Alternatives for managing the weaned parity 1 sow

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Introduction

One of the great failures of the pork production industry has been an inability to capture the true production potential of the excellent dam-lines already available. To realize the greatest production from sows in the breeding herd, producers in today's swine industry must continue to specialize production efforts and enhance their managerial focus on finer details (Tonsor and Dhuyvetter, 2008).

Excellent lifetime performance of sows in the breeding herd is achievable with attention to good management. However, these targets can only be achieved by recognizing the key physiological characteristics of contemporary dam-line females, and particularly their exceptional lean growth potential. By controlling body condition at first breeding (particularly overall body mass rather than "fatness") and selecting gilts for inclusion in the breeding herd on the basis of recorded first standing estrus, producers can maximize first litter performance of gilts and improve sow lifetime performance in the breeding herd.

A Review --- Setting up gilts for lifetime performance

Successful introduction and retention through the early parities drives lifetime performance of the breeding herd and represents an opportunity to improve and enhance overall production. Implementation of an effective GDU system (BEAR, Magic '42') is absolutely necessary and is the pivotal starting point in the system to select gilts with the greatest reproductive potential.

We recommend gilts that are cyclic within a defined number of days after boar exposure be considered "Select" gilts: All others are considered "Opportunity" gilts and are only entered into the herd if breeding targets cannot be met from the Select pool. "Opportunity" gilts will have fewer pigs born per lifetime, accumulate more non-productive days (NPD), and have lower retention in the herd. Therefore, management systems should implement planned culling procedures and remove these sows early in their productive life.

Finally, gilts must have sufficient body condition (135 to 150 kg of body weight) and sexual maturity (at least second estrus) when first bred to be sure they achieve an adequate number of parities (>3).

Changes in metabolic and suckling effects on sow productivity

Changing relationships between lactational catabolism, the primary inhibitory effects of suckling, and reproductive performance of sows after weaning are becoming increasingly apparent. In most of our research, this relationship is studied almost exclusively in the context of the lactating and weaned first parity sow, on the basis that a second parity "dip", or at least an inability to achieve a high level of productivity in the second parity, is an ongoing issue for the industry.

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Table 1: Data from various studies demonstrating changing biology of the modern sow.

Experimental group	Feed Restriction				Skip-a-Heat breeding after weaning *unpublished, 2005*
	Early lactation *Zak, et al. 1997*	Late lactation *Zak, et al. 1997*	Late lactation *Vinsky et al. 2006*	Late lactation *unpublished, 2005*	
Weaning-to-estrus interval (hr)					
Control	88.7 ± 11.2*	88.7 ± 11.2*	127.2 ± 7.2	160.03 ± 3.65	111.7 ± 5.9
"Treated"	134.7 ± 8.7*	122.3 ± 9.8*	129.6 ± 7.2	167.35 ± 3.72	113.6 ± 5.9
Ovulation rate at d30					
Control	19.8 ± 1.6*	19.8 ± 1.6*	18.3 ± 0.7	18.57 ± 0.52*	19.0 ± 0.6
"Treated"	15.4 ± 1.9*	15.4 ± 2.3*	18.2 ± 0.6	16.72 ± 0.47*	19.6 ± 0.6
Embryo survival at d30					
Control	87.5 ± 6.4*	87.5 ± 6.4*	79.2 ± 4.0*	64.00 ± 4.08	68.1 ± 3.6*
"Treated"	86.5 ± 7.6*	64.4 ± 6.1*	67.9 ± 3.9*	69.03 ± 3.81	77.4 ± 3.6*

* Significant difference in WEI as a result of the "treatment" applied; $p<0.05$

In the past, weaning-to-estrus intervals (WEI) were reported to be delayed by factors including, lactation length, litter size, season, nutrition, and management practices[3,4]. Experimentally, previous literature has suggested that metabolic or litter manipulations during lactation can have drastic effects on subsequent reproductive performance, especially in first parity sows. When considering WEI, Foxcroft et al. (1995) noted that with feed restriction at any time during lactation, WEI is generally increased (Table 1). However, in most modern sow farms, more than 90% of sows typically return to estrus within 3 to 5 days after weaning. Even during periods of experimentally-induced feed restriction of up to 50% during the last week of lactation, no effect on WEI was detected.

The trend toward a lack of treatment effects on key benchmarks of post-weaning fertility is also apparent when ovulation rate is studied. Again, when compared to data from Control primiparous sows that were fed close to appetite during a 4-week lactation in an earlier metabolic study, both periods of feed restriction applied during lactation produced a significant reduction in ovulation rate (Zak et al. 1997a). This was partly attributed to a metabolic effect on LH secretion during lactation, as LH concentrations and LH pulse frequency were lower, especially in the group restricted late in lactation. The reduction in ovulation rate was also likely related to the reported differences in insulin and IGF-1 which were assumed to change the sensitivity of the ovary to LH and FSH stimulation. However, in recent studies previously mentioned, for the most part ovulation rate has become more consistent in the sows studied (Table 1).

Table 2. Least-square means (± s.e.m.) for sex-specific embryo characteristics collected at day 30 of gestation (Vinsky et al., 2006)

Item	Control (*n* = 16)	Restrict (*n* = 17)
Wean-to-estrous interval (days)	5.3 ± 0.3	5.4 ± 0.3
Ovulation rate	18.3 ± 0.7	18.2 ± 0.6
Pregnancy rate (% of sows bred)	100	100
Day of gestation at slaughter	30.3 ± 0.2	30.1 ± 0.2
Number of live embryos*	14.4 ± 0.8	12.3 ± 0.8
Embryonic survival rate (%)*	79.2 ± 4.0	67.9 ± 3.9
Number of males	7.7 ± 0.6	7.5 ± 0.6
Number of females*	6.5 ± 0.6	4.7 ± 0.6
Embryo weight (g)**	1.53 ± 0.07	1.38 ± 0.07

*$P < 0.05$, **$P < 0.005$ difference only between treatments.

Analysis of embryonic survival rate performed on arcsin transformed data

Although embryonic survival was affected in earlier studies (Zak et al. 1997a), the timing of the period of feed restriction seemed to be a critical aspect of this response. However, as WEI and ovulation rate were also affected in the worst scenario, a change in embryonic survival tended to compound the other effects of treatment on subsequent fertility (Table 1). However, in recent studies involving feed restriction in late lactation, the implications of this change in response seems to be more complex than simply being limited to an effect on the number of surviving embryos in the absence of treatment effects on WEI and ovulation rate (Vinsky, et al., 2006). These latest results suggest that both a sex-dependent loss of embryos is involved and, regardless of their sex, the surviving embryos are developmentally delayed (Table 2).

Collectively, the results of these studies suggest that although modern, primiparous sows are able to come into estrus at a consistent interval and ovulate at the same rate independent of treatment, the emerging pre-ovulatory follicles are of poorer quality, even in control animals, and detrimental conditions during lactation compromise this quality even further. This poor quality may be reflected in the size of the follicle prior to ovulation. Data recently obtained on the size of pre-ovulatory follicles in weaned primiparous sows, considered in the context of the endocrine data from the same studies, indicates that the dynamics of follicle maturation has changed substantially over the last two decades of selection for increased sow prolificacy. Smaller, more steroidogenic follicles make up the pre-ovulatory population in primiparous sows, reminiscent of the follicular characteristics described for prolific Chinese breeds like the Meishan. The lack of any delay in follicular development, previously associated with the negative effects of catabolism and the inhibitory effects of the suckling stimulus during lactation in primiparous sows and mediated by inadequate LH and FSH stimulation of follicular growth immediately after weaning, presents us with a new dilemma.

Options for contemporary weaned sow management

The primary cause of increased embryonic loss, the sex-dependent impact of these limitations to second parity litter size, and reduced embryonic development of all surviving embryos in contemporary commercial dam-lines, seems to be associated with the ovulation of relatively immature follicles. Because of the change in the dynamics of follicular development, and a gonadotropic stimulus that allows those follicles present at weaning to be immediately recruited into the pre-ovulatory phase of growth, the development of techniques that would delay the emergence of the pro-ovulatory cohort of follicles may be the most realistic way of improving the post-weaning fertility of the first parity female.

Given the positive responses in lower parity sows reported previously (Clowes et al., 1994); skip-a-heat breeding still seems to be a possible technique to consider. We have begun to re-evaluate the use of the oral progestagen, allyl-trenbolone, for delaying emergence of pre-ovulatory follicles, without incurring the full economic cost of 21 NPD associated with skip-a-heat breeding. In addition, we will re-examine the role PG600 may play in modern contemporary genotypes.

Skip-a-heat breeding

A "second parity dip" due to lactational catabolism is common in primiparous sows and is associated with extended WEI (Zak et al., 1997a) and reduced embryonic survival in the subsequent parity (Clowes et al., 1994). Delaying breeding to the second post-weaning estrus (skip-a-heat) allows recovery from lactational catabolism and improves sow productivity. First and second parity sows subjected to "skip-a-heat" breeding (bred at the second estrus after weaning, or "skipped") exhibited an increase of two pigs born compared to sows bred at first post-weaning estrus (Clowes et al., 1994) but this increase in litter size also resulted in an accumulation of 21 NPD and a 9% chance of sows not standing to be bred at second estrus.

In contemporary sows it appears that the negative impacts of poor lactational feed intake, weight loss, and management may be overcome by applying "skip-a-heat" breeding. We have recently re-examined the effects of skip-a-heat. All sows were fed a standard lactation diet "to appetite" for the 21-day lactation period(?) and assigned to control and bred on the first post-weaning estrus (PE1), or be "skipped" and bred at second estrus (PE2). Skipped sows had a greater positive weight change between weaning and breeding than sows bred at their post-weaning estrus. As discussed earlier, although there was no difference in ovulation rate between treatments, sows bred at their second post weaning estrus sows had greater numbers of live embryos and higher embryonic survival at d30 of gestation compared to sows bred at their first estrus sows (Table 3). In addition, the idea that follicular quality may be related to follicular size is supported by skip-a-heat data in which follicle sizes increased by approximately 1mm on average in sows bred on their second post-weaning estrus (Table 3), and embryonic survival was also improved. In a second trial supporting the notion of improved follicular quality, sows subjected to the skip-a-heat protocol, corpora lutea (CL) weight at d9 of gestation appears to be improved compared to the feed restricted controls (unpublished data, SRTC). In addition, under good management practices, high production performance is achievable: 95% of sows returned to estrus within 10 days, 98% of sows bred, 100% of "skipped" sows were detected in heat, and a 92% conception rate was achieved.

Table 3. Least-square means (± s.e.m.) for sex-specific embryo characteristics collected at day 30 of gestation (Vinsky et al., 2006)

	Control	"Skip-a-heat"	SEM	*P*-Value
Ovulation Rate	19.0	19.6	0.6	0.50
Largest Follicle --- First PWE	7.2^{x}	7.1	0.2	0.65
Largest Follicle --- Second PWE	-	8.2^{y}	0.2	0.002
Number of Live Embryos	12.9	15.2	0.8	0.04
Embryo Survival to d30 (%)	68.1	77.4	3.6	0.03*
Ovulation Rate	19.0	19.6	0.6	0.50

^{x,y} Significant difference in size of the largest follicle at breeding $P < 0.002$.

Oral Progestagen

We have also begun to re-evaluate the use of the oral progestagen, allyl-trenbolone, for delaying emergence of pre-ovulatory follicles, without incurring the full economic cost of 21 NPD associated with skip-a-heat breeding. Altrenogest treatment effectively delays estrus after weaning in sows (Wood et al., 1992; Martinat-Botté et al., 1995; Tilton and Weigl, 2000; Santos et al., 2004; Fernández et al., 2005) by exerting negative feedback on GnRH release and, thus, LH and FSH secretion (Stevenson et al., 1985). Altrenogest treatment from the day of weaning is normally effective in blocking the increase in LH secretion that is triggered by removal of the litter. Particularly in lower parity sows, delaying estrus with oral progestagen allows additional time for recovery from lactational catabolism (Santos et al., 2004; Fernández et al., 2005). The changing physiology of the weaned sow (Kemp et al., 2006) suggests that longer periods of progestagen treatment may produce fertility outcomes more analogous to the effects of "skip-a-heat" breeding.

In a recent collaborative study in a large commercial sow farm (Patterson et al., 2008), sows weaned over consecutive 3-wk periods and classified as parity 2 and 3 (P2-3) 4, 5, and 6 (P4-6) ,parity 7, or higher (P7+), were organized into two breeding groups using one of three strategies: 1) oral progestagen for 2 d before and 12 d after weaning (M14; n = 249); 2) oral progestagen for 2 d before and 5 d after weaning (M7; n = 250); or 3) no progestagen treatment (M0; n = 250) (Figure 1). Progestagen (altrenogest) was administered directly into the sow's mouth at a dosage of 6.8 mL (15 mg altrenogest) daily. Sows were bred using artificial insemination at first detection of estrus after weaning (M0) or altrenogest withdrawal, and every 24 h thereafter, until they no longer exhibited the standing reflex.

The WEI for the untreated M0 sows was 5.1 ± 0.1 d. Estrus was recorded sooner after withdrawing treatment in M14 than in M7 sows (6.9 ± 0.1 vs 7.4 ± 0.1 d, respectively) and more M14 sows (88.6 ± 2.5%) were bred within 10 d of altrenogest withdrawal than M7 (72.8 ± 2.8%) sows, or within 10 d of weaning in M0 sows (78.8 ± 2.6%) (Figure 1). Reproductive tracts were recovered after slaughter at either d 30 or d 50 of gestation. For P2-3 sows, ovulation rate in M7 (23.1 ± 1.0) was greater ($P < 0.001$) than in M14 (20.7 ± 1.0) or M0 (19.7 ± 1.0) sows; no differences were detected in P4-6 and P7+ sows. At d 30, M7 and M14 sows had more embryos (16.4 ± 0.6 and 15.8 ± 0.4, respectively) than M0 (13.9 ± 0.5) sows and at d 50 of gestation the number of fetuses in M14 sows (13.6± 0.4) was higher than in M0 (11.8 ± 0.4) and M7 (12.2 ± 0.3) sows (Figure 2). Use of oral progestagen to delay the return to post-

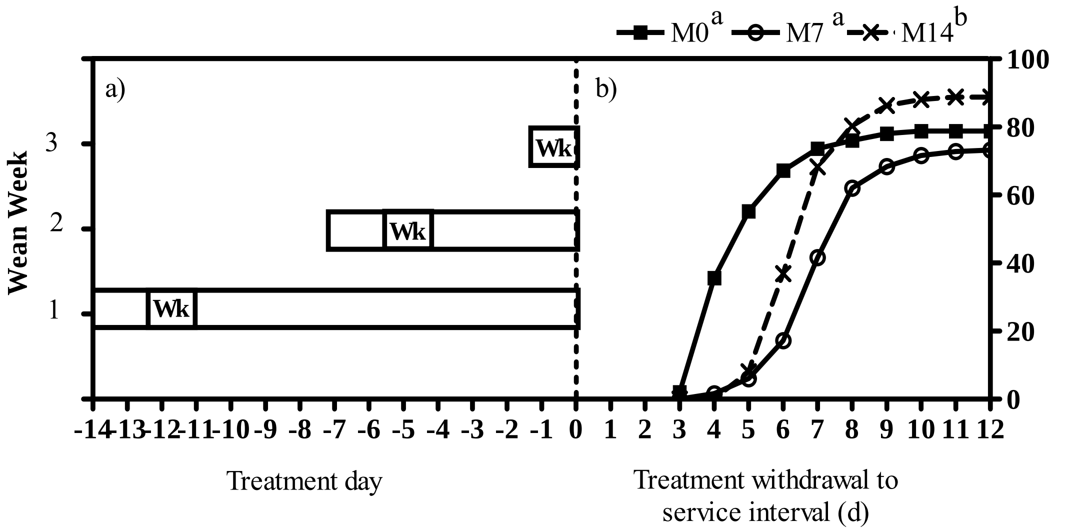

Figure 1. a) Description of the experimental design; sows weaned over two 3-wk periods were allocated by wean wk to M14 (wean wk 1 and 4), M7 (wean wk 2 and 5) or M0 (wean wk 3 and 6) treatments. The rectangle represents duration of altrenogest treatment for M14 and M7 sows. W indicates the d of weaning. b) Overall distribution of sows exhibiting standing heat by d. [a,b,c] Different superscripts indicate differences ($P < 0.05$)in the proportion of sows bred within 10 d of weaning (MO) or treatment withdrawal (M7 and M14). (From Patterson et al., 2008)

weaning estrus for greater than 18 d appears to have potential for improving weaned sow productivity. Given the incidence of high ovulation rates and associated evidence of intra-uterine crowding of embryos around d 30 of gestation, the changing dynamics of prenatal loss resulting from longer periods of progestagen treatment may represent an additional production advantage.

Overall, therefore, the concept that a controlled delay in the onset of post-weaning estrus may result in the development of better ovulatory follicles and result in an improvement in subsequent litter size born, seems to be consistent with the results of this recent study. A delay of 12 to 13 days to post-weaning ovulation in the M7 sows (the 5-day period of altrenogest treatment added to the 7 day interval to estrus onset after withdrawing treatment) still may not have been sufficient to achieve all the benefits seen in the M14 sows that had a post-weaning to ovulation interval of approximately 20 days. Altrenogest was effective in synchronizing the return to estrus in weaned sows and the duration of altrenogest treatment affected subsequent sow productivity. Sows treated with altrenogest for 12 d after weaning produced the greatest percentage of sows bred within 10 d of altrenogest withdrawal and pregnant at d 50 of gestation, and an increase in the number of fetuses at d 50 of gestation, comparable to that seen in previous “skip-a-heat” studies. Use of oral progestagens to delay the return to post-weaning estrus for greater than 18 d may also optimize the dynamics of embryonic and fetal survival in higher parity sows.

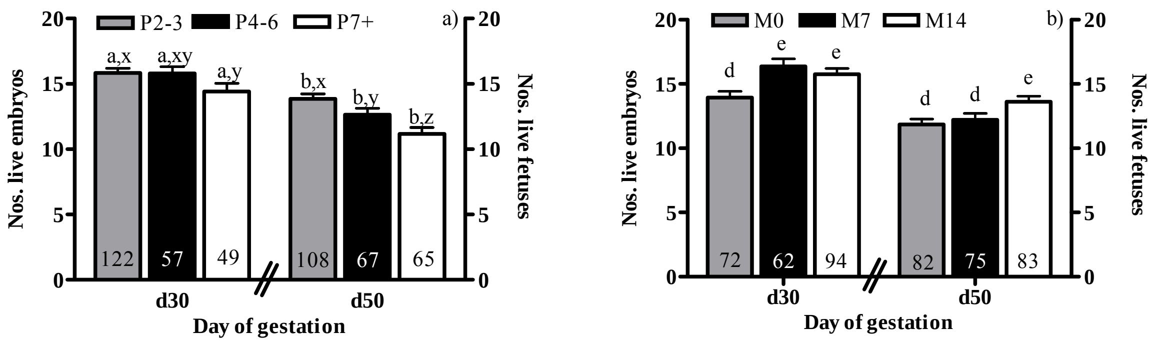

Figure 2. a) Effect of parity (P2-3, P4-6 and P7+) on total number of live embryos and fetuses (least squares means ± standard error) at d 30 and 50 of gestation. [a,b]Different superscripts indicate differences between d of gestation within parity group (P < 0.05). [x,y,z] Different superscripts indicate differences between parity group within d of gestation (P < 0.05). Numbers within bars are the number of sows represented. b) Effect of progestagen treatment (M7 and M14) after weaning on total number of live embryos and fetuses (least squares means ± standard error) at d 30 and d 50 of gestation. [d,e] Different superscripts indicate differences between treatment groups within d of gestation (P < 0.05). Numbers within bars are the number of sows represented. (From Patterson et al., 2008)

Exogenous gonadotrophin treatment at weaning

The principal goal of commercial breeding herds is to consistently meet weekly breeding targets. Weaned sows failing to return to estrus within 7 d after weaning contribute to missed breeding targets and increased non-productive sow days. Treatment with low doses of exogenous gonadotrophins (GT) has traditionally been used to advance and synchronize estrus in weaned primiparous sows. However, in well-managed contemporary commercial sow farms, more than 90% of sows may return to estrus within 7 d after weaning (Poleze et al., 2006) , posing questions about the likely efficacy of exogenous GT treatments.

A combination dose of 400 IU eCG and 200 IU hCG (PG600; Intervet, USA, De Soto, KS) has been proven to induce a synchronized estrus in both weaned sows and gilts. In a recent study, primiparous crossbred sows (PIC C22, n = 275; and PIC C29, n = 131) from a 5,000 sow commercial farrow-to-wean facility (Wildcat, Carthage Veterinary Service, Carthage, IL) were blocked by estimated farrowing weight and genetic line and then randomly allocated to either receive a combination dose of 400 IU eCG and 200 IU hCG (PG600, Intervet, USA, De Soto, KS) I.M. in the neck on the morning of weaning (PG group; n = 189), or to be untreated controls (CON group; n = 218). From the day after weaning, all sows were provided twice daily fence-line contact with mature boars for stimulation and detection of estrus. Sows were bred according to established herd protocols with doses of 3.0×10^9 sperm cells/insemination. Reproductive parameters analyzed were estrus synchronization rate (ESR), determined as the number of sows with observed standing heat within 7 d after weaning, weaning-to-estrus interval (WEI), proportion of sows bred over a 3-d period (BRD3), proportion of sows bred that farrowed (FR), total litter size (TB), and total live born piglets (BA) at farrowing. Based on WEI, sows were retrospectively grouped into 4 categories (WCAT); 1) Target Breed Week: sows bred within 7 d post-weaning, 2) "Tail-enders": sows with an extended 8-19 d WEI , 3) "Missed heats" sows detected in heat ≥ 20 d post weaning, or 4) No detected heat by d 30.

Estimated farrowing (193.6 ± 1.5 vs 192.2 ± 1.6) and weaning (189.4 ± 1.3 vs 188.0 ± 1.4) weights were similar in CON and PG sows, respectively, and marginal weight loss in lactation was recorded across all sows (4.2 kg). Considering data from all sows assigned to treatment (Table 4), treatment did not affect the proportion of sows bred within 7 d after weaning (ESR), or within a 3-d breeding window (BRD3). However, the timing of this 3-d breeding window (d 4, 5, and 6 for CON vs d 3, 4, and 5 for PG sows) reflected a shorter (P <0.001) WEI in PG compared to CON sows. PG treatment also eliminated the incidence of sows with an extended WEI (classified as "tail enders"), and reduced variance (P <0.05) in WEI in PG (0.07) compared to CON (0.14) sows when considered over the 19-d period after weaning (Figure 3). For those sows bred within 7 d after weaning, farrowing rate (82.8 vs 86.4%), total born (12.2 ± .3 vs 12.9 ± .3) and born alive (11.6 ± .3 vs 12.1 ± .3) were not different (P >0.05) between PG and CON sows, respectively, and a combined Fertility Index (as defined in Table 4) indicated no gain in productivity in response to GT treatment.

Table 4. Effects of treatment (T; exogenous GT at weaning (PG) or untreated controls (CON)), genotype (G), and their interaction on the distribution of observed estrus in all sows on experiment, and productivity of those sows bred within 7 days after weaning.

Treatment	**CON**	**PG**	***P*-Value of effect**		
			T	**G**	**T x G**
Sows assigned (n)	218	189			
ESR (%)	88.1	92.1	0.22	0.07	0.38
WEI (d)	4.5 ± .07	4.0 ± .07	0.001	0.42	0.88
BRD3 (%)	79.2	85.2	0.27	0.34	0.13
Sows farrowed (n)	166	144			
FR (%)	86.5	82.8	0.71	0.28	0.32
TB	12.9 ± .3	12.2 ± .3	0.11	0.45	0.24
BA	12.1 ± .3	11.6 ± .3	0.20	0.38	0.22
Fertility index[1]	983	930			
	CON	**PG**	**T**	**WCAT**	**T x WCAT**
Sows per WEI category (1/2/3/4)	88.1/2.8/2.3/6.9	92.1/0.5/3.1/4.2	0.34	0.001	0.14

[1] Fertility index = sows bred in < 7 days after weaning and farrowed per 100 sows weaned x TB

Consistent with earlier reports (Kirkwood et al. 1999; Knox et al. 2001; Vargas et al.,. 2006), exogenous GT treatment in the present study shortened the WEI, but as also reported by Bates et al. (2000) had no effect on estrus synchronization rate, farrowing rate, or subsequent litter size born. These results contrast earlier reports of a negative relationship between a shorter WEI and subsequent litter size born (Kirkwood et al., 1999; Knox et al. 2001; Vargas et al. 2006). These differences in the response to GT treatment may reflect the very synchronous return to estrus seen in the Control sows and good

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lactational management as reflected in the marginal overall loss in estimated sow body weight at weaning.

The absence of sows classified as "tail enders" in the PG group may be of practical significance. Assuming that the incidence of "tail enders" will increase at more adverse times of year due to seasonal effects on lactation feed intake and overall reproductive performance, the apparent ability of GT treatment to induce an early ovulation in these sows is of interest. Those GT treated sows showing a silent first heat and then detected in estrus at 19 or more days after weaning will have active corpora lutea at days 17-19 after weaning. These sows should therefore respond to luteolytic prostaglandin treatment and could then either be bred if they show a clear standing estrus or be reliably culled as either showing persistent silent heats or as being totally anovulatory. The return on investment of being able to impose a standardized protocol for reaching a culling decision based on reliable indicators of reproductive performance after weaning, and thus reduce unwarranted non-productive sow days seen in many herds, may be substantial.

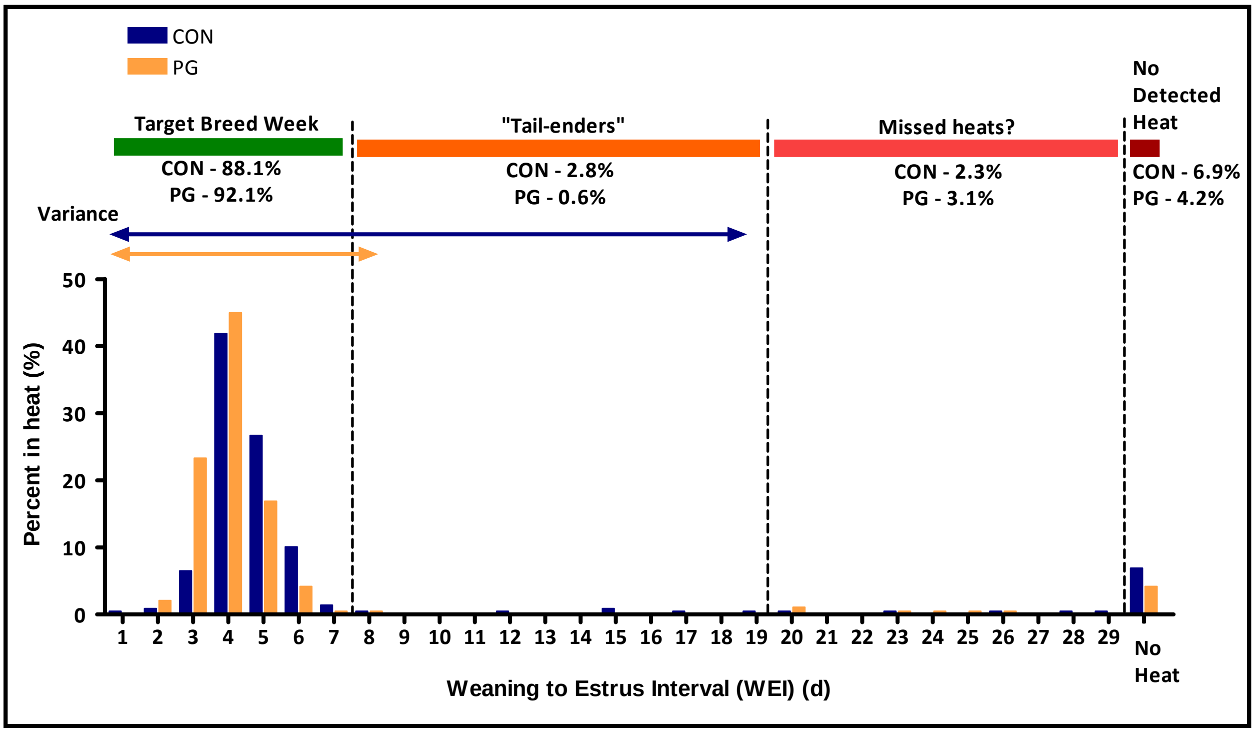

Figure 3. Overall distribution of weaning to estrus interval (WEI) for PG and CON sows grouped into 4 categories (WCAT); 1) Target Breed Week: sows bred within 7 d post-weaning, 2) "Tail-enders"; sows with an extended 8-19 d WEI , 3) Possible "Missed heats"; sows detected in heat ≥ 20 d post weaning, or 4) No detected heat by d 30.

Summer infertility and high ambient temperatures often result in extended WEI, increased regular returns, and decreased litter size; furthermore, primiparous females may be most susceptible (Almond et al., 2005; Vargas et al., 2006). This study was completed during the months of February to March, a period when summer infertility would not normally be considered a risk in North America. In contrast to Kirkwood et al., (1998), we reported no gain in the fertility index (total pigs produced per weaned sow) in response to GT treatment. However, if the percentage of untreated sows in heat within 7 days after weaning were to decrease by 5% or more (88 to 83%), and even assuming farrowing rate and litter size remained constant, the fertility index would be similar or higher for GT treated sows compared to untreated sows. This may support the use of GT treatment during more adverse periods of seasonal infertility, poor nutrition and breeding management practices.

The absence of sows classified as "tail enders" in the PG group may be of practical significance. Assuming that the incidence of "tail enders" in CON group will increase at more adverse times of year due to seasonal effects on lactation feed intake and overall reproductive performance, the apparent ability of GT treatment to induce an early ovulation but "silent heat" in these sows is of interest. Those GT treated sows showing a silent first heat but still ovulated and then detected in estrus at 19 or more days after weaning will have active corpora lutea at days 17-19 after weaning. These sows should, therefore, respond to luteolytic prostaglandin treatment. Sows could either then be bred if they show a clear standing estrus, or be reliably culled as either showing persistent silent heats or as being totally anovulatory. The return on investment of being able to impose a standardized protocol for reaching a culling decision, based on reliable indicators of reproductive performance after weaning, would be substantial and would reduce the unwarranted non-productive sow days seen in many herds.

Conclusion

The need to develop management techniques that reflect the changing biology of contemporary dam-line females seems to be an urgent issue. In most of our recent studies, early emergence of pre-ovulatory follicles, and the lack of any variation in WEI and ovulation rate, has been associated with pregnancy rates at d 30 of gestation of between 90 and 100 percent. Consequently, the key economic question that should drive the development of alternative management techniques in contemporary weaned sows will be a cost-benefit analysis of the trade-off between high pregnancy rates and minimal NPD after weaning in untreated sows, compared to the cost of extra NPD incurred by delaying post-weaning estrus but improving the number and quality of pigs born.

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