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Effect of Body Weight and Age at Puberty and Mating on Subsequent Gilt Development Weights, Litter Traits, and Colostral Immunoglobulin G of the F1 Large White X Landrace Gilts

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Abstract: The purpose of this study was to assess how body weight and age at puberty and mating in F1 Large White x Landrace pigs influence subsequent gilt development weights, litter characteristics, and colostral immunoglobulin G levels. A total of 168 gilts were categorized into different weight groups, i.e., body weight at puberty (lighter gilts: <103 kg, moderate gilts: 103-109 kg) and heavier gilts: >109 kg), different age groups at mating (Young age: <224 Days of Age (DOA), Middle age: 224-229 DOA and Older age: >229 DOA) body weight at mating (lighter gilts: <155 kg), moderate gilts: 155-163 kg, heavier: >163 kg). A digital Brix refractometer was utilized to measure colostral immunoglobulin G levels. The General Linear Model in Minitab 17 was used to analyze the data generated in this study and Fisher's LSD test was done using mean separation ($p<0.05$). The weight at the second estrus for the heavier gilts at puberty (123.01 kg) was higher ($p<0.05$) than that of the lighter gilts on the second estrus (121.88 kg). The age at mating for young, middle, and older were 220.63, 226.85, and 233.50 Days of Age, respectively. Gilts mated at an older age had a lower ($p<0.05$) backfat at mating (12.03 mm) than those mated at a young age (13.08 mm) and middle age (12.84 mm). Gilts mated in middle age farrowed at a higher ($p<0.05$) weight (239.68 kg) than those mated at young age (233.63 kg). The litter traits and colostral immunoglobulin G were comparable ($p>0.05$) among the body weight groups at puberty as well as between different age groups at mating. Litter traits and colostral immunoglobulin G are more hereditary (genotype) than environmentally regulated.

Keywords: Colostrum, Gestation Gain, Litter Size, Sus Scrofa Domesticus

Introduction

Global climate is becoming increasingly drier and warmer, posing a threat to agriculture in producing affordable and nutritious by-products to meet the needs of an expanding global population (Tigchelaar *et al*., 2018). The climate change effect often results in reduced production and the quality of available food and these extremes are often felt by poor consumers (Headey *et al*., 2016; Call *et al*., 2019). Many households in South Africa are classified as poor which is approximately 30.8% of the population (Statistics South Africa, 2022) with 23% living below bread standard (Statistics South Africa, 2022) and the effects of climate change are not an exception to them (Maloma, 2016). Amid the climate change challenge, the pig (*Sus scrofa domesticus*) industry remains one of the most important industries in agriculture, supplying essential nutrients for these households (Ederer *et al*., 2023). The South African pig industry produces up to 182,000 tonnes of pork annually, with an additional 25,000 tonnes imported into the country. South Africa consumes approximately 200,000 tonnes of pork meat (both fresh and processed) each year, contributing 0.5% to global pork production (Ederer *et al*., 2023). It is therefore important to adopt a conscious selection of gilt that can produce or keep up with the above-mentioned tons (Faccin *et al*., 2022). Choosing the appropriate gilts does not guarantee profit, stability, or high business efficiency, but it is critical for achieving success (Malapolska *et al*., 2018). The Estimated Breeding Value (EBVs) have been utilized in selecting replacement gilts resulting in increased genetic turnover (Craig *et al*., 2017).

To address this, there are limited insights regarding the effect of F1 crossbred pigs (Large White x Landrace) gilt developmental weights at puberty and first mating on litter traits and subsequent colostral immunoglobulins. Farmers opt to use these gifts for their high reproductive efficiency, rapid growth rate, robust health, excellent mothering ability, adaptability, and improved carcass quality (Guan *et al*., 2021).

Producing replacement gilts is feed-costly since gilts are considered growers and consume a lot of feed before producing, requiring space, whereas a weaned sow is more economical to have in production (Thomas *et al*., 2021). Hence, it would be advantageous to select gilts that can start to produce at an early age without adversely affecting their future production performance (Szostak, 2011). As a result, early adolescence allows for two or three estrous cycles prior to the first mating, which helps to prepare the uterus and provide optimum progesterone levels in females (Cottney *et al*., 2012). The number of estruses before mating in gilts influences litter size at farrowing (Cottney *et al*., 2012). Additionally, postponing gilt breeding to an older age or higher weight can lead to negative outcomes such as decreased longevity, a longer generational interval, higher disease risks, and lower reproductive performance (Kraeling and Webel, 2015), even though breeding gilts at a higher weight can improve litter size (Bruun *et al*., 2020). Furthermore, age and weight are linked to adverse effects on successful breeding practices when gilts are re-mated later for their second parity (Bruun *et al*., 2020). Therefore, farmers should carefully consider the optimal mating time for young gilts to extend their reproductive lifespan (Lee *et al*., 2019).

Generally, it is essential for the replacement gilts to produce a sufficient amount of colostrum to support their litters. This remains imperative because, colostrum is essential for piglets' survival and growth throughout the lactation phase (Nuntapaitoon *et al*., 2019). Furthermore, like in many other species, piglets receive maternal-derived immunity from colostrum in the form of immunoglobulin immune cells (Jennewein *et al*., 2017; Poonsuk and Zimmerman, 2018). Immunoglobulin G is a well-known anti-infectious component, serving as a primary defense and assisting to neutralize viruses, bacteria, and toxins to prevent any disease build-up or growth retardation (Gocki and Bartuzi, 2016). This immunoglobulin G is transferred to the piglets' bloodstream through absorption in their gastrointestinal tract prevents infection by bacteria and viruses and helps the piglet to develop a strong immune system (Maciag *et al*., 2022).

Previous studies have employed various methods to assess colostrum quality in pigs, including Radial Immunodiffusion (RID) and Enzyme-Linked Immunoassay (ELISA) (Hasan *et al*., 2016). However, these techniques have several drawbacks: They are costly, require specialized equipment and skilled technicians, and are time-consuming, taking 18-72 h to produce results, making them unsuitable for routine farm use (De Souza *et al*., 2021). Lately, the digital Brix refractometer has emerged as a practical alternative for measuring colostrum quality on farms. This method is considered highly promising for on-farm monitoring of colostrum quality because it requires only minimal sample quantities, is quick, easy to perform, and is cost-effective in terms of equipment and reagents (De Souza *et al*., 2021). Notably, colostrum samples evaluated using a Brix refractometer show a positive correlation with IgG levels measured by ELISA (Hasan *et al*., 2016). Therefore, this study was conducted to assess the effect of body weight, age at puberty, and mating on subsequent gilt development weights, litter traits, and colostral immunoglobulin G in F1 Large White x Landrace pigs.

Materials and Methods

Study Area

The study was conducted at the Topigs Norsvin South Africa-Animal Genetics Centre, located in the Kungwini Local Municipality in the Gauteng Province. The farm is positioned in a subtropical highland climate with dry winters.

Experimental Animals and Management

A total of 168 F1 (Large White x Landrace) gilts were used in this study, recorded from the year 2022-2023. Weight at puberty and age at insemination were collected were among the parameters recorded. These gilts were bred from the Nucleus Unit of Topigs Norsvin South Africa and arrival weight was between 30 and 35 kg.

These gilts were housed in an automated ventilation house with Hotraco boxes that control the inlet, minimum, and maximum fans responsible for airflow and the temperature inside the houses. Houses were also fitted with a backup generator that switches on if there is a power failure for temperature and light control. During winter, diesel heaters were installed at the gilt house and farrowing house to control the temperature inside the houses, to prevent scour (wet manure) on piglets at the farrowing house, and to prevent sows from using all the fat body reserves to warm their body since it results into low feed intake. Stocking density was approximately 5 m^2/pig. Daily monitoring of animals was done to observe cases of illness. Also, there was a trained animal health personnel or veterinarian assigned to administer treatment.

Gilts were divided into different body weight groups i.e., body weight at puberty (lighter gilts: <103 kg, moderate gilts: 103-109 kg) and heavier gilts: >109 kg), different age groups at mating (Young age: < 224 Days of Age (DOA), Middle age: 224-229 DOA and Older age: >229 DOA) and different body weight groups at insemination (lighter gilts: <155 kg), moderate gilts: 155-163 kg, heavier gilts: >163 kg).

Semen from one fertility-tested boar with a concentration of at least 1.8 billion cells/dose was utilized for artificial insemination. Semen before artificial insemination was analyzed using Computer Assisted Semen Analysis (CASA). Semen ejaculate with less than 65% motile/live sperm, and less than 60% progressive motility were not used for artificial insemination.

Data Collection and Measurements

All gilts were weighed at puberty, during their second and third estrus, at insemination, and at farrowing using an electronic scale from Libra Measuring Instruments (LMi), South Africa, Pretoria. At farrowing, the litter size was determined by counting the Total number of piglets Born including stillborn (TB), the Total number of piglets Born Alive (TBA), and the number of piglets Born Dead/stillborn (BD). After farrowing the colostrum was collected at three different times, at farrowing (3 h), medium (12 h), and late (24 h) to determine the immunoglobulin G. The sample of colostrum was milked from the same teat to minimize variation from teat Twelve (12) gilts were collected in the front seats, 12 gilts were collected in the middle teats and 12 gilts were collected in the hind teats. Digital Brix Refractometer was used to measure the immunoglobulin G. A 0.3 mL of colostrum was poured into the surface prism of the Digital Brix Refractometer to determine the percentages of the colostral immunoglobulin G, following the manufacturer's protocol.

Statistical Analysis

General Linear Model (GLM) was used to analyze the data and Fisher's LSD test was the tool used for mean separation at $p<0.05$.

Results

The gilt development, backfat, litter traits, and colostral immunoglobulin G values were summarised statistically using means, standard deviation, minimum and maximum Table (2). There were variations in weight at the first estrus and second estrus with a Standard Deviation (SD) of 6.37 and 6.54 kg, respectively. The average weight at the third estrus was 139.65 kg and the weight ranged from 123-158 kg. The highest SD observed was for the gestation gain (12.26 kg) and farrowing weight (14.65 kg), whereas the smallest SD observed was for backfat (1.86) at mating. There was a variation in weight change at the first to second estrus and at the second to third estrus with an SD of 4.71 and 4.60 kg, respectively. The age at mating and weight change at second to third estrus and mating weights range from 138-181 and 0-3 kg, respectively, with a mean of 158.82 kg and SD of 0.51 kg. Variations were observed in the number of total piglets born and those born alive, with SD of 2.58 and 2.47, respectively. The range for total piglets born was from 4-21, while for those born alive, it was from 4-20. There were 0-7 dead piglets born, with an average standard deviation of 1.05. Colostral immunoglobulin G levels ranged from 11.30-31.20%, with an average of 6.12%.

Table 1: Gilt feeding program

Gilt stage	Diet	kg/day
At puberty	Gilt 3	3-3.2
Before mating	Sow and boar	3.2-3.4
At mating	Sow and boar	2.6
From 56 days of gestation	Sow and boar	2.6-2.9
At farrowing	Transition	2.8

Table 2: Means, Standard Deviation (SD), Minimum (Min), and Maximum (Max) for gilt development, backfat, litter traits, and colostral immunoglobulin G

Variables	N	Mean	SD	Min	Max
Weight at first estrus (kg)	168	105.64	6.37	91.00	121.00
Weight at second estrus (kg)	168	123.09	6.54	105.00	139.00
Weight change from puberty to second estrus (kg)	168	17.45	4.71	6.00	30.00
Weight at third estrus (kg)	168	139.65	7.72	123.00	158.00
Weight change from second to third estrus (kg)	168	16.50	4.60	5.00	30.00
Backfat at mating	168	12.73	1.86	8.00	18.00
Age at mating (days)	168	226.80	5.32	211.00	251.00
mating weight (kg)	168	158.82	8.49	138.00	181.00
Weight change from third estrus to mating (kg)	168	19.17	6.58	0.03	8.00
Gestation gain (kg)	168	79.38	12.26	45.00	114.00
Backfat at farrowing	168	15.86	2.15	10.00	22.00
Farrowing weight (kg)	168	238.18	14.65	186.00	280.00
Litter size at birth	168	14.99	2.58	4.00	21.00
Born alive	168	14.35	2.47	4.00	20.00
Born dead	168	0.64	1.05	0.00	7.00
Colostral immunoglobulin G (%)	36	19.40	6.12	11.30	31.20

Body weight at puberty significantly ($p<0.05$) influenced the weights at the second and third estrus, weights change between the first and second estrus and second estrus and mating Table (3). The weights at puberty for the heavier, moderate, and lighter gilts at puberty were 112.03, 105.78, and 99.80 kg, respectively. The moderate gilts at puberty (123.01 kg) yielded similar ($p>0.05$) weights to the lighter gilts (121.88 kg) size gilts at the second estrus. However, the weight at the second estrus between the moderate (123.01 kg) and heavier (123.94 kg) gilts at puberty was also similar ($p>0.05$). Furthermore, the weight at the second estrus for the heavier gilts at puberty (123.01 kg) was higher than that of lighter gilts (121.88 kg). While there was a non-significant difference ($p>0.05$) in the weight of the heavier (140.46 kg) and moderate (140.04 kg) gilts at puberty at third estrus, the lighter gilts' weight (138.77 kg) was considerably ($p<0.05$) lower than that of the two groups (moderate and heavier gilts) at third estrus. The highest ($p<0.05$) weight change from the second to third estrus was recorded in the lighter gilts at puberty (22.09 kg), whilst the lowest was observed for the heavier gilts (11.91 kg). The highest weight change from third estrus to mating was observed in the lighter gilts at puberty (20.07 kg). However, the weight change from third estrus to mating age for the moderate (18.07 kg) and heavier (18.54 kg) gilts at puberty were similar ($p>0.05$). The weight change from third estrus to mating for heavier (18.54) and lighter (20.07) gilts at puberty were also similar ($p>0.05$). Furthermore, the weight change from third estrus to mating weight for the lighter gilts was higher ($p<0.05$) than the moderate gilts at puberty. In addition, weight change from second to third estrus, backfat at mating, age at mating, mating weight, gestation gain, backfat at farrowing, farrowing weight, total born, born alive, born dead, and colostral immunoglobulin G were similar ($p>0.05$) between studied body weight were grouped at puberty.

Body weight of gilts at mating significantly ($p<0.05$) influenced the weight at mating, weight change from third estrus to mating age, and gestation gain Table (4). The weight at mating for the heavier, moderate, and lighter gilts at mating were 167.46, 158.83, and 149.64 kg, respectively. Weight change from third estrus to mating weight for heavier, moderate, and lighter gilts at mating were 26.58, 18.49, and 11.61 kg, respectively. Furthermore, the highest gestation gain was observed in the lighter (86.26 kg) size gilts at mating, followed by the moderate (79.08 kg) and heavier (71.60 kg) gilts at mating. Backfat at mating, age at mating, backfat at farrowing, farrowing weights, total born, born alive, born dead, and colostral immunoglobulin G were similar ($p>0.05$) in all the studied body weight groups at mating.

Table 3: Least Square Means (LSM) and their Standard Errors (SE) for the effect of body weight at puberty on subsequent development weights, backfat, litter traits, and colostral immunoglobulin G

Variables	Lighter <103 kg	Moderate 103-109 kg	Heavier >109 kg
Weight at second estrus (kg)	121.88^{b}±0.42	123.01^{ab}±0.37	123.94^{a}±0.44
Weight change from first to second estrus (kg)	22.09^{a}±0.49	17.22^{b}±0.44	11.91^{c}±0.52
Weight at third estrus (kg)	138.77^{b}±0.44	140.04^{a}±0.40	140.46^{a}±0.47
Weight change from second to third estrus (kg)	16.88^{a}±0.50	17.02^{a}±0.44	16.52^{a}±0.52
Backfat at mating (mm)	13.02^{a}±0.28	12.50^{a}±0.25	12.48^{a}±0.30
Age at mating (days)	226.10^{a}±0.81	226.21^{a}±0.73	227.90^{a}±0.86
Mating weights (kg)	158.84^{a}±0.54	158.10^{a}±0.49	159.00^{a}±0.57
Weights change third estrus to mating (kg)	20.07^{a}±0.64	18.07±^{b}0.57	18.54^{ab}±0.68
Gestation gain (kg)	79.26^{a}±1.12	79.80^{a}±1.00	77.87^{a}±1.18
Backfat at farrowing (mm)	16.08^{a}±0.34	15.73^{a}±0.30	15.44^{a}±0.35
Farrowing weight (kg)	238.13^{a}±0.10	237.8^{a}±60.98	236.8^{a}±41.16
Litter size at birth	14.81^{a}±0.40	15.44^{a}±0.35	14.72^{a}±0.42
Born alive	14.32^{a}±0.38	14.60^{a}±0.34	14.29^{a}±0.40
Born dead	0.49^{a}±0.16	0.84^{a}±0.14	0.43^{a}±0.17
Colostral immunoglobulin G (%)	20.19^{a}±1.25	18.32^{a}±1.05	19.28^{a}±1.21

Table 4: Least Square Means (LSM) and their Standard Errors (SE) for the effect of body weight at mating on subsequent gilt development weights, backfat, litter traits, and colostral immunoglobulin G

Variables	Lighter <155 kg	Moderate 155-163 kg	Heavier >163 kg
Backfat at mating	12.67^{a}±0.29	12.69^{a}±0.25	12.63^{a}±0.29
Age at mating (days)	226.52^{a}±0.85	226.38^{a}±0.73	227.31^{a}±0.85
mating weight (kg)	149.64^{c}±0.57	158.83^{b}±0.49	167.46^{a}±0.57
Weight change from third estrus to mating (kg)	11.61^{c}±0.67	18.49^{b}±0.58	26.58^{a}±0.67
Gestation gain (kg)	86.26^{a}±1.17	79.08^{b}±1.00	71.60^{c}±1.17
Backfat at farrowing	15.58^{a}±0.35	15.70^{a}±0.30	15.97^{a}±0.35
Farrowing weight (kg)	235.92^{a}±1.15	237.86^{a}±0.98	239.04^{a}±1.15
Litter size at birth	14.85^{a}±0.41	14.90^{a}±0.35	15.21^{a}±0.41
Born alive	14.36^{a}±0.40	14.38^{a}±0.34	14.47^{a}±0.40
Born dead	0.50^{a}±0.17	0.52^{a}±0.14	0.74^{a}±0.17
Colostral immunoglobulin G (%)	17.79^{a}±1.48	20.95^{a}±1.24	19.06^{a}±2.00

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The effect of age at mating, backfat, litter traits, and colostral immunoglobulin G is presented in young gilts (13.08 mm) yielded similar ($p>0.05$) backfat at mating to middle (12.84 mm) Table (5). However, older gilts (12.03 mm) were lower ($p<0.05$) than young gilts (13.08 mm) and middle-aged gilts (12.84 mm). The average age at mating for young, middle, and older gilts was 220.63, 226.85, and 233.50 mm, respectively. Older (239.00 kg) gilts yielded similar ($p>0.05$) weights to middle (239.68 kg) for farrowing weights. However, farrowing weights between older (239.00 kg) and young ($p<0.05$) (233.68 kg) gilts were also similar ($p>0.05$). Furthermore, farrowing weights for middle gilts were higher ($p<0.05$) than those of young gilts. Mating weights, gestation gain, backfat at farrowing, total born, born alive, born dead, and colostral immunoglobulin G were similar ($p>0.05$) in young, middle, and older gilts. The colostral immunoglobulin G of the lighter, moderate, and heavier gilts at puberty was high soon after farrowing and declined over time Fig. (1). All the body weight groups at puberty had similar colostral immunoglobulin G at 3, 12, and 24 times from farrowing. A similar trend was also observed in the different body weight groups at insemination Fig. (2).

Table 5: Least Square Means (LSM) and their Standard Errors (SE) for the effect of age range at mating on subsequent gilt development weights, backfat, and litter traits

Variables	Young <224 days	Middle 224-229 days	Older >229 days
Backfat at mating	$13.08^{a}\pm0.30$	$12.84^{a}\pm0.19$	$12.03^{b}\pm0.32$
Age at mating (days)	$220.63^{c}\pm0.53$	$226.85^{b}\pm0.33$	$233.50^{a}\pm0.56$
Mating weight (kg)	$156.87^{a}\pm1.37$	$159.10^{a}\pm0.86$	$160.21^{a}\pm1.45$
Gestation gain (kg)	$76.87\pm^{a}1.99$	$80.57^{a}\pm1.25$	$78.79^{a}\pm2.10$
Backfat at farrowing	$16.18^{a}\pm0.35$	$15.72^{a}\pm0.22$	$15.88^{a}\pm0.37$
Farrowing weight (kg)	$233.68^{b}\pm82.36$	$239.68^{a}\pm81.48$	$239.00^{ab}\pm2.49$
Litter size at birth	$14.58^{a}\pm0.42$	$15.21^{a}\pm0.26$	$14.82^{a}\pm0.44$
Born alive	$14.1^{a}\pm10.40$	$14.46^{a}\pm0.25$	$14.32^{a}\pm0.43$
Born dead	$0.47^{a}\pm0.17$	$0.75^{a}\pm0.11$	$0.50^{a}\pm0.18$
Colostral immunoglobulin G (%)	$19.95^{a}\pm1.26$	$19.00^{a}\pm0.86$	$19.63^{a}\pm1.07$

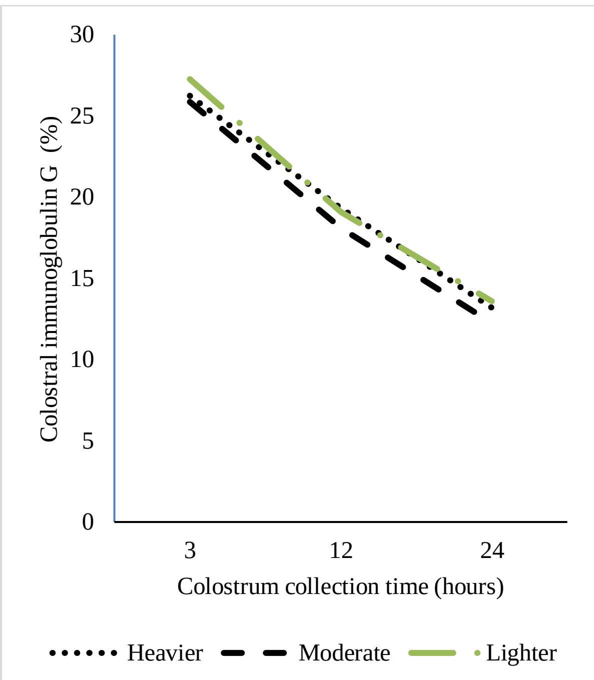

Fig. 1: The colostral immunoglobulin G (%) of different body. Weight groups at puberty over time

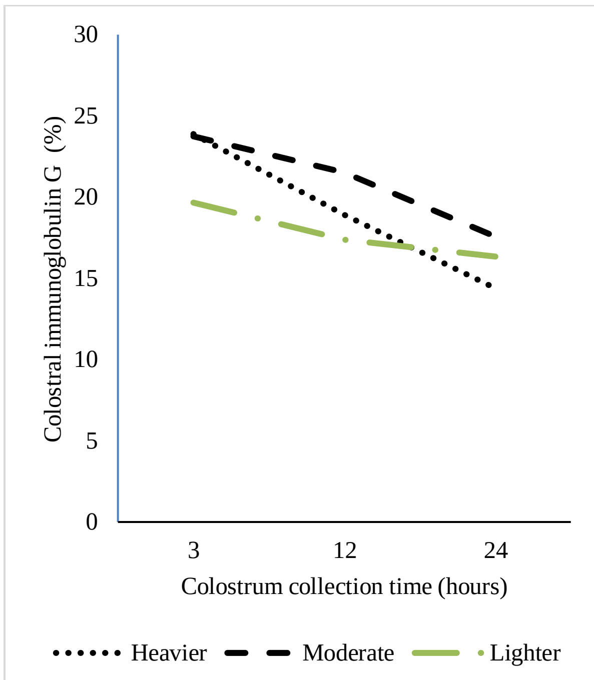

Fig 2: The colostral immunoglobulin G (%) of different body weight groups at insemination over time

Discussion

Gilts must start reproducing at an early age to increase feed consumption efficiency. Hence, gilts must reach the targeted breeding weights as early as possible. Therefore, correct strategies in selection, rearing, and puberty induction of replacement gilts are important in breeding herds. It has been suggested that gilts shouldn't be bred at their first estrus because the number of ovulations is low resulting in small litter size (Malapolska *et al*., 2018). The number of ovulations increases if mating is delayed until the third heat (Hagan and Etim, 2019), a larger litter will result. The age at mating of the gilts in the present study was between 211 and 251 DOA. The development of the female reproductive system is influenced by an animal's age (Kapelański *et al*., 2013; Lents *et al*., 2020), therefore, gilts should not be bred at the earliest age. Breeding gilts between 233-253 DOA is an optimal age for increasing lifetime total piglets born compared to those younger than 223 days of age (Joab *et al*., 2019). In this present study, the age at first mating did not influence the litter traits. Contrary to our findings Lida *et al*. (2015) observed that gilts that were first mated at the latter age (278 DOA) had farrowed fewer alive piglets than those mated at the earliest age (229 DOA). Similar litter traits across different ages at mating observed in the current study suggest that these traits are more hereditary (genotype) than environmental. Similar to our findings, weight at mating does not influence the litter size from parity 1 6 (Lee *et al*., 2019). A lower mating age (220 DOA) is suggested to be more efficient for greater litter performance (Lee *et al*., 2019). Conversely, (Joab *et al*., 2019) are of the view that the age at first breeding of gilts has consequences on reproduction performances and longevity.

A delay in the age at first mating to approximately 254-330 DOA is associated with a reduction in litter size in later parities (4 and 5) (Joab *et al*., 2019). Similarly, (Hoving *et al*., 2010) observed that gilts mated at a younger age (230 DOA) had smaller litter sizes in their second and subsequent parities, although no significant relationship was observed between age at first mating and litter size in the first parity. In a four-year study (2017-2020) by Tretyakova *et al*. (2021), the age at first mating and the litter size at birth of the Large White gilts were studied. In 2017, the largest litter size at farrowing was recorded in a group where the age at first mating was 241-253 and 281-311 DOA, with 12.5 and 12.7 units, respectively. In the following year, 2018, the largest litter size at farrowing was recorded on gilts first mated between 257-268 DOA with 12.4 units. In 2019 largest litter size at farrowing was observed in a group where the age at mating was between 242-253 days with 11.4 units. In 2020, the largest litter size at farrowing was observed where the age at first mating was 242-254 days with 13.7 units. The variations found in litter size were caused by the age at first mating, (Tretyakova *et al*., 2021), recorded a decrease in age at first mating in 2020 as the gilts were mated younger at 7-8 months, and in 2017 the gilts were mated 7-10 months. Several authors indicate that the most optimal age of first mating is considered 210-240 DOA (Muroski *et al*., 2016; Liu *et al*., 2017). The observations made by some researchers (Szulc *et al*., 2015; Tretyakova *et al*., 2021), are in contrast with our findings as they indicate that the litter size at farrowing and total born dead (stillbirths) differs with age at first mating. (Lee *et al*., 2019) also stated that longevity and reproductive performances were not impacted by the age of gilts at first mating. (Lee *et al*., 2019) observed that age at mating is crucial for determining the backfat thickness at mating and not later stages of gilt development of the primiparous sows. Gilts in higher age classes yielded higher backfat at mating compared to those in lower age groups during their first parity (Lee *et al*., 2019). This was also the observation in the current study wherein the gilts in the lower and middle age groups were observed to have lower backfat thickness at mating compared to those in the older age group during their first parity. Additionally, it is noted that the fatter gilts were also the eldest at puberty or first mating (Patterson and Foxcroft, 2019).

The mating weights in the present study for heavier, moderate, and lighter body gilts were <155, 155-163, and >163 kg, respectively. If gilts are mated at a heavier body weight (170 kg), as compared with a small body weight (140 kg), their daily maintenance remains high throughout their lifespan (Patterson *et al*., 2010; Bruun *et al*., 2022). Furthermore, this consequently compromises their feed efficiency. The body weight at first mating influenced litter size, wherein the lighter body weight gilts had 1.5 fewer piglets than heavier gilts (Carrión-López *et al*., 2022), the same trend was also observed by Kim *et al*. (2016). Gilts of different body weights at mating (lighter: <140, moderate: 140-160 kg, and heavier: >170 kg) yielded similar piglets born alive, stillborn, and mummified at their first farrowing (Szulc *et al*., 2015). This was also the case with our findings as the gilts of different body weights at mating produced similar litter sizes, and number of piglets born alive and stillborn. In the same study by Szulc *et al*., (2015), gilts of moderate body weight at mating showed a tendency ($p>0.05$) to farrow and rear the largest litters and produced the fewest mummified fetuses. However, this was not the case in this study as the heavier gilts showed a tendency ($p>0.05$) to farrow greater litter size, stillborn and mummified compared to the other frame sizes. In line with the current study's findings that gilt body weight at first mating does not significantly impact litter size, Mucha and Strandberg (2011) observed similar results. However, on the contrary, some earlier studies (Foxcroft *et al*., 2002; Williams *et al*., 2005; Carrión-López *et al*., 2022) reported that weight at mating is an important factor that influences the litter size at farrowing. Gilts bred at a lighter weight have lower litter sizes in their first farrowing (Carrión-López *et al*., 2022) and second and following parities (Hoving *et al*., 2010) compared to those bred at a moderate and heavier weight. A comparable pattern was also noted in the present study, wherein a similar number of total piglets born dead were observed across the gilts mated at different body weights, a similar trend was also observed by Carrión-López *et al.* (2022).

Backfat thickness has been identified as a critically important factor affecting the reproductive performance of gilts (Roongsitthichai and Tummaruk, 2014; Strathe *et al*., 2019), growth and vitality of piglets (Lavery *et al*., 2019) and the quality of the pork meat (Fortin *et al*., 2005; Ros-Freixedes *et al*., 2013; Davoli *et al*., 2019). Excessive or insufficient backfat thickness can adversely affect mating efficiency, reproductive performance, and gilts' longevity (Rozeboom, 2015; Strathe *et al*., 2019). Gilts should be mated when their backfat thickness reaches approximately 18 mm for Yorkshire pigs and between 10.6 and 13 mm for Landrace pigs (HU *et al*., 2016). Different body weights of gilts at mating yielded similar backfat thickness at mating was observed in the present study. Conversely to our findings, several researchers (Lee *et al*., 2019; Carrión-López *et al*., 2022) reported that backfat thickness at mating in gilts of different body weights differs, wherein those in greater weight classes yielding higher backfat thickness compared to the lighter gilts. The same trend was observed till the second parity. The backfat thickness at mating for both the different body weights at mating in the present study (12.63-12.69 mm) was within those recommended by HU *et al*. (2016) for the landrace pigs (10.6-13 mm) and (Bruun, 2019) for the inbred gilts (12 mm). There is no consensus amongst researchers on the ideal backfat thickness of gilts at mating. For example, different ideal backfat thickness was proposed by different researchers, 16 and 20 mm (Flisar *et al*., 2012), 10.6-13 mm (Hu *et al*., (2016), 12 mm (Bruun, 2019), 18.0-23.0 mm (Filha *et al*., 2010; Roongsitthichai and Tummaruk, 2014), these ranges vary and are influenced by the sow genetics at farrowing. Backfat thickness is crucial for piglet quality and survival rates (Thongkhuy *et al*., 2020). Excessive backfat thickness prior to parturition can cause difficulties during birth (Williams *et al*., 2005; Peltoniemi *et al*., 2016). Additionally, sows with more than 15 mm of backfat at farrowing tend to produce the smallest litters (Więcek *et al*., 2023).

The current study observed that body weight at mating determines the gestation gain of gilts during their first parity. Similarly, several authors (Lee *et al*., 2019; Carrión-López *et al*., 2022) reported that the gestation gain differs with the weight class at mating. In the current study, the gestation gain of the heavier gilts at mating was lower than that of lighter and moderate body weight at mating (71.60 vs 86.26, 79.08 kg). A comparable pattern was reported by Carrión-López *et al.* (2022) who reported that the gestation body weight gain of sows with lighter and moderate body weight at mating was higher than that in the heavier gilts at mating (51, 46 vs 37%). On the contrary, (Lee *et al.* 2019) reported that the lighter sows at mating gained less weight compared to the gilts of moderate weight, whilst the heaviest gilts gained similar weight to that of the lighter gilts at mating. In the same study, it was also noted that the gestation gains from the second to the fifth parity were similar across the gilts of different body weights at mating. This may be due to the case that the primiparous sows have higher nutrient requirements to cater for both the growth and development of the litter before and after farrowing compared to the multiparous sows (Calderón Díaz *et al*., 2017; Craig *et al*., 2019). Furthermore, the body weight of sows increases during the gestation period independent of body weight at first mating (Carrión-López *et al*., 2022). The lighter and moderate group gilts did not reach the optimal body weight of 226-249 kg at farrowing as recommended by Kim *et al*. (2016). However, overfeeding sows in late gestation can lead to a spike in stillborn piglets, therefore, reducing the piglets born alive (Gonçalves *et al*., 2016).

Colostrum, like in most mammals, is described as the first milk produced by the mammary gland within the first 24 h after parturition (Hurley, 2015). It provides energy, warmth, nutrients, and immunity to the piglet (Miguel *et al*., 2021). Piglets need to consume colostrum within their first 24 hs of life for various benefits, including supporting health and immunity (Silva *et al*., 2019; Zeng *et al*., 2021), promoting growth (Ferrari *et al*., 2014; Miura *et al*., 2022) and reducing pre-weaning mortality (Ferrari *et al*., 2014). Low levels of blood immunoglobulins, which reflect inadequate colostrum intake on day one, are linked to reduced growth, delayed puberty, fewer piglets born alive, and a lower pre-weaning growth rate (Vallet *et al*., 2016). The immunity is passed from the sow to the piglets in the form of colostrum immunoglobulins (Cabrera *et al*., 2012). The colostrum immunoglobulin G was assessed using the Brix Refractometer in this present study. The IgG estimation using the Brix Refractometer can be categorized as poor (<20 Brix%), borderline (20-24 Brix%), adequate (25-29 Brix%), or very good (≥30 Brix%) (Hasan *et al*., 2016). The body weight and age at puberty and mating do not influence the colostral immunoglobulin G in the present study. At 7 days of age, the production of IgG begins in piglets and the quantity produced is influenced by the amount of IgG absorbed from colostrum (Rooke *et al*., 2003). It is important to note that the concentration of IgG in piglet serum is dependent on the IgG content of the sow's colostrum (Cabrera *et al*., 2012). There isn't much data on the use of a Brix refractometer for analyzing colostrum immunoglobulins in sows of varying weights.

Existing studies primarily focus on the correlation between Brix refractometer readings and results from Radial Immunodiffusion (RID) (Balzani *et al*., 2016) and Enzyme-linked Immunoassay (ELISA) (Hasan *et al*., 2016). A highly significant positive correlation (r = 0.87) was observed between Brix values and IgG concentration as determined by ELISA (Souza *et al*., 2021). Therefore, the digital Refractometer results could be comparable to those attained using the ELISA method.

Conclusion

The body weight at puberty and mating, including the age at mating did not influence the litter traits and colostral immunoglobulin G. The colostral immunoglobulin G tends to be high soon after farrowing and then declines over time. Age at mating is an important factor determining subsequent farrowing weight. In the F1 Large White x Landrace, the litter traits and colostral immunoglobulin G are more hereditary (genotype) than environmentally regulated. Future studies need to explore the effect of gilt development on post-weaning performance lifetime production and health.

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Author's Contributions

Thembela Happines Matukane: Conducted all experiments, collected and analyzed the data, and drafted the manuscript.

Khathutshelo Agree Nephawe, Bohani Mtileni and Takalani Judas Mpofu: Conceptualization of research idea and design, data collection and analysis, interpretation of data review of the manuscript.

Peter Ayodeji Idowu: Interpretation of data, review of the manuscript.

Mamokoma Catherine Modiba, Keabetswe Tebogo Ncube and Jabulani Nkululeko Ngcobo: Review of the manuscript.

Hezekiel Mpedi: Conceptualization of research idea and design, data collection, review of the manuscript.

Ethics

The Animal Research Ethics Committee (AREC202306003) of Tshwane University of Technology and Topigs Norsvin South Africa have authorized experimental techniques and animal handling. The study followed the Animal Research: Reporting of In Vivo Experiments guidelines. The authors declare no conflicts of interest.

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