The effect of estrus duration and number of artificial inseminations on fertility of gilts and multiparous sows having a four-day wean-to-estrus interval

Casimiro Tarocco, DVM; Roy N. Kirkwood, DVM, PhD

Summary

Objective: To determine the relationship between duration of estrus (DE) and farrowing rate and litter size of gilts and sows receiving a single or double artificial insemination.

Methods: Gilts (n=503) and multiparous sows having a 4-day wean-to-estrus interval (n=901) received either a single or double artificial insemination. Gilts were inseminated the afternoon of the day of detection of their second estrus and, where indicated, again the next morning. Sows were inseminated 24 hours after detection of estrus and, where indicated, again the next morning. Gilts were grouped by DE of <24, 24 to 36, and >36 hours and sows by DE of <36, 36 to 48, and >48 hours.

Results: Insemination frequency had no overall effect on farrowing rate of gilts, but within insemination frequencies, farrowing rates were lower in gilts having a longer DE, and, also, those having the longest DE had a lower farrowing rate with a single insemination. Within the entire sow population, and in sows having a DE 36 hours, farrowing rate was lower after a single insemination. Within insemination frequencies, farrowing rates were lower in sows having a longer DE. Litter size was unaffected by insemination frequency or DE in gilts or sows. These results suggest that a single insemination is usually adequate when DE is relatively short, but where a relatively long DE is expected, multiple inseminations are indicated. Before a breeding management protocol is implemented on any farm, average DE should be determined in gilts and in sows having different wean-to-estrus intervals.

Key words: swine, fertility, duration of estrus, artificial insemination

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In pigs, ovulation occurs when approximately 70% of estrus has been completed, and optimal fertility is obtained by insemination during the 24 hours before ovulation.[1] It is assumed that, because of the variable duration of the estrous period, multiple inseminations should be performed in order to have sperm deposited during the 24-hour period before ovulation. However, as long as fertility is not compromized, there is an obvious economic advantage to the performance of single inseminations. It is recognised that sows returning to estrus 6 or more days after weaning have lower fertility than do those returning 4 or 5 days after weaning.[2,3,4] In earlier studies, the potential confounding effects of the wean-to-estrus interval on fertility of artificially inseminated sows were not recognised (eg, Harbison et al),[5] but it has been suggested that a single mating is sufficient for sows having wean-to-estrus intervals of 3 to 5 days.[6] More recently, there have been conflicting reports on the efficacy of single services. Xue et al[7] observed that gilts receiving a single natural service had a greater farrowing rate but smaller litter sizes than gilts receiving two natural services. Service frequency had no effect on sow fertility, but these authors did not record the weaning-to-service intervals. In contrast, a retrospective analysis of a database by the same research group determined that a single natural service reduced farrowing rates in both gilts and sows but resulted in smaller litters only in gilts.[8] In the latter study, the wean-to-mating intervals were recorded, but no interaction was found between wean-to-mating interval and service frequency on sow fertility.

With our current knowledge on the effects of wean-to-estrus interval on the duration of the estrous period, and hence the likely time of ovulation, a potential mating strategy for sows with wean-to-estrus intervals of less than 6 days is to employ a single insemination 24 hours after the detection of estrus onset. Also, because gilts tend to have a shorter apparent duration of estrus, a single insemination at the detection of estrus may be adequate. The present study was undertaken to investigate the efficacy of these strategies in gilts, and in sows with a wean-to-estrus interval of 4 days.

Methods

The present study was conducted between January and December 1997, in a commercial herd with 850 White hybrid sows in the Po River plains, Italy. A total of 503 gilts at their second observed estrus and 901 mixed parity sows at their first observed estrus after weaning were employed. For gilts, estrus detection commenced at 180 to 200 days of age, and inseminations were performed at approximately 240 days of age. Gilts, and sows after a lactation of 18±3.6 days, were housed in individual stalls, and estrus was detected by boar contact in front of the stalls at 0700 and 1600

CT: DIPROVAL, Sezione Allevamenti Zootecnici, University of Bologna, 42100 Reggio Emilia, Italy; RNK: FAEMS, Royal Veterinary College, Hawkshead Lane, Herts AL9 7TA, UK.

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hours each day. Boar exposure was continued until the end of estrus in order to determine the duration of the estrous period (DE). The end of estrus was deemed to be the mid-point between the last observed standing estrus and the time when the estrus response was absent. Retrospectively, gilts were arbitrarily assigned to groups having a DE<24 hours, 24 to 36 hours, or >36 hours, and sows into groups having a DE<36 hours, 36 to 48 hours, or > 48 hours, with the different time intervals for gilts and sows reflecting the shorter mean DE in gilts. To remove the potentially confounding effects of the wean-to-estrus interval on subsequent fertility, only those sows first detected in estrus 4 days after weaning were included in the study. Very few parity one sows met this criterion, so this parity group was excluded from the study.

At estrus detection, gilts and sows were assigned to receive either a single or a double artificial insemination with 3×10^9 live sperm cells in 80 mL Beltsville Thawing Solution. Both insemination frequencies were equally represented in each breeding week. If a female assigned to receive a double insemination failed to stand for the second insemination, she was not included in the study. Semen was collected on-farm daily from a pool of 22 boars, with each boar collected twice weekly. Extended semen doses were stored at 18°C and used not more than 2 days after collection. Inseminations were homospermic and sires were equally represented among treatments. Gilts detected in estrus in the morning were first inseminated the afternoon of that day, while gilts detected in estrus in the afternoon were first inseminated at detection of estrus. In this way, gilts were inseminated as a group as near to the detection of estrus as was practical. Gilts assigned to receive a double insemination were bred the morning after the first insemination if judged to be still in good standing estrus. All sows were bred 24 hours after detection of estrus and, if assigned to double insemination, again on the morning after the first insemination. All inseminations were subjectively judged to be acceptable when the gilt or sow remained immobile and there was a good catheter lock, good semen uptake, and minimal semen backflow during insemination. The few sows failing to meet these criteria were removed from the study. Boar exposure was employed between days 18 and 25 after insemination to detect regular returns to estrus. During the period July to September, all sows and gilts were inseminated twice to limit the problems of summer infertility, and these inseminations were not included in the study.

Statistical analysis

The effect of parity (ie, gilt vs sow) on DE and, within parity, the main effects of DE and insemination frequency and first order interaction, on the subsequent litter size were examined using the GLM procedure of SAS® (Statistical Analysis Systems Inc., Cary, North Carolina). As an initial analysis revealed no difference in performance of second parity sows and older sows, data for all sows were pooled. The effects of insemination frequency and duration of estrus on farrowing rates were examined within parity using the chi square test.

Results

Single inseminations were performed in 217 gilts and 440 sows, and double inseminations in 286 gilts and 461 sows. The mean duration (±SD) of the estrous period was shorter (P<.001) in gilts (31.8±5.9 hours) than in sows (49.3±11.4 hours). This is reflected by 18.4% of gilts having a DE >36-hours but 37.5% of sows having a DE >48-hours. In the gilt DE groups, the mean DE was 19±0.0 hours for the <24-hour group, 29.1±0.02 hours for the 24- to 36-hour group, and 40.4±0.18 hours for the >36-hour group. In the sow DE groups, the mean DE was 29.5±0.1 hours for the <36-hour group, 39.9±0.03 hours for the 36- to 48-hour group, and 58.8±0.3 hours for the >48-hour group. The effects of DE and of insemination frequency on the farrowing rate and litter size in gilts and sows are shown in Table 1.

For the overall gilt population, there was no effect of insemination frequency on farrowing rate. However, compared to double insemination in gilts, single insemination was associated with a lower farrowing rate (P<.05) in gilts having the longest DE (>36 hours). Within gilt insemination frequencies, farrowing rates were lower (P .01) in those animals having a DE >36 hours compared to those with a shorter DE. There

Table 1: Effect of single or double artifical inseminations on farrowing rates and litter sizes (mean±SD) of gilts and sows having different durations of estrus (DE).

	Farrowing rate		Litter size	
	Single AI	Double AI	Single AI	Double AI
Gilts				
All gilts	168/217 (77.4%)	235/286 (82.2%)	10.2±2.7	10.2±2.4
DE <24 h	19/24 (79.2%) ^{w}	NA	10.0±2.5	NA
DE 24-36 h	128/153 (83.7%) ^{wxy}	159/184 (86.4%) ^{y}	10.2±2.6	10.2±2.9
DE >36 h	21/40 (52.5%) ^{axz}	76/102 (74.5%) ^{bz}	10.2±2.9	10.1±2.1
Sows				
All sows	373/440 (84.8%) ^{c}	421/461 (91.3%) ^{d}	10.7±2.9	11.1±2.9
DE <36 h	61/76 (91%) ^{w}	12/15 (80.0%) ^{w}	10.2±3.2	11.3±1.9
DE 36-48 h	179/208 (86.1%) ^{awx}	110/117 (94.3%) ^{bx}	10.8±2.9	11.1±3.1
DE >48 h	133/165 (80.6%) ^{cx}	298/329 (90.6%) ^{dwx}	10.8±2.8	11.1±2.9

NA: No gilts fell into this category

^{a,b,c,d} Within parity and DE, means with different superscripts differ; ab, P<.05; cd, P<.01.

^{w,x,y,z} Within parity and insemination frequency, means with different superscripts differ; wx, P .05; yz, P .01.

Table 2: Effect of single or double artificial inseminations and duration of estrus on the number of non-farrowing gilts and sows having a regular return to estrus.

	Single insemination	Double insemination
Gilts		
All gilts	28/49 (57%)	23/51 (45%)
DE <24 h	4/5 (80%)	NA
DE 24-36 h	10/25 (40%) [b]	14/29 (48%) [b]
DE >36 h	14/19 (74%) [a]	9/22 (41%) [b]
Sows		
All sows	40/67 (60%)	21/40 (53 %)
DE <36 h	1/6 (17%)	2/3 (67%)
DE 36-48 h	13/29 (45%) [z]	3/6 (50%)
DE >48 h	26/32 (81%) [y]	16/31 (52%) [z]

NA: No gilts fell into this category

[a,b,y,z] Within parity, means with different superscripts differ; ab, $P<0.05$; yz, P 0.01

Table 3: Service outcome in gilts and sows that did not farrow after single or double artifical inseminations.

	Number of inseminations			
	Gilts		Sows	
	1 n= 49	2 n= 51	1 n=67	2 n=40
Regular return 1 (18-25 d)	24	19	35	17
Irregular return (26-37 d)	2	9	17	3
Regular return 2 (38-46 d)	4	4	5	4
Late return (47-108 d)	0	0	3	1
Anestrus	13 [a]	12 [a]	2 [b]	5 [b]
Abortion	2	1	2	4
Non-reproductive cull	4	6	3	6
Regular 1: Regular 2	6:1	4.8:1	7:1	4.3:1
Regular: Irregular	14:1	2.6:1	2.4:1	7:1

[a,b] Means with different superscripts differ; ab, $P<.001$

was no significant effect of either DE or insemination frequency on litter size (Table 1).

For the overall sow population, a single insemination was associated with a lower ($P<.01$) farrowing rate than was a double insemination. Also, compared to double insemination, a single insemination was associated with lower farrowing rates in those sows having a DE of 36 to 48 hours ($P<.05$) and a DE of >48 hours ($P<.01$). For sows receiving a single insemination, farrowing rate was lower ($P<.05$) in sows with a DE of >48 hours compared to those with a DE of <36 hours. In sows receiving a double insemination, increasing DE was associated with an initial increase (P .05) and then a non-significant decrease in farrowing rate. However, only 15 double-inseminated sows had an apparent DE of <36 hours. Litter sizes of sows were not significantly affected by insemination frequency or DE, although they tended to be larger ($P<0.1$) in double-inseminated sows (Table 1).

In gilts failing to farrow, there was no effect of insemination frequency on the proportion of those that showed a regular return to estrus (Table 2). However, if we ignore the five single-inseminated gilts that had a regular return in the <24 hour DE group, more single-inseminated gilts ($P<.05$) having a DE of >36 hours had a regular return than did the other groups. Similarly, in sows failing to farrow, a greater proportion of those in the single-inseminated group with DE >48 hours had a regular return (Table 2).

The effects of parity and insemination frequency on service outcome are shown in Table 3. It was noted that there was a relatively high number of irregular returns for gilts receiving a double insemination and for sows receiving a single insemination. Further, the proportion of returns represented by anestrus was higher ($P<.001$) for gilts than for sows (Table 3).

Discussion

These results demonstrate no overall effect of insemination frequency on the farrowing rate of gilts or litter size of gilts or sows. However, farrowing rate was lower in both single- and double-inseminated gilts when the DE was >36 hours, and this was particularly evident in the single-inseminated gilts. Similarly, in the sow population, longer DEs were associated with lower farrowing rates. An exception to this trend was noted for double-inseminated sows having a DE of <36 hours. However, there were only 15 of these sows and a type 2 error can not be discounted. It is expected that approximately 10% of pigs will have a short DE and approximately 25% will have a long DE.[9] The high number of sows with a DE >48 hours in this study is likely the result of selecting only those sows with a 4-day wean-to-estrus interval, since a short wean-to-estrus interval is associated with a longer DE.[4]

Previous research has demonstrated that when sows are inseminated more than 24 hours before ovulation, fertility is decreased.[1, 10] In practice, when a single artificial insemination is performed, the insemination-to-ovulation interval may be more likely to exceed 24 hours. Single insemination reduced gilt farrowing rates only when the DE was >36 hours, suggesting that most of the gilts (89%) were inseminated within 24 hours of ovulation. In the present study, all sows received an insemination 24 hours after first detection of estrus, which should have been effective until 48 hours after estrus onset. However, 37.5% of sows had a DE >48 hours, so the reduced farrowing rate of single inseminated sows is, again, likely the result of a prolonged insemination-to-ovulation inter-

val. The hypothesis that a decreased farrowing rate for single-inseminated gilts and sows having long DE's can be attributed to a longer insemination-to-ovulation interval is supported by the higher rates of regular return in these animals, since this implies a greater incidence of fertilization failure. Why a relatively low regular-irregular return ratio should occur in single-inseminated sows is unclear, but it may be the result of longer insemination-to-ovulation intervals resulting in a poor fertilization rate and few embryos. If this were followed by high embryo mortality during the early part of maternal recognition of pregnancy, an irregular return might result. High irregular returns in double-inseminated gilts may be the result of inseminations late in estrus, which are known to depress fertility.[11] The reason that a large number of bred gilts were not pregnant and failed to return to estrus (presumed anestrus) remains undetermined. These gilts were unresponsive to both prostaglandin and gonadotropin treatment.

Implications

- When a long DE is anticipated, such as in sows having a short wean-to-estrus interval, multiple inseminations are indicated.
- When a short DE is expected, such as in most gilts and in sows having a wean-to-estrus interval of 6 days or more, a single insemination is likely adequate.
- Before a breeding management protocol is implemented on any farm, the farm-specific average duration of estrus in gilts and in sows having different wean-to-estrus intervals should first be determined.

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