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Analysis of true sow longevity

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ABSTRACT Data from the National Pork Producers Council Maternal Line National Genetic Evaluation Program were used to compare the sow longevity of six different genetic lines, and to estimate the associations of gilt backfat thickness, age at first farrowing, litter size at first farrowing, litter weight at first farrowing, average feed intake during lactation, and average backfat loss during lactation with sow longevity. The lines evaluated were American Diamond Genetics, Danbred North America, Dekalb-Monsanto DK44, Dekalb-Monsanto GPK347, Newsham Hybrids, and National Swine Registry. The dataset contained information from 3,251 gilts, 17% of the records being right censored (sows lived longer than six parities). The line comparison was carried out by analyzing all the lines simultaneously, and including genetic line in the statistical model. Because the survival distribution functions differ between the genetic lines, the analyses were carried out separately for all the genetic lines. All analyses were based on nonparametric proportional hazard models (Cox model). The results suggest that Dekalb-Monsanto GPK347 sows had a lower risk of being culled when compared to sows from the other five lines. Moreover, the shape of the survival distribution function of the Delkab-Monsanto GPK347 line is clearly different from the other five lines. Higher culling rates occurred before the first parity and were due to reproductive failure in sows from the five other lines. The results further suggest that sows with lower feed intake and greater backfat loss during lactation had a shorter productive lifetime. Thus, producers should implement management practices having positive effects on sow lactation feed intake. Additionally, the swine genetics industry is facing the challenge of selecting simultaneously for improved feed efficiency and high feed intake during lactation. Recording sow feed intake and backfat loss during lactation in nucleus and multiplication breeding herds should be considered. Between line differences in this study indicate that it is possible to select for sow longevity. More research is needed to determine the most efficient selection methods to improve sow longevity.

Introduction

Sow longevity plays an important role in economically efficient piglet production (Lacy and Stalder, 2004). Moreover, heritability estimates presented in the literature indicate that genetic variation exists for sow longevity (Serenius and Stalder, 2004; Yazdi, et al., 2000; Tholen et al., 1996). Thus, one might expect that between line differences exist among sow lines available to commercial swine producers. However, comparison of different commercial genetic lines has been almost impossible due to the time, facilities, and cost of conducting such experiments. Naturally, all sow lines available to commercial producers are advertised to have the "best" genetics for many traits including sow longevity.

Comparison of different genetic lines is possible only by standardizing the management factors or by having the ability to model the environmental effects. The Maternal Line National Genetic Evaluation Program (MLP) was initiated to evaluate the reproductive performance and sow longevity of different maternal lines available to U.S. swine producers. The program was designed and conducted by the National Pork Producers Council

(NPPC) Genetic Programs Committee (GPC) (Des Moines, Iowa). A more complete description of the MLP study is presented in Moeller et al. (2004).

Rapid genetic improvement has been attained for production traits, such as daily gain, feed conversion ratio and backfat thickness, during recent years. Simultaneously, there has been a decrease in sow longevity. Thus, one might expect that these traits are unfavorably associated. In order to control sow longevity, these associations should be known.

The objective of this study was to compare the sow longevity of different genetic lines, and to evaluate the associations of sow longevity with gilt backfat thickness (at 100 kg), average daily gain (from birth to 100 kg), age at first farrowing, litter size at first farrowing, litter weight at first farrowing, backfat loss during lactation, and feed intake during lactation.

Materials and Methods

Data in this study were obtained from the National Pork Producers Council Maternal Line National Genetic Evaluation Program. Six lines/suppliers included in the study were American Diamond Swine Genetics (ADSG) (Prarie City, IA), Danbred North America (DB) (Seward, NE), Dekalb-Monsanto DK44 (DK44) (St. Louis, MO), Dekalb-Monsanto GPK347 (GPK347) (St. Louis, MO), Newsham Hybrids (NH) (West Des Moines, IA), and National Swine Registry (NSR) (West Lafayette, IN).

The dataset contained performance information from 3,251 gilts, with 17% of the records being right-censored (sows lived longer than six parities). From these gilts, 78.4% reached their first parity, i.e., 21.6% of the gilts never farrowed. For this reason, the analyses were carried out in three steps. First, the line comparison was completed by fitting one baseline hazard function for all the lines. Second, the effects of gilt backfat thickness and average daily gain on sow longevity were estimated separately for each genetic line. Each genetic line was analyzed separately because the survival distribution functions differ between the genetic lines, especially between the GPK347 and the other lines studied. Additionally, the associations between the traits might be different between the genetic lines. Third, the effects of age at first farrowing, litter size at first farrowing, litter weight at first farrowing, backfat loss during last lactation, and feed intake during last lactation on sow longevity were studied similarly as the second approach, but the information was utilized only from sows that had farrowed at least once.

All analyses were carried out by fitting the proportional nonparametric (Cox) model on longevity records. The hazard function of a sow's length of productive life (LPL), t days after the entrance of the breeding herd, can be written as:

$$h(t) = h_0(t)\, e^{x'b},$$

where $h_0(t)$ is the nonparametric baseline hazard function, $\boldsymbol{b}$ is the vector of fixed effects, and $\boldsymbol{x}$ is the corresponding incidence matrix. All the effects mentioned above were included in $\boldsymbol{b}$. The effects of gilt backfat thickness, average daily gain, age at first farrowing, litter weight at first farrowing, backfat loss during lactation

and feed intake during the lactation were included as fixed regressions in ***b***, whereas, the effect of litter size in the first parity was included as a fixed effect. In addition, the effect of common contemporary group was included in the vector ***b***. Statistical analyses were carried out with The Survival Kit package (Ducrocq and Solkner, 2001).

Results and discussion

Results show that sows from the GPK347 line have a lower risk of being culled when compared to the other five lines evaluated in this study (Table 1). For example, sows from the GPK347 line have 1.37 times lower risk of being culled when compared to sows from the NSR line, who were the second most robust animals in the current comparison. The survival distribution functions indicate that the greatest difference in sow removal occurs before the first parity. Sows from the other five lines had difficulty in conceiving their first litter, whereas the GPK347 sows did not demonstrate such difficulties. Differences in sow longevity appear to be relatively low among the other five genetic lines when managed under the same system.

Table 1. Proportional risks of sows being culled (*Risk Ratio*) between six genetic lines evaluated in the National Pork Producers Council Maternal Line National Genetic Evaluation Program

Line[1]	Risk Ratio[2]					
	NH	**NSR**	**ADSG**	**DK44**	**GPK347**	**DB**
NH	1	1.03	1.02	0.97	1.41	0.92
NSR	0.97	1	0.99	0.94	1.37	0.89
ADSG	0.98	1.01	1	0.95	1.38	0.90
DK44	1.04	1.06	1.06	1	1.46	0.95
GPK347	0.71	0.73	0.72	0.69	1	0.65
DB	1.09	1.12	1.11	1.05	1.53	1

[1] NH = Newsham Hybrids, NSR = National Swine Registry, ADSG = American Diamond Genetics, DK44 = Dekalb-Monsanto DK44, GPK347 = Dekalb-Monsanto GPK347, DB = Danbred North America.

[2] Risk ratios are scaled proportional to each line (column) separately

As there is no detailed description about the breeding programs of these lines available in the literature, it is difficult to determine the reasons for the superiority in sow longevity demonstrated by GPK347 sows. However, GPK347 is known as a line made up of half of the Nebraska selection line that was selected only for sow productivity traits (Neal et al., 1989; Johnson et al., (1999), which may explain its superiority, at least in part.

When all gilts were included in the analysis, and only gilt backfat thickness and average daily gain were included in the statistical model, gilt backfat thickness significantly affected sow longevity, except in the GPK347 line (Table 2). The estimated hazard coefficients were negative for all the breeds, i.e., the higher the gilt backfat thickness, the lower is the risk of sow being culled. When gilts that never farrowed were excluded from the data, gilt backfat thickness was not significantly associated with sow longevity in the GPK347, NH, and DB lines (Table 3).

Feed intake during lactation and backfat loss during lactation are factors associated with sow longevity for most of the breeds (Table 3). Feed intake during lactation had significant effect on longevity for all lines, except for the NH line. Similarly, GPK347 and DB were lines that did not demonstrate a significant association between longevity and backfat loss during lactation. Generally, however, lower feed intake and higher backfat loss during lactation is associated with a higher risk of a sow being culled. Estimated hazard coefficients ranged between -1.40 and 0.05 per kg/day/piglet weaned for feed intake, and between 2.96 and 13.31 per cm in backfat loss during lactation.

Based on current results, feed intake and backfat loss during lactation are the factors having the greatest effect on sow longevity. Because selection for low feed intake or superior feed conversion ratio (kg meat / kg feed) has been practiced for many generations in most breeding programs, the association is unfavorable, at least from the breeding perspective. In the other words, a challenge exists to select pigs which utilize feed more efficiently, but without decreasing or depressing the animal's appetite. Moreover, the results of this study highlights the importance of having highly palatable feed available and feeder management for sows during lactation.

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Table 2. Estimates of hazard regression coefficients (*b*) and proportions of reduced model R^2 out of the full model R^2 (%), when the effect is not accounted in the statistical model of National Pork Producers Council Maternal Line National Genetic Evaluation Program[1]

	NH[2]		NSR[2]		ADSG[2]		DK44[2]		GPK347[2]		DB[2]	
Trait[3]	*b*	%	*b*	%	*b*	%	*b*	%	*b*	%	*b*	%
giltBF, cm	-0.39**	77.50	-0.57**	49.14	-0.34**	69.05	-0.62**	62.58	-0.07	99.16	-0.49**	78.20
ADG, kg/day	-2.27*	84.15	-1.12	96.85	0.11	100.00	-4.25**	73.98	1.87†	90.54†	-0.77	98.28

† P < 0.10; * P < 0.05; ** P < 0.01

[1] All the gilts are included in survival analysis

[2]NH = Newsham Hybrids, NSR = National Swine Registry, ADSG = American Diamond Genetics, DK44 = Dekalb-Monsanto DK44, GPK347 = Dekalb-Monsanto GPK347, DB = Danbred North America.

[3]giltBF = gilt backfat thickness at 100 kg, ADG = average daily gain from birth to 100 kg.

Table 3. Estimates of hazard regression coefficients (*b*)[1] and proportions of reduced model R^2 out of the full model R^2 (%), when the effect is not accounted in the statistical model of the National Pork Producers Council Maternal Line National Genetic Evaluation Program[1]

	NH[2]		NSR[2]		ADSG[2]		DK44[2]		GPK347[2]		DB[2]	
Trait[3]	*b*	%	*b*	%	*b*	%	*b*	%	*b*	%	*b*	%
giltBF, cm	-0.13	98.39	-0.40*	86.51	-0.22†	94.88	-0.30†	92.15	0.08	99.43	0.08	99.59
ADG, kg/day	0.64	99.31	0.11	100	2.01†	95.22	-0.62	99.52	3.17*	86.62	1.12	95.32
LW, kg	0.00	99.89	-0.02	99.48	-0.02	97.27	0.00	100	0.03	96.68	0.00	99.92
FI, kg/day/piglet	0.05	100	-0.66†	94.12	-0.62†	94.79	-1.01**	84.01	-1.38**	76.87	-1.40**	79.29
Bfloss, cm	13.31**	51.21	6.76*	87.89	7.17**	86.42	5.37†	92.34	2.96	97.82	4.85	95.73
AFF, day	0.27	95.98	0.27	100	0.27	97.87	0.27	97	0.27	99.91	0.27†	93.43
TNB		94.37		96.97		98.55		92.25		91.66		87.84

† P < 0.10; * P < 0.05; ** P < 0.01

[1] Only sows that farrowed at least once are included in the survival analysis.

[2] NH = Newsham Hybrids, NSR = National Swine Registry, ADSG = American Diamond Genetics, DK44 = Dekalb-Monsanto DK44, GPK347 = Dekalb-Monsanto GPK347, DB = Danbred North America.

[3]giltBF = gilt backfat thickness at 100 kg, ADG = average daily gain from birth to 100 kg, LW = litter weight at birth, FI = feed intake during lactation, BFloss = backfat loss during lactation, AFF = age at first farrowing, TNB = total number of piglets born.