Incorporation of new reproduction and meat quality traits into genetic evaluation programs

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Introduction

The National Swine Registry (NSR) has offered STAGES^{TM}, a BLUP genetic improvement program with bio-economic indexes for over 17 years. Historically, NSR members submitted information on three sow productivity traits and three postweaning performance traits and in return receive across-herd Expected Progeny Deviations (EPDs) for these traits along with indexes for Sow Productivity, Maternal Line (sow productivity and postweaning performance) and Terminal (postweaning traits only) to be used in genetic selection. Not only is this genetic information available to members but genetic values and trends for these traits are also available to any commercial producer or genetic advisor. This program has led NSR members to make substantial genetic improvement for these traits within the Yorkshire, Duroc, Hampshire and Landrace breeds. In addition, this transparent system allows commercial producers to design programs and select animals that allow them the greatest potential for their situation. As the pork industry continues to change, multiple pork chains are forming to meets distinct specifications desired by subsets of consumers. To continue to meet the demand of these dissimilar pork chains, differentiated genetic lines are necessary to provide products that match their specifications. In addition, as profit per pig continues to decline pork producers must be able to increase product sold per unit of investment. To facilitate this key profitability indicator, the fertility of breeding females must improve. To address these two key drivers in today's pork industry, the NSR have updated their genetic improvement program in these two areas by evaluating additional traits for meat quality and reproduction.

Meat Quality

The pork industry is diversifying into multiple pork chains. These chains specify particular attributes that meet qualifications for differing consumer groups. Some of these pork chains emphasize improved meat quality, such as improved color, marbling, juiciness and flavor. These aspects of meat quality are influenced by both genetic and non-genetic (management, feed, environment, etc) factors. The NSR developed a project to estimate the genetic parameters of specific traits related to meat quality and subsequently implemented a meat quality genetic improvement program. Traits evaluated were CIE L*, pH at 24 hours after harvest and marbling score, using the 1-10 scale recommended by the National Pork Board, Des Moines, IA. All measurements were taken on the loin muscle.

This project utilized 1,413 Duroc, Yorkshire and Landrace pigs from 17, NSR member farms and National Pork Board projects. Pigs were harvested at one of three cooperating commercial packing plants. Each animal was identified with a unique tattoo so to maintain identity through

the harvest process. Near 24 hours after exsanguination, loins were removed from the carcass and evaluated near the tenth rib, for CIE L*, pH and Marbling score. Data was recorded by tattoo and then matched with the appropriate animal identification number for analysis purposes.

For analysis, pH at 24 hours after harvest was transformed to hydrogen ion concentration. The model used to estimate genetic parameters was a multivariate model for the three traits of CIE L*, hydrogen ion concentration and marbling score. The genetic and residual variances and their respective covariances were included in the calculations. The model included the fixed effects of contemporary group nested within herd, breed and sex. Contemporary groups were defined as those animals from one herd and breed that were harvested on one day. The random effects included the animal and error terms. The relationship matrix among all animals within a breed that had harvest data was included in the analysis to better account for the genetic relationships that existed among animals with common ancestry. Genetic parameters are presented in Table 1.

Table 1. Heritability estimates (diagonal), genetic correlations (above the diagonal) and phenotypic correlations (below the diagonal) for meat quality traits.

	CIE L*	Hydrogen ion concentration	Marbling Score
CIE L*	0.16	0.05	-0.19
Hydrogen ion concentration	0.18	0.21	-0.39
Marbling Score	-0.07	0.17	0.34

Using the information presented in Table 1, NSR has developed a meat quality evaluation program. Their members regularly harvest purebred barrows and gilts which culminates in EPDs for CIE L*, pH at 24 hours after harvest and marbling score on sires and dams of harvested pigs as well as their littermate prospective replacement parents. This program provides members the opportunity to develop lines that meet developing pork chains with enhanced meat quality specifications. Participating members receive EPDs for pH, Marbling and Minolta L (Table 2). To date indexes have not been developed due to the wide range of specification for pork quality across the U.S. pork industry.

Table 2. Meat quality EPD percentile groups for Duroc sires.

Percentile	Marbling EPD	Minolta L* EPD	pH EPD
Maximum	0.32	-1.79	0.05
75%	0.06	-0.08	0.01

Reproduction

To further bolster maternal performance, the traits of litter birth weight and wean to estrus interval have been added to the present maternal trait evaluation of number born alive, number weaned and litter 21 day weight. NSR members have been able to provide historical records for litter birth weight and wean to estrus as well their ongoing submission of information. This historical information will improve the accuracy of these two new EPDs as breeders begin to use them in their selection programs. In addition, a new sow index is in development to include these

two new EPDs along with the previous three maternal traits undergoing selection, so as to balance their importance when practicing simultaneous selection for these 5 maternal traits.

Optimal sow productivity occurs with maximum number of pigs per litter, litters per year and lactation yield while also optimizing pig birth weight, sow longevity and lifetime productivity. Most genetic evaluation systems focus on only some of these traits for selection. For example, the Swine Testing and Genetic Evaluation System (STAGES) has traditionally addressed genetic evaluation of number of pigs born alive, 21-day litter weights and number of pigs weaned. However, litter birth weight and the interval from weaning to mating are additional traits that deserve consideration to fully optimize sow productivity. This presentation will focus on the genetic contribution of these five traits to optimal sow productivity and describe how they can be implemented into genetic evaluation and commercial breeding programs.

This project utilized 11,578 records of pigs born alive, litter birth weight, 21-day litter weights, number of pigs weaned, and weaning to mating interval from Duroc, Yorkshire, Hampshire and Landrace sows from 10, National Swine Registry member farms. The analysis model for litter birth weight included the genetic effect of the sow and the fixed effects of contemporary group, herd, parity of sow and number of pigs born alive. The analysis model for weaning to mating interval included the genetic effect of the sow, a covariate for 21-day litter weight adjusted for age at weighing, and the fixed effects of contemporary group, herd, and parity of sow. Heritability estimates pooled across breeds were 0.32 and 0.20 for litter birth weight and weaning to mating interval, respectively.

Genetic correlations with number born alive (NBA), number weaned (NW), and 21 day litter weight (LWT) were estimated using a five trait animal model (Table 3). An additional 291,028 Yorkshire reproductive records were used. However, implementation of genetic evaluation of WTE and LBW in STAGES is done with a two-trait evaluation due to the smaller of number of breeders currently submitting data.

Table 3. Estimates of heritabilites (diagonal) and genetic correlations (below diagonal) for reproductive traits in Yorkshire swine.

	WTE	LBW	NBA	NW	LWT
WTE	0.24				
LBW	0.29	0.19			
NBA	-0.05	-0.07	0.08		
NW	0.34	-0.14	0.61	0.03	
LWT	0.47	0.55	0.35	0.39	0.11

The range in EPDs (Table 3) for the 451 Yorkshire sires represented with daughter records was 4.92 pounds of litter birth weight and 2.15 days in weaning to mating interval indicating dramatic genetic differences for these traits amongst animals. Assuming the cost of a non-productive sow day is $1.65/day the additional value due to genetic differences between daughters of the highest ranking and lowest ranking Yorkshire boars for weaning to mating interval would be $3.55/litter.

Table 3. Percentile distribution for sires that have produced daughters with WTE or LBW records.

	Yorkshire		Landrace		Duroc		Hampshire	
Percentile	WTE	LBW	WTE	LBW	WTE	LBW	WTE	LBW
Maximum	-0.99	2.89	-0.94	3.68	-0.49	1.79	-0.12	1.38
95%	-0.29	1.98	-0.33	1.66	-0.25	1.11	-0.10	0.94
90%	-0.21	1.55	-0.27	1.28	-0.20	0.80	-0.07	0.72
75%	-0.09	1.01	-0.14	0.64	-0.05	0.40	-0.03	0.57
50%	0.05	0.33	-0.05	0.12	0.05	0.06	0.00	0.18
25%	0.18	-0.41	0.06	-0.46	0.20	-0.30	0.05	-0.07
Minimum	1.16	-2.03	1.49	-2.15	0.83	-2.19	0.14	-1.19

A comprehensive sow productivity index has also been developed that includes number of pigs born alive, litter birth weight, number of pigs weaned, litter weight at 21-days, and weaning to mating interval. Utilization of these five traits in genetic selection allows for the selection of optimal sow productivity that more closely resembles the accepted industry measure of pigs per sow per year. This genetic evaluation system does not account for the longevity or lifetime production of the sow because of the selection and culling practices followed in nucleus herds. More comprehensive genetic evaluation and selection for sow productivity should allow pork producers to enhance overall productivity and profitability.

Summary

Breeders within the Yorkshire, Landrace, Duroc and Hampshire breeds have been successful in improving the genetic merit of their herds for number born alive, litter 21 day weight, growth and carcass merit. The addition of these new EPDs to the STAGES genetic evaluation program provide everyone the tools to better direct genetic change of their herds to improve sow fertility and productivity and be able to market into pork chains that have specific meat quality attributes. Furthermore, this transparent system provides advisors and producers the greatest knowledge and flexibility for the implementation of genetic improvement programs.