Synthetic lying mats may improve lying comfort of gestating sows

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Abstract

A prototype lying mat as an alternative to straw bedding for improving sow lying comfort was evaluated using a dynamic group of 47 gestating sows housed in a pen with 5 communal lying areas. Mats were installed in 3 lying areas while the concrete floors of the remaining lying areas remained uncovered (period 1). After 5 weeks the position of the lying mats was rotated (period 2). 24 h image-recordings were made from 5 weeks prior to the installation of the mats (period 0) until 5 weeks after rotation of the mats. The effect of the mats on lying area occupancy and behaviour was analysed.

The occupancy of lying areas with a mat increased as compared to both the same lying areas before the installation of the mats (period 0), and to the other lying areas without a mat during the same observation period (periods 1 and 2, \( P = 0.011 \)). This preference was more pronounced amongst sows that had been habituated to the experimental set-up for more than 7 days (\( P < 0.001 \)) and in period 2 than period 1 (\( P = 0.004 \)). However, the effects of period, stocking density and ambient temperature were confounded and could not be determined unambiguously. Mats did not significantly affect activity (proportion of time standing, sitting, and lying), lying bout duration, duration of lying per lying posture (sternal, half recumbent, recumbent) or getting-up duration. Sows lying on mats as compared to concrete, however, changed lying posture more often (\( P = 0.002 \)) and were more likely to adopt a recumbent instead of sternal lying posture (\( P = 0.003 \)). Under conditions of this experiment covering concrete floors with synthetic mats appeared to improve sow lying comfort. It is questionable whether this finding can be generalised to other (climatic)
conditions. Furthermore, before such mats should be considered as an alternative to straw bedding for improving lying comfort further research is warranted to improve the durability of the mats and to investigate the long-term health consequences.

Keywords: Animal welfare; Behaviour; Housing; Lying behaviour; Pigs; Preference test

1. Introduction

As gestating sows spend about 80% of their time lying (Jeppsen et al., 1980; Buckner et al., 1998; Bergeron et al., 2000), lying comfort is of paramount importance for their welfare. Yet, relatively few studies and efforts have been made to improve sow lying comfort. In the EU and many other parts of the world, sows are predominantly kept in fully or partly slatted housing systems (SVC, 1997). These housing systems are durable and offer advantages concerning labour and hygiene, but provide little comfort to sows. Apart from functioning as a stimulus and outlet for exploration, foraging, rooting and chewing behaviour, the use of straw bedding has been shown to increase physical and thermal comfort and to ease the stress resulting from concrete floors (Warnier and Zayan, 1985; Andersen and Bøe, 1999; Tuyttens, 2005). Yet straw bedding is not commonly provided in commercial farms because it is costly and requires more labour, it may be incompatible with the liquid manure handling system, and it may provide ideal conditions for the growth of certain pathogens (Tuyttens, 2005).

Synthetic lying mats may overcome these disadvantages. Consequently, for cattle organic bedding is increasingly being replaced by such mats. At least some of these soft lying mats seem to provide equal lying comfort to cattle as straw does (Buchwalder et al., 2000; Manninen et al., 2002; Tuyttens, 2005). To our knowledge such mats have not yet been commercialised for sows. The potential use of such mats has been investigated in a few studies on lactating sows and their piglets in the farrowing house only. Gravås (1979) reported that 5 mm rubber mats improved lying comfort of sows in farrowing pens as total lying time was higher than on concrete floors or epoxy-painted concrete floors. Although floor type did not influence the number of knee wounds of the piglets, the wounds were larger and deeper on the rubber mats than on the concrete floors. Boyle et al. (2000) confirmed that providing pigs with mats in the farrowing house could greatly improve their welfare, but further research is needed to identify materials that are less abrasive. They found that sows on mats slipped less often and went slower from kneeling to lowering their hindquarters when lying down than sows on metal flooring, indicating that mats provide better footholds for manoeuvring and a cushioning effect when kneeling. Mats encouraged piglets to lie on the heat pad but also increased damage to the skin of their front legs possibly due to the higher coefficient of sliding friction of mats compared to metal floors. Phillips et al. (1995) illustrated that piglet leg injuries can be almost eliminated by combining cushioning and reduced friction, as with a closed-cell neoprene sponge impregnated with mineral oil. Zurbriggen (2006) found that rubber mats in farrowing crates decreased the time required to heal shoulder lesions in lactating sows.

Despite these promising results on the effects of mats on the lying comfort of sows in the farrowing house, the use of mats for dry sows in gestation pens has not been investigated previously. In the present study we investigate, therefore, the effect of a prototype multi-layer mat on the occupancy of the lying area and on the lying behaviour of loose-housed gestating sows in an open-choice test.
2. Animals and methods

2.1. Animals and housing

The experiment was conducted on a dynamic group of 47 gestating sows housed in a group housing system of Ghent University (Biocentre Agri-Vet, Melle, Belgium) with a thermostatically controlled ventilation system and no heating. The partly slatted pen consisted of 5 communal lying compartments (solid concrete flooring) separated by concrete walls of 1 m high, a dunging area (slatted concrete floor), a semi-removable separation area and an electronic feeding system (Fig. 1). This feeding system was programmed so that sows could eat their complete daily ration of pellets from 20:00 h onwards. The size of the lying areas varied from 2.82 to 7.50 m². Apart from the ventilation openings there were no windows allowing natural lighting. Artificial lights were switched on and off by personnel when they started (ca. 8–9 A.M.) and finished (ca. 4–6 P.M.) duty.

All sows were hybrids of the Seghers-line and were individually marked with a colour spray. The number of sows in the gestating pen varied according to the reproductive cycle of the individual sows (Table 1). Five to 6 days before the scheduled farrowing date sows were moved from the gestating pen to the farrowing crates. At least 3 weeks after farrowing sows were moved to the service pen where they stayed for approximately 1 week. Serviced sows were subsequently returned to the gestating pen. Sows that failed to attain or maintain pregnancy were re-bred in the service pens. The number of sows re-bred and the number of sows removed from the group were greater than usual due to an outbreak of porcine reproductive and respiratory syndrome at the beginning of the experiment. Consequently, the stocking

Fig. 1. Layout of the pen for group-housed sows where the experiment was carried out.
density was lower than usual (normally the pen can accommodate 35 sows) and new sows were introduced into the gestation group throughout the experiment.

The experiment was divided into three periods. During period 0 (18th September 2002–22nd October 2002) none of the lying areas were covered with a mat. During period 1 (25th October–30th November 2002) the floors of three lying areas (compartments 1, 3 and 5) were covered with a prototype lying mat (Sarl Agglorex, Lommel, Belgium) while the floors of the two remaining lying areas (compartments 2 and 4) remained uncovered. The mat consisted of two polyurethane foam layers of different density (bottom layer: 290 kg/m$^3$, upper layer: 200 kg/m$^3$) enclosed in a plastic sheet and covered with a strong polyvinylchlorid (PVC) top layer. At the edges and corners the PVC sheet was fixated under a wooden frame. In period 2 (4th December–8th January 2003) the positions of the lying mats versus concrete floors were changed (mats in lying areas 2 and 4 and bare concrete in lying areas 1, 3 and 5).

For the entire duration of the experiment ambient temperature at 40 cm above floor level was recorded every 10 min using a Grant 1200c data logger and a ptc-100 heat sensor (Lambda Instruments, Brussels). On seven and six separate occasions during periods 1 and 2, respectively, the surface temperature of each lying compartment was measured using an infrared thermometer (KM826, Kane-May, Dimed n.v., Antwerpen, BE). These surface temperatures were higher on the mats (average period 1: 21.6 °C, average period 2: 22.3 °C) than on the concrete lying floors (average period 1: 20.4 °C, average period 2: 15.6 °C). However, as the latter measurements were not carried out during the video-recording days and as these measurements heavily depended on the presence of sows on the lying compartments, only ambient temperatures were used in the further analyses.

### 2.2. Lying area preference

Using two cameras and a digital image recorder, 24 h time-lapse recordings (1 picture/s) were made for 2 consecutive days during period 0, and for 5 separate days (at 4–8 day intervals) in both periods 1 and 2 (Table 1). Every 10 min, it was recorded for every sow in the pen whether or not she was in a lying area. If so, it was recorded which lying area she was in (for testing the effect of the lying mat on lying area preference) and whether she was standing, sitting or lying (for testing the effect of lying mat on main behavioural activities in the lying area).

To investigate whether there was a preference to lie on the mats, a mixed model was fitted to the relative mat occupancy (response variable) with individual sow as random effect. Differences between lying areas in

<table>
<thead>
<tr>
<th>Date of recording</th>
<th>Ambient temperature Mean ± S.D.</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Group size (no. of sows)</th>
</tr>
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<tr>
<td><strong>Period 0</strong></td>
<td></td>
<td></td>
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<tr>
<td>28-09-2002</td>
<td>19.6 ± 0.5</td>
<td>18.8</td>
<td>20.5</td>
<td>19</td>
</tr>
<tr>
<td>29-09-2002</td>
<td>20.1 ± 0.8</td>
<td>19.3</td>
<td>22.0</td>
<td>19</td>
</tr>
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<td><strong>Period 1</strong></td>
<td></td>
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<tr>
<td>27-10-2002</td>
<td>18.5 ± 0.4</td>
<td>17.6</td>
<td>19.2</td>
<td>14</td>
</tr>
<tr>
<td>05-11-2002</td>
<td>17.5 ± 0.4</td>
<td>16.4</td>
<td>18.4</td>
<td>16</td>
</tr>
<tr>
<td>12-11-2002</td>
<td>18.5 ± 0.2</td>
<td>18.0</td>
<td>19.6</td>
<td>18</td>
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<tr>
<td>19-11-2002</td>
<td>17.2 ± 0.2</td>
<td>16.8</td>
<td>17.6</td>
<td>18</td>
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<tr>
<td>26-11-2002</td>
<td>17.3 ± 0.2</td>
<td>16.8</td>
<td>18.5</td>
<td>21</td>
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<tr>
<td><strong>Period 2</strong></td>
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</tr>
<tr>
<td>06-12-2002</td>
<td>14.7 ± 0.2</td>
<td>13.9</td>
<td>15.4</td>
<td>21</td>
</tr>
<tr>
<td>10-12-2002</td>
<td>13.5 ± 0.5</td>
<td>12.7</td>
<td>14.5</td>
<td>21</td>
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<tr>
<td>18-12-2002</td>
<td>14.4 ± 0.2</td>
<td>13.5</td>
<td>15.3</td>
<td>23</td>
</tr>
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<td>25-12-2002</td>
<td>16.0 ± 0.2</td>
<td>15.1</td>
<td>17.5</td>
<td>23</td>
</tr>
<tr>
<td>01-01-2003</td>
<td>15.4 ± 0.4</td>
<td>14.3</td>
<td>16.5</td>
<td>25</td>
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</table>
surface area were adjusted for by defining the relative mat occupancy as the difference between the proportion of time a sow spent in lying areas with mats and the proportional lying area surface covered by mats. This response variable took values zero if there was no preference, i.e. the sows spent the same percentage of time on the mats as the percentage of the lying area surface covered by the mats. Introducing sow as random effect in the model corresponded to imposing the compound symmetry correlation structure on the repeated measurements within a sow (Brown and Prescott, 1999). The model included also two fixed effects: period (1 or 2) and habituation time (<7 days versus >7 days). The latter variable was defined as the number of days sows had been in the gestating pen since the start of the installation of the mats and reflected the time during which they could have habituated to the experimental set-up (i.e. the presence and location of the lying mats). As the experiment was conducted on a dynamic group of sows (sows were taken out and re-introduced into the gestation group depending on their reproductive cycle and on the sow replacement policy), the habituation time could differ between sows throughout the experiment. The hypothesis was tested whether the relative mat occupancy was greater than zero, indicating a preference to lie on the mat, based on the F-statistic within the context of the mixed model at the 5% significance level using SAS (SAS Version 9.1).

The mixed model with sow as random effect was also used to investigate the effects of mats on the percentage time spent sitting, standing and lying during the time that sows occupied lying areas.

2.3. Lying and stand up behaviour

In order to analyse lying and stand up behaviour in more detail, additional 24 h recordings in real-time mode (25 images/s) were made during 1 day at the end (week 5) of periods 1 and 2. Every lying bout that was initiated between 00:00 h and 07:00 h was recorded until it was finished (i.e. when the sow was getting up). For each lying bout, we recorded the sow’s ID, the beginning and end of the lying bout, the lying area (1–5), the number of other pigs present in the same lying area at the beginning and end of the lying bout, the beginning and end of each lying posture (sternum, half recumbent, fully lateral recumbent – sensu Ekkel et al., 2003), the beginning and end of stand up behaviour, and whether or not standing up seemed to have been caused by another sow. Mixed models with sow as random effect were used to test whether the presence of a mat affected lying bout duration, lying duration/posture, and stand up duration. All three response variables were log-transformed so that the data showed a normal distribution. Period (1 or 2), lying area (1–5) and the number of sows in the lying area were adjusted for in all models. Whether or not standing up seemed to have been caused by another sow was also included as independent variable for the models on lying bout duration and stand up duration. In addition, lying bout duration was included as independent variable in the model of stand up duration. The mat effect on the dominant lying posture (i.e. the posture that was adopted for the greatest proportion of the lying bout) was assessed by the cumulative logits model with ordinal categories sternal, half recumbent and recumbent lying posture using the likelihood ratio test ($\chi^2$-test statistic) at the 5% significance level (for an explanation of the cumulative logits model, see Agresti, 1990). The cumulative logits model was also used to evaluate the mat effect on the number of postural changes with 5 ordinal categories ranging from 1 to 5 postural changes.

3. Results

3.1. Influence of mats on lying area preference

The occupancy of lying areas with a mat increased as compared to both the same lying areas before the installation of the mats (period 0), and to the other lying areas without a mat during the same observation period (Fig. 2). Sows spent on average 15% more time in lying areas covered with a mat than expected from the surface areas of the different lying compartments ($F_{1,42,4} = 7.02, P = 0.011$). This preference was more pronounced amongst sows that had been habituated to the experimental set-up for >7 days versus <7 days ($F_{1,187} = 12.74, P < 0.001$).
The preference was also more pronounced in period 2 than period 1 ($F_{1,183} = 8.33$, $P = 0.004$). However, the latter variable should be interpreted with caution as it co-varied with group size (period 1: mean = 17.4 sows, period 2: mean = 22.6 sows) and ambient temperature (period 1: mean = 17.8 °C, period 2: mean = 14.8 °C) (Table 1). Moreover, there already was a tendency for this same preference prior to the introduction of any mats (period 0). Mats did not significantly affect the proportion of time spent standing ($F_{1,143} = 0.01$, $P = 0.932$), sitting ($F_{1,142} = 2.54$, $P = 0.113$) or lying ($F_{1,144} = 0.54$, $P = 0.463$).

3.2. Influence of mats on lying and stand up behaviour

Accounting for period, lying area, number of other sows in the lying area and whether or not the lying bout seemed to have been terminated by another sow, covering lying floors with a mat did not affect lying bout duration ($F_{1,143} = 0.01$, $P = 0.932$). The duration of lying per lying posture was also not affected by the presence of a mat ($F_{1,144} = 0.65$, $P = 0.422$), nor was the duration of stand up behaviour ($F_{1,142} = 2.54$, $P = 0.113$). The time taken to change from lying to standing was positively associated with the time the sow had been lying ($F_{1,142} = 2.78$, $P = 0.031$), and was longer when standing up seemed to have been caused by another sow ($F_{1,142} = 13.04$, $P < 0.001$). The odds that sows predominantly adopted a sternal lying posture was 2.66 times higher on concrete versus mats. Indeed, sows lying on a mat were significantly more likely to predominantly lie in the (semi-)recumbent posture as compared to sows lying on concrete ($\chi^2_{1} = 8.58$, $P = 0.003$; Fig. 3). Adjusting for the effect of lying bout duration, sows changed lying posture more often on mats than on concrete ($\chi^2_{1} = 9.30$, $P = 0.002$).

4. Discussion

Covering solid floors with a soft synthetic mat appears to have the potential to improve the physical/thermal comfort of lying areas for pregnant sows. Indeed, under conditions of the
present experiment, sows showed a preference for lying areas covered with mats compared to concrete floors. This preference was more pronounced amongst sows that have had more time to gain experience of the experimental set-up, confirming observations by Phillips et al. (1996) that sow flooring preferences depend on the length of time the animals are exposed to unfamiliar options. An alternative explanation is that sows that were newly introduced into the group prioritized avoidance of pen mates over floor preference in their choice of lying compartment. Independent of this habituation/introduction-effect, the preference for the mats was stronger during period 2 than period 1. Period co-varied with stocking density, total area covered by mats, and ambient temperature such that their effects could not be determined separately. It is unlikely, however, that the stronger preference for mats during period 2 was related to the increased stocking density. To the contrary, the higher stocking density is likely to have decreased the possibility of sows having a free choice between lying areas with or without mats at all times thereby potentially masking the true magnitude of the sows’ preference. Indeed, the 8.5 m² area covered by mats was probably insufficient to allow free choice to all 21–25 sows at all times during period 2. We speculate, instead, that sows showed a stronger preference for mats during period 2 because lying areas 2 and 4 appear to have been preferred already prior to the introduction of the mats, and/or because it was colder during period 2 than period 1. Other studies

Fig. 3. Mean observed percentages of dominant lying postures (i.e. the posture- sternal, semi recumbent and fully lateral recumbent-that was adopted for the greatest proportion of time during a lying bout) for (a) period 1 (mats in lying areas 1, 3 and 5) and (b) period 2 (mats in lying areas 2 and 4) of the experiment.
have also demonstrated that the pigs’ preference for insulating floor types depends on the thermal conditions in the pig house (Fraser, 1985; Morrison et al., 1987; Marx and Mertz, 1989). In fact, ambient temperature during period 2 of the present experiment was often below the lower threshold of the thermoneutral zone for group-housed sows. The lower critical temperature of individually housed sows ranges between 20 and 23 °C (Noblet et al., 1989) and has been estimated to be ca. 6 °C lower in group-housed sows (Geuyen et al., 1984).

The difference in lying posture observed in the present study confirms the added comfort provided in a cold environment by the insulating properties of the mats compared to bare concrete floors. Sows were more likely to adopt a sternal lying posture on concrete than on a mat. When the effective temperature is low, pigs adopt a sternal lying posture which minimises their contact with, and hence the transfer of heat to, the floor (Baldwin and Ingram, 1967; Geers et al., 1986; Huynh et al., 2005; Geers, 2007). Research combining measurements of energy metabolism and behaviour confirms that the thermal neutral or comfort lying behaviour for pigs is the fully recumbent posture (Baldwin and Ingram, 1967; Close et al., 1981).

Generalisation of the findings of the present experiment to other (climatic) conditions may be problematic. During summer, and in badly insulated pig holdings in particular, when effective ambient temperature rises above the thermal comfort zone, sows may well prefer to lie on concrete floors for cooling down rather than on mats which may be softer but reduce the loss of body heat to the floor. In addition, the design of the present experiment did not allow an investigation of the (long-term) effect of mats on leg health, pressure sores and other skin lesions. As has been documented by experiments with mats in farrowing pens, the use of mats may be associated with more frequent (Boyle et al., 2000) or more severe (Gravås, 1979) skin injuries.

5. Conclusion

There is circumstantial evidence that the preference of sows for mats versus concrete flooring was related to the thermal insulation provided by the mats, although it cannot be excluded that the cushioning or some other property of the mats had an effect as well. Our results indicate that, at least under (climatic) conditions of the present experiment, synthetic lying mats may be a promising alternative to straw bedding for improving sow lying comfort. Of course, lying mats cannot be considered as a full substitute for straw bedding. Apart from improving floor comfort straw bedding also functions as a stimulus and outlet for exploration, foraging, rooting, chewing and nest building behaviours. These other welfare functions of straw might be fulfilled by other types of environmental enrichment that could be provided in combination with lying mats (Tuyttens, 2005). Perhaps, such a combination of lying mats for improving lying comfort and some other environmental enrichment for the expression of behaviours that sows are motivated to perform, has more potential to be implemented on commercial farms than the use of straw. However, further research is required to compare the occupancy and lying posture of sows on mats versus concrete flooring versus straw bedding across a wider range of climatic conditions, to evaluate the consequences on aspects such as leg health and skin lesions in the long-term, and to improve the durability of the mats. Regarding the latter, it should be noted that shortly after the experiment the mats had to be removed as they had become damaged at the edges (cause not known).

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