

## OPTIMAL PARITY DISTRIBUTION – WHEN IS THE BEST TIME TO CULL SOWS?

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### Summary

The economic impact of alternative sow-culling strategies was examined by simulating costs and returns for a farrowing-to-weaning swine operation. Culling strategies considered were to sell sows after parity 1 (P1) through parity 10 (P10). These 10 culling strategies resulted in different parity distributions. The optimal parity distribution is a complex issue, because it is related to conception rates, litter size, feed intake, as well as other factors. Results of this analysis indicate that the most economical time to cull a sow is after her eighth or ninth parity. This results in a breeding herd comprised of 18 to 20% gilts and a herd average parity of 3.5 to 4.0. However, the additional benefits of keeping a sow beyond about six parities are relatively small. The optimal time to cull a sow decreases as the cost of replacement gilts increases and vice versa. Feed costs impact the level of costs and returns but have very little impact on the optimal parity distribution. Similarly, over a range of conception rates and litter sizes, the optimal time to cull a sow is relatively constant.

(Key Words: Parity Distribution, Culling, Farrowing-to-Weaning, Economics.)

### Introduction

From perspectives of both the industry and the individual producer, producing a high quality product at the lowest cost possible is important. Numerous factors impact the cost of production, and many of these factors are interrelated. However, to quantify the impact of a specific factor that requires a management decision, an

economic analysis must focus on this key factor. Specifically, this research examined the impact sow attrition rate has on the cost and returns of producing a weaned pig. This information is useful for producers as they identify strategies for culling sows that best fit their operations.

It has been suggested that 15 to 20% of a breeding herd should be comprised of gilts and that the herd average parity should be 2.5 to 3.0. However, the economic consequences of varying from this optimal parity distribution (OPD) have not been quantified. Quantifying the economic costs and returns associated with sow attrition is complicated because of the many interacting factors. This may be one reason why OPDs have not been quantified in terms of costs and returns. This analysis identifies key factors affecting OPD, how sensitive OPD is to these factors, and what the cost is of not being at the OPD.

### Procedures

Projected budgets based on full economic costs were developed for sow operations that cull sows after their first through their tenth parities to identify the optimal parity distribution. Each of these 10 budgets or scenarios represents a different parity distribution. For example, an operation that culls sows after their first parity would be a gilt farm with 100% one-parity sows. Similarly, an operation that culls all sows after their second parity would be comprised of only one- and two-parity sows. On the other hand, an operation that does not cull sows until after their tenth parity would have a distribution of first-parity through tenth-parity sows.

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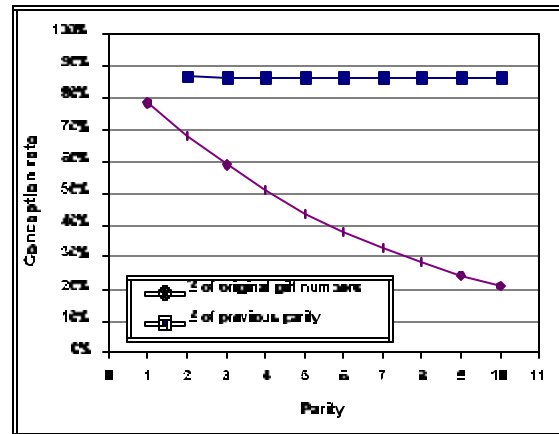
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Numerous assumptions were required in order to construct budgets for the 10 different sow-culling strategies (i.e., parity distributions). The following are some of the key assumptions made that impact costs and returns.

- Weaned pig value is constant by parity.
- 220 farrowings occur every 4 weeks.
- Cost of a replacement gilt is \$200/head.
- Sow cull income varies by weight of the sow only. Gilts not conceiving are sold at a higher price.
- Sow death loss is 4% for first parity sows and increases linearly by 0.33% for each successive parity.
- Genetic charge is based on the cost of replacement gilt, the salvage value of cull sow, and the replacement rate.
- Feed costs are \$143/ton and \$134/ton for lactation and gestation diets, respectively (based on 5-year average prices).
- Feed consumption varies by parity. Gestation intake ranges linearly from 5.15 to 6.00 lbs/head/day for parities 1 through 10. Lactation intake ranges nonlinearly from 10.25 to 12.55 lbs/head/day for parities 1 through 10.
- Total costs for labor, repairs, utilities, and professional fees are constant across strategies. However, these costs on a per-weaned-pig basis do vary based on production.
- Costs for marketing and transportation and veterinary, drugs, and supplies are constant on a per-weaned-pig basis.

Two other major assumptions affect the costs and returns – conception rates and pigs weaned per litter. Assumed conception rates for gilts and sows by parity level are shown in Figure 1. Conception rate as a percent of original gilt numbers is slightly below 80% for gilts and then decreases to approximately 20% by the tenth parity. Conception rate as a percent of

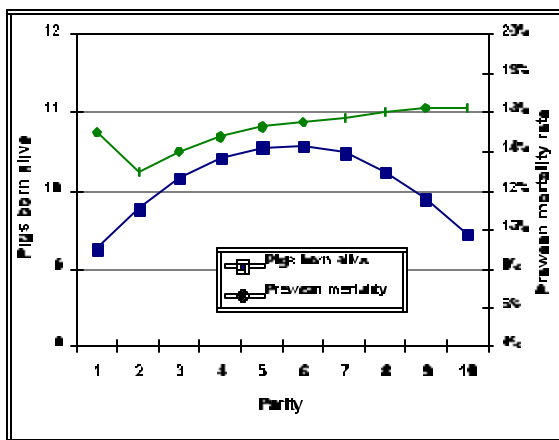
the previous parity is constant at 86%. The ability to get sows bred back plays a significant role in the optimal parity distribution. Therefore, the sensitivity of costs and returns to the conception rate assumption was examined.



**Figure 1. Conception Rate by Parity.**

Another major assumption impacting the OPD is pigs weaned per sow by parity. Pigs weaned per sow is a function of pigs born alive and preweaning mortality. Figure 2 shows the levels of pigs born alive and preweaning mortality by parity used in the analysis. The relationship between pigs born alive per litter and parity was estimated from previous research data – studies spanning multiple countries and decades – and indicates that pigs born alive is maximized at the sixth parity. Preweaning mortality was based on several studies and combined with pigs born alive to give pigs weaned per litter by parity, which was used to calculate costs and returns for each of the 10 parity distributions examined. Similar to conception rate, pigs weaned per litter by parity will impact the optimal parity distribution, so the sensitivity of costs and returns to this relationship was examined.

Given the assumptions listed, the production and cost and returns were estimated for each of the 10 different strategies for culling sows. All analyses were based on steady state production. That is, the swine operation was assumed to be operating at a point where the sow herd size is constant from month to month (i.e., gilts purchased exactly equaled sows culled and sow death loss).



**Figure 2. Sow Production per Litter by Parity.**

### Results and Discussion

Table 1 reports the production information for the different sow-culling strategies. Based on the assumptions, in order for producers to achieve a parity distribution with less than 20% gilts, they need to keep sows that breed back for at least 8 parities. The total pigs weaned/sow/year is maximized when sows are kept for 8 parities; however, differences between culling sows after 5 through 10 parities are quite small. Given the production information in Table 1, costs and returns can be estimated allowing for the most profitable sow culling strategy (i.e., parity distribution) to be identified.

Costs and returns of the 10 sow-culling strategies are given in Table 2. As expected, selling sows after their first parity (i.e., a gilt farm) is extremely unprofitable because of the high sow depreciation cost. The cost of producing a weaned pig decreases at a decreasing rate as sows are kept for additional parities. The total cost of producing a weaned pig is minimized when sows are kept through 8 or 9 parities before culling. However, for sows kept between 6 to 10 parities, the difference in cost is less than 40¢ per head. Based on the assumptions used, returns per head are approximately twice as high when sows are kept for 7 to 10 parities before culling (average of \$2.95/head) compared to culling after four parities (\$1.45/head).

A sensitivity analysis was conducted to determine how changing various cost

assumptions impacted returns over total costs (i.e., line F in Table 2). Because differences in breeding herd depreciation cost was the greatest, several gilt-replacement costs were considered. If replacement gilts are valued at \$150 per head (original assumption was \$200), returns were still maximized when sows are kept for 8 parities (Table 3). However, with these lower gilt prices, the advantage in returns for sows kept for 7 to 10 parities (average of \$4.54/head) compared to sows kept for 4 parities (\$3.91) is less than half of what it was when gilts were valued at \$200 per head. On the other hand, with gilts valued at \$250 per head, keeping sows for 9 parities maximizes returns. At this higher gilt price, the advantage in returns for sows kept for 7 to 10 parities (average of \$1.37/head) compared to sows kept for 4 parities (-\$1.02) increases almost a dollar per head compared to when gilts were valued at \$200 per head. Although returns were maximized in all cases with sows kept for 8 or 9 parities, the advantage of doing so increases (decreases) as the price of replacement gilts increases (decreases).

Costs for both the gestation and lactation diets were varied by +/- 25% to determine how sensitive returns are to feed costs (Table 3). Although increasing or decreasing feed costs impacts the level of returns, it has almost no impact on relative differences between parity distributions. As feed costs increase, the optimal culling strategy is to sell sows slightly quicker, and when feed costs decrease, the optimal strategy is to keep sows a little longer. However, the changes are quite small. Therefore, from a management perspective, the optimal sow-culling strategy is basically invariant to feed costs, even though absolute returns are very sensitive to them.

Cost and return results presented in Tables 2 and 3 were based on the pigs weaned per litter and conception rate relationships with parity displayed in Figures 1 and 2. Because these factors have major impacts on economic returns, the relationships displayed in Figures 1 and 2 were modified to see what impact this had on optimal parity for culling sows.

Several alternative relationships between conception rate and parity were considered.

The first variation was to use the base conception rate (i.e., that shown in Figure 1) as well as conception rates that were +/- 10%. In other words, this answers the following question. What is the impact if the conception rate is higher or lower at every parity by 10% compared to the initial assumption? Another scenario considered the impact of starting at the same conception rate as the base scenario but decreasing at a faster or slower rate. In this scenario, conception rates were equal at parity 1, but then decreased to a level at parity 10 that was +/- 40% of the base scenario. Given these alternative scenarios, five conception rate-parity relationships were considered (base, base +10%, base -10%, +40% at P10, and -40% at P10). The steady state number of gilts purchased every month and the resulting parity distribution for each culling strategy were recalculated for each of these scenarios.

In addition to considering alternative conception rates, an alternative litter size by parity relationship was considered. The alternative was entirely hypothetical, because it was not estimated from previous research. The hypothetical scenario represents sows that reach their peak litter size at an earlier parity compared to the relationship displayed in Figure 1. Over 10 parities, the average litter size was held constant, but the distribution was changed. The reason for "shifting" the peak litter size to the left (i.e., at an earlier parity) was to see if this pattern in litter size by parity would result in optimal culling of sows after fewer parities.

The net returns per head for the various conception rate and litter size assumptions for the 10 different sow-culling strategies are given in Table 4. All cost and price assumptions are held constant at their original values. In the base scenario for both conception rate and litter size, returns were maximized when sows were culled after 8 or 9 parities (these are the same numbers as Line F in Table 2). At the alternative conception rates, returns also were maximized when sows were culled after either eight or nine parities. Additionally, when conception rates increased (base +10% and +40% at P10), the level of returns increased considerably. For example, with a strategy of culling sows after 8 parities, returns increased by 76¢ per head when conception rates increased 10% (\$3.79 vs. \$3.03). For an operation producing 24,000 pigs per year, 76¢ per head would equate to an increase in returns of \$18,240. Similarly, by decreasing the rate of decline in conception rates between parities (i.e., +40% at P10), returns increased by 50¢ per head (\$3.53 vs. \$3.03). Likewise, when conception rates decreased (i.e., base -10% and -40% at P10), returns decreased considerably. Furthermore, the increases and decreases were not symmetric. That is, a 10% decrease in conception rates had a negative impact on returns that was much greater than the positive impact from a 10% increase in conception rates.

When the litter size assumption was changed to the hypothetical scenario, net returns were maximized with sows being culled after their eighth parity for all conception-rate scenarios. With the exception of sows culled after their first parity, the level of returns increased with the hypothetical litter size by parity relationship compared to the base scenario, because larger litter sizes occur at the lower preweaning mortality rates. The information in Table 4 shows that the level of returns varies with productivity, but the OPD is quite robust over the conception rate and litter size scenarios considered.

**Table 1. Parity Distribution and Production from Sow Herd**

Item	Parity prior to Culling <sup>a</sup>									
	1	2	3	4	5	6	7	8	9	10
<u>Percent of farrowings from each parity (steady-state parity distribution)</u>										
Parity 1	100.0	53.6	38.2	30.7	26.4	23.3	21.4	19.7	18.5	17.7
Parity 2		46.4	33.2	26.6	22.7	20.2	18.6	17.0	16.2	15.5
Parity 3			28.6	23.0	19.5	17.4	15.9	14.7	13.9	13.2
Parity 4				19.8	16.8	15.2	13.6	12.7	12.1	11.4
Parity 5					14.5	12.9	11.8	10.9	10.3	10.0
Parity 6						11.1	10.0	9.5	8.9	8.6
Parity 7							8.6	8.2	7.6	7.3
Parity 8								7.3	6.7	6.4
Parity 9									5.8	5.5
Parity 10										4.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Average parity <sup>b</sup>	1.00	1.46	1.90	2.32	2.70	3.07	3.40	3.76	4.05	4.32
Sow inventory	1,220	1,196	1,188	1,184	1,184	1,182	1,182	1,179	1,179	1,180
Annual purchases	3,640	1,950	1,391	1,112	962	849	780	719	672	650
Replacement rate	298%	163%	117%	94%	81%	72%	66%	61%	57%	55%
Total litters/year <sup>c</sup>	2,860	2,860	2,860	2,860	2,860	2,860	2,860	2,860	2,860	2,860
Litters/sow/year	2.34	2.39	2.41	2.42	2.42	2.42	2.42	2.43	2.43	2.42
Pigs born alive/litter	9.25	9.49	9.68	9.83	9.93	10.01	10.04	10.06	10.05	10.03
Pigs weaned/litter	7.96	8.25	8.42	8.53	8.61	8.66	8.68	8.68	8.67	8.64
Pigs weaned/sow/year	18.7	19.7	20.3	20.6	20.8	20.9	21.0	21.1	21.0	20.9
Total pigs sold/year	22,756	23,599	24,078	24,399	24,614	24,758	24,823	24,839	24,792	24,704

<sup>a</sup>Represents the sow-culling strategy. For example, “3” indicates that sows are kept for three parities and then culled. Sows that do not breed back prior to their final parity are culled when they are open.

<sup>b</sup>Average parity is simply the weighted average parity. For example, the average parity for sows culled after their third parity is calculated in the following manner:  $(38.2\% \times 1 + 33.2\% \times 2 + 28.6\% \times 3) = 1.90$ .

<sup>c</sup>Based on 220 sows farrowing every 4 weeks.

**Table 2. Cost-Return Budget for a Farrowing-to-Weaning Pig Operation**

Item	Parity prior to Culling <sup>a</sup>									
	1	2	3	4	5	6	7	8	9	10
<b>VARIABLE COSTS PER PIG SOLD:</b>										
1. Grain	\$4.09	\$3.99	\$3.98	\$3.99	\$4.02	\$4.05	\$4.10	\$4.15	\$4.21	\$4.29
2. Protein	1.89	1.86	1.86	1.87	1.88	1.90	1.92	1.94	1.97	2.00
3. Base mix: vitamins, minerals, etc.	0.98	0.96	0.96	0.96	0.97	0.97	0.98	1.00	1.01	1.03
4. Pig starter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5. Feed processing	0.56	0.54	0.54	0.54	0.55	0.55	0.56	0.56	0.57	0.58
6. Labor	7.25	6.99	6.85	6.76	6.70	6.66	6.65	6.64	6.66	6.68
7. Veterinary, drugs, and supplies	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8. Utilities, fuel, and oil	1.32	1.27	1.25	1.23	1.22	1.21	1.21	1.21	1.21	1.21
9. Transportation and marketing costs	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10. Building and equipment repairs	1.18	1.13	1.10	1.08	1.07	1.07	1.06	1.06	1.06	1.07
11. Breeding/genetic charge										
a. Depreciation	16.83	7.54	4.87	3.67	3.06	2.63	2.38	2.18	2.02	1.97
b. Semen	2.01	1.94	1.90	1.88	1.86	1.85	1.84	1.84	1.85	1.85
c. Interest	0.80	0.80	0.79	0.79	0.79	0.79	0.79	0.78	0.79	0.79
d. Insurance	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
12. Professional fees (legal, accounting, etc.)	0.53	0.51	0.50	0.49	0.49	0.48	0.48	0.48	0.48	0.49
13. Interest on 1/2 variable costs	0.82	0.60	0.53	0.50	0.49	0.48	0.48	0.47	0.47	0.48
<b>A. TOTAL VARIABLE COSTS</b>	<b>\$40.34</b>	<b>\$30.20</b>	<b>\$27.21</b>	<b>\$25.83</b>	<b>\$25.17</b>	<b>\$24.72</b>	<b>\$24.53</b>	<b>\$24.39</b>	<b>\$24.38</b>	<b>\$24.51</b>
<b>FIXED COSTS PER PIG SOLD:</b>										
14. Depreciation on bldgs and equip	4.21	4.02	3.92	3.87	3.83	3.81	3.80	3.79	3.80	3.81
15. Interest on bldgs and equip	3.16	3.02	2.95	2.90	2.88	2.86	2.85	2.85	2.85	2.86
16. Insurance and taxes on bldgs and equip	0.78	0.74	0.73	0.72	0.71	0.71	0.70	0.70	0.70	0.71
<b>B. TOTAL FIXED COSTS</b>	<b>\$8.14</b>	<b>\$7.78</b>	<b>\$7.60</b>	<b>\$7.49</b>	<b>\$7.42</b>	<b>\$7.37</b>	<b>\$7.35</b>	<b>\$7.34</b>	<b>\$7.35</b>	<b>\$7.38</b>
<b>C. TOTAL COSTS PER PIG SOLD</b>	<b>\$48.48</b>	<b>\$37.98</b>	<b>\$34.81</b>	<b>\$33.32</b>	<b>\$32.60</b>	<b>\$32.10</b>	<b>\$31.88</b>	<b>\$31.73</b>	<b>\$31.73</b>	<b>\$31.90</b>
<b>D. GROSS RETURNS PER PIG SOLD</b>	<b>\$34.77</b>	<b>\$34.77</b>	<b>\$34.77</b>	<b>\$34.77</b>	<b>\$34.77</b>	<b>\$34.77</b>	<b>\$34.77</b>	<b>\$34.77</b>	<b>\$34.77</b>	<b>\$34.77</b>
<b>E. RETURNS OVER VC (D-A),\$/hd</b>	<b>-\$5.57</b>	<b>\$4.57</b>	<b>\$7.56</b>	<b>\$8.93</b>	<b>\$9.59</b>	<b>\$10.05</b>	<b>\$10.24</b>	<b>\$10.37</b>	<b>\$10.39</b>	<b>\$10.25</b>
<b>F. RETURNS OVER TC (D-C), \$/hd</b>	<b>-\$13.71</b>	<b>-\$3.21</b>	<b>-\$0.04</b>	<b>\$1.45</b>	<b>\$2.17</b>	<b>\$2.67</b>	<b>\$2.88</b>	<b>\$3.03</b>	<b>\$3.03</b>	<b>\$2.87</b>
<b>G. NET RETURN ON INVESTMENT</b>	<b>-12.8%</b>	<b>1.8%</b>	<b>6.5%</b>	<b>8.8%</b>	<b>10.0%</b>	<b>10.8%</b>	<b>11.1%</b>	<b>11.4%</b>	<b>11.4%</b>	<b>11.1%</b>

<sup>a</sup>Represents the sow-culling strategy (sows are culled after the parity number listed).

**Table 3. Sensitivity of Returns over Total Costs to Various Cost Assumptions**

Costs	Return over Total Costs, \$/hd									
	1	2	3	4	5	6	7	8	9	10 <sup>a</sup>
<u>Replacement Gilt, \$/hd</u>										
\$150 (-25%)	\$5.39	\$1.15	\$3.05	\$3.91	\$4.30	\$4.56	\$4.62	\$4.64	\$4.55	\$4.35
\$200 (base)	\$13.71	-\$3.21	-\$0.04	\$1.45	\$2.17	\$2.67	\$2.88	\$3.03	\$3.03	\$2.87
\$250 (+25%)	\$22.03	-\$7.57	-\$3.13	-\$1.02	\$0.04	\$0.79	\$1.15	\$1.42	\$1.52	\$1.39
<u>Gestation/Lactation Diets, \$/ton</u>										
\$100/\$107 (-25%)	-\$11.79	-\$1.33	\$1.84	\$3.33	\$4.07	\$4.58	\$4.82	\$4.99	\$5.02	\$4.89
\$134/\$143 (base)	-\$13.71	-\$3.21	-\$0.04	\$1.45	\$2.17	\$2.67	\$2.88	\$3.03	\$3.03	\$2.87
\$167/\$178 (+25%)	-\$15.64	-\$5.09	-\$1.92	-\$0.44	\$0.28	\$0.76	\$0.95	\$1.08	\$1.05	\$0.85

<sup>a</sup>1 to 10 = parity prior to culling.

**Table 4. Sensitivity of Returns over Total Costs to Productivity Assumptions**

Conception Rate Scenario	Return over Total Costs, \$/hd									
	1	2	3	4	5	6	7	8	9	10 <sup>a</sup>
<u>Litter size by parity relationship – “Base”</u>										
Base	\$13.71	-\$3.21	-\$0.04	\$1.45	\$2.17	\$2.67	\$2.88	\$3.03	\$3.03	\$2.87
Base + 10%	\$11.36	-\$1.85	\$0.94	\$2.26	\$3.04	\$3.54	\$3.66	\$3.79	\$3.63	\$3.59
Base –10%	\$16.84	-\$5.02	-\$1.51	\$0.27	\$1.15	\$1.61	\$1.77	\$1.90	\$1.87	\$1.87
+40% at P10	\$13.71	-\$2.96	\$0.35	\$1.80	\$2.67	\$3.19	\$3.42	\$3.53	\$3.54	\$3.43
-40% at P10	\$13.71	-\$3.66	-\$0.62	\$0.73	\$1.43	\$1.79	\$2.11	\$2.18	\$2.17	\$1.94
<u>Litter size by parity relationship – “Hypothetical”</u>										
Base	\$13.72	-\$2.80	\$0.50	\$1.95	\$2.59	\$3.00	\$3.12	\$3.18	\$3.14	\$2.98
Base + 10%	\$11.37	-\$1.45	\$1.47	\$2.76	\$3.45	\$3.85	\$3.86	\$3.91	\$3.71	\$3.66
Base –10%	\$16.85	-\$4.59	-\$0.95	\$0.79	\$1.59	\$1.96	\$2.03	\$2.10	\$2.03	\$2.02
+40% at P10	\$13.72	-\$2.55	\$0.89	\$2.31	\$3.08	\$3.50	\$3.63	\$3.64	\$3.60	\$3.49
-40% at P10	\$13.72	-\$3.26	-\$0.09	\$1.24	\$1.87	\$2.14	\$2.36	\$2.38	\$2.33	\$2.11

<sup>a</sup>1 to 10 = parity prior to culling.