EFFECTS OF HEAT STRESS ON RECTAL TEMPERATURE, RESPIRATORY RATE AND ACTIVITY RATES IN PERIPARTAL SOWS AND GILTS

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SUMMARY

Respiratory rate (RR) and rectal temperature (RT) of seven crossbred, second-litter sows and 11 crossbred gilts and rates of sitting and standing activity of 10 sows and gilts were measured from about 109 days of gestation to 5 days after farrowing at thermoneutral (T, 20.5 C) or hot (H, 29.8 C) ambient temperatures. Respiratory rate and RT were higher in heat-stressed sows and gilts (P<.05) before and during parturition. After parturition, neither RR nor RT differed (P>.05) among sows and gilts that were heat-stressed or held at thermoneutrality. Rectal temperature was elevated (P<.01) during the 4-hr period before parturition in all but the heat-stressed sows. Rectal temperature was higher (P<.01) during the 4 hr preceding parturition than during parturition for sows and gilts held at thermoneutrality. Rectal temperature was higher (P<.05) for gilts than for sows during parturition. Respiratory rate was lower (P<.05) during parturition than during the 4-hr period before parturition. From the time recording began until 12 hr before parturition the number of times standing-up, length of time standing and length of time sitting averaged 3.4 per hr, 1.6 min per hr and 4.1 min per hr, respectively. During the 12-hr period before parturition these activity rates were 5.0, 12.8 and 6.4, but during parturition they were only .2, .7 and 1.4, respectively. Activity rates were not affected by parity or ambient temperature. After parturition RT was lower (P<.05) than during parturition in all treatments, but at T it remained about .9 C (P<.001) above that during late gestation. Respiratory rate was lower (P<.01) after parturition than during late gestation for all but thermoneutral sows, and times standing-up and standing time were less (P<.05). Sitting time was less (P<.001) when piglets were with the dam than when the dam was alone.

(Key Words: Parturition, Heat Stress, Rectal Temperatures, Respiratory Rate, Activity, Sows, Gilts.)

INTRODUCTION

Shortly before parturition sows and gilts become restless, nest-building behavior is manifested and abdominal straining occurs (Jones, 1966a). During parturition they strain to expel piglets. These activities increase the rate of energy expenditure (Kelley et al., 1978a). If the excess heat produced is not dissipated, deep-body temperature will rise and heat stroke may result (Fraser, 1970a). High ambient temperature during parturition exacerbates this effect (Cox et al., 1964; Fraser, 1970b) by tending to reduce heat flow to the environment.

Our objective was to quantitate rectal temperature, respiratory frequency and rates of sitting and standing activity of peripartal sows and gilts and the effects of ambient temperature on these parameters.

MATERIALS AND METHODS

This study was carried out during the period June 1974 to June 1975 inclusive. Eleven crossbred gilts and seven crossbred, second-litter sows were studied. They were maintained in a total confinement gestation building at the University farm and were fed 1.8 kg of a 13% crude protein corn-soybean meal diet (3,254 kcal ME per kg) daily throughout gestation until 5 days postpartum. Ambient temperature was maintained around 20 C in the gestation building. During the last 10 days that sows and gilts remained in the gestation building ambient temperature was 19.7 C ± 2 (mean ± SD).

Around 109 days of gestation, each female

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was weighed and placed in a farrowing crate contained in an environmental chamber which served as the respiration chamber of an open-circuit, indirect calorimeter (Kelley et al., 1978a). Females were randomly assigned within parity groups to ambient-temperature treatments of either 20.5 C (T) or 29.8 C (H). This thermoneutral temperature of 20.5 C is slightly above the lower critical temperature of non-pregnant sows (Holmes and McLean, 1974). The higher temperature (H) was expected to cause moderate heat stress. Dew-point temperature never exceeded 27 C.

Measurements generally began on the day the pregnant sow or gilt was sealed into the chamber. Respiratory rate was measured by observation of flank movements. Rectal temperature was measured by a telethermometer with a thermistor probe inserted to a depth of 6 centimeters. Both measurements were recorded three to five times daily until around 12 hr before parturition. Beginning at this time, measurements were recorded at approximately hourly intervals until parturition was completed. To avoid feeding effects, neither RR nor RT was recorded within 3 hr postprandially. Following parturition, these items were recorded only when the dam was alone, generally once or twice daily for periods of several hours. Measurement was terminated 3 to 5 days postpartum.

Three types of activity were measured. Whenever the female adopted a sitting or standing position, her body interrupted a light beam to a photocell, giving a continuous record of time in the risen position. A second beam was intercepted only when she stood up on four legs. Time sitting was calculated as the difference between the two records.

Rectal temperature and RR were summarized during four periods: A — from time measurements began until 4 hr before the first pig was born; B — end of A to birth of the first pig; C — end of B to birth of the last pig; D — end of C to 3 or 4 days postpartum.

Activity data were summarized during five periods: 1) from time measurements began until 12 hr before the first pig was born; 2) end of 1 to birth of first pig; 3) end of 2 until birth of the last pig; 4) end of 3 until termination of observation of dam; and 5) end of 3 until termination of observation of dam with piglets present.

RESULTS

Rectal temperature was higher (P<.05) at H than at T during periods A, B and C (table 1). During parturition, RT of gilts was higher (P<.05) than that of sows. During period D there was no significant difference in RT due to ambient temperature, parity or their interaction.

Rectal temperature increased (P<.01) in all treatments but the heat-stressed sows as parturition approached (table 2). It continued to rise during parturition, significantly at T, but not at H. Rectal temperature declined (P<.01) in all treatments after birth of the last pig, but remained higher (P<.001) at T during the first few days after parturition than it was during period A.

Respiratory rate (table 1) was higher (P<.001) at H than at T during all periods. It did not change (P>.05) during the 4-hr period before parturition (table 3). Respiratory rate declined (P<.05) during parturition in all treatments. This effect was somewhat more pronounced at H than at T. During parturition, RR did not differ from period A at T but was lower (P<.05) at H. During the first 4 or 5 days after parturition RR was lower (P<.01) than during period A for all animals but the sows held at thermoneutrality.

Ambient temperature and parity had no significant effect on any activity rate during any period, so only the means are reported (table 4). All types of activity increased (P<.05) during the 12 hr before birth of the first pig (table 5). During periods 3 and 4, rates of standing-up and standing were less (P<.05) than those in period 1. Females stood longer (P<.01) after than during parturition. Finally, when piglets were with the dam (period 5), sitting time was reduced (P<.001) compared to that of the dam when alone.

Discussion

Jones (1966a) attempted to measure RT of sows and gilts near parturition, but found the females to be very nervous and excitable. Our females sometimes stood when RT was measured, but this tendency was minimized by lubricating the thermistor probe with petroleum jelly. The chamber was enclosed with
### TABLE 1. MEAN RECTAL TEMPERATURE AND RESPIRATORY RATE OF PERIPARTAL SOWS AND GILTS

<table>
<thead>
<tr>
<th>Ambient temperature</th>
<th>Parity</th>
<th>No. of animals</th>
<th>Perioda</th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>RTb</td>
<td>RRb</td>
<td>RTb</td>
<td>RRb</td>
<td>RTc</td>
<td>RRb</td>
<td>RT</td>
</tr>
<tr>
<td>20.5 C</td>
<td>Gilts</td>
<td>6</td>
<td>39.35 ± .15d</td>
<td>35 ± 6e</td>
<td>39.92 ± .17</td>
<td>48 ± 9</td>
<td>40.70 ± .15</td>
<td>32 ± 9</td>
<td>40.25 ± .12</td>
</tr>
<tr>
<td>20.5 C</td>
<td>Sows</td>
<td>4</td>
<td>39.22 ± .18</td>
<td>26 ± 7</td>
<td>39.94 ± .21</td>
<td>44 ± 11</td>
<td>40.61 ± .18</td>
<td>25 ± 11</td>
<td>40.03 ± .15</td>
</tr>
<tr>
<td>29.8 C</td>
<td>Gilts</td>
<td>5</td>
<td>40.38 ± .16</td>
<td>119 ± 6</td>
<td>41.18 ± .19</td>
<td>121 ± 10</td>
<td>41.44 ± .16</td>
<td>95 ± 10</td>
<td>40.43 ± .13</td>
</tr>
<tr>
<td>29.8 C</td>
<td>Sows</td>
<td>3</td>
<td>40.34 ± .21</td>
<td>120 ± 8</td>
<td>40.45 ± .24</td>
<td>116 ± 13</td>
<td>40.73 ± .21</td>
<td>86 ± 12</td>
<td>40.19 ± .17</td>
</tr>
</tbody>
</table>

aThe periods are defined in the text.
bT < H (P<.001).
cT < H (P<.05), S < G (P<.05).
dMean ± SE, Celsius.
eMean ± SE, breaths per min.

### TABLE 2. MEAN PERIOD-TO-PERIOD CHANGE IN RECTAL TEMPERATURE OF PERIPARTAL SOWS AND GILTS

<table>
<thead>
<tr>
<th>Ambient temperature</th>
<th>Parity</th>
<th>No. of animals</th>
<th>B−A</th>
<th>C−B</th>
<th>D−C</th>
<th>D−A</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.5 C</td>
<td>Gilts</td>
<td>6</td>
<td>.57 ± .17b**</td>
<td>.78 ± .13***</td>
<td>-.45 ± .16*</td>
<td>.90 ± .11***</td>
</tr>
<tr>
<td>20.5 C</td>
<td>Sows</td>
<td>4</td>
<td>.72 ± .21**</td>
<td>.67 ± .16**</td>
<td>-.58 ± .20*</td>
<td>.81 ± .14***</td>
</tr>
<tr>
<td>29.8 C</td>
<td>Gilts</td>
<td>5</td>
<td>.80 ± .19***</td>
<td>.26 ± .14</td>
<td>-1.01 ± .18***</td>
<td>.05 ± .13</td>
</tr>
<tr>
<td>29.8 C</td>
<td>Sows</td>
<td>3</td>
<td>.11 ± .24</td>
<td>.28 ± .18</td>
<td>-.54 ± .22*</td>
<td>-.15 ± .16</td>
</tr>
</tbody>
</table>

aThe periods are defined in the text.
bMean ± SE, Celsius.
*p<.05; **p<.01; ***p<.001.
### TABLE 3. MEAN PERIOD-TO-PERIOD CHANGE IN RESPIRATORY RATE OF PERIPARTAL SOWS AND GILTS

<table>
<thead>
<tr>
<th>Ambient temperature</th>
<th>Parity</th>
<th>No. of animals</th>
<th>Period comparison&lt;sup&gt;a&lt;/sup&gt;</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>20.5 C</td>
<td>Gilts</td>
<td>6</td>
<td>13 ± 7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-16 ± 7*</td>
<td>-12 ± 6</td>
<td>-3 ± 9</td>
<td>-15 ± 5**</td>
</tr>
<tr>
<td>20.5 C</td>
<td>Sows</td>
<td>4</td>
<td>18 ± 9</td>
<td>-19 ± 9*</td>
<td>-9 ± 8</td>
<td>-1 ± 11</td>
<td>-10 ± 6</td>
</tr>
<tr>
<td>29.8 C</td>
<td>Gilts</td>
<td>5</td>
<td>2 ± 8</td>
<td>-26 ± 8**</td>
<td>-25 ± 7**</td>
<td>-24 ± 10*</td>
<td>-49 ± 5**</td>
</tr>
<tr>
<td>29.8 C</td>
<td>Sows</td>
<td>3</td>
<td>-4 ± 10</td>
<td>-30 ± 10**</td>
<td>-19 ± 9</td>
<td>-34 ± 12*</td>
<td>-53 ± 7**</td>
</tr>
</tbody>
</table>

<sup>a</sup>The periods are defined in the text.

<sup>b</sup>Mean ± SE, breaths per min.

*P<.05; **P<.01; ***P<.001.

### TABLE 4. MEAN ACTIVITIES OF PERIPARTAL SOWS AND GILTS

<table>
<thead>
<tr>
<th>Activity type</th>
<th>No. of animals</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting time&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9</td>
<td>3.35 ± 1.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.38 ± 2.2</td>
<td>1.37 ± .3</td>
<td>1.39 ± .5</td>
<td>.77 ± .3</td>
</tr>
<tr>
<td>Times standing-up&lt;sup&gt;c&lt;/sup&gt;</td>
<td>10</td>
<td>1.61 ± .5</td>
<td>5.01 ± 1.4</td>
<td>.22 ± .1</td>
<td>.36 ± .1</td>
<td>.37 ± .1</td>
</tr>
<tr>
<td>Standing time&lt;sup&gt;d&lt;/sup&gt;</td>
<td>10</td>
<td>4.06 ± .9</td>
<td>12.76 ± .9</td>
<td>.67 ± .4</td>
<td>1.55 ± .5</td>
<td>1.47 ± .4</td>
</tr>
</tbody>
</table>

<sup>a</sup>The periods are defined in the text.

<sup>b</sup>Minutes sitting per hr.

<sup>c</sup>Number of times standing-up per hr.

<sup>d</sup>Minutes standing per hr.

<sup>e</sup>Mean ± SE.
plexiglass, which permitted her to observe caretaker activity. However, there was constant noise at a low level inside the chamber and continuous lighting, and most animals seemed oblivious to events outside.

An ambient temperature of 29.8 °C was sufficient to cause heat stress, as evidenced by both RT and RR being higher at H than at T during periods A, B and C. The significant reduction in RR of females at H after parturition probably reflects partial acclimation to the heat stress (Wildt et al., 1975), but RR also declined at T.

Rectal temperature increased during the 4-hr period before birth of the first pig in all treatments except the heat-stressed sows, probably because of prepartal activity (table 4). In cattle and sheep, RT of the dam declines before parturition (Wrenn et al., 1958; Ewbank, 1963, 1969; Winfield and Makin, 1975), so the increase observed here in swine apparently represents a species difference.

Respiratory rate was higher during period B for all but the heat-stressed sows presumably in an attempt to compensate for the greater heat load, but these increases were not significant (P > .05). Jones (1966a) also observed increased RR before delivery in swine, but Pardee and Mendelson (1941) found little change in RR of women in labor.

As energy-expenditure rate is less during than it is before parturition for all but thermoneutral sows (Kelley et al., 1978a,b), rising RT during parturition cannot be due to increased metabolism. However, even though respiratory minute volume was not measured, rising RT may have been due to reduced respiratory-evaporative heat loss. Respiratory rate declined during parturition, despite high rectal temperature. Reduced RR during delivery may occur because respiratory movements are interrupted by straining during parturition.

All activity rates increased during the 12-hr period before parturition, regardless of ambient temperature. Despite the generally higher RT before parturition, females also pursued vigorous nest-building and other prepartal activities which increased their endogenous heat loads. Wildt et al. (1975) observed that physical activities increased in mated female pigs when their rectal temperature was greater than 41 °C. In contrast, Ingram (1964) found that heat-stressed young pigs tended to remain quiescent. In the present study, this increase in activity rate was probably related to impending parturi-

| TABLE 5. MEAN PERIOD-TO-PERIOD CHANGE IN ACTIVITIES OF PREPARTAL SOWS AND GILTS |
|---|---|---|---|
| Activity type | No. of animals | Period comparison | Period comparison |
| | | | 2-1 | 3-1 | 4-1 | 5-4 |
| Sitting time | 9 | 3.01 ± 1.2** | 3.40 ± 1.0*** | 8.70 ± 2.0*** |
| Times standing | 10 | 1.98 ± 1.2 | 1.39 ± 0.8 | 3.39 ± 0.8 |
| Standing time | 10 | 1.25 ± 1.5 | 2.51 ± 0.6*

Note: The periods are defined in the text.

*p < .05; **p < .01; ***p < .001.
tion. Restlessness before parturition has also been reported in dogs (Murlin, 1910), swine (Jones, 1966a) and humans (Carpenter and Murlin, 1911). Gilts were more susceptible to heat stress than were sows during parturition, but this effect was neither due to differing rates of activities nor higher energy-expenditure rates (Kelley et al., 1978b).

During the first few days after parturition RT was lower in all treatments than that during parturition. However, RT remained above that of period A for females at T (table 2). Hyperthermia could result from a change in the hypothalamic setpoint caused by parturition, periodic removal of piglets from the sow or the mastitis-metritis-agalactia (MMA) syndrome. Symptoms of the MMA complex (Tharp, 1970) were only occasionally noticed, even though mean farrowing time was near 12 hours. Piglet survival and weight gains to weaning were similar to the University herd average.

Standing time for females in our farrowing crate was only 40% of that reported for growing pigs in pens (Hornicke, 1970). Fraser (1975) reported that tethered gilts spent about 71% of the time lying, 28% sitting and 1% standing, or 43, 17 and 1 min per hr, respectively. During period 1, peripartal sows and gilts spent over three times longer sitting but only 20% as long standing as Fraser's gilts. Our animals were watered by nipple valve, which could be operated from the sitting position, and may account for the greater amount of time sitting. Further, Fraser's data were recorded over selected 2-hr periods, whereas our data were recorded continuously.

Females were recumbent most of the time during parturition (table 4), similar to the observations of Jones (1966b). After parturition, both times standing-up and standing time were less than during period 1, but standing was longer than during parturition (table 5). It also appears that the presence of the piglets reduced sitting time.

LITERATURE CITED