The Effect of Sow Body Weight Change During Gestation on Sow Body Weight Change and Litter Average Daily Gain During Lactation

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Summary

A retrospective study was conducted to assess the impact of sow BW change during gestation on sow BW change and litter ADG during lactation. Data from 1,978 gilts and sows across three studies were categorized by parity (gilts: n = 1,098; sows: n = 880). Maternal BW gain during gestation was calculated as the difference between estimated BW at 24-h post-farrowing and BW at d 1 of gestation, while lactation BW change was determined as the difference between BW at weaning and estimated BW at 24-h post-farrowing. Litter ADG was calculated as the difference between litter weight at weaning and litter weight after cross-fostering, divided by lactation length. Regression analyses were performed to model gestation BW change as a function of sow BW at d 1 of gestation, lactation BW change as a function of gestation BW change, and litter ADG as a function of gestation and lactation BW change, along with other covariates. Final models were selected using the Akaike Information Criterion (AIC). Results indicated that in both parity categories, sow BW at day 1 of gestation was negatively associated with gestation BW change ($P < 0.05$), and gestation BW change was negatively associated with lactation BW change ($P < 0.05$). Conversely, litter ADG was positively related to both gestation and lactation BW gain ($P < 0.05$). In gilts, the effect of gestation BW change on litter ADG was modest and can be explained by the offsetting effect of lactation BW change that is negatively influenced by gestation BW change. In contrast, the offsetting effect of lactation BW change on the relationship between gestation BW change and litter ADG was less substantial in sows. In conclusion, the dynamics of sow BW change during gestation and lactation significantly influence litter ADG. Increased BW gain in gilts during gestation led to greater BW loss in lactation without negatively affecting litter ADG, whereas BW loss in sows during gestation led to compensatory gain during lactation at the expense of litter ADG.

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Introduction

The dynamics of sow BW change during gestation and lactation are critical determinants of reproductive performance. Numerous studies have highlighted the importance of achieving adequate maternal weight gain during gestation and minimizing BW loss during lactation, as both factors are closely linked to milk production and, consequently, litter growth. For example, Ha et al. (2024)[3] emphasized that appropriate BW gain during gestation prepares sows for the metabolic demands of lactation, with greater mobilizable body reserves supporting higher milk production, particularly when lactation feed intake is insufficient. Similarly, Hoving et al. (2012)[4] observed a positive association between lactation BW gain and litter ADG. Moreover, excessive BW loss during lactation has been associated with reduced embryo survival in subsequent parities.

Despite these findings, the relationship between BW changes during gestation and lactation and their combined effect on litter ADG remains poorly understood. Some studies suggest a negative correlation between BW changes across these reproductive stages, indicating potential biological trade-offs. Therefore, this retrospective study aimed to evaluate how BW changes during gestation influence subsequent BW changes during lactation and how these patterns together affect litter ADG. We hypothesize that sows experiencing BW loss during gestation will compensate by gaining weight during lactation, potentially at the expense of litter growth.

Materials and Methods

Data

This retrospective study utilized data from three separate trials. Two of the studies investigated SID Lys levels during gestation in multiparous sows (n = 931), while the third study examined different feeding levels in gestating gilts (n = 1,187). All datasets were evaluated to ensure they included the necessary variables to calculate maternal BW changes during both gestation and lactation, as well as litter ADG. These include BW at early gestation, at transfer to farrowing room, and at weaning, litter weight after cross fostering and at weaning, and lactation length.

Unlike the feeding level study, which recorded initial BW on d 1 of gestation, the SID Lys studies measured initial BW on d 35 of gestation. To allow for consistency across datasets, these BW values were standardized to d 1 using prediction equations adapted from Orlando et al. (2023,[5] Equation 1). The model included both linear and quadratic terms for day of gestation to estimate sow BW trajectories by parity. The ratio of actual to predicted BW at d 35 was then applied as an adjustment factor to estimate the corresponding BW at d 1 from the model's y-intercept. The regression coefficients used in Equation 1 are summarized in Table 1.

[3] Ha, S. H., Y. H. Choi, J. Y. Mun, S. R. Park, E. Kinara, H. J. Park, J. S. Hong, Y. M. Kim, and J. S. Kim. 2024. Correlation between reproductive performance and sow body weight change during gestation. J. Anim. Sci. Technol. 66:543–554. doi:10.5187/jast.2023.e105.
[4] Hoving, L., N. Soede, H. Feitsma, and B. Kemp. 2012. Lactation weight loss in primiparous sows: Consequences for embryo survival and progesterone and relations with metabolic profiles. Reprod. Domest. Anim. 47:1009–1016. doi:10.1111/j.1439-0531.2012.02007.x.
[5] Orlando, U. A., C. M. Vier, R. A. Navales, G. Silva, L. Thomas, N. Lu, J. C. Montoro, W. R. Cast, and S. Dritz. 2023. 221 Assessment of modern gilts and sows body weight (BW) throughout gestation and how different gilt BW at breeding impact the energy requirement for maintenance at each parity. J. Anim. Sci. 101:121–122. doi:10.1093/jas/skad341.135.

$$\text{Estimated BW at d 1 of gestation,kg} = \frac{(\text{BW at d 35 of gestation} \times \beta_0)}{\beta_0 + (\beta_1 \times 35) + (\beta_2 \times 35^2)} \quad \text{(Equation 1)}$$

On the other hand, the final BW of the gestating sows was recorded at the time of transfer to the farrowing room (d 110.9 ± 1.37 of gestation). These were converted to estimated BW at 24-h post-farrowing using a predictive equation developed by Mallmann et al. (2018,[6] Equation 2). This model uses pre-farrowing weight along with total born alive (TBA) and stillborn (SB) as predictor variables.

$$\text{BW at 24-h post-farrowing,kg} = 13.03 + (0.93 \times \text{pre-farrowing BW}) + [-1.23 \times (\text{TBA} + \text{SB})] \quad \text{(Equation 2)}$$

After BW standardization, gestation BW change and lactation BW change were calculated using Equations 3 and 4, respectively. The calculation of gestation BW change accounted solely for maternal weight, excluding the weight of the conceptus. Additionally, litter ADG was computed based on litter weights recorded at cross-fostering and weaning, along with the duration of lactation (Equation 5).

$$\text{Gestation BW change,kg} = \text{BW at 24-h post-farrowing,kg} - \text{BW at d 1 of gestation,kg} \quad \text{(Equation 3)}$$

$$\text{Lactation BW change,kg} = \text{BW at weaning,kg} - \text{BW at 24-h post-farrowing,kg} \quad \text{(Equation 4)}$$

$$\text{Litter ADG,kg/d} = \frac{(\text{litter weight at weaning, kg} - \text{litter weight after cross-fostering, kg})}{\text{lactation length}} \quad \text{(Equation 5)}$$

Following initial screening, an additional 20 gilts and sows were excluded due to either a lactation length of less than 10 d or gestation/lactation BW changes equal to more than 100% of their initial BW that were considered as potentially inaccurate weight recordings. After these exclusions, a total of 1,978 gilts and sows remained for analysis. Animals were categorized by parity: 1,098 gilts and 880 sows. Due to the limited number of observations, sows were not further categorized.

In addition to the variables described above, gestation length, litter size after cross-fostering and at weaning, and caliper score (CS) measurements were included in the analysis. Caliper score was recorded at three time points: early gestation (day 1 of gestation for gilts and day 35 for sows), at transfer to the farrowing room, and at weaning. However, the specific version of the caliper used was not documented. Therefore, changes in CS were used rather than absolute values. Gestational CS change was calculated as the difference between CS at transfer to the farrowing room and CS at early gestation, while lactational CS change was defined as the difference between CS at weaning and CS at transfer. Additionally, metabolizable energy (ME) intake was calculated as a percentage of the ME requirement for maintenance (MEm) at d 1 of gestation for the gilt dataset.

[6] Mallmann, A. L., G. D. S. Oliveira, J. Z. Rampi, F. B. Betiolo, D. P. Fagundes, J. E. G. Faccin, I. Andretta, R. D. R. Ulguim, A. P. G. Mellagi, and F. P. Bortolozzo. 2018b. Proposal of equations for predicting post-farrowing sow weight. Acta Sci. Vet. 46:8. doi:10.22456/1679-9216.83867.

Statistical analysis

All regression analyses were performed using the lme4 package in R (version 4.3.1; R Core Team, Vienna, Austria). Linear mixed-effects models were fitted using the lmer function, with the experiment included as a random effect in the sow analyses. Model selection was conducted using the lmerTest package, where the step function enabled stepwise selection of fixed effects. The Akaike Information Criterion (AIC) was used to identify the best-fitting model. Additionally, the hierarchical principle was applied to ensure that lower-order terms were retained whenever higher-order terms were included.

For the gestation BW change model, the following variables were considered: BW on day 1 of gestation (linear and quadratic terms), gestation length, and change in CS during gestation. For the lactation BW change model, candidate predictors included gestational BW change (linear and quadratic terms), BW at 24 h post-farrowing, litter size after cross-fostering and at weaning (and their interaction), lactation length, and CS changes during both gestation and lactation (and their interaction). For the litter ADG model, the following variables were used in model selection: gestation and lactation BW change (linear, quadratic, and interaction terms), litter size after cross-fostering and at weaning (and their interaction), lactation length, and CS changes during gestation and lactation (including their interaction). For the gilt dataset, ME intake as a percentage of MEm at day 1 of gestation was also included in all model selection procedures. For the litter ADG modeling, lactation BW change was first predicted based on gestational BW change, and this predicted value was subsequently used to estimate litter ADG. Statistical significance was set at $P < 0.05$.

Results and Discussion

Gilts

A quadratic decrease in maternal BW gain during gestation was observed with increasing BW at day 1 of gestation (Table 2 and Figure 1). This pattern aligns with findings from Young et al. (2005),[7] who reported reduced maternal BW gain with higher initial BW. This response likely reflects physiological nutrient partitioning, where energy is first allocated to maintenance and conceptus development before maternal tissue accretion (Goodband et al., 2013).[8] The quadratic model predicted the highest maternal BW gain during gestation at an initial body weight of 156 kg. Similarly, BW at day 1 of gestation exhibited a non-linear relationship with lactation BW change. Specifically, BW loss during lactation increased with BW at day 1 of gestation up to approximately 180 kg. Beyond this point, lactation BW loss plateaued with no further loss as initial gestation BW continued to increase. Additionally, gestation BW gain and lactation BW loss increased with higher ME intake as a percentage of their maintenance requirement during gestation.

Consistent with previous studies, modeling lactation BW change as a function of gestation BW change revealed a negative relationship (Table 3 and Figure 2). Greater BW gain during gestation was associated with increased BW and often with body fatness at

[7] Young, M. G., M. D. Tokach, F. X. Aherne, R. G. Main, S. S. Dritz, R. D. Goodband, and J. L. Nelssen. 2005. Effect of sow parity and weight at service on target maternal weight and energy for gain in gestation. J. Anim. Sci. 83:255–261. doi:10.2527/2005.831255x.

[8] Goodband, R. D., M. D. Tokach, M. A. D. Goncalves, J. C. Woodworth, S. S. Dritz, and J. M. DeRouchey. 2013. Nutritional enhancement during pregnancy and its effects on reproduction in swine. Anim. Front. 3:68–75. doi:10.2527/af.2013-0036.

farrowing, both of which are known to negatively affect voluntary feed intake during lactation through long-term regulatory mechanisms. This reduction in intake leads to greater mobilization of body reserves to support milk production (Eissen et al., 2000).[9] Similarly, a negative association was observed between BW at 24 h post-farrowing and lactation BW gain, further supporting the notion that heavier sows at farrowing are more likely to lose weight during lactation.

Both gestation and lactation BW changes were independently associated with increased litter ADG (Table 4). However, the increase in litter ADG with greater gestation BW gain was relatively modest (Figure 4). This limited effect may be explained by the negative relationship between gestation and lactation BW gain, which could partially offset the positive influence of gestation BW gain on litter growth. In the absence of lactation feed intake data, it can only be speculated that high gestation BW gain led to reduced voluntary feed intake during lactation, thereby increasing the mobilization of maternal body reserves to support milk production. If this assumption is true, it may suggest that gilts prioritize milk production by mobilizing body tissue during lactation when feed intake is limited.

Sows

A quadratic decrease in maternal BW gain during gestation was observed with increasing BW at d 1 of gestation (Table 2 and Figure 3). As previously discussed for gilts, gestation BW gain remained relatively stable at lower BW at d 1 of gestation but declined beyond 156 kg. In contrast, the relationship in sows appeared more linear, likely because nearly all individuals in this group had initial BW exceeding 150 kg. This trend suggests that sows may exhibit reduced feed efficiency during gestation, as gilts are generally more efficient due to a higher proportion of energy being directed toward protein rather than fat deposition, a balance that shifts around 156 kg in gilts. Beyond this point, as BW increases, heavier gilts and sows allocate more feed to maintenance, leaving less available for growth, which leads to diminished gains.

In contrast to the situation in gilts, the increase in BW at d 1 of gestation is associated with increasing lactation BW gain in sows. Although the effects of BW at d 1 of gestation on gestation and lactation BW change were different in sows than in gilts, the negative relationship between gestation BW change and lactation BW change were similar (Table 3 and Figure 2). Similar to gilts, this pattern may be driven by the negative effect of gestational BW gain on voluntary feed intake during lactation, resulting in increased reliance on body reserves and reduced lactation BW gain when gestational gain is high. For sows, there was a greater proportion of sows with low gestation weight gain or weight loss during gestation, which resulted in these sows gaining weight during lactation. It is interesting to note that litter size at weaning has a negative association with lactation BW gain (both of gilts and sows). This relationship needs further elucidation to determine whether a reduced number of pigs at weaning, leading to lower milk demands, drives greater BW gain during lactation, or if the increased BW gain during lactation results in lower milk production and consequently fewer pigs weaned.

Similar to gilts, both gestation and lactation BW gain were positively associated with litter ADG in sows (Table 4). However, in contrast to gilts, the regression coefficient for lactation BW change as a predictor of litter ADG was smaller in sows, indicating

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[9] Eissen, J. J., E. Kanis, and B. Kemp. 2000. Sow factors affecting voluntary feed intake during lactation. Livest. Prod. Sci. 64:147–165. doi:10.1016/S0301-6226(99)00153-0.

that its offsetting effect on the relationship between gestation BW gain and litter ADG was less substantial. When sows lost maternal weight during gestation, they tended to compensate with greater BW gain during lactation (Figure 2), but this compensation appeared to come at the expense of litter ADG (Figure 4). On the other hand, when sows gained maternal weight during gestation, litter ADG was optimized at the expense of lactation BW gain.

In conclusion, the dynamics of sow BW change during gestation and lactation significantly influence litter ADG. Body weight at d 1 of gestation negatively affects maternal BW gain during gestation, which in turn is inversely related to BW change during lactation. In gilts, increased gestation BW gain leads to greater BW loss during lactation without compromising litter ADG. In contrast, in sows, BW loss during gestation results in compensatory BW gain during lactation, but this appears to occur at the expense of litter ADG. Further research is needed to investigate the effects of gestation and lactation BW change on subsequent reproductive performance and sow retention.

Acknowledgments

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Table 1. Equation coefficients to estimate sow body weight as a function of day of gestation for each parity category[1,2]

Coefficients	Parity 1/ Gilts	Parity 2	Parity 3	Parity 4	Parity 5	Parity 6+
Intercept, β_0	156.3300781	186.5035948	215.2179016	225.6908523	225.9512488	237.8683921
β_1	0.0726757	0.0319315	0.0238872	-0.0281347	0.0256892	0.0222663
β_2	0.0043481	0.0035190	0.0033888	0.0026358	0.0022998	0.0019674

[1] Sow BW, kg = β_0 + (β_1 × d of gestation) + (β_2 × d of gestation^2).
[2] Adapted from Orlando et al., 2023.

Table 2. Final model used to predict gestation maternal body weight change, kg[1,2]

Predictors	Gilts	Sows
Intercept	-146.30	43.89
Sow BW at d 1 of gestation (quadratic), kg	-0.004841	-0.000503
Sow BW at d 1 of gestation (linear), kg	1.5090	-0.0366
ME intake as % of MEm, %	0.1561	---
Gestation length, d	0.4073	---
Gestation caliper score change	4.0990	3.2960
Marginal R-square[3]	0.35	0.40

[1] A total of 1,098 gilts and 880 sows were used in the analysis.
[2] Sow weight at d 1 of gestation (linear and quadratic terms), ME intake as percentage of MEm at d 1 of gestation (gilt dataset), gestation length, and caliper score change during gestation were used in model selection using stepwise method. Variables shown in the table were selected based on the lowest AIC. Coefficients of the selected variables are significant ($P < 0.05$).
[3] Proportion of variance explained by the fixed effects.

Table 3. Final model used to predict lactation body weight change, kg[1,2]

Predictors	Gilts	Sows
Intercept	73.59	33.21
Gestation BW change (quadratic), kg	0.0029	---
Gestation BW change (linear), kg	-0.6869	-0.5690
ME intake as % of MEm, %	-0.0201	---
BW at 24-h post-farrowing, kg	-0.1694	-0.0549
Litter size after fostering	0.2128	---
Litter size at weaning	-0.2113	-0.6794
Lactation length, d	-0.5350	---
Gestation caliper score change	3.5290	3.5183
Lactation caliper score change	3.5100	4.8374
Gestation × lactation caliper score change	0.2292	---
Marginal R-square[3]	0.62	0.44

[1] A total of 1,098 gilts and 880 sows were used in the analysis.
[2] Gestation maternal BW change (linear and quadratic), ME intake as percentage of MEm at d 1 of gestation (gilt dataset), BW at 24 h post-farrowing, litter size after cross-fostering and at weaning and their interaction, lactation length, and caliper score change during gestation and lactation and their interaction were used in model selection using stepwise method. Variables shown in the table were selected based on the lowest AIC. Coefficients of the selected variables are significant ($P < 0.05$).
[3] Proportion of variance explained by the fixed effects.

Table 4. Final model used to predict litter average daily gain, kg/d[1,2]

Predictors	Gilts	Sows
Intercept	-2.057521	-0.514800
Lactation BW change (quadratic), kg	---	-0.000079
Gestation BW change (linear), kg	0.004249	0.004381
Lactation BW change (linear), kg	0.004106	0.001602
Litter size after fostering	0.095572	-0.050910
Litter size at weaning	0.451027	0.372900
Lactation length, d	---	0.023720
Gestation caliper score change	-0.022631	---
Lactation caliper score change	-0.032883	---
Litter size after cross-fostering × weaning	-0.014456	-0.006970
Marginal R-square[3]	0.41	0.60

[1] A total of 1,098 gilts and 880 sows were used in the analysis.
[2] Gestation and lactation BW change (linear, quadratic and interaction), litter size after cross-fostering and weaning and their interaction, lactation length, and caliper score change during gestation and lactation, and their interaction were used in model selection using the stepwise method. Variables shown in the table were selected based on the lowest AIC. Coefficients of the selected variables are significant (*P* < 0.05).
[3] Proportion of variance explained by the fixed effects.

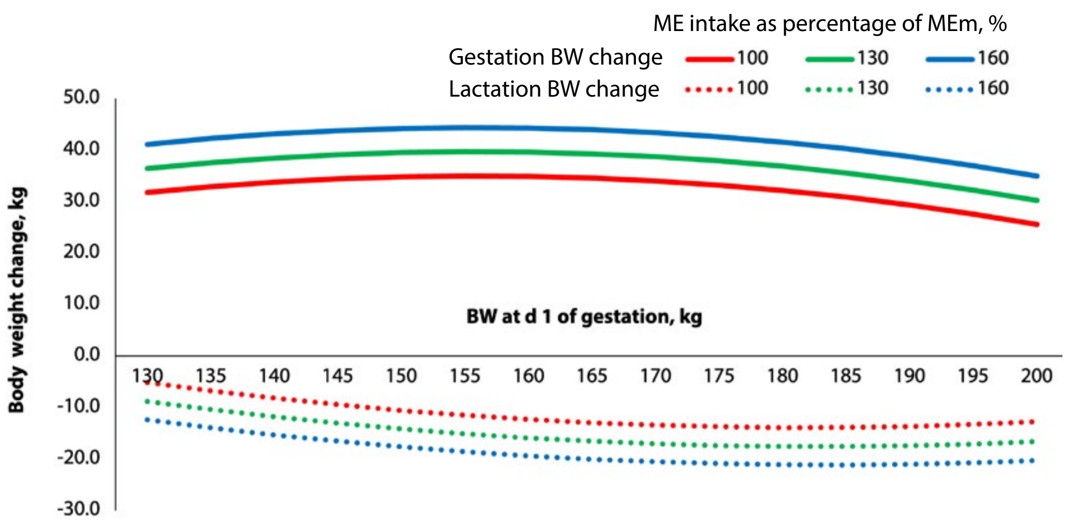

Figure 1. Effect of BW on d 1 of gestation on BW change during gestation and lactation in gilts at different ME intake as a percentage of MEm on d 1 of gestation. Data from 1,098 gilts were used. For the plotting, the average values for each covariable were used (gestation length: 115 d and gestation caliper score change: 0.30). For lactation BW change, the BW at 24 h post farrowing was calculated from BW at d 1 of gestation and predicted gestation BW change.

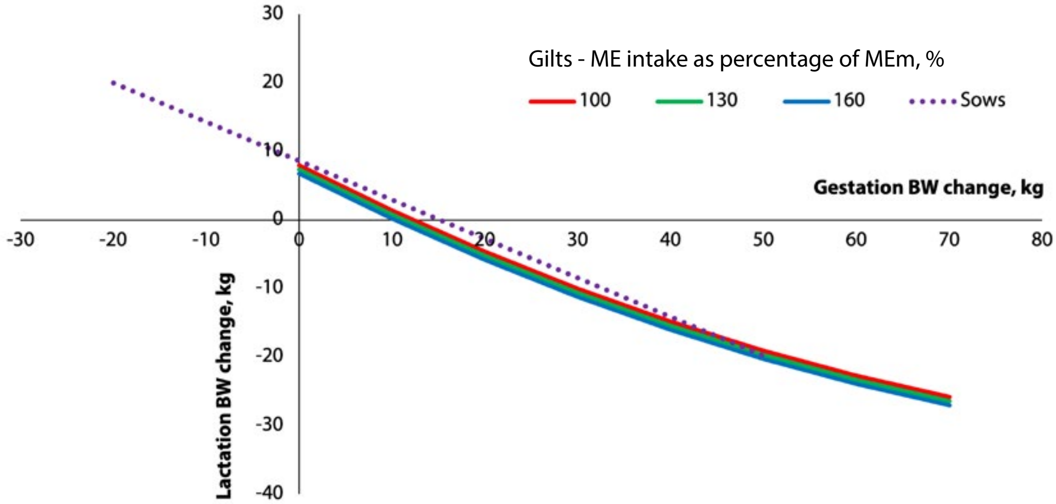

Figure 2. Effect of gestation BW change on lactation BW change in gilts (at different ME intake as percentage of MEm on d 1 of gestation) and sows. Data from 1,098 gilts from one study was used. For plotting, the average values for each covariables were used (BW at 24 h post-farrowing: 195.5 kg, litter size after cross-fostering: 16, litter size at weaning: 14, lactation length: 23 d, gestation caliper score change: 0.30, and lactation caliper score change: -5.50). For sows, data from 880 sows were used. For plotting, the average values for each covariable were used (BW at 24-h post-farrowing: 227.4kg, litter size at weaning: 12, gestation caliper score change: -0.30, and lactation caliper score change: -0.60).

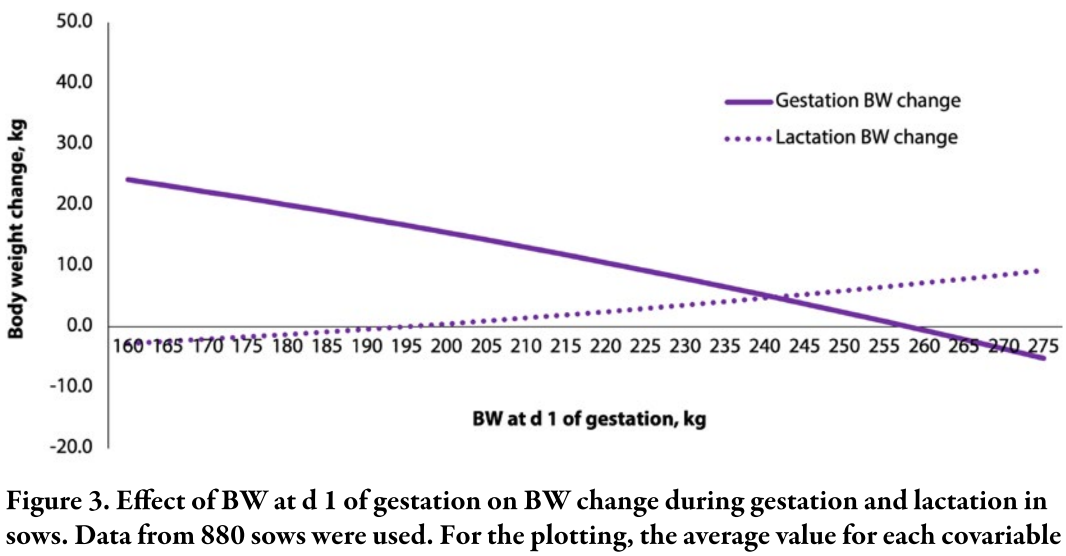

Figure 3. Effect of BW at d 1 of gestation on BW change during gestation and lactation in sows. Data from 880 sows were used. For the plotting, the average value for each covariable was used (gestation caliper score change: -0.30). For lactation BW change, the BW at 24 h post farrowing was calculated from BW at d 1 of gestation and predicted gestation BW change.

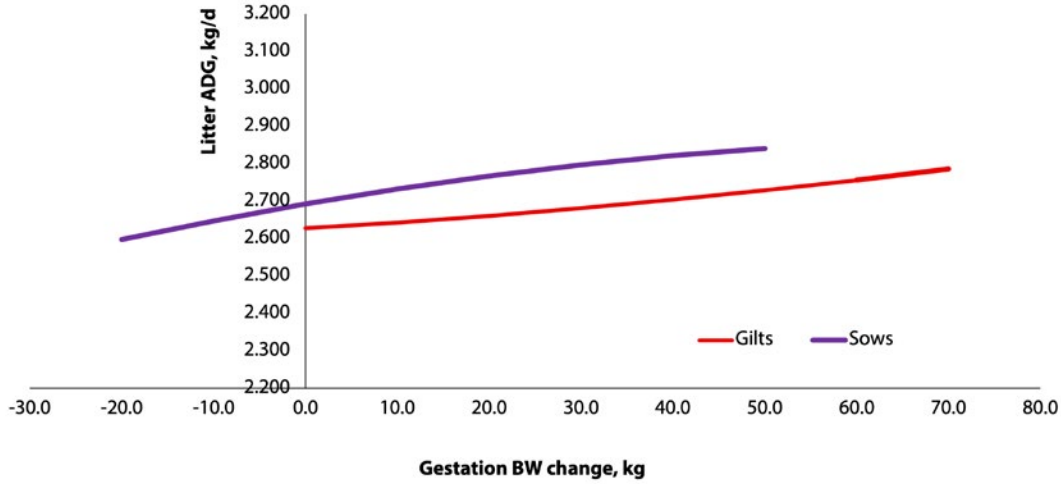

Figure 4. Effect of gestation BW change on litter average daily gain in gilts and sows. Data from 1,098 gilts were used. For plotting, the average values for each covariable were used (litter size after cross-fostering: 15, litter size at weaning: 13, gestation caliper score change: 0.30, and lactation caliper score change: -5.50). For sows, data from 880 sows were used. For plotting, the average values for each covariable were used (i.e., litter size after cross-fostering: 15, litter size at weaning: 13, and lactation length: 20 d). Lactation BW change was first predicted from gestation BW change using 100% ME intake as percentage of MEm.