MANAGING THE SOW TO STIMULATE LACTATION OVULATION

1A-102

Report prepared for the Co-operative Research Centre for High Integrity Australian Pork

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June, 2013

An Australian Government Initiative

Established and supported under the Australian Government's Cooperative Research Centres Program

Executive Summary

There is increasing retailer and consumer pressure to rationalize the welfare of animal production systems. The improvement of housing conditions for breeding sows by adopting housing practices which enable freedom of movement and sow-sow and sow-piglet social interactions, is a priority for the Australian pig industry. Equally important, negative public perception of early weaning strategies combined with impaired post-weaning performance of 'light' piglets weaned at 21 days of age, means that management systems which also enable extended lactation to occur require investigation. However, the number of pigs weaned / sow / year is a key determinant of breeding herd productivity. Therefore, unless oestrus can be reliably stimulated during lactation, extended lactations will inevitable result in reduced farrowing frequency and thus fewer piglets sold per sow per year. It is, therefore, reasonable to suggest the sustainability of the Australian pig industry depends, at least in part, on its capacity to develop natural methods of stimulating lactation oestrus which result in similar productivity levels to conventional weaning and re-mating systems.

Towards the development of commercially viable and natural methods of stimulating lactation oestrus, two experiments were conducted. Experiment one determined the effect of split weaning (permanent removal of a proportion of the litter) at day 18 of lactation on lactation oestrus expression in boar exposed sows. Experiment two determined the effect of commencing boar exposure on days 10, 14 and 18 post-farrowing on lactation oestrus expression in response to boar stimulation. In experiment one, 72 Large White and Large White x Landrace multiparous (parity 2.9 ± 0.17) sows were allocated to one of four treatment groups: (i) Control (SPW0): continuous lactation of 10 piglets, all piglets weaned on day 30 of lactation; and three split wean (SPW) treatments as follows (ii) SPW3: 3 piglets removed from the sow on day 18 of lactation, (iii) SPW5: 5 piglets removed from the sow on day 18 of lactation, (iv) SPW7: 7 piglets removed from the sow on day 18 of lactation. All sows, including the controls, started boar exposure on day 18 of lactation. Individual piglets were identified for SPW based on their body weight on day 17 of lactation, with the heaviest piglets selected for weaning. Boar exposure began on day 18 of lactation, and consisted of walking sows daily from their farrowing crate to a detection mating area (DMA), where they received fence-line exposure with multiple mature boars for 20 minutes. Sows were inseminated at first detection of oestrus, with all sows weaned on day 30 post-partum. In experiment two, a total of 38 first lactation (primiparous; PP) and 80 multiparous (parity 3.1 ± 0.18; MP) sows were used. The eight treatments in this 2X4 factorial experiment were as follows: either PP and MP sows, with boar exposure starting on day 10, day 14, day 18 and weaning. The experiment was replicated across four farrowing batches and two seasons (winter / spring and autumn). Boar exposure took place in the same DMA as experiment one, but involved sows having full physical contact with a mature boar, in groups of three, for 15 minutes.

The data from these two experiments demonstrated that both fenceline and physical boar contact in a DMA are effective methods of stimulating lactation oestrus. In experiment one, the incidence of lactation oestrus was 56%, 83%, 89% and 94% for the SPW0, SPW3, SPW5 and SPW7 treatment groups, with 90% of sows expressing lactation oestrus within 6 days of the start of boar stimulation. Although, removing a proportion of the litter increased lactation oestrus expression, the effects on subsequent reproductive performance were less profound. Specifically, pregnancy rates and subsequent total born, respectively, were: 100% and 8.9 ± 1.1 (SPW0); 67% and 13.1 ± 1.1 (SPW0); 81% and 12.5 ± 1.0 (SPW5); 100% and 11.6 ± 0.9 (SPW7). In experiment two, the incidence of lactation oestrus was lower and the interval from boar exposure to lactation oestrus were significantly longer for PP compared to MP sows (36% versus 63% and 8.1 ± 1.14 versus 5.4 ± 0.62 days; $P < 0.05$). Interestingly there was a significant seasonal effect with the incidence of lactation oestrus significantly lower in autumn compared to winter / spring

(15% versus 51%). The highest incidence of lactation oestrus was observed in MP sows starting boar exposure on day 18 of lactation, and commencing boar exposure on days 14 and 18 of lactation resulted in an interval to lactation oestrus expression similar to the weaning to oestrus interval of control sows (5.3 ± 1.02, 4.9 ± 0.82 and 4.9 ± 0.67 days for BE14, BE18 and Control, respectively).

In conclusion, the current study provides the first evidence that a high incidence of lactation oestrus expression can be achieved through the use of full physical boar exposure or fenceline boar exposure in conjunction with weaning of the heaviest piglets in the litter (split-weaning). These data demonstrate that providing multiparous sows with boar exposure from day 18 onwards is an effective method of maintaining a commercially viable farrowing to insemination interval whilst increasing piglet age at weaning.

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1. Introduction

Increasing the reproductive performance of breeding sows and improving public perception of pork production are paramount to improving the productivity and sustainability of Australia's pig industry. The pig industry, both within Australia and worldwide, is facing increasing pressure to improve housing conditions for breeding sows by eradicating the use of dry sow stalls and farrowing crates and adopting housing practices which enable freedom of movement and sow-to-sow and sow-to-piglet social interaction. Equally important, negative public perception of early weaning strategies combined with poor post-weaning performance of 'light' piglets weaned at 21 days of age, means that management practices which also enable extended lactations to occur require investigation. However, the number of pigs weaned / sow / year is a key determinant of breeding herd productivity, and unless oestrus can be reliably stimulated during lactation, extended lactations will inevitably result in reduced farrowing frequency and thus fewer numbers of pigs sold per sow per year. It is, therefore, reasonable to suggest the sustainability of the Australian pig industry depends, at least in part, on its capacity to develop alternative housing systems for lactating sows which increase sow and piglet welfare and improve public perception whilst maintaining, or even improving, sow productivity.

The ability to stimulate lactating sows to ovulate and conceive within 35 days of farrowing would enable piglet weaning age to be increased and still result in approximately 2.4 litters per sow per year. During lactation, the later stages of ovarian follicle growth and ovulation are prevented by suckling induced inhibition of luteinising hormone (LH) release. It is also common for sows to mobilise body reserves in order to fulfil their nutrient requirements for maintenance and milk yield, with the resultant catabolic state further reducing endocrine and metabolic support for ovarian follicle growth and development. It is, therefore, reasonable to suggest that increasing ovarian maturity from day 21 post-parturition onwards, by improving gonadotrophin and metabolic support for growth of the follicle-oocyte complex, will make lactational ovulation possible.

It is also likely that a reduction in suckling intensity, in conjunction with an associated improvement in sow metabolic status, will enable lactational ovulation to occur provided the sow receives sufficient stimulation. Intermittent suckling strategies, involving removal of the entire litter for 22 to 12 hours each day, have previously been shown to result in lactation ovulation, normal conception rates and litter size. However, such strategies are labour intensive and thus impractical on a commercial scale. In contrast, split weaning is a more practical option, not only because it is easier to implement within commercial systems but also because it represents a strategy whereby lighter piglets which are not yet ready to be weaned can remain on the sow for longer. Pluske and Williams (1996) concluded that split weaning increases the growth of light piglets during lactation; however, the effect of split weaning on incidences of lactational ovulation has not been investigated. Interestingly, reducing suckled litter size to 4 piglets 7 days prior to weaning at 35 days post-partum resulted in 44% of sows expressing oestrus on day of weaning (Stevenson and Davis, 1984). In addition to reducing suckling demand, previous work suggests that housing conditions which enable the sow to avoid the piglets will increase the interval between suckling, thus reducing suckling intensity and increasing incidences of lactational ovulation. In particular, housing lactating sows in groups has previously been associated with significantly higher incidences of lactation oestrus (Henderson and Stolba, 1989; Hulten et al., 1995).

Further, a stimulatory effect of boar contact on lactation ovulation has previously been demonstrated in partially weaned sows (Newton et al., 1987) and outdoor reared sows (Kongsted and Hermansen, 2009).

Based on the available data, it is evident that it is possible to stimulate ovulation in lactating sows. However, the ability to reliably and repeatedly stimulate synchronous lactational ovulation within cohorts of sows requires that we optimise a number of factors, in particular suckling demand and intensity and exogenous stimulation of the hypothalamic-pituitary ovarian axis.

The current project consisted of two experiments. Experiment one determined the effect of split weaning (permanent removal of a proportion of the litter) on lactation oestrus expression in boar exposed sows. Experiment two determined the effect of commencing boar exposure on days 10, 14 and 18 post-farrowing on lactation oestrus expression in response to boar exposure.

2. Methodology

Both studies were conducted in accordance with the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes (NHMRC 2004). All experimental procedures were conducted at the University of Adelaide's Roseworthy piggery, South Australia, with approval from the Animal Ethics Committee of The University of Adelaide, South Australia

Experiment One: Split weaning increases the incidence of lactation oestrus in boar exposed sows

2.1. Animals, management and treatments

The experiment consisted of four replicates conducted between September 2010 and April 2011. Seventy two Large White and Large White x Landrace sows (parity 2 to 6; 2.9 ± 0.17) were individually housed in conventional farrowing crates from 1 week before expected farrowing until day 30 post-parturition (day 0 = first 24 hours post-parturition). Throughout lactation sows received a commercial lactation diet (14.6 MJ DE/kg, 18.7% CP, 1.0% total lysine) fed at increasing amounts from 1 kg on the day of farrowing reaching a maximum of 7 to 8 kg/day fed over three meals by day 7 of lactation. Within 3 days of farrowing, litters were standardised to 10 piglets per sow and maintained at 10 until day 18 of lactation or weaning, depending on treatment. Sows were weighed on days 1, 13, 18 and 30 of lactation. Sows were stratified according to average live weight (LW) loss from day 1 to day 13 of lactation (-8.95 ± 0.85 kg) and randomly allocated to one of four treatments, with Large White and Large White x Landrace sows distributed evenly across treatments (n= 18 sows / treatment). Treatments were: (i) Control (SPW0): continuous lactation of 10 piglets, all piglets weaned on day 30 of lactation; and three split wean (SPW) treatments as follows (ii) SPW3: 3 piglets removed from the sow on day 18 of lactation, (iii) SPW5: 5 piglets removed from the sow on day 18 of lactation, (iv) SPW7: 7 piglets removed from the sow on day 18 of lactation. All sows started boar exposure on day 18 of lactation.
Individual piglets were identified for SPW based on their body weight on day 17 of lactation, with the heaviest piglets selected from weaning. Piglets identified to be split weaned were permanently removed between 08:00-09:00 hours on day 18. Piglets that were left on the sow from day 18 to day 30 remained in the farrowing

crate. From seven days of age piglets had access to a commercial starter diet (15.7 MJ DE/kg, 22% CP, 1.53% total lysine) as was standard practice at the piggery. Following weaning, piglets were housed in a weaner pen (2.3 x 5.4 m) with *ad libitum* access to a commercial weaner diet (14.6 MJ DE/kg, 23% CP, 1.27% total lysine) and water. During the first week post-weaning piglets were given access to a heated creep area.

2.2. Sow and piglet measures

Sow body weight, P2 backfat and eye muscle depth were measured on days 1, 13 and 18 of lactation and at weaning (day 30). P2 backfat and eye muscle depth were measured over the last rib, 65 mm from the vertebrae, using a 5MHz linear probe (Aquila Vet, Pie Medical Equipment)
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At 2 days of age, piglets were tagged and individual piglet weights were recorded at 2, 17, 30 and 40 of days of age.

2.3. Reproduction

2.3.1. Boar exposure and oestrus detection

Beginning on day 18 of lactation sows were taken daily from the farrowing crate to a detection mating area and given fence-line exposure with multiple mature boars for 20 minutes. The detection mating area was located in a separate building and was a 50 metre walk for the sows. Sows were checked for oestrus using the back pressure test within the first 3 minutes of entering the pen, with a standing reflex defined as the first sign of oestrus. At first detection of oestrus sows were artificially inseminated (AI) and again every 24 hours until the end of behavioural oestrus or when the sow had received a total of four inseminations, whichever came first. Inseminations were performed as per standard commercial practice using a disposable spirette catheter with each insemination containing an 80 ml dose of fresh, extended semen (3×10^9 spematozoa per inseminate; < 4 days old). Semen was purchased from a commercial artificial insemination collection centre (SABOR Pty. Ltd, Clare, South Australia) and was collected from Large White, Landrace, or Duroc boars. Boar genetics were split equally across treatments. The interval from the start of treatment (day 18) to the first expression of a standing oestrus during lactation was recorded. The duration of oestrus expression (days) was also recorded.

2.3.2. Pregnancy status and farrowing rates

Pregnancy status was determined in all sows by transabdominal ultrasound, 28-35 days post AI. The number of piglets born alive, stillborns, and mummies were recorded from the subsequent litter of the sows that were inseminated during lactation.

2.4. Blood progesterone concentrations

A pre-prandial blood sample was taken by jugular venipuncture into a 9 ml Heparin-Lithium coated collection tube (Vacuette, Greiner Labortechnik, Austria) at 10 days after the first detection of oestrus. Blood samples were maintained on ice and processed within an hour of collection. Blood samples were centrifuged for

15 minutes at 3000 rpm and plasma was stored at -20°C, until assayed for progesterone concentration.
Blood samples were analysed for progesterone concentration in 50 µl of plasma, in duplicate using a coated tube radio immunoassay (RIA), according to the manufacturer's instructions (M118; Beckman Coulter, Brea, CA, USA). The lowest detectable concentration was 1 ng per ml. The intra assay coefficient of variation was less than 10%. The inter assay coefficient of variation was less than 15%.

2.5. Sow body composition and energy and lysine
Sow weight and P2 backfat depth were measured at different time points in lactation to indirectly determine body protein loss and body fat loss by using the equations set out by Whittemore and Yang (1989).

$$\text{Sow body fat (kg)} = -20.4 + (0.21 \times \text{liveweight (kg)}) + (1.5 \times \text{P2 backfat (mm)})$$
$$\text{Sow body protein (kg)} = -2.3 + (0.19 \times \text{liveweight (kg)}) - (0.22 \times \text{P2 backfat (mm)})$$

Milk production was estimated based on piglet liveweight gain, with the assumption being that piglets consumed 3.7 g of milk for every g of weight gain (Noblet and Etienne 1986). The equations of Noblet and Etienne (1989) and Pettigrew (1993) respectively, were used to estimate the ME requirement (ME_{milk}) and lysine requirement ($Lysine_{milk}$) for milk production:

$$ME_{milk}\ \text{(kJ ME/day)} = [4.92 \times \text{litter gain, g/day}) - 90 \times \text{No. pigs})]/0.72] \times 4.184)$$
$$Lysine_{milk}\ \text{(g / day)} = 26 \times \text{litter gain (kg/day)}$$

2.6. Statistical Analysis

Unless otherwise stated, data are expressed as mean ± standard error of the mean (SEM). A general analysis of variance (ANOVA), with experimental replicate built in and sow parity as a co-variate, was used to determine treatment effects on sow body condition measures. Sow body condition change was included in the ANOVA model when determining treatment effects on days to oestrus, duration of oestrus and subsequent litter size. The cumulative proportion of sows expressing oestrus during lactation was analysed as χ^2. Treatment effects on piglet body weight and body weight gain were analysed using an ANOVA, with experimental replicate included in the model and piglet body weight on day 2 and sow body condition change during lactation used as co-variates.

All analysis, excluding the cumulative proportion expressing oestrus, was done using Genstat, 10th Edition (Rothamsted Experimental Station, Harpenden). Probability values < 0.05 were described as significant.

Experiment two: Effect of timing of boar exposure relative to parturition on lactation oestrus expression

A total of 38 primiparous (or first lactation) sows and 80 multiparous (parity 3.1 ± 0.18) sows were used in this study. The experiment in 2011 / 2012 and consisted of four replicates or farrowing batches: August / September (n = 34), October (n = 26), November (n – 31) and March (n = 27). All sows were housed in standard farrowing crates during lactation, and in groups of 4 – 8 post-weaning. The experiment was designed as a 2 times 4 factorial, incorporating two sow parity groups (primiparous versus multiparous) and boar exposure commencing on one of four days post-farrowing (days 10, 14 and 18 of lactation and weaning (day 26)). Primiparous (PP) sows were allocated to treatment based on liveweight (LW) at farrowing entry, with parity also used in the allocation process for multiparous (MP) sows. Allocations were conducted at farrowing shed entry to ensure sows in different treatments were housed in different farrowing rooms (note, rooms were alternated between blocks). The eight treatments were as follows: PP sows, boar exposure starting on day 10 (D10, n = 10), day 14 (D14, n = 9), day 18 (D18, n = 9) and weaning (W, N = 10); MP sows boar exposure starting on day 10 (D10, n = 20), day 14 (D14, n =20), day 18 (D18, n = 20) and weaning (W, N = 20). Due to lack of availability, there were no PP sows used in block 4.

Within 72 hours of farrowing, litter size was standardized to 11 piglets and maintained at this level, by cross-fostering, until weaning. Boar exposure consisted of 15 minutes of full, physical contact with a mature boar (> 12 months of age) in a detection mating area (DMA). Sows were artificially inseminated (AI'd) at first detection of oestrus and every 24 hours thereafter until a standing reflex was no longer observed or they had been AI'd four times. Sows receiving boar exposure during lactation were weaned on day 28 post-parturition (day 0 = first 24 hours post-parturition), with those commencing boar exposure at weaning weaned on day 26 post-parturition. Sows commencing boar exposure at weaning, were removed from their farrowing crate for 5 minutes each day from day 10 post-parturition to weaning and checked for oestrus behaviours without a boar being present. Post-weaning, and regardless of treatment, sows which failed to display oestrus during lactation continued to receive 15 minutes of daily, physical boar contact until first expression of oestrus or day 14 post-weaning. Sows failing to express oestrus within 14 days of weaning were described as anoestrus.

Sow LW and P2 backfat were measured on day 1 of lactation and weaning. Whole litter weights were recorded on day 3 of lactation and weaning. The interval from start of boar exposure to first detection of oestrus and the length of oestrus were recorded. Sows expressing oestrus during lactation were defined as having a lactation oestrus, with those animals expressing oestrus post-weaning defined as having a post-weaning oestrus. The proportion of sows experiencing a lactation oestrus, a post-weaning oestrus, and an oestrus by day 14 post-weaning were recorded. Subsequent reproductive performance, including pregnancy rates and litter size were recorded.

2.6. Statistical Analysis

Unless otherwise stated, data are expressed as mean ± standard error of the mean (SEM). A general analysis of variance (ANOVA), with experimental replicate built in, was used to determine treatment effects on sow body condition measures. Sow body condition change was included in the ANOVA model when determining treatment effects on days to oestrus, duration of oestrus and subsequent litter size. The cumulative proportion of sows expressing oestrus during lactation was analysed as χ^2. Treatment effects on litter weight and litter weight gain analysed using an ANOVA, with experimental replicate included in the model.

All analysis, excluding the cumulative proportion expressing oestrus, was done using Genstat, 10th Edition (Rothamsted Experimental Station, Harpenden). Probability values < 0.05 were described as significant.

3. Outcomes

Experiment One: Split weaning increases the incidence of lactation oestrus in boar exposed sows

Sow body condition throughout lactation

Sow body tissue loss was similar for all treatments between days 1 and 18 of lactation (Table 1). Total weight loss and protein loss during lactation (days 1-30) were lower ($P < 0.05$) for sows suckling 5 and 3 piglets compared to those suckling 10 or 7 piglets. Between days 18 and 30, sows with a suckling load of 3 and 5 gained weight and calculated body protein. Backfat loss during lactation did not differ between groups. There was no difference between treatments for energy and lysine output in milk between days 3 and 18 of lactation. In late lactation, between days 18 and 30, energy and lysine output in milk decreased with decreasing suckled litter size ($P<0.05$; Table 1).

Table 1 - Sow body weight and change, backfat and change, sow body protein change and sow body fat change at farrowing, day 18 of lactation and day 30 of lactation (Mean ± SEM).

Item	Treatment			
	SPW 0	SPW 3	SPW 5	SPW7
Number of sows	18	18	18	18
piglets suckling: d 18-30	10	7	5	3
Parity	2.8 ± 0.2	3.0 ± 0.2	2.6 ± 0.2	3.1 ± 0.2
Sow body weight, kg				
Day 1, post-partum	265.3 ± 6.0	270.1 ± 6.0	268.1 ± 6.0	270.5 ± 6.0
Day 18, post-partum	251.3 ± 6.1	256.8 ± 6.1	258.0 ± 6.0	258.2 ± 6.1
Day 30, post-partum	244.5 ± 6.2	253.4 ± 5.9	261.8 ± 5.9	259.6 ± 6.1
Sow body weight change, kg				
Days 1-18	-12.9 ± 2.0	-14.2 ± 2.0	-10.9 ± 2.0	-11.5 ± 2.0
Days 18-30	-5.4 ± 1.4 [a]	-2.9 ± 1.4 [a]	4.6 ± 1.3 [b]	2.0 ± 1.4 [b]
Days 1-30	-18.8 ± 2.2 [a]	-16.7 ± 2.1 [a]	-6.4 ± 2.1 [b]	-9.4 ± 2.2 [b]
Sow backfat change, mm				

Item	Treatment			
	SPW 0	SPW 3	SPW 5	SPW7
Days 1-18	**-1.3 ± 1.0**	**-2.8 ± 1.0**	**-1.7 ± 1.0**	**-3.1 ± 1.1**
Days 18-30	**-1.4 ± 0.9**	**0.9 ± 0.9**	**0.6 ± 0.9**	**0.8 ± 0.9**
Days 1-30	**-2.9 ± 1.1**	**-1.8 ± 0.9**	**-1.0 ± 0.9**	**-2.8 ± 1.0**
Sow body protein change[1], %				
Days d1-18	**-4.9 ± 0.8**	**-4.9 ± 0.9**	**-3.9 ± 0.9**	**-3.1 ± 0.9**
Days d18-30	**-2.0 ± 0.7** [a]	**-1.6 ± 0.7** [ab]	**1.9 ± 0.7** [c]	**0.3 ± 0.76** [bc]
Days d1-30	**-6.9 ± 0.8** [a]	**-6.3 ± 0.8** [a]	**-2.2 ± 0.8** [b]	**-2.9 ± 0.9** [b]
Sow body fat change[1], %				
Days d1-18	**-6.7 ± 1.7**	**-7.2 ± 1.8**	**-6.6 ± 1.7**	**-10.3 ± 1.8**
Days d18-30	**-4.8 ± 1.8** [a]	**-0.8 ± 1.8** [ab]	**3.4 ± 1.7** [b]	**2.5 ±1.8** [b]
Days d1-30	**-11.7 ± 2.2**	**-7.7 ± 2.2**	**-3.7 ± 2.2**	**-8.2 ±2.3**
Energy output in milk[2], MJ/d				
Days 3 – 18	**72.1 ± 3.25**	**70.3 ± 3.25**	**67.6 ± 3.15**	**65.9 ± 3.02**
Days 18 – 30	**79.2 ± 2.35** [a]	**61.4 ± 2.30** [b]	**44.7 ± 2.28** [c]	**24.4 ± 2.18** [d]
Lysine output in milk[3], kg/d				
Days 3- 18	**70.3 ± 2.96**	**68.6 ± 2.90**	**66.3 ± 2.87**	**64.7 ± 2.75**
Days 18 - 30	**76.8 ± 2.14** [a]	**59.2 ± 2.09** [b]	**43.1 ± 2.07** [c]	**23.6 ± 1.98** [d]

[abcd]Means within a row with different superscripts differ significantly (P<0.05); [1]Sow body protein and body fat were calculated using the equations set out by Whittemore and Yang (1989) and the change between days (%) subsequently calculated; [2]Energy output in milk calculated using the equation set out by Noblet and Etienne (1989); [3]Lysine output in milk calculated using the equation set out by Pettigrew (1993).

Oestrus data

Compared to sows suckling 10 piglets from day 18 to 30 of lactation, split weaning, regardless of the number of piglets removed, resulted in more sows exhibiting a lactation oestrus (90% versus 56%; x^2 = 9.58, P < 0.01). The incidence of lactation oestrus was higher between days 0 – 6 after the start of boar exposure than days 7 – 12 (90% versus 10%; x^2 = 72.97, P < 0.01; Figure 1). The interval from day 18 of lactation to lactation oestrus was similar across all treatments, as was the duration of oestrus (Table 2). There was no treatment effect on progesterone concentration 10 days after the first detection of lactation oestrus, (SPW0 20.2 ±1.5; SPW3 17.1 ± 1.8; SPW5 18.0 ± 2.1; SPW7 17.3 ± 1.0 ng/ml).

Of the sows that didn't show an oestrus during lactation the interval from weaning to the first post-weaning oestrus was 3.8 ± 0.3 days (range 1 – 5 days; n=12)

Table 2 - Cumulative percentage of sows expressing oestrus during lactation and pregnancy rate of sows mated in lactation.

	Cumulative % of sows expressing lactation oestrus		*n* of sows expressing lactation oestrus	Pregnancy rate[1]	Farrow rate[1]	Days to oestrus[2]	Duration of oestrus
	Day 18-24	Day 18-30					
SPW0	33.3[a]	55.6[a]	10/18	100%[a]	100%	5.4 ± 0.6	2.5 ± 0.2
SPW3	77.8[b]	83.3[b]	15/18	67%[b]	100%	4.5 ± 0.5	3.0 ± 0.2
SPW5	88.9[b]	88.9[b]	16/18	81%[ab]	92%	4.0 ± 0.4	3.1 ± 0.2
SPW7	88.9[b]	94.4[b]	17/18	100%[a]	94%	4.7 ± 0.4	3.1 ± 0.2

[ab]Means within a column with different superscripts differ significantly (P<0.05);[1] Proportion of pregnant sows on day 28 – 35 post-insemination that farrowed a litter [2]Number of days from the start of treatment (day 18) to expression of oestrus for those sows that exhibited oestrus before weaning

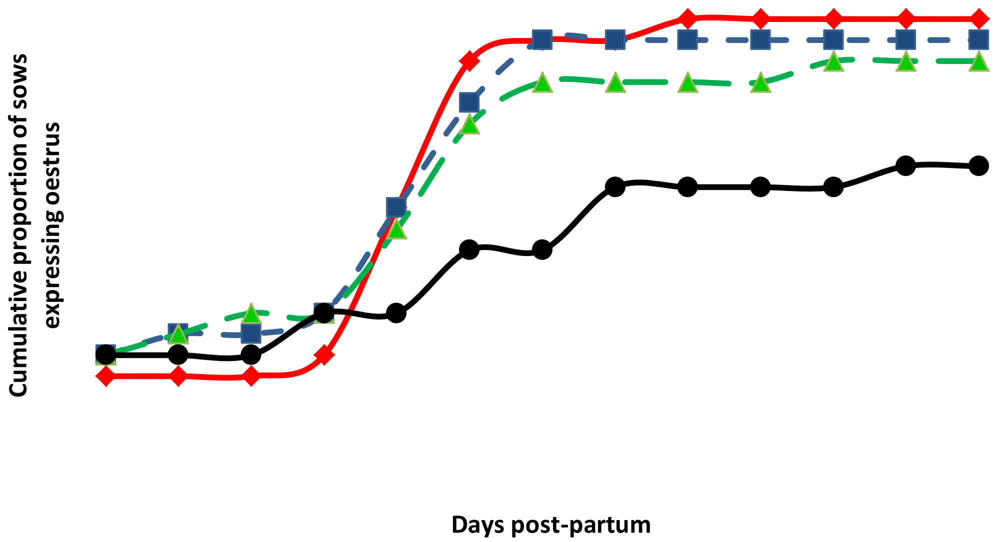

Figure 1 - Cumulative proportion of sows expressing oestrus relative to the day post-partum, for treatments SPW7 (◆), SPW5 (■), SPW3 (▲) and SPW0 (●), (n= 17, 16, 15, 10, respectively) beginning on day 18 and finishing on day 30 post-partum.

Pregnancy and farrowing rates, and subsequent reproductive performance of sows mated during lactation

Of the sows mated during lactation, a lower proportion of sows in the SPW3 group were pregnant on day 28 post-mating compared to those in the SPW0 and SPW7 treatments (P<0.05; Table 2). There was no effect of treatment (P>0.05; Table 2) on the proportion of sows that were pregnant on day 28 post-mating that farrowed.

At their subsequent farrowing, sows that had suckled 10 piglets during lactation gave birth to fewer (P < 0.05) piglets (total born) when compared to sows that had suckled 7 or 5 piglets (Table 3). Although SPW3 sows had the lowest pregnancy rate they had the highest total born and born alive of all the treatments. All other parameters were comparable across groups. As a comparison, multiparous sows (n=238) housed at the same piggery, which were not included in this experiment but were mated at their first post-weaning oestrus during the same period, had a total born of 11.7 ± 0.2, a born alive rate of 10.9 ± 0.2, a still birth rate of 0.6 ± 0.1, and mummified fetuses of 0.2 ± 0.04.

Table 3 - Subsequent reproductive performance of sows mated during lactation

	n	Total born	Born alive	Still born	Mummified fetuses
SPW0	**10**	**8.9 ± 1.1**^{a}	**8.9 ± 1.1**	**0.04 ± 0.3**	**0.19 ± 0.2**
SPW3	**10**	**13.1 ± 1.1**^{b}	**12.3 ± 1.1**	**0.79 ± 0.3**	**0.28 ± 0.2**
SPW5	**12**	**12.5 ± 1.0**^{b}	**11.7 ± 1.0**	**0.83 ± 0.3**	**0.17 ± 0.1**
SPW7	**16**	**11.6 ± 0.9**^{ab}	**10.8 ± 0.9**	**0.80 ± 0.2**	**0.45 ± 0.1**

^{ab}Means within a column with different superscripts differ significantly (P<0.05).

The final weaning to oestrus interval for sows that failed exhibit oestrus during lactation was significantly shorter than the mean interval from the start of boar exposure to lactation oestrus (3.5 ± 0.70 versus 4.8 ± 0.23 days; P = 0.01). Subsequent litter size (total born) was higher for sows mated post-weaning as opposed to during lactation (13.0 ± 1.49 versus 11.3 ± 0.49 piglets; P < 0.05).

Overall, and regardless of treatment, 97% of sows were mated within 35 days of parturition.

Piglet BW pre-weaning and post-weaning

As intended, piglets weaned on day 18 were 1.3 kg heavier (P<0.05) compared to those left on the sow (Table 4). For piglets remaining on the sow, body weight gain from day 17 to 30 was unaffected by suckled litter size. Weaning at 18 compared to 30 days of age resulted in a 2 kg decrease (P < 0.05) in weight gain between day 17 and 30, but a 1.6 kg increase (P<0.05) in weight gain between day 30 and 40 (Table 4). Piglets weaned at 18 days of age were lighter on day 30 but heavier on day 40 compared to piglets weaned on day 30 (Table 4). Body weight gain between day 17 and 40 post-partum was unaffected by age at weaning.

Table 4 - Piglet body weight (BW) for piglets split weaned at 18 days of age or late weaned at 30 days of age

Age at weaning[1]	30				18[3]	Weaning age		Pooled SEM
Suckled litter size[2]	10	7	5	3		day 18	day 30	
Treatment	SPW0	SPW3	SPW5	SPW7				
BW, kg								

Age at weaning[1]	30				18[3]	Weaning age		
Suckled litter size[2]	10	7	5	3		day 18	day 30	Pooled SEM
Treatment	SPW0	SPW3	SPW5	SPW7				
Day 2	**2.0**	**2.0**	**1.9**	**1.9**	**2.1**	**2.1^{d}**	**1.9^{e}**	**0.10**
Day 17	**5.7^{a}**	**5.6^{a}**	**5.2^{a}**	**4.5^{b}**	**6.4^{c}**	**6.4^{d}**	**5.2^{e}**	**0.11**
Day 30	**9.5^{a}**	**9.7^{a}**	**9.5^{a}**	**8.9^{ab}**	**8.4^{b}**	**8.4^{d}**	**9.4^{e}**	**0.13**
Day 40	**11.0^{a}**	**10.8^{a}**	**11.0^{a}**	**10.4^{a}**	**11.4^{b}**	**11.4^{d}**	**10.8^{e}**	**0.13**
BW gain, kg								
Days 2-17	**3.8**	**2.9**	**3.2**	**3.6**	**4.1**	**4.3^{d}**	**3.3^{e}**	**0.09**
Days 17-30	**3.9^{a}**	**4.2^{a}**	**4.2^{a}**	**3.8^{a}**	**2.0^{b}**	**2.0^{d}**	**4.0^{e}**	**0.13**
Days 17-40	**5.2**	**5.2**	**5.9**	**5.2**	**5.0**	**5.0**	**5.4**	**0.13**
Days 30-40	**1.4^{a}**	**1.1^{a}**	**1.6^{a}**	**1.4^{a}**	**3.1^{b}**	**3.1^{d}**	**1.4^{e}**	**0.17**
Days 2-40	**8.9^{ab}**	**8.8^{ab}**	**9.1^{a}**	**7.9^{b}**	**9.3^{a}**	**9.3^{d}**	**8.7^{e}**	**0.14**

[1]Refers to when the piglets were weaned [2]Number of piglets suckling from d 18 – 30 post-partum
[abc]Means within a row with different superscripts differ significantly (P<0.05); [de]Means within a row for weaning age with different superscripts differ significantly (P<0.05)
[3]Please note that the weight of all piglets split weaned on day 18 have been grouped and the replicates were individual litter weight means

Experiment two: Effect of timing of boar exposure relative to parturition on lactation oestrus expression

Sow body condition and litter weight change

As expected, MP sows were heavier than PP sows (P < 0.05; Table 5). Despite having similar P2 on day 1 of lactation, MP sows had more P2 at weaning, and lost less P2 during lactation than PP sows (2.1 ± 0.52 versus 5.7 ± 0.61 mm; P < 0.05). There was also an interaction between treatment and parity for P2 loss, with primiparous sows starting boar exposure at weaning losing less P2 than those starting boar exposure during lactation (P<0.05; Table 5). Regardless of parity, sows starting boar exposure at weaning lost less weight than those starting boar exposure during lactation.

Table 5 - Liveweight (kg) and P2 backfat (P2) for primiparous (PP) and multiparous (MP) sows commencing daily boar exposure (BE) on day 10, 14 or 18 of lactation or at weaning.

Parity	Start BE$_1$	Sow liveweight (kg)			Sow P2 backfat (mm)		
		Day 1	Weaning	Change	Day 1	Weaning	Change
PP	Day 10	215	191	-23	25.0	17.8	-7.1
PP	Day 14	212	197	-13	22.9	20.1	-2.6
PP	Day 18	222	198	-21	25.1	17.8	-6.9

Parity	Start BE$_1$	Sow liveweight (kg)			Sow P2 backfat (mm)		
		Day 1	Weaning	Change	Day 1	Weaning	Change
PP	Weaning	204	200	-4	23.0	20.1	-2.9
Pooled SEM		*4.11*	*3.17*	*3.29*	*0.95*	*0.70*	*1.00*
MP	Day 10	276	259	-17	22.5	21.2	-1.4
MP	Day 14	249	237	-25	21.5	20.0	-2.6
MP	Day 18	258	247	-13	23.2	21.0	-2.3
MP	Weaning	268	255	-14	25.3	22.2	-3.2
Pooled SEM		*4.24*	*3.94*	*3.15*	*0.64*	*0.55*	*0.46*
P-value							
Start of BE		*0.27*	*0.36*	*0.41*	*0.37*	*0.57*	*0.87*
Parity		*<0.01*	*<0.01*	*0.72*	*0.51*	*<0.05*	*<0.05*
Start BE x Parity		*0.30*	*0.41*	*0.39*	*0.42*	*0.54*	*0.06*

There was no effect of timing of start of boar exposure relative to parturition on litter weight or litter weight gain (Table 6). However, there was a significant effect of parity (MP versus PP) on litter weight on day 3 (20.8 ± 0.62 versus 18.0 ± 0.71 kg), day 28 (87.2 ± 2.74 versus 76.2 ± 3.16 kg) and pre-weaning litter weight gain (70.1 ± 2.92 versus 60.4 ± 3.37).

Table 6 - Weight and weight change during lactation for litters suckling primiparous (PP) and multiparous (MP) sows commencing daily boar exposure (BE) on day 10, 14 or 18 of lactation or at weaning.

Parity	Start BE$_1$	Total Litter weight (kg)		
		Day 3	Weaning	Gain
PP	Day 10	17.9	78.8	60.3
PP	Day 14	19.1	72.0	48.1
PP	Day 18	19.6	84.0	64.8
PP	Weaning	17.4	67.0	38.6
Pooled SEM		*0.65*	*3.10*	*4.29*
MP	Day 10	21.9	95.9	74.2
MP	Day 14	21.0	87.7	63.6
MP	Day 18	18.7	80.8	57.3
MP	Weaning	23.1	84.7	62.4
Pooled SEM		*0.52*	*2.25*	*2.27*
P-value				
Start of BE		*0.27*	*0.25*	*0.07*

Parity	*<0.01*	*<0.01*	*0.01*
Start BE x Parity	*0.05*	*0.17*	*0.06*

Oestrus data

The effect of parity and boar exposure commencement day on the incidence and timing of lactation and post-weaning oestrus expression is described in Table 7. There was no effect of replicate (or block) on the timing of lactation oestrus, and therefore the data for all blocks was analysed together, and are presented as such. However, there was a significant (P < 0.01) effect of block on the incidence of lactation oestrus. Specifically, regardless of parity or day of boar exposure commencement the incidence of lactation oestrus was significantly lower in block 4 (autumn) than in the other three blocks (winter / spring; 0.15 versus 0.51; P < 0.01; Table 8). Unfortunately, the weaning to oestrus data for block four was accidentally destroyed due to a pig related mishap.

The interval from start of boar exposure to first oestrus expression (lactation or post-weaning) was shorter for sows starting boar exposure at weaning compared to during lactation (P < 0.05). However, sows starting boar exposure on day 10 post-partum expressed their first post-partum oestrus earlier than those commencing at weaning (P < 0.05). Commencing boar exposure on days 14 and 18 of lactation resulted in an interval to lactation oestrus expression similar to the weaning to oestrus interval of control sows (5.3 ± 1.02, 4.9 ± 0.82 and 4.9 ± 0.67 days for BE14, BE18 and Control, respectively).Regardless of parity, commencing boar exposure on day 18 compared to day 10 post-partum significantly reduced the interval from boar exposure to lactation oestrus expression (4.5 ± 0.84 versus 7.7 ± 0.83 days; P < 0.05). However, the time lactation oestrus expression occured sooner relative to parturition for sows starting boar exposure on day 10 as opposed to day 18 of lactation (17.7 ± 0.83 versus 22.5 ± 0.84 days; P < 0.05). However, the boar exposure to lactation oestrus interval was significantly longer in sows commencing boar exposure on day 10 (7.8 ± 0.81 days).

Regardless of the timing of boar exposure, the interval from the start of boar exposure to lactation oestrus expression was shorter for MP compared to PP sows (5.4 ± 0.62 versus 8.1 ± 1.14 days, P = 0.07). The first post-partum oestrus (either lactation or post-weaning) occurred earlier relative to parturition for MP compared to PP sows (25.3 ± 0.82 versus 28.7 ± 1.02 days post-partum).

In blocks 1 – 3, regardless of when boar exposure started, a significantly higher proportion of MP compared to PP sows experienced a lactation oestrus (0.65 versus 0.36; P < 0.01). For MP sows only, lactation oestrus expression was lower for sows starting boar exposure on day 14 compared to day 18 post-partum (0.38 versus 0.79; P < 0.05), but was similar for sows starting boar exposure on days 10 and 18 of lactation. There was no effect of treatment on the proportion of MP or PP sows expressing oestrus within 14 days of weaning (Table 7).

The effect of treatment and parity on subsequent reproductive performance is presented in Table 9. There was no effect of treatment on subsequent litter size. However, subsequent total born tended to be higher (P = 0.08) and incidence of still born piglets was significantly higher for MP compared to PP sows: 12.5 ± 0.36 versus 11.3 ± 0.53 and 0.78 ± 0.12 versus 0.32 ± 0.18, respectively. There was no main effect of insemination during lactation or post-weaning on subsequent litter size. However, day of boar exposure tended to interact with whether sows were mated in lactation or post-weaning to affect subsequent total born (Figure 2).

There was a significant effect of parity on the duration of lactation oestrus, with the mean oestrus length longer in MP (2.89 ± 0.14 days; range 2 – 4 days) compared to PP (1.97 ± 0.24 days; range 1 – 3 days).

Table 7 - Timing of oestrus for primiparous (PP) and multiparous (MP) sows commencing daily boar exposure (BE) on day 10, 14 or 18 of lactation or at weaning (All blocks).

Parity	Start BE_1	Interval (days) from			
		BE to oestrus	BE to lactation oestrus	Farrow to oestrus	Farrow to lactation oestrus
PP	Day 10	21.4	9.7	26.9	19.7
PP	Day 14	19.1	6.5	27.1	20.5
PP	Day 18	18.2	7.3	29.6	25.3
PP	Weaning	5.5	-	31.4	-
Pooled SEM		*1.28*	*1.00*	*0.98*	*1.17*
MP	Day 10	18.6	7.0	21.5	17.0
MP	Day 14	18.6	5.7	27.0	19.7
MP	Day 18	20.6	3.5	23.1	21.5
MP	Weaning	4.8	-	30.8	-
Pooled SEM		*0.94*	*0.70*	*0.93*	*0.74*
P-value					
Start of BE		<0.01	<0.05	<0.01	<0.01
Parity		0.53	0.07	<0.01	0.07
Start BE x Parity		0.13	0.67	0.22	0.67

Table 8 - Incidence of oestrus for primiparous (PP) and multiparous (MP) sows commencing daily boar exposure (BE) on day 10, 14 or 18 of lactation or at weaning (All blocks).

Parity	Start BE_1	Blocks 1 - 3 (spring / winter)			Block 4 (summer / autumn)		
		Proportion of sows oestrus			Proportion of sows oestrus		
		During lactation	Post weaning	By day 14 post-weaning	During lactation	Post weaning	By day 14 post-weaning
PP	Day 10	0.40	0.50	0.90	-	-	-
PP	Day 14	0.33	0.44	0.78	-	-	-
PP	Day 18	0.33	0.56	0.89	-	-	-
PP	Weaning	-	1.00	1.00	-	-	-
MP	Day 10	0.69	0.31	1.00	0.29	-	-
MP	Day 14	0.38	0.62	1.00	0.00	-	-
MP	Day 18	0.79	0.14	0.93	0.17	-	-

Parity	Start BE1	Blocks 1 - 3 (spring / winter)			Block 4 (summer / autumn)		
		Proportion of sows oestrus			Proportion of sows oestrus		
		During lactation	Post weaning	By day 14 post-weaning	During lactation	Post weaning	By day 14 post-weaning
MP	Weaning	-	0.76	0.83		-	-
P-value							
Start of BE		P > 0.05	P > 0.05	P > 0.05	P > 0.05		
Parity		P < 0.05	P > 0.05	P > 0.05			

Table 9 - Subsequent litter size for primiparous (PP) and multiparous (MP) sows commencing daily boar exposure (BE) on day 10, 14 or 18 of lactation or at weaning.

Parity	N	Start BE1	Subsequent reproductive performance			
			Total born	Born alive	Still born	Mummies
PP	8	Day 10	10.2	9.7	0.14	0.35
PP	7	Day 14	11.3	10.4	0.35	0.55
PP	5	Day 18	11.7	10.7	0.26	0.74
PP	9	Weaning	12.0	11.3	0.47	0.19
Pooled SEM			*0.51*	*0.44*	*0.11*	*0.16*
MP	13	Day 10	13.4	12.1	0.99	0.34
MP	16	Day 14	12.2	10.9	1.10	0.24
MP	12	Day 18	11.0	10.5	0.41	0.12
MP	18	Weaning	12.9	11.9	0.62	0.39
Pooled SEM			*0.34*	*0.32*	*0.13*	*0.08*
P-value						
Start of BE			0.40	0.37	0.34	1.00
Parity			0.08	0.17	<0.05	0.46
Start BE x Parity			0.20	0.45	0.45	0.34

Table 10 - Pregnancy rates for primiparous (PP) and multiparous (MP) sows commencing daily boar exposure (BE) on day 10, 14 or 18 of lactation or at weaning.

Parity	Start BE1	Farrowing rates for sows inseminated			P - value
		During lactation	Post-Weaning	By day 14 post-weaning	Lact vs Post Wean
PP	Day 10	1.00	0.80	0.89	P > 0.05
PP	Day 14	1.00	1.00	1.00	P > 0.05
PP	Day 18	1.00	0.60	0.67	P > 0.05
PP	Weaning	-	1.00	1.00	P > 0.05
MP	Day 10	0.56	0.75	0.62	P > 0.05
MP	Day 14	0.80	0.88	0.85	P > 0.05

Parity	Start BE$_1$	Farrowing rates for sows inseminated			P - value
		During lactation	Post-Weaning	By day 14 post-weaning	Lact vs Post Wean
MP	Day 18	0.55	1.00	0.62	P > 0.05
MP	Weaning	-	0.83	0.83	P > 0.05
P-value					
Start of BE		P > 0.05	P > 0.05	P > 0.05	
Parity		P < 0.05	P > 0.05	P > 0.05	

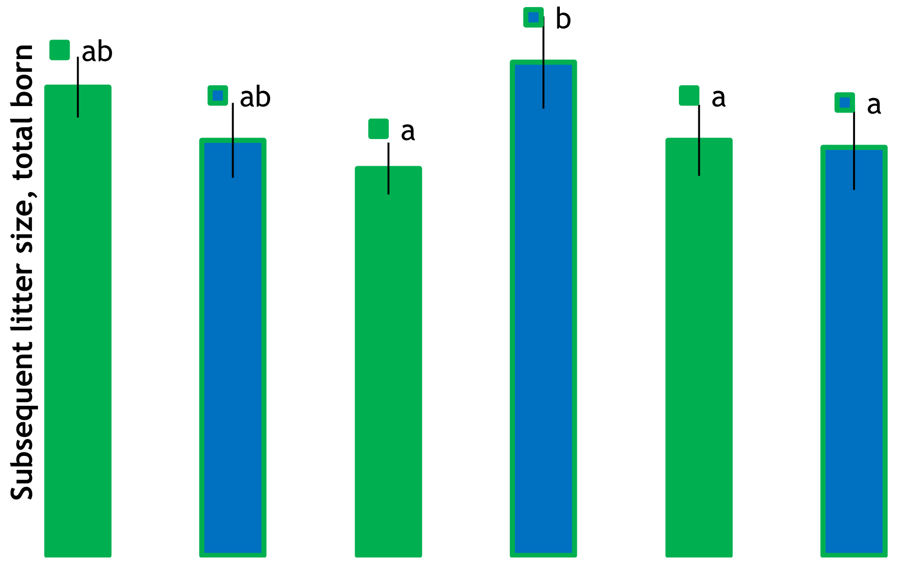

Figure 2 - Effect starting boar exposure on day 10 (BE10), day 14 (BE14) or day 18 (BE18) and inseminating sows during lactation or post-weaning on subsequent litter size (total born). ^{ab} indicates significant difference; $P < 0.05$

4. Application of Research

The data from experiment one demonstrated that split weaning in combination with good fence-line boar exposure in a DMA is an effective stimulant of lactation oestrus in individually housed sows, with the incidence of lactation oestrus further improved when a greater number of piglets are removed. Previously, less than 14% of sows exhibited lactation oestrus in response to boar exposure in various forms, with or without split weaning (Rowlinson and Bryant 1982; Walton 1986; Newton *et al.* 1987a). Therefore, to the best of our knowledge, the current data provided the first evidence that a high proportion of lactating sows can respond to split weaning and boar exposure with the sequence of endocrine and ovarian changes necessary for ovulation. Of note, is the finding that the mean interval from the start of boar stimulation to lactation oestrus expression (e.g. 4.0 – 5.5 days) is similar to what would normally be achieved post-weaning. Split weaning increased the number of piglets born at the subsequent farrowing to sows mated during lactation, extending previous data that split weaning increased follicle growth prior to weaning and embryo number in sows mated after weaning (Grant 1989; Zak *et al.* 2008). Notably, no long term adverse effects on piglet growth were observed when weaning occurred at 18 compared to 30 days of age.

The data from experiment two demonstrated quite clearly that multiparous sows have an increased capacity to ovulate during lactation than primiparous (or first lactation) sows. Overall, the incidence of lactation oestrus was low in primiparous sows (36%) but was unaffected by the day on which boar exposure commenced. Interestingly, although a high proportion of multiparous sows ovulated during lactation (70%), starting boar exposure on day 14 appeared to impair the capacity of sows to ovulate whilst lactating. Importantly, providing multiparous sows with full physical boar exposure commencing on day 10 and 18 of lactation resulted in the majority of sows ovulating during lactation as opposed to post-weaning (74% compared to 22%). In other words, providing boar exposure to lactating multiparous sows from day 10 or 18 of lactation onwards resulted in 69% and 79% having a farrowing to mating interval of less than 28 days, compared to an average of 31 days (28 – 40) for those commencing boar exposure post-weaning. Commencing boar exposure on day 14 and 18 of lactation resulted in an interval to lactation oestrus similar to the weaning to oestrus interval of Control (conventionally weaned) sows. These data suggest the timing of the sequence of physiological events required for sows to ovulate in response to boar exposure is similar in lactating and weaned sows, as long as boar exposure commences later in lactation.

Overall, the lack of an adverse effect on subsequent litter size of mating sows in lactation compared to post-weaning is promising for the commercial adoption of this management strategy. However, for those sows commencing boar exposure on day 14 of lactation, sows inseminated in lactation produced fewer piglets than those mated post-weaning. Combining this finding with the reduced capacity of sows in this treatment group to ovulate during lactating suggests there may some, as yet, unidentified impairment of the ovarian or endocrine axis at this point of lactation. In study two, the lower farrowing rates of MP sows inseminated during lactation as opposed to post-weaning is of concern; however, such an effect has not been observed in subsequent trials (data not shown), nor was it observed in study one of this project. Interestingly, the farrowing rates of PP sows mated during lactation was similar to that of their counterparts inseminated post-weaning, and was significantly higher than that of MP sows mated during lactation. The only measurable difference in oestrus expression between PP and MP sows was in the proportion of sows expressing lactation oestrus and oestrus length. It could, therefore, be suggested that perhaps only more fertile PP sows will exhibit a lactation oestrus, with a higher and more varied range of MP sows able to ovulate during lactation. Alternatively, the longer oestrus duration of MP compared to PP sows could indicate a sub-optimal insemination to ovulation interval in MP sows expressing oestrus during lactation.

Although comparisons between trials should be treated with extreme caution, the data from the current two studies suggests that full, physical boar exposure is a more effective stimulus of lactation oestrus than fence line contact. More specifically, full boar contact commencing on day 18 of lactation resulted in 79%

of sows experiencing a lactation oestrus whilst suckling 11 piglets, compared to 56% of sows suckling 10 and receiving fence-line boar contact.

From a commercial point of view, the removal of sows from farrowing crates and movement to a detection mating area for full physical boar contact is not ideal. However, it is worth remembering that once sows are mated in lactation they do not need to be run to the boar post-weaning. The other advantage of such a system is that sows can be housed individually whilst lactating, with the timing of mixing into groups occurring at weaning. In this way, group formation can occur when the pregnancy is less sensitive to environmental stressors (i.e. stress) and when sows are no longer expressing oestrus and mounting behaviours. From a purely practical point of view, our experiences suggest that after one or two days of movement to the detection mating area, sows are enthusiastic about leaving the farrowing crate, and it is the process of ensuring each sow is returned to the correct farrowing pen that is most time consuming.

The significant reduction in lactation oestrus expression during autumn in the second experiment can be attributed to the suppression in LH release and ovarian follicle growth associated with this time of year. However, such a dramatic drop in the capacity of sows to express a lactation oestrus emphasizes the need to develop strategies to overcome this issue if lactation oestrus management systems are to be commercially viable.

Taking into account that the re-mating of sows post-parturition requires at least some degree of boar stimulation, with the most efficacious form involving physical boar contact, the use of boars to stimulate oestrus in lactating sows shouldn't significantly increase the cost of production. Although labour requirements will be higher in such a system, the need to stimulate sows post-weaning is removed, effectively minimizing space requirements and feeding costs. The other major advantage is that full physical boar contact appears to remove the need to manipulate suckling load or duration prior to complete weaning, allowing weaning age of all piglets to be determined on their requirements, rather than the need to reduce the farrowing to re-mating interval.

5. Conclusion

In conclusion, the current data is, to my knowledge, the first to demonstrate that boar contact on its own, when conducted in a detection mating area, can be used to stimulate a high proportion of sows to exhibit a rapid and synchronous oestrus and ovulation during lactation. Although previous work has demonstrated that intermittent suckling and exogenous gonadotrophins can be effective methods of inducing sows to ovulate during lactation, there are some concerns around the use of these methods. Specifically, the effect of enforced separation of piglets, especially young piglets (< 18 days old) on their behaviour, welfare and performance remains to be established, together with the length of separation time for an adequate response. Equally important, the use of gonadotrophins does not fit with consumer and retailer requirements from production systems.

These data demonstrate the sows are less likely to ovulate during their first lactation than in subsequent lactations, and that the capacity of sows to exhibit a lactation oestrus is impaired when boar exposure commences on day 14 as opposed to day 10 or 18 of lactation. It is also noteworthy that removal of a portion of the litter or increasing the degree of boar stimulation from fenceline to full physical (in a DMA) increased the proportion of sows exhibiting lactation oestrus.

6. Limitations/Risks

The major limitation to the current outcomes is the additional labour required above current post-weaning oestrus stimulation protocols. Equally, there is a need to determine whether boar exposure is an effective stimulant of lactation oestrus in a commercial setting and on a large enough scale to obtain meaningful results for subsequent litter sizes. The development of housing systems which consist of separate sow and piglet areas, and allow boars to be introduced, may alleviate some of the labour costs.

7. Recommendations

As a result of the outcomes in this study the following recommendations have been made:

- The use of daily boar contact from day 18 of lactation onwards represents an efficient and “natural” method of inducing lactation oestrus, thus maintaining commercially viable farrowing to conception intervals and allowing piglet age at weaning to be increased.
- Providing multiparous sows with 15 – 20 minutes of daily, physical boar contact in a detection mating area from day 18 of lactation onwards is an effective method of stimulating a rapid and synchronous lactation oestrus
- A rapid and synchronous lactation oestrus can be obtained when suckled litter size is reduced to 7 piglets, or less on day 18 of lactation and sows receive fence line contact with a mature boar in a detection mating area.
- The use of boar contact to stimulate lactation oestrus has a number of advantages, including the fact that it is a process that most stockmen are familiar with and it involves the use of a natural method of stimulating oestrus.
- Further research is required in a number of areas, specifically
  - Understanding and alleviating the effect of season on lactation oestrus expression
  - Developing more commercially applicable strategies of incorporating natural methods of lactation oestrus stimulation (i.e. boar contact) into current production systems.
  - Development of sow and stockman controlled housing systems which minimize the labour costs associated with boar stimulation

8. References

Grant SA (1989) Ovarian function in the gilt and lactating sow. Ph.D thesis, University of Nottingham, UK.

Henderson, R., Stolba, A. (1989). Incidence of oestrus and oestrous trends in lactating sows housed in different social and physical environments. Appl. Anim. Beh. Sci. 22; 235 - 244.

Hewitt, R. J. E., Chick, S., van Barneveld, R. J. (2009). The effect of diet density and lactational demand during the first lactation on susbequent reproductive performance. Manipulating Pig Production XII. 141

Hulten, F., Dalin, A. -M., Lundeheim, N., Einarsson, S. (1995). Ovulation frequency among sows group housed during late lactation. Anim. Reprod. Sci. 39; 223-233

Kongsted, A. G., Hermansen, J. E. (2009). Induction of lactational estrus in organic piglet production. Therio. 72; 1188-1194.

Newton, E. A., Stevenson, J. S., Davis, D. (1987). Influence of duration of litter separation and boar exposure on estrous expressiion of sows during and after lactation. J. Anim. Sci. 65; 1500-1506

Pluske, J. R., Williams, I. H. (1996) Split weaning increases the growth of light piglets during lactation. Aust. J. Agric. Res. 47; 513 - 523.

Rowlinson P, Bryant M (1982) Lactational oestrus in the sow 2. The influence of group-housing, boar presence and feeding level upon the occurrence of oestrus in lactating sows. Animal Production 34(03), 283-290.

Soede, N. M., Hazeleger, W., Gerritsen, R., Kemp, B. (2009). Ovarian responses to lactation management strategies. J. Repro. Fert. 66; 177-186.

Stevenson, J. S., Davis, D. L. (1984) Influence of reduced litter size and daily litter separation on fertility of sows at 2 to 5 weeks postpartum. J. Anim. Sci. 59; 284 - 293.

Tarocco, C., De Rensis, F., Kirkwood, R. N., Yang, R,-C. (2000) Effect of split weaning interval on return to estrus and sow fertility. Swine Health and Production, 8; 221-223.

Walton J (1986) Effect of boar presence before and after weaning on estrus and ovulation in sows. Journal of animal science 62(1), 9 – 15.

Zak, L., Foxcroft, G. R., Aherne, F. X., Kirkwoon, R. N. (2008) Role of luteinising hormone in primiparous sow responses to split weaning. Reprod. Dom. Anim. 43; 445-450.