The influence of the weaning-to-breeding interval on ovulation rate in parity-two sows

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Summary

Objective: To determine whether changes in litter size with respect to the postweaning interval were associated with changes in ovulation rate.

Methods: Three hundred and seventy-six white crossbred sows of four different parities were bred if they showed estrus by day 14 postweaning. They were slaughtered at 21-33 days of gestation and the ovaries dissected to determine the number of corpora lutea. The number of corpora lutea were assumed to equal the ovulation rate.

Results: Average ovulation rate for all sows in the study was 14.58 +/- 0.32 ova and for the parity-two sows was 14.0 +/- 0.23 ova. The mean weaning-to-breeding interval for the parity-two sows was 5.87 +/- 0.14 days. Ovulation rate in the parity-two sows increased by 0.25 +/- 0.09 ova as the number of piglets weaned in the sow's previous parity increased by one piglet ($P < .05$). The parity-two sow's population line and the season she was weaned were also associated with ovulation rate ($P < .001$). Compared with sows with weaning-to-breeding intervals of 4-5 days, ovulation rate decreased by 1.04 +/- 0.39 ova for parity-two sows with weaning-to-breeding intervals of 6 days, increased by 3.08 +/- 0.96 for sows returning to estrus 9 days postweaning, and decreased by 2.62 +/- 1.13 for sows returning 10-12 days postweaning ($P < .05$).

Implications: Ovulation rate is highly associated with with weaning-to-breeding intervals.

Key words: swine, sows, postweaning interval, ovulation, season, lactational weight loss

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The weaning-to-breeding interval is a vital component in the reproductive efficiency of a sow herd. It is a major part of nonproductive sow days, and an important determinant of litters per sow per year and pigs per sow per year.[1] Ovulation rate is also an important component of reproductive productivity in the pig,[2] and establishes the upper limit for litter size.[3] A relationship between weaning-to-breeding interval and litter size is recognized by several researchers.[4-6] Their results indicate that a weaning-to-breeding interval greater than 15-22 days is associated with an increase in subsequent litter size. A different pattern emerges when the relationship between weaning-to-breeding interval and subsequent litter size was examined on a daily basis.[7-9] These results indicate that litter size is optimal when the sow is bred on days 2-4 postweaning, decreases progressively on days 5,6, and 7, then remains at this low level on days 8,9, and 10 postweaning. Litter size begins to rise again when the sow is bred on days 11-14 postweaning.

The purpose of this research was to determine whether this litter-size pattern may be explained by changes in ovulation rate after controlling for:

population line,
the sow's lactational weight loss,
number of piglets weaned in the previous parity,
the previous litter's weaning weight, and
season of weaning.

Materials and methods

This study used 376 multiparous white crossbred sows from the Roman L. Hruska United States Meat Animal Research Center (Clay Center, Nebraska). The composite population consisted of Chester White, Landrace, Large White, and Yorkshire. The four lines within this population included: the original control line, a line selected for ovulation rate, a line selected for uterine capacity, and a second control line which was specifically included for the uterine capacity study. All of the lines were randomly selected from the first control line in 1986. The replacements for both control lines were randomly selected from offspring within each line, with the condition that all boar lines be represented. The ovulation rate line was selected for numbers of corpora lutea based on laparoscopic examination.[10,11] The uterine capacity line consisted of sows that were selected at 154 days of age for increased uterine capacity using the unilaterally-ovariectomized-hysterectomized sow model.[12] Liveborn litter size was the selection criterion for uterine capacity line replacements.

Although sows of parities two, three, four, and five were included in our study design, the data set was heavily biased toward parity-two

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sows. Because the ovulation rate for sows in the second parity cannot be reliably generalized to sows of other parities, we confine our analysis to parity-two sows only.

This study was conducted from April 1993-August 1994. After weaning at 28-32 days of lactation, sows were penned in groups of four to six. Sows were checked for estrus twice daily from days 1-14 postweaning. During estrus detection, an intact boar was brought to the heat check area and sows were exposed through fence-line contact. Sows identified in estrus in the morning were hand-bred in the afternoon and again the following morning. Similarly, sows identified in estrus in the afternoon were bred the following morning and again in the afternoon. A pool of seven white crossbred boars per 120 sows was used on a rotational basis. Two different boars bred each sow. At 18-24 days postbreeding an intact boar was used daily to detect sows returning to estrus using the same procedure as the initial heat checks.

Sows were slaughtered at 21-33 days of gestation. The reproductive tracts were removed at evisceration. Corpora lutea were removed from the ovaries and the number of corpora lutea per ovary was recorded. Ovulation rate was considered to be equal to the number of corpora lutea.

Lactational weight loss was calculated as:

sow weight at 110 days gestation - sow weight at weaning - the birth weight of the litter.

The number of pigs weaned and the litter weaning weight were recorded in the Roman L. Hruska United States Meat Animal Research Center database.

Statistical analysis

Ovulation rate was regressed individually on the number of piglets weaned, the sow's lactational weight loss, and previous litter weaning weight. Variables with a significant simple association ($P < .05$) were kept for the multivariate model.

Sows were assigned to season according to their weaning date. Season was included in the model using two dummy variables: June 22-September 21 ("summer") was the first season, September 22-December 21 ("fall") was the second season, and March 22-June 21 ("spring") was the referent season. No sows were weaned between December 22 and March 21. Population lines were included in the model using three dummy variables with the first control line as the referent group.

Differences in ovulation rate among parities, previous numbers of piglets weaned, population lines, and season were tested with pair-wise T-tests using the ANOVA procedure.

Threshold dummy variables were created as described by Walter, et al.,[13] for each weaning-to-breeding interval. This method allowed us to detect progressive changes in ovulation rate as weaning-to-breeding interval changed by 1-day increments. The multivariate model included these variables.

The final model was selected using a backward elimination selection process. The final model included variables with a significant partial F-statistic ($P < .05$). Quadratic and interaction terms for the final variables were offered for inclusion. The model was evaluated by plotting the residuals against the predicted ovulation rate and by examining the distribution of the residuals.[14] Slaughter data were entered into the dBase III Plus™ database system (Ashton-Tate, 1986, Torrance, California). All other sow variables were obtained from the Roman L. Hruska United States Meat Animal Research Center database. Descriptive statistics and multiple regression were done using the statistical analysis system for personal computers (PC/SAS).[15]

Results

Three hundred seventy-six sows entered this trial at weaning. Twenty-six of these sows were anestrus as defined by an absence of visible signs of estrus and no corpora lutea on the ovaries at slaughter. Ninety-six sows were behaviorally anestrus, defined as an absence of visible signs of estrus with corpora lutea present on the ovaries at slaughter. Seven sows died or were euthanized prior to showing estrus. Postmortem examination of the seven sows revealed five skeletal injuries and one bronchopneumonia. The remaining sow died of undetermined causes. Skeletal injuries consisted of a broken toe, a rupture of the round ligament of the femur, a bilateral femoral head fracture, a unilateral femoral head fracture, and a midshaft femoral fracture. Two sows with weaning-to-breeding intervals of 14 days were removed from the data set because they were outliers and 47 sows were parity 3, 4, or 5; hence, 193 parity-two sows were included in the final analyses.

Mean ovulation rate for the study was 14.00 +/- 0.23 for parity-two sows; it was 145 +/- 0.32 for sows across all parities. Mean weaning-to-breeding interval for the study was 5.87 +/- 0.14 days for parity-two sows; it was 5.88 +/- 0.14 for sows across all parities. Ovulation rate differed with respect to parity of the sow (Table 1), number of piglets weaned in the sow's previous parity (Figure 1), population line (Table 2), and season (Figure 2). Weaning-to-breeding intervals of 6, 9, and 10 days were associated with changes in ovulation rate (Table 3).

The final model indicates that ovulation rate decreased significantly when the weaning-to-breeding interval was 6 days, remained low for weaning-to-breeding intervals of 7 and 8 days, and then rose when the weaning-to-breeding interval was 9 days. Ovulation rate decreased again when the weaning-to-breeding interval was 10-13 days. Therefore, when the average season parameter was used, a second control-line, second-parity sow

Table 1

Ovulation rate by sow parity

Parity	n	Mean	SE
2	193	14.00[a]	.23
3	29	15.86[b]	.44
4	8	18.50[c]	1.21
5	10	18.80[c]	.80

abc Means within a column lacking a common superscript letter differ ($P < .01$)

with a weaning-to-breeding interval of 4 or 5 days was predicted to have an ovulation rate of approximately 13.85 ova;
with a weaning-to-breeding interval of 6,7, or 8 days was predicted to have an ovulation rate of 12.81 ova;
with a weaning-to-breeding interval of 9 days was predicted to have an ovulation rate of 16.93 ova; and
with a weaning-to-breeding interval of 10-13 days was predicted to have an ovulation rate of 14.31 ova (Figure 3).

Discussion

The mean ovulation rate in the parity-two sows in this study was 14.00 +/- 0.23 ova, which is similar to the reported values of 16.4 in Poland China and crossbred sows,[16] 13.45 in Duroc, Hampshire, Yorkshire, and crossbred gilts and sows,[17] and 14.5 in 14-breed composite gilts.[3]

Reported values for the weaning-to-breeding interval include 6.6 days for Lacombe primiparous sows,[18] and 5.3 days for white crossbred sows.[19] A general target for commercial swine operations is less than 7 days.[1] In this study, sows that did not demonstrate signs of estrus within the first 14 days after weaning were not included in the calculation of the average weaning-to-breeding interval in this trial. Therefore, the trial mean for parity-two sows of 5.87 +/- 0.14 days was lower than the actual mean weaning-to-breeding interval in the study population.

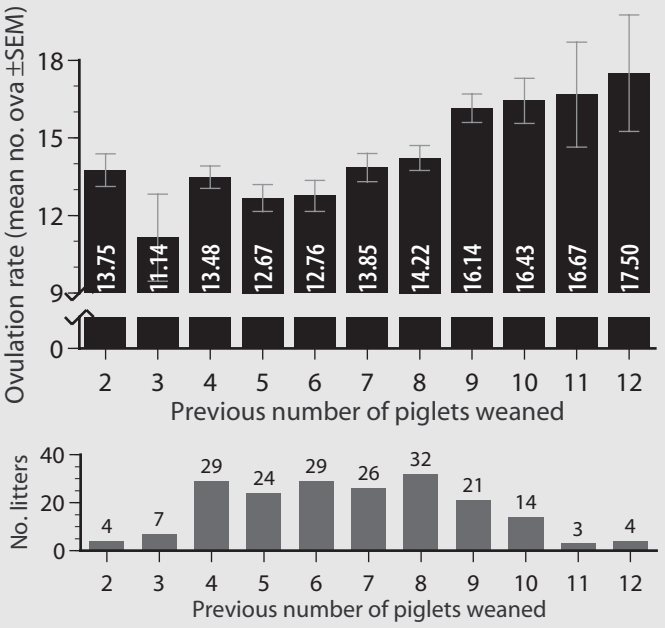
Almond[20] found anestrus rates of 5%-30% in the United States, Canada, and Norway. Therefore, the visible anestrus rate of 7% in this study was within the normal range of the swine industry. The prevalence of behavioral anestrus is very difficult to estimate in the commercial situation because it can only be differentiated from true anestrus at slaughter, by laparoscopy, or by blood sampling. Estimates of prevalence of anestrus from experimental situations where one of these techniques was used indicate that the rates of anestrus range from 0%-16%. [21-26] The 25.5% anestrus rate found in the present study is above this range. This herd has a historical problem with behavioral anestrus that may be responsible for this elevated rate.[27]

Sows became lame in this study due to claw injuries, femoral fractures, joint abcessation, and riding injuries. Rates of lameness that have been reported in the Canadian swine industry range from 1.2%-38%.[28,29] The percentage of lameness in this trial was expected to be lower than that found on commercial operations since only multiparous sows were involved.[30]

We included four different population lines to provide the necessary number of sows in a reasonable period of time. Population line was included in the model to account for differences in ovulation rate between lines. The second control line had the highest ovulation rate (16.54 +/- 0.59) followed by the ovulation rate line (15.00 +/- 0.39). The first control line (13.67 +/- 0.63) and the uterine capacity line (12.30 +/- 0.22) had the lowest ovulation rates.

We found a rise in ovulation rate in the summer and fall when contrasted with the spring months (Figure 2, Table 3). When compared to sows weaned in the spring, predicted ovulation rate was increased by 5.77 ova for sows weaned in the summer and by 1.86 ova for sows

Figure 1



Ovulation rate of parity-two sows by previous number of piglets weaned

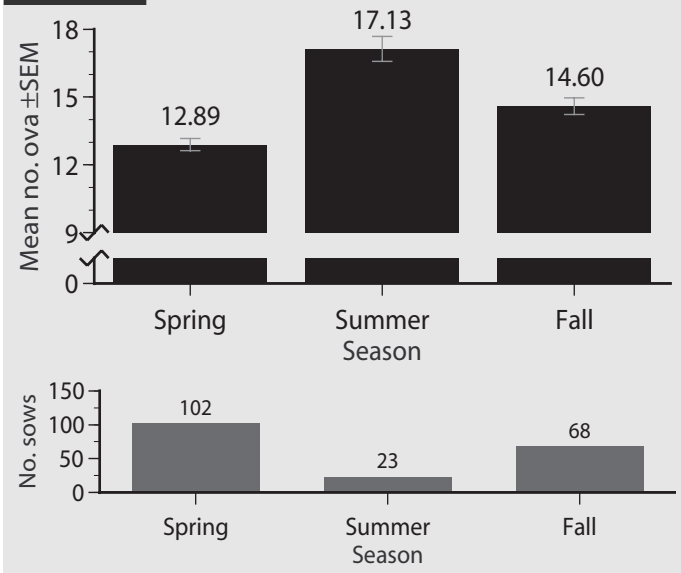
Table 2

Ovulation rate of parity-two sows by population line

	# sows	Mean	SE
First control line	27	13.67	0.63
Uterine capacity	73	12.30	0.22
Ovulation rate	67	15.00	0.39
Second control line	26	16.54	0.59

$P < .01$ between all lines

Figure 2



Ovulation rate of parity-two sows by season

Table 3

Factors associated with ovulation rate in white crossbred parity-two sows at the Roman L. Hruska United States Meat Animal Research Center, 1993-1994

Variable	*P* estimate	SE	Prob > F
Intercept	9.64	1.56	< .001
Weaned	.25	.09	.008
Uterine capacity line	.89	1.49	.55
Ovulation rate line	3.21	1.50	.033
First control line	1.55	1.53	.313
Summer	5.77	1.58	< .001
Fall	1.86	.39	< .001
Wean-to-breed ≥ 6	–1.04	.39	.009
Wean-to-breed ≥ 9	3.08	.96	.002
Wean-to-breed ≥ 10	–2.62	1.13	.022
Adjusted R^2 = .38			

weaned in the fall (Table 3). The effect of season on ovulation rate has not been examined previously.

The number of pigs weaned in a sow's previous litter had a significant and positive relationship with ovulation rate (Figure 1). In the final model, the ovulation rate was predicted to increase by 0.25 ova for every additional pig weaned in the previous litter (Table 3). Clark and Leman[33] and Dewey, et al.,[32] have found in observational studies that previous litter size has a significant and positive association with current litter size. There has been no research conducted on the relationship between previous litter size and ovulation rate.

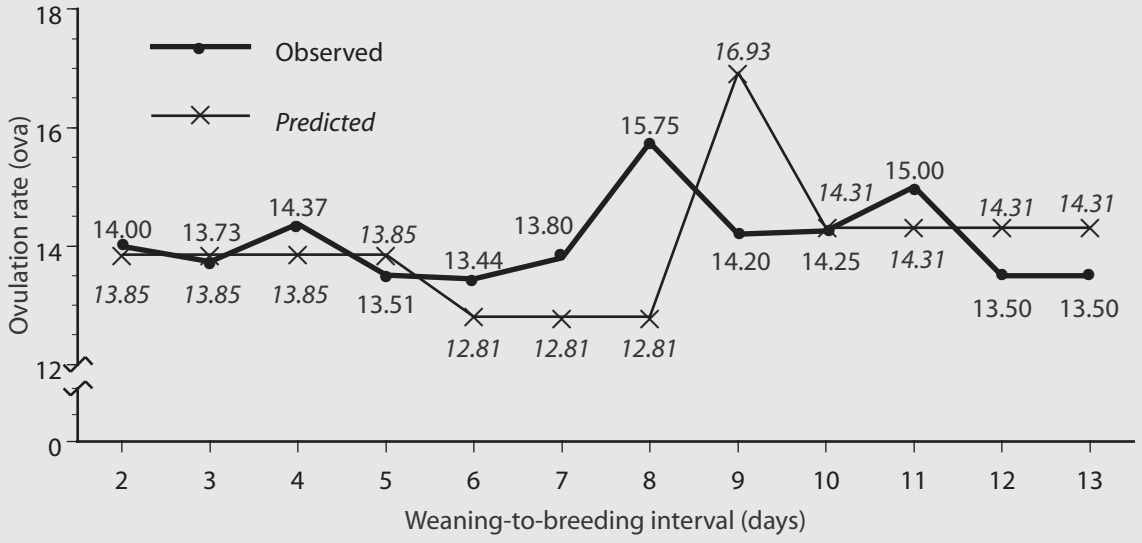
Previous litter weaning weight had no significant association with ovulation rate. The relationship between previous litter weaning weight and current litter size or current ovulation rate has not been investigated.

Previous studies have found mean lactational weight losses of 18.5 kg (40.7 lb),[5] 16.9 kg (37.2 lb),[34] and 12.4 kg (27.3 lb).[35] The mean lactational weight loss for sows in the present trial was 15.52 +/- 1.93 kg (34.15 lb), which is consistent with that found in other studies. The maximum loss was 52.45 kg (115.4 lb) and the maximum gain was 14.68 kg (32.3 lb). Sow lactational weight loss was associated with the weaning-to-breeding interval but not with ovulation rate. Many trials have shown a relationship between lactational weight loss and the weaning-to-breeding interval; however, there does not appear to be a relationship between ovulation rate and the lactational weight loss of the sow.[36]

Dewey, et al.,[9] found litter size was optimal when the sow was bred on days 2-4 postweaning, decreased progressively on days 5,6, and 7, and then remained at this low level on days 8,9, and 10. Litter size began to rise again when the sow was bred on days 11-14 postweaning. The period within the weaning-to-breeding interval associated with reduced subsequent litter sizes was shorter in this study and appears to be less gradual in its onset and resolution. This difference could be due, in part, to herd-to-herd variation.[8] The significant increase in ovulation rate on day 9 followed by the large decrease on day 10 does not have an obvious biological explanation. The biological phenomenon that causes ovulation to decrease on days 6,7, and 8 did not appear to affect sows on day 9. Since there were eight sows with a weaning-to-breeding interval of 9 days, and they did not have any other variable in common, there was no justification for disregarding this result. This pattern of ovulation rate by weaning-to-breeding interval requires further study.

In conclusion, we found that ovulation rate decreased in sows with weaning-to-breeding intervals of 6-8 days and 10-13 days. This

Figure 3



Ovulation rate by weaning-to-breeding interval, predicted and observed, in white crossbred sows at the Roman L. Hruska United States Meat Animal Research Center, 1993-1994

partially explains the decrease in litter size seen in these weaning-to-breeding intervals.

Implications

The decrease in litter size for sows with weaning-to-breeding intervals of 5-10 days was due, in part, to a decrease in ovulation rate. There is no practical method of predicting, at weaning, a particular sow's weaning-to-breeding interval in the commercial situation. However, because a sow's weaning-to-breeding interval is similar from parity to parity,[8] these sows can be targeted on the basis of their previous weaning-to-breeding interval. Sows with weaning-to-breeding intervals of 6-8 and 10-13 days can be managed in any of several ways:

- These sows can be culled because they are likely to fall into that group on succeeding parities.
- You can skip the first estrus on these sows and breed them on the second estrus after weaning. Love[4] and Morrow[5] have shown that litter size in second-parity sows is significantly improved when this technique is employed. In a retrospective study,[8] Wilson, et al., found a significant improvement in pigs per mated female when sows in the affected weaning-to-breeding intervals were delay-mated.

The option of choice for any particular operation would depend on the economic specifics and production performance of that operation.[37]

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