Effect of exposure to a boar on circulating concentrations of LH, FSH, cortisol and oestradiol in prepubertal gilts

D. L. Kingsbury and N. C. Rawlings

Veterinary Physiological Sciences, Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, Saskatchewan, S7N 0W0, Canada

Serum concentrations of LH, FSH, oestradiol and cortisol were measured in control gilts not exposed to a boar and in gilts with fence-line exposure to a boar that allowed full muzzle contact. All gilts were between 134 and 200 days of age. Control gilts showed first oestrus at 193 ± 7 days of age (n = 5). Twelve of the gilts exposed to the boar showed first oestrus at 169 ± 5 days of age and five had not shown oestrus by 200 days of age. Introduction of a boar produced a transient increase in LH pulse frequency lasting no longer than 20 days (P < 0.001) in gilts responding to the boar with oestrus. Basal and mean serum LH concentrations were also increased (P < 0.05) in the gilts that responded to a boar with oestrus, but only in the 6 h after introducing the boar. Mean serum concentrations of FSH were lower in gilts exposed to a boar compared with the controls at 10 days after introduction of the boar, but by 20 days only gilts responding to the boar with oestrus had lower FSH concentrations (P < 0.05). Serum concentrations of cortisol decreased over the day the boar was introduced in all groups of gilts (P < 0.05) and were always highest in gilts exposed to a boar but not showing oestrus by 200 days of age (P < 0.05). There were no significant trends in serum concentrations of oestradiol but oestradiol concentrations varied over a wide range in gilts that did not respond to the boar with oestrus. These data suggest that the presence of an intact male stimulates an increase in LH pulse frequency over 10 days in prepubertal gilts, and that this increase may stimulate some gilts to become cyclic before 200 days of age. It was of interest that high cortisol concentrations were measured in the gilts that did not respond to the boar with oestrus. An increase in cortisol secretion would not appear to mediate the ability of a boar to induce oestrus in gilts.

Introduction

In several species, the introduction of a male of the same species can be used under certain physiological conditions to induce oestrus in females (Brooks and Cole, 1970; Martin et al., 1983; Fadem, 1989). Exposure to a mature, intact boar is an effective means of stimulating early oestrus in gilts (Brooks and Cole, 1970). Gilts are generally reared isolated from males until they reach 135–170 days of age (Hughes and Cole, 1976; Kirkwood and Hughes, 1979). They are then either moved on a daily basis to a boar’s pen or are permanently relocated to a novel pen adjacent to the boar’s pen. Continuous exposure to a boar, or exposure for 30 min day⁻¹ several days a week, or as little as 10 min day⁻¹ every day, results in the early induction of first oestrus in gilts (Van Lunen and Aherne, 1987; Paterson et al., 1989).

The mechanism by which the boar can induce first oestrus in gilts is not clear. A major part of the ability of the female to respond to the boar is olfactory (Kirkwood and Hughes, 1980). The stress of moving gilts to novel surroundings is synergistic with the effect of being exposed to a boar in inducing first oestrus (Van Lunen and Aherne, 1987), but stress itself is ineffective at inducing sexual maturity (Pearce and Hughes, 1985). Pearce and Hughes (1987) postulated that stress, generated by full physical contact with a mature boar, was reflected by a substantial rise in plasma cortisol concentrations. They speculated that this increase in cortisol resulted in an increase in LH secretion (Pearce et al., 1988). However, Pearce and Paterson (1992) concluded that increased cortisol secretion was not a factor in the induction of first oestrus in gilts by a boar, but full facial contact of the boar with the gilt was critical. It has been suggested that exposure of gilts to 3α-androstenol, a steroid in boar saliva, will induce early oestrus (Kirkwood and Hughes, 1983) but in that study there was a confounding effect of transport stress, so no causal relationship could be inferred.

When rams are introduced to anoestrous ewes, the increase in LH secretion is dramatic and rapid (Martin et al., 1983). Separation from piglets and the introduction of boars to postpartum sows resulted in increased LH secretion (Newton et al., 1987), but the effects of introduction of a boar on gonadotrophin secretion in peripubertal gilts are not known. It is reasonable to assume that introduction of a boar must induce early first oestrus in gilts by an effect on the hypothalamic–pituitary–gonadal axis. In commercial practice, exposing gilts to mature boars to induce first oestrus.
by 200 days of age is ineffective in a small number of pigs. Why some animals should be unresponsive while others respond is not known. It is logical to assume that in gilts that fail to respond to boar stimulation some internal hormonal change fails to occur.

In the present study, we examined the patterns of serum concentrations of LH, FSH, oestradiol and cortisol in gilts with fence-line exposure to a boar, that allowed full muzzle contact, in contrast to gilts raised without exposure to a boar. We also examined the differences in hormonal profiles between gilts exposed to a boar that had an early first oestrus or no oestrus before 200 days of age. Our objective was to determine whether induction of early first oestrus in the peripubertal gilt by a boar involved changes in the hypothalamic–pituitary–ovarian axis.

Materials and Methods

Experimental animals

A total of 22 Landrace × Yorkshire gilts were purchased from the Prairie Swine Research Centre (Saskatoon, Saskatchewan). Gilts were moved to the Western College of Veterinary Medicine (Saskatoon) when 128 days old and housed in groups of five or six in 4 m × 3.2 m rooms. Fluorescent lighting was set at 12 h light:12 h dark, and the temperature maintained at 21°C. There were four replicates of five or six gilts. All gilts were fed, ad libitum, Pork-Gro (16% protein, 2% fat; Federated Co-operatives Limited, Saskatoon) and had continuous access to fresh water through nipple waterers.

Experimental protocol

Gilts received a vena cava catheter and were placed in 0.75 m × 1.5 m metal carts when 133 days old. In the carts, gilts received water from nipple waterers and were bucket fed twice a day. At 135 days of age, blood samples (4 ml) were collected from the vena cava catheter every 15 min for 6 h, starting at 08:00 h. The gilts (n = 17) to be exposed to boars were then moved, in the carts, to an adjacent housing unit where they were transferred into individual pens (1.2 m × 1.5 m). These pens were adjacent to pens containing mature, intact boars at least 2 years old. Pens were arranged such that four gilts were exposed to one boar. Pen railings allowed full muzzle contact between boars and gilts. Five control gilts were moved between pens within the housing unit they were initially kept in, to produce an equivalent transport stress to that experienced by gilts exposed to the boar, and to introduce them to novel surroundings. Blood samples were then taken from all gilts for a further 6 h every 15 min. At 144 and 154 days of age, all gilts were recatheterized and blood samples collected every 15 min for 8 h on the day following catheterization (145 and 155 days of age). Blood samples were allowed to clot for at least 4 h. Samples were then centrifuged (3000 g, 10 min). Serum was stored at −20°C until analysed.

Gilts were checked daily from 135 days to 200 days of age for external signs of oestrus, which included a standing lordosis response and a red swollen vulva. First oestrus was taken as the first of two consecutive periods of oestrus 21 ± 3 days apart.

Catheterization procedure

Gilts were catheterized in the vena cava using clear vinyl tubing (Dural Plastics and Engineering, Auburn, NSW, Australia, o.d. 1.50 mm, i.d. 1.00 mm), 60 cm length for gilts up to 60 kg and 75 cm lengths for gilts over 60 kg.

Catheters were inserted under diazepam (Valium, Hoffmann-LaRoche Ltd., Etobicoke, Ontario: 0.5 mg kg⁻¹) and ketamine (M.T.C. Pharmaceuticals, Cambridge, Ontario; 5 mg kg⁻¹) anaesthesia, with drugs administered through an ear vein. With the gilt in dorsal recumbency, the catheter was inserted through a 14-gauge needle, directed toward the midline at an angle of 30° to both the median and frontal planes approximately 2.5 cm anterior to and 2.5 cm lateral from the mandibrium sterni (a steeper angle was used as the animals increased in size). The catheter was secured in place with Elastoplast tape (Smith and Nephew, Lachine, Quebec), and the free end exposed on the dorsal surface of the neck. A single 3 ml dose of antibiotics (Borgal, Hoechst Canada, Montreal, Quebec) was administered intravenously to each pig within 6 h of catheterization.

Radioimmunoassays

Serum concentrations of LH and FSH were determined in an ovine/bovine radioimmunoassay system (Rawlings et al., 1984; Currie and Rawlings, 1989) using the porcine standards USDA-pLH-B-1 and USDA-pFSH-B-1, respectively.

Sensitivity of the LH assay, defined as the lowest concentration of standard different from zero (P < 0.05), was 0.06 ng LH ml⁻¹ serum, and the curve range was to 64 ng LH serum ml⁻¹. Intra- (n = 7) and interassay (n = 21) coefficients of variation for LH were 9.2% and 10.7% or 9.8% and 15%, respectively for reference sera replicated in each assay and with mean LH concentrations of 1.5 ng ml⁻¹ or 11.3 ng ml⁻¹, respectively. The high reference serum was made by adding 10 ng porcine LH ml⁻¹ (USDA-pLH-B-1) to the low reference serum (measured difference 9.8 ± 1.45 ng ml⁻¹; X ± SD). Sensitivity of the FSH assay was 0.13 ng ml⁻¹, and the curve range was to 64 ng ml⁻¹ serum. Intra- and interassay coefficients of variation were 8.3% (n = 7) and 8.3% (n = 21) or 8.9% (n = 7) and 8.9% (n = 21) for reference sera replicated in each assay and with mean FSH concentrations of 8.5 ng ml⁻¹ or 13.5 ng ml⁻¹, respectively. The high reference serum was made by adding 5 ng porcine FSH ml⁻¹ (USDA-pFSH-B-1) to the low reference serum (measured difference 5.0 ± 0.45 ng ml⁻¹; X ± SD).

Serum oestradiol concentrations were determined by established radioimmunoassay (Rawlings et al., 1984). Intra- and interassay coefficients of variation were 18.5% (n = 5) and 22.2% (n = 10) or 2.2% (n = 5) and 9.4% (n = 10) for porcine reference sera with means of 5.4 pg ml⁻¹ or 16.3 pg ml⁻¹, respectively. The high reference serum was made by adding 10 pg oestradiol ml⁻¹ to the low reference serum (measured difference 10.9 ± 1.38 pg ml⁻¹; X ± SD). Sensitivity of the assay was 1 pg ml⁻¹ (P < 0.05). The assay blank in the oestradiol assay was not different from zero. Extraction efficiency was 86 ± 1.2% (X ± SEM) for oestradiol. Oestradiol concentrations were determined for each gilt from serum pools corresponding to each of the four sampling times: before and after introduction of the boar and then 10 and 20 days following continuous exposure to the boar.
Table 1. LH pulse frequency (pulses h⁻¹) and amplitude (ng ml⁻¹), and mean (ng ml⁻¹) and basal concentrations (ng ml⁻¹) of LH in blood serum from gilts sampled every 15 min for 6 h immediately before, and immediately after, boar introduction at 135 days of age and following 10 and 20 days of continuous exposure to a boar or transportation to a new pen only (controls). Responders showed oestrus before 200 days of age, nonresponders had not shown oestrus by 200 days of age.

<table>
<thead>
<tr>
<th>Group</th>
<th>LH</th>
<th>Before</th>
<th>After</th>
<th>Day 10</th>
<th>Day 20</th>
<th>Average‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls (5)</td>
<td>Frequency</td>
<td>0.31 ± 0.08</td>
<td>0.31 ± 0.03</td>
<td>0.50 ± 0.10^A</td>
<td>0.34 ± 0.09</td>
<td>0.35 ± 0.04</td>
</tr>
<tr>
<td></td>
<td>Amplitude</td>
<td>1.17 ± 0.23</td>
<td>1.72 ± 0.26</td>
<td>1.24 ± 0.15</td>
<td>1.12 ± 0.17</td>
<td>1.29 ± 0.10^A</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>0.35 ± 0.07</td>
<td>0.46 ± 0.09</td>
<td>0.42 ± 0.07</td>
<td>0.34 ± 0.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basal</td>
<td>0.18 ± 0.03^A</td>
<td>0.22 ± 0.03</td>
<td>0.18 ± 0.03</td>
<td>0.15 ± 0.02</td>
<td></td>
</tr>
<tr>
<td>Nonresponders (5)</td>
<td>Frequency</td>
<td>0.31 ± 0.10</td>
<td>0.50 ± 0.14</td>
<td>0.35 ± 0.10^B</td>
<td>0.42 ± 0.10</td>
<td>0.40 ± 0.05</td>
</tr>
<tr>
<td></td>
<td>Amplitude</td>
<td>0.77 ± 0.11</td>
<td>1.00 ± 0.10</td>
<td>0.76 ± 0.10</td>
<td>0.93 ± 0.08</td>
<td>0.87 ± 0.05^B</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>0.26 ± 0.04</td>
<td>0.42 ± 0.06</td>
<td>0.29 ± 0.03</td>
<td>0.37 ± 0.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basal</td>
<td>0.13 ± 0.02^AB</td>
<td>0.20 ± 0.03</td>
<td>0.14 ± 0.02</td>
<td>0.25 ± 0.05</td>
<td></td>
</tr>
<tr>
<td>Responders (12)</td>
<td>Frequency</td>
<td>0.26 ± 0.05^A</td>
<td>0.57 ± 0.08^b</td>
<td>0.44 ± 0.07^AB</td>
<td>0.29 ± 0.06^Ed</td>
<td>0.39 ± 0.04</td>
</tr>
<tr>
<td></td>
<td>Amplitude</td>
<td>1.07 ± 0.16</td>
<td>1.08 ± 0.11</td>
<td>0.94 ± 0.11</td>
<td>1.01 ± 0.07</td>
<td>1.05 ± 0.07^AB</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>0.22 ± 0.03^A</td>
<td>0.31 ± 0.03^b</td>
<td>0.22 ± 0.03^ab</td>
<td>0.32 ± 0.04^b</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basal</td>
<td>0.13 ± 0.01^Aa</td>
<td>0.15 ± 0.03^b</td>
<td>0.14 ± 0.02^b</td>
<td>0.19 ± 0.04^b</td>
<td></td>
</tr>
</tbody>
</table>

* Raw data are given; statistical analysis was performed on transformed data except for LH pulse frequency.
† Values are means ± SEM.
‡ Average values (P < 0.05) across the row; upper case superscripts indicate significant differences (P < 0.05) across the row; lower case superscripts indicate significant differences (P < 0.05) down the columns.

Serum cortisol concentrations were determined directly without extraction, using a fluorescence polarization immunoassay (TD System, Abbott Laboratories, Irving, Texas). Crossreactivity in this assay was 4.7% and 4.5% for 11-deoxycortisol and corticosterone, respectively, and <0.1% for progesterone and testosterone. Sensitivity was 12.4 nmol l⁻¹. The assay blank was not different from zero. Intra- and interassay coefficients of variation were 8.42% and 7.23%, respectively, for control serum (mean = 110.4 nmol l⁻¹) replicated in every assay. When 50, 100 or 200 nmol l⁻¹ of cortisol were added to serum, concentrations of 57 ± 0.7, 109 ± 1.6 or 215 ± 3.3 nmol l⁻¹ were estimated after subtraction of the concentration (106 ± 1.8 nmol l⁻¹) of endogenous cortisol. Serum cortisol concentrations were determined for the 4 h before introduction of the boar, for 1 h immediately after introduction and then for a further 4 h.

Transformed data were analysed using the general linear models analysis of variance for repeated measures (SAS, Version 6). A model statement was written to determine the main effects of group (controls or gilts with first oestrus prior to or later than 200 days of age), time of blood sampling (prior to, immediately after, or 10 or 20 days after introduction of the boar) and any interactions. As the experiment was done in four replicates, replicate was included as an independent variable in the model statement. In no case was replicate found to be significant (P > 0.10), so data from all four replicates were combined into one data set for analysis. No significant interactions were found.

Overall effects of group and time of blood sampling were determined with Tukey's and Scheffe's tests (SAS, version 6). Group effects within times of blood sampling and effects of time of blood sampling within groups were determined using orthogonal contrasts (Steel and Torrie, 1980).

Statistical analysis

Homogeneity of variance for each set of data was determined using Bartlett's test in the Statistical Analysis System (SAS, Version 6, SAS Institute Inc., Cary, NC). When homogeneity was not present (P > 0.1) the data were subjected to analysis by the Box-Cox Procedure (BMDP Statistical Software, University of California Press, Berkeley, Los Angeles, CA) to determine an appropriate transformation to remove heterogeneity of variance. The data for LH pulse frequency and serum concentrations of cortisol exhibited homogeneity of variance and no transformation was applied. The data for mean serum concentrations of FSH and LH and basal serum LH were log transformed. Data for oestradiol and LH pulse amplitude exhibited non-homogeneous variances and the data were subjected to the rank procedure (SAS, Version 6). Values were transformed before the results were statistically analysed. All tabular data presented in this paper are raw data.

Results

Age at first oestrus

Twelve of 17 gilts exposed to boars showed their first oestrus at 169 ± 5 days of age, earlier than in gilts not exposed to boars (controls), which showed first oestrus at 193 ± 7 days of age (P < 0.05). The remaining five gilts exposed to a boar did not show oestrus by 200 days of age.

LH

LH pulse frequency increased twofold in the 6 h immediately after introduction of a boar in gilts that showed oestrus prior to 200 days of age (Table 1; P < 0.001). LH pulse frequency then decreased after 20 days of housing with a boar, to concentrations similar to those seen before introduction of the boar.
Table 2. Mean FSH concentrations in blood serum (ng ml⁻¹)† from gilts sampled every 15 min for 6 h immediately before and after introduction of a boar at 135 days of age and following 10 and 20 days of continuous exposure or transportation to a new pen only (controls). Responders showed oestrus before 200 days of age; nonresponders had not shown oestrus by 200 days of age.

<table>
<thead>
<tr>
<th>Group (n)</th>
<th>Before</th>
<th>After</th>
<th>Day 10</th>
<th>Day 20</th>
<th>Average‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (5)</td>
<td>2.6 ± 0.6</td>
<td>2.6 ± 0.5</td>
<td>3.3 ± 0.3A</td>
<td>4.1 ± 0.8A</td>
<td>3.1 ± 0.3A</td>
</tr>
<tr>
<td>Nonresponders (5)</td>
<td>3.0 ± 0.9ab</td>
<td>2.2 ± 0.8a</td>
<td>0.6 ± 0.2ab</td>
<td>3.1 ± 0.9ab</td>
<td>1.9 ± 0.4b</td>
</tr>
<tr>
<td>Responder (12)</td>
<td>2.2 ± 0.6</td>
<td>2.1 ± 0.4</td>
<td>1.5 ± 0.3b</td>
<td>1.5 ± 0.3b</td>
<td>1.9 ± 0.2b</td>
</tr>
</tbody>
</table>

*Values are means ± SEM.
†Raw data are given; statistical analysis performed on log transformed data.
‡Mean FSH concentration over all 20 days for each group.
Lower case superscripts indicate significant differences (P < 0.05) across the row; upper case superscripts indicate significant differences (P < 0.05) down the column.

Fig. 1. Mean serum concentrations of cortisol (mean ± SEM, nmol l⁻¹) in gilts bled every 15 min for 4 h before introduction of a boar or simple repennng (Before), 1 h immediately after introduction of the boar or repennng (During) and for a further 4 h (After). Controls (■). Responders (□) showed oestrus before 200 days of age, nonresponders (■) had not shown oestrus by 200 days of age. Overall means for each time are shown (■) as well as overall means for each group (Combined). Lower case superscripts indicate significant differences (P < 0.05) between times; upper case superscripts indicate significant differences (P < 0.05) between groups (controls, responders, nonresponders).

Ten days after moving the gilts, LH pulse frequency was higher in control gilts than in gilts exposed to boars but not showing oestrus before 200 days of age (P < 0.05; Table 1). LH pulse amplitude did not change after introduction of the boar but, overall, gilts responding to introduction of a boar with early oestrus had LH pulse amplitudes intermediate between those seen in the control gilts and gilts not responding to the boar (first oestrus > 200 days of age; Table 1).

Before exposure to a boar, basal LH concentrations were similar in both groups of gilts housed with the boar, but control gilts had higher basal LH concentrations compared with gilts responding to the boar (P < 0.05; Table 1). Immediately following introduction of a boar, mean and basal serum concentrations of LH increased (P < 0.004 and P < 0.01, respectively) in gilts that showed early oestrus, but for no longer than 10 days (Table 1).

FSH

When data were combined within groups of gilts, mean serum concentrations of FSH were shown to be higher in control gilts than in those exposed to boars (P < 0.05; Table 2). After being housed with the boar for 10 days, gilts that did not respond to boars had lower mean serum concentrations of FSH than those gilts that responded with early oestrus; control gilts had the highest concentrations of FSH (P < 0.05). At 20 days after introduction to a boar, gilts that did not respond to the boar had mean serum concentrations of FSH that were intermediate to the control gilts and gilts responding to a boar with early oestrus. The gilts that did not respond to the boar experienced a transient drop in mean serum concentrations of FSH after being housed with a boar for 10 days.

Cortisol

Serum concentrations of cortisol fell in all gilts throughout the course of the day when boars were introduced or gilts repenned (control gilts; Fig. 1); with the greatest falls occurring in the control gilts not exposed to the boar. When cortisol data were combined within groups of gilts, it was found that gilts that did not respond to the boar had higher (P < 0.05) cortisol concentrations than did either the control gilts or gilts exposed to a boar but that showed early oestrus (Fig. 1).

Oestradiol

No significant difference in oestradiol values were detected between any of the groups of gilts at any of the four times of blood sampling following introduction of a boar (Table 3).

Discussion

Control gilts exhibited their first oestrus at an age commonly reported for gilts not exposed to a boar (Kirkwood and Hughes,
Table 3. Mean concentrations of oestradiol (pg ml⁻¹) in blood serum from gilts sampled every 15 min for 6 h immediately before and after introduction of a boar at 135 days old and following 10 and 20 days of continuous exposure to a boar or transportation to a new pen only (controls). Responders showed oestrus before 200 days old; nonresponders had not shown oestrus by 200 days old.

<table>
<thead>
<tr>
<th>Group (n)</th>
<th>Before</th>
<th>After</th>
<th>Day 10</th>
<th>Day 20</th>
<th>Average‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (5)</td>
<td>3.7 ± 0.3</td>
<td>2.5 ± 0.3</td>
<td>3.7 ± 0.5</td>
<td>3.5 ± 0.5</td>
<td>3.4 ± 0.2</td>
</tr>
<tr>
<td>Nonresponders (5)</td>
<td>3.6 ± 0.4</td>
<td>4.2 ± 0.7</td>
<td>9.7 ± 3.3</td>
<td>8.6 ± 5.0</td>
<td>6.8 ± 1.6</td>
</tr>
<tr>
<td>Responder (12)</td>
<td>3.8 ± 0.8</td>
<td>3.5 ± 0.7</td>
<td>4.2 ± 0.8</td>
<td>4.1 ± 1.1</td>
<td>3.9 ± 0.4</td>
</tr>
</tbody>
</table>

*Values are means ± SEM.
‡Mean oestradiol value over all 20 days for each group.

1980, 1983; Paterson and Lindsay, 1980; Caton et al., 1986; Van Lunen and Aherne, 1987). The age at first oestrus in the gilts exposed to a boar and showing early oestrus was also similar to that published elsewhere (Kirkwood and Hughes, 1979; Paterson and Lindsay, 1980; Eastham et al., 1984; Eastham and Cole, 1987) and to the average for the herd from which our gilts were derived.

When a ram is introduced to anoestrous ewes, the increase in LH pulse frequency is dramatic (Martin et al., 1983). In prepubertal ewe lambs, the onset of first oestrus is preceded by an increase in LH pulse frequency (Rawlings and Churchill, 1990). In the present study, the only group of gilts showing significant changes in LH secretion following introduction of boars was the group that showed an early first oestrus; but this increased LH secretion was transient. In addition, no long term trend in LH secretion, indicative of a cascade leading to first oestrus and ovulation, was seen. However, the limited changes in LH secretion seen in gilts in response to a boar in this study could have been sufficient to trigger some maturational mechanism, resulting in first oestrus.

There was no acute change in serum concentrations of FSH following introduction of a boar. However, 10 and 20 days of exposure to a boar resulted in a depressed FSH secretion compared with control gilts. FSH concentrations fell to values lower than those reported elsewhere (Colenbrander et al., 1982; Diekmann et al., 1983; Camous et al., 1985). Depressed FSH secretion would not appear to be a reasonable explanation for the induction of first oestrus in gilts by a boar.

Serum concentrations of oestradiol did not follow the trends in either LH or FSH secretion. No significant trends in serum concentrations of oestradiol were seen, but over the period the gilts were housed with a boar, serum concentrations of oestradiol appeared to be increased and were quite variable in gilts that did not show oestrus before 200 days of age. There was no evidence for gonadotrophic stimulus for these changes in serum concentrations of oestradiol. These observations indicate, as Foxcroft et al. (1984) have suggested, that a stable ovarian steroid environment is required for a normal response to the boar, in terms of induced oestrus.

As expected, serum concentrations of cortisol decreased throughout the day the boar was introduced, as a result of normal circadian rhythms (Whipp et al., 1970). There was no transient increase in serum concentrations of cortisol immediately following introduction of the boar or simple repenning of the gilts as reported previously (Pearce and Hughes, 1987; Dalin et al., 1988). Pigs in our study were allowed only pen-line and not full physical contact, in contrast to the study of Pearce and Hughes (1987). When serum concentrations of cortisol were pooled for the whole day of boar introduction, cortisol concentrations were found to be higher in gilts that did not respond to the boar, than in gilts that did respond to the boar or control gilts. If cortisol is taken as an indicator of stress, it would appear that gilts not responding to the boar were more stressed than those that did respond and that this extra stress could have interfered with induction of early oestrus by the boar. This is in contrast to previous speculation that an increase in cortisol secretion, mediated through the stress of relocation and mixing with new pigs, is an essential component of induction of oestrus by a boar (Pearce and Hughes, 1987). Our study suggested that those gilts that released the most cortisol were those that were unlikely to show signs of early oestrus. This result corroborated a study by Dalin et al. (1988), in which it was concluded that high serum concentrations of cortisol following transport stress inhibited the early onset of oestrus in gilts.

It has been postulated that the mechanism of induction of oestrus by the boar involves the male stimulation of a release of cortisol in the gilt, which in turn causes an increase in basal serum LH concentrations (Fujihara and Shiino, 1980; Liptrap and Raeside, 1983; Pearce et al., 1988). This increased basal LH secretion may result in accelerated follicular development and oestradiol production, leading to the first pre-ovulatory LH surge. However, our results indicated that increased serum concentrations of cortisol were inhibitory to the onset of oestrous cycles in prepubertal gilts. In addition, there was no transient increase in serum concentrations of cortisol with the introduction of a boar, even though LH pulse frequency increased for a short time in gilts that experienced an early oestrus. This suggested that the boar's signal was not a cortisol message to the hypothalamic–pituitary axis or that the cortisol signal was inhibitory in the gilts not showing oestrus in response to the boar. In a more recent study (Pearce and Patterson, 1992), it was also concluded that cortisol was not a mediator of boar-induced oestrus in the prepubertal gilt.

In summary, the ability of the boar to induce oestrus in gilts does not involve an increase in serum concentrations of cortisol. Cortisol would not appear to be a mediator of increased LH pulse frequency at introduction of the boar. In fact, cortisol may be inhibitory to the ability of the boar to induce first oestrus in the gilt. The hormonal milieu following introduction of a boar to gilts that did not respond with oestrus was characterized by
low, but fluctuating, serum FSH concentrations, apparent high and variable serum oestradiol concentrations and no significant trend in LH secretion. In contrast, gilts showing oestrus in response to the boar showed a transient increase in LH secretion, stable and low serum concentrations of oestradiol but similar low serum FSH concentrations. No single, major endocrine change was as obvious following the introduction of a ram as was the increase in LH pulse frequency following the introduction of a ram to anoestrous ewes (Martin et al., 1983). In gilts, a transient increase in LH secretion following introduction of a boar may be sufficient to mediate induction of first oestrus by the boar.

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References


Dierkman MA, Trout WE and Anderson LL (1983) Serum profiles of LH, FSH, and prolactin from 10 weeks of age until puberty in gilts Journal of Animal Science 56 139–145


Fujikawa N and Shino M (1980) The participation of corticosterone in luteinizing-hormone-releasing-hormone action on luteinizing hormone release from anterior pituitary cells in vitro Life Sciences 26 777–781


Kirkwood RN and Hughes PE (1979) The influence of age at first boar contact on puberty attainment in the gilt Animal Production 29 231–236


Liptrap RM and Raeside JI (1983) Effect of cortisol on the response to gonadotrophin-releasing hormone in the boar Journal of Endocrinology 97 75–81


Paterson AM and Lindsay DR (1980) Induction of puberty in gilts. 1. The effects of rearing conditions on reproductive performance and response to mature boars after early puberty Animal Production 31 291–297


Pearce GP and Paterson AM (1992) Physical contact with the boar is required for maximum stimulation of puberty in the gilt because it allows transfer of boar pheromones and not because it induces cortisol release Animal Reproduction Science 27 209–224


Rawlings NC, Jeffcoat IA and Rieger DI (1984) The influence of estradiol-17β and progesterone on peripheral serum concentration of lutetinising hormone and follicle stimulating hormone in the ovariectomised ewe Theriogenology 22 743–748

