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Abstract

Factors to standardize litter weights of nursing pigs to 21 d of age were calculated from daily weights measured on 64 crossbred litters from 10 to 32 d of age. The results were compared to published factors derived from a data set of Duroc pigs weighed every 3 to 4 d. Dams in the present study were white crossbred sows and gilts, and sires were maternal or terminal breed types. Multiplicative factors were calculated by dividing the mean 21-d litter weight (LW21) by mean daily litter weight. Linear and quadratic regression coefficients of LW21 on age at weighing were fitted to the factors (R2 = .997). The final equation for adjusting litter weights to a 21-d basis was 2.5246 - .1041 x (d of age) + .0015 x (d of age)2. There were good agreement with published factors for d 19 to 25, but divergence for younger and older litters resulted in significant differences between the linear coefficients. These differences may be due to departure from a linear growth curve, which daily measurements would incorporate, or differences in sow populations. Thus, use of the new factors should be considered for white crossbred sow populations. A least squares analysis indicated that LW21 was significantly altered by parity, not by the number of pigs allowed to nurse or by breed of sire. After adjustment to 21 d, litter weights also should be adjusted for differences in parity before evaluating sow productivity, by using additive factors such as those recommended by the National Swine Improvement Federation.

Keywords

Pigs, Litter Weight, Standardization, Weaning Weight

Disciplines

Agriculture | Animal Sciences

Comments

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FACTORS TO ADJUST LITTER WEIGHT OF PIGS TO A STANDARD 21 DAYS OF AGE[1]

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ABSTRACT

Factors to standardize litter weights of nursing pigs to 21 d of age were calculated from daily weights measured on 64 crossbred litters from 10 to 32 d of age. The results were compared to published factors derived from a data set of Duroc pigs weighed every 3 to 4 d. Dams in the present study were white crossbred sows and gilts, and sires were maternal or terminal breed types. Multiplicative factors were calculated by dividing the mean 21-d litter weight (LW21) by mean daily litter weight. Linear and quadratic regression coefficients of LW21 on age at weighing were fitted to the factors (R^2 = .997). The final equation for adjusting litter weights to a 21-d basis was 2.5246 − .1041 × (d of age) + .0015 × (d of age)^2. There was good agreement with published factors for d 19 to 25, but divergence for younger and older litters resulted in significant differences between the linear coefficients. These differences may be due to departure from a linear growth curve, which daily measurements would incorporate, or differences in sow populations. Thus, use of the new factors should be considered for white crossbred sow populations. A least squares analysis indicated that LW21 was significantly altered by parity, not by the number of pigs allowed to nurse or by breed of sire. After adjustment to 21 d, litter weights also should be adjusted for differences in parity before evaluating sow productivity, by using additive factors such as those recommended by the National Swine Improvement Federation.

(Key Words: Pigs, Litter Weight, Standardization, Weaning Weight.)

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Introduction

Litter weight at 21 d (LW21) is an indication of a sow's milking ability and litter size. To ensure accuracy, litter weights should be measured at the same age, but this is not always feasible. Accurate records are also important in evaluating daughters of sows as potential replacements. Swiger and Irvin (1978) suggested using average daily gain of pigs to adjust weights to 21 d, but this method required the recording of birth weights. Stewart (1978) weighed a set of Duroc pigs every 3 to 4 d from 13 to 30 d of age and calculated multiplicative factors for that age range. Bereskin and Norton (1982) fitted quadratic regression equations to 3,587 Duroc and Yorkshire records collected over a 5-yr period to derive adjustment factors for age at weighing.

The above data sets yielded different adjustment factors. Additionally, no published reports have addressed the use of adjustment factors in crossbred sow populations, which compose a large proportion of commercial herds. Therefore, this study was conducted to determine factors appropriate for adjusting weights of crossbred litters to a 21-d basis, using daily weights measured from 10 d to 32 d, and to compare results to currently recommended factors.

Experimental Design

Data. Litters evaluated in this study were farrowed at the Iowa State University Swine

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Breeding Farm at Madrid, IA, during July and August 1985, and were part of a static-rotational crossbreeding project. Dams were white crossbred sows from three lines. Line 1 consisted of a two-breed rotation for female replacements, with Yorkshire and Landrace boars bred to Yorkshire-Landrace sows. Line 2 was composed of Yorkshire-Landrace-Chester sows in a three-breed rotational cross, whereas Line 3 contained Yorkshire-Landrace sows bred to F_1 Yorkshire-Landrace boars to produce replacement gilts. Sows that ranked in the top 20% based on mean sow productivity index in each line were bred to boars of the appropriate white breed or cross (maternal). All other sows and all gilts were bred to Duroc, Hampshire or Duroc-Hampshire (terminal) boars. Within a week after farrowing, each sow and her litter were moved from a farrowing house to a pen located in a modified open-front building. To reduce variation in litter size when a large disparity occurred in litters born at approximately the same time, pigs were cross-fostered within 3 d of birth. Individual pigs were weighed at birth, at 21 d of age and at weaning (42 d of age). Litters were identified by ear notches at birth and received standard vaccinations and care. Beginning at 10 d of age, 64 litters were weighed daily through 32 d of age. Number of live pigs per litter was recorded daily, and cause of any deaths was noted. Of the 786 pigs alive at the start of weighing, 16 died between 10 and 32 d of age; these 16 pigs weighed an average of 2.3 kg.

Statistical Analysis. Arithmetic means and variances were obtained for litter weight at each age. Departure of the data from normality was tested by using standard tests of skewness and kurtosis contained in the UNIVARIATE procedure in SAS (1985). Multiplicative adjustment factors were calculated by dividing the mean LW21 by the mean litter weight on each day from 10 through 32 d of age. A quadratic regression equation then was fitted to the multiplicative constants to obtain an algorithm for calculating adjustment factors. A *t*-test was used to detect heterogeneity of regression coefficients calculated from subsets based on parity, classification of sire (maternal versus terminal) and number of pigs allowed to nurse ($\leq$10 pigs versus > 10 pigs). In addition, *t*-tests were used to compare the factors from this study with those recommended by NSIF (1988).

A least squares analysis of LW21 was conducted to determine the effects of dam line, sire breed, parity, and number of pigs allowed to nurse on litter weight for this population of maternal crossbred sows. The model used was

$$Y_{ijklm} = \mu + L_i + B_j + P_k + N_l + e_{ijklm},$$

where Y_{ijklm} = LW21, μ = underlying mean, L_i = fixed effect of the i^{th} dam line (i = 1, 2, 3), B_j = fixed effect of the j^{th} sire breed type (1 = maternal, 2 = terminal), P_k = fixed effect of the k^{th} parity (k = 1, 2, 3, 6), N_l = fixed effect of the l^{th} litter size class (l = $\leq$10 pigs; 2 = >10 pigs), and e_{ijklm} = random residual effect with mean zero and variance σ_e^2 associated with each litter weight measurement. Due to the makeup of the population of white crossbred sows, which originated with third-parity sows and gilts, parities four and five were not represented in this study. Parity was cross-classified with dam lines and sire type. Based on results reported by Wilson and Johnson (1980), litter size was included in the model. It was analyzed as a classification variable because the range of litter sizes was narrow, 6 to 17 pigs, with 50 litters having more than 10 pigs. Ten was chosen as an arbitrary division because it is considered the standard by which 21-d weight is adjusted (National Swine Improvement Federation, 1988). Interactions were included in the residual error term after preliminary analyses indicated that interactions were not significant.

Results and Discussion

Means and variances for litter weights by day of age are presented in Table 1. Because variance increased with litter weight over time, multiplicative factors are more appropriate than additive factors. Preliminary analysis indicated that the data did not depart from normality ($P < .10$). In contrast, Bereskin and Norton (1982) used the natural log of pig weights to obtain multiplicative factors because residual variances of weights were different when measured at d 1 versus those recorded near 21 and 42 d of age. The authors attributed the differences to the variability in age of litters at weighing.

An algorithm was developed for calculating factors by using the adjustment factors (Table 1). Inclusion of linear and quadratic coeffi-

TABLE 1. MEANS AND VARIANCES OF DAILY LITTER WEIGHTS FROM 10 TO 32 DAYS OF AGE AND MULTIPLICATIVE FACTORS FOR ADJUSTING LITTER WEIGHTS TO A 21-DAY BASIS

Age, d	N	Mean, kg	Variance	SE	Adjustment factor[a]
10	64	33.8	76.2	1.1	1.67
11	64	35.9	88.8	1.2	1.57
12	64	37.9	95.6	1.2	1.48
13	64	40.0	103.7	1.3	1.41
14	64	42.3	111.7	1.3	1.33
15	64	44.3	124.2	1.4	1.27
16	64	46.2	133.2	1.4	1.22
17	64	48.4	142.9	1.5	1.16
18	64	50.2	152.0	1.5	1.12
19	64	52.0	159.5	1.6	1.08
20	64	54.0	171.0	1.6	1.04
21	64	56.3	179.5	1.7	1.00
22	64	58.5	193.3	1.7	.96
23	64	60.6	205.8	1.8	.93
24	64	62.3	219.7	1.9	.90
25	64	64.7	237.5	1.9	.87
26	64	66.6	268.0	2.1	.84
27	64	69.0	279.2	2.1	.81
28	64	71.4	296.2	2.2	.79
29	64	73.3	320.0	2.2	.77
30	64	75.9	340.3	2.3	.74
31	64	77.8	357.7	2.4	.72
32	57	79.6	408.1	2.7	.71

[a]Calculated by dividing the mean 21-d litter weight by the mean litter weight for each day.

cients resulted in an R^2 of .997 (Table 2). Stewart (1978) utilized weights taken on pigs every 3 to 4 d between the ages of 13 and 30 d to derive multiplicative factors to adjust litter weights to a 21-d basis. He also used a quadratic regression equation to develop an algorithm for calculating adjustment factors. In a different approach, Bereskin and Norton (1982) utilized regression analysis to obtain adjustment factors centering on 14, 21 and 28 d of age.

On the basis of reports of differences in sow performance due to the effects of parity and number of pigs allowed to nurse (Swiger and

TABLE 2. REGRESSION COEFFICIENTS USED TO DEVELOP ALGORITHMS FOR CALCULATING 21-DAY LITTER WEIGHT ADJUSTMENT FACTORS FROM DAY OF AGE[a]

Data set	b_o	b_1	b_2	R^2
Overall	2.5171[b]	−.1041	.0015	.997
Parity				
1	2.5068	−.1036	.0015	.994
2	2.6147*	−.1115	.0016	.997
3	2.3574*	−.0913	.0012	.997
6	2.5843*	−.1107	.0016	.995
No. of pigs allowed to nurse				
≤10	2.6382*	−.1136	.0017	.996
>10	2.3692*	−.0912	.0012	.996
Sire breed type				
Maternal	2.3963*	−.0916	.0012	.997
Terminal	2.5388	−.1063	.0016	.996

[a]b_o = intercept; b_1 = linear coefficient; b_2 = quadratic coefficient.

[b]Adjusted to 2.5246 to force unity of equation at d 21.

*Coefficients are different from the overall coefficient ($P < .05$).

TABLE 3. LEAST SQUARES MEANS OF 21-DAY LITTER WEIGHT FOR LINE, NUMBER OF PIGS ALLOWED TO NURSE, BREED TYPE OF SIRE, AND PARITY

Variable	N	Mean, kg	SE	Level of significance
Line[a]				NS[c]
1	19	48.79	3.43	
2	29	53.70	2.89	
3	16	55.26	4.02	
No. of pigs allowed to nurse				NS
≤10	14	51.96	3.77	
>10	50	53.21	2.77	
Breed type of sire[b]				$P < .05$
Maternal	10	47.25	4.36	
Terminal	54	57.92	2.34	

[a]Line 1 = Yorkshire and Landrace two-breed rotation. Line 2 = Yorkshire, Landrace and Chester White three-breed rotation. Line 3 = Yorkshire and Landrace *inter se* breeding.

[b]Maternal = Yorkshire, Landrace, Chester White or Yorkshire-Landrace F_1, Terminal = Duroc, Hampshire, or Duroc-Hampshire F_1.

[c]NS = not statistically significant.

Irvin, 1978; Wilson and Johnson, 1980; Bereskin and Norton, 1982), adjustment factors in the present data set were calculated for subsets based on parity, sire classification, and number of pigs allowed to nurse. *T*-tests were used to compare results from algorithms based on these subsets to results from the overall algorithm (Table 2). Intercepts (b_0) of most of the subset regression equations were different ($P < .05$) from the overall equation, but the linear (b_1) and quadratic (b_2) coefficients were not significantly different. This result appeared to indicate that the average value of the age adjustment differed due to various effects in the data set, but that the changes in differences followed the same pattern over time. Interpretation of these differences in intercepts must be done carefully, because they represent an extrapolation from d 10 to d 0.

To gain a better understanding of the causes of differences in intercepts among data subsets, effects on LW21 due to line, parity, breed type of sire, and number of pigs allowed to nurse were analyzed by using least squares. There were no significant differences due to dam line (Table 3), which was not surprising because sows shared similar genetic backgrounds. Parity, however, was a significant source of variation so the parity effect was left in the model.

In contrast to other reports (Swiger and Irvin, 1978; Wilson and Johnson, 1980; Yen et al., 1987), LW21 was not significantly affected by number of pigs allowed to nurse when 10 was arbitrarily chosen as the break point (Table 3). However, in this data set, 50 of 64 sows nursed more than 10 pigs. Use of other data sets containing litters more normally distributed along the spectrum of number of pigs per litter would constitute a more sensitive test of differences, as found by Wilson and Johnson (1980). Yen et al. (1987) analyzed data from 10,976 litters and, although 78% of those litters had between 8 and 12 pigs, LW21 was significantly affected by number of pigs per litter.

Litters sired by terminal boars were heavier ($P < .05$) at 21 d than those sired by maternal boars (Table 3). This result may have been due to more heterosis in the terminal-cross litters or to sire breed effects. Sampling also may have been responsible for this difference,

TABLE 4. COMPARISON OF REGRESSION COEFFICIENTS FROM THE PRESENT STUDY WITH THOSE CURRENTLY USED BY THE SWINE INDUSTRY FOR CALCULATION OF 21-DAY LITTER WEIGHT ADJUSTMENT FACTORS

Algorithm	b_0	b_1	b_2
Industry[a]	2.218	−.0811	.0011
Present study[b]	2.5246*	−.1041*	.0015

[a]Algorithm based on adjustment factors calculated by regression of litter age on litter weight for litters weighed at various ages close to 21 d. Currently recommended by the National Swine Improvement Federation (1988).

[b]Derived from multiplicative factors obtained by weighing the same litters daily from 10 to 32 d of age.

*Coefficients in the same column are different ($P < .05$).

TABLE 5. COMPARISON OF MULTIPLICATIVE 21-DAY LITTER WEIGHT ADJUSTMENT FACTORS CALCULATED FROM ALGORITHMS BASED ON THE PRESENT STUDY VERSUS THOSE CURRENTLY USED BY THE SWINE INDUSTRY

	Adjustment factors	
Age, d	Present study[a]	Industry[b]
10	1.63	
11	1.56	
12	1.49	
13	1.43	
14	1.36	1.30
15	1.30	1.25
16	1.24	1.20
17	1.19	1.15
18	1.14	1.11
19	1.09	1.07
20	1.04	1.03
21	1.00	1.00
22	.96	.97
23	.92	.94
24	.89	.91
25	.86	.88
26	.83	.86
27	.81	.84
28	.79	.82
29	.77	
30	.75	
31	.74	
32	.73	

[a]These factors are estimates from the algorithm, and differ slightly from factors in Table 1.

[b]Derived from the National Swine Improvement Federation (1988).

however, because there were only 10 maternal litters and 54 terminal-cross litters.

Bereskin and Norton (1982) found differences in adjustment factors derived from subsets based on breed and sex, but they concluded that one overall equation would be more useful and acceptable for producers. In addition, NSIF recommends a single algorithm for adjusting litter weights to a 21-d basis. Thus, because the linear and quadratic coefficients did not differ among subsets, the overall equation developed in this study was compared with National Swine Improvement Federation factors.

In writing computer programs to evaluate sow productivity, it is more efficient to use an equation to adjust litter weights to a 21-d basis than to enter a series of multiplicative factors. But use of such an equation must not cause a significant change in weights of litters measured exactly at 21 d. Use of the algorithm in Table 2 resulted in such a shift, but by slightly modifying the intercept from 2.5171 to 2.5246, the 21-d factor remained at 1.00.

Our modified algorithm was compared with the one recommended by the National Swine Improvement Federation (NSIF) in 1988. The intercept and linear coefficients differed significantly from those derived from the present data set (Table 4). There are several possible reasons for these differences. Comparison of factors (Table 5) shows that, although factors for weights taken close to 21 d were quite similar, there was more divergence at each end of the range of comparison. This might be expected because factors in this study were derived from weights measured daily on the same litters, whereas NSIF factors were obtained from weights measured every 3 to 4 d. The NSIF data base also contained litters out of purebred dams rather than crossbreds. G. Peterson (personal communication) indicated that multiplicative factors calculated from a data set containing crossbred sows were similar to factors reported here, but that the total data set containing purebred and crossbred sows yielded different factors.

Implications

Assuming that litters cannot be weighed at exactly 21 d (the best course of action), factors reported here are appropriate for adjustment to 21 d for litters weighed between 10 and 32 d of age that are produced by and are nursing white crossbred sows. Factors for ages close to 21 d are similar to those obtained from a combination of purebred and crossbred litters; however, further work in this area is warranted to determine the magnitude of differences among sow populations. The least squares analysis reiterated the need for adjusting litter weights for parity of the dam, but it did not definitively prove that adjusting for litter size or for breed type of sire was necessary.

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