Management routines at the time of farrowing—effects on teat success and postnatal piglet mortality from loose housed sows

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A B S T R A C T

The aim of this experiment was to study the effects of six different management routines at the time of farrowing on latency to first suckle, heat loss, weight gain and postnatal mortality. A total of 872 piglets from 67 loose housed sows in a commercial pig unit were subjected to one of six different management routines: control (CON n = 14), no treatment; (CREEP n = 13), placed in creep area; (UDDER n = 10), placed at the udder; (DRY n = 10), dried and placed back where found; (DRYCREEP n = 9), dried and placed in creep area; and (DRYUDD n = 11), dried and placed at the udder. The latency from birth to first suckle, rectal temperature at birth, 2 hours and 24 hours were measured for each piglet, in addition to weight at birth, 2 hours and 24 hours. Latency from birth to first suckle was shortest for piglets in the DRYUDD treatment, followed by the UDDER treatment (P < 0.001). More live born piglets died in the UDDER treatment compared to the other treatments (P < 0.001), but there were no other differences between the treatments with regards to postnatal mortality. There was a significant interaction between treatment and batch, with a significantly lower postnatal mortality in the DRYUDD treatment than CON in batch 2, but not in batch 1 and 3 (P < 0.001). Large litter sizes resulted in a higher postnatal mortality in all treatments (P < 0.001), and tended to reduce latency to suckle (P < 0.1). In conclusion, drying the piglets after birth and placing them at the udder resulted in reduced postnatal mortality in batch 2, but not in the other two batches. Despite having the largest mean litter size of the treatments, less than 10% of the piglets in DRYUDD died, which is remarkably low for loose housed sows. Regardless of treatment, several piglet-related factors were found to be highly important for postnatal mortality, such as the number of functional teats per piglet (P < 0.001), birth weight (P < 0.001), the latency from birth to first suckle (P < 0.01), and rectal temperature at 2 hours after birth (P < 0.001).

1. Introduction

Prenatal factors, maternal behaviour, physical environment and the management around farrowing all play an important role in piglet survival (e.g. Andersen et al., 2005; Baxter et al., 2008; Andersen et al., 2009). Temperatures in the farrowing unit are normally kept below the piglets' lower critical temperature (34 °C), which can induce cold stress and render the piglets less viable (e.g. English, 1993). Heat loss is especially critical for piglets directly after birth, as they are wet with birth fluids, have no insulating layer of fat or fur, and have a poorly developed thermoregulatory capacity (Herpin et al., 2002). Newborn piglets can lose more than 2 °C in body temperature from birth until they find a teat or enter the heated creep area, and this heat loss may be fatal for weak and small piglets, as they are in greater risk of starvation or being crushed by the sow (Baxter et al., 2008; Pedersen et al., 2008). Colostrum intake is vital in order to improve thermoregulation and survival in newborn piglets, as body
temperature and heat production are positively related to colostrum intake (e.g. Gentz et al., 1970), and piglets without colostrum intake are unable to reach thermostability (Noblet and Le Dividich, 1981). In addition, hungry piglets often stay close to the sows’ udder, which may further increase the risk of crushing (Weary et al., 1996). Previous studies found that piglets who survive to weaning are generally heavier, born earlier in the litter and spend less time from birth to first suckling (Hartsock and Graves, 1976; Tuchscherer et al., 2000; Baxter et al., 2008). Knowing that it can take up to 3 hours for a piglet to reach a teat after birth (e.g. Thingnes et al., 2008), it is important to reduce the heat loss after birth, and subsequently, perhaps reduce the time from birth to colostrum intake.

In order to reduce piglet heat loss, the farrowing pen is often equipped with a suitable microclimate (34–36 °C) for the piglets. However, it is well known that piglets prefer to remain near the sow and littermates for the first few days after birth (e.g. Andersen et al., 2007; Vasdal et al., 2009), and attempts to increase the use of the creep area by providing attractive stimuli have not been successful (Vasdal et al., 2010). Previous studies found several management routines that reduced piglet mortality, including supervising the farrowings and provision of oxygen, giving milk and fluids orally or tying the umbilical cord (e.g. Holyoake et al., 1995; White et al., 1996; Alonso-Spilsbury et al., 2007). An efficient and simple way of reducing the heat loss after birth is to dry the piglets and place them under the heat lamp, which alone can reduce piglet mortality by 6–8% (McGinnis et al., 1981; Christison et al., 1997; Andersen et al., 2009). However, Christison et al. (1997) did not find a relationship between drying piglets, placing them in the creep area, and time to first suckle. Comparatively, helping piglets to get colostrum after birth by placing them near the udder has improved piglet survival in commercial loose-housed sow herds (Andersen et al., 2007). For the pig farmer, it is important to know which of these routines are the most efficient with regards to reducing postnatal mortality, and thus being able to wean more piglets. To develop some rules of thumb on management around the time of farrowing would benefit pig welfare and survival, thus improve the farmer’s economic return, as long as the routines are simple and not too time-consuming.

The aim of the present experiment was to study the effects of six different management routines at the time of farrowing on latency to first suckle, heat loss, weight gain and postnatal piglet mortality.

2. Materials and methods

2.1. Experimental design

A total of 872 piglets of sows kept in individual farrowing pens were subjected to one of six different management routines, directly after the birth of each piglet. During three farrowing batches, a total of 67 healthy sows were, prior to farrowing, randomly allotted to one of the following treatments: control (CON n = 14), no treatment; (CREEP n = 13), placed in creep area; (UDDER n = 10), placed at the udder; (DRY n = 10); dried and placed back where found (DRYCREEP n = 9); dried and placed in creep area and (DRYUDD n = 11); dried and placed at the udder. All piglets in the experiment were thus handled by experimental staff in order to obtain the data at birth, 2 hours and 24 hours. All piglets in a litter were subjected to the same treatment, and all treatments were represented in each batch.

2.2. Animals and housing

This experiment was conducted on a commercial Norwegian farm with loose housed sows. The sows were Yorkshire × Norwegian Landrace inseminated with Norwegian Landrace × Duroc boar semen. Sow parities ranged from one to seven (average, 2.7 ± 0.2). The parities were categorized as 1 = parity 1–2 (n = 32), 2 = parity 3–4 (n = 22), 3 = parity 4–7 (n = 13). The sows were moved from the group housing gestation unit to the farrowing unit at day 110 post-insemination. The farrowing unit where the farrowing pens were located was insulated and mechanically ventilated and the air temperature was kept at 20 °C until farrowing, and then reduced to 16 °C the day after farrowing.

The sows were housed in standard Tunby® individual farrowing pens, measuring 6.2 m² in total. The sow area measured 5.0 m² with 2.7 m² slatted plastic floor (Fig. 1). There was a 2-cm layer of sawdust on the solid floor in the sow area and in the creep area at the time of farrowing. The creep area (1.2 m²) was separated from the sow by a diagonal wall with a gap at the bottom for piglets to enter. The creep area was heated by floor heat, providing a surface temperature around 28 °C. There were no heat lamps in the creep areas. The sows were automatically fed a standard lactation concentrate (5% CF, 20% CP) at 08:00 hours, 14:00 hours and 1800 hours. From day 113 until farrowing the sows got 1 kg of straw in the morning for nest building. Then pens were
cleaned out and new sawdust was provided both in the sow area and the creep area twice a day. Wet straw and litter was removed shortly after farrowing and replaced with dry and fresh litter.

Irrespective of treatment, all piglets were tooth ground before 24 hours of age, and male piglets were castrated around day five. To avoid interference with the treatments, no assistance other than the experimental treatments was given to piglets after birth. Piglets in the largest litters were cross-fostered to the smaller litters between 12 and 24 hours after birth, and a total of 58 piglets were cross-fostered during the experiment. Data from the cross-fostered piglets were not included in the results. Piglets were only cross-fostered within treatments. Litter size in this study is thus defined as: no. of liveborn piglets + piglets fostered on – piglets fostered off.

All dead piglets were subjected to a post mortem to determine cause of death, and piglets not able to survive because of injuries or starvation were euthanized by the staff. The dead piglets were categorized as stillborn (lungs sink in water), dead before milk intake (no milk in stomach), dead after milk intake (milk in stomach), crushed before milk intake (physical signs of crushing, no milk in stomach) and crushed after milk intake (physical sign of crushing, milk in stomach). Physical signs of crushing included bruising to the body, cranial bone fractures, haemorrhage or crushed internal organs.

2.3. Experimental procedure

The following parameters were registered for all the piglets in the experiment;

• Initial registrations: Time of birth, birth weight and rectal temperature at birth. All piglets were marked with their birth number.
• Latency from birth to first suckle (three consecutive sucks on a teat).
• 2 hour registrations: weight at 2 hours after birth and rectal temperature 2 hours after birth.
• 24 hour registrations: weight at 24 hours after birth and rectal temperature at 24 hours after birth.

In addition to the registrations mentioned above, one of the following treatments was conducted on the piglet directly after the initial registrations:

• CON: Piglet placed back at birth location
• CREEP: Piglet placed in the creep area
• UDDER: Piglet placed at an available spot at the udder
• DRY: Piglet was dried with straw and paper towel for 15 seconds and placed back where it was found
• DRYCREEP: Piglet was dried with straw and paper towel for 15 seconds and placed in the creep area
• DRYUDD: Piglet was dried with straw and paper towel for 15 seconds and placed at an available spot at the udder

After the 2 hour and the 24 hour registrations, the piglet was placed back where it was found at the time. Registrations on each sow included parity and number of functional teats, and the number of functional teats per piglet in each litter was then calculated.

2.4. Statistical methods

The difference between treatments with respect to latency to suckle, weight gain and heat loss were analyzed using a generalized linear model, GLIMMIX procedure (with Poisson distribution) in SAS including both fixed and random effects, and with individual piglets as the statistical unit. The model included the following fixed effects: treatment (1–6), batch (1, 2, 3), sow parity category (1, 2, 3), and the interactions between treatment and batch and between treatment and number of functional teats per piglet were included in the model. Sow was included as a random effect, and birth weight, birth order and teats per piglet was included as continuous variables in the model. Postnatal piglet mortality (with Poisson distribution) and causes of mortality (with Gamma distribution) were analyzed using a generalized linear model, GENMOD procedure in SAS only including fixed effects, and with mean value per litter as statistical unit. This model included the following fixed effects variables: treatment (1–6), batch (1, 2, 3) and sow parity category (1, 2, 3). The interactions between treatment and batch and between treatment and teats per piglet were also included in the model. Birth weight, latency to suckle, rectal temperature at 2 hours and number of functional teats per piglet were included as continuous variables. Differences in litter size, birth weight and farrowing duration between treatments were analyzed using a GLM procedure in SAS with mean value per litter as statistical unit. This model included the following class variables: treatment (1–6), batch (1, 2, 3) and sow parity (1–7). LSmeans were used to analyse differences between means. Only significant results are presented in the Results section.

3. Results

Litters in DRYUDD treatment had, on average, a larger litter size compared to litters in DRYCREEP and CON treatments ($F_{5,23} = 21.2, P < 0.05$; Table 1). The average number of functional teats per sow was 15.0 ± 0.1 (range 13–17). Batch 1 had a higher litter size compared to batch 3 (batch 1, 14.7 ± 0.5; batch 2, 14.3 ± 0.4; batch 3, 13.0 ± 0.3, $F_{2,23} = 3.9, P < 0.05$).

3.1. Postnatal piglet mortality

Postnatal mortality (% of litter size) until weaning in this experiment was on average 10.1 ± 1.4%, while the percentage of stillborn piglets was on average 5.9 ± 1.0% (of total born). More liveborn piglets died in UDDER treatment compared to CON and DRYCREEP ($\chi^2_{5,39} = 75.2, P < 0.001$), but there were no other significant differences in postnatal mortality between treatments (Table 1). There was a significant interaction between treatment and batch, with a significantly lower postnatal mortality in the DRYUDD treatment than CON in batch 2, but not in batch 1 and 3 (mortality (% of litter size) in batch 2: CON: 11.8 ± 3.7%, DRYUDD: 2.0 ± 2.0%, $\chi^2_{2,39} = 18.3, P < 0.001$). The majority of the dead piglets died before they received milk (65.2 ± 13.9%) and litters in DRY and CREEP had the lowest percentage of piglets in this category ($\chi^2_{5,39} = 11.5, P < 0.05$). Significantly fewer piglets were crushed before receiving milk in CON compared to CREEP, UDDER and
Both before receiving milk (\(\chi^2_{5, 39} = 12.4, P < 0.001\); Fig. 3), and a higher rectal temperature at 2 hours after birth (\(\chi^2_{4, 39} = 8.1, P < 0.01\); Fig. 4) were all associated with overall higher postnatal mortality (\(\chi^2_{3, 39} = 8.2, P < 0.001\)) and after receiving milk (\(\chi^2_{3, 39} = 8.2, P < 0.001\)). Latency to first suckle was also shorter when there were fewer piglets per teat (\(\chi^2_{3, 39} = 23.2, P < 0.01\); Fig. 2), in piglets with higher birth weight (\(F_{1, 694} = 18.2, P < 0.001\)), a higher weight at 2 hours (\(F_{1, 694} = 17.4, P < 0.001\), and in piglets with higher rectal temperature at 2 hours after birth (\(F_{1, 694} = 8.1, P < 0.01\); Fig. 4). Increased litter size tended to increase latency to first suckle (\(F_{1, 694} = 6.9, P < 0.1\)). Piglets had a shorter latency to suckle in batch 2 compared to batch 1 and 3 (\(F_{2, 694} = 9.8, P < 0.001\)).

### 3.2. Teat success

Latency from birth to first suckle (average: 62 ± 1.9, range: 1–496 min) was shortest in DRYUDD, followed by UDDER (\(F_{5, 694} = 5.8, P < 0.001\); Table 2). Latency to first suckle was also shorter when there were fewer piglets per teat (\(\chi^2_{3, 39} = 23.2, P < 0.01\); Fig. 2), in piglets with higher birth weight (\(F_{1, 694} = 18.2, P < 0.001\)), a higher weight at 2 hours (\(F_{1, 694} = 17.4, P < 0.001\), and in piglets with higher rectal temperature at 2 hours after birth (\(F_{1, 694} = 8.1, P < 0.01\); Fig. 4). Increased litter size tended to increase latency to first suckle (\(F_{1, 694} = 6.9, P < 0.1\)). Piglets had a shorter latency to suckle in batch 2 compared to batch 1 and 3 (\(F_{2, 694} = 9.8, P < 0.001\)).

### 3.3. Rectal temperature

Piglets in CREEP had a lower heat loss from birth until 2 hours compared to the other treatments (\(F_{3, 716} = 6.5, P < 0.01\), but there was no effect of treatment on heat loss from birth until 24 hours (Table 2). Heat loss until 2 hours after birth was smaller in piglets born early in the litter (\(F_{5, 716} = 11.2, P < 0.001\), in heavier piglets (\(\chi^2_{1, 39} = 59.1, P < 0.001\), and in piglets with shorter latency to suckle (\(\chi^2_{1, 39} = 11.2, P < 0.01\)). Increased litter size decreased heat loss from birth until 2 hours (\(F_{1, 716} = 14.3, P < 0.001\), especially in CREEP (\(F_{5, 716} = 5.7, P < 0.001\). Piglets of first and

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**Table 1**

Causes of postnatal mortality in the different treatments (mean ± S.E.).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Postnatal mortality*</th>
<th><em>χ^2</em> value</th>
<th><em>P</em> value</th>
<th>Batch</th>
<th>Interaction <em>B</em>T</th>
<th><em>χ^2</em> value</th>
<th><em>P</em> value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON</td>
<td>7.9 ± 2.1b</td>
<td>11.5 ± 2.1b</td>
<td>15.1 ± 3.8a</td>
<td>9.7 ± 2.7ab</td>
<td>7.1 ± 2.7b</td>
<td>9.3 ± 3.5ab</td>
<td>75.2</td>
</tr>
<tr>
<td>CREEP</td>
<td>2.7 ± 1.0</td>
<td>2.4 ± 0.8</td>
<td>2.4 ± 0.9</td>
<td>3.1 ± 1.1</td>
<td>2.6 ± 0.9</td>
<td>3.0 ± 0.7</td>
<td>8.4</td>
</tr>
<tr>
<td>UDDER</td>
<td>13.3 ± 0.5b</td>
<td>14.5 ± 0.5b</td>
<td>14.8 ± 0.6b</td>
<td>13.8 ± 0.8b</td>
<td>12.6 ± 0.7b</td>
<td>14.9 ± 0.6b</td>
<td>21.2</td>
</tr>
<tr>
<td>DRY</td>
<td>4.0 ± 2.1</td>
<td>5.1 ± 1.2</td>
<td>6.0 ± 2.0</td>
<td>5.2 ± 1.7</td>
<td>6.5 ± 2.1</td>
<td>6.2 ± 1.9</td>
<td>5.2</td>
</tr>
</tbody>
</table>

Different superscript denotes significant differences between treatments. *% of litter size.* †F values from GLM.
However, contrary to earlier findings (Baxter et al., 2008; Pedersen et al., 2008), there were no clear differences in postnatal mortality between the control treatment and the three dried treatments. The control treatment resulted in less disturbance of the sow and that this could explain the good results. However, overall sows in Norwegian herds are quite used to being handled and interact with the stock person during the lactation period (e.g. Andersen et al., 2007), and there was no situations with aggression towards the experimenter when conducting the treatments in the present study.

The highest postnatal mortality was found in litters that were placed at the udder without being dried first. Although the control piglets were not dried either, the litter size in the control treatment was on average 1.5 piglets less per litter compared to the latter. Placing piglets in the creep area, in particular without drying them first, had clear negative effects on latency to suckle and weight gain, both of which is important for piglet survival. However, the mortality was still lowest in the DRY and DRYCREEP treatments compared to the other treatments, but not the control treatment. This is contrast to Andersen et al. (2009) who documented much lower mortality when piglets were either placed directly in the creep area immediately after birth or both dried and placed under the heat lamp compared to control litters. The less clear effects of the treatments in the present study may be explained by the suboptimal design of the creep area and the exceptionally high litter sizes in some of the treatments. The sows were commonly observed resting towards the entrance of the creep area and thus blocking the piglets from getting to the udder. In fact, time to first suckle for piglets that were just placed in the creep area without drying them first, was twice as long compared to litters that were placed at the udder. If we look at all results together and the results from other studies (Andersen et al., 2007, 2009), we may still conclude that routines to reduce heat loss such as drying and helping the piglets to the udder or placing them under the heat lamp would be beneficial for survival provided that the piglets have free access to the creep area. In the DRYUDD treatment the mean litter size was almost 15, but nonetheless mortality was below 10%, which is remarkably well for loose-housed sows.

Large litter sizes had a negative effect on most of the parameters measured in this experiment; increased mortality both before and after milk intake, increased latency to suckle and reduced weight gain. Any positive effects of being placed at the udder may thus have been camouflaged by the negative effects of increased litter competition at the udder. On the second parity sows had the highest drop in rectal temperature from birth to 2 hours ($F_{2,716} = 7.8, P < 0.01$).

### 3.4. Weight gain

Piglets in CREEP had the lowest weight gain from birth to 2 hours ($F_{5,728} = 3.2, P < 0.01$), while at 24 hours, the piglets in CREEP, UDDER and DRY had a lower weight gain compared to the other treatments ($F_{5,728} = 8.9, P < 0.001$, Table 2). Weight gain until 24 hours was higher in piglets born early in the litter ($F_{1,728} = 15.2, P < 0.001$).

### 4. Discussion

The three treatments that included drying the piglets all had postnatal mortality below 10%, supporting previous findings that reduced heat loss after birth is one of the key factors for early piglet survival (Baxter et al., 2008; Pedersen et al., 2008). However, contrary to earlier findings (McGinnis et al., 1981; Christison et al., 1997; Andersen et al., 2009), there were no clear differences in postnatal mortality between the control treatment and the three dried treatments. The control treatment in the present study was handled in order to compare the weight gain and temperature development, and this stimulation was perhaps enough to increase piglet viability and reduce potential differences between treatments. It could be argued that the control treatment resulted in less disturbance of the sow and that this could explain the good results. However, overall sows in Norwegian herds are quite used to being handled and interact with the stock person during the lactation period (e.g. Andersen et al., 2007), and there was no situations with aggression towards the experimenter when conducting the treatments in the present study.

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**Table 2**

<table>
<thead>
<tr>
<th></th>
<th>CON</th>
<th>CREEP</th>
<th>UDDER</th>
<th>DRY</th>
<th>DRYCREEP</th>
<th>DRYUDD</th>
<th>$F_{5,728}$</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latency to suckle (min)</td>
<td>59.3±3.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>96.3±4.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>41.6±4.8&lt;sup&gt;c&lt;/sup&gt;</td>
<td>57.4±3.4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>77.7±5.9&lt;sup&gt;e&lt;/sup&gt;</td>
<td>43.2±3.2&lt;sup&gt;f&lt;/sup&gt;</td>
<td>5.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Weight at birth (kg)</td>
<td>1.5±0.1</td>
<td>1.5±0.0</td>
<td>1.4±0.2</td>
<td>1.4±0.1</td>
<td>1.5±0.1</td>
<td>1.4±0.1</td>
<td>7.8</td>
<td>ns</td>
</tr>
<tr>
<td>Weight at 2H (kg)</td>
<td>1.59±0.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.50±0.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.51±0.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.44±0.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.67±0.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.48±0.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.4</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Weight gain birth – 2H (g)</td>
<td>42.9±12.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>−29.4±8.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>19.8±9.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>21.2±11.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>24.7±11.3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>16.8±10.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.2</td>
<td>&lt;0.01</td>
</tr>
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<td>Weight at 24H (kg)</td>
<td>1.71±0.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.59±0.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.56±0.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.54±0.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.78±0.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.60±0.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7.7</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Weight gain birth – 24H (g)</td>
<td>163.8±18.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>61.3±11.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>64.2±10.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>84.1±15.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>128.1±16.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>118.7±18.4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>8.9</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Temperature at birth (°C)</td>
<td>37.8±0.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>37.9±0.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>38.0±0.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>37.1±0.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>37.8±0.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>38.0±0.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Temperature at 2H (°C)</td>
<td>36.8±0.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>37.1±0.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>37.1±0.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>36.6±0.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>37.1±0.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>37.4±0.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>8.2</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Diff temp birth – 2H (°C)</td>
<td>−1.0±0.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>−0.6±0.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>−0.8±0.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>−1.0±0.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>−0.7±0.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>−0.8±0.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.5</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Temperature at 24H (°C)</td>
<td>37.7±0.1</td>
<td>37.7±0.1</td>
<td>37.9±0.1</td>
<td>37.5±0.1</td>
<td>37.8±0.2</td>
<td>37.7±0.1</td>
<td>1.2</td>
<td>ns</td>
</tr>
<tr>
<td>Diff temp birth – 4H (°C)</td>
<td>0.04±0.1</td>
<td>−0.02±0.0</td>
<td>−0.2±0.1</td>
<td>−0.1±0.1</td>
<td>0.1±0.0</td>
<td>−0.3±0.1</td>
<td>1.7</td>
<td>ns</td>
</tr>
</tbody>
</table>

Different superscripts denote significant differences between treatments.
other hand, heat loss was actually reduced in large litters, in particular when the piglets were placed in the creep area, which highlights the positive effects of social thermoregulation and external heat sources. It is interesting that piglets born from gilts and second parity sows had the highest heat loss at 2 hours as there were no significant differences in litter size or latency to suckle between the parities. This might be due to a smaller udder size to gain heat from and the lower milk production in younger sows compared to older sows (e.g. Eisen et al., 2000). Difference in litter size may also partly explain the varying postnatal mortality between the batches. However, the reduced mortality when piglets were dried and placed at the udder in batch 2, but not in batch 1 and 3, when litter size in this treatment was similar, illustrates just how complex this picture is. Despite the large litter sizes, there was an overall low piglet mortality of liveborn piglets in this study compared to the Norwegian average of 14.7% (Norsvin, 2008). The management on the present farm included a well functioning protocol around farrowing regarding cross-fostering, tooth grinding and provision of nest building material. In the commercial farm used in the study by Andersen et al. (2009), postnatal mortality was almost 20% prior to the study, and there was generally little systematic management around farrowing, with little or no nest building material provided. Provision of nest building material is documented to reduce piglet mortality and stimulate maternal behaviour (Cronin and van Amerongen, 1991; Herskin et al., 1998). These results indicate that it may be more difficult to further reduce postnatal mortality in a farm where the mortality is already at such a relatively low level.

Regardless of treatment, several piglet-related factors were highly important for survival, such as the number of functional teats per piglet, birth weight, the latency from birth to first suckle, and rectal temperature at 2 hours after birth. In addition to the direct negative effect on the piglet, these factors also likely interact with each other; fewer teats per piglet will increase latency to first suckle, which reduce weight gain and rectal temperature at 2 hours, which again reduce survival rate, especially in the lighter piglets in the litter. The negative consequence of reduced colostrum intake is also illustrated by the fact that the majority of the dead piglets died before receiving milk. Interestingly, there was no effect of piglet weight on percent of piglets crushed after receiving milk. Large litter size also reduce maternal investment and responsiveness to piglet scream (e.g. Wechsler and Hegglín, 1997; Andersen et al., 2005; Torsethaugen, 2008), which might partly explain the increase in crushing in larger litters. Knowing that increased litter sizes increases birth weight variability (e.g. Herpin et al., 1993; Canario et al., 2007), and that lighter piglets have a higher risk of dying (e.g. Tuchscherer et al., 2000), makes it even more important to focus on the negative effects of selecting for increased litter size. Considering that large litter sizes have a negative impact both on piglet related factors and on the maternal motivation in sows, the effect of these management routines will likely be reduced in large litters.

In conclusion, drying the piglets after birth and placing them at the udder resulted in reduced latency to suckle in all three batches, and a reduced postnatal mortality in batch 2, but not in the other two batches. Despite having the largest mean litter size of the treatments, less than 10% of the piglets in DRYUDD died, which is very low for loose housed sows. Regardless of treatment, several piglet-related factors were found to be highly important for postnatal mortality, such as the number of functional teats per piglet, birth weight, the latency from birth to first suckle, and rectal temperature at 2 hours after birth.

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