Generating an Equation to Predict Post-Farrow Maternal Weight in Multiple Parity Sows[1,2]

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Summary

Post-farrow maternal weight is required when partitioning maternal and fetal weight gains throughout gestation. Equations were developed from the analysis of 150 females (Line 1050, PIC, Hendersonville, TN) to predict the weight of conceptus by difference of pre- and post-farrowing weight change in multi-parity sows. Females were individually weighed as they were moved into the farrowing house at d 110 to 112 of gestation and again at 12 to 24 h after farrowing. Data were divided into 4 groups: (1) parity 1 sows; (2) parity 2 sows; (3) parity 3 sows; and (4) parity 4+ sows. Each group tested 3 predictor variables: pre-farrow weight, total born, and difference in days between the pre- and post-farrow weights. Prediction equations were then developed using models with significant terms based on the Bayesian Information Criterion (BIC). The optimum equations to predict maternal body weight were similar for all parities except for the intercept (b) and can be described as:

Post-farrow maternal body weight (lb) = b + (0.897 × pre-farrow BW, lb) - (1.118 × total born, n) + (6.87 × days pre to post-farrow, d)

Where the intercept (b) for parities 1, 2, 3, and 4+ were -5.93, 5.15, 11.90, and 32.31, respectively.

The prediction equations were then used to estimate post-farrow maternal BW using 332 mixed parity sows (PIC 1050). Pre-farrow weights were taken on d 113 of gestation and maternal BW was taken within 24 h of farrowing. On average, the predicted post-farrow maternal BW was overestimated by 3.3 lb of the actual. Management practices differed in how females were fed from the validation experiment, possibly contributing to the overestimating of post-farrow maternal BW. This indicates that further evalua-

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tion of the equation is needed to see if the difference is due to litter size, parity distribution, or feeding management practices.

Key words: sows, post-farrow maternal weight

Introduction

A successful gestation feeding program is one that yields a large, vigorous litter of pigs and a healthy sow equipped with adequate mammary development and body nutrient stores to produce large quantities of milk for the suckling litter. Variations in body size, productivity, and environmental conditions dictate different daily concentrations of nutrients to satisfy the sow's requirement. Models have been developed for sow nutrient requirements in gestation (NRC 1998,[4] NRC 2012[5]). These models attempt to partition nutrient requirements into three components: sow maintenance, products of conception, and maternal weight gain.

The process of reproduction from conception to weaning involves both homeostatic and homeorhetic control of nutrient partitioning (Dourmad et al., 1999[6]). The maintenance of the body is the main homeostatically controlled process, whereas the products of conception and maternal weight gain are regulated through homeorhetic controls. Maintenance of the sow and growth of the conceptus receive the highest priority for nutrients. When these two needs are satisfied, any remaining nutrients can then be deposited in maternal tissue (fat and protein deposition). If nutrient supplies are not sufficient, body proteins and lipids are mobilized to support maintenance requirements and conceptus growth.

Thus, optimal sow performance and longevity require a careful approach to determining the nutrient requirement during pregnancy in order to control the sow's body reserves. Overfeeding in gestation can cause increases in weight and body condition of the sow at the end of pregnancy, causing farrowing difficulties, decreased appetite in lactation, and increasing the risk of heat and environmental stress in the farrowing house (Dourmad et al., 1999). Underfeeding in gestation lowers body fat reserves at farrowing and at weaning, lowers conception rate, delays return to estrus, and ultimately decreases sow longevity.

Previous models provide equations for the prediction of sow maintenance requirements, products of conception, and maternal weight gain; however, when determining products of conception, a post-farrow maternal BW, in addition to pre-farrow BW, is required.

Unfortunately, in commercial research, removing a newly farrowed sow from a farrowing crate and walking her to a scale to be weighed, can be challenging. Producers express concerns when moving sows in and out of the farrowing crate after farrowing because of its impact on pre-wean mortality. Therefore, a prediction equation is necessary to estimate post-farrow BW from pre-farrow BW to determine products of conceptus.

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[4] NRC. 1998. *Nutrient Requirements of Swine,* 10th Rev. Ed. Washington, DC: National Academy Press.
[5] NRC. 2012. *Nutrient Requirements of Swine,* 11th Rev. Ed. Washington, DC: National Academy Press.
[6] Dourmad, J.Y., L. Noblet, M.C. Pere, and M. Etienne. 1999. Mating, pregnancy and prenatal growth. Pp. 129-152 in *Quantitative Biology of the Pig*, I. Kyriazakis, ed. Wallingford, UK: CABI.

The objective of the present study was to develop a model that can predict post-farrow maternal BW in order to determine maternal and fetal weight gains throughout gestation.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The experiment was conducted at a commercial sow farm in central Nebraska in early spring, 2016. Females were individually housed from weaning until d 4 after breeding. They were then placed in pens with 260 sows per pen and 22 sq. ft per sow and 21 sq. ft per gilt until moved into the farrowing house. Each group pen was equipped with 6 electronic sow feeding stations (NEDAP, The Netherlands) and 28 nipple waterers to provide ad libitum access to water.

Between d 110 to 112 of gestation, 150 females (Line 1050, PIC, Hendersonville, TN; 46 gilts and 104 sows) were moved to the farrowing house and provided ad libitum access to feed and water. The average parity for sows after farrowing was 3.0 ± 1.9 (mean ± SD). The gestation and lactation diets were corn-soybean meal-based and presented in meal form. All nutrients met or exceeded the NRC (2012) recommendations. Females were weighed individually as they were moved from gestation into the farrowing rooms and again at 12 to 24 h after farrowing.

PROC MIXED in SAS (SAS Institute, Inc., Cary, NC) was used to develop prediction equations. The statistical significance for inclusion of terms in the model was determined at $P < 0.05$. Further evaluation of models with significant terms was then conducted based on the Bayesian Information Criterion (BIC). A model comparison with a reduction in BIC of more than 2 was considered improved (Kass and Raftery, 1995[7]). The fixed effects evaluated were pre-farrow BW, total born, difference in days between the pre- and post- farrow BW, and parity group (Parity 1, 2, 3, and 4+). The random effect evaluated was the date when the post-farrow BW was obtained. There was no total born by parity group interaction or quadratic response of total born, thus these terms were removed from the model. The final model contained pre-farrow body weight, total born, the difference in days between the pre- and post- farrow BW and parity as input variables.

Prediction Equation Evaluation

To evaluate the prediction equation used to estimate post-farrow maternal body weight, a data set with a total of 332 mixed parity sows (PIC 1050) was used. Pre-farrow weights were obtained on d 113 of gestation and post-farrow maternal BW were taken within 24 h of farrowing. Sows were given ad libitum access to water but feed intake was limited to 6 lb/d. Agreement was measured using a paired t test to evaluate the difference between actual and predicted weights. Limits of agreement were calculated.

Results and Discussion

The pre-farrow weights and post-farrow maternal BW ranged from 419 to 697 lb and 357 to 680 lb, respectively. Parity after farrowing ranged from 1 to 7 and total born

[7] Kass, R.E., and A.E. Raftery. 1995. Bayes Factors. J. Am. Statist. 90:773-795.

ranged from 7 to 22 piglets. The difference in days between the pre-and post-farrow weights ranged from 1 to 7 d (Table 1).

Significant single-variable models used to predict post-farrow maternal BW included pre-farrow BW, difference in days between the pre-and post-farrow BW, and parity group ($P = 0.001$). Total born was not statistically significant in the model ($P = 0.072$), but reduced BIC, indicating a better fit and was therefore included in the final model. When evaluating bias for all 4 parity groups, the final equations tended to overestimate the weight gain of the lighter sows and underestimate the weight of heavier sows, especially for younger parity groups (Figure 1).

The optimum equations to predict maternal body weight were similar for all parities except for the intercept (b) and can be described as:

> Post-farrow maternal body weight (lb) = b + (0.897 × pre-farrow BW, lb) - (1.118 × total born, n) + (6.87 × days pre to post-farrow, d)
>
> Where the intercept (b) for parities 1, 2, 3, and 4+ were -5.93, 5.15, 11.90, and 32.31, respectively.

Prediction equations are tools that can become an integral part of a pork enterprise; however, it is essential that they are used correctly to prevent the generation of faulty information. It is important to realize that the equations are valid only as long as the input variables consist of values within the ranges used to generate the predictive equation.

The sows from this farm were provided ad libitum feed once they were placed into the farrowing crate. Therefore, the days spent in the farrowing crate prior to farrowing becomes important in predicting post-farrow maternal BW. The model predicts that for every day in the farrowing crate prior to farrowing, the sow gains 6.9 lb of BW. The body weight gain during this time is attributed to the conceptus and sow maternal gain. The model also suggests that as parity increases, the sow loses less weight and starts to progressively gain weight. We expect that gilts in comparison to older sows would increase their maternal body size at a faster rate compared to older sows if they consumed the same amount of feed; however, our model tells us that parity 1 sows are losing more weight in comparison to parity 2+ sows. This could be because gilts under consume and sows over consume what is required for their respective maternal and conceptus needs.

The range of prediction equation input variables derived from the validation experiment and the actual and estimated post-farrow maternal BW are presented in Table 2. Pre-farrow body weight, total born, difference in days between the pre- and post- farrow BW, and parity were used as input variables in the model to predict post-farrow maternal BW and then compared to the actual post-farrow maternal BW. On average, the predicted post-farrow maternal BW was 3.3 lb greater than the actual with 95% confidence interval -5.35 to 17.8 lb (Figure 2). The statistical difference was significant ($P = 0.002$) between the actual and the estimated post-farrow maternal BW. The limits of agreement (-41.6 and 35.1 lb) also lead us to believe that the predicted post-farrow maternal BW was overestimated compared to the actual. Although the statistical difference between the actual and estimated post-farrow maternal BW was significant, there is evidence to believe that there is no biological difference. When applying this difference (3.3 lb) to sow gestation models, the impact on daily maintenance requirement and expected maternal gain is a difference of 32 kcal and 0.01 kg, respectively.

It is important to note that the validation experiment was conducted at a campus research facility among 11 farrowing groups. Management practices differed in how the females were fed in the farrowing house, with sows from the validation experiment receiving up to 6 lb per day compared to the sows used to develop the prediction equation receiving ad libitum access to feed. Therefore, the difference between the predicted vs. actual post-farrow maternal BW may be attributed to these varying factors. This indicates that further evaluation of the equation is needed to see if the difference is due to genetic background or feeding management practices.

Equations incorporating appropriate criteria to estimate post-farrow maternal BW will allow us to partition differences in maternal weight gain throughout gestation as well as that of the conceptus. This will allow for a better understanding of where dietary energy intake is utilized and how much is deposited as maternal tissue.

Table 1. Descriptive statistics for data included in the evaluation[1]

Item	Mean	SD	Minimum	Maximum
Pre-farrow weight, lb	520.1	53.06	419	697
Maternal body weight, lb	490.5	61.35	357	680
Parity	3.0	1.87	1	7
Total born	16.1	2.77	7	22
Days pre- to post-farrow, d[2]	4.2	1.37	1	7

[1]A total of 150 females (PIC 1050) were used to develop a prediction equation to estimate post-farrow maternal weight.

[2]Days pre- to post-farrow = Date post-farrow weight was obtained – date pre-farrow weight was obtained.

Table 2. Descriptive statistics for data used for the prediction equation evaluation[1]

Item	Mean	SD	Minimum	Maximum
Pre-farrow weight, lb	576.4	66.46	419	694
Actual post-farrow weight, lb	546.6	63.10	383	680
Estimated post-farrow weight, lb	549.85	69.00	378	687
Parity	2.8	1.40	1	7
Total born	14.8	2.94	7	22
Days pre- to post-farrow, d[2]	5.3	1.37	1	7

[1]A total of 332 females (PIC 1050) were used to validate the prediction equation to estimate post-farrow maternal weight.

[2]Days pre- to post-farrow = Date post-farrow weight was obtained – date pre-farrow weight was obtained.

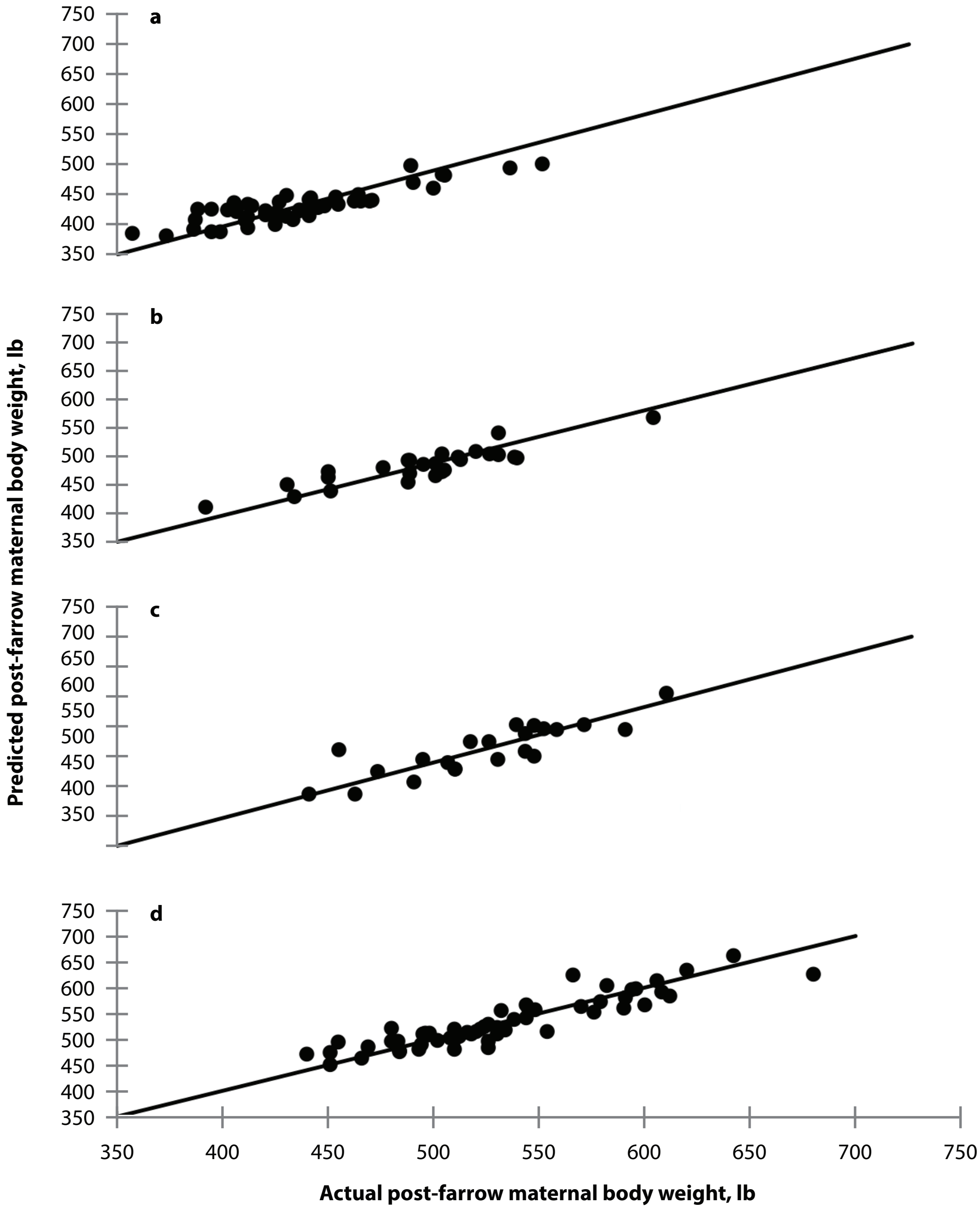

Figure 1. Plot of actual maternal body weight (lb) vs. predicted maternal body weight (lb) relative to the line of equality for (a) parity 1, (b) parity 2, (c) parity 3, and (d) parity 4+ sows from the mixed model analysis. The optimum equations to predict maternal body weight were similar for all parities except for the intercept (b) and can be described as:

Post-farrow maternal body weight (lb) = b + (0.897 × pre-farrow BW, lb) - (1.118 × total born, n) + (6.87 × days pre to post-farrow, d)

Where the intercept (b) for parities 1, 2, 3, and 4+ were -5.93, 5.15, 11.90, and 32.31, respectively.

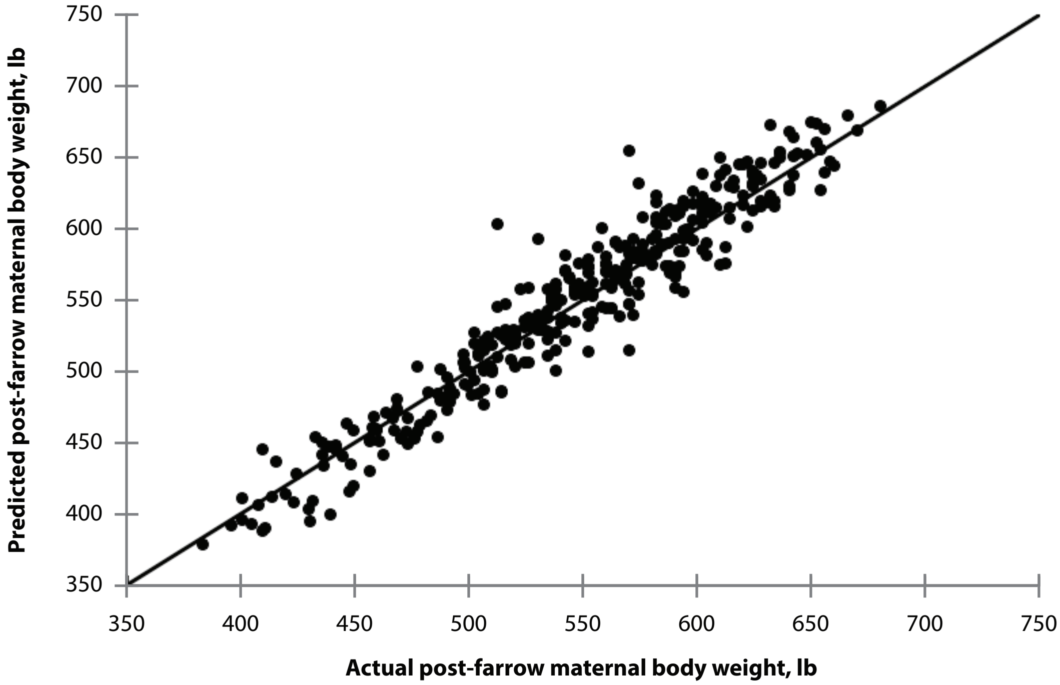

Figure 2. Comparison of actual and predicted maternal BW relative to the line of equality for sows in the validation experiment. The following equation was used for the prediction of maternal BW:

Post-farrow maternal body weight (lb) = b + (0.897 × pre-farrow BW, lb) - (1.118 × total born, n) + (6.87 × days pre to post-farrow, d)

Where the intercept (b) for parities 1, 2, 3, and 4+ were -5.93, 5.15, 11.90, and 32.31, respectively.