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The effect of nesting material on the nest-building and maternal behavior of domestic sows and piglet production

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ABSTRACT: Nest building is an important part of maternal behavior in domestic pigs. The aim of the study was to assess the effect of nesting material sawdust vs. straw on sow behavior 24 h before and after birth of the first piglet (BFP) and piglet production. Sows, housed in farrowing crates, were randomly divided into 2 treatments: sawdust (n = 12) and straw (n = 13). Sawdust and straw were provided during the pre- and parturient period; after parturition, straw was given to both experimental groups. The prepartum nesting period (the time interval between the first and last nest-building records, including all other activity and resting before BFP), the nesting records (number of nesting records), nesting duration (duration of all nesting records), the start and termination of nesting, and the frequency of prepartum postural changes were collected 24 h before BFP. After BFP, number of nesting records and time to first sucking of the litter were collected. Frequency of postural changes and duration of udder access were collected 24 h after BFP during 3 time periods (during parturition, from the end of parturition to 12 h after BFP, and 12 to 24 h after BFP) and the frequency of nursing during 2 time periods (from the end of parturition to 12 h after BFP, and 12 to 24 h after BFP). Piglet BW gain and mortality were estimated 24 h after BFP. Data were analyzed using PROC MIXED and the probability of the piglet mortality using PROC GENMOD in SAS. Nesting material did not affect (P > 0.10) most of sow prepartum nesting behavior and had no effect (P > 0.10) on the prepartum frequency of postural changes. Sows from the sawdust treatment had a longer nesting period (P < 0.05), and nest building tended to start sooner (P < 0.10) than in the straw treatment. Nesting material had only a small effect on later maternal behavior. Sows from the straw treatment tended to have more nesting records after BFP (P < 0.10). The frequency of postural changes was affected by the interaction (P < 0.01) between treatments and time period: sow from the straw treatment had more postural changes during parturition compared with other time periods and sawdust treatment. No effect (P > 0.10) of the nesting material on piglet BW gain and mortality was found. The results suggest that sawdust compared with straw as nesting material provided to sows before and through parturition does not negatively affect maternal behavior during the 24 h before and after parturition or piglet production. Therefore, sawdust can be recommended as a suitable nesting material for farrowing sows when straw is not available.

Key words: maternal behavior, mortality, nest building, nesting material, piglet growth, sow

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INTRODUCTION

Within 24 h of parturition, sows in farrowing pens and crates are highly motivated, even without nesting material, to perform nest-building behavior such as rooting, nosing, and pawing (Jensen, 1986). However, sow behavior can be negatively affected when there is no nesting material available compared with sows with access to bedding: more oral-nasal stereotypes, greater heart rate (Damm et al., 2003), greater concentrations of cortisol before farrowing (Lawrence et al., 1994), longer duration of parturition (Cronin et al., 1993), shorter nursing duration (Herskin et al., 1999), and more postural changes the first 24 h postpartum (Herskin et al.,...
Based on this empirical evidence, recent European Union legislation requires that sows must be given “suitable nesting material in sufficient quantity unless it is not technically feasible for the slurry system used in the establishment” (Council of the European Union, 2001). This raises an important question: which type of nesting material can be used? Researchers have found a positive effect of straw provision on the nest-building behavior of sows compared with having no nesting material (Cronin and Smith, 1992). There is some evidence that sawdust may have a positive effect on the duration of birth and reduction of the rate of stillborns compared with sows housed without bedding (Cronin et al., 1993), even though sawdust does not allow for building of a functional nest. It is not clear, however, whether provision of sawdust as a nesting material can stimulate prepartum nest-building behavior and as well the postpartum maternal behavior of sows similar to that of straw. Sawdust could be a solution in intensively housed sows when the availability of straw is limited.

In this study, we assessed the effect sawdust compared with straw as nesting material provided to farrowing sows before and through parturition on the nest-building behavior before parturition and its effect on the maternal behavior and piglet production during the 24 h after birth of the first piglet (BFP).

MATERIALS AND METHODS

All procedures involving animals were approved by the Animal Care and Use Committee of the Institute of Animal Science (Prague, Czech Republic).

Animals and Housing

Twenty-five multiparous crossbred sows (Large White × Landrace sows, inseminated by Hampshire or Pietrain × Hampshire boars) with piglets (13 ± 2.2 piglets/litter) were enrolled in the study. One week before the expected farrowing individual sows were moved to farrowing pens (2.3 × 2.0 m) that had concrete floors. Sows were divided using a completely randomized design in 2 groups with different nesting material treatments available 1 wk before their expected parturition date: sawdust (fine wood shavings in length up to 0.5 cm, n = 12, parity 6.50 ± 3.16 mean ± SD) or straw (n = 13, parity 7.54 ± 4.18, mean ± SD). Because of European Union legislation (Council Directive 91/630/EEC laying down minimum standards for the protection of pigs) and Czech regulation (208/2004 Sb.), the farrowing sows had to be provided with some bedding material, and therefore, we were not able to include a control group without bedding. Each pen was equipped with a “walk-around” octagonal farrowing crate (2.3 × 1.5 m) with small partitions in its center and on a side, which prevents the sow from lying in this place (Figure 1). The crate allowed the sow to walk around in a single direction, but not to turn around or to reach the creep area of the piglets (2.3 × 0.5 m) in the pen.

Supplemental heat from a warm plate in the creep area was provided.

Sawdust was provided before and throughout parturition. Within 3 h after the end of parturition, sawdust in sawdust-treated farrowing crates was replaced with straw. This was necessary because of technological problems with cleaning of crates. Therefore, both treatment groups had only straw bedding from this point forward. Based on previous work, sow responsiveness decreased toward external disturbance after parturition (Peder sen et al., 2003; Chaloupková et al., 2008); therefore, we assumed that the activity of replacing of sawdust with straw during this time period would not affect sow responses. In fact, the initial statistical analysis did not detect any time effect of changing the nesting material, and therefore, this variable was omitted from further statistical models. In straw-treated crates, new straw bedding was given within a routine cleaning after parturition.

Sows were fed twice each day a complete feed designed to meet the nutrient requirements of lactating sows (Sano, Czech Republic; 12.99 MJ per 1 kg of feed). Water was continuously available from 1 nipple for the sow and another for the piglets. The room had some natural daylight from windows, combined with 24 h of artificial lighting.

Video Recordings

A separate closed-circuit video camera (Panasonic WV CP 450/G, Panasonic WV CL350, Osaka, Japan) and video cassette recorder (Panasonic AG 6730E, AG TL750E) was used for each pen. The camera was positioned 2 m above the pen. A microphone (Sennheiser evolution 825-S, Sennheiser electronic GmbH & Co., KG, Wedemark, Germany), positioned 1.8 m above the
pen, was connected via cables to the video cassette recorder in an adjacent room.

**Behavioral Observation and Variables**

The undisturbed behavior of the sows was videotaped 2 d before the expected parturition using 24 h time-lapse recording. Nest-building behavior was analyzed for the 24-h period before BFP and during parturition. Other postpartum maternal behaviors were analyzed during the 24 h after BFP.

**24 h Before BFP.** A nest-building record was considered to start when the sow manipulated the nesting material or floor (pawing, rooting, carrying, or arranging straw/sawdust) for at least 60 s and was considered to end when the nest building was interrupted for more than 10 s. Thus, for each nest-building record, we recorded its duration (s).

Nest building was characterized by the following variables: prepartum nesting records (total number of nest-building records); prepartum nesting duration (duration of all nest-building records, h); prepartum nesting period (time interval between the first and last nest-building record including all other activity and resting before BFP, h); start of prepartum nesting (time interval between the first nesting records and BFP, h); and termination of prepartum nesting (time interval between the last prepartum nesting and BFP, h). The last variable characterized sow activity, prepartum frequency of postural changes per hour, and was defined as the total number of shifts between the 4 postures (lateral lying, sternal lying, sitting, and walking combined) calculated for the 24 h before BFP (Table 1).

**24 h After BFP.** The occurrence of the nest-building behavior after BFP was observed during parturition and was characterized with the variable nesting records after BFP (total number of nesting records after BFP). After the birth of the last piglet, we observed the time of the first sucking of the litter, defined as the interval between birth of the last piglet and sucking activity of at least 80% of the litter (teat in mouth while performing sucking movements, min). We also recorded the duration of the parturition (time interval between the BFP and the birth of the last piglet, h).

Based on studies concerning sow activity and responsiveness 24 h after parturition (Jarvis et al., 1999; Pedersen et al., 2003), the first 24 h after BFP was divided into 3 time periods: parturition (from BFP to birth of last piglet), phase 1 (from birth of last piglet to 12 h after BFP), and phase 2 (from 12 h after BFP to 24 h after BFP). Sow behavior after BFP was characterized by these variables: the frequency of postural changes per hour, defined as the total number of shifts between the 4 postures (lateral lying, sternal lying, sitting, standing, and walking combined) calculated during parturition, phase 1 and phase 2 (Table 1); the duration of the udder access per hour (total percentage of lateral lying with free udder access), calculated during parturition, phase 1 and phase 2; and the frequency of nursing per hour, calculated only during phase 1 and phase 2 (Table 1).

**BW Gain and Mortality of Piglets**

Piglets were weighed after birth and at 24 h after BFP. The difference between these BW was used to calculate BW gain during the first 24 h. The mortality of live-born piglets during 24 h after BFP was calculated as the total number of live-born piglets immediately after birth minus the total number of piglets alive 24 h after BFP.

**Statistics**

All data were analyzed using SAS (SAS Inst. Inc., Cary, NC). Results were considered statistically significant when $P \leq 0.05$ and as a tendency to differ when $0.05 < P \leq 0.10$. The explanatory variables nesting material (sawdust and straw) and time period (parturition, phase 1 and phase 2) were included as categorical variables in the models. Litter size and piglet birth weight were included as continuous variables in the models. In the initial analysis, the continuous effect parity of sows showed no significant effects and was removed from all final models.

**24 h Before BFP.** A general linear model (PROC MIXED) was used to analyze the prepartum nesting records, prepartum nesting duration, prepartum nesting period, start of prepartum nesting, termination of prepartum nesting, and prepartum frequency of postural changes. The fixed effects included nesting material and litter size.

**24 h After BFP.** A general linear model (PROC MIXED) was used in the analysis of the number of nesting records after BFP, duration of parturition, and

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**Table 1. Definition of sow postures and nursing behavior**

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral lying</td>
<td>Sow is lying on her side with one shoulder touching the floor.</td>
</tr>
<tr>
<td>Sternal lying</td>
<td>Sow is lying on her belly without a shoulder touching the floor.</td>
</tr>
<tr>
<td>Sitting</td>
<td>Both feet on the front legs as well as the posterior of the sow are touching the floor.</td>
</tr>
<tr>
<td>Standing/walking</td>
<td>Sow stands on all 4 legs.</td>
</tr>
<tr>
<td>Nursing</td>
<td>A nursing event was considered to start when 50% of the piglets were suckling at the udder (teat in mouth while performing sucking movements) and to finish when sow terminated or 80% of the piglets stopped being active at the udder.</td>
</tr>
</tbody>
</table>
time of first sucking of the litter. The fixed effects included nesting material and litter size.

A general linear mixed model (PROC MIXED) was used to analyze the frequency of postural changes, duration of udder access, and frequency of nursing. In the models with repeated measures, the fixed effects were nesting material, litter size, time period, and the interaction between nesting material and time period. The sow identity was included as a random effect.

Piglet Production. A logistic regression (PROC GENMOD) was used to analyze piglet mortality with the fixed effects nesting material, litter size, and piglet birth weight. A linear model (PROC MIXED) was applied to analyze the piglet BW gain with the fixed effects of nesting material, litter size, and piglet birth weight.

In the mixed models analyses, the significance of the pairwise differences of the nesting material and time period between levels was assessed using least squares means. The least squares means were computed for each level, and their difference was tested using a t-test adjusted through the Tukey-Kramer (Bonferroni) method for multiple comparisons.

RESULTS

Three sawdust-housed sows were omitted from the analysis because of technical problems with the video recordings.

Table 2. The effect of the nesting material on nest-building behavior 24 h before the birth of the first piglet (BFP) and on sow behavior 24 h after BFP and piglet production

<table>
<thead>
<tr>
<th>Item</th>
<th>Prepartum treatment</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sawdust (n = 9)</td>
<td>Straw (n = 13)</td>
<td>F (df 1, df 2)</td>
</tr>
<tr>
<td>Prepartum nesting records, n</td>
<td>24.6 ± 4.8</td>
<td>25.1 ± 4.0</td>
<td>0.01 (1, 19)</td>
</tr>
<tr>
<td>Prepartum nesting duration, h</td>
<td>1.0 ± 0.4</td>
<td>1.8 ± 0.3</td>
<td>1.80 (1, 19)</td>
</tr>
<tr>
<td>Prepartum nesting period, h</td>
<td>12.9 ± 2.2</td>
<td>6.8 ± 1.8</td>
<td>4.54 (1, 19)</td>
</tr>
<tr>
<td>Start of prepartum nesting, h</td>
<td>13.7 ± 2.2</td>
<td>8.2 ± 1.8</td>
<td>3.68 (1, 19)</td>
</tr>
<tr>
<td>Termination of prepartum nesting, h</td>
<td>0.8 ± 0.6</td>
<td>1.4 ± 0.5</td>
<td>0.67 (1, 19)</td>
</tr>
<tr>
<td>Prepartum frequency of postural changes</td>
<td>7.0 ± 0.9</td>
<td>7.2 ± 0.7</td>
<td>0.04 (1,17)</td>
</tr>
<tr>
<td>Nesting records after BFP</td>
<td>2.7 ± 2.3</td>
<td>8.5 ± 2.0</td>
<td>3.68 (1, 19)</td>
</tr>
<tr>
<td>Duration of parturition, h</td>
<td>3.9 ± 0.5</td>
<td>4.5 ± 0.4</td>
<td>0.62 (1, 19)</td>
</tr>
<tr>
<td>Time of first sucking of litter, min</td>
<td>10.5 ± 4.4</td>
<td>6.2 ± 3.3</td>
<td>0.57 (1, 16)</td>
</tr>
<tr>
<td>Frequency of postural changes in interaction with time period</td>
<td>3.9 ± 0.7</td>
<td>4.8 ± 0.6</td>
<td>4.72 (1, 19)</td>
</tr>
<tr>
<td>Duration of udder access, h</td>
<td>0.7 ± 0.1</td>
<td>0.7 ± 0.04</td>
<td>0.63 (1, 19)</td>
</tr>
<tr>
<td>Frequency of nursing</td>
<td>1.5 ± 0.2</td>
<td>1.6 ± 0.1</td>
<td>0.06 (1, 19)</td>
</tr>
<tr>
<td>BW gain, g</td>
<td>86.4 ± 17.2</td>
<td>99.9 ± 13.3</td>
<td>0.37 (1, 17)</td>
</tr>
<tr>
<td>Mortality, %</td>
<td>4.2</td>
<td>7.8</td>
<td>χ² = 0.64 (1)</td>
</tr>
</tbody>
</table>

1Prepartum treatment: providing of nesting material (sawdust or straw) 1 wk before expected parturition.
2Least squares means (±SE).
3Time interval (min) between the birth of the last piglet and first sucking of the litter.
4For more details see Figure 2.
5Piglet mortality was analyzed using of a logistic regression.

The Effect of the Nesting Material Before and After BFP

24 h Before BFP. A significant effect of the nesting material was detected on the prepartum nesting period (P < 0.05); sows provided with sawdust had a longer prepartum nesting period compared with those sows provided with straw. We found a tendency for the prepartum nesting to start sooner in the sows provided with sawdust compared with those sows provided with straw (P < 0.10). There was no significant effect of the nesting material on the prepartum nesting records, prepartum nesting duration, termination of prepartum nesting, and prepartum frequency of postural changes (Table 2).

24 h After BFP. Nesting material treatments provided before and through parturition tended (P < 0.10) to have an effect on the nesting records after BFP; sows provided with sawdust tended (P < 0.10) to have a smaller number of nesting records after BFP than sows provided with straw. The duration of parturition and the time of first sucking of the litter were not affected by the nesting material. The frequency of postural changes was significantly affected by the interaction between nesting material and time period (Figure 2, P < 0.05). The frequency of nursing and the duration of udder access were not affected by nesting material available prepartum and through parturition (Table 2).

BW Gain and Mortality of Piglets. The nesting material available before and through parturition
had no effect on piglet BW gain and mortality during the 24 h after BFP (Table 2). There was a significant effect of the piglet birth weight on the BW gain \((P < 0.01)\), with increasing birth weight resulting in increased piglet BW gain during that time period. Litter size tended to have the effect on the piglet BW gain \((P < 0.10)\); with increasing litter size, piglet BW gain tended to decrease.

**DISCUSSION**

The results show that that provision of sawdust bedding prepartum compared with providing straw did not elicit any negative response concerning prepartum nest-building behavior, maternal behavior, and piglet production within the first 24 h. Sawdust could, therefore, be a solution in intensively housed sows when the availability of straw is limited.

In the current study, the replacement of sawdust with straw 3 h after the birth of last piglet was necessary due to technological problems with cleaning of the crates. Nonetheless, both the activity of replacing and new bedding material did not evoke more postural changes, decreased udder access, or reduced nursing in the sawdust group in phase 1 (birth of the last piglet to 12 h after BFP) and phase 2 (12 h after BFP to 24 h after BFP) compared with the straw treatment. Our results are similar to previous studies where it has been demonstrated that sow responsiveness toward external disturbances, such as blood sampling; responsiveness toward piglet naso-nasal contacts; or sow activity, decrease after parturition and increases again about 12 h postpartum (Jarvis et al., 1999; Pedersen et al., 2003; Chaloupková et al., 2008). The decrease in activity and maternal responsiveness shortly after parturition is likely to be advantageous for the piglets because it reduces the risk of piglet crushing while at the same time giving early access to the udder and to warmth from the sow (Jarvis et al., 1999).

**The Effect of the Nesting Material Before BFP**

Sawdust had nearly the same effect as straw on the nest-building behavior of sows before parturition. Sows from both treatments did not differ in the number of nest-building records, the duration of nest building and the time of termination of the nest-building behavior before parturition. Furthermore, the frequency of postural changes 24 h before parturition was similar in both treatments, indicating that sows provided with sawdust were not more restless. It has been suggested that prepartum activity is more influenced by housing system (pens vs. crates) than by substrate type (no straw vs. straw; Cronin and Smith, 1992). Nevertheless, there was one unexpected difference between treatments. Sows provided with sawdust had a longer nest-building period, indicating that they began their nest-building behavior earlier. This suggests that these sows had a greater motivation to start engaging in prepartum nest-building behavior. This finding is difficult to explain; it is possible that the start of the nest-building behavior may be less important because these sows devoted the same frequency and duration for prepartum nest-building behavior compared with the sows provided with straw.

There is previous evidence that sows perform more nest-building behavior when they have access to nesting material compared with when they do not have access to any nesting material [e.g., straw (Jensen, 1993; Thodberg et al., 1999) or sawdust (Cronin et al., 1993)]. Our results suggest that sawdust can fulfill the behavioral need of the sow to perform this nest-building behavior, even though sawdust does not allow the building of a functional nest. The sow can, however, still engage in rooting and manipulating with sawdust, which are important components of nest-building behavior. This result agrees with previous studies, where it was found that the structure of straw (Damm et al., 2005), or its amount (Arey et al., 1992), did not influence the frequency and duration of nest-building behavior before parturition. Researchers have, however, found that short-cut straw may result in increased manipulation of pen equipment before farrowing, and was, therefore, suggested to be less suitable than long-cut straw (Burri et al., 2009). On the other hand, nest-building behavior (manipulation with straw and frequency of pawing) were not affected by straw length in that study (Burri et al., 2009).
The Effect of the Nesting Material After BFP

The postpartum maternal behavior of sows provided with sawdust before and through parturition was not negatively affected. In contrary, in the straw treatment, sows had a tendency of greater nest-building behavior in this group. A greater proportion of sows on the straw treatment (85 vs. 45%) continued in nest-building behavior after BFP. This contrasts with the results of other studies in which a more suitable nesting material resulted in less nest building during parturition [e.g., straw and branches vs. straw only (Damm et al., 2000), or straw vs. no material (Thodberg et al., 1999)].

It has been suggested that reduced frequency of postural changes reduces the risk of crushing during and immediately after parturition (Weary et al., 1996; Marchant et al., 2001) because piglets are either not vigilant or mobile enough to escape dangerous situations (English and Smith, 1975). However, even though sows from the straw treatment had more postural changes during parturition, this did not cause greater piglet mortality in the current study. This suggests that the careful change of posture (Pedersen et al., 2003) and a greater response to screams of crushed piglets might be important for reducing piglet crushing (Illmann et al., 2008) than simply the frequency of postural changes.

The duration of parturition was not prolonged in the sawdust treatment. This is an important result because it has been shown that no access to bedding around parturition prolongs the duration of the parturition and increases the rate of stillborn piglets and piglet mortality (Cronin et al., 1993; Thodberg et al., 1999). It is possible that the absence of bedding is stressful for the sow, as indicated by increased cortisol concentrations (Lawrence et al., 1994; Jarvis et al., 2001, 2002) and greater heart rate (Damm et al., 2003); this stress could prolong the course of parturition and increase piglet mortality.

The time of first sucking of the litter, which is important for piglet survival (Bünger, 1985; De Passillé and Rushen, 1989; Tyler et al., 1990; Tuchscherer et al., 2000), was not delayed in the sawdust treatment. Our data, as indicated by the same duration of udder access and the same nursing frequency, suggest that sows in both groups had the same motivation to nurse their litter.

The Effect of the Nesting Material on BW Gain and Piglet Mortality

Piglet mortality and piglet BW gain during the first 24 h were similar in both treatments, indicating that sawdust compared with straw as nesting material provided before and through parturition did not negatively affect piglet survival. This is an important result because in commercial pig production, piglet mortality remains a problem in both crated and loose-housed sows with mortality rates ranging between 10 and 30%. The majority of piglets die within the first 1 to 3 d of life with a peak occurring during the first 24 h due to crushing and starvation (Edwards and Malkin, 1986; Marchant et al., 2000). Our results confirmed the previous finding (Castrén et al., 1991; Weary et al., 1998; Tuchscherer et al., 2000) that increasing piglet birth weight and decreasing litter size was related to greater BW gain of piglets 24 h after BFP.

In conclusion, the current study showed that sawdust compared with straw as nesting material provided to sows before and through parturition does not negatively affect maternal behavior during the 24 h before and after parturition or piglet production. Therefore, based on these results, sawdust can be recommended as a suitable nesting material for farrowing sows when straw is not available.

LITERATURE CITED


