Genetic Factors Impacting Sow Longevity

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Introduction

Sow longevity continues to be both an economic and welfare concern for the pork industry. High culling levels, particularly at younger ages, result in decreased lifetime sow productivity. Within a single operation, culling of breeding herd females prior to reaching a profitable productivity status is not economically sustainable for a long period of time. The length of productive life necessary to reach a break-even point varies from herd to herd because of differing investment, productivity, variable cost and other factor levels (Stalder *et al.*, 2003; Stalder *et al.*, 2000). Improving sow longevity would improve a pork producer's profitability by reducing replacement gilt expenses and associated development, isolation, and acclimation costs. Additionally, an even greater impact is possible if improving longevity results in improved health levels in finishing pigs by maintaining an older sow herd.

Defining the appropriate longevity trait is not as easy as it may first appear. Certainly, from an economic perspective, the number and / or weight of pigs produced per some unit of time would be a factor that drives the financial aspects of sow longevity. Many cattle breeds are evaluating stayability or the probability that a cow will remain in the herd to produce an additional calf given that the cow has made it to the previous calving. D'Allaire *et al.* (1992) suggested that there are several ways to evaluate longevity in swine operations including removal rate, culling rate, replacement rate, percent gilts in herd, mean parity of females in inventory, and mean parity at removal. When making comparisons across herds or to other studies, culling and replacement rate values can differ based on methods used to calculate values (D'Allaire *et al.*, 1987). In many cases, some of these values may be difficult to measure or obtain. If replacement gilts are purchased and their birth dates are not provided, there is no way to accurately arrive at a length of life measure.

Measures examined in retrospective studies of field data can be deceiving. From strictly a management and productivity standpoint, some researchers (Deen, 2003a) have made the argument that parity, age at removal, and removal rate are not appropriate measures of longevity because old, less productive sows can be retained just to improve parity or age structure of the herd. They further suggest that a target, from a management perspective, should be the proportion of the herd removed in early parities. To accomplish this, Deen and Matzat (2003) suggest that the appropriate longevity measure may be average parity at removal. Pigs weaned per day of life were used as a measure of longevity in a study reported by Culbertson and Mabry (1995). It is clear that appropriate measures of longevity are dependent upon the objectives of the evaluation.

Before attempting to improve longevity, producers should examine why sows are leaving the sow herd. This may give breeders an opportunity to focus on a specific trait that is adversely impacting the length of productive life. The reasons sows are removed from the breeding herd of commercial swine operations are numerous and have been documented in the scientific literature for some time. From early research (Pomeroy, 1960; Jones, 1967; Svendson *et al*., 1975; Pattison *et al.*, 1980) to more recent studies, (Friendship *et al.*, 1986; Pederson, 1996; Lucia *et al.*, 2000b), reproductive failure is the predominant reason sows are removed from the breeding herd. It is clear that reproductive failure, which can encompass a variety of problems including, failure to cycle, inability to conceive, etc., is the single biggest reason for a sow's removal from the breeding herd. A listing of studies that have investigated reasons for sow removal is shown in Table 1.

Even closer examination of reported data identifies specific reasons for sow removal by parity. Clearly, the most prevalent reason for sow removal among low parity sows (1-3) is failure to breed (did not cycle, did not conceive, etc.) (Dagorn and Aumaitre, 1978). A substantial percentage of sows are removed because of lameness problems from parity one to three. As sows reach later parities, old age becomes the predominant reason for sow removal while failure to breed is still a major reason but to a lesser degree. The percentage of sows culled because of lameness problems becomes less problematic as sows become older (Dagorn and Aumaitre, 1978). These data indicate that breeders could focus selection efforts on the component aspects of failure to breed and lameness issues in order to indirectly improve sow longevity.
Breeders have not focused their attention on sow longevity at the nucleus level for several reasons. First of all, determining length of productive life is in direct conflict with improving the rate of genetic improvement. To make the most rapid genetic gain at the nucleus level, very few if any females are retained in the breeding herd long enough to determine productive lifetime. Additionally, longevity or similar traits are considered fitness traits and have associated heritability estimates typically found for these traits. They also are likely heavily influenced by heterosis. Therefore, improvement of longevity at the nucleus level of production would have to occur through selection on some indicator trait.

As is the case with most, if not all, economically important pork production traits, longevity is influenced by genetics and/or breeding system. Heritability estimates for longevity indicate that selection for improved longevity is possible, but improvement would likely be slow. Tholen *et al.* (1996a) reported that for stayability, a measure of longevity, estimates for parity one to two, one to three, and one to four were 0.05, 0.06 and 0.09, respectively. Yazdi *et al.* (2000a) reported heritability estimates for longevity ranging from 0.11 to 0.27. Serenius and Stalder (2004) reported a range of heritability from 0.05 to 0.19, depending on the model used to analyze the data. Crump (2001) reported heritability estimates ranging from 0.11 to 0.21, depending on whether survival analysis, linear model, or generalized linear model methods were used. Lopez-Serrano *et al.* (2000) found heritability estimates for stayability ranged from 0.07 to 0.11 in Landrace sows. Fortin and Cue (2002) reported genetic parameters for length of productive life, defined as number of days from first service until culling. This study reported heritability for this trait in the Yorkshire and Landrace populations of 0.16 and 0.13, respectively
Some of the genetic effects can impact longevity through other important traits. Rydhmer *et al.* (1994) and Bidanel *et al.* (1996) have shown that genetics can impact age, weight, and backfat at puberty. Crump (2001) reported unfavorable genetic correlations between backfat and survival.

Serenius and Stalder (2004) concluded that leg conformation is genetically correlated with length of productive life. Similarly, reports that buck-kneed front legs were negatively associated with age at first farrowing, first farrowing interval, total number born, and piglet mortality from birth to weaning (Serenius et al., 2004). Other reports have shown buck-kneed front legs, swaying hind quarters, and upright pasterns on the rear legs have, when evaluated at six months of age, had unfavorable effects on a sow's ability to survive through three parities (Jorgensen, 1996). This same study reported that weak front leg pasterns, when evaluated at six months of age, were favorably associated with a sow's ability to survive through three parities. Thus, it seems that the genetic correlations are population dependent. Moreover, it is possible that the relationship between longevity and other traits may be non-linear.

If one considers sow longevity a fitness trait, it should be expected that crossbreeding should have a positive impact. Crossbred sows averaged 5.3 litters while purebred sows averaged 4.4 litters at culling, a significant difference of 12% or 0.9 litters per sow (Živković *et al.*, 1986). They also noted that 55.2% of culling in purebred sows occurred in the first three parities while only 40.4% of the overall culling occurred in the first three parities of crossbred sows. Mean age and number of litters at removal were lower in purebred Yorkshire sows when compared to crossbred sows (Jorgensen, 2000). In that same study, purebred sows had higher culling rates for locomotion problems and reproductive failure. Sehested and Schjerve (1996) reported similar results in which parity at culling averaged 3.01 for purebreds and 3.61 for crossbreds. Longevity may also be influenced by the breed makeup of crossbred breeding females. Hall *et al.* (2002) noted that sows that were one-quarter Meishan had significantly higher mean days of productive lifetime (778 d) when compared to sows that were one-eighth Duroc or one-quarter Duroc (674 d and 639 d, respectively). This translated into a significantly higher mean parity at culling for the one-quarter Meishan sows (4.54) compared to the one-eighth Duroc (3.79) or the one-quarter Duroc sows (3.67), and a higher mean pigs born alive per lifetime of 55.0 compared to 42.7 and 42.3, respectively. A single study reported similar percentages of culling by parity between purebred Large White and crossbred Large White x Landrace sows (Dagorn and Aumaître, 1979).

Choice of breeding stock source could also impact a producer's ability to retain sows in the breeding herd for longer periods of time. The National Pork Board's Maternal Line Project demonstrated that traits contributing to longevity and attrition are heritable (Johnson, 2000). The same report noted line differences for percentage of sows producing four litters, live pigs per sow life, and average sow life. Goodwin (2002) extended the analysis of the same maternal line study and found similar differences through the sixth parity. Rodriguez-Zas *et al.* (2003) reported genetic line differences that approached one parity between some genetic lines. Because genetic line differences exist and the heritability for longevity traits is greater than zero, pork producers have opportunities to choose lines that have improved sow longevity. At the same time, genetic suppliers can continue to improve this trait through selection. Producers should keep in mind that they would be responsible for a portion of the improvement in sow longevity if internal gilt multiplication systems are employed. In that case, genetic improvement of sow longevity must occur through the use of purchased boars or semen from their genetic supplier.

New developments related to molecular genetics offer the ability to investigate individual gene effects on longevity. Three genes have been identified that have shown promise of having significant effects on longevity (Mote et al., 2005). However, the size and direction of genotypic effects vary among lines and herds. Two of these genes have additive effects on other production traits, suggesting that if selection for the beneficial form of the gene is made, then the producer can benefit from improvement in multiple traits. Testing on different and larger populations must be done before these can be used for selection in different populations. However, these results, combined with earlier results on other reproductive longevity markers, suggest that sow longevity is influenced genetically. Thus breeders have the ability to select the beneficial forms of certain genes to improve the ability of sows to live longer.

In addition to the molecular work being conducted at Iowa State, additional projects examining longevity are being undertaken. In one experiment, F_1 Yorkshire x Landrace females that have known parentage will be used to focus on determining genetic parameters for longevity and prolificacy traits from this crossbred population, including dominance effects. A second large-scale commercial study is being initiated to evaluate a representative sample of cull sows at harvest for body condition, feet and leg injuries, shoulder lesions, ovarian functionality, pneumonic lesions, teeth and palate problems, and numerous additional identifiable and quantifiable factors in an attempt to determine the causes for culling sows. Educational resources are being developed to provide producers with tools to assist producers in process of evaluating replacement gilt candidates for feet and leg structure and reproductive soundness.

From past research it is clear that sow longevity is a complex trait. Sow longevity continues to be primarily an economic concern for most commercial producers. Because industry mortality rates for breeding herd females have continued to increase to levels as high as 15 percent and replacement rates continue to meet or exceed 50 percent during the past five to ten years, sow longevity is increasingly becoming a welfare problem. Studies have been conducted and are currently underway to address these issues so U.S. swine producers remain viable in an increasingly competitive global pork production marketplace.

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Table 1. Summary of the percentage of sows culled and reason for culling.[1,2]

Study[3]	Reprod. Failure	Poor Perf.	Old Age	Feet, Leg, & Locomotion Disorders	Death	Farrowing Problems	Injury, Health, & Disease	Milking Problems
Pomeroy, 1960	21.4	22.4	17.1	NR[4]	NR	2.0	13.3	6.1
Jones, 1967	8.8	NR	2.2	9.4	10.1	NR	2.4	5.6
Svendsen *et al.*, 1975	28.8	10.0	3.9	15.0	NR	NR	NR	NR
Dagorn & Aumaître, 1979	39.2	8.4	27.2	8.8	6.5	4.0	NR	NR
Pattison *et al.*, 1980	37.5	13.8	24.4	11.8	NR	NR	NR	NR
Joo & Kang, 1981	32.6	15.7	16.7	9.7	NR	NR	NR	NR
Muirhead, 1981	35.4	NR	28.2	10.8	4.6	2.8	NR	5.0
Stone, 1981	12.9	20.6	33.4	11.0	NR	1.6	4.2	8.9
Friendship *et al.*, 1986	23.7	14.5	19.2	11.8	3.0	2.3	2.5	9.0
D'Allaire et al., 1987	32.4	16.8	14.0	8.9	11.6	7.2	1.6	NR
Dijkhuizen *et al.*, 1989	34.2	20.1	11.0	10.5	NR	NR	NR	NR
Stein *et al.*, 1990	29.6	9.4	17.9	11.0	10.7	5.0	0.8	8.8
Cederberg and Jonsson, 1996	29.0	1.0	8.0	14.0	7.5	NR	NR	13.0
Kangasniemi, 1996	28.2	14.4	16.8	13.5	3.2	2.4	1.4	1.9
Paterson *et al.*, 1996	21.3	2.3	7.2	9.3	5.0	NR	3.5	1.6
Pedersen, 1996	34.5	4.6	18.8	6.1	12.3	NR	NR	NR
Sehested & Schjerve, 1996	28.7	4.8	11.3	10.2	4.2	1.9	4.9	0.9
Boyle *et al.*, 1998	29.8	11.1	31.3	11.3	6.6	NR	7.4	NR
Lucia *et al.*, 2000[b]	33.6	20.6	8.7	13.2	7.4	NR	3.1	NR

[1] This table was published in Stalder et al., 2004.
[2] Portions of this table have been adapted from D'Allaire and Drolet, 1999.
[3] All of the studies reviewed did not report results exactly in the same categories. When this occurred, the authors attempted to summarize the study and place results in the appropriate classification.
[4] NR = not reported.