Lifetime reproductive and financial performance of female swine

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Objective—To evaluate reproductive and financial performance for commercial swine herds grouped on the basis of pattern of removal of female swine.

Design—Cohort study.

Sample Population—25 swine herds.

Procedures—Lifetime reproductive productivity was summarized as number of pigs weaned per herd day per mated female and as number of herd days per pig weaned per mated female. Factors associated with these 2 measures were determined by use of linear regression. Financial data from a commercial database were used to estimate maximum number of parities at removal associated with profitability. Sensitivity analysis was used to simulate how variations in daily maintenance cost and value per weaned pig would influence profitability.

Results—Mean number of pigs weaned per herd day per mated female was 0.054; mean number of herd days per pig weaned per mated female was 20.2. Both these measures were associated with proportion of nonproductive days during herd life, preweaning mortality rate per litter weaned, mean lifetime number of pigs born alive per litter weaned, and mean lifetime lactation duration. Maximum parity at time of removal associated with profitability ranged from 5 to 8. Daily maintenance costs per female had a greater impact on lifetime profitability than did value per weaned pig.

Conclusions and Clinical Relevance—Results suggest that lifetime reproductive and financial performance is optimized among swine herds that have higher proportions of high-parity females. (*J Am Vet Med Assoc* 2000;216:1802–1809)

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Reproductive performance is a function of output per unit of time. For female swine, reproductive performance is traditionally expressed as the **number of pigs weaned per female per year (PWFY)**.[1,2] Number of pigs weaned per female per year is determined by interval traits, such as **number of nonproductive days (NPD)** and lactation duration, and litter traits, such as litter size, number of stillborn pigs per litter, and **preweaning mortality rate (PWM)**. The NPD (eg, days when breeding females are not gestating or lactating) is the most important factor determining PWFY.[1,3]

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Annualized measures of reproductive performance, such as PWFY and its components, are based on the assumption that the breeding inventory is stable during the period of analysis and, thus, may not be accurate estimators of reproductive performance during periods longer than a year. Moreover, as culling rates in commercial herds are typically as high as 45 to 50%,[4-7] a considerable proportion of the breeding females are removed without spending an entire year in the herd.[8] In the absence of comprehensive estimators of lifetime productivity, parity at the time of removal is commonly used to approximate life expectancy of female swine.[4,9] However, even though female swine removed at a higher parity spend more days in the herd, parity at the time of removal does not accurately reflect either longevity or reproductive life.[8]

The purposes of the study reported here were to generate summary estimators of lifetime reproductive performance for female swine (pigs weaned per herd day and herd days per pig weaned) and to identify which performance parameters would be associated with these 2 estimates. As different parity distributions commonly reflect differences in female removal rates and lifetime productivity, estimates of lifetime reproductive performance were measured for 3 different patterns, defined according to the distributions of parity at the time of removal during a 5-year period. Costs and revenues during herd life were also estimated for each female swine to determine the maximum parity number at removal to yield profitability for each pattern.

Materials and Methods

Patterns of female removal and estimates of lifetime productivity—Data files from commercial swine herds using the PigCHAMP computerized record software[a] were reviewed, and herds for which quality and integrity of data for 5 consecutive years met minimum criteria standards were eligible for inclusion in the study. Only herds for which breeding herd inventory fluctuated < 10% and for which records of < 5% of all mating, farrowing, and weaning events during the 5-year period were missing were eligible for inclusion in the study. Twenty-five herds met the criteria for inclusion in the study.

Frequency distributions for parity of female swine at the time of removal were calculated for all herds included in the study. All females admitted in the breeding herd and removed by the last day of the 5-year data collection period were included. Three patterns of removal were identified (**Fig 1**), and results of the Kolmogorov-Smirnov test[10] indicated that the 3 patterns were different from each other. For 14 herds, comprising lifetime records for 5,594 female swine, > 20% of the females were parity 1 at the time of removal, and the percentage of females that were parity 0 at the time of removal was similar to the percentages of females that were parity 2,

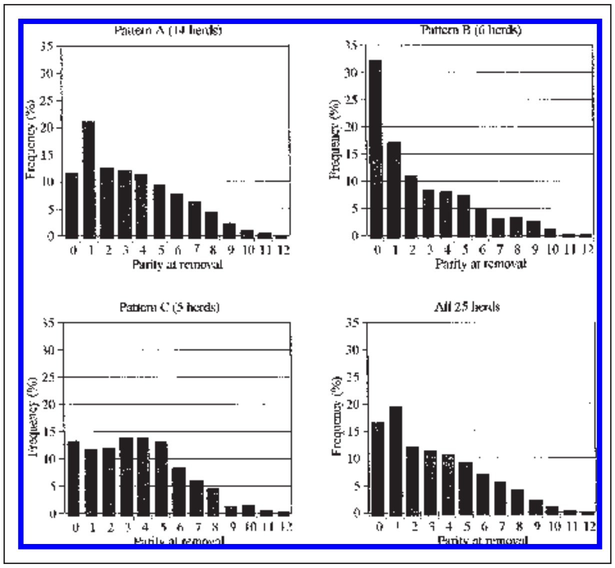

Figure 1—Frequency distributions of parity at the time of removal for female swine removed from 25 commercial herds illustrating the 3 patterns of removal that were identified.

3, or 4 at the time of removal (removal pattern A). For 6 herds, comprising lifetime records for 1,984 female swine, > 30% of the females were parity 0 at the time of removal, and as parity increased, percentage of females at each parity at the time of removal decreased (removal pattern B). For the remaining 5 herds, comprising lifetime records for 664 female swine, percentages of females that were parity 0 through 5 at the time of removal were similar. Mean culling rates during the 5-year data collection period were 47% for the 14 herds with removal pattern A, 55% for the 6 herds with removal pattern B, and 38% for the 5 herds with removal pattern C.

The following information was obtained from the data files for each female swine included in the study: identity code of the female swine, date of entry into the herd, date of removal from the herd, parity at the time of removal from the herd, total number of pigs born per litter, number of pigs born alive per litter, number of stillborn and mummy pigs per litter, net number of pigs fostered, number of pigs weaned, gestation duration, and lactation duration. For each female swine, lifetime totals for number of pigs born, **number of pigs born alive (PBA)**, number of stillborn and mummy pigs, **number of pigs weaned (PW)**, gestation days, and lactation days were calculated. Total lifetime PWM for each female was calculated by use of the following formula:

$$\text{Lifetime PWM} = \frac{(\text{lifetime PBA} + \text{lifetime net No. of pigs fostered} - \text{lifetime PW})}{(\text{lifetime PBA} + \text{lifetime net No. of pigs fostered})} \times 100$$

Number of days spent in the breeding herd (herd days) was calculated as the difference between the date of removal and the date of entry. As described previously,[8] estimates were calculated by including all recorded days (herd days per inventoried female) and by excluding the entry-to-first service interval (herd days per mated female). Estimates of herd days per mated female were considered to be more precise indicators of time spent in the breeding herd, because they eliminated management discretion in establishing time of first mating relative to time of entry into the herd.[6] Proportions of days spent in gestation and in lactation were calculated per inventoried female and per mated female. Lifetime NPD per inventoried female were then calculated as follows[8]:

$$\text{Lifetime NPD (\%)} = \frac{(\text{herd days} - \text{lactation days} - \text{gestation days})}{(\text{herd days})} \times 100$$

Lifetime counts of number of pigs born, PBA, number of stillborn and mummy pigs, PW, PWM, and lactation days were then divided by number of parities at the time of removal to generate estimates of lifetime performance per litter weaned. Estimates of annual lifetime productivity were calculated considering only females that stayed in the herd for at least 1 year on a per inventoried female and per mated female basis and included NPD per year of herd life, litters weaned per year of herd life, and pigs weaned per year of herd life.[8] Number of pigs weaned per year of herd life was calculated by use of the following equation:

$$\text{Pigs weaned per year of herd life} = \frac{(\text{lifetime PW})}{(\text{herd days})} \times 365$$

Two summary measures of lifetime productivity were also generated. The first was number of pigs weaned per herd day, which was calculated by dividing lifetime PW by herd days. The second was number of herd days per pig weaned, which was calculated by dividing herd days by lifetime PW. These measures were estimated on a per inventoried female and on a per mated female basis. Because females for which parity at the time of removal was 0 did not have any litters, they did not contribute any data regarding numbers of pigs born or weaned, PWM, weaning-to-service days, lactation days, or gestation days. Therefore, these females were naturally excluded from further analyses of lifetime reproductive performance. Females for which records were of unreliable quality were also excluded from further analyses.

Statistical analyses—Descriptive statistics were obtained for estimates of lifetime productivity for all females and for females in herds with each removal pattern. Analysis of variance, using 2 different models, was used to analyze data for herds with each removal pattern. One model used herd days per pig weaned per mated female as the dependent variable; the other used pigs weaned per herd day per mated female as the dependent variable. In both models, the independent variables were parity at the time of removal, herd, month of entry into the herd, and month of removal from the herd. Females that were parity 5 or 6 at the time of removal were grouped, as were females that were parity 7 or 8 at the time of removal, and females that were parity 9 or higher at the time of removal. Analyses were conducted using the general linear models procedure.[11]

Two linear regression models were generated.[10] The first used herd days per pig weaned per mated female as the outcome variable; the second used pigs weaned per herd day per mated female as the outcome variable. Each model was run separately for herds with each pattern of removal; therefore, 6 models were generated. Independent variables were the estimates of lifetime reproductive performance. To adjust for the effect of individual herds, an independent variable representing individual herd was forced into each model as described.[12] The proportional contribution of each predictor to the total variation in the response was assessed by use of stepwise procedures.

Financial analyses—Although they were not considered in analyses of lifetime reproductive productivity, females that were parity 0 at the time of removal from the herd were included in financial analyses, because these females were responsible for costs associated with maintenance, labor, and feeding. Historical monthly financial estimates for the same 5-year period used for evaluation of reproductive productivity were obtained from 81 farms participating in a commercial database.[b] Information obtained included **acquisition**

price of replacement gilts (APRG), **slaughter value of culled females (SVCF)**, **value per pig weaned (VPW)**, and **daily maintenance cost per female (DMCF)**. Mean SVCF per month were estimated and assigned to each female according to corresponding month of removal from the herd. Similarly, mean APRG per month were calculated and assigned to each female according to corresponding month of entry into the herd. Value per pig weaned and DMCF were summarized on an annual basis and assigned to each female according to corresponding year of removal from the herd. The SVCF, VPW, and DMCF were discounted, using an annual rate of 7% on a monthly basis to account for the time value of money.[13] Individual values were multiplied by $1/(1 + 0.07/12)^n$, where n is the number of months spent in the herd, derived from herd days per mated female. Estimates of DMCF were multiplied by 30.4575 (365.25/12) to assess cost per month spent in the herd. The APRG were not discounted, because it was assumed that such costs would be fixed. Revenues for SVCF were estimated by multiplying discounted SVCF by assumed body weights assigned to each female according to parity at the time of removal. Body weight at the time of removal was assumed to be 125 kg for females that were parity 0 at the time of removal, 160 kg for females that were parity 1 at the time of removal, 170 kg for females that were parity 2 at the time of removal, and 180 kg for females that were parity 3 or higher at the time of removal. Revenues from sale of weaned pigs were estimated by multiplying lifetime PW by mean annual discounted VPW. Total lifetime revenue was obtained by summing revenues from weaned pigs and SVCF. Because females that were parity 0 at the time of removal had not weaned any pigs, total lifetime revenue for these females was equal to SVCF. Total lifetime maintenance cost was estimated by multiplying number of months in the breeding herd by discounted maintenance cost per month. Lifetime maintenance cost was added to APRG to estimate total outflow during herd life. Lifetime gross profit per female was estimated as the difference between total revenues and total outflow. Sensitivity analysis[13] was performed by estimating lifetime gross profit per female for females grouped on the basis of parity at the time of removal for each removal pattern and multiplying by the percentage of females in each parity category at the time of removal. This yielded adjusted estimates of profit that reflected each removal pattern. Differences between adjacent parity categories in regard to adjusted estimates of profit were used as estimates of the marginal profit expected from keeping a female through the following parity, or the maximum number of parities expected to yield a profit.

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Results

Reproductive productivity—For all females, mean parity at the time of removal from the herd was 3.3. Mean parities at the time of removal for females from herds with removal patterns A, B, and C were 3.2, 2.4, and 3.6, respectively. Mean number of days in the breeding herd for females that were parity 0 at the time of removal was 97 days, whereas mean number of days in the breeding herd for all females, calculated per inventoried female, was 700 days (**Table 1**). Females from herds with removal pattern C weaned about 39 pigs during herd life, which was numerically higher than the number of pigs weaned for females from herds with removal pattern A or B. Females from herds with removal pattern B apparently accumulated more NPD and weaned fewer litters and fewer pigs per year spent in the breeding herd than did females from herds with other removal patterns. Mean percentage of herd days

Table 1—Estimates of reproductive performance for 25 commercial swine herds classified on the basis of pattern of removal of female swine from the breeding herd

Variable	Pattern A	Pattern B	Pattern C	All herds
Cumulative lifetime reproductive productivity				
Herd days/IF	695.5 ± 364.8	700.5 ± 364.1	736.5 ± 320.1	700.0 ± 361.2
Herd days/MF	684.6 ± 366.8	656.5 ± 365.1	697.9 ± 327.1	680.1 ± 363.4
Gestation days/IF (%)	68.0 ± 12.7	60.7 ± 13.4	65.0 ± 12.6	66.3 ± 13.1
Gestation days/MF (%)	69.6 ± 12.2	66.2 ± 12.9	69.6 ± 12.1	68.9 ± 12.4
Lactation days/IF (%)	14.0 ± 3.7	13.3 ± 3.5	12.1 ± 2.8	13.7 ± 3.6
Lactation days/MF (%)	14.3 ± 3.7	14.5 ± 3.4	13.0 ± 2.7	14.2 ± 3.6
NPD/IF (%)	18.0 ± 14.8	26.0 ± 15.9	22.8 ± 14.6	20.0 ± 15.3
NPD/MF (%)	16.1 ± 14.2	19.3 ± 15.1	17.4 ± 13.8	16.8 ± 14.4
Total pigs born	46.9 ± 30.3	42.6 ± 29.3	50.1 ± 27.9	46.3 ± 30.0
Pigs born alive	43.3 ± 27.9	39.2 ± 27.1	45.0 ± 25.1	42.6 ± 27.5
Pigs born dead	3.6 ± 4.1	3.4 ± 4.1	5.1 ± 5.0	3.7 ± 4.2
PWM (%)	12.4 ± 10.6	14.0 ± 10.8	12.5 ± 9.9	12.8 ± 10.6
Pigs weaned	38.2 ± 24.1	34.1 ± 23.0	39.4 ± 21.8	37.5 ± 23.8
Pigs weaned/herd day/IF	0.053 ± 0.013	0.045 ± 0.011	0.052 ± 0.012	0.051 ± 0.013
Pigs weaned/herd day/MF	0.054 ± 0.013	0.049 ± 0.011	0.055 ± 0.013	0.053 ± 0.013
Herd days/pig weaned/IF	20.5 ± 6.9	24.0 ± 8.0	20.9 ± 6.7	21.2 ± 7.2
Herd days/pig weaned/MF	19.9 ± 6.4	21.7 ± 6.3	19.4 ± 6.0	20.2 ± 6.4
Lifetime reproductive performance per litter weaned (LW)				
Total born/LW	10.6 ± 2.2	10.5 ± 2.1	11.5 ± 2.3	10.7 ± 2.2
Born alive/LW	9.8 ± 2.0	9.6 ± 1.9	10.3 ± 2.0	9.8 ± 2.0
Born dead/LW	0.8 ± 0.9	0.9 ± 1.0	1.1 ± 1.1	0.9 ± 0.7
PWM/LW (%)	4.6 ± 7.0	5.7 ± 8.1	3.9 ± 5.0	4.7 ± 7.1
Pigs weaned/LW	8.9 ± 1.8	8.5 ± 1.5	9.1 ± 1.6	8.8 ± 1.7
Lactation days/LW	23.5 ± 5.5	25.0 ± 4.5	21.4 ± 3.7	23.7 ± 5.3
Lifetime reproductive performance per year in the herd				
NPD/IF/year	65.8 ± 54.0	94.8 ± 58.1	83.6 ± 53.4	73.0 ± 56.3
NPD/MF/year	58.7 ± 52.0	70.6 ± 55.3	63.5 ± 50.6	61.5 ± 52.7
Litters weaned/IF/year	2.19 ± 0.39	1.95 ± 0.42	2.09 ± 0.39	2.13 ± 0.4
Litters weaned/MF/year	2.24 ± 0.38	2.12 ± 0.39	2.24 ± 0.37	2.21 ± 0.4
Pigs weaned/IF/year	19.2 ± 4.8	16.5 ± 4.2	18.8 ± 4.6	18.7 ± 4.8
Pigs weaned/MF/year	19.7 ± 4.7	18.0 ± 4.1	20.2 ± 4.8	19.4 ± 4.7

Values are given as mean ± SD. IF = Inventoried female. MF = Mated female. NPD = Nonproductive days. PWM = Preweaning mortality rate.

Table 2—Least square mean ± SEM number of herd days per pig weaned per mated female as a function of parity at the time of removal from the breeding herd for 25 commercial swine herds classified on the basis of pattern of removal of female swine from the breeding herd

	Herd days per pig weaned per mated female		
Parity	Pattern A	Pattern B	Pattern C
1	24.7 ± 0.24[a]	27.5 ± 0.35[a]	25.7 ± 0.71[a]
2	23.6 ± 0.25[b]	24.5 ± 0.39[b]	23.5 ± 0.62[b]
3	21.9 ± 0.24[c]	22.4 ± 0.42[c]	20.7 ± 0.57[c]
4	19.8 ± 0.25[d]	20.4 ± 0.43[d]	19.8 ± 0.56[d]
5–6	19.0 ± 0.21[e]	19.6 ± 0.35[e]	18.5 ± 0.44[e]
7–8	17.9 ± 0.25[f]	18.4 ± 0.48[f]	17.4 ± 0.61[e,f]
≥ 9	17.2 ± 0.36[f]	17.6 ± 0.60[f]	16.0 ± 1.10[f]

In each column, values with different superscripts are significantly ($P < 0.05$) different.

Table 3—Least square mean ± SEM number of pigs weaned per herd day per mated female as a function of parity at the time of removal from the breeding herd for 25 commercial swine herds classified on the basis of pattern of removal of female swine from the breeding herd

	Pigs weaned per herd day per mated female		
Parity	Pattern A	Pattern B	Pattern C
1	0.046 ± 0.01[a]	0.040 ± 0.01[a]	0.044 ± 0.01[a]
2	0.047 ± 0.01[b]	0.043 ± 0.01[b]	0.048 ± 0.01[b]
3	0.049 ± 0.01[c]	0.047 ± 0.01[c]	0.052 ± 0.01[c]
4	0.053 ± 0.01[d]	0.051 ± 0.01[d]	0.054 ± 0.01[d]
5–6	0.055 ± 0.01[e]	0.053 ± 0.01[e]	0.057 ± 0.01[e]
7–8	0.058 ± 0.01[f]	0.056 ± 0.01[f]	0.059 ± 0.01[e]
≥ 9	0.060 ± 0.01[g]	0.058 ± 0.01[f]	0.064 ± 0.01[f]

See Table 2 for key.

that were nonproductive was 20%, and mean lifetime PW was 37.5.

For females in all herds, there was a mean of 20 to 21 herd days per pig weaned, and 0.052 to 0.054 pigs were weaned per herd day (Table 1). Lower parity at the time of removal was associated with a higher number of herd days per pig weaned (**Table 2**) and with a lower number of pigs weaned per herd day (**Table 3**).

For all 3 removal patterns, there was a significant linear relationship between herd days per pig weaned, calculated on a per mated female basis, and lifetime NPD per mated female (calculated as a percentage of herd days), PWM per litter weaned, mean lifetime number of pigs born alive per litter weaned, and mean lifetime lactation duration (ie, lactation days per litter weaned; **Table 4**). For herds with removal pattern C, the regression equation was as follows: herd days per pig weaned per mated female = 28.20 + 0.27 (lifetime NPD per mated female) + 0.39 (PWM per litter weaned) – 0.90 (No. of pigs born alive per litter weaned) – 0.25 (lactation days per litter weaned). Thus, for these herds, if all other variables were held at their mean values, a 1% reduction in lifetime NPD per mated female would correspond to a reduction of 0.26 herd days per pig weaned per mated female.

The same variables were found to have a significant linear relationship with number of pigs weaned per herd day per mated female (**Table 5**). For herds with removal pattern C, the regression equation was as follows: No. of pigs weaned per herd day per mated female = 0.0358 – 0.0006 (lifetime NPD per mated female) – 0.0006 (PWM per litter weaned) + 0.0021 (No. of pigs born alive per litter weaned) + 0.0004 (lactation days per litter weaned). Thus, for these herds, if all other variables were held at their mean values, a 1% reduction in lifetime NPD per mated female would correspond to an increase of 0.0006 pigs weaned per herd day per mated female.

Financial analyses—For all herds, mean DMCF was approximately $1.10, and mean VPW was $26.80

Table 4—Factors linearly associated with number of herd days per pig weaned per mated female for 25 commercial swine herds classified on the basis of pattern of removal of female swine from the breeding herd

	Pattern A (R^2 = 0.56)		Pattern B (R^2 = 0.66)		Pattern C (R^2 = 0.69)	
Variable	β	Partial R^2	β	Partial R^2	β	Partial R^2
Constant	25.31	NA	26.21	NA	28.02	NA
NPD/MF (%)	0.23	0.34	0.24	0.42	0.27	0.48
PWM/LW (%)	0.36	0.49	0.34	0.59	0.39	0.56
Born alive/LW	–0.64	0.54	–0.83	0.65	–0.90	0.68
LCD/LW	–0.16	0.56	–0.11	0.66	–0.25	0.69

NPD/MF = Nonproductive days per mated female. PWM/LW = Preweaning mortality rate per litter weaned. Born alive/LW = No. of pigs born alive per litter weaned. LCD/LW = Lactation days per litter weaned.

Table 5—Factors linearly associated with number of pigs weaned per herd day per mated female for 25 commercial swine herds classified on the basis of pattern of removal of female swine from the breeding herd

	Pattern A (R^2 = 0.52)		Pattern B (R^2 = 0.63)		Pattern C (R^2 = 0.63)	
Variable	β	Partial R^2	β	Partial R^2	β	Partial R^2
Constant	0.0417	NA	0.0407	NA	0.0358	NA
NPD/MF (%)	–0.0005	0.33	–0.0004	0.42	–0.0006	0.45
PWM/LW (%)	–0.0006	0.44	–0.0005	0.54	–0.0006	0.50
Born alive/LW	0.0013	0.50	0.0016	0.62	0.0021	0.61
LCD/LW	0.0003	0.51	0.0001	0.63	0.0004	0.63

See Table 4 for key.

Table 6—Mean values for financial variables for 25 commercial swine herds classified on the basis of pattern of removal of females from the breeding herd

Variable ($)	Pattern A	Pattern B	Pattern C
APRG	229.32	228.32	231.12
DMCF	1.11	1.10	1.11
VPW	26.80	26.80	26.80
SVCF (per 100 kg)	80.37	81.18	79.71
Monthly maintenance cost[a]	28.58	30.81	30.02
Lifetime maintenance cost[b]	534.70	440.96	585.00
Total outflow during herd life[c]	764.02	669.18	816.12
Discounted VPW[d]	22.30	23.71	23.51
Revenue from weaned pigs[e]	797.99	770.70	894.43
Discounted SVCF (per 100 kg)[f]	68.40	74.60	71.14
Discounted slaughter value[g]	114.35	115.81	119.45
Total lifetime revenue[h]	810.01	619.59	884.21
Lifetime gross profit[i]	45.99	–49.59	68.10

APRG = Acquisition price of replacement gilts. DMCF = Daily maintenance cost per female. VPW = Value per pig weaned. SVCF = Slaughter value of culled females.

[a]DMCF X (365.25/12) discounted using an annual rate of 7% on a monthly basis. [b]DMCF X duration of herd life. [c]Lifetime maintenance cost + APRG. [d]VPW discounted using an annual rate of 7% on a monthly basis. [e]Discounted VPW X lifetime No. of pigs weaned. [f]SVCF discounted using an annual rate of 7% on a monthly basis. [g]Discounted SVCF X (assumed body weight/100). [h]Revenues from weaned pigs + discounted SVCF. [i]Total lifetime revenue – total outflow during herd life.

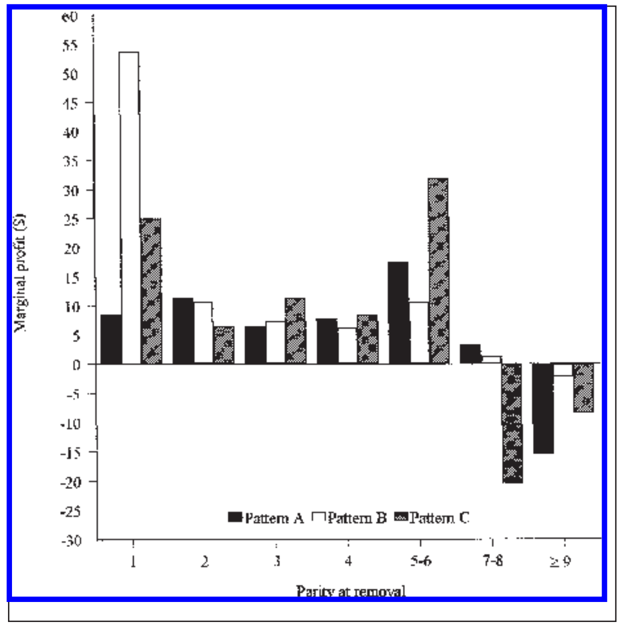

Figure 2—Marginal profit expected for keeping a female in the breeding herd through the next parity for 25 commercial swine herds classified on the basis of pattern of removal of female swine from the breeding herd.

(**Table 6**). Mean lifetime profit ranged from –$49.59 per female to $68.10 per female.

Lifetime gross profit per female generally increased as parity at the time of removal from the herd increased (**Table 7**). For herds with removal pattern A or C, positive cash flow was first achieved for females that were parity 3 at the time of removal. However, for herds with removal pattern B, positive cash flow was first achieved for females that were parity 4 at the time of removal. Evaluation of marginal profits indicated that retention of females beyond 6 parities was expected to be unprofitable for herds with removal pattern C (**Fig 2**). On the other hand, for herds with removal pattern A or B, retention of females for 7 to 8 parities still yielded a small marginal profit.

A decrease in DMCF to $1.00 would increase lifetime gross profit for herds with removal pattern A or C and decrease lifetime gross losses for herds with removal pattern B, and would make retention of females beyond 6 parities economically unfeasible for herds with all removal patterns (**Table 8**). An increase in DMCF to $1.20 would still be associated with positive cash flow for females that were parity 5 or 6 at the time of removal from herds with removal pattern A or B, but an increase in DMCF to $1.30 or higher would be related to negative cash flow, regardless of removal pattern. With mean DMCF ≥ $1.30, the profitable life expectancy for females from herds with removal pattern B would be increased by at least 1 parity.

Even with a reduction in VPW to $26.00, mean lifetime gross profit per female would still be $15.00 for herds with removal pattern A and > $30.00 for herds with removal pattern C. An increase in VPW to $28.00 would be associated with a mean lifetime gross profit per female of $75.00 for herds with removal pattern A and of nearly $105.00 for herds with removal pattern C. However, even with such a high VPW, total outflow during herd life would be greater than total lifetime revenue for herds with removal pattern B. Regardless of changes in VPW, the maximum life expectancy associated with profitability would remain unchanged (**Table 9**).

Table 7—Mean gross lifetime profit (GP) and adjusted estimate of lifetime profit (AP) per female as a function of parity at the time of removal for 25 commercial swine herds classified on the basis of pattern of removal of female swine from the breeding herd

	Pattern A			Pattern B			Pattern C		
Parity	%*	GP	AP†	%	GP	AP	%	GP	AP
0	11.53	–225.17	–25.96	32.21	–227.81	–73.38	13.25	–272.84	–36.15
1	21.22	–81.84	–17.37	17.09	–114.54	–19.57	11.75	–95.07	–11.17
2	12.55	–47.53	–5.97	10.99	–79.95	–8.79	11.90	–39.37	–4.69
3	11.92	3.59	0.43	8.42	–17.57	–1.48	13.86	48.41	6.71
4	11.21	73.66	8.26	8.22	56.99	4.68	13.86	109.43	15.17
5–6	16.91	152.33	25.76	12.50	122.59	15.32	21.53	218.65	47.08
7–8	10.83	267.71	28.99	6.56	253.43	16.63	10.54	250.37	26.39
≥9	3.82	353.93	13.52	4.03	355.48	14.33	3.31	544.37	18.02

*Percentage of females with indicated parity at time of removal from the breeding herd. †Calculated by multiplying GP by percentage of females with indicated parity at time of removal from the breeding herd.

Table 8—Marginal profit ($) expected for keeping a female through the next parity as a function of daily maintenance cost per female for 25 commercial swine herds classified on the basis of pattern of removal of female swine from the breeding herd

	Daily maintenance cost per female ($)											
	Pattern A				Pattern B				Pattern C			
Parity	1.00	1.20	1.30	1.40	1.00	1.20	1.30	1.40	1.00	1.20	1.30	1.40
1	11.57	5.27	2.12	–1.03	54.42	53.15	52.45	51.79	25.51	23.87	23.04	22.21
2	11.39	11.74	11.91	12.08	11.31	10.97	10.81	10.64	8.47	5.30	3.72	2.13
3	7.90	5.62	4.48	3.34	7.57	7.33	7.21	7.09	14.15	9.56	7.26	4.96
4	9.22	7.50	6.64	5.78	7.44	5.86	5.07	4.28	10.07	7.08	5.59	4.10
5–6	24.02	13.31	7.95	2.60	15.56	6.87	2.47	–1.93	40.65	25.89	18.52	11.14
7–8	–0.08	4.85	7.31	9.77	–2.40	3.73	6.80	9.86	–27.19	–15.82	–10.14	–4.45
≥ 9	–21.71	–11.18	–5.91	–0.65	–4.71	–1.17	0.59	2.36	–15.53	–3.52	2.49	8.50

Table 9—Marginal profit ($) expected for keeping a female through the next parity as a function of value per weaned pig for 25 commercial swine herds classified on the basis of pattern of removal of female swine from the breeding herd

	Value per weaned pig ($)											
	Pattern A				Pattern B				Pattern C			
Parity	25.50	26.00	27.50	28.00	25.50	26.00	27.50	28.00	25.50	26.00	27.50	28.00
1	5.84	6.78	9.60	–10.54	51.80	52.48	54.60	55.31	23.37	23.91	25.51	26.04
2	11.36	11.38	11.42	11.44	10.27	10.42	10.79	10.92	5.10	5.56	6.93	7.38
3	5.50	5.85	6.90	7.25	7.22	7.33	7.68	7.79	9.43	10.15	12.30	13.02
4	7.01	7.34	8.35	8.69	5.23	5.53	6.40	6.69	7.62	8.11	9.58	10.07
5–6	14.04	15.64	20.45	22.05	8.31	9.54	13.21	14.43	26.49	28.79	35.70	38.00
7–8	6.03	5.48	3.82	3.27	3.84	3.12	0.97	0.25	–14.83	–16.57	–21.77	–23.51
≥ 9	–12.13	–13.70	–18.41	–19.89	–1.05	–1.53	–2.95	3.42	–4.95	–6.55	–11.32	–12.91

Discussion

Female swine that are the same parity at the time of removal but that come from herds with different removal patterns can have had different herd lives. Also, lifetime PW can differ for females with similar herd lives that are the same parity at the time of removal from the herd.[8] Therefore, parity at the time of removal and lifetime PW are only approximations for life expectancy and lifetime reproductive performance, and lifetime reproductive performance is better defined as a function of output per unit of time. In the present study, output was expressed as lifetime PW, and the unit of time was days spent in the breeding herd, and 2 summary measurements of lifetime reproductive productivity were generated: number of pigs weaned per herd day and number of herd days per pig weaned. Number of pigs weaned per day has previously been referred to as a summary measure for lifetime productivity.[14,c] However, this estimate has limited practical application, because breeding females do not produce any output measurable on a daily basis, even though they accumulate costs during each day spent in the herd. Also, mean values for number of pigs weaned per herd day are low, making interpretation at the field level difficult. Therefore, lifetime reproductive productivity is better expressed by the number of herd days per pig weaned. Although calculation of number of herd days per pig weaned is not mathematically possible for females that are parity 0 at the time of removal (because number of pigs weaned = 0), from a biological standpoint, it should be considered that number of herd days per pig weaned for females that are parity 0 at the time of removal should be considered equal to total number of days in the breeding herd, which was a mean of 97 days for females in the present study. For females that are parity 0 at the time of removal, all days in the breeding herd should be considered nonproductive days because these females did not produce any weaned pigs prior to removal.

According to financial analyses in the present study, higher profitability during herd life could be achieved by decreasing DMCF or by increasing VPW, but the former would have more impact on profitability than the latter. At the lowest DMCF simulated in the sensitivity analysis ($1.00), gross losses per female for herds with removal pattern B would be dramatically reduced. However, even the highest simulated VPW ($28.00) would not be enough to yield a gross profit for these herds or to change the highest parity at removal associated with profitability. Typical daily costs would be $1.11/female, but daily costs are higher for nonproductive days because of additional opportunity costs, defined as the costs of a delay on obtaining revenues after any key event.[3] Daily opportunity cost was estimated to be equal to $0.61 in a study conducted in Holland[15] and $0.32 in a study conducted in the United States.[3] Daily maintenance cost per female does not depend exclusively on nonproductive days, because productive days also incur costs. However, even when DMCF remains unchanged, total outflow during herd life is higher with longer herd life. Thus, decreasing NPD at any stage of herd life would improve lifetime productivity and profitability.

Considering that the mean lifetime NPD per inventoried female in this study was equal to 120.4 days and mean proportion of lifetime NPD per inventoried female was 20%, a change in proportion of 1% would correspond to nearly 6 days (120.4/20). A similar calculation considering mean lifetime NPD per mated female (100.5 days) and mean proportion of

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lifetime NPD (16.8%) would produce a similar result. Thus, a reduction in lifetime NPD by 1% would correspond to nearly 6 days, or to 0.25 herd days per pig weaned per mated female, as estimated by linear regression models in this study. A nonproductive interval of 6 days corresponds to a little less than the mean weaning-to-first service interval observed in some studies.[3,16,17] Thus, minimizing NPD by targeting the weaning-to-first service interval would yield little improvement on lifetime productivity. Opportunities for decreasing lifetime NPD by shortening weaning-to-first service interval occur at each farrowing interval, but the weaning-to-first service interval after the first parity probably has a greater impact in lifetime productivity, because it is commonly longer than subsequent intervals.[16-18] Considering the same approach, a reduction in lifetime NPD of 4 to 5% would be equivalent to a reduction of nearly 1 herd day per pig weaned per mated female, or to 24 to 30 days, a period that could include at least 1 estrus cycle. Such a reduction in lifetime NPD could be achieved by avoiding the practice of skipping the first postweaning estrus for primiparous females, which may improve subsequent litter size[19] but increases NPD. A similar reduction in lifetime NPD could be obtained by mating gilts at their first postpubertal estrus. Potential benefits of delayed mating of gilts, such as longer lifetime or larger first-parity litter size, are not large enough to compensate for the costs of extra nonproductive days[14,15] or are questionable.[20-22] Also, delayed first breeding is related to production of fewer pigs weaned per day.[c] The ideal age at first conception appears to be between 200 and 220 days, because first mating at later ages is related to lower lifetime profit per female.[15] Lifetime production of weaned pigs is probably not influenced by duration of the entry-to-first service interval or duration of subsequent farrowing-to-farrowing intervals. However, revenues would be generated earlier and more often when those intervals are shorter. Thus, among females for which lifetime PW were similar, costs would be lower for those that spent less time in the breeding herd. Because low-parity females have longer farrowing-to-farrowing intervals[18] and higher proportions of lifetime nonproductive days,[8] the cost per time unit is expected to be higher for weaned pigs produced by sows of low parity than by sows of high parity.

In the present study, the maximum number of parities at removal associated with profitability was 6 for herds with removal pattern C and 8 for herds with removal pattern A or B, whereas other studies[23,24] reported that retention of females in the breeding herd would still be profitable for up to 9 parities. This disagreement between results probably reflects differences in reproductive performance and financial variables among different production systems. The higher apparent profitability observed for herds with removal pattern C in the present study was possibly attributable to the high proportion of females at intermediate parities (3 to 6). Higher-parity females have lower lifetime NPD,[8] which may offset initially higher DMCF and may be associated with higher PW because of larger litter size. The large percentage of females that were parity 0 at the time of removal was likely the major reason for the financial losses observed among herds with removal pattern B. Females that are parity 0 at the time of removal are most often removed because of reproductive failure,[4,23,25,26] which maximizes NPD, DMCF, and replacement costs and emphasizes that lifetime reproductive productivity is critically influenced by gilt pool management. The difference between APRG and SVCF decreases with parity and is highest for females that are parity 0 at the time of removal. Therefore, culling decisions should ideally balance the SVCF and the future reproductive performance of a female currently in the herd against the APRG and the potential reproductive performance of a replacement.[23,24] Findings of the present study indicate that the influence of NPD on reproductive productivity is accentuated at low parities, when litter traits are not maximized, which suggests that benchmarks used to improve lifetime productivity should be parity-specific.

Improvements in lifetime productivity could also be achieved by reducing the number of pigs that die during lactation or by increasing the number born alive per litter. However, a reduction of 1 herd day per pig weaned per mated female would not be achieved even if PWM were decreased by as much as 2% per litter. In absence of major infectious diseases, PWM could be decreased by increasing supervision during the perinatal period,[27] but probably not without also increasing DMCF because of the greater labor. Additionally, a decrease of 1 herd day per pig weaned per mated female would not be achieved even if mean number of pigs born alive per litter could be increased by 1, which is unlikely given that litter size is highly dependent on genetics.[14,20,28]

The effects of mean lifetime lactation duration on the 2 outcome variables suggested that short lactation duration would be detrimental to lifetime productivity. However, interpretation of these findings requires caution, because the contribution of mean lifetime lactation duration to the total explained variation was very small in all models, indicating a weak association. Among females within the same farrowing group, those from which piglets were weaned earlier were more likely to be removed from the herd than those from which piglets were weaned later.[29] However, associations between lactation duration and lifetime productivity may be confounded by the fact that, within the same group, females to be culled because of suboptimal performance (eg, low litter size, high PWM, poor physical condition) can have shorter lactation durations than do those that will be rebred. Also, lifetime mean lactation durations do not reflect the fact that not all lactations during a lifetime have the same duration, and that parity at the time of removal may occasionally be higher than the number of lactations.

Results of the present study support the assumption that lifetime reproductive performance is better among herds that have higher proportions of high-parity females. However, inferences about effects of culling rates on reproductive performance could not be drawn in this study, because performance estimators were calculated only for removed females. Use of retrospective data allowed estimation of lifetime reproductive performance for a large number of females.

However, as sampling was not random, conclusions from this study should be used as basis for management interventions only for herds having standardized record systems and stable inventories. Also, the definition of patterns of removal considered distributions within a given period, which implies that the pattern during a different period may be distinctly different.

[a]PigCHAMP, St Paul, Minn.
[b]Swine Graphics Enterprises, Webster City, Iowa.
[c]Culbertson MS, Mabry JW. Effect of age at first service on first parity and lifetime female performance (abstr). *J Anim Sci* 1995; 73(suppl 1):21.

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