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Effect of Birth Weight and Litter Size on the Performance of Landrace Gilts until Puberty*

Mirian de Almeida[1], Mari Lourdes Bernardi[2], Alana Pinheiro Motta[1], Fernando Pandolfo Bortolozzo[1] & Ivo Wentz[1]

ABSTRACT

***Background*:** The selection for larger litter size has resulted in reduction of average birth weight and in increase of within-litter birth weight variation in pigs. Birth weight is one of the most important factors affecting the survival and performance of piglets until weaning. The aim of this study was to evaluate the effect of litter size into which gilts were born and their individual birth weight on mortality and culling rate until the time of selection, as well as on puberty onset.

***Materials, Methods & Results*:** Female Landrace piglets (n = 1525) were identified and weighed within 18 h after birth. They were also weighed at weaning (n = 1379), and at the end of the nursery (n = 1198) and rearing phases (n = 940). Three classes of litter size were created: Small LS (7-11 piglets), Intermediate LS (12-13 piglets) and Large LS (14-19 piglets). Gilts were also separated in three classes according to their birth weight: Low BW (530-1200 g), Intermediate BW (1205-1600 g) and High BW (1605-2535 g). When compared to High BW gilts, the risk of death until weaning was greater ($P < 0.05$) in Low BW gilts from Intermediate LS and Large LS litters, but not in Low BW gilts from Small LS litters. Within the Low BW class, the risk of mortality until weaning was greater or tended to be greater if gilts were born in Intermediate LS ($P < 0.05$) or Large LS ($P = 0.079$) litters compared to those from Small LS litters. Average daily weight gain (ADWG), and weights at 22, 75 and 155 days of age, increased according to the increase in birth weight ($P < 0.05$). There was no effect of birth weight or litter size on mortality and culling rate, during nursery and rearing phases, and on percentages of gilts in anoestrous until 30 days after boar stimulation ($P > 0.05$). The risk of not being selected for breeding was greater ($P < 0.09$) in Light BW gilts than in High BW gilts in all litter size classes. Low BW gilts were older at the beginning of boar exposure and had a lower boar exposure-puberty interval compared to High BW gilts ($P < 0.05$), but there was no effect of birth weight on puberty age ($P > 0.05$).

***Discussion*:** The importance of birth weight for survival until weaning and for development until the selection time was confirmed in this study. Since birth weight was associated with ADWG, the expectation was that puberty onset would happen earlier in gilts with greater ADWG. In other studies, gilts with greater growth rates reached puberty earlier if stimulated at an early age (~140 days of age). In the present study, however, puberty onset was not affected by birth weight, probably because gilts were exposed to boars at ≥165 days of age. This aspect may indicate that, after a certain age, puberty is less dependent on growth rate. The greater risk of mortality until weaning and of not being selected for reproduction, in Light BW gilts, contribute to economic losses in replacement gilt units. Segregation of gilts based on their birth weight can be performed at birth or in subsequent phases. Early selection may help to reduce costs for maintaining gilts that will probably not be selected, hence increasing the profitability of pig production. In addition, it provides the opportunity to pay special attention to gilts with greater potential to be future breeders. The results show that birth weight is more important than litter size into which gilts were born for their survival until weaning, as well as for an adequate weight gain, which will ensure their retention in the herd until the selection time. When the gilts are stimulated close to 165 days of age, age at puberty and anoestrous rate are not affected by birth weight or litter size into which they were born.

Keywords: birth weight, litter size, mortality, selection of gilts.

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*Article based on a Dissertation submitted by the senior author in partial fulfillment of requirements for the Master's Degree, Post Graduate Program in Veterinary Sciences (PPG-CV), Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre, RS, Brazil. [1]Setor de Suínos, Faculdade de Veterinária (FaVet)-UFRGS, Porto Alegre. [2]Departamento de Zootecnia, Faculdade de Agronomia-UFRGS, Porto Alegre. CORRESPONDENCE: F.P. Bortolozzo [fpbortol@ufrgs.br - Tel.: +55 (51) 3308-8044]. Av. Bento Gonçalves n. 9090, Bairro Agronomia. CEP 91540-000 Porto Alegre, RS, Brazil.

INTRODUCTION

Genetic selection for increased litter size has resulted in lower birth weight and greater within-litter birth weight variation. These aspects can contribute to increase the pre-weaning mortality [16,17,19,30], directly influencing on the pool of gilts available for breeding. Low birth weight represents risks of stillbirth [19], diseases and pre-weaning mortality [1,5,30], in addition to lower post-natal growth performance in piglets [4,5,19,30].

The reproductive performance of gilts greatly contributes to the profits of pig farms because they represent a relatively high percentage of females in reproduction. Growth rate and age at puberty are associated with long-term productivity of swine females [14,22,23,28]. Gilts with greater growth rates can be mated earlier [2,11,26], providing the opportunity to select females with characteristics that increase their longevity, hence increasing the profitability of pig production [22].

The objective of this study was to verify the influence of litter size and birth weight on growth, mortality and culling rates until selection time, as well as on the onset of puberty in purebred Landrace gilts.

MATERIALS AND METHODS

The study was run in a multiplier unit that had an inventory herd of 5300 sows. Data were collected from December 2012 to September 2013 and included information from birth of the gilts until 30 days after the onset of boar stimulation for their puberty induction. Data were collected from 274 litters, from which seven were excluded for having fewer than 7 piglets, providing a total of 1525 gilts at birth.

Housing and management of sows

The evaluated gilts were born from Landrace sows of parity order (PO) ranging from 1 to 6, which had been mated with Landrace boars[1]. During gestation, sows were fed twice a day with a corn-soybean diet (3064 kcal ME/kg, 16.0% CP and 0.84% lysine). From breeding up to day 5 of gestation (day 0 = insemination day), sows received 1.8 kg feed per day. Between 6 and 85 days of gestation, they were fed 2.0 kg daily. From 86 to 110 days of gestation, they received 3.3 kg per day. After that, there was a gradual reduction in the feed amount until reaching 1 kg the day before the expected farrowing. At farrowing day sows were not fed. In the first four days of lactation, sows were fed twice daily, with a gradual increase from 2 to 4 kg until the fourth day after parturition. From the fourth day until weaning, sows were fed *ad libitum* with a standard corn-soybean lactation diet (3273 kcal ME/kg, 20.0% CP and 1.38% lysine). Water was available *ad libitum* throughout the experimental period.

Sows were transferred to individual farrowing crates equipped with semiautomatic feeders, at approximately 5 days before the expected farrowing day. Farrowing crates had solid concrete floors in the middle area and galvanized iron slatted floor at the rear end of the sow, whereas the piglet circulation area had a plastic slatted floor. There was a creep area for the piglets with electric heating lamps and a heated floor.

Housing and management of gilts from birth to puberty

Piglets born alive and stillborn piglets were individually weighed within 18 h after birth with a digital balance (5 g of precision). Only live piglets of female gender were followed in this study. Female piglets were tattooed and cross fostered in numbers of 11-13 piglets in Landrace sows[2] of 3-6 parities. Sows used as foster dams had at least 12 functional teats and good health status. The within-litter birth weight variation at cross fostering was no greater than 300 g.

On the third day of life, the following procedures were performed on piglets: tail docking, iron injection, and reduction of teeth using an eletric wire cutter. Piglets received rations from the third week of lactation onwards. Weaning was performed on average at 22 days of age.

The gilts remained, on average, in the nursery facilities for seven weeks, housed in pens with plastic floors and a capacity of 30 animals (density of 0.3 gilts/m^2). During the nursery phase, they received a diet containing 3098 kcal ME/kg, 18.1% CP and 0.98% lysine, *ad libitum*. Upon leaving the nursery, gilts were weighed and transferred in batches of 22-26 animals to rearing facilities, where they were housed in pens with a density of 1 gilt/m^2. During this phase, they received a diet containing 3079 kcal ME/kg, 17.0% CP and 1.0% lysine, *ad libitum*.

At approximately 155 days of age, the gilts were submitted to phenotypic evaluation. The reasons for exclusion were the following: occurrence of hernias, locomotion problems (lameness, hoof lesions, joint swelling), low ADWG and fewer than 12 teats. At selection time, backfat thickness was measured at the level of the last rib, on the right side, at approximately 6 cm from the midline, by A-mode ultrasonography[3].

Groups of 15 gilts were kept in each replacement barn, with a space allowance of 1.2-1.5 m^2/gilt. The day after the transfer of gilts to replacement facilities, the stimulation of puberty was started using sexually mature boars. Oestrus detection was performed once a day by introducing a boar in the barn of gilts for approximately 15 min. The gilts were considered to be in oestrus when they exhibited a standing reflex in the presence of the boar. Gilts in oestrus were identified and transferred to individual cages.

Statistical Analysis

All analyses were performed with SAS software, version 9.1.3 [20]. Three classes were created according to the litter size into which the gilts were born: Small LS (7 to 11 piglets); Intermediate LS (12 to 13 piglets), and Large LS (14 to 19 piglets). Gilts were also distributed in three classes according to their birth weight: Low BW (530–1200 g); Intermediate BW (1205-1600 g), and High BW (1605-2535 g). The following variables were analysed using the GLM procedure, with the effects of litter size, birth weight and litter size × birth weight interaction: weight at 22, 75 and 155 days of life; ADWG during suckling, rearing phase and until the selection time; age of selection; backfat at selection; age at the onset of boar exposure; age at puberty; and interval between boar stimulation and puberty (IBEP). The results are shown as means ± standard error of the means.

Logistic regression models (PROC LOGISTIC) were used to investigate the effect of litter size and birth weight classes on the following binary variables: mortality rate, culling rate, percentage of selected gilts, and percentage of gilts showing anoestrous until 30 days after boar stimulation.

Table 1. Developmental characteristics and puberty of gilts according to the litter size of origin and birth weight on a farm in Santa Catarina state, Brazil.

Variable	Classes of litter size[1]			Classes of birth weight, g		
	Small LS (7-11 piglets)	Intermediate LS (12-13 piglets)	Large LS (14-19 piglets)	Low BW (530-1200)	Intermediate BW (1205-1600)	High BW (1605-2535)
Birth weight, g (n = 1525)	1417 ± 8.0A	1400 ± 6.5AB	1393 ± 6.3B	1013 ± 8.3a	1411 ± 5.2b	1787 ± 7.0c
ADWG until weaning, g (n = 1379)	184.9 ± 2.9	188.3 ± 2.5	187.6 ± 2.3	174.9 ± 3.2a	188.4 ± 1.9b	197.4 ± 2.5c
Weight at 22 d, kg (n = 1379)	5.5 ± 0.06	5.5 ± 0.05	5.5 ± 0.05	4.9±0.07a	5.6 ± 0.04b	6.1 ± 0.06c
ADWG at nursery phase, g (n = 1198)	420.8 ± 4.4	423.1 ± 3.7	418.4 ± 3.6	406.8 ± 4.9a	421.3 ± 2.9b	434.1 ± 3.8c
Weight at 75 d, kg (n = 1198)	27.9 ± 0.25	28.1 ± 0.21	27.8 ± 0.20	26.5 ± 0.27a	28.0 ± 0.16b	29.3 ± 0.21c
ADWG at rearing phase, g (n = 940)	876.0 ± 8.2	887.6 ± 6.5	883.8 ± 6.5	850.2 ± 9.0a	892.9 ± 5.1b	904.2 ± 6.7b
Weight at 155 d, kg (n = 940)	98.2 ± 0.71	99.5 ± 0.57	98.8 ± 0.56	94.9 ± 0.78a	99.8 ± 0.44b	101.8 ± 0.58c
Age at selection, days (n = 940)	158.5 ± 0.5	158.6 ± 0.4	157.6 ± 0.4	161.0 ± 0.6a	157.7 ± 0.3b	156.0 ± 0.4c
ADWG at selection, g (n = 940)	627.4 ± 4.8	634.1 ± 3.9	632.0 ± 3.8	605.1 ± 5.3a	637.8 ± 3.0b	650.7 ± 4.0c
BFT at selection, mm (n = 940)	11.4 ± 0.16	11.4 ± 0.13	11.4 ± 0.13	11.5 ± 0.17	11.5 ± 0.10	11.3 ± 0.13
Age at boar exposure, days (n = 569)	167.6 ± 0.7	167.7 ± 0.6	166.7 ± 0.6	170.0 ± 0.8a	166.9 ± 0.4b	165.1 ± 0.6c
Age at puberty, days (n = 504)	184.7 ± 1.1	184.3 ± 0.8	185.0 ± 0.9	185.8 ± 1.2	184.9 ± 0.6	183.4 ± 0.9
IBEP, days (n = 504)	17.3 ± 0.8	16.7 ± 0.6	18.7 ± 0.7	15.8 ± 0.9a	17.9 ± 0.5ab	18.9 ± 0.7b

[1]Numbers of born alive and stillborn piglets were taken into account. ADWG= average daily weight gain; BFT= backfat thickness; IBEP= Interval between boar exposure and puberty. None of the variables was affected by the interaction between litter size and birth weight ($P > 0.05$). A,B= Different uppercase letters in the row indicate differences between classes of litter size ($P < 0.05$). a,b= Different lowercase letters in the row indicate differences between classes of birth weight ($P < 0.05$). LS= means ± standard error of mean.

RESULTS

The evaluated gilts were born from sows with on average 1.7 (± 0.07) parities and 12.9 (± 0.15) piglets born. Overall, the mean birth weight was 1407 g (± 5.7 g), whereas piglets of female gender weighed on average 1420 g (± 7.9 g), with a coefficient of variation of 17.8% (± 0.4%).

There were no effects of the interaction litter size × birth weight ($P > 0.05$) on the weight and ADWG from birth until selection, age and backfat at selection, age at the onset of boar stimulation, age at puberty and IBEP. The effect of litter size was observed only on the birth weight, which was lower ($P < 0.05$) in Large LS than in Small LS gilts (Table 1). The weight and ADWG ($P < 0.05$) from birth to selection increased together with the increase in birth weight (Table 1). Gilts of Intermediate BW and High BW had a lower age at boar exposure ($P < 0.05$). There was no difference in age at puberty among birth weight classes ($P > 0.05$), but High BW gilts showed a greater IBEP ($P < 0.05$) than Low BW gilts (Table 1).

Percentages of dead gilts, culled gilts, selected gilts and gilts in anoestrous are shown in Tables 2 and 3. The risk of mortality until weaning was greater ($P < 0.05$) in Low BW than in High BW gilts, within Intermediate LS and Large LS classes but not in the Small LS class (Table 4). When Low BW gilts were from Intermediate LS ($P < 0.05$) and Large LS ($P = 0.079$) classes, their risk of mortality until weaning was greater than if they were born into Small LS class (Table 4). If compared to High BW gilts (Table 4), the risk of not reaching the selection phase was greater in Low BW gilts within Small LS and Intermediate LS classes ($P < 0.05$) and tended to be greater within Large LS class ($P = 0.085$). Mortality and culling during the rearing and finishing phases, percentage of gilts selected for breeding, as well as percentage of gilts in anoestrous until 30 days after the onset of boar stimulation were not influenced by birth weight or litter size.

Table 2. Percentages of mortality and culling according to the litter size of origin and birth weight of gilts on a farm in Santa Catarina state, Brazil.

classes[1]	classes, g	Until weaning	Nursery	Rearing	Nursery	Rearing
Small LS	530-1200	8.9 (5/56)	2.0 (1/51)	4.5 (2/44)	11.7 (6/51)	29.5 (13/44)
(7-11 piglets)	1205-1600	8.2 (13/159)	3.4 (5/146)	4.1 (5/123)	12.3 (18/146)	14.6 (18/123)
	1605-2535	5.8 (10/173)	1.2 (2/163)	2.1 (3/143)	11.0 (18/163)	14.7 (21/143)
Intermediate LS	530-1200	21.4 (22/103)	3.7 (3/81)	2.9 (2/69)	11.1 (9/81)	20.3 (14/69)
(12-13 piglets)	1205-1600	4.9 (15/303)	1.7 (5/288)	3.5 (9/255)	9.7 (28/288)	15.3 (39/255)
	1605-2535	4.3 (6/141)	1.5 (2/135)	3.2 (4/123)	7.4(10/135)	15.4 (19/123)
Large LS	530-1200	19.2 (37/193)	5.1 (8/156)	3.1 (4/128)	12.8 (20/156)	21.1 (27/128)
(14-19 piglets)	1205-1600	10.9 (33/302)	2.2 (6/269)	5.9 (14/237)	9.7 (26/269)	19.4 (46/237)
	1605-2535	5.3 (5/95)	2.2 (2/90)	3.9 (3/76)	13.3 (12/90)	19.7 (15/76)

[1]Numbers of born alive and stillborn piglets were taken into account. LS = litter size.

Table 3. Percentages of gilts not arriving at selection, approved for reproduction and anoestrous rate according to the litter size of origin and birth weight of gilts on a farm in Santa Catarina state, Brazil.

Litter size classes[1]	Birth weight classes, g	Do not reach the selection	Approved for reproduction	Anoestrous rate[2]
Small LS (7-11 piglets)	530-1200	48.2 (27/56)	58.6 (17/29)	29.4 (5/17)
	1205-1600	37.1 (59/159)	70.0 (70/100)	25.7 (18/70)
	1605-2535	31.2 (54/173)	56.3 (67/119)	34.3 (23/67)
Intermediate LS (12-13 piglets)	530-1200	48.5 (50/103)	56.6 (30/53)	23.3 (7/30)
	1205-1600	31.7 (96/303)	60.4 (125/207)	28.0 (35/125)
	1605-2535	29.1 (41/141)	65.0 (65/100)	36.9 (24/65)
Large LS (14-19 piglets)	530-1200	49.7 (96/193)	67.0 (65/97)	30.8 (20/65)
	1205-1600	41.4 (125/302)	56.5 (100/177)	31.0 (31/100)
	1605-2535	38.9 (37/95)	51.7 (30/58)	30.0 (9/30)

[1]Numbers of born alive and stillborn piglets were taken into account. [2]Percentage of gilts in anoestrous until 30 days after boar exposure for puberty induction. LS = litter size.

Table 4. Results of logistic regression for the risk of mortality until weaning or of not being selected for reproduction according to the litter size of origin and birth weight of gilts in a farm of Santa Catarina state, Brazil.

Litter size	Birth weight	Mortality until weaning			Non-approved at selection		
classes[1]	classes, g	Odds ratio	CI 95%	*P*-value	Odds ratio	CI 95%	*P*-value
Small LS (7-11 piglets)	530-1200	1.6	0.5-4.7	0.411	2.0	1.1-3.8	0.022
	1205-1600	1.4	0.6-3.5	0.393	1.3	0.8-2.0	0.258
	1605-2535	Reference			Reference		
Intermediate LS (12-13 piglets)	530-1200	6.1	2.5-17.2	0.0002	2.3	1.4-3.9	0.002
	1205-1600	1.2	0.5-3.3	0.748	1.1	0.7-1.8	0.580
	1605-2535	Reference			Reference		
Large LS (14-19 piglets)	530-1200	4.3	1.8-12.7	0.003	1.5	0.9-2.6	0.085
	1205-1600	2.2	0.9-6.6	0.110	1.1	0.7-1.8	0.673
	1605-2535	Reference			Reference		
Large LS	530-1200	2.4	1.0-7.3	0.079	1.1	0.6-1.9	0.841
Intermediate LS		2.8	1.1-8.7	0.053	1.0	0.5-1.9	0.968
Small LS		Reference			Reference		
Large LS	1205-1600	1.4	0.7-2.8	0.350	1.2	0.8-1.8	0.372
Intermediate LS		0.6	0.3-1.3	0.172	0.8	0.5-1.2	0.241
Small LS		Reference			Reference		
Large LS	1605–2535	0.9	0.3-2.6	0.860	1.4	0.8-2.4	0.202
Intermediate LS		0.7	0.2-2.0	0.543	0.9	0.5-1.5	0.682
Small LS		Reference			Reference		

[1]Numbers of born alive and stillborn piglets are taken into account. CI= confidence interval; LS = litter size.

DISCUSSION

The effect of birth weight on losses until weaning [17,19,30], weight at slaughter and carcass quality [4,5,8,21] has been extensively studied. The effects of birth weight [27] or growth rate [2,10,28] on puberty onset or on longevity of swine females [22, 23] have been reported in other studies. The present study differs from others because it includes, in addition to the birth weight, the effect of litter size into which the gilt was born and information about the approval of gilts in the selection phase and on puberty manifestation, which are crucial elements for the incorporation of gilts into the breeding herd.

The greater risk of mortality until weaning of Low BW gilts coming from Large LS and Intermediate LS can be attributed to their low birth weight. Genetic selection for greater prolificacy has resulted in lower individual birth weight [24,25], hence reducing the postnatal survival, mainly in larger litters [12,15]. Birth weight has been considered the most important factor that influences piglet survival [13], with a low birth weight representing a high risk of morbidity and mortality until weaning [5,17,30]. In a study in which the birth weights of seven groups (variation of 200 g among the groups) were evaluated, piglets weighing less than 1 kg at birth had a little chance of surviving to weaning [19]. Birth weight is correlated with weaning weight, and it can be important for survival in the nursery [19]. This indicates that the impact of birth weight on survival in the nursery is mainly due to its influence on weaning weight [5].

Greater ADWG until weaning, and at the nursery and rearing phases, observed in High BW gilts, indicates that birth weight is important not only for survival but also for the subsequent performance of piglets, as previously reported [4,19]. Usually, piglets with greater birth weight achieve slaughter weight earlier. In fact, piglets with 2 kg at birth were slaughtered two weeks before piglets with 1 kg at birth [19]. The variation in growth performance may be pre-programmed during early uterine development, affecting birth weight and, consequently, postnatal growth [7]. In the present study, gilts with low birth weight may have suffered intrauterine growth retardation, which has a negative impact on pre-weaning survival and post-natal growth [31].

The greater risk of Low BW gilts not being selected for breeding, regardless of the size of the litter into which they were born, is explained by their cumulative losses occurring in the pre-selection period, either by mortality until weaning or by culling during the nursery and rearing phases. It is likely that age at puberty was not affected by birth weight because Low BW gilts were stimulated later, resulting in a shorter boar-puberty interval, which confirms the results of previous studies [2,18,29].

Although the association of age at puberty with growth rate [3,9] has not yet been completely elucidated, lower age at puberty [2,10] or lower anoestrous rate [10] have been observed in gilts with greater growth rates, e.g. in crossbred gilts. Since Low BW gilts had a lower ADWG than High BW gilts, at boar exposure, the expectation was that they would reach puberty later, but this was not verified. The influence of growth rate on puberty is more easily evidenced when stimulation occurs earlier, i.e. at 130-149 days instead of at 150-170 days of age [2], suggesting that, after a certain age, puberty is less dependent on growth rate. In the present study, the mean age of all groups, at boar exposure, was ≥165 days, which probably explains their similar age at puberty, although they had different growth rates. Growth rates at boar exposure averaged 605, 639 and 651 g/d for Low BW, Intermediate BW and High BW gilts, respectively. These values are within the range of 550 and 800 g/d, considered not to limit puberty onset in gilts of modern genotypes [6], which seems to apply also to purebred Landrace gilts in the present study.

A low birth weight represents a greater risk of mortality and of a lower number of gilts selected for reproduction, hence contributing to economic losses in replacement gilt units. Selection of gilts based on their weights at birth can be performed at birth or in subsequent rearing phases. If performed at weaning, this selection can be facilitated because lighter gilts can be destined to finishing units. This selection may help to reduce costs for maintaining gilts that will probably not be selected, and provides the opportunity to pay special attention to gilts with greater potential to be future breeders.

CONCLUSIONS

Birth weight is more important than litter size into which the gilts were born for survival until weaning, weight gain and retention of purebred Landrace gilts in the herd until selection time. When the gilts are stimulated close to 165 days of age, the age at puberty and anoestrous rate are not affected by their birth weight or litter size into which they were born.

SOURCES AND MANUFACTURES

[1]AG 1010 Agroceres PIC®, Agroceres PIC, Patos de Minas, MG, Brazil.

[2]AG1062 Agroceres PIC®, Agroceres PIC, Patos de Minas, MG, Brazil.

[3]Renco Lean-Meater, Renco Corp., Minneapolis, MN, USA.

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