatty acids and thyroxine may suggest an increased metabolism, but since this was a small pilot study, more data should be provided to fully address this relationship. An increased thyroxine level at low temperatures is also documented in dairy cows (Broucek et al., 1991), sheep (Sano et al., 1995) and pregnant sows (Andersen et al., 2000). The fact that the level of the recorded physiological measures declined after a few days, suggests that the goats may acclimate after a short period of cold exposure. In contrast, the behavioural responses, such as increased activity maintained throughout the entire cold period, suggests that the goats are in the cool thermoregulatory zone (Curtis, 1983).

An increased time standing with the head above the feed in the cold period may indicate an increased feed intake, but since the actual feed intake was not recorded we cannot make any reliable conclusions about this. Norwegian goat kids in an uninsulated house had a normal growth rate after a few days of adaptation to a temperature of around –4 °C (Eik, 1991).

Flooring treatment did not affect the overall activity/resting pattern in the present study. This means that even in the cold period, none of the flooring alternatives affected the lying time negatively. In the moderate temperature period, straw was the least preferred flooring.
Expanded metal was preferred to solid wood, but there was no significant difference between solid wood and mattress or expanded metal and mattress. This suggests that the goats do express a need for flooring with higher thermal conductivity at a moderate temperature as expected. Softness of the floor did not appear to have any effect on the choices made by the goats. Nilsson (1992) emphasized that the softness of the floor is of greater importance for larger than for smaller animals. Under wild conditions, the goats are adapted to rest on rocks in steep hills or in caves, which can be explained by the need for protection against weather and predation (Shackleton and Shank, 1984; O’Brian, 1983). Fully coated sheep did not show any preference for soft flooring materials such as straw (Færevik et al., 2005a). On the contrary, dairy cattle show a clear preference for soft bedding (e.g. reviewed by Tucker and Weary, 2001), and the lying time is declined when forced to lie on hard surfaces (O’Connell and Meaney, 1997; Haley et al., 2000). However, it is important to bear in mind that both in the study on sheep (Færevik et al., 2005a) and the present study on goats, the animals were only familiar with expanded metal before the start of the experiment. Previous experience with a particular environment strongly affects the choices made by farm animals (e.g. Tucker et al., 2003). The floors in the present study were kept clean and dry throughout the entire experimental period, but under commercial conditions, dirty and wet floors may be avoided irrespective of the flooring material (Panagakis et al., 2004).

As expected from other species (sheep: Bøe, 1990; pigs: Fraser, 1985; cattle: Manninen et al., 2002), the goats’ preference shifted towards flooring materials with a lower thermal conductivity in the cold period. Mattress and solid wood were most preferred in the cold period, but no difference between mattress and expanded metal. Surprisingly, straw was not perceived as an attractive flooring material by the goats. Rubber mattress appeared to be a good compromise since it possesses several interesting properties in that it is comfortable and
firm, dry and clean, and has a low thermal conductivity. Cattle also choose mattress when only harder flooring alternatives are available (eg. Herlin, 1997).

In conclusion, the goats responded to the low temperature by reducing the lying time while increasing the time spent active and eating. A short-term physiological response in the cold period may indicate an increased metabolism, but more data is needed to reach a reliable conclusion on this matter. In the moderate temperature period, straw was the least and expanded metal the most preferred flooring, whereas solid wood and mattress was most preferred in the cold period. Hence, softness did not appear to be an important flooring characteristic for the goats.

ACKNOWLEDGEMENTS
The authors would like to acknowledge Tine Norske Meierier BA for financing this experiment. We will also thank research technician Kari Eikanger, for collecting the blood samples and for analysing the videotapes in experiment 1.
REFERENCES

Andersen, I.L., Bøe, K.E., Hove, K., 2000. Behavioural and physiological thermoregulation in
groups of pregnant sows housed in a kennel system at low temperatures. Can. J. Anim. Sci.,

Aulie, A., Astrup, H.N., Nedkvitne, J.J., Velle, W, 1971 Serum non-esterified fatty acids and
plasma glycerol as indicators of fat mobilization in pregnant sheep subjected to cold stress.

of different housing in winter on behaviour of dairy cows. Zivocisna Vyroba 40: 135-143.

Bøe, K., 1990. Thermoregulatory behaviour of sheep housed in insulated and uninsulated

and feeding regimes on the performance and rectal temperature of sheep. Anim.
Prod., 53 : 331-337.

Christopherson, R.J., Gonyou, H.W., Thompson, J.R., 1979. Effects of temperature and feed
661.


ACKNOWLEDGEMENTS

The authors want to acknowledge Kari Eikanger and Agnes Klouman for taking well care of the goats and for doing the blood sampling. Thanks also to Ole Fladstad for building the experimental pens. This experiment was financed by the Norwegian Dairy Association.
Table 1: Overview of treatments offered the goats to choose between two types of different flooring materials in the lying area.

<table>
<thead>
<tr>
<th>Treatment 1</th>
<th>Experiment 1</th>
<th>Experiment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment 1</td>
<td>Expanded metal vs. solid wood</td>
<td>Straw vs. expanded metal</td>
</tr>
<tr>
<td>Treatment 2</td>
<td>Solid wood vs. straw</td>
<td>Solid wood vs. rubber mattress</td>
</tr>
<tr>
<td>Treatment 3</td>
<td>Straw vs. rubber mattress</td>
<td>Expanded metal vs. rubber mattress</td>
</tr>
</tbody>
</table>
Table 2. Effects of air temperature and flooring treatment on general activity

<table>
<thead>
<tr>
<th>% of observations</th>
<th>Air temperature</th>
<th>Flooring treatment</th>
<th>1. Exp. met. vs. solid wood</th>
<th>2. Solid wood vs. straw</th>
<th>3. Straw vs. rubber mattress</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moderate</td>
<td>Cold</td>
<td>F</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>Experiment 1</td>
<td>Lying</td>
<td>73.2 ± 0.7</td>
<td>63.8 ± 1.1</td>
<td>69.89</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Standing</td>
<td>6.6 ± 0.7</td>
<td>8.0 ± 0.9</td>
<td>2.98</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>Moving</td>
<td>2.2 ± 0.2</td>
<td>3.5 ± 0.3</td>
<td>17.09</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Eating</td>
<td>18.1 ± 0.6</td>
<td>24.7 ± 0.8</td>
<td>88.51</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

|                   | Moderate | Cold | F       | P    |                   | 1. Straw vs. exp. met. | 2. Solid wood vs. rubber mattress | 3. Exp. met. vs. rubber mattress |
| Experiment 2      | Lying     | 73.7 ± 0.8 | 65.4 ± 1.2 | 43.32 | <0.0001 | 69.5 ± 1.4 | 70.9 ± 1.4 | 68.3 ± 1.8 | 1.52 | ns       |
|                   | Standing | 5.7 ± 0.6 | 10.2 ± 1.1 | 19.73 | <0.0001 | 7.9 ± 1.0 | 7.7 ± 1.3 | 8.2 ± 1.4 | 0.09 | ns       |
|                   | Moving   | 1.3 ± 0.2 | 1.5 ± 0.2 | 0.99 | ns       | 1.3 ± 0.3 | 1.5 ± 0.2 | 1.3 ± 0.2 | 0.60 | ns       |
|                   | Eating   | 19.4 ± 0.8 | 22.9 ± 0.8 | 33.56 | <0.0001 | 21.3 ± 0.9 | 19.9 ± 0.8 | 22.2 ± 1.3 | 5.07 | <0.05    |
Table 3. Preference for different types of floors (proportion of animals). The criteria for flooring preference was that a goat spent 60% or more of her total lying time of both the two 24 h observation periods in one of the lying areas.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Flooring Treatment</th>
<th>Temperature treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Moderate</td>
</tr>
<tr>
<td>1 1</td>
<td>Expanded metal</td>
<td>5/9</td>
</tr>
<tr>
<td></td>
<td>Solid wood</td>
<td>1/9</td>
</tr>
<tr>
<td></td>
<td>No clear preference</td>
<td>3/9</td>
</tr>
<tr>
<td>1 2</td>
<td>Solid wood</td>
<td>8/9</td>
</tr>
<tr>
<td></td>
<td>Straw bedding</td>
<td>0/9</td>
</tr>
<tr>
<td></td>
<td>No clear preference</td>
<td>1/9</td>
</tr>
<tr>
<td>1 3</td>
<td>Straw bedding</td>
<td>0/9</td>
</tr>
<tr>
<td></td>
<td>Mattress</td>
<td>9/9</td>
</tr>
<tr>
<td></td>
<td>No clear preference</td>
<td>0/9</td>
</tr>
<tr>
<td>2 1</td>
<td>Expanded metal</td>
<td>9/9</td>
</tr>
<tr>
<td></td>
<td>Straw bedding</td>
<td>0/9</td>
</tr>
<tr>
<td></td>
<td>No clear preference</td>
<td>0/9</td>
</tr>
<tr>
<td>2 2</td>
<td>Solid wood</td>
<td>2/9</td>
</tr>
<tr>
<td></td>
<td>Mattress</td>
<td>6/9</td>
</tr>
<tr>
<td></td>
<td>No clear preference</td>
<td>1/9</td>
</tr>
<tr>
<td>2 3</td>
<td>Expanded metal</td>
<td>5/9</td>
</tr>
<tr>
<td></td>
<td>Mattress</td>
<td>4/9</td>
</tr>
<tr>
<td></td>
<td>No clear preference</td>
<td>0/9</td>
</tr>
</tbody>
</table>
LEGENDS TO FIGURES

Figure 1  Experimental pen

Figure 2  Preference for lying area in the moderate (a) and cold (b) temperature period in experiment 1 (ab P<0.1, cd P<0.001)

Figure 3  Preference for lying area in the moderate (a) and cold (b) temperature period in experiment 2 (ab P<0.1, cd P<0.001)

Figure 4  Serum concentration of free fatty acids in the moderate temperature and cold period (ab P<0.0001)

Figure 5  Serum concentration of thyroxine (T4) in the moderate temperature and cold period (ab P<0.001)