

# Benefits of synchronizing ovulation with porcine luteinizing hormone in a fixed-time insemination protocol in weaned multiparous sows

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## Summary

**Objective:** To determine reproductive performance of weaned sows inseminated twice at fixed times after controlling time of ovulation with porcine luteinizing hormone (pLH) administered at onset of behavioral estrus.

**Materials and methods:** Multiparous sows were randomly assigned to treatment at weaning. From weaning, twice-daily boar exposure facilitated estrus detection. Untreated control sows ( $n = 150$ ; CONT) were artificially inseminated at least twice. Treated sows ( $n = 168$ ; LUT) received 5 mg pLH intramuscularly concomitant with the first detection of standing heat. To coincide with the normal working day, sows in estrus

in the morning were inseminated at 24 and 30 hours (AM and PM), while sows in estrus in the afternoon were inseminated at 24 and 42 hours (PM and AM), after pLH administration.

**Results:** For multiparous sows bred on days 4 to 6 after weaning, total-born litter size was greater in LUT than in CONT (12.88 and 11.80, respectively;  $P < .01$ ), whereas adjusted farrowing rate was not affected by treatment, (LUT, 87.28%; CONT, 83.20%;  $P > .05$ ). Neither variable was affected by day of breeding or a treatment  $\times$  day interaction ( $P > .05$ ). Fewer inseminations ( $P < .001$ ) were performed in LUT (2.00) than in CONT (2.13).

**Implication:** Double insemination of multiparous sows, timed to coincide with optimal sow fertility, may improve litter size.

**Keywords:** swine, porcine luteinizing hormone, fertility, controlled ovulation, weaned sow

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## Resumen - Beneficios de sincronizar la ovulación con la hormona luteinizante porcina en un protocolo de inseminación fijo en hembras multíparas destetadas

**Objetivo:** Determinar el desempeño reproductivo de hembras destetadas inseminadas dos veces en momentos determinados después de controlar el tiempo de ovulación con la hormona luteinizante porcina (pLH por sus siglas en inglés) administrada al inicio de la conducta de estro.

**Materiales y métodos:** Al destete, se asignó el tratamiento al azar a hembras multíparas.

A partir del destete, la exposición dos veces al día al macho facilitó la detección del estro. Se inseminaron artificialmente las hembras control no tratadas ( $n = 150$ ; CONT) por lo menos dos veces. Las hembras tratadas ( $n = 168$ ; LUT) recibieron 5 mg pLH intramuscularmente concomitante con la primera detección de calor. Para coincidir con el día de trabajo normal, las hembras que presentaron estro en la mañana se inseminaron a las 24 y 30 horas (AM y PM), mientras que las hembras que presentaron estro por la tarde se inseminaron a las 24 y

42 horas (PM y AM), después de la administración del pLH.

**Resultados:** Para las hembras multíparas inseminadas 4 a 6 días después del destete, el tamaño total de la camada fue mayor en LUT que en CONT (12.88 y 11.80, respectivamente;  $P < .01$ ), mientras que el porcentaje de fertilidad ajustado no se afectó con el tratamiento (LUT, 87.28%; CONT, 83.20%;  $P > .05$ ). Ninguna variable fue afectada por el día de inseminación ó por una interacción de tratamiento  $\times$  día ( $P > .05$ ). Se realizaron menos inseminaciones ( $P < .001$ ) en LUT (2.00) que en CONT (2.13).

**Implicación:** La doble inseminación de hembras multíparas, programada para coincidir con la fertilidad óptima de la hembra, puede mejorar el tamaño de la camada.

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## Résumé - Bénéfices de la synchronisation de l'ovulation avec l'hormone lutéinisante porcine dans le cadre d'un protocole d'insémination à temps déterminé chez des truies multipares sevrées

**Objectif:** Déterminer les performances de reproduction de truies sevrées inséminées deux fois à des temps déterminés après maîtrise du temps de l'ovulation avec l'hormone lutéinisante porcine (pLH) administrée au début de la manifestation de l'œstrus.

**Matériels et méthodes:** Des truies multipares ont été assignées de manière aléatoire au traitement au moment du sevrage. À partir du sevrage, l'exposition au verrat deux fois par jour a facilité la détection de l'œstrus. Les truies témoins

non-traitées (n = 150; CONT) ont été inséminées artificiellement au moins deux fois. Les truies traitées (n = 168; LUT) ont reçu 5 mg de pLH par voie intramusculaire, de manière concomitante avec la première détection de chaleur debout. Afin de coïncider avec la journée de travail usuelle, les truies en œstrus le matin ont été inséminées à 24 et 30 heures (AM et PM), alors que les truies en œstrus en après-midi ont été inséminées à 24 et 42 heures (PM et AM) après l'administration de pLH.

**Résultats:** Pour les truies multipares saillies aux jours 4 et 6 après le sevrage, le nombre total de porcs nés était plus grand dans le groupe LUT que dans le groupe CONT (12.88 et 11.80, respectivement,  $P < .01$ ), alors que le taux de mise-bas

ajusté n'était pas affecté par le traitement (LUT, 87.28%; CONT, 83.20%;  $P > .05$ ). Aucune de ces deux dernières variables n'était affectée par le jour de saillie ou une interaction traitement  $\times$  jour ( $P > .05$ ). Moins d'insémination ( $P < .001$ ) ont été effectuées dans le groupe LUT (2.00) que dans le groupe CONT (2.13).

**Implication:** Une double insémination des truies multipares, synchronisées pour coïncider avec la fertilité optimale des truies, peut améliorer la taille de la portée.

Insemination protocols are usually based on the onset of estrus, with a view to inseminating in a window of 24 hours before ovulation, coincident with the time of optimal fertility.<sup>1</sup> Optimal fertility was defined by Soede et al<sup>2</sup> as being insemination resulting in high accessory sperm counts, which is indicative of the correct timing of insemination relative to the oocytes' ability to be fertilized, and rates of normal embryo development of 90% or more. Onset of behavioral estrus is the parameter commonly used to initiate insemination protocols. Transrectal ultrasonography has shown that most sows ovulate within 24 to 56 hours after onset of behavioral estrus. However, the range in the onset of estrus-to-ovulation interval can be as large as 10 to 85 hours,<sup>3,4</sup> reducing the likelihood that a limited number of inseminations timed from the onset of estrus will result in optimal fertility in all sows. The moment of ovulation relative to first detection of estrus is partly dependent on the weaning-to-estrus interval (WEI), frequency of estrus detection, and duration of estrus.<sup>5-8</sup> Although duration of estrus is the most useful predictor of the time of ovulation, accounting for up to 60% of the variance,<sup>7</sup> an inability to determine estrus duration prospectively limits its usefulness in fixed-time insemination protocols. Variation in the timing of the pre-ovulatory luteinizing hormone (LH) surge relative to onset of estrus is assumed to cause these differences in the time of ovulation.<sup>8,9</sup>

The interval between human chorionic gonadotrophin (hCG) injection and

ovulation in the pig was first reported to be 36 to 40 hours,<sup>10</sup> which is similar to the endogenous peak of the LH-surge-to-ovulation interval in the weaned sow as reported by Willis et al.<sup>11</sup> Consistent with these earlier results, ovulation in response to administration of homologous porcine luteinizing hormone (pLH) occurred approximately 38 hours after treatment in the gilt<sup>12</sup> and sow.<sup>13,14</sup> The endocrine study of Degenstein et al<sup>12</sup> also confirmed that when 5 mg pLH (Lutropin-V; Bioniche Animal Health, Belleville, Ontario, Canada) in 4 mL of vehicle was administered intramuscularly (IM) in the gilt, the pLH-enhanced LH-surge amplitude was greater than that of the spontaneous LH surge in untreated gilts, and the treatment-to-ovulation interval was more synchronized in response to pLH.

On the basis of these observations, and using pLH injection at the onset of first observation of behavioral estrus, timed insemination at 24 hours after administration of pLH, followed by a second insemination within 6 hours of the predicted time of ovulation in response to pLH, should ensure optimal oocyte fertilization rates. The present experiment was conducted as a further essential step towards establishing single fixed-time artificial insemination (AI) as a reliable and preferred breeding technology in the swine industry. To this end, the results of combining pLH administration at first detection of standing heat in weaned multiparous sows in a commercial operation, with fixed-time double insemination, was compared to results

from sows conventionally managed and inseminated until no longer in standing estrus.

## Materials and methods

The study was peer reviewed and approved by the Bioniche Animal Care and Use Committee.

This trial was performed under field conditions at an 800-sow commercial farrow-to-wean unit. All sows were housed in individual crates. Sows were fed twice daily and water was available ad libitum. A veterinarian selected the farm on the basis that knowledgeable staff, with excellent animal-husbandry and record-keeping skills, were employed, and high levels of sow productivity were routinely achieved. This study was conducted on 14 weaned-sow groups between August and October, 2007. Sows were weaned on consecutive Mondays and Thursdays. At the time of weaning, after a 21-day lactation, a total of 344 sows were randomly assigned within parity to two treatments while still in the farrowing crates. After weaning, sows were housed in the breeding room in individual stalls according to the sequence in which they entered the room.

## Estrus-detection protocol

Estrus detection was initiated for all sows in the afternoon of the day of weaning and was facilitated by twice-daily fence-line boar exposure at 8 AM and 2 PM. At these times, a mature, high-libido boar was brought into the breeding room and allowed fence-line contact with up to four sows for

**Table 1:** Artificial insemination (AI) schedule for untreated control sows (n = 150)\*

Wean-to-estrus interval	Estrus onset	1st in semination	Estrus-to-1st-AI interval (hours)	2nd in semination	Estrus-to-2nd-AI interval (hours)†
≤ 4 days	AM	Same day PM	6	Next day AM	24
	PM	Next day AM	18	Following day AM	42
> 4 days	AM	Same day AM	0	Next day AM	24
	PM	Same day PM	0	Next day AM	18

\* Included 14 weaned sow groups between August and October in an 800-sow commercial farrow-to-wean unit. Sows were housed in individual stalls when weaned (21-day lactation). Estrus detection began in the afternoon of the day of weaning, with twice-daily fence-line boar exposure at 8 AM and 2 PM.

† Sows were then inseminated at 24-hour intervals until no longer in standing estrus.

**Table 2:** Artificial insemination (AI) schedule for sows\* treated intramuscularly with 5 mg porcine luteinizing hormone (pLH) concomitant with first detection of behavioral estrus (n = 168)

Estrus onset and pLH administration	Time of 1st in semination	pLH-to-1st-AI interval (hours)	Time of 2nd in semination	pLH-to-2nd-AI interval (hours)†
AM	Next day AM	24	Next day PM	30
PM	Next day PM	24	Next day AM	42

\* Sows in the herd described in Table 1.

† Sows were bred the 2nd time only if still in behavioral estrus. All inseminations coincided with usual barn insemination hours, and no additional inseminations were given.

a 10-minute period. The boar was then led down the line to the next four sows. Onset of behavioral estrus was defined as the time that sows first showed a standing response (rigid stance, arched back, and pricked ears) to back pressure in the presence of a boar. Boar libido was maintained by periodic mating with cull sows.

### Insemination protocols

At onset of standing estrus, control (CONT) sows were managed and inseminated according to standard herd practice. CONT sows were inseminated on an AM-PM barn schedule that corresponded to inseminations at 6-, 18-, and 24-hour intervals, determined by their WEI and the time of day (AM or PM) when they were first recorded in estrus (Table 1). After the second insemination, inseminations were made at 24-hour intervals until the sows were no longer in standing estrus. Sows assigned to pLH treatment (Lutropin-V; LUT) were administered 5 mg pLH

concomitant with the first detection of standing estrus. If sows were first detected in estrus in the morning (8 AM), they were inseminated at 8 AM and 2 PM the next day (24 and 30 hours after pLH injection; Table 2). If estrus was first detected in the afternoon (2 PM), sows were inseminated at 2 PM the next day and 8 AM the following day (24 and 42 hours after injection; Table 2). LUT sows were bred for the second time only if they were still in behavioral estrus. The second insemination in the LUT group was timed such that it was as close as possible to the predicted time of ovulation, but was still scheduled within the daily routine of the unit.

Extended semen used for all inseminations was obtained from a single source and was pooled from the same group of boars. Semen was < 3 days old when used, and contained a minimum of  $3 \times 10^9$  live spermatozoa per 80-mL dose.

All sows were checked daily for pregnancy status, between day 18 and 25 after the

first insemination, by fence-line contact with a mature boar. Farrowing rate was adjusted to exclude sows that failed to farrow because of non-reproductive problems, and data from 11 sows with non-reproductive complications (injury, heart failure, ear infection, and prolapse) were removed. Results from sows recorded as having a wean-to-breed interval of < 3 days were removed from the data due to the possibility of unusual follicular development. In light of a technical constraint, in which any sow with a wean-to-breed interval of ≥ 7 days was not administered pLH, the data from all sows (LUT or CONT) having a wean-to-breed interval of ≥ 7 days were not included in the analysis. These parameters resulted in the exclusion of another 15 sows. The final data set represented 92% of all sows initially assigned to the experiment, and data from a total of 150 CONT and 168 LUT sows with a wean-to-last-insemination interval of 3 to 6 days were finally included in the analysis of treatment effects. Sows of parities 7, 8, and 9 were analyzed as a single parity group (Parity 7+).

### Statistical analysis

The statistical model included effects of treatment (CONT or LUT), parity (2 to 7+), and the interaction of treatment and parity, which were individually regressed on the following dependent variables: number of inseminations, age of semen used for AI, wean-to-first- and wean-to-last-insemination intervals, litter size, and litter weight at day 3 of lactation. There were no treatment-by-parity interactions ( $P > .05$ ); therefore, only treatment and parity effects are presented. Data were analyzed using a linear mixed effect model (SAS Institute, Inc, Cary, North Carolina). Treatment and parity were considered fixed effects and no random effects were considered in this model. Lactation length was used as a covariate in the analysis of wean-to-first-insemination and wean-to-last-insemination intervals. All variables were tested for normality and homogeneity of variance. Proportions of sows bred that were pregnant and farrowed (adjusted farrowing rate) were analyzed using a chi-squared test.

### Results

Treatment (Table 3) and parity (Table 4) were associated with sow performance, but no treatment-by-parity interactions were established for any variable measured. The LUT sows had a mean WEI of 3.9 days. The quality of breeding for all inseminations

**Table 3:** Effect of treatment with 5 mg porcine luteinizing hormone at onset of estrus followed by fixed-time double insemination (LUT), or no pLH treatment (CONT), on reproductive performance (least squares mean  $\pm$  SE) in a commercial farrow-to-wean unit\*

Variable	Treatment		P†
	CONT	LUT	
n	150	168	NA
Total born‡	11.80 $\pm$ 0.29	12.88 $\pm$ 0.27	< .01
Born alive‡	10.80 $\pm$ 0.29	11.80 $\pm$ 0.27	< .01
Litter weight day 3 of lactation (kg)‡	16.05 $\pm$ 0.42	17.95 $\pm$ 0.39	< .001
Average piglet weight day 3 of lactation (kg)‡	1.57 $\pm$ 0.03	1.61 $\pm$ 0.03	> .05
Semen age (days)‡	2.6 $\pm$ 0.04	2.7 $\pm$ 0.04	> .05
No. inseminations‡	2.13 $\pm$ 0.02	2.00 $\pm$ 0.02	< .001
Wean-to-last-insemination interval (days)‡	4.6 $\pm$ 0.06	4.9 $\pm$ 0.05	< .001
Pregnancy rate (%)§	85.18	89.27	> .05
Adjusted farrowing rate (%)§	83.20	87.28	> .05

\* Sows in the herd described in Table 1.

† Within a row, values differ significantly when  $P < .05$  (analysis of variance).

‡ Data were analyzed using a linear mixed effect model (SAS Institute, Inc, Cary, North Carolina).

§ Proportions of sows bred that were pregnant and farrowed (adjusted farrowing rate) were analyzed using a chi-squared test.

NA = not applicable

**Table 4:** Effect of parity on reproductive performance (least squares mean  $\pm$  SE) in a commercial farrow-to-wean unit\*

Variable	Parity						P†
	2	3	4	5	6	7+	
n	53	54	51	55	46	59	NA
Total born‡	12.81 $\pm$ 0.47	13.25 $\pm$ 0.48	12.73 $\pm$ 0.47	13.22 $\pm$ 0.44	11.00 $\pm$ 0.55	11.02 $\pm$ 0.50	< .001
Born alive‡	11.90 $\pm$ 0.46	12.40 $\pm$ 0.48	11.70 $\pm$ 0.47	11.90 $\pm$ 0.44	9.70 $\pm$ 0.55	10.20 $\pm$ 0.49	< .001
Litter weight day 3 of lactation (kg)‡	17.54 $\pm$ 0.67	18.68 $\pm$ 0.71	17.15 $\pm$ 0.68	17.53 $\pm$ 0.64	15.32 $\pm$ 0.81	15.82 $\pm$ 0.72	< .05
Average piglet weight day 3 of lactation (kg)‡	1.58 $\pm$ 0.04	1.59 $\pm$ 0.05	1.54 $\pm$ 0.04	1.56 $\pm$ 0.04	1.64 $\pm$ 0.05	1.65 $\pm$ 0.05	> .05
Semen age (days)‡	2.7 $\pm$ 0.07	2.7 $\pm$ 0.07	2.6 $\pm$ 0.07	2.7 $\pm$ 0.06	2.7 $\pm$ 0.07	2.8 $\pm$ 0.06	> .05
No. inseminations‡	2.06 $\pm$ 0.03	2.05 $\pm$ 0.03	2.04 $\pm$ 0.03	2.13 $\pm$ 0.03	2.06 $\pm$ 0.04	2.06 $\pm$ 0.03	> .05
Wean-to-last-insemination interval (days)‡	4.9 $\pm$ 0.09	4.8 $\pm$ 0.09	4.5 $\pm$ 0.10	4.7 $\pm$ 0.09	4.8 $\pm$ 0.10	4.9 $\pm$ 0.09	> .05
Pregnancy rate (%)§	88.57	87.17	89.74	96.20	81.48	80.18	> .05
Adjusted farrowing rate (%)§	86.49	84.79	89.74	94.45	79.63	76.33	> .05

\* Breeding protocols described in Tables 1 and 2; treatments described in Table 3. Parity 7+ included parities 7, 8, and 9.

† Within a row, values differ significantly when  $P < .05$  (analysis of variance).

‡ Data were analyzed using a linear mixed effect model (SAS Institute, Inc, Cary, North Carolina).

§ Proportions of sows bred that were pregnant and farrowed (adjusted farrowing rate) were analyzed using a chi-squared test.

NA = not applicable

**Table 5:** Effect of treatment with 5 mg porcine luteinizing hormone (pLH) at onset of estrus followed by fixed-time double insemination (LUT), or no treatment (CONT),\* on total litter size born and farrowing rate (least squares means  $\pm$  SE) for sows with a wean-to-last-insemination interval (WLII) of 4, 5, or 6 days

Variable	Wean-to-last-insemination interval (days)		Treatment			P¶	
	n	CONT	n	LUT	Treatment	WLII	
Total born†	4	72	11.6 $\pm$ 0.42	36	13.0 $\pm$ 0.61	< .05	> .05
	5	52	12.0 $\pm$ 0.49	99	13.1 $\pm$ 0.35		
	6	20	11.9 $\pm$ 0.84	24	12.7 $\pm$ 0.73		
Farrowing rate (%)§	4	72	86.1	36	86.1	> .05	> .05
	5	52	88.5	99	90.9		
	6	20	75.0	24	87.5		

\* Sows in the herd described in Table 1.

† Data were analyzed using a linear mixed effect model (SAS Institute, Inc, Cary, North Carolina).

§ Proportions of sows bred that farrowed (adjusted farrowing rate) were analyzed using a chi-squared test.

¶ Values differ when  $P < .05$  (analysis of variance). Treatment-by-parity interaction was not significant for either variable measured.

in this experiment was routinely excellent (rigid stand, good lock, and minimal back-flow of semen) and did not differ between LUT and CONT groups (data not shown). The last insemination occurred later after weaning for LUT than for CONT ( $P < .001$ ), and fewer inseminations were performed ( $P < .001$ ). Farrowing rate was not affected by treatment ( $P > .05$ ). Total number of pigs born (born alive plus stillborn) and pigs born alive were higher ( $P < .01$ ) in LUT than in CONT, and average piglet weight at day 3 after farrowing was independent of treatment ( $P > .05$ ) (Table 3).

The effect of treatment (LUT versus CONT) on total-born litter size and farrowing rate was also determined for sows whose last insemination was on day 4, 5, or 6 after weaning (Table 5). LUT sows again had more total pigs born than CONT ( $P < .05$ ), and no effects of day ( $P > .05$ ) or an interaction of treatment by day were apparent. Farrowing rate was not affected by treatment, day, or their interaction ( $P > .05$ ; Table 5).

## Discussion

This study was, to our knowledge, the first to describe the efficacy of synchronizing ovulation by means of homologous pLH administration at onset of the first spontaneous estrus after weaning, followed by fixed-time inseminations estimated to coincide with the time of optimal fertility in a commercial setting.

In fixed-time insemination protocols

described previously,<sup>11,13,14</sup> equine chorionic gonadotrophin (pregnant mare serum gonadotrophin) was commonly administered within 24 hours after weaning to stimulate and synchronize follicle growth. These protocols have been shown to accomplish a high degree of control of the WEI; however, wean-to-ovulation interval is not better synchronized.<sup>15</sup> Control of the wean-to-breed interval is achieved by administration of pLH at a fixed time (56 to 96 hours) after administration of eCG, followed by a single fixed-time insemination or multiple fixed-time inseminations, which are timed to coincide with the time of optimal fertility (reviewed by Brussow et al<sup>16</sup>). When the wean-to-breed interval is controlled, the variation in piglet age at weaning is also controlled, which reduces the variability in pig age; this is advantageous, especially in all-in, all-out production systems.<sup>17</sup> Using another approach to breed-herd management, the estrus-to-ovulation interval can be synchronized using pLH in sows expressing spontaneous estrus behavior.

Exposure to boar stimuli after weaning, in combination with tactile stimulation of the flank and the back-pressure test, is common practice in commercial units. Langendijk et al<sup>18,19</sup> reported that boar exposure advanced estrous behavior and the proportion of sows ovulating, and that the onset of spontaneous estrus after weaning was more synchronous. More recently, Patterson et al<sup>20</sup> reported that in well-man-

aged, weaned, first-parity commercial sows, even untreated control sows had a short and synchronous WEI ( $4.50 \pm 0.07$  days), and nearly 80% of control sows were bred in a 3-day period after weaning. However, even with good boar stimulation and in herds with little variance in wean-to-estrus interval, the timing of ovulation relative to first detection of behavioral estrus is variable.<sup>15,21</sup> This variation in time of ovulation relative to first detection of behavioral estrus does not allow accurate prediction of the time of ovulation and, therefore, precludes the certainty of inseminations coinciding with period of optimal fertility. However, following administration of homologous pLH at onset of behavioral estrus, 90% of sows ovulated within 40 hours after treatment.<sup>14</sup> In the present study, WEI in treated sows was 3.9 days. It can be estimated that approximately 40% to 50% of the sow population exhibiting a similar WEI would likely have an estrus-to-ovulation interval of  $> 40$  hours.<sup>17,21</sup> For sows treated with pLH, as many as 50% would have had a pLH-induced reduction in estrus-to-ovulation interval. In the pLH-treated sows, in which time of ovulation was controlled and this treatment was combined with a fixed-time double insemination, total litter size was greater than in conventionally managed control sows, and farrowing rates were similar in the two groups.

The control-sow insemination schedule accommodates the shift in relative timing of estrus onset and ovulation by inseminating immediately on detection of standing

heat for sows with a WEI of > 4 days. The control-sow insemination protocol employed on the study unit generates consistent numbers of pigs born and a consistent farrowing rate when wean-to-last-insemination intervals of 4, 5, and 6 days are compared. For sows treated with pLH, in which the insemination protocol was independent of the WEI and the first insemination was delayed 24 hours, farrowing rate and litter size were not affected by the day of breeding. When treated sows were compared to control animals, there was no difference in farrowing rate, whereas litter size in pLH-treated sows was consistently larger on each breed day. Together, these data indicate that when the time of ovulation is brought forward in up to 50% of the treated sow population, farrowing rate for sows bred at day 4, 5, or 6 after weaning is not affected by treatment, and that litter size is consistently larger in sows treated with pLH followed by a double fixed-time insemination protocol.

The larger total number of pigs born and born alive in response to a double fixed-time insemination is also in agreement with previous findings.<sup>14</sup> The larger litter size was associated with a proportionally larger litter weight, such that average piglet weight at birth was similar in treated and control sows. Because of the practice of cross-fostering at day 3 on this unit, pigs could not be followed through to weaning. The data presented in this report shows that irrespective of the wean-to-last-insemination interval, total-born litter size and litter size born alive were consistently larger in sows inseminated at fixed times after administration of pLH than in sows inseminated according to a conventional breeding protocol. The mechanism for larger litter size in response to fixed-time insemination after pLH is not certain. It is unlikely that these observations are due to an increase in ovulation rate, as, in the gilt, ovulation rates in response to treatment with 5 mg pLH or in response to spontaneous ovulation were similar.<sup>12</sup> The difference in litter size could be attributed to a large proportion of control sows being inseminated at times of suboptimal fertility; however, as insemination continued until the end of standing estrus, the breeding protocol for control sows would have likely excluded this possibility. Although Xue et al<sup>22</sup> reported that pregnancy rates and litter size did not differ

in weaned sows inseminated once, twice, or three times after onset of estrus, Terqui et al<sup>23</sup> suggested that application of multiple inseminations without accurate knowledge of when ovulation occurs (as in the spontaneously ovulating controls sows in the present study) may increase the likelihood of having oocytes fertilized by aged spermatozoa still present in the reproductive tract from the previous insemination, resulting in lower developmental competence.<sup>1,6</sup> In the pig, LH receptors are located within the reproductive tract.<sup>24</sup> Gawronska et al<sup>25</sup> suggested that in addition to its role in ovulation and luteinization, the LH surge also controls oviductal motility and may contribute to synchronizing events leading to fertilization and the migration of embryos towards the uterus. Given these important physiological roles of the LH surge, the increased litter size associated with pLH and a fixed-time double insemination may be in part dependent on the magnitude of the pLH-induced LH surge, which is consistently larger than the LH surge of littermate control gilts.<sup>12</sup>

In other units utilizing an insemination protocol in which sows are inseminated at various intervals until no longer in estrus (similar to the control-sow breeding schedule in the present study), the increased labor demands of multiple inseminations and continued estrus detection may result in lower quality inseminations<sup>26</sup> and unnecessary semen usage.

While these preliminary results are promising, further research is required to determine whether administration of pLH concomitant with estrus might be used to facilitate a single fixed-time insemination 24 to 30 hours after pLH administration. These data show that sow productivity is enhanced by administration of endogenous pLH at time of first detection of behavioral estrus to synchronize ovulation. The ability to predict the time of ovulation during spontaneous estrus enables inseminations to be tailored to the period of optimal fertility.

## Implication

- Double insemination of multiparous sows timed to coincide with optimal sow fertility may improve litter size.

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