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Breed-Specific Adjustment Factors for Reproductive Traits in Duroc, Hampshire, Landrace, and Yorkshire Swine

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ABSTRACT: Number born alive (NBA) and litter weaning weight (LWT) can be influenced by many factors, including environment, parity, age at farrowing, lactation length, and genetic merit as well as number of pigs after transfer (NAT) and weaning age (WNAGE) for LWT. The objectives of this study were to estimate adjustment factors for NBA and LWT using all effects in the model and to refine parity effects by including age of the sow in parity 1 (P1) and parity 2 (P2). The models used included fixed effects of contemporary groups and parity/age class, random direct genetic and permanent environment effects, as well as the fixed effects of NAT and WNAGE for LWT. A large effect due to age of the sow at breeding within P1 and P2 was found and new

adjustments were found to differ from previous studies. In the Yorkshire population, for example, the average P1 adjustment was 1.0 pig in this study, compared to the current .69; however, this ranges from 1.46 for the youngest P1 females to .57 for the oldest. Similarly, in P2 the average adjustment was found to be .50, with an adjustment of .99 for the youngest P2 and 0 for the oldest. Also, age of dam was found to contribute variation to P1 litter records for LWT. A residual analysis showed nonsignificant differences ($P > .60$) across the age classes after using the new adjustments; however, significant differences ($P < .01$) remained after using the current adjustments.

Key Words: Pigs, Litter Traits, Age

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Introduction

Rate of genetic improvement depends on the use of tools that allow producers to accurately measure performance and estimate genetic merit. Traditionally, adjustment factors have been used to standardize performance records and better allow for isolation of the genetic component of observed variation. Current litter adjustment factors are provided by the National Swine Improvement Federation (NSIF, 1987) and were assumed common to all breeds. Litter adjustments for the American Landrace and Yorkshire populations were updated by Brubaker et al. (1994) and found to differ between breeds and from the NSIF factors.

Reproductive performance of sows can be affected by many factors (Clark and Leman, 1986; Almond, 1992). Litter size can be affected by, but not limited to, contemporary group (environment), parity, age at farrowing, previous lactation length, weaning to

conception interval, and genetic merit. Litter weight is influenced by those factors and age at weaning and number weaned. Current adjustment factors were derived by accounting for parity, weaning age or number after transfer, and the environment. Factors such as genetic merit and age at farrowing have been ignored. However, computing power and programs have advanced and now allow for the use of animal models that include a variety of fixed and random effects. The inclusion of these additional effects, including genetic merit, should increase the accuracy of estimating adjustment factors.

Therefore, the objectives of this study were 1) to derive new litter adjustment factors using a more complete estimation model, 2) to analyze the need for breed-specific adjustments for the major breeds of swine, and 3) to analyze the efficacy of these adjustment factors compared with those currently in use.

Materials and Methods

Data

Duroc, Hampshire, Landrace, and Yorkshire litter records were obtained from the National Swine

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Table 1. Number of litter records, contemporary groups (cg), and dams as well as phenotypic means for number born alive (NBA) and 21-day litter weight (LWT) for Duroc, Hampshire, Landrace, and Yorkshire swine

Item	Duroc	Hampshire	Landrace	Yorkshire
No. of records	35,063	49,279	30,521	163,262
No. of cg	4,819	5,920	4,353	21,439
No. of dams	28,730	33,966	16,528	96,265
Mean-NBA ^a	9.16	8.69	10.08	10.21
Mean-LWT, kg ^a	48.36	49.18	58.92	56.0

^aUnadjusted mean.

Registry. Duroc, Hampshire, and Landrace data included all records collected from 1985 through May 1996, and Yorkshire data included all records collected up to November 1995. Data sets included identification, herd, birth date, pedigree of the sow, animal identification, contemporary group, farrowing date, number born alive (NBA), litter weaning weight (LWT), number weaned (NW), number after transfer (NAT), weaning date, and parity of the dam of the litter. In an attempt to use more common production terminology, age of the sow at farrowing was defined by age of the sow at breeding to produce the litter record and was calculated as farrowing date – birth date – 114 and weaning age of litter as weaning date – farrowing date. Editing was conducted to ensure connectedness of the final data set. Also, records that were outside 4 SD from the mean or did not include birth date of the sow or birth date or weaning date of the litter were eliminated to remove biological extremes and ensure completeness. Number of records, contemporary groups, dams, and phenotypic means after editing are shown by breed in Table 1.

Estimation Method for Adjustment Factors

A multiple-trait, reduced animal mixed model program (Feng and Culbertson, 1995) was used to generate solutions for all genetic and nongenetic effects for NBA and LWT. Variance components used for the analysis were those currently used by the national genetic evaluation for each breed. Contemporary group was determined by the National Swine Registry and defined as a group of sows that were bred, gestated, and farrowed in a group under the same management and environmental conditions. The model for NBA included a direct genetic effect for the sow of the litter, an uncorrelated random permanent environmental effect for the sow, and fixed effects of age of the sow at breeding and(or) parity class and contemporary group. The model for LWT included the above effects and the fixed effects of NAT and weaning age of the litter.

Age of the sow at breeding was analyzed for possible influence on reproductive performance in parity 1 and parity 2 litter records with multivariate models and unequal design matrices. Discrete age

within parity classes were used to better allow for estimation of the effect of age at the extremes of the age distribution where fewer records were found. Initially, classes for age of the sow at breeding were constructed based on 10-d intervals within parities 1 and 2. Multiple subsequent analysis runs were used to construct the final classes for each breed-trait-parity combination. Outer classes for each parity-trait represent records approximately 1 SD from the mean. Visual examination was used to form the final class intervals. Criteria used for determining these intervals included maximizing the difference between classes and ensuring an adequate number of records within the classes.

For analysis of LWT, solutions for weaning ages were obtained for ages of 14 to 28 d. Multiplicative weaning age adjustments, of a form similar to that currently used in the industry, for LWT were then obtained for adjustment of litter weight to a 21-d base by dividing the solution for day of interest by the solution for 21-d weight.

Analysis of Results

Possible improvements through use of an animal model that included parity and age within parity effects, over an animal model that included parity effects only, were analyzed with the procedure outlined by Boik et al. (1993). This test uses reduction in sum of squares expressions and yields optimal tests when variances are proportionally constant.

Results and Discussion

New adjustment factors, number of records within each class, and current adjustments in the Duroc, Hampshire, Landrace, and Yorkshire populations for NBA are presented in Tables 2 to 5, respectively. Newly derived adjustment factors differed from those currently used and also differed between breeds. Overall parity differences followed the expected pattern; however, substantial differences were found within parities 1 and 2 due to age of the sow at time of farrowing. The pattern of these differences was in agreement with previous work (Sherritt, 1962;

Table 2. Adjustment factors and numbers within class for number born alive in Duroc swine

Parity	Age at breeding	New adjustment	Current adjustment ^a	No. within class
1	< 240 d	.98	1.5	3,087
1	240–329 d	.73	1.5	7,789
1	≥ 330 d	.55	1.5	1,115
2	< 365 d	.78	.9	713
2	365–424 d	.37	.9	3,466
2	425–534 d	.08	.9	3,074
2	≥ 535 d	.17	.9	733
3, 4		0	.3, 0	10,206
5		.09	0	2,506
6		.28	0	1,286
> 6		.67	0	1,088

^aNSIF, 1987.

Table 3. Adjustment factors and number within classes for number born alive in Hampshire swine

Parity	Age at breeding	New adjustment	Current adjustment ^a	No. within class
1	< 240 d	1.04	1.5	1,970
1	240–299 d	.84	1.5	8,528
1	300–329 d	.65	1.5	1,951
1	≥ = 330 d	.49	1.5	2,510
2	< 395 d	.79	.9	1,225
2	395–424 d	.47	.9	2,063
2	425–484 d	.25	.9	4,520
2	485–564 d	0	.9	2,124
2	≥ 565 d	.18	.9	1,219
3, 4		.08	.3, 0	14,678
5		.2	0	3,991
6, 7		.55	0	3,421
> 7		1.06	.4	1,079

^aNSIF, 1987.

Table 4. Adjustment factors and numbers within class for number of pigs born alive in Landrace swine

Parity	Age at breeding	New adjustment	Current adjustment ^a	No. within class
1	< 240 d	1.10	.57	2,028
1	240–329 d	.73	.57	5,034
1	330–359 d	.45	.57	369
1	≥ 360 d	.81	.57	657
2	< 395 d	1.04	.29	1,317
2	395–424 d	.71	.29	1,359
2	425–484 d	.53	.29	1,978
2	≥ 485 d	.23	.29	1,461
3, 4, 5		0	0	11,336
6		.09	.32	1,926
7		.42	.64	1,257
> 7		.97	.84	1,799

^aBrubaker et al., 1994.

Table 5. Adjustment factors and numbers within classes for number of pigs born alive in Yorkshire swine

Parity	Age at breeding	New adjustment	Current adjustment ^a	No. within class
1	< 210 d	1.46	.69	2,511
1	210–239 d	1.24	.69	11,406
1	240–269 d	.96	.69	16,937
1	270–299 d	.81	.69	9,517
1	≥ 300 d	.57	.69	10,082
2	< 365 d	.99	.23	2,377
2	365–424 d	.60	.23	14,507
2	425–534 d	.18	.23	15,474
2	≥ 535 d	0	.23	4,144
3, 4, 5		0	0	60,471
6		.34	.51	7,584
7		.50	.77	4,267
> 7		.86	1.09	3,985

^aBrubaker et al., 1994.

Table 6. Parity and age adjustment factors and number within classes for 21-day litter weight in Duroc swine

Parity	Age at breeding	New adjustment, kg	Current adjustment, kg ^a	No. in class
1	< 210 d	6.00	2.95	719
1	210–269 d	4.59	2.95	6,718
1	270–359 d	3.64	2.95	3,873
1	≥ 360 d	1.91	2.95	681
2		0	0	7,986
3		.50	0	6,249
4		1.41	.68	3,957
5		2.91	2.04	2,506
6		3.91	2.04	1,286
> 6		4.91	2.04, . . .	1,088

^aNSIF, 1987.

Table 7. Parity and age adjustments and number within classes for 21-day litter weight in Hampshire swine

Parity	Age at breeding	New adjustment, kg	Current adjustment, kg ^a	No. in class
1	< 270 d	4.64	2.95	6,867
1	270–329 d	4.14	2.95	5,582
1	≥ 330 d	2.18	2.95	2,477
2	< 395 d	1.68	0	1,225
2	≥ 395 d	.45	0	9,926
3, 4		0	0, .68	14,678
5		.50	2.04	3,991
6		.73	2.04	2,234
7		1.86	2.04	1,187
> 7		2.27	3.86, . . .	1,079

^aNSIF, 1987.

Table 8. Parity and age adjustments and number within classes for 21-day litter weight in Landrace swine

Parity	Age at breeding	New adjustment, kg	Current adjustment, kg ^a	No. in class
1	< 240 d	6.36	4.57	2,028
1	240–299 d	4.95	4.57	4,236
1	≥ 300 d	3.45	4.57	1,824
2, 3		0	0, .08	11,120
4, 5		.55	.81, 1.51	6,331
6		2.59	3.19	1,926
7		3.18	3.91	1,257
> 7		4.55	5.83	1,799

^aBrubaker et al., 1994.

Table 9. Parity and age adjustments and number within classes for 21-day litter weight in Yorkshire swine

Parity	Age at breeding	New adjustment, kg	Current adjustment, kg ^a	No. in class
1	< 240 d	4.55	2.53	13,917
1	240–299 d	3.27	2.53	26,454
1	≥ 300 d	1.95	2.53	10,082
2		0	0	36,502
3		.23	.55	28,279
4		1.14	1.91	19,228
5		2.14	3.10	12,964
6		3.27	4.6	7,584
7		4.18	5.69	4,267
> 7		5.36	7.25	3,985

^aBrubaker et al., 1994.

Strang, 1970; Clark and Leman, 1986), which showed an increase of .003 to .009 pigs per parity 1 litter for each additional day of age of the sow at breeding. Duroc and Hampshire populations, compared to the current NSIF adjustments, were found to have smaller average adjustments for the initial parities and larger adjustments for later parities. Larger adjustments were also found for the younger females relative to the older females within parities 1 and 2. Landrace and Yorkshire adjustments for NBA were larger than the current adjustments derived by Brubaker et al.

(1994). Again, age was a highly important component of variation within parities 1 and 2 with adjustments for younger Yorkshire sows differing from older sows by almost one pig within parity 1 or 2.

In addition to the larger adjustments found for the youngest females within each parity, an increase in adjustment, compared to the average of the parity, was also found for the oldest females within P1 for Landrace and P2 for Duroc and Hampshire. This effect has also been observed in a large commercial data set (Culbertson and Mabry, 1995).

Table 10. Number after transfer (NAT) adjustments for 21-day litter weight in Duroc, Hampshire, Landrace, and Yorkshire swine

NAT	Duroc, kg	Hampshire, kg	Landrace, kg	Yorkshire, kg
1, 2	31.45	36.59	42.86	42.59
3	29.64	32.45	33.73	34.36
4	24.73	26.68	26.55	28.27
5	19.73	20.91	22.00	22.50
6	14.63	15.86	17.09	17.18
7	9.95	11.00	11.95	12.00
8	6.23	6.64	7.27	7.45
9	2.77	2.82	2.91	3.27
10+	0	0	0	0

Table 11. Weaning age multiplicative adjustment factor for 21-day litter weight in Duroc, Hampshire, Landrace, and Yorkshire swine

Age, d ^a	Duroc	Hampshire	Landrace	Yorkshire
14	1.19	1.18	1.24	1.20
15	1.16	1.18	1.20	1.18
16	1.15	1.14	1.15	1.15
17	1.11	1.11	1.13	1.12
18	1.09	1.06	1.09	1.09
19	1.05	1.04	1.07	1.06
20	1.02	1.02	1.03	1.03
21	1.0	1.0	1.0	1.0
22	.97	.97	.96	.97
23	.93	.93	.93	.94
24	.90	.9	.90	.91
25	.86	.89	.87	.88
26	.82	.84	.84	.85
27	.79	.82	.83	.82
28	.77	.79	.79	.79

^aWeaning age of litter.

Parity and(or) age adjustments for 21-d litter weight in Duroc, Hampshire, Landrace, and Yorkshire are presented in Tables 6 to 9, respectively. Duroc and Hampshire adjustments were found to be larger in magnitude than those currently recommended by NSIF. Landrace and Yorkshire adjustments, on average, were found to be similar to the current adjustments. However, age of the sow contributed considerable variation to parity 1 litter records in all breeds with larger adjustments needed for the younger females. Age of the sow at conception of the litter record was found to have decreasing importance in parity 2.

Number after transfer and multiplicative weaning age adjustments for 21-d litter weight are presented in Tables 10 and 11, respectively. Adjustments for number after transfer and weaning age are in general agreement with previous studies (NSIF, 1987; Brubaker et al., 1994) and relatively consistent across breed populations.

An evaluation of the possible improvement attained by including additional fixed effects to define age within parity was conducted with the procedure outlined by Boik et al. (1993). The animal model that included the effects of parity and age of the sow within parity 1 and 2 was found to be significantly better ($P < .01$) for all breed and trait combinations than an animal model that included only parity effects.

Production and economic efficiencies often lead producers to attempt to mate females at younger ages. Current adjustments do not differentiate between sows that conceive their initial litters at younger ages and those that conceive their initial litters at older ages. Therefore, sows with the economic benefits of being able to reach puberty and conceive at younger ages may have their genetic evaluation for reproductive traits biased downward. Consequently, the accurate identification of sires and herds of increased genetic merit should be increased using the new

adjustments from estimation procedures taking these effects into account.

Implications

Industry standard adjustment factors should be updated to a breed-specific basis using techniques that allow for inclusion of genetic merit. Further improvements in evaluation of animals or herds with a young initial breeding age should be achieved by better defining the effects of parity to include the effect of age of the sow on first and second parity records.

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