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EFFECT OF BIRTH WEIGHT ON RETENTION RATE AND REPRODUCTIVE PERFORMANCE OF THE HYPERPROLIFIC SOW AT FIRST PARITY

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ABSTRACT

The reproductive efficiency of sows is crucial for the sustainability of any swine herd. A female's ability to contribute to the herd earlier, for a longer period, and more efficiently impacts her individual performance, characterizing her lifetime productivity. Birth weight is one of the factors that influence a sow's lifetime reproductive performance. To determine the influence of birth weight on sow performance during the first three farrowings, a prospective comparative study was conducted using 703 gilts preselected as future breeding stock at weaning. The sows were classified based on their birth weight (BW): ≤1.1 kg (n = 175), 1.2 to 1.4 kg (n = 223), 1.5 to 1.6 kg (n = 183), and ≥1.7 kg (n = 122). First-parity gilts with a birth weight (BW) between 1.2 and 1.6 kg had a higher selection rate, tended to have a higher service rate, reached puberty, and were bred at a younger age. Sows with a BW ≥ 1.7 kg had a higher growth rate and body weight at the time of service. The results of the study, at first farrowing, indicate that sows with a BW ≤ 1.1 kg are not candidates for selection as future breeding stock.

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INTRODUCTION

Modern sows are characterized by their high prolificacy. In the last two decades, the total number of piglets born has increased from 12.9 in 2000 to 19.6 piglets per litter in 2020 (Danish Pig Research Centre, 2020; cited by Theil *et al*., 2022). This increase in litter size is accompanied by a decrease in the average birth weight of piglets (Moreira *et al*., 2020), an increase in the number of small piglets and in the variation of birth weight within the litter (Foxcroft *et al*., 2009; Matheson *et al*., 2018), and a decrease in the amount of colostrum consumed per piglet (Vadmand *et al*., 2015), which increases vulnerability and reduces the growth potential of newborn pigs (Krogh *et al*., 2016). The above has implications for the selection criteria of hyperprolific replacement gilts. Positive relationships have been observed between birth weight and the size of most internal organs, including the brain, intestines, liver, and the number of fibers in some skeletal muscles (Gondret *et al*., 2005; Foxcroft *et al*., 2009), age at puberty, ovulation rate, and early embryonic survival (Flowers, 2012).

Furthermore, low birth weight has been observed to have negative effects on growth rate, reproductive performance, and lifetime productivity in replacement gilts (Magnabosco *et al*., 2016; Patterson *et al*., 2020). The detrimental effects of low birth weight are not limited to small piglets within a litter but can also extend to entire litters that are prenatal programmed to have a below-average birth weight (litter low birth weight phenotype; LLBW) and compromised postnatal growth performance (Foxcroft *et al*., 2009; Smit *et al*., 2013). Almeida *et al*. (2017) reported that low birth weight affects ovarian and uterine development by 150 days of age, which could lead to poor future reproductive performance, such as ovulation rate and, consequently, litter size. Sows weighing less than 1.0 kg at birth have been observed to have higher pre-weaning mortality rates and a low chance of surviving to weaning. As a result, if they survive beyond the nursery phase, they exhibit poor growth until the end of their life and are significantly lighter than their littermates with higher birth weights (Magnabosco *et al*., 2015). Furthermore, they have fewer live births in their first farrowing, fewer piglets produced in three farrowings, and higher culling rates due to anestrus, compared to gilts weighing more than 1.0 kg at birth (Magnabosco *et al*., 2016).

Patterson and Foxcroft (2021) observed that sows weighing less than 1.18 kg at birth generally die within four days of birth, increasing mortality rates before weaning. The objective of this study was to determine the effect of birth weight on the retention rate and reproductive performance of hyperprolific first-parity sows.

MATERIALS AND METHODS

***Location of the study area*:** The study was conducted at the La Huerta pig farm, located in the Culiacancito district of Culiacán, Sinaloa, in northwestern Mexico, with geographic coordinates of 24° 49' 38" North latitude and 107° 22' 47" West longitude, at an altitude of 60 meters above sea level (INEGI, 2009). The climate is classified as very hot semi-arid (BS1(h')), with an average annual temperature of 24.9°C, with highs of 45°C in July and August, and lows of 7°C in December and January. Rainfall is 671.4 mm, with peak rainfall in July, August, and September (García, 2004).

Management of gilts: 703 PIC Camborough® gilts were used, weighed, and identified at birth and preselected as future breeding stock at weaning. Gilts were weighed at the time of service. The puberty stimulation period began when the gilts were, on average, 150 days old. For this purpose, the gilts were exposed to a sexually mature boar (>12 months old), which was introduced into the pen twice a day (morning and afternoon) for 15 to 20 minutes. A gilt was considered in estrus when she exhibited the standing reflex in response to back pressure in the presence of the boar.

Data recording: Data collection and measurements were carried out by the research team with the assistance of farm staff. Body weight was recorded immediately before first service. Body condition score (BCS) was calculated by dividing weight by age, considering weight gain from birth to first service.

Study design: This is a prospective, comparative observational study (Méndez *et al*., 1990) in which preselected replacement gilts were classified into four birth weight (BW) groups: ≤ 1.1 kg (n = 175), 1.2 to 1.4 kg (n = 223), 1.5 to 1.6 kg (n = 183), and ≥ 1.7 kg (n = 122). The measured response variables were age at puberty, selection rate at puberty, service rate, gestation rate, farrowing rate, growth rate at service, age, and body weight at first service, as well as litter size and weight at birth and weaning.

Statistical analysis: The frequencies of sows that reached puberty and were selected, according to the birth weight category, were analyzed with the Chi-square test. Data on growth rate, age at puberty, age and weight at first service, litter size and weight at birth and weaning were tested for normality with the Kolmogorov-Smirnov test corrected by Lilliefors (Lilliefors, 1967) for n ≥ 50 data points, or Shapiro-Wilk (n < 50) using the nortest library in the R package (Gross and Ligges, 2015) and homogeneity of variances with Levene's test (Fox and Weisberg, 2019). Analysis of variance was performed using the general linear model (GLM) procedure for unbalanced data in SAS 9.0 (SAS, 2002) with the following general linear model: $yij = \mu + BWi + \varepsilon ij$; where: yij = the response variable; μ = the overall mean; BWi = birth weight group effect; and εij = the random error. When variances were heterogeneous, Welch's ANOVA was used to obtain the statistical significance of the F-test for the classification group. Mean comparisons were performed using Tukey's test. The alpha level for considering an association between categories or a statistical difference between means was ≤ 0.05, and a trend toward statistical significance was considered when alpha was > 0.05 and ≤ 0.11. The unit of observation was each sow. Results are presented as absolute frequency and percentage, as well as mean ± standard deviation.

RESULTS AND DISCUSSION

The effect of birth weight on the selection rate, fertility, and culling rate of first-parity replacement gilts is presented in Table 1. Gilts with a birth weight between 1.2 and 1.4 kg and 1.5 and 1.6 kg had a higher selection rate at puberty than those with a birth weight ≤ 1.1 kg and ≥ 1.7 kg (50.22% and 57.37% vs. 42.28% and 48.36%, respectively; p = 0.04). These results are like those observed by Romo-Rubio *et al*. (2025), who observed a lower retention rate at 148 days of age (prepubertal) in gilts with a birth weight ≤ 1.1 kg. Previous studies have shown that birth weight affects the selection rate of females from the first week after birth, after weaning, and throughout the sow's development phase. In this regard, Patterson *et al*. (2018) reported a lower retention rate within the first four days after birth, at 24 and 70 days of age, and during pre-selection when they analyzed gilts born to sows with a low-birth-weight phenotype (LWB; average litter birth weight < 1.15 kg), based on at least two successive farrowings, compared to categories with a birth weight greater than 1.16 kg. Similarly, it has been observed that gilts with a high birth weight phenotype (HBW) are more likely to grow exceptionally fast, so they may be inseminated at too high a weight, which impairs their reproductive performance in the first four farrowings (Patterson *et al*., 2020). It has also been observed that gilts with lower birth weight had the highest culling rates due to anestrus (22.9%); in addition, those weighing less than 1.3 kg produced significantly fewer piglets (≤ 4.5) in three farrowings compared to their heavier counterparts (Magnabosco *et al*., 2015, 2016; Flowers, 2019).

Table 1. Effect of birth weight on selection rate, fertility, and culling rate of replacement sows at first farrowing

Variable	Birthweightcategories				p-value
	≤ 1.1 kg	1.2 a 1.4 kg	1.5 a 1.6 kg	≥ 1.7 kg	
Birth weight, kg	0.940	1.311	1.543	1.800	
Pre-selectedgilts, n	175	223	183	122	
Selection rate, %	42.28 (74/175)[a]	50.22 (112/223)[ab]	57.37(105/183)[b]	48.36 (59/122)[a]	0.0407
Service rate, %	90.54 (67/74)	83.03 (93/112)	93.33 (98/105)	89.83 (53/59)	0.1011
Pregnancy rate, %	94.02 (63/67)	93.54 (87/93)	92.85 (91/98)	94.33 (50/53)	0.9840
Birth rate, %	74.62 (50/67)	73.11 (68/93)	78.57 (77/98)	81.13 (43/53)	0.8230
Cullingrate 1st delivery, %	37.84 (28/74)	39.28 (44/112)	37.14 (39/105)	33.90 (20/59)	0.6445

Different literals a-b on the same line indicate statistical difference (Tukey; p < 0.05)

Knauer (2016), in a study that grouped gilts into three birth weight categories (≤ 1.0, 1.1 to 1.4, and ≥ 1.5 kg), found that the proportions of sows bred after their sixth farrowing were 5.2, 20.3, and 28.4%, respectively. Faccin *et al*. (2022) recommend that gilts with a low birth weight (< 1 kg) or gilts from litters with low birth weights should be eliminated early in the selection process. Other studies have observed that low birth weight is associated with intrauterine growth retardation (Wu *et al*., 2006), and that gilts with low birth weight have fewer medium-sized follicles and more atretic follicles in the ovary than young sows with high birth weights as they approach expected puberty (Almeida *et al*., 2017). Therefore, young sows with low birth weights should not be selected, nor should those born to sows that have given birth to large litters with significant variation in birth weight. In addition to reproductive performance, high weaning weights and high pre-weaning growth in young sows are associated with high survival rates and good performance as replacement gilts (Douglas *et al*., 2014). A trend (p = 10) of a higher percentage of sows bred after selection was observed among those with a birth weight of 1.5 to 1.6 kg; the average selection rate was 89.18%. No difference (p = 0.98) was observed in the gestation rate, farrowing rate (p = 0.82), or culling rate at first farrowing (p = 0.64); the averages for the study group were 93.68%, 76.86%, and 37%, respectively. The high culling rate observed at first parturition is like the 41.3% observed by Masaka *et al*. (2014), in young and primiparous sows.

Table 2. Effect of birth weight on growth rate, physical condition, age at puberty and at first service

Variable	Birthweightcategories				p-value
	≤ 1.1 kg	1.2 a 1.4 kg	1.5 a 1.6 kg	≥ 1.7 kg	
Gilts, n	67	93	98	53	
Growth rate, kg	0.580±0.07[b]	0.590±0.07[ab]	0.603±0.06[ab]	0.612±0.06[a]	0.03
Puberty age, d	222.15±30.05	214.65±29.15	217.33± 29.22	226.37±30.42	0.06
Age of service, d	260±27.59	252±25.52	249.67±23.76	253±23.59	0.09
Body weight at service, kg	150.364±10.25[b]	148.788±12.29[b]	151.534±11.10[ab]	155.841±11.89[a]	0.004
BFT at service, mm	13.6±2.99	13.7±2.97	13.5±2.62	13.6±2.88	0.97

Different literals a-b on the same line indicate statistical difference (Tukey; $p < 0.05$); BFT= Back fat thickness

Table 3. Effect of birth weight on body condition and reproductive performance at first calving

Variable	Birthweightcategories				p-value
	≤ 1.1 kg	1.2 a 1.4 kg	1.5 a 1.6 kg	≥ 1.7 kg	
Sows, n	50	68	77	43	
BFT at 80 days of gestation, mm	15.54±3.16	15.8±3.03	16±3.13	15.98±3.66	0.84
BFT at 109 days of gestation, mm	15.9±3.38	16.07±3.05	16±2.95	15.53±3.06	0.81
Totalpigletsborn, n	15.3±2.6	14.32±3.2	14.8±2.8	15±3.1	0.33
Live pigletsborn, n	13.5±3.2	12.15±3.4	12.14±3.8	13.19±3.3	0.08
Stillbornpiglets, n	1.8±2.2	2.16±2.4	2.67±3.0	1.83±1.9	0.18
Low birth weight (≤ 800 g), n	0.82±1.32	0.54±1.08	1.0±2.68	0.93±1.57	0.48
Litter weight at birth, kg	16.916±4.0	16.048±3.56	15.512±4.84	17.169±4.22	0.13
Piglet weight at birth, kg	1.262±0.14	1.294±0.15	1.302±0.17	1.313±0.18	0.44
Litter weight at weaning, kg	64.119±13.52	62.547±12.24	59.529±10.69	63.385±12.35	0.15
BFT at weaning, mm	11.43±2.75	11.7±2.23	11.6±2.58	11.55±2.80	0.95
Weaning-to-estrus interval, d	10.54±10.25	9.96±9.82	9.08±10.64	11.88±10.52	0.66
Weaning-to-estrus interval rate ≤10 d, %	79.48	75.51	81.35	66.66	0.43

BFT = Back fat thikness

The results of the effect of birth weight on growth rate, physical condition, age at puberty, and age at first service are shown in Table 2. Sows with a birth weight ≥ 1.7 kg showed a higher growth rate compared to those weighing 1.5 to 1.6 kg, 1.2 to 1.4 kg, and ≤ 1.1 kg (0.612 ± 0.06 vs. 0.603 ± 0.06, 0.590 ± 0.07, and 0.580 ± 0.07, respectively; $p = 0.03$). Low birth weight piglets have been observed to have a reduced capacity to take colostrum (Ferrari *et al*., 2014), which may affect their future performance. In this regard, it has been reported that birth weight is a determining factor in the productive efficiency and profitability of pig production units. It affects the mortality rate during the lactation period, as well as the average daily weight gain and the body weight that the pig reaches in each of the production phases, thus determining the economic performance of the production unit (Crespo and Gadea, 2021). The importance of a high birth weight in reducing the risk of low performance was also reported by Panzardi *et al*. (2013), who observed that piglets weighing < 1.27 kg at birth were more likely to belong to the group of light piglets at weaning. In another study, piglets with a birth weight greater than 1.3 kg were found to weigh 1.2 kg more at 42 days of age than piglets born weighing less than 1.3 kg, demonstrating that 1.3 kg appears to be a critical birth weight value to ensure good growth before and after weaning.

Furthermore, piglets with a colostrum intake greater than 250 g weighed an average of 0.7 kg more at 42 days of age (Quesnel, Farmer, and Devillers, 2012), which is associated with birth weight. A tendency to reach puberty at a younger age was observed in sows that had a birth weight of 1.2 to 1.4 and 1.5 to 1.6 kg, compared to those that weighed ≤ 1.1 kg and ≥ 1.7 kg (214.65 ± 29.15 and 217.33 ± 29.22 vs. 222.15 ± 30.05 and 226.37 ± 30.42 d, respectively; $p = 0.06$). Likewise, sows with a birth weight ≤ 1.1 kg tended to be served at an older age compared to those with a weight of 1.2 to 1.4, 1.5 to 1.6 and ≥ 1.7 kg (260 ± 27.59 vs. 252 ± 25.52, 249.67 ± 23.76 and 253 ± 23.59 d, respectively; $p = 0.09$). Sows with a birth weight ≥ 1.7 kg showed a higher weight at first service compared to those with a weight ≤ 1.1 kg, 1.2 to 1.4 kg, and 1.5 to 1.6 kg (155.841 ± 11.89 vs. 150.364 ± 10.25, 148.788 ± 12.29, and 151.534 ± 11.10, respectively; $p = 0.004$). However, all sows were within the target weight range at 240 days of age; body weight which, according to PIC (2022), should be between 135 and 160 kg at the second or third observable estrus. Beltranena *et al*. (1991) observed that when the growth rate (GR) is less than 0.550 kg/d, puberty is delayed. In the present study, sows weighing ≤ 1.1 kg had the lowest growth rate, reached puberty, and were bred at an older age than sows weighing between 1.2 and 1.6 kg at birth (Table 2). Similar results were observed by Romo-Rubio *et al*. (2025). Birth weight did not modify body condition or reproductive performance at the first farrowing of hyperprolific sows (Table 3). However, it was observed that sows with a birth weight ≤ 1.1 and ≥ 1.7 kg tended to have more live-born piglets than sows with a birth weight of 1.2 to 1.4 kg and 1.5 to 1.6 kg (13.5 ± 3.2 and 13.19 ± 3.3 vs. 12.15 ± 3.4 and 12.14 ± 3.8, respectively; $p = 0.08$).

CONCLUSIONS

Gilts born weighing less than 1.2 kg have a lower selection and service rate; they also reach puberty and are bred at an older age. The results indicate that gilts born weighing between 1.2 and 1.6 kg should be selected. It is recommended that replacement gilts achieve a growth rate of 600 to 700g/day at first service, at an age of 230 to 260 days.

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