ORIGINAL RESEARCH

The associations between weaning-to-estrus interval and sow efficiency

Michael R. Wilson, BVSc, PhD; Catherine E. Dewey, DVM, PhD

Summary — *We conducted two retrospective studies, one involving 2800 sows in a single herd in Australia over 3 years, the other involving 22,715 litters from 112 herds in Ontario, Canada over 5 years. Litter size and farrowing rate were studied individually and combined as an index — pigs produced per mated female (PPMF) — to investigate how they relate to length of weaning-to-estrus interval. Litter size, farrowing rate, and PPMF all decreased among sows mated on days 7–10 postweaning compared to sows mated either 3–6 days postweaning or 11–14 days postweaning. PPMF was reduced by approximately 30% in that less-efficient period. Approximately 11% of sows were detected in estrus during the less-efficient period. Forty percent of parity-one sows with a weaning-to-estrus interval of 7–10 days also had weaning-to-estrus intervals of 7–10 days in parity two. If sows that came into estrus 7–10 days postweaning were not mated until their next estrus (between days 28 and 31), their efficiency at least equalled that of sows that came into estrus during the more-efficient interval. Almost 30% of the delay- mated sows came into estrus 7–10 days postweaning in their next parity. We discuss the dip in efficiency associated with the occurrence of estrus 7–10 days postweaning and compare it to the second-litter productivity drop described by other investigators.*

Highly efficient herds tend to have larger litters than less-efficient herds.[1] The number of litters produced per sow per year[5] is influenced by litter size, weaning-to-estrus interval, and farrowing rate. Leman[5] and Wilson[6] have presented data suggesting that females that return to estrus 7–10 days postweaning have smaller litters and a depressed farrowing rate compared to females that return to estrus either 3–6 days postweaning or 11–14 days postweaning. This study attempts to confirm and expand upon those observations.

Materials and methods

We performed two retrospective studies to examine the relationship between the weaning-to-estrus interval, the number of pigs born alive (litter size), and farrowing rate.

Study 1

We analyzed computer records collected from 1986–1988 for a herd in New South Wales, Australia that was comprised of 2800 sows. After weaning their piglets at 18–24 days of age, sows were penned next to boars and observed for estrus morning and afternoon. Because parity-one sows were bred on their second observed estrus (at least 12 days after weaning), we excluded them from the analyses. Thus, this study included only parity-two-or-greater sows. The data we analyzed included:

- the number of sows mated;
- the number of sows farrowed;
- the mean number of pigs born alive per litter;
- the mean number of pigs born alive per litter by parity; and
- weaning-to-estrus interval.

MRW, Department of Population Medicine, Ontario Veterinary College, University of Guelph, Guelph Ontario N1G 2W1 Canada; CED, University of Nebraska – Lincoln, Great Plains Veterinary Educational Center, PO Box 187 Clay Center Nebraska 68933.

Weaning-to-estrus interval: The number of days between weaning and the first day on which standing heat is observed, where day one is the first day postweaning.

Weaning-to-conception interval: The number of days between weaning and the service that results in a litter. If the farrowing date is 109-124 days after the service date, the sow is recorded as having successfully farrowed due to that breeding. If the sow farrowed after this interval or if she returned to service, the farrowing is not presumed to be attributable to the initial service.

Farrowing rate: The proportion of mated sows that survived and produced a litter between 109-124 days after their initial service.

Adjusted farrowing rate: Sows that are culled prior to farrowing are not included in the data set for calculating farrowing rate.

Pigs produced per mated female (PPMF): A measure of reproductive efficiency, calculated by multiplying the number of pigs born alive per litter by the farrowing rate, divided by 100.

Study 2

In the second retrospective study, we analyzed individual sow records from 112 commercial swine farms in Ontario recorded on PigTales™ Inc. software (Pig Improvement Company Inc., PO Box 251, Franklin, Kentucky, 42134 USA) between 1987 and 1991. Lactation length for these herds, which ranged from 23–36 days, averaged 27.6 days (SD 7.5) with a median of 27 days. We included all parities in the data set. We used an adjusted farrowing rate for farrowing rate calculations, so that sows that were culled before farrowing were removed from the dataset. Of 54,198 sow records in the data set, 43% (23,439) included weaning dates with a subsequent farrowing and thus were eligible for inclusion in this study.

Statistical analysis

After the initial descriptive analyses of data from study 1, it seemed clear that those sows that returned to estrus either 3–6 days or 11–14 days postweaning were more efficient than those that returned to estrus 7–10 days postweaning. We therefore devised a statistical model in which we compared:

- the reproductive efficiency of sows that returned to estrus 7–10 days postweaning (defined as "less efficient"); versus
- the reproductive efficiency of sows that returned to estrus either 3–6 days postweaning or 11–14 days postweaning (defined as "more efficient").

For both studies, we used Student's *t* tests to compare the litter size and the number of pigs produced per mated female (PPMF) in the more-efficient and less-efficient weaning-to-estrus intervals. We used a Yates' corrected Chi-squared test to examine the relationship between the weaning-to-estrus interval and the farrowing rate.[7] We also compared litter size, farrowing rate, and pigs produced per mated female between:

- sows with weaning-to-estrus intervals of 7–10 days; versus
- sows with weaning-to-estrus intervals of 28–31 days

using a Student's *t* test.

We used Yates' corrected Chi-squared tests to determine whether parity-one sows that were bred either:

- 7–10 days postweaning; or
- 28–31 days postweaning

would have similar weaning-to-breeding intervals during their next parity.

For study 2, we analyzed weaning-to-estrus intervals across all parities and then separately for parity-one sows and parity-two-or-greater sows. We used Yates' corrected Chi-squared tests to determine whether parity-one sows were more likely to be bred in the 7–10-day interval than parity-two-or-greater sows. Additionally, for study 2, we used multiple linear regression to investigate the effects of weaning-to-conception intervals of up to 14 days on litter size. We included the parity of the sow, the year of farrowing, and the farm of origin in all equations. We used a Poisson regression to determine the association between weaning-to-conception interval and parity. We used the Statistical Analysis System for Personal Computers (PC/SAS) (SAS Institute Inc., 1985) to perform descriptive and analytic statistics.

Results and discussion

Weaning-to-estrus interval

In study 1, the mean weaning-to-breeding interval was 7.6 days and the median was 5 days. Seventy percent of all breedings occurred on or before day 6 postweaning, while 12.6% of the sows were bred between days 7–10 postweaning.

In study 2, the mean weaning-to-breeding interval was 8.7 days (± 16.8) and the median was 5 days. Seventy-seven percent of all breedings occurred by day 6 postweaning, while 11% of the sows were bred between days 7 and 10.

Litter size

In both studies, the mean number of pigs born alive was higher for sows that were bred in the more-efficient weaning-to-estrus interval than for sows bred in the less-efficient weaning-to-estrus interval ($P < 0.0001$) (Fig 1). Sows with

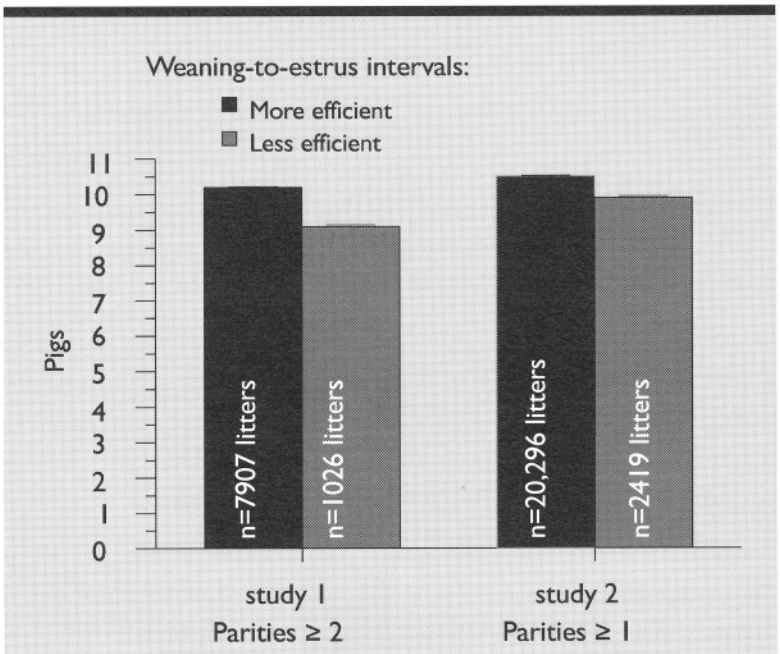

Fig 1.— Average born alive litter size as related to weaning-to-estrus intervals.

Table 1.— A model of litter size regressed on the weaning-to-estrus interval. Data from 112 Ontario swine herds, 1987–1991.

Variable	Coefficient	*P*
Intercept	9.5	0.0001
Year	-0.10	0.001
Parity	0.61	0.0001
Parity squared*	-0.05	0.0001
Wean-estrus 5 days	-0.25	0.0001
Wean-estrus 6 days	-0.30	0.0001
Wean-estrus 7-10 days	-0.21	0.003
Wean-estrus 11-14 days	0.38	0.005

* Parity squared = parity multiplied by parity.

weaning-to-conception intervals of 2–4 days had the highest litter sizes, while litter size decreased progressively for sows with weaning-to-conception intervals of 5, 6, and 7 days (Table 1). Sows with weaning-to-conception intervals of 7–10 days had the smallest litters (Fig 2). Litter size increased in sows with weaning-to-conception intervals of 11 or more days.

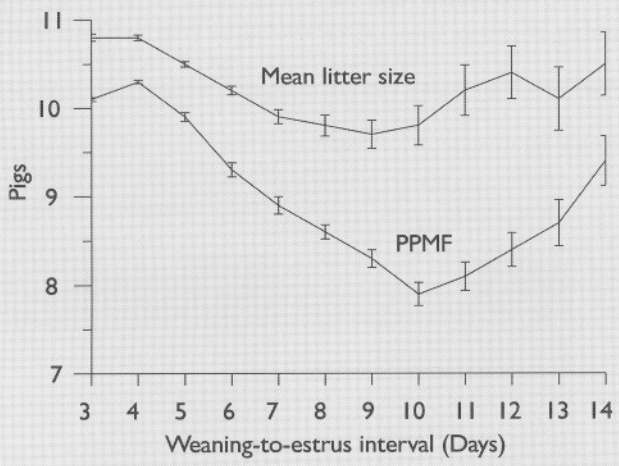

Fig 2.— Average litter size and pigs per mated female (PPMF) by weaning-to-estrus interval observed on 112 Ontario swine herds, 1987–1991.

Farrowing rate

In both studies, farrowing rates were also lower in sows bred in the 7- to 10-day weaning-to-estrus interval than those bred in the more-efficient intervals (Fig 3). In study 2, sows with less-efficient weaning-to-estrus intervals were 3.6 times more likely not to farrow than those with more-efficient weaning-to-estrus intervals ($P < 0.001$) (Fig 3). In study 1, sows bred during this less-efficient weaning-to-estrus interval were 2.5 times more likely to return to estrus than sows bred during the more-efficient weaning-to-estrus interval ($P < 0.01$).

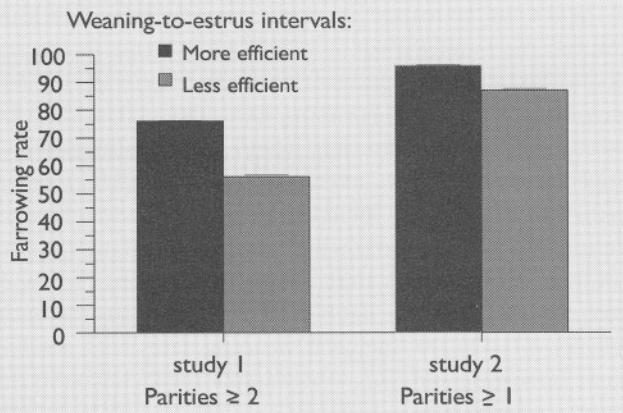

Fig 3.— Farrowing rate as related to weaning-to-estrus intervals. Study 1 (1986–1988) data is from a single, 2800-sow herd in Australia. Study 2 (1987-1991) data is from 112 herds in Ontario, Canada. In Study 2, the farrowing rate was adjusted to exclude sows that were culled prior to farrowing.

Pigs produced per mated female

In both studies, PPMF was lower in sows bred in the 7–10-day postweaning period than sows bred during the more-efficient intervals ($P < 0.0001$) (Figs 4–5). The reduction in farrowing rate, litter size and PPMF were smaller in study 2 than in study 1, probably because we used an adjusted farrowing rate in study 2, which artificially enhanced the farrowing rate and mating efficiency.

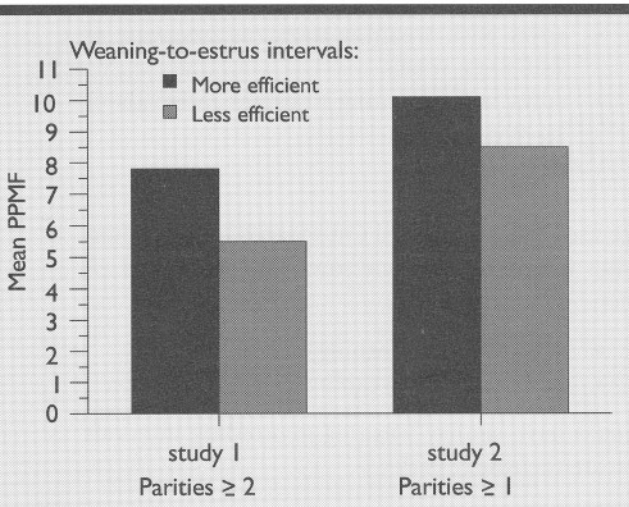

Fig 4.— Pigs per mated female in more-productive vs less-productive weaning-to-estrus intervals.

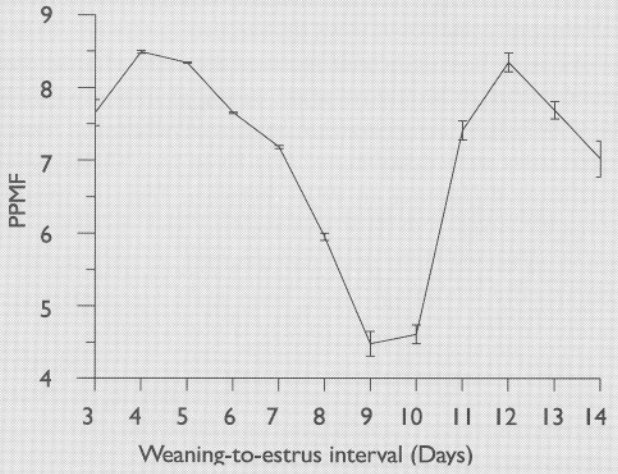

Fig 5.— Pigs per mated female (PPMF) by weaning-to-estrus interval.

The reduction in both farrowing rate and litter size that occurred when sows came into estrus during the less-efficient weaning-to-estrus interval confirmed the observations of Leman,[6] Wilson,[7] and Love and Wilson.[11] We conclude that in sows that returned to estrus after day 4 postweaning, a progressive biological phenomenon was occurring that affected subsequent reproductive efficiency. The sow's reproductive efficiency was equally and statically reduced throughout the 7- to 10-day weaning-to-estrus interval. In sows that returned to estrus after day 10, reproductive performance was improved, indicating that either the physiological effects that were influencing the sows on days 5–10 had changed or that another process was occurring.

The least-efficient period may vary from herd to herd and may extend beyond day 10 postweaning in some herds. In the study 2 herds, the least fertile period occurred a day later than in the study 1 herd (Fig 2). PPMF should be used as the overall mating efficiency parameter, once the time of onset of this decrease in PPMF is determined for an individual herd.

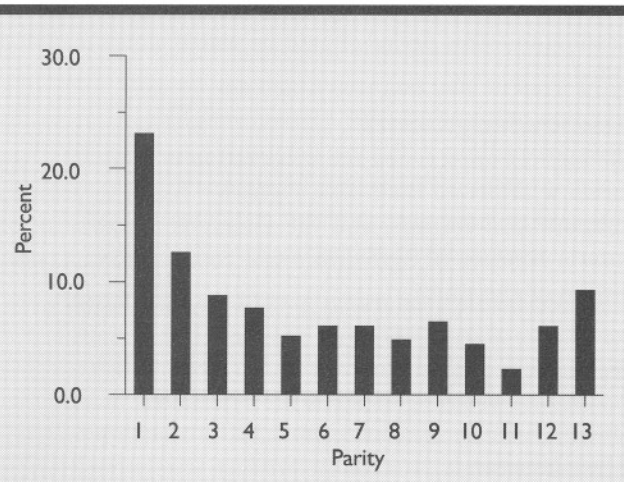

Fig 6.— Percent of sows in study 2 in less-productive weaning-to-estrus interval by parity.

Parity

Parity-one sows were 3.4 times more likely to return to estrus on days 7–10 postweaning than were older sows ($P < 0.0001$) (Fig 6). Twenty-three percent of parity-one sows fell into the less-efficient period compared to 8.2% of sows in parity-two-or-greater ($P < 0.0001$) (Fig 6). Older sows had shorter weaning-to-estrus intervals ($P < 0.001$) (Figs 6–7).

The parity-two drop in litter size reported by Love[12] and Morrow, et al.[13] may or may not be accounted for by the fact that these sows were more likely to return to estrus in the less-efficient weaning-to-estrus interval.

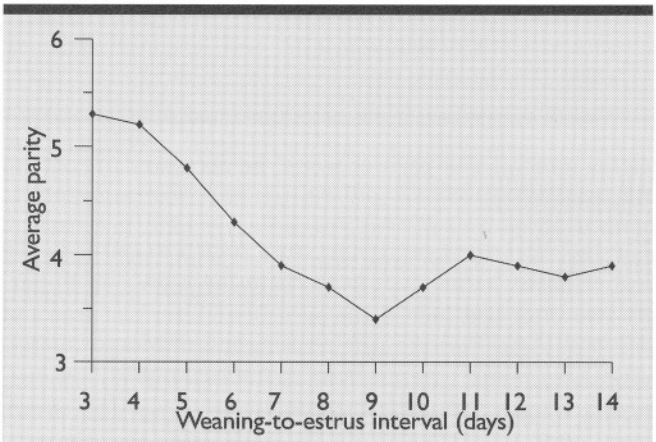

Fig 7.— Average parity by weaning-to-estrus interval.

Some suspect that the parity-two drop in litter size is associated with the loss of body condition during lactation that leads to delayed weaning-to-estrus intervals.[14,15] They have surmised that most parity-one sows cannot consume enough feed for both continued growth and for lactation.

We noted, however, that the same sows continued to fall in the less-efficient weaning-to-estrus intervals in subsequent parities. In study 2, 41% of parity-one sows that returned to estrus during the less-efficient period also returned to estrus during the less-efficient period in their second parity (Table 2). These sows were 2.3 times more likely to repeat a less-efficient weaning-to-estrus interval in their second parity than were parity-one sows that returned to estrus in one of the more-efficient intervals (only 18% of which returned to estrus in the less-efficient mating period in their next parity) ($P < 0.001$).

Therefore, the loss of condition in the first parity may be associated with enhanced lactational demands, which are repeatable between parities. A prospective study measuring milk production or litter growth in relation to weaning-to-

Table 2.— The number of sows in more-efficient (3- to 6- day and 11- to 13-day), less-efficient (7- to 10-day), and delay-mated (28- to 31-day) weaning-to-estrus periods in parity one and their subsequent estrus (parity two) in 112 Ontario swine herds, 1987 to 1991.*

	Parity two	
Parity one	Less efficient	More efficient
Less efficient	48	69
More efficient	160	712
Delayed	20	50

*includes only sows that had two weaning-to-estrus intervals in a row of either up to 14 days or 28–31 days.

estrus interval and parities would be necessary to confirm this possibility.

The fact that more parity-one sows return to estrus in the less efficient period does exacerbate the reduction in parity-two litter size. Indeed, the parity-two litter size drop and the 7- to 10-day fertility drop may both be different expressions of the same cause, as both are "corrected" by delaying mating to the next estrus. A physiological explanation of the reduced litter size observable in the two phenomena is required before they can be reliably linked or individually explained.

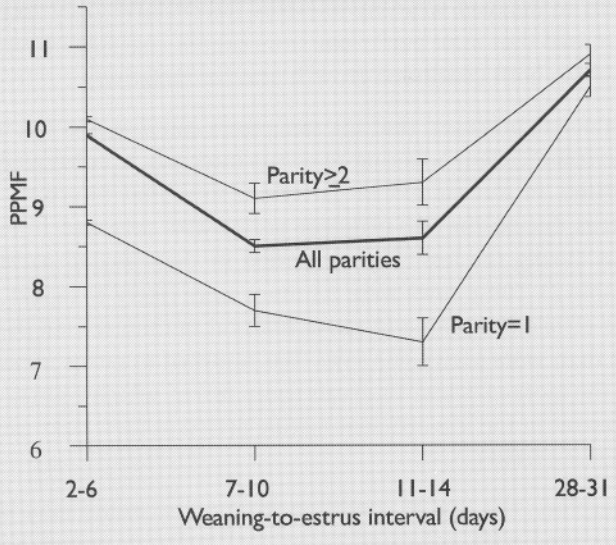

Fig 8.— Pigs per mated female (PPMF) for sows in study 2 at all parities, parity one only, and parity two-or-greater as related to weaning-to-estrus interval.

Delay-mating

Will the performance of sows that return to estrus 7–10 days postweaning be enhanced if matings are delayed until their second estrus at 28–31 days after weaning? In study 2, litter size, PPMF, and farrowing rate improved when the less-efficient sows were delay-mated (Fig 8). In fact, there was no significant difference in PPMF between females that returned to estrus 7–10 days postweaning and those that returned to estrus 11–14 days postweaning. It may be, then, economically advantageous to delay-mate any female that has not returned to estrus by day 6 postweaning. The improvement in PPMF in delay-mated females occurred across all parities, but was particularly pronounced in parity-one sows. Their increased production was similar to the increase in litter sizes in delay-mated parity-two sows (Morrow, et al. 1990)[18]. Interestingly, 28% of delay-mated parity-one sows (mated on days 28 to 31 postweaning) returned to estrus 7–10 days postweaning in their parity-two estrus, whereas 41% of the parity-one sows bred between 7 and 10 days postweaning were also mated in the 7–10-day interval as parity-two sows.

Conclusions

Between 10%–15% of all sows will come into estrus and mate in the less-efficient 7- to 10- day postweaning interval. Because the findings of study 1 were validated in study 2, we anticipate that other investigators will find similar associations between weaning-to-estrus interval and reproductive efficiency in other herds. Because both litter size *and* farrowing rate (i.e. PPMF) are affected when less-efficient sows are delay-mated, producers can use this strategy to effect a relatively large improvement in overall mating efficiency rather than accepting the lower efficiency expected from these females at their first postweaning estrus. A cost:benefit analysis is required to determine whether sows that repeatedly return to estrus during the less-efficient, 7- to 10-day weaning-to-estrus period should be mated, delay mated, or culled.

Acknowledgments

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