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The Effect of Breeding Herd Parity Structure on Genetic Improvement of the Sow Herd

Caitlyn E. Abell
Western Kentucky University

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by

CAITLYN E. ABELL

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Approved by:

Gordon F. Jones

Kenneth J. Stalder

Amy Chester

THE EFFECT OF GENETIC LAG AND ITS ASSOCIATED ECONOMIC VALUE ON GILT REPLACEMENT DECISIONS IN COMMERCIAL SWINE BREEDING HERDS

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Under the Direction of Gordon F. Jones

ABSTRACT

This study focuses on the value of the genetic lag associated with maintaining sows for additional parities in a commercial swine herd. Three traits were included in this study: number born alive (NBA), 21 day litter weight (W21), and days to market (D250). The economic values assigned to these traits were $22.00/pig, $0.70/lb., and $0.17/day, respectively. The genetic improvement per generation made for each trait was assumed to be 0.3 pigs, 3.0 lbs., and 3.0 days, respectively. It was estimated that the value of the genetic lag associated with retaining a sow to P3, P5, and P7 was $24.80, $46.89, and $73.97 in a herd whose seedstock supplier has a generation interval of 1.5 years. This minimal loss does not justify the costs of developing a gilt and decreased P1 production. Therefore, sows should remain in the breeding herd until culling for non-voluntary reasons or inferior production becomes necessary.

INDEX WORDS: Genetic lag, Generation interval, Parity, Sow, Swine

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CAITLYN E. ABELL

Committee Chair: Gordon Jones

Committee: Kenneth Stalder

Amy Chester

Electronic Version Approved:

Honors College

Western Kentucky University

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INTRODUCTION

The ultimate goal of swine producers is to optimize net returns/pig marketed from their operation. Various production parameters are related to profit potential in any swine production system. Profit potential is greatly influenced by input costs, the major one being feed cost. Feed inputs account for 73.4% of the costs associated with pig production from farrow to finish (Kliebenstein et al., 2007). Since a substantial portion of the U.S. corn crop is now being devoted to ethanol production (20.5%) (Ethanol Across America, 2008), corn prices have risen significantly during 2007 and 2008. The USDA reports that the price of #2 yellow corn increased from $2.09/bu. in August 2006 to $5.26/bu. in August 2008. This has caused feed costs to become an increasingly larger proportion of production costs from 2006 to present. Other major input costs include overhead (principle, interest, depreciation, etc.), labor, utilities, veterinary/medical, and the cost of breeding stock or genetic resources for each operation. The breeding stock or genetic resources are used to improve the production level of the herd.

The goals of the genetic component of most commercial swine operations are to increase pigs marketed per sow per year (P/S/Y), to decrease the number of days required for finishing and to improve carcass cutability and/or carcass quality. Increasing the P/S/Y is important to raise the number of market hogs produced by the operation without having to increase the number of sows. This decreases the variable and fixed costs per pig produced and maximizes throughput (output per unit of fixed costs or assets). Additionally, increasing the pigs' growth rate should decrease the amount of feed required to produce a market hog and decrease the associated number of days in the finishing phase. An increase in the carcass cutability increases the revenue obtained per pig for producers who market pigs on a carcass merit basis. Each of the factors have the potential to affect the financial status of the operation which is critical for the viability of not only the indivual operation but also the swine industry.

Theoretically, genetic progress toward improving the profitability of commercial producers steadily occurs in great-grandparent (GGP) and grandparent (GP) herds. For purposes of this paper, it will be assumed that the same rate of genetic progress will occur whether the commercial producer is purchasing replacements or using an "in-house" or internal multiplication approach for replacement gilt production. As a result, commercial producers should be improving the aggregate genetic value (AGV) of the sowherd with each progressive generation.

Sows can be replaced in the herd for both non-voluntary and voluntary reasons. Non-voluntary replacement results when the producer must remove the female from the breeding herd because she is unproductive due to reproductive or structural reasons. This replacement is referred to as culling. Reasons sows were culled are shown in Table 1 (Lucia et al., 2000).

Table 1: Reasons for culling (Lucia et al., 2000)

Reason for Culling	Percent of All Culling
Reproductive Failure	33.6
Litter Performance	20.6
Miscellaneous	13.3
Locomotion	13.2
Old Age	8.7
Death	7.4
Disease/Peripartem	3.1

Voluntary culling occurs when a sow reaches the maximum parity that the operation allows or production levels become unacceptable. Voluntary culling, non-volunary culling, and gilt replacement determine the parity structure of the sow herd. The recommended ideal parity distribution of a sow herd is shown in Table 2.

Table 2: Ideal Parity Structure by Percent (Stalder et al, 2004)

Parity	Straw (1984)	Parsons et al (1990)	Muirhead and Alexander (1997)	Morrison et al (2002)
0	20	30	17	19.1
1	18	23	15	16.5
2	17	19	14	16.9
3	16	14	13	14.1
4	15	10	12	10.2
5	14	5	11	8.2
6	–	2	10	5.1
7	–	1	5	4.9
8+	–	0	3	4.9

The producer should diligently monitor each sow’s production record. For reasons such as infertility or structural unsoundness, a decision for non-voluntary or involuntary culling must be made. Once decisions have been made for sows that must be non-voluntarily culled, the process for voluntary culling can be determined. The parity chosen for the voluntary culls will be the parity that the producer determines will optimize the operation’s production. This is the parity at which the producer judges that the sows become less productive than the standard set by the herd. This determined parity results in a variable herd parity structure; meaning the percent of sows in the breeding herd at each parity varies (Dhuyvetter, 2000). Varibles that the producer should consider when setting the parity limit or maximum for the herd include the AGV of replacement gilts compared to sows in the herd, the value of the genetic loss associated with maintaining sows for additional parities, the cost of obtaining and developing new gilts to replace the sows, the lower levels of production by parity 1 (P1) females, and the declining production of high parity (P7+) sows.

The AGV of replacement gilts is assessed and a determination is made whether the replacement gilts' AGV would be higher than the current sows' genetic potential to increase P/S/Y, decrease days to market, and improve the carcass cutability/quality of the operation. If the determination is made that the genetic potential is in fact greater, the producer must still consider the cost of the replacement gilt, development costs and the lower P1 production. Burkey et al. (2008) found there were higher IgG and IgA concentrations in the serum of the progeny of the P3 females than P1 females. The higher immunoglobulin levels in the piglets may account for at least a portion of the increased growth rate of the piglets produced from sows that are in their second parity or greater.

A maternal line selection index is used for four traits. In the maternal line index, maternal traits (NBA and W21) are given 2/3 relative weighting and terminal traits (D250 and backfat) are given 1/3 relative weighting (National Swine Improvement Federation [NSIF], 1999). If a swine operation is practicing internal gilt multiplication, selection should logically be based on some type of maternal line index to ensure that genetic improvement occurs for NBA, W21, D250, and carcass cutability/quality. By use of an appropriate selection scheme, successive generations of replacement gilts should produce at a greater level than previous generations and aid in ensuring that producers will remain profitable. In other words, a commercial producer utilizing within herd or internal gilt multiplicaion is responsible for some of the genetic improvement needed by the operation to remain viable.

The cost of obtaining and developing replacement gilts is a variable that must be considered. The genetic gain resulting from bringing a new gilt into the herd may not offset the costs associated with the purchase and development of the replacement. However, at some point the cost is unavoidable in order to keep a commercial pork operation producing and in business. It is important to note that a gilt does not have as high NBA as a sow (Gama & Johnson, 1993; NSIF, 1997; Whittemore, 1998) because gilts do not reach production maturity until approximately P3. The value of a cull sow usually does not cover the costs of a bringing a new replacement gilt into the breeding herd. From 1996 to 2005, the average price of a cull sow weighing 136-205kg (300-450lbs.) was between $99.28 and $149.65, and the average price of a cull sow weighing 205-227kg (450-500lbs.) was between $164.00 and $181.60 (Fitzgerald et al., 2008). Based on data from the 2000 National Pork Producers Council (NPPC) Maternal Line National Genetic Evaluation Program, the average weight for a P1 female was 181.1kg and the average weight for a P4 female was 221kg (Moeller et al., 2004). This would suggest that sows culled at later parities would have greater economic value at culling when compared to sows culled at earlier parities. A herd practicing internal gilt production would likely receive a somewhat reduced value for the gilts not chosen to be replacement gilts because they are typically sold as market hogs and are discounted if they exceed the packer's buying matrix which is usually around 135 kg (300lbs.).

Typically, a producer employing an internal gilt multplication program incurs several costs for maintaining this type of production. First, maternal line animals usually have less value as market hogs because they are fatter, have less muscle, and convert feed to marketable weight less efficiently when compared to standard terminal production. This is especially true of maternal line barrows. Secondly, increased management is needed to track replacement gilts as they grow through the production system. The associated increased management results in additional producer expense. Thirdly, a producer using an internal multiplication program is responsible for at least some genetic improvement. At a minimum, this increases the cost that must occur through selection. This could even mean weighing and ultrasonically evaluating all replacement gilt candidates, all of which ultimately is an expense to the producer. Finally, if a producer has greater selection intensity than his supplier normally would have, this results in needing a greater number of gilts produced to meet the number of gilts needed by the operation to maintain maximum production efficiency.

Seedstock suppliers, who are in the business of selling replacement gilts, have encouraged swine producers to have high replacement rates for the sows in their herds. Their argument for this relatively high replacement rate is that the superior AGV of the replacement gilts more than offsets the purchase price and the costs of developing the gilts. This, of course, is economically beneficial to the seedstock supplier whose primary focus is selling gilts and who obtains a genetic premium for each gilt sold. However, the swine producer does not receive a net gain from his sow until she has been kept for several parities. For example, a gilt costing $200 usually does not pay for herself until she reaches P3 (Stalder et al., 2000).

The AGV of replacement gilts compared to sows in the herd, the value of the genetic loss associated with maintaining sows for additional parities, and the cost of obtaining and developing new gilts to replace the sows are all important when commercial pork producers make a decision regarding when to voluntarily cull sows from a breeding herd. This study relates specifically to the value of the temporary genetic loss associated with maintaining sows for additional parities. The objective was to assign an economic value to the average temporary genetic loss associated with different herd parity structures. This has great significance for commercial swine producers and their ability to cost-effectively maintain a commercial pork production system.

Capstone Experience/Thesis Organization

A paper to be submitted to the *Professional Animal Scientist* is included as a part of this thesis. The paper follows the literature review section.

LITERATURE REVIEW

The review of literature will focus on genetic gain theory in relationship to parity structure of commercial sow herds. It is organized by selected topics including production by parity, genetic gain theory, gilt selection, gilt development, and non-voluntary culling.

Production by Parity

The National Swine Improvement Federation (NSIF) Guidelines (1997) for Uniform Swine Improvement provide standardized adjustment factors for partity performance measures. Included in these parity performance measures are NBA and W21. The adjustment factors for both traits are listed in Table 3. The adjustment factors can be interpreted as the difference in performance between sows at the parity and the mature equivalent (ME). Sows in parities before and after the ME age have lower performance.

Table 3: Adjustment factors (NSIF, 1997)

Parity	NBA (pigs)	W21 (lbs)
1	1.2	6.2
2	0.9	0.0
3	0.2	1.0
4	0.0	3.8
5	0.0	6.2
6	0.2	9.5
7	0.5	11.6
8	0.9	15.2

Whittemore (1998) reported a somewhat different correction factor for NBA. The reported factors noted by Whittemore are 1.0 for P1 and1.0 for P8.

Burkey et al. (2008) conducted a study with 4 P1 females, 20 of their progeny, 5 P3 females, and 20 of their progeny to determine the immunoglobulin (Ig) levels in the colostrum of the dams and in the piglets. They found that P3 females have higher IgG concentrations in their colostrum and milk than P1 females ($P < 0.05$). There was no signficant difference in the IgA concentrations in the colostrum and milk of the two parities ($P > 0.05$). However, there were higher IgG and IgA concentrations in the serum of the progeny of the P3 females than the P1 females. The higher Ig levels in the piglets may account for the increased growth rate of the piglets.

A sow's production changes as she reaches different parities. Gama and Johnson (1993) conducted a study to examine the association of selecting for litter size and ovualtion rate, uterine capacity, uterine dimensions, and parity performance. They utilized three groups as follows: one sample from the Nebraska Gene pool which was the control line (RS), one sample from a line selected for litter size (LS), and one sample selected using an index of ovulation rate and embyronic survival (I). Gama and Johnson (1993) crossed the RS and LS lines with the I line. Additionally, they used the purebred lines in their study. In regards to number born alive by parity, the researchers consistently found that P2 sows on average farrowed 1.2 more pigs per litters than P1 sows. They also found that there was on average an increase of 0.5 in NBA from P2 to P3.

Moeller et al. (2004) analyzed data from the 2000 NPPC Maternal Line National Genetic Evaluation Program to examine P1 through P4 production utilizing six maternal lines of females including lines from American Diamond Genetics (ADSG), Danbred North America (DB), Dekalb-Monsanto DK 44 (DK), Dekalb-Monsanto GPK347 (GPK347), Newsham Hybrids (NH), and National Swine Registry (NSR). The total number studied included 3,599 females; 1,656 completed four productive parities. Findings in all maternal lines showed that the change in NBA was not statistically significant from P1 to P2 ($P > .05$). When comparing the change in NBA from P2 to P3, an increase was noted for ADSG (9.16

pigs to 9.39 pigs) and DB (9.80 pigs to 10.32 pigs) (*P* < .05). Moeller et al. (2004) further reported NBA from P2 to P3 decreased for DK (10.44 pigs to 10.22 pigs) and NH (9.60 pigs to 9.49 pigs) (*P* < .05). These results could be due to the differences among the lines used in the study.

Moeller et al. (2004) reported an increase in the litter weight of live pigs at birth from P1 to P2 for DK (15.22 kg to 16.84 kg) and GPK347 (14.45 kg to 16.32 kg) (*P* < .05). The litter weights for the NH line decreased (15.67 kg to 15.14 kg) from P2 to P3 (*P* < .05). From P3 to P4 increased litter weights were observed for the ADSG line (15.94 kg to 16.20 kg) while a decrease was observed in litter weights for the NH line (15.14 kg to 15.07 kg) (*P* < .05). This suggests that litter production varies among differenet lines of females.

Moeller et al. (2004) found no change in W21 from P1 to P2 for any line (*P* > .05). A decrease in W21 from P2 to P3 was reported for the DK (50.7 kg to 48.9 kg), GPK347 (49.9 kg to 49.2 kg), NH (50.3 kg to 48.6 kg), and NSR (51.6 kg to 51.0 kg) lines (*P* < .05). Additionally, when comparing weaning weights for these two parities a statistically signficant increase was not observed for any line (*P* > 0.05). From P3 to P4, weaning weights in the DK (48.9 kg to 47.9 kg), GPK347 (49.2 kg to 47.5 kg), and NH (48.7 kg to 48.5 kg) lines decreased signficantly (*P* < .05) (Moeller et al., 2004).

The farrowing interval was also examined by Moeller et al. (2004). A statistically signficant change in the farrowing intervals between P1 and P2 and between P2 and P3 was not observed for any lines. A statistically signficant decrease in the farrowing interval between P2 and P3 and the farrowing interval between P3 and P4 farrowing interval was reported for ADSG (143.8 days to 141.9 days) and NH (144.4 days to 141.2 days) (*P* < .05) (Moeller et al., 2004).

In summary, Gama and Johnson (1993) reported an increase in litter size from P1 to P2 and from P2 to P3. Even though the NSIF Guidelines (1997) and Whittemore's (1998) corrections were not the same, they both indicated an increase in litter size with increasing parities until the mature equivalent was reached. Findings from Moeller et al. (2004) were somewhat inconsistent as they did not report a change in litter size from P1 to P2 and reported an increase in litter size from P2 to P3 in only two of the six lines studied. This could be because of the different selection indices that had been used for the lines.

Genetic Gain Theory

The rate of genetic gain is calculated as follows: $\Delta G = \frac{iA\sigma p}{L}$ where ΔG is the amount of genetic gain, i is the seletion intensity, A is the accuracy of the trait in question, σ_p is the amount of variance of the trait, and L is the generation interval (Bourdon, 1997; Whittemore, 1998). There is a positive correlation between the genetic gain and each component of the equation except for generation interval. There is a negative correlation between generation interval and genetic gain.

The selection intensity is determined by the number of gilts retained as replacements in relation to the number of gilts available for selection. A high selection intensity would mean that the producer is able to choose a relatively small number of replacement gilts from a large number of available gilts. This can be achieved by choosing fewer replacement gilts with a constant number of available gilts or by increasing the number of available gilts and choosing the same number of replacements. A low selection intensity would mean that the producer is selecting a high proportion of the available gilts to become replacement gilts. High selection intenstity allows for the selection of replacements that are well above average genetically. Low selection intensity would force a producer to choose replacements that are closer to average or even below average in some cases. This may result in offspring that are closer to average or even below average. Table 4 shows the selection intensity resulting from the proportion of available animals selected (Bourdon, 1997).

Table 4: Selection intensity expected from truncation selection (Bourdon, 1997)	
Proportion Saved	Selection Intensity
.10	1.76
.20	1.40
.30	1.16
.40	.97
.50	.80
.60	.64
.70	.50
.80	.35
.90	.20
1.00	.00

The accuracy of selection is based largely on the heritability of the trait. The heritability is the proportion of the total phenotypic variance associated with a trait that is due to genetic, rather than environmental, factors. An increased heritability means that the trait is influenced relatively less by environmental factors and can more easily be improved just by breeding animals with a higher genetic potential or having superior individual performance for the trait (Bourdon, 1997). NSIF (2002) reported heritability estimates of 10% for NBA, 15% for W21, 30% for D250. Rothschild and Bidanel (1998) reported heritability estimates of 9% for NBA and 17% for W21. Accuracy is also influenced by the records kept on the sows used in the breeding program. Having more performance records increases the accuracy of selection by giving producers more information about the breeding value of the animal. The accuracy is increased because the realized genetic potential of the animal is evident by the performance records.

The variance is the amount of variability among the breeding values in the herd. Having a higher variance allows breeders to select animals that are farther away from the mean breeding value for the trait of interest. Without adequate variance, little improvement can be made (Bourdon, 1997; Whittemore, 1998).

The generation interval is the average age of parents when their offspring are selected to replace them (Bourdon, 1997). The generation interval is calculated by taking the reciprocal of the annual replacement rate for the population (Sellers, 1994). This is the time needed to completely replace the herd. Decreasing the generation interval increases the rate of genetic change that can be made in the herd (Bourdon, 1997).

Gilt Selection

Gilt selection is an ongoing process. The rate at which replacement gilts are purchased from the genetic supplier or produced in an internal gilt multiplication program must balance the rate at which sows are culled. Gilts are often selected using a selection index. The selection index theory was proposed by Hazel (1943). Selection indices should be developed to match current levels of prouduction when the index is developed, and the relative economic value for each trait is found. The genetic gain of each trait included in the index is given an economic value based on the profit expected from improving the trait. This allows the producers to quantiatively evaluate replacement animals (gilts and boars) and gives a means of comparison to enhance the selection process (Bourdon, 1997). Selection indices allow producers to make selection decisions based on the traits that are economically influential in their operation. Further, simultaneous selection for several traits can occur at once. However, one should remember the greater number of traits included in a selection index or selected upon individually, the slower the rate of progress for any one trait occurs.

Maternal line selection by most genetic suppliers is likely based on some type of index, such as the National Swine Registry Maternal Line Index (MLI) which is used as the primary selection tool for purebred seedstock suppliers. The indices used by large commercial seedstock suppliers are proprietary information and not commonly publically available; however, selection is most likely based on an index of the traits described in this thesis. The MLI considers both maternal and terminal traits in selection. Maternal traits are given 2/3 weight while terminal traits are given 1/3 weight (NSIF, 1999). Replacement gilts can either be obtained by purchasing new replacement gilts from seedstock suppliers or by practicing internal multiplication of gilts. If internal gilt multipication is practiced, then a major portion of the genetic change results from the selection of superior maternal line boars or semen from elite maternal line boars.

The goal of seedstock suppliers is to market a high percentage of the gilts produced, maybe as high as 70-90% of the gilts. This means that there is little selection intensity associated with purchasing gilts from a seedstock supplier. Producers purchase replacement gilts from a seedstock supplier based on the assumption that the genetic potential of the purchased gilts exceeds the current genetic level of their herd. Seedstock suppliers assume that genetic progress has been made from the superior great-grandparent and grandparent stocks. The older stocks have been selected based on phenotypic records and genetic evaluation of breedig values while the gilts are selected based on assumed genetic potential. The seedstock suppliers do not generally keep performance records (average daily gain, backfat, loin muscle area, D250, etc.) on the gilts that are sold to commercial producers which decreases the accuracy of selection.

When practicing internal gilt multiplication, a producer often has a higher selection intensity than a seedstock supplier. More gilts than needed as replacements are often available for the producer to make selections. Also, a producer replacing his sows “in-house” is able to keep performance records for the mothers producing the replacement gilts and the replacement gilts themselves which increases the accuracy of selection.

Producers must also consider the value of a cull sow when deciding whether or not to remove sows from the herd. Cull sow values, particularly for lighter weight sows, are generally not as high as the value of market hogs. Increasing the body condition score of the sow will improve her cull sow value (Fitzgerald et al., 2008). The average price of cull sows by weight from 1996 to 2005 is shown in Table 5.

Table 5: Cull sow value by weight (Fitzgerald et al., 2008)

Weight of Cull Sows	Cull Sow Value
136-205kg (300-450lbs)	$99.28 - $149.65
205-227kg (450-500lbs)	$164.00 - $181.60
227-250kg (500-550lbs)	$188.41 - $207.50
250-341kg (550-750lbs)	$217.50 - $296.67

This implies that it may be advantageous to retain sows in the herd for additional parities in order to increase their cull sow value. Sows become heavier with increasing parities up to at least P4 (Rozeboom et al, 1996; Moeller et al. 2004). Larger more highly conditioned sows generally sell for greater economic values when used in the sausage processing industry.

Gilt Development

Gilts in the 2000 NPPC National Maternal Line Genetic Evaluation Program had an average age at first estrus of 221 days or approximately 7 months of age (Moeller et al., 2004). Rozeboom et al. (1996) reported average first estrus of 172 days with a standard deviation of 31.3 days. Williams et al. (2005) reported an NBA advantage of 1.1 for gilts bred at the second estrus versus the first estrus ($P < .05$). Young and King (1981) examined the differences in reproductive performance of gilts mated at first estrus and gilts mated at third estrus using 112 Yorkshire gilts. The conception rate at first breeding was 7.8% higher for gilts mated at the third estrus. Number born alive for gilts bred at first versus third estrus was not statistically significant ($P > 0.10$).

Prior to breeding, selected gilts are acclimated into the herd by exposure to older sows in the herd. This integration allows the new gilts to develop immunity against the pathogens present in the sow herd. In addition to exposure to herd pathogens, vaccines should be administered at least 2 weeks prior to breeding for disease prevention. Time should be allotted for the administration of two doses of vaccine 4 weeks apart (Vansickle, 2004). In order to accomplish this, gilts must enter the herd at least 5-6 weeks before being bred.

Chiba (2004) reported that approximately 5-10% of all gilts are non-breeders and 20-30% are "questionable". This leaves only 60-70% of the retained gilts that will become productive in the breeding herd. Stalder et al. (2000) noted an "assumed" value of 10% for the percentage of selected gilts that will not enter the breeding herd. Moeller et al. (2004) reported that only 80% of the gilts selected for the 2000 NPPC Maternal Line National Genetic Evaluation Program project actually farrowed.

Rozeboom et al. (1996) conducted a study to analyze the effect of age and body composition of gilts at first breeding on lifetime reproductive performance. The study included 87 Landrace × Yorkshire gilts. Eight prebreeding strategies were incorporated in the study. Gilts were bred at puberty, second estrus, or third estrus. The gilts not bred at puberty were fed three different rations: high energy, maintenance, and ½ maintenance. Some gilts being fed the two low energy diets became anestrous and were fed higher energy rations to resume their estrous cycle. There was no relationship among gilt body composition and NBA or preweaning survival ($P > .10$). Number born alive and preweaning survival may be more influenced by the age of the gilt. With an additional estrus before breeding, the piglet birth weight at P1 was increased by 34 g on average. Slightly heavier piglets were produced from older gilts with greater fat reserves overall.

The studies show that there is a need to develop gilts past their first estrus in order to maximize their reproductive life. However, the costs associated with this development must be considered when examining the economic rewards of more rapid sow herd turnover or relatively higher replacement rates. Therefore, it is critical that gilt development be properly carried out to enhance the production of the herd.

Reasons for Non-voluntary Culling

The reasons for culling can include reproduction failure, locomotion problems, low productivity, illness, and old age (D'Allaire, 1987). Reproduction failure includes a sow becoming anestrous, failing to conceive, etc. Locomotion problems include lamness, sickle-hocks, weak pasterns, etc. Low productivity may include low performance for NBA, number weaned, W21, etc.

D'Allaire et al. (1987) conducted a study to determine the culling patterns of 89 commercial swine breeding herds in Minnesota. There were 7,242 culled females analyzed during the 12-month study. The top two reasons for overall culling were reproductive failure and inadequate performance. The greatest percenatge of P0 females were culled due to reproductive failure and transfer to another herd for breeding purposes. The greatest percenatge of P1 females were culled due to reproductive failure and death. The greatest percenatge of P2 to P6 females were culled due to reproductive failure and inadequate performance. The greatest percenatge of P7+ females were culled due to old age and inadequate performance.

Lucia et al. (2000) conducted a study on the lifetime performance of sows with distinct culling reasons. The study used data compiled by PigCHAMP for 5 years from 28 herds. This included 7,973 females. Their findings are presented in Table 6. Reproductive failure (33.6%) and litter performance (20.6%) were the two main reasons for overall culling. For P0 and P1 females, the top two reasons for culling were reproductive failure and locomotion. Reproductive failure and litter performance were the two main reasons for P2 to P6 sows. For P7+ females, old age and litter performance were the two main reasons for culling.

Table 6: Reasons for overall culling and culling by parity (Lucia et al., 2000)

		Parity							
Reason for Culling	Percent of All Culling	0	1	2	3	4	5-6	7-8	9+
Reproductive Failure	33.6	64.5	43.5	31.9	28.9	24.7	21.1	12.3	7.5
Litter Performance	20.6	-	14.5	23.7	26.6	32.3	30.4	27.5	21.5
Miscellaneous	13.3	13.2	14.2	14.3	15.6	15.4	13.6	9.5	5.3
Locomotion	13.2	14.4	17.5	16.4	15.6	12.4	11.6	7.1	4.4
Old Age	8.7	0.2	0.1	0.3	1.0	2.3	12.0	36.3	54.1
Death	7.4	5.6	7.0	9.8	9.3	9.2	7.6	5.3	4.4
Disease/Peripartem	3.1	2.1	3.2	3.5	2.9	4.2	4.1	1.9	2.5

Hughes and Varley (2003) reviewed 12 previous studies related to reasons for culling. They compared the reported causes for overall culling and noted reproductive failure was the number one reported reason for culling in 10 of the 12 studies. They analyzed findings from these previous studies and found that 61% of early culls were due to reproductive failure.

In the review, the main reason for nonvoluntary culling at P1 and P2 was reproductive failure, for P3 to P7 it was health problems/death and reproductive failure, and for P8+ it was old age. Premature culling was reported as a major concern; the researchers stated that only about 20% of females reached an age in which culling decisions need to be made (Hughes & Varley). Non-voluntary culling is noted as a concern for those in the pig industry. D'Allaire et al. (1987), Lucia et al. (2000) and Hughes and Varley (2003) reported reproductive failure as the main reason for culling. Additionally, old age was noted as the number one reason for culling after P7 (D'Allaire et al.; Lucia et al.; Hughes & Varley). Sows making it to older parities would have been producing large litters previously, and clearly do not have reproductive problems. Therefore, older parity sows would be culled due to age rather than production performance.

Sow mortality is a concern for swine operations. Understanding why sows are dying can help producers to reduce the percent of culls due to death. Table 7 shows the causes of death by percent from three different studies.

Table 7: Causes of death by percent

Cause of Death	Chagnon et al. (1991)	Sanford et al. (1994)	Irwin et al. (1999)
Torsions/gastrointestinal accidents	15.3	47.4	–
Gastritis	3.6	21.0	12.9
Retained fetuses/toxemia	–	10.5	–
Heart	31.4	5.2	4.0
Cystitis-pyelonephritis	8.0	2.6	2.2
Pneumonia	3.6	2.6	9.9
Musculo-Skeletal	–	–	38.2
Streptococcus suis meningitis	–	2.6	–
Reproductive System	6.6	–	12.1
Uterine Prolapse	6.6	–	–
Downer Sow Syndrome	2.2	–	–
Other	8.0	5.2	8.9
Undiagnosed	14.6	2.6	11.8

Gastrointestinal, reproductive, and heart problems seem to be the most prevalent cause of death to sows in the breeding herd. The causes of death with the highest average age of sows were uterine prolapse at P6 (Chagnon et al., 1991), and heart failure at 3.0 years (Sanford et al., 1994).

When reviewing the literature, there is little information regarding the economic value of the genetic gain associated with replacing sows with gilts. Therefore, the objective of this project was to examine the economic value of the genetic loss associated with retaining sows for additional parities.

THE EFFECT OF GENETIC LAG AND ITS ASSOCIATED ECONOMIC VALUE ON GILT REPLACEMENT DECISIONS IN COMMERCIAL SWINE BREEDING HERDS

C. E. Abell*, G. F. Jones*, and K. J. Stalder[†]

*Department of Agriculture, Western Kentucky University, Bowling Green, Kentucky 42104
[†]Department of Animal Science, Iowa State Unversity, Ames, Iowa 50011

ABSTRACT

The objective of this study was to estimate the value of the genetic lag associated with maintaining sows for additional parities. To estimate the value of the genetic lag, a spreadsheet was developed in which the culling rate by parity, the generation interval, assumed genetic potential for each trait, and the economic values for each trait can be changed. Three traits were included in this study: number born alive (NBA), 21 day litter weight (W21), and days to market (D250). The economic values assigned to these traits were $22.00/pig, $0.70/lb., and $0.17/day, respectively. The genetic improvement per generation made for each trait was assumed to be 0.3 pigs, 3.0 lbs., and 3.0 days, respectively. Backfat was not included in this study because of the lack of genetic improvemnt being made in the trait. It was determined that the value of the genetic lag associated with retaining a sow to P3, P5, and P7 was $24.80, $46.89, and $73.97 in a herd whose seedstock supplier has a generation interval of 1.5 years. Using the spreadsheet to determine the herd parity distribution developed by Dhuyvetter (2000), an average economic value for each sow in a herd was calculated. With a 19% culling rate by parity, the average value of the genetic loss in herds with forced culling at P3, P5, and P7 was $15.41, $22.45, and $29.29. This minimal loss does not justify the costs of developing a gilt and decreased P1 production. Therefore,

sows should remain in the breeding herd until culling for non-voluntary reasons or inferior production becomes necessary.

Key Words: Genetic lag, Generation interval, Parity, Sow, Swine

INTRODUCTION

The goal of a commercial farrow-to-finish or breed-to-wean pork operation is to make each replacement gilt more profitable/productive than the sow being replaced. Genetic progress needs to be optimized in order to make phenotypic improvement in economically important traits for a pork operation. To accomplish this, replacement rate, parity management, genetic gain, and genetic lag must be optimized (Hughes and Varley, 2003). The next generation has to obtain at least a portion of the predicted genetic gain (called realized genetic gain) so that their production potential is greater than the previous generation.

Reduced productivity should be anticipated when replacing a sow with a gilt based on parity differences in NBA, W21, etc. (Gama and Johnson, 1993; NSIF, 1997; Whittemore, 1998). If producers attempt to obtain maximum genetic gain by utilizing a replacement rate that is 60% or greater, negative production and hence economic consequences are likely. This is a result of attempting to attain a relatively small amount of genetic improvement by reducing generation interval at the commercial sow herd level at the expense of a potentially large production loss (NBA, number weaned, W21, etc.). The drawback to keeping sows in the breeding herd of a commercial sow herd for an extended period is that sows older than the maximum mature equivalent parities (usually parities 3 through 5) often do not perform as well as young sows (NSIF, 1997; Whittemore, 1998). When a replacement gilt is as productive or even more productive than sows from greater parities, the older sows can become less economically efficient to maintain in the breeding herd.

A sow should not be culled from the breeding herd voluntarily before she has “paid” for herself. This typically is around the third or fourth parity (Stalder et al., 2000 and Stalder et al. 2003). If she is removed from the herd before she pays for herself, she has not been sufficiently productive to become profitable. The animal replacing her is likely from the same generation of animals, and hence, little or no genetic difference is expected between the two animals.

From an economic viewpoint, Rodriguez et al. (2006) reported that the optimal sow removal parity was 4 or 5. This is the optimal parity for a sow to be most profitable to the producer based on salvage value and sow replacement cost. Dhuyvetter (2000) determined the optimal removal parity of a sow to be 8 or 9. The study focused on the cost of a replacement gilt as the main factor for when a sow should be replaced in order to be most profitable. Neither study took the genetic effects into consideration when determining optimal culling parity.

The objective of this study was to determine the value of the genetic loss associated with retaining sows in a commercial herd for additional parities. With this information, commercial producers would be able to optimize genetic gain by developing better parity management strategies in cases where excessive replacement rates are occurring. Replacing sows with gilts at a more opportune time should minimize pig throughput reduction when sows are replaced.

MATERIALS AND METHODS

An Excel spreadsheet was developed to determine the optimal parity for a sow to be replaced in the breeding herd taking into consideration generation interval of the seedstock supplier as well as the genetic progress for economically important maternal traits. The spreadsheet involved a sensitivity analysis for generation intervals. The values were chosen based on generation intervals from seedstock suppliers (personal communications). A spreadsheet based on the values reported in Dhuyvetter (2000) to determine herd parity structure was used for the calculations. The different herd parity structures are distinguished by the maximum number of parities a sow is allowed to reach before being culled from the herd and the replacement rate per parity. Once the maximum parity is reached by the sows, they would be voluntarily culled. The spreadsheet was designed to determine a herd parity structure based on the maximum parity a sow is allowed to reach and the rate at which sows are replaced in the herd.

In this study, genetic lag of the commercial breeding herd associated with maintaining sows in the herd for additional parities was calculated using the following generation intervals for the seedstock suppliers: 1.5, 2.0, 2.5 and 3.0 years. The genetic gain assumed for the three traits was 0.3 pigs born alive per litter per generation interval, 3 lb. per litter for 21-day litter weight per generation interval, and 3 fewer days to market per generation interval. Then the combinations were compared with the different parity structures. The genetic gain was given economic values by multpliying the assumed genetic improvement by the econimic value associated with the trait of interest. The economic values associated with each trait were obtained from Swine Testing and Genetic Evaluation System

(STAGES) (NSR, 2009). The economic values given for each trait were $22 per pig born alive, $0.70 per lb. of 21-day litter weight, and $0.17 per day to market.

Number born alive and 21-day litter weight are maternal traits and only expressed by the sow herself while days to market and backfat are terminal traits expressed in each pig produced by the sow as well as the sow herself. Therefore, the genetic lag value was calculated as the total of the direct values for the maternal and terminal traits multiplied by improvement made per generation and each terminal trait's value multiplied by the improvement made per generation and by the number of offspring produced.

Generation Interval

The generation interval for the seedstock supplier was used to determine the genetic improvement made after each parity. The longer the generation interval resulting at the nucleus and multiplier levels of seedstock production, the longer the genetic lag before the improvement is realized at the commercial herd level. This study compared the improvement made at differing generation intervals with the production from retaining sows to examine the profitability with the interaction between genetic improvement and differing generation intervals.

Using the age of sows at each parity in terms of generation units, the average age of sows in a herd in terms generation units was calculated. The average generation of the parity structure was used to determine the genetic lag associated with each parity structure. The longer the generation interval for the seedstock supplier, the less the genetic lag would be affected by retaining sows in the breeding herd for additional parities. In other words, the genetic loss resulting from retaining a sow in the herd for an additional parity would be smaller with the associated increased generation interval from the seedstock supplier providing replacement gilts for this scenario. An average culling rate at each parity of 18.8% (PigCHAMp 2007 and 2008) was used to find the parity distributions. This is the equivalent of an annual culling rate of 42.3%.

The spreadsheet developed by Stalder et al. (2000) was used to determine the average number of generations in the herd parity structures based on the values for the generation interval considered. The average generation of the parity structure can be used to determine the genetic loss due to retaining a sow beyond her first parity. If a sow is replaced with a gilt before sufficient time has passed for the genetic supplier to make sufficient genetic progress, then the replacement gilt will essentially be from the same generation as the sow she is replacing.

Age of sows

The age at first breeding for replacement gilts was assumed to be approximately 7.5 months or by the time she would have likely reached the second estrus and first farrowing would occur at 12 months of age (Whittemore, 1998). The age of sows in the commercial breeding herd at subsequent parities was calculated by first dividing the parity of the sow by the litters /female/year. This quotient was then added to the age at first breeding. The average litters/female/year for this analysis is assumed to be 2.25 (PigCHAMP, 2008). The sow's generation interval age was calculated as follows: ((Farrowing Interval)*(Parity – 1) + 1)/(Generation Interval). Table 8 shows the sow's age in generation interval units by parity using 4 different generation interval values. For example, a sow at parity 3 (1.44 years of age) would be 1.26 generations old in a herd where the generation interval of the seedstock supplier is 1.5 years and 0.63 generations old in a herd where the generation interval is 3.0

years. Hence, as the generation interval increases, a sow's generation interval age is less given the same parity.

Sensitivity Analysis

In this study, the generation interval is the average age of parents when their offspring are selected to replace them (Bourdon, 1997; Falconer, 1960). The generation interval and genetic gain values for the present sensitivity analysis were based on mean values from two seedstock suppliers who provided imformation anonymously (author's personal communication with suppliers). The sensitivity analysis was used to determine the genetic gain per generation for each genetic gain and generation interval combination. The potential genetic gain for each parity is equal to the genetic loss obtained by not replacing the sow with a gilt. The loss is based on the greater genetic potential of the gilts that could be replacing older sows in the herd. The longer a sow is in the herd, the longer the lag. This results in greater genetic loss and it is likely that a greater phenotypic performance difference exists between the older sows remaining in the herd and a replacement gilt that enters the breeding herd. This difference can be reduced by voluntarily culling sows for poor performance and leaving only high producing sows in the commercial breeding herd.

Economics

Economic values were given to NBA, W21, and D250. These values, along with the greater genetic potential of the gilt, were used to determine an economic value associated with keeping a sow in the herd for additional parities. The genetic gain was given an economic value based on the increased income the producer would receive due to having a swine herd with superior genetics.

The STAGES (NSR, 2009) economic estimates for production traits were used as the basis for determining the economic values for traits that would likely be included in a maternal line selection program. The traits included in the economic analysis of each herd parity structure were NBA, W21, and D250. The values used were $22/pig born alive, $0.70/ lb. of 21-day litter weight, and $0.17/day to market (NSR). Backfat was not included as it would normally have been in a typical maternal line index because recent genetic trends in maternal lines suggest zero improvement for backfat is occuring, and hence, it adds no value to the index (NSR, 2009). Other traits were assumed to have relatively less economic value and therefore were not included in the analysis. The genetic improvement per generation was used to determine how much value the genetic lag has that is associated with keeping a sow in the herd for additional parities when compared to the opportunity to replace an older sow with a replacement gilt.

Genetic Lag

The genetic lag was calculated for each parity distribution. The distributions differ based on mandatory culling parity and replacement rate. Producers often cull sows based on old age after the sows have passed ME (D'Allaire et al., 1987; and Lucia et al., 2000). Genetic lag is increased each time a sow is retained for an additional parity. The longer a sow is in a herd, the greater the genetic difference between the sow and the eventual replacement gilt. However, once a sow is replaced by a gilt in the breeding herd, the genetic potential is immediately improved to the level of the genetic suppliers multiplication system if the producer purchases gilts or to the level of that of the producer's internal multiplication program if the producer creates his own replacement gilts. The increase in genetic lag is only an issue if the genetic potential that would be passed on to the next generation would be large enough to offset the loss of production that results from replacing a sow with a gilt. For example, the gilts must produce as many NBA as the sow she is replacing, meaning that if she is replacing a P2 female, she must have approximately 1 pig genetic improvement. The genetic lag associated with each parity is shown in Tables 9 and 10. The genetic lag was determined by multiplying the assumed genetic improvement per generation by the sow's age in generation units at each parity. The lag for W21 and D250 are the same since the genetic improvement for both traits was assumed to be the same except for their units, pounds and days, respectively. For example, in a herd with a generation interval of 3.0 years, keeping a sow until P3 would result in a genetic lag of 0.19 NBA, 1.89 lbs. of W21, and 1.89 D250.

Value of Genetic Loss

To estimate the average value of genetic lag (in dollars) per sow in the herd at each parity the genetic lag for each of the three traits involved in the study (NBA, W21, and D250) was multiplied by the economic value associated with each trait and then these three values were summed together. Using these values, the average value of the genetic lag (in dollars) per sow in the herd with each herd parity distribution was determined. Using the percent of sows at each parity with each herd parity structure as reported by Dhuyvetter (2000), the value was calculated by averaging the genetic lag obtained with each sow in the herd.

The value of the genetic lag (V) was calculated as follows:

$$V = G_{NBA(P)}*E_{NBA} + G_{W21(P)}*E_{W21} + G_{D250(P)}*E_{D250(P)} + G_{BF(P)}*E_{BF} + (G_{D250(P)}*E_{D250} + G_{BF(P)}*E_{BF})N_P + (G_{D250(P-1)}*E_{D250} + G_{BF(P-1)}*E_{BF})N_{(P-1)} + \ldots + (G_{D250(1)}*E_{D250} + G_{BF(1)}*E_{BF})N_1$$

where, G is the genetic lag for each trait at parity P, E is the economic value for each trait, and N is the total number of pigs that were produced by the sow at parity P. For this study, it was assumed that no genetic improvement was made in backfat. Therefore, G_{BF} is equal to zero and does not affect the value of the genetic lag. The cumulative value of the genetic lag for the previous and current parities is the overall value of the difference in the genetic potential of the sow in the herd and the gilt available from the seedstock supplier or from internal multiplication.

RESULTS AND DISCUSSION

This study examined the value of the genetic lag associated with retaining sows in the commercial breeding herd for additional parities. The findings support that it is not profitable to replace sows in the breeding herd at rates currently employed if the goal is solely to replace sows in order to keep up with genetic improvement that is occurring at the level of the genetic supplier. When considering the replacement costs of gilts and the higher production of sows, sows are more profitable to the producer than gilts until the sows have paid for themselves (Stalder, 2000). The value of the genetic improvement does not offset the costs associated with a replacement gilt. The costs associated with replacing a sow with a gilt include initial cost ($200), breeding cost ($15.00), and housing and feed for isolation and acclimation of gilts ($35.56) (Stalder et al., 2000; and Stalder et al., 2003). When sows are kept for additional parities, the cost of developing gilts can be spread over larger numbers of pigs produced, thereby reducing the cost to produce a market hog.

Table 11 presents the average value of the difference in genetic potential between the sow and an available replacement gilt associated with a sow at each parity and each generation interval with 0.3 improvement per generation and $22/pig for NBA, 3 lbs. improvement per generation and $0.70/lb. for W21, and 3 days improvement per generation and $0.17/day D250. For example, a producer would expect $24.80 worth of genetic lag by keeping a sow to P3 in a herd with a generation interval of 1.5 years at the seedstock level, or only $12.40 in a herd with a generation interval of 3.0 years at the seedstock level. These values differ due to the sow being able to have multiple parities before a generation has passed. Therefore, the genetic improvement made per parity is smaller when the generation interval is larger.

The value of the difference in genetic potential between sows in the herd at each parity structure and available replacement gilts with different generation intervals is shown in Table 12. For example, in a herd where the maximum parity is set at 5 and a generation interval of 1.5 years, the average value of the genetic difference between a gilt from the seedstock suppliers and a sow currently in the commercial breeding herd is $22.45. This shows the value of the genetic gain that would have been achieved if sows in the herd were replaced after the first parity.

The economic value of the genetic gain would not even cover the price of the feed ($28.06) associated with developing a gilt (Stalder et al., 2000). The purchase price of a replacement gilt is typically more than the market price for the sow it is replacing, and as reported by Moeller et al. (2004) only 80% of the gilts that entered the NPPC Maternal Line National Genetic Evaluation Program farrowed. Hughes and Varley (2003), in their review of 12 studies, reported that only 20% of females reached an age in which culling decisions need to be made due to premature culling. This would mean that the number of gilts being developed must be greater than the number of sows being taken out of the breeding herd. This must be considered for proper gilt pool management (Sellers, 1994). Additionally, the cost of developing gilts that never enter the breeding herd has to recovered by the gilts that enter the breeding herd and produce for some number of parities.

When determining whether or not to replace a sow with a gilt, producers must consider the value of a cull sow. Cull sow values, particularly for lighter weight sows, are generally not as high as the value of market hogs. Increasing the body condition score of the sow will improve her cull sow value (Fitzgerald et al., 2008). The average price of cull sows by weight from 1996 to 2005 is shown in Table 13. This implies that it may be advantageous to retain sows in the herd for additional parities in order to increase their cull sow value. Sows become heavier with increasing parities up to at least P4 (Rozeboom et al, 1996; Moeller et al. 2004). Larger more highly conditioned sows generally sell for greater economic values when used in the sausage processing industry.

Based on the data in Table 12, it can be recommended that sows should not be voluntarily culled when the average value of the genetic loss of the sows in the herd is not sufficient to jusitfy the purchase/development of a new gilt. Sows should be allowed to stay in the breeding herd as long as they are still producing satisfactorially based on number born alive and growth rate of the pigs.

The differences in production by parity must be considered when making culling decisions. Not only are there improvements of NBA and W21 with increasing parity, progeny from P2 versus P1 females have higher average daily gain (Burkey et al, 2008). Furthermore, it has been reported that progeny from P3 females have higher immunogloubin levels than progeny from P1 females (Burkey et al., 2008).

The economic value of the genetic lag associated with retaining a sow for additional parities that were presented in the results represent the upper limits with respect to the amount of genetic progress one would expect to make in a swine breeding program. Hence, the values used for the genetic gain per generation are the very highest one could expect to happen. However, when assigning values to compare making replacement decisions based on the amount of genetic gain using the extreme values is justified in order to compare differences assuming the very best improvement occurs at the seedstock level. Table 14 shows the average value of the difference in genetic potential between the sows in the herd in each parity structure with different genetic improvement made per generation. The value of the genetic difference becomes smaller as less genetic improvement is made per generation.

In the NPPC Maternal Line National Genetic Evaluation the maternal line progeny clearly have lower productive performance. The highest performing maternal line (Moeller et al, 2004) had the lowest performing terminal progeny (Cassady et al., 2004). This would imply that females selected for maternal qualities alone such as NBA would have slower growing pigs, thus increasing the D250.

The three traits of interest are correlated with each other and with other economically important production traits, and therefore would be affected when selecting for one of the other traits. When selection based on reproductive traits is occuring, genetic improvement in terminal traits often suffers. Using more attainable genetic improvement values would show that the values presented for the value of the genetic difference between a sow in the breeding herd and a gilt from a seedstock supplier are maximum values that one would expect. This means that most commercial herds would be able to retain sows in the herd for additional parities with a smaller value associated with the genetic difference between the sows in the breeding herd compared to gilts at the seedstock level.

Even though it takes longer to make genetic improvement at the commercial herd level when sows are kept for additional parities, it may not be profitable to decrease the lag time. The genetic potential of the gilts may not be worth replacing a high producing sow until later parities. It is imperative that commercial swine producers consider the fact that just because a gilt has a greater genetic potential than the current sow in the breeding herd it does not mean that the sow should be removed from the herd. The sow must be maintained in the herd for a period of time so that she continues to produce at a profitable level in the operation for as long as possible.

IMPLICATIONS

The low dollar value associated with the genetic loss of retaining a sow in the herd for additional parities does not seem to justify the costs of obtaining and developing replacement gilts. Producers should focus on sound development of their replacements gilts to enhance sow longevity. Maintaining sows in the herd for additional parities is profitable as long as the sows reproduce regularly and wean large litters with near average W21.

Table 8: Age of sows in each parity in generation units in a study of the affect of genetic lag on gilt replacement decisions in commercial sow breeding herds[1]					
		Generation Interval at the seedstock level (years)			
Parity	Age at Farrowing (years)	1.5	2.0	2.5	3.0
1	1	0.6667	0.5000	0.4000	0.3333
2	1.44	0.9630	0.7222	0.5778	0.4815
3	1.89	1.2593	0.9444	0.7556	0.6296
4	2.33	1.5556	1.1667	0.9333	0.7778
5	2.78	1.8519	1.3889	1.1111	0.9259
6	3.22	2.1481	1.6111	1.2889	1.0741
7	3.67	2.4444	1.8333	1.4667	1.2222
8	4.11	2.7407	2.0556	1.6444	1.3704
9	4.56	3.0370	2.2778	1.8222	1.5185
10	5.00	3.3333	2.5000	2.0000	1.6667
11	5.44	3.6296	2.7222	2.1778	1.8148
12	5.89	3.9259	2.9444	2.3556	1.9630
13	6.33	4.2222	3.1667	2.5333	2.1111
14	6.78	4.5185	3.3889	2.7111	2.2593
15	7.22	4.8148	3.6111	2.8889	2.4074

[1]Assumed 2.25 litters/year, and age at first farrowing – 1 year

Table 9: Genetic lag at each parity for number of pigs born alive in a study of the affect of genetic lag on gilt replacement decisions in commercial sow breeding herds[1]				
	Generation Interval at the Seedstock level			
Parity	1.5	2.0	2.5	3.0
1	0.200	0.150	0.120	0.100
2	0.289	0.217	0.173	0.144
3	0.378	0.283	0.227	0.189
4	0.467	0.350	0.280	0.233
5	0.556	0.417	0.333	0.278
6	0.644	0.483	0.387	0.322
7	0.733	0.550	0.440	0.367
8	0.822	0.617	0.493	0.411
9	0.911	0.683	0.547	0.456
10	1.000	0.750	0.600	0.500
11	1.089	0.817	0.653	0.544
12	1.178	0.883	0.707	0.589
13	1.267	0.950	0.760	0.633
14	1.356	1.017	0.813	0.678
15	1.444	1.083	0.867	0.722

[1]Genetic Improvement per generation assumed: 0.3 pigs born alive

Table 10: Genetic lag at each parity for lbs. of 21-day litter weight and days to market in a study of the affect of genetic lag on gilt replacement decisions in commercial sow breeding herds assuming the same genetic improvement per generation for both traits[1]				
	Generation Interval at the Seedstock Level			
Parity	1.5	2.0	2.5	3.0
1	2.000	1.500	1.200	1.000
2	2.889	2.167	1.733	1.444
3	3.778	2.833	2.267	1.889
4	4.667	3.500	2.800	2.333
5	5.556	4.167	3.333	2.778
6	6.444	4.833	3.867	3.222
7	7.333	5.500	4.400	3.667
8	8.222	6.167	4.933	4.111
9	9.111	6.833	5.467	4.556
10	10.000	7.500	6.000	5.000
11	10.889	8.167	6.533	5.444
12	11.778	8.833	7.067	5.889
13	12.667	9.500	7.600	6.333
14	13.556	10.167	8.133	6.778
15	14.444	10.833	8.667	7.222

[1]Genetic Improvement per generation assumed: 3.0 lbs of W21 and 3.0 days to market

Table 11: Value of the difference in genetic potential between sows in the herd at each parity and available replacement gilts with different generation intervals[1]				
	Generation Interval at the Seedstock Level			
Parity	1.5	2.0	2.5	3.0
1	$8.77	$6.57	$5.26	$4.38
2	$15.96	$11.97	$9.58	$7.98
3	$24.80	$18.60	$14.88	$12.40
4	$35.11	$26.33	$21.07	$17.55
5	$46.89	$35.17	$28.14	$23.45
6	$59.77	$44.83	$35.86	$29.89
7	$73.97	$55.48	$44.38	$36.99
8	$89.46	$67.09	$53.67	$44.73
9	$106.07	$79.55	$63.64	$53.04
10	$124.06	$93.04	$74.43	$62.03
11	$143.41	$107.56	$86.05	$71.71
12	$164.13	$123.10	$98.48	$82.07
13	$186.23	$139.67	$111.74	$93.11
14	$209.69	$157.27	$125.81	$104.85
15	$234.52	$175.89	$140.71	$117.26

[1]Economic values assumed: $22.00/pig born alive, $0.70/lb. of 21-day litter weight, $0.17/day to market, Genetic Improvement per generation assumed: 0.3 pigs born alve, 3.0 lbs. of W21, and 3.0 D250

Table 12: Average value of the difference in genetic potential between sows in the herd at each parity structure and available replacement gilts with different generation intervals[1]				
	Generation Interval at the Seedstock level			
Parity of forced culling	1.5	2.0	2.5	3
1	$8.77	$6.57	$5.26	$4.38
2	$11.99	$8.99	$7.19	$5.99
3	$15.41	$11.56	$9.24	$7.70
4	$18.91	$14.19	$11.35	$9.46
5	$22.45	$16.84	$13.47	$11.22
6	$25.92	$19.44	$15.55	$12.96
7	$29.29	$21.97	$17.57	$14.65
8	$32.53	$24.40	$19.52	$16.27
9	$35.62	$26.71	$21.37	$17.81
10	$38.53	$28.90	$23.12	$19.27
11	$41.26	$30.95	$24.76	$20.63
12	$43.80	$32.85	$26.28	$21.90
13	$46.16	$34.62	$27.69	$23.08
14	$45.34	$34.00	$27.20	$22.67
15	$47.35	$35.51	$28.41	$23.67

[1]Economic values assumed: $22.00/pig born alive, $0.70/lb. of W21, $0.17/day to market,
Genetic Improvement per generation assumed: 0.3 pigs born alve, 3.0 lbs. of W21, and 3.0 days to market

Table 13: Cull sow value by weight (Fitzgerald et al., 2008)	
Weight of Cull Sows	**Cull Sow Value**[1]
136-205kg (300-450lbs)	$99.28 - $149.65
205-227kg (450-500lbs)	$164.00 - $181.60
227-250kg (500-550lbs)	$188.41 - $207.50
250-341kg (550-750lbs)	$217.50 - $296.67

[1]Average values from 1995 - 2005

Table 14: Average value of the difference in genetic potential between sows in the herd and available replacement gilts with different rates of genetic improvement made per generation[1]				
	Genetic Improvement (NBA, W21, and D250)[2]			
Parity of forced culling	0.15, 1.5, 1.5	0.2, 2.0, 2.0	0.25, 2.5, 2.5	0.3, 3.0, 3.0
1	$4.38	$5.84	$5.26	$8.77
2	$5.99	$7.99	$7.19	$11.99
3	$7.70	$10.27	$9.24	$15.41
4	$9.46	$12.61	$11.35	$18.91
5	$11.22	$14.96	$13.47	$22.45
6	$12.96	$17.28	$15.55	$25.92
7	$14.65	$19.53	$17.57	$29.29
8	$16.27	$21.69	$19.52	$32.53
9	$17.81	$23.75	$21.37	$35.62
10	$19.27	$25.69	$23.12	$38.53
11	$20.63	$27.51	$24.76	$41.26
12	$21.90	$29.20	$26.28	$43.80
13	$23.08	$30.77	$27.69	$46.16
14	$22.67	$30.22	$27.20	$45.34
15	$23.67	$31.56	$28.41	$47.35

[1]Economic values assumed: $22.00/pig born alive, $0.70/lb. of 21-day litter weight, $0.17/day to market, 1.5 years generation interval at the seedstock level

[2]Units: NBA – pigs, W21 – lbs., D250 – days

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GENERAL CONCLUSIONS

Retaining sows in commercial herds for additional parities would slow the rate of genetic improvement made in the herds. However, the economic loss associated with the resulting genetic lag does not justify the rapid turnover or replacement rate of the sows with gilts. The costs associated with replacing a sow with a gilt exceed the value gained from the superior genetics of the gilt. The cost of inputs per pig marketed should decrease as sows are retained for additional parities and fewer gilts are developed.

Feed costs have dramatically increased in recent years due to a high percentage of the corn crop being devoted to ethanol production. Due to the increased cost of feed inputs, producers should strive to keep sows in the herd for additional parities in order to reduce the costs asociated with gilt development. Seedstock suppliers should note the importance of selectng with an emphasis on sow longevity.

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