Magnabosco, Diogo; Pereira Cunha, Evandro César; Bernardi, Mari Lourdes; Wentz, Ivo; Bortolozzo, Fernando Pandolfo
Impact of the Birth Weight of Landrace x Large White Dam Line Gilts on Mortality, Culling and Growth Performance until Selection for Breeding Herd
Acta Scientiae Veterinariae, vol. 43, 2015, pp. 1-8
Universidade Federal do Rio Grande do Sul
Porto Alegre, Brasil

Available in: http://www.redalyc.org/articulo.oa?id=289039763008
Impact of the Birth Weight of Landrace x Large White Dam Line Gilts on Mortality, Culling and Growth Performance until Selection for Breeding Herd

Diogo Magnabosco¹, Evandro César Pereira Cunha¹, Mari Lourdes Bernardi², Ivo Wentz¹ & Fernando Pandolfo Bortolozzo¹

ABSTRACT

Background: Piglets weighing less than 1 kg have become a common occurrence in pig farms due to selection for increasing litter size. Large litters imply a decrease in the mean piglet birth weight and an increase in the within-litter variability of birth weight with a greater risk of mortality and lower growth performance. The aim of this study was to evaluate the effects of birth weight of female piglets on growth performance and on removal rates until selection for entry into the breeding herd (170 days) of Landrace x Large White crossbred gilts.

Materials, Methods & Results: A total of 1495 Landrace x Large White (DB 25® - DanBred) crossbred female piglets were individually weighed after birth (BiW) and housed on the same farm from birth onwards. During the following developmental stages, gilts were again individually weighed: at 10 days, at weaning, nursery, rearing and selection (170 days). A phenotypic evaluation was performed to select the gilts that would be included in the breeding herd. Predicted probabilities for mortality, according to BiW, were estimated using logistic regression models. Female piglets were also retrospectively classified into eight classes of BiW based on percentiles, i.e., approximately 12.5% in each group. Cumulative losses by death or removal until weaning, nursery and selection phase were analysed using logistic regression models. The ability of pigs to compensate for low BiW was estimated using the percentages of gilts that changed at least one body weight (BW) category from birth to 170 days of age. For this purpose, eight classes of BW at 170 days were also created. BW and average daily weight gain (ADWG) were analysed as repeated measures. Overall, the mean BiW of the female piglets was 1387.8 ± 8.8 g, with a coefficient of variation of 24.4%. The removal rate until 170 days was 27.0% (403/1495) and locomotion problems were the major cause of culling (16.4%). The best cut-off point estimation for mortality until 24 h after birth was 1020 g (Area Under the Curve - AUC = 0.98%; P < 0.0001), increasing to 1090 g for mortality until 20 days (AUC = 0.87%; P < 0.0001) and to 1100 g for mortality until 70 days (AUC = 0.79%; P < 0.0001). Cumulative mortality and cumulative losses until 170 days were greater for piglets born weighing less than 1000 g (P < 0.0001). Piglets of the three lightest BiW classes had the greatest percentage of compensatory increase in the weight category (ranging from 52% to 57%). Throughout the developmental stages, the ADWG was different between the two lightest BiW categories (410-1160 g) and those belonging to the three heaviest BiW classes (1510-2400 g). This resulted in the lower BW of the lightest BiW piglets at the end of rearing and finishing phases compared with other BiW categories.

Discussion: The great occurrence of low BiW piglets in high prolific females and their high susceptibility to mortality and poor growth performance were confirmed in the present study. The most serious consequences for survival and growth occurred in piglets with a BiW of <1.1 kg. It has been reported that smaller piglets have lower colostrum intake and hepatic glycogen reserves, are more susceptible to hypothermia and have a higher risk of crushing. In spite of the partial ability for growth compensation shown by lighter piglets, the differences in BiW seemed to have an amplified detrimental effect on growth, mainly at rearing and finishing periods, since differences between the lightest and the heaviest BiW category increased from 1.1 kg at birth to 21 kg at 170 days of age. The implications of the present study are that piglets with low BiW have low survival and poor growth to finishing, hence reducing the opportunity for their selection as future breeders.

Keywords: piglets, lifetime performance, swine, removal rate, survival.
INTRODUCTION

The increase in litter size over the years has been shown to be connected to a decrease in the mean piglet birth weight and an increase in the within-litter variability of birth weight [20]. There is a great incidence of piglets weighing less than 1 kg, especially in large litters [1,12,15]. This occurrence can have a dramatic impact on mortality and culling rates as well as on growth performance of piglets [15,20]. Although several studies focus on the effect of birth weight on survival and growth performance of commercial market pigs [5,7,12,15,20], there is a scarcity of studies showing the impact of low birth weight on survival and growth development of female piglets designated for the breeding herd [1]. Studies concerning this aspect may contribute to breeding selection programs, in order to select females with characteristics that increase their longevity and reproductive performance.

The aim of this study was to evaluate the effects of birth weight of female piglets on body development performance and on removal rates until the selection for the entry into the breeding herd (170 days) of Landrace x Large White crossbred gilts (DB 25®).1

MATERIALS AND METHODS

Animals and location

The study was performed on a multiplier commercial pig farm with an inventory of 5,300 sows, located in Midwest Santa Catarina State (27°16’58”S, 50°35’04”W, altitude 987 m), southern Brazil. The study was conducted over ten months from September through June with data collected only from litters with more than 7 piglets. A total of 1495 female piglets Landrace x Large White (DB 25® - DanBred), a maternal genetic line, were housed on the same farm from birth onwards. A total of 1495 female piglets, a maternal genetic line, were housed on the same farm from birth onwards. All of the evaluated gilts were born from sows of parity order (PO) ranging from 1 to 7 (3.2 ± 0.6 parities) and litters with 15.5 ± 0.08 total born piglets. Farrowing induction was performed at Day 114 of gestation using 0.06 mg PGF2-alfa analogue (Dinoprost Tromethamine, Lutalyses) injection by vulvar submucosa route. Farrowings were assisted for 24 h a day, and the numbers of piglets born alive, stillborn piglets, and mummified foetuses were recorded. Piglets born alive and stillborn piglets were individually weighed within a maximum of 12 h after birth with a digital balance (10 g of precision), and were identified with both an ear tag and a tattoo.

The female piglets were cross-fostered between 8 and 24 h after birth among foster sows with a minimum of 14 teats and PO ranging from 2 to 7 (3.9 ± 0.03 parities). Litters were equalised with 13-14 (13.5 ± 0.01) piglets of similar size. Tail docking and iron injections were performed three days after birth. Weaning was performed when piglets were 20 days old on average.

After weaning, groups of 25 gilts were housed in nursery facilities, within pens with a full plastic-slatted floor (density of 0.3 gilts/m²), for seven weeks on average. At approximately 70 days after birth, gilts were transferred to rearing/finishing facilities where they remained until the day of selection for entry into the breeding herd (on average at 170 days of age). They were housed in pens with a partial concrete slatted floor, in batches of 15-20 animals/pen, with a density of 1.0 gilt/m². During this time, they received ad libitum and standardised corn and soybean diets according to the growing phase and had free access to water.

In addition to the birth weight (BiW), gilts were again individually weighed during the following developmental stages: at 10 days, at weaning (20 days), nursery (70 days), rearing (115 days) and selection (170 days). Average daily weight gain (ADWG) was calculated individually at the same developmental stages considering the weight gain divided by the number of days between the beginning and end of each evaluated phase. The ADWG of each phase was used to adjust the body weight (BW) for a specific age.

At the end of the finishing phase, when gilts were approximately 170 days old, a phenotypic evaluation was performed to select replacement gilts for the breeding herd. Gilts having hoof lesions, lameness, angulations, excessive callus, hernias and infantile vulva were not selected. Gilts with hoof lesions, lameness, angulations, excessive callus, the occurrence of hernias and those with infantile vulva were excluded. Only gilts with a minimum of 14 functional teats and with ADWG (from birth until selection time) above 500 g/d were considered eligible to remain in the herd. The percentage and causes of death or removal were recorded for each developmental phase.

Statistical Analyses

All data were analysed using the software Statistical Analysis System (SAS) version 9.1 [17]. Differences were considered significant at $P < 0.05$. Throughout the
text, numerical data are expressed as LS means ± SEM or as percentages, according to the variable type.

Predicted probabilities for mortality, according to birth weight as a continuous variable, were estimated using logistic regression models (GLIMMIX procedure). The predicted probabilities were used to obtain Receiver Operating Characteristic curves – ROC curves (LOGISTIC procedure) and a critical threshold for predicting mortality. The overall model fit was assessed using the area under the curve (AUC) of the ROC curves. The accuracy of prediction considered that no discrimination exists if the AUC is 0.5, because the true- and false-positive proportions are equal; the accuracy increases as AUC is closer to 1.0, where the discrimination is considered perfect [18].

In another statistical approach, female piglets were retrospectively classified into eight classes of BiW based on percentiles, i.e., approximately 12.5% in each group, from low to high (1 denoting the lightest and 8 the heaviest class) as described: class BiW 1 (410-990 g; 828.5 ± 9.59 g; n = 193); class BiW 2 (1000-1160 g; 1086.3 ± 3.60 g; n = 185); class BiW 3 (1170-1280 g; 1232.2 ± 2.59 g; n = 190); class BiW 4 (1290-1390 g; 1344.9 ± 2.22 g; n = 186); class BiW 5 (1400-1500 g; 1449.6 ± 2.34 g; n = 195); class BiW 6 (1510-1610 g; 1562.4 ± 2.36 g; n = 176); class BiW 7 (1620-1770 g; 1685.9 ± 3.34 g; n = 184) and class BiW 8 (1780-2400 g; 1945.2 ± 10.62 g; n = 186). Cumulative losses by death or removal until weaning, nursery and selection phase were analysed using logistic regression models (GLIMMIX procedure). In these models, BiW class was considered a fixed effect and the following factors were included as random effects: foster dams, parity order of foster dams, size of cross-fostered litters and parity order of foster dams were included in the models as random effects.

RESULTS

Overall, the mean BiW of the female piglets was 1387.8 ± 8.8 g, with a coefficient of variation of 24.4%. They were weaned with 5.9 ± 0.04 kg and reached the end of the nursery phase (70 days) weighing 25.5 ± 0.12 kg. At the end of finishing phase, at approximately 170 days of age, the 835 gilts selected for the entry into the breeding herd weighed 108.5 ± 0.38 kg on average.

Overall, the removal rate until 170 days was 27.0% (403/1495) and locomotion problems were the major cause of culling (16.4%; 246), followed by hernias (5.5%; 82), low development (4.1%; 62), illness (0.6%; 9) and an insufficient number of teats (0.3%; 4). Cumulative mortality rates were 2.3%, 9.1%, 16.7% and 17.2% until 24 h, 20 d, 70 d and 170 d, respectively. Starvation (6.3%; 95) accounted for the largest proportion of deaths, followed by diarrhea (3.3%; 49), epidermitis (2.7%; 41), crushing (2.6%; 39) and other diseases (2.2%; 33).

The best cut-off point estimation (Figure 1) for mortality until 24 h after birth was 1020 g (AUC = 0.98%; P < 0.0001), increasing to 1090 g for mortality until 20 days (AUC = 0.87%; P < 0.0001) and to 1100 g for mortality until 70 days (AUC = 0.79%; P < 0.0001).

Cumulative mortality and cumulative losses until 170 days were greater for piglets born with less than 1000 g (Table 1; P < 0.0001). Relatively high mortality rates were observed in piglets with a BiW ranging from 1000 to 1280 g (22.6% of mortality). The lowest cumulative mortality rates (7.9% to 9.8%) until the end of finishing phase were observed in the three heaviest BiW classes, i.e., in piglets weighing 1510-2400 g.

The percentages of piglets that remained, increased or decreased by at least one BW category from BiW to BW170 days are shown in Figure 2. Piglets belonging to the three lightest BiW classes (410-1280 g) had the greatest percentage of increase in the category of weight (ranging from 52% to 57%). In contrast, piglets from the two heaviest BiW classes (1620-2400 g) showed the greatest percentage of decrease (ranging from 60% to 67%). The percentage of piglets that remained in the same category throughout their life was greater in lightest
(43%) and heaviest (33%) BiW classes, whereas similar
percentages were observed among the intermediate BiW
classes (ranging from 13% to 25%).

The BW and ADWG were affected by the interac-
tion between BiW classes and the moment of weighing (P < 0.05; Table 2). At weaning, the lightest piglets at birth had
lower BW than piglets belonging to the heaviest BiW class.
At the end of the rearing and finishing phase, gilts of the
lightest group at birth remained lighter than piglets of the
other BiW classes. Throughout the developmental phases,
the ADWG was different between the lightest piglets at
birth and those belonging to the three heaviest BiW classes.

### Table 1. Results of logistic regression analyses for mortality, culling and cumulative losses from birth until 170 days, according to birth weight classes of female piglets.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Birth Weight Classes, g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>410-990 (n = 193)</td>
</tr>
<tr>
<td>Cumulative mortality</td>
<td></td>
</tr>
<tr>
<td>24 h after birth, % (n)</td>
<td>11.4 (22)a</td>
</tr>
<tr>
<td>Pre-weaning, 20 d, % (n)</td>
<td>27.5 (53)a</td>
</tr>
<tr>
<td>Nursery, 70 d, % (n)</td>
<td>37.8 (73)a</td>
</tr>
<tr>
<td>Finishing, 170 d, % (n)</td>
<td>37.8 (73)a</td>
</tr>
<tr>
<td>Cumulative culling</td>
<td></td>
</tr>
<tr>
<td>Nursery, 70 d, % (n)</td>
<td>8.8 (17)</td>
</tr>
<tr>
<td>Finishing, 170 d, % (n)</td>
<td>30.6 (59)</td>
</tr>
<tr>
<td>Cumulative losses( ^1 )</td>
<td></td>
</tr>
<tr>
<td>Nursery, 70 d, % (n)</td>
<td>46.6 (90)</td>
</tr>
<tr>
<td>Finishing, 170 d, % (n)</td>
<td>68.4 (132)</td>
</tr>
</tbody>
</table>

\( ^1 \)Mortality and culling reasons are included in this item. Lowercase letters in the row indicate significant statistical differences (P < 0.05).

### Table 2. Growth performance of female piglets at 10 days, weaning (20 days), nursery (70 days), rearing (115 days) and finishing (170 days) stages according to birth weight (BiW) classes.

<table>
<thead>
<tr>
<th>BiW Class, g</th>
<th>10 days Weight, kg</th>
<th>Weaning Weight, kg</th>
<th>Nursery Weight, kg</th>
<th>Rearing Weight, kg</th>
<th>Finishing Weight, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>410-990</td>
<td>2.5 ± 0.6</td>
<td>4.2 ± 0.6a</td>
<td>21.0 ± 0.6a</td>
<td>46.2 ± 0.6a</td>
<td>96.2 ± 0.7a</td>
</tr>
<tr>
<td>1000-1160</td>
<td>3.0 ± 0.5</td>
<td>4.9 ± 0.5ab</td>
<td>22.9 ± 0.5ab</td>
<td>51.4 ± 0.6b</td>
<td>101.4 ± 0.6b</td>
</tr>
<tr>
<td>1170-1280</td>
<td>3.2 ± 0.5</td>
<td>5.2 ± 0.5ab</td>
<td>24.8 ± 0.5bc</td>
<td>53.5 ± 0.5bc</td>
<td>105.4 ± 0.6c</td>
</tr>
<tr>
<td>1290-1390</td>
<td>3.6 ± 0.5</td>
<td>5.7 ± 0.5ab</td>
<td>25.7 ± 0.5bcde</td>
<td>56.3 ± 0.5cde</td>
<td>107.2 ± 0.5c</td>
</tr>
<tr>
<td>1400-1500</td>
<td>3.7 ± 0.5</td>
<td>5.8 ± 0.5ab</td>
<td>25.4 ± 0.5bcde</td>
<td>55.6 ± 0.5cde</td>
<td>107.7 ± 0.5c</td>
</tr>
<tr>
<td>1510-1610</td>
<td>3.8 ± 0.5</td>
<td>5.9 ± 0.5ab</td>
<td>26.0 ± 0.5cde</td>
<td>57.9 ± 0.5cde</td>
<td>111.4 ± 0.5d</td>
</tr>
<tr>
<td>1620-1770</td>
<td>4.1 ± 0.5</td>
<td>6.4 ± 0.5ab</td>
<td>27.6 ± 0.5de</td>
<td>58.4 ± 0.5e</td>
<td>112.4 ± 0.5d</td>
</tr>
<tr>
<td>1780-2400</td>
<td>4.6 ± 0.5</td>
<td>7.1 ± 0.5b</td>
<td>28.6 ± 0.5e</td>
<td>62.1 ± 0.5f</td>
<td>117.1 ± 0.5e</td>
</tr>
</tbody>
</table>

Average daily weight gain, g/day

<table>
<thead>
<tr>
<th>BiW Class, g</th>
<th>10 days Average daily weight gain, g/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>410-990</td>
<td>172.2 ± 11.1A</td>
</tr>
<tr>
<td>1000-1160</td>
<td>203.3 ± 10.1AAB</td>
</tr>
<tr>
<td>1170-1280</td>
<td>215.2 ± 10.0ABC</td>
</tr>
<tr>
<td>1290-1390</td>
<td>232.7 ± 9.8BC</td>
</tr>
<tr>
<td>1400-1500</td>
<td>232.0 ± 9.5BC</td>
</tr>
<tr>
<td>1510-1610</td>
<td>232.5 ± 9.8BC</td>
</tr>
<tr>
<td>1620-1770</td>
<td>257.9 ± 9.8CD</td>
</tr>
<tr>
<td>1780-2400</td>
<td>274.9 ± 9.7D</td>
</tr>
</tbody>
</table>

Differences (P < 0.05) in the columns are indicated by lowercase letters for weight and capital letters for ADWG. The female piglets were categorised into eight birth weight classes using percentiles, resulting in a similar number of pigs per category, i.e., approximately 12.5% per group.
Figure 1. Predicted probabilities for mortality until 24 h, 20 d and 70 d estimated using logistic regression models. Arrows (↓) indicate the best cut-off points of birth weight for mortality at each evaluated phase. Left panels display the Receiver Operating Characteristic (ROC) curves, where true-positive (sensitivity) proportion is plotted against the false-positive (100-specificity) proportion. The critical threshold (cut-off point) was the point on the ROC curve that had the highest combined sensitivity and specificity. The accuracy of the prediction is greater as the AUC (Area under the Curve) is closer to 1.0.

Figure 2. Percentage of gilts that decrease, remain or increase at least 1 weight class from birth (BiW) to 170 days (BW170). The gilts were categorised into 8 classes of approximately 12.5% animals per group in both BiW and BW170. A gilt is categorised as “decrease” when it has decreased at least 1 category from BiW to BW170. A gilt is categorised as “remain” when it has not changed the class from BiW to BW170. A gilt is categorised as an “increase” when it has increased at least 1 category from BiW to BM170.
The great occurrence of low BiW piglets in high prolific females was confirmed in the present study. In a previous study [15] with a litter size of 12.5 piglets, 9% of them weighed less than 1 kg, contrasting with 13% of them belonging to this BiW category in the present study, in which the litter size was 15.5 piglets. BiW has been considered a critical indicator of postnatal survival and performance [5,11], with a low BiW representing a high risk of mortality until weaning [7,12,13,20]. Therefore, it has been suggested that selection on litter size should be accompanied by selection for an increased minimal birth weight [20].

Considering the great accuracy (AUC ≥ 0.79%) of the critical threshold, our results show that the cut-off point of a BiW > 1.1 kg seems realistic for reducing piglet's mortality in addition to providing the potential for an adequate growth performance until the breeding selection time. However, the mortality rate of piglets with a BiW close to this cut-off point (1.17-1.28 kg) is still relatively high until the end of the nursery period (22%). High mortality rates until weaning have also been reported [15] in piglets belonging to 0.6 and 0.8 kg BiW classes (85% and 52%, respectively). In addition to being lighter at birth, piglets exposed to some degree of intrauterine growth restriction have lower colostrum intake and hepatic glycogen than piglets of normal weight, hence reducing their survival chance [3, 9]. Indeed, a greater amount of colostrum has been shown to be necessary to assure the survival of piglets weighing 1.1-1.2 kg compared with heavier piglets [6]. Furthermore, smaller piglets are more susceptible to hypothermia [10] and have a higher risk of crushing [19].

The greater probability of lighter piglets being removed from the herd corroborates the results of a previous study [1]. The greater mortality until the end of the nursery phase (21.6% to 37.8% vs. 7.5% to 8.1%) had the main contribution for the greater removal rate of piglets belonging to the three lowest BiW categories (410-1280 g) compared with piglets belonging to the three highest BiW categories (1510-2400 g). Cumulative culling until 170 d (27% on overall) was not affected by BiW categories, probably because the criteria of selection for entry into the breeding herd take into account problems other than low development. Indeed, locomotor disorders accounted for 61% (246/403) of removals until 170 days of age.

It has been suggested that in the majority of low birth weight piglets, a low number of muscle fibres differentiate during prenatal myogenesis and piglets with reduced fibre numbers are unable to exhibit postnatal catch-up growth [16]. However, in the present study, 57% of the lowest BiW gilts increased by at least one category in the final weight, showing that they had, to some extent, growth compensation. In another study [5], the ability of piglets with low birth weight to compensate growth during the postnatal life was also observed, with 70-80% of them increasing at least one weight class. However, the greater incidence of increasing in BiW classes can be explained because only finishing pigs were used in this study. Thus the culling of animals by phenotypic disorders at the selection did not occur, differentiating this from the present study. The fact that a subpopulation of light piglets has the potential to catch up its growth raises the question of how to identify these animals and what physiological mechanisms help them to compensate the weight gain [14].

The importance of birth weight for growth performance [4,8,15] was confirmed in the present study since piglets belonging to the lowest BiW category had lower ADWG and BW at 170 days than those belonging to the heaviest BiW category. This result is also in agreement with the differences in weight until 150 days [2] that were observed for two classes of BiW piglets (0.8-1.2 vs. 1.8-2.2 kg). Although under-developed pigs were removed during the developmental phases in the present study, aiming to select the future breeders, differences between the lightest and the heaviest BiW category increased from 1.1 kg at birth to 21 kg at 170 days of age. Likewise, the difference between the lightest and heaviest piglets at birth (<0.61 vs. >2.4 kg) increased to 5.4 kg at weaning and to 11.9 kg at 63 days of age [15]. In spite of the partial ability for growth compensation shown by lighter piglets, the differences in BiW seemed to have an amplified detrimental effect on growth, mainly during the rearing and finishing periods.

The implications of the present study are that piglets with low BiW have low survival and poor growth to finishing, hence reducing the opportunity for their selection as future breeders. It is necessary to evaluate the economic costs of additional assistance that would help the small piglets to increase their survivability and compensate for the growth delay. It is also important to known whether the low birth weight will have long-term effects on the reproductive performance of small piglets that survive and are selected for entry into the breeding herd.
CONCLUSIONS

Birth weight is critical for the survival of Landrace x Large White crossbred female piglets. Piglets weighing less than 1 kg at birth have a little chance of being alive at weaning. Moreover, when they survive, their growth performance is lower than that of heavier piglets. The consequence is less female piglets of low birth weight being selected as future breeders.

REFERENCES


