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Effect of selection for lean growth on gonadal development of commercial pig genotypes in South Africa

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Abstract

A primary objective of commercial pig production is lean meat yield in order to satisfy consumer needs. The majority of the commercial pig breeds in South Africa have been selected for high lean growth potential and reduced backfat thickness. There are indications that selection for high lean meat yield may affect the gonadal development and possibly reproductive potential of commercial pig genotypes, because both testicular and ovarian growth appear to be important indicators of reproductive performance in boars and gilts, respectively. The effects of selection for lean growth on gonadal development were studied in five South African commercial pig genotypes (1, 2, 3, 4 and 5) from 116 to 214 days of age. Gonadal growth and development were measured and compared in 112 gilts and 112 boars. Differences between means were tested using genotype and age as fixed effects, while the relationships between gonadal parameters were evaluated by means of correlation analysis. Gilts from genotype 1 had a significantly shorter ovary length than those from genotypes 2 and 3. Gilts from genotype 3 also had heavier ovaries and larger ovary volumes than gilts from genotype 1. However, genotype did not influence ovary width or height. Correlations between P2 backfat thickness and gonadal development were generally poor in gilts. In boars, genotype 3 had significantly heavier testes than boars from genotype 1. Testes volume of genotype 1 also tended to be smaller compared to genotype 3. Correlations between gonadal measurements and P2 backfat thickness of boars were positive and moderately high ($0.560 \leq r \leq 0.587$). It is concluded from the study that there are differences between commercial pig genotypes in terms of gonadal development. These results suggest that selecting against backfat thickness may delay gonadal development and sexual maturation in boars, while the results are not conclusive in sows.

Keywords: Pig, growth, backfat thickness, gonadal development, reproduction
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Introduction

A primary objective of commercial pig production is lean meat yield in order to satisfy consumer needs. The majority of the commercial breeds in South Africa have been selected for high lean growth potential and reduced backfat thickness. Reproductive efficiency is essential in pig production and this can theoretically be achieved by crossing F_1 crossbred sows with a high reproductive performance with sire lines selected for high lean growth. The most important sire lines currently used in South Africa include the Large White, Landrace, and to a lesser extent the Duroc and Hampshire (Rossouw, 1998). The majority of these improved breeds have been selected for high lean growth potential and reduced backfat thickness. Gonadal growth may be an indicator of reproductive performance in pigs (Schinkel *et al.*, 1983). Growth and development of the ovaries and testes appear to be important indicators of reproductive performance in boars and gilts, respectively. There are indications that selection for high lean meat yield may affect the gonadal development and possibly reproductive potential of commercial pigs. It was suggested that selecting for high lean growth in pigs tends to delay sexual maturity since such pigs reach maturity at a later chronological age (Schinckel *et al.*, 1983; O'Dowd *et al.*, 1997; Whittemore, 1998). The aim of the present study was to assess the effects of selection for lean growth as characterised in five South African commercial pig genotypes of different ages ranging from 116 to 214 days, on gonadal development of gilts and boars.

Materials and Methods

A total of 112 gilts and 112 boars, representative of the five most commonly used commercial pig genotypes in South Africa (Rossouw, 1998) were obtained from the Agricultural Research Council at Irene as part of an on-going growth study (numerically denoted as genotypes 1, 2, 3, 4 and 5). Genotypes 1 and 5 were characteristic of commercial genotypes selected for high lean growth, while genotypes 2, 3 and 4 were characteristic of genotypes selected for moderate lean growth. The pigs entered the trial at an age of 10 weeks (25 to 30 kg live weight) and were housed in commercial type grower houses with temperature controlled (maintained at 20 °C) by self-opening curtains. Eight pigs of the same sex were kept in a pen and each pen was equipped with a self-feeder and an automatic water nipple.

Table 1 Experimental design indicating the number of pigs by genotype and sex

	Group housing (n = 224)	
	Gilts (n = 112)	Boars (n = 112)
Genotype 1	22	23
Genotype 2	22	23
Genotype 3	23	23
Genotype 4	23	21
Genotype 5	22	22

Pigs were fed a commercial type grower diet containing 1.1% lysine until 60 kg live weight, followed by a diet containing 0.9% lysine until slaughter. Diets were formulated in such a manner to conform to the highest specifications as supplied by the breeding companies involved. All pigs were weighed weekly to determine their average daily gains. Backfat thickness of the live pigs was measured weekly by means of a Renco ultrasound P2 backfat probe supplied by Instavet SA. However, for the purpose of this study, only the final P2 backfat thicknesses at slaughter and slaughter weights were used.

The pigs were slaughtered at different slaughter weights, ranging from 65 to 148 kg, at the following estimated ages: 116 days, 130 days, 144 days, 158 days, 172 days, 186, 200 days and 214 days. All pigs were slaughtered at Rietvlei abattoir in Benoni, Gauteng according to prescribed standard procedures and legislation. To remove the testes from boars, a cut was made along the central pelvic line from the penis to the anus, which leaves the testes exposed. The skin was also cut along the inner side of the hind leg until these cuts met the central cut. Testes from each boar were collected in clearly labelled plastic bags. Abdominal organs (stomach, intestines, liver, heart, lungs, uterus and ovaries) were cut free from the cavity walls caudal to the diaphragm. The gonadal organs (uterus and the ovaries) of each sow were separated from the abdominal organs and also collected in a clearly labelled plastic bag. Permanent markers were used to label plastic bags with a pig's identity number and date of slaughter. Estimates of body development that were recorded included warm carcass weight, P2 backfat thickness, carcass length and chest depth. Carcasses were hung overnight in a cold storage room at *ca*. 4 ^{o}C.

Gonadal organs from gilts and boars were collected and transferred to the laboratory at the University of Pretoria to record gonadal measurements of boars and gilts. Parameters measured included testicular measurements (testes weight, testes length, testes width, testes volume), ovary measurements (ovary length, ovary width, ovary height, ovary weight, ovary volume, number of follicles > 3 mm in diameter and size of the largest follicle) as well as slaughter weight, warm carcass weight and P2 backfat thickness by means of ultrasound, as previously described. Testicular measurements used in analyses were averages from left and right testicular measurements (including the caput, corpus and cauda of the epididymis) while ovarian measurements were averages from left and right ovarian measurements

Gonadal measurements of gilts and boars were analyzed separately. Results were analyzed by means of ANOVA procedures with SAS (SAS® 2001, Version 8.2). Differences between genotypes and ages were assessed by means of the PDIFF procedure (pair-wise comparisons of least square means (LSmeans) values) in the General Linear Model (GLM) model. Correlations between gonadal measurements, slaughter weights, carcass weights and backfat thicknesses were performed for both gilts and boars. Results were significantly different when $P \leq 0.05$, while a tendency to significance was when $0.05 < P \leq 0.10$.

Results and Discussions

Age influenced ($P < 0.01$) the gonadal development of boars and sows. In both sexes, all gonadal measurements typically increased from 144 days of age and older. Results of the influence of genotype on gonadal measurements of gilts are presented in Table 2. Gilts from genotype 5 recorded ($P < 0.05$) shorter ovary lengths compared to gilts from both genotypes 2 ($P < 0.01$) and 4 ($P < 0.05$), but did not differ from gilts of genotypes 1 and 3. Gilts from genotype 5 tended to have lower ovary widths than gilts from genotype 2 ($P = 0.06$). With regard to ovary weight and ovary volume, genotype 2 gilts recorded heavier ovary weights ($P < 0.05$) and larger ovary volumes ($P < 0.05$) than gilts from genotype 5. Gilts from genotype 2 recorded the highest values for ovary weight and ovary volume, followed by gilts from genotypes 4 and 1, while those from genotype 5 recorded the lowest ovary weights and volumes. The greater ovarian size in gilts from genotype 2 compared to those from genotype 5 suggests an earlier age at puberty and gonadal development in genotype 2. Gilts from genotype 3 recorded significantly bigger follicle sizes than gilts from genotypes 2, 4 and 5, but it was similar compared to those of genotype 1.

Table 2 Gonadal measurements (LSmeans and s.e. in brackets) of gilts from five different genotypes commonly used in SA for pork production with slaughter age as covariate

Genotype (n = 62)	Ovary length (cm)	Ovary width (cm)	Ovary hight^{+} (cm)	Ovary weight (g)	Ovary volume (cm^3)	Number of follicles^{+}	Largest follicle size (cm)
Genotype 1	2.60^{ab}	1.79	1.01	4.16^{ab}	4.07^{ab}	13.80	0.59^{ab}
	(0.07)	(0.06)	(0.05)	(0.33)	(0.31)	(2.94)	(0.04)
Genotype 2	2.74^{b}	1.94	0.98	4.48^{b}	4.50^{b}	16.75	0.55^{a}
	(0.08)	(0.07)	(0.06)	(0.37)	(0.35)	(3.14)	(0.04)
Genotype 3	2.56^{ab}	1.84	0.98	4.02^{ab}	3.98^{ab}	11.71	0.67^{b}
	(0.07)	(0.06)	(0.05)	(0.31)	(0.29)	(2.77)	(0.03)
Genotype 4	2.72^{b}	1.84	1.03	4.37^{ab}	4.18^{ab}	17.43	0.52^{a}
	(0.08)	(0.07)	(0.06)	(0.35)	(0.34)	(3.21)	(0.04)
Genotype 5	2.41^{a}	1.74	0.95	3.45^{a}	3.31^{a}	15.43	0.54^{a}
	(0.07)	(0.06)	(0.05)	(0.33)	(0.32)	(2.80)	(0.03)

a - b: LSmeans in the same column with different superscript differ at $P \leq 0.05$; s.e. - standard error
+: GLM model not significant (i.e. $P > 0.05$)

Table 3 provides a summary of the influence of genotype on the gonadal measurements of boars. Boars from genotype 2 had significantly heavier testes ($P < 0.05$) compared to those from genotype 5. There was also a tendency for differences ($P = 0.0899$) between genotype 1 boars and genotype 2 boars in terms of testes weights, with genotype 2 recording heavier testes than genotype 1. Boars from genotype 2 also tended ($P = 0.0549$) to have larger testes volumes compared to boars from genotype 5. Gonadal measurements of boars suggest that genotype 2 outperformed genotype 5 in terms of testis weight and testis volume. Research has shown that testicular growth may be an indicator of the reproductive performance and that boars with larger testes at a constant age generally have greater sperm numbers and superior mating efficiency (Schinkel *et al*., 1983). Therefore, this suggests that boars from genotype 2 with heavier and larger testes volume can be assumed to have a greater sperm production potential and higher mating efficiency compared to boars from genotype 5.

A significant negative correlation ($r = -0.305$; $P < 0.05$) was observed between dressing percentages and the size of the largest follicle in gilts. Similarly a negative correlation was observed between follicle number and P2 fat thickness ($r = -0.121$; $P < 0.05$). Dressing percentage correlated significantly with the size of the largest follicle ($r = -0.305$; $P < 0.05$), while the size of the largest follicle also correlated with ovary volume ($r = 0.211$; $P < 0.05$).

Slaughter weight correlated with gonadal measurements of boars ($r = 0.841$ to $r = 0.871$; $P < 0.0001$), while moderately positive correlations were found between P2 backfat thickness and gonadal measurements ($0.560 \geq r \leq 0.587$; $P < 0.05$). These results agree with that of Schinkel *et al.* (1983). In addition, heritability of testes length has been estimated at $h^2 = 0.33$ ($0.30 < h^2 < 0.39$), while the heritability of testes weight was estimated at $h^2 = 0.44$ ($0.24 < h^2 < 0.73$) (Moeller, 2002). The correlation between testes weight and sperm production is also positive. Therefore, selection for testes weight can result in a lower age at puberty, increased daily sperm production and increased sperm concentration (Moeller, 2002).

Table 3 Gonadal measurements (LSmeans and s.e. in brackets) of boars from five different genotypes commonly used in SA for pork production with slaughter age as covariate

Genotype (n = 54)	Testis length (cm)	Testis width (cm)	Testis weight (g)	Testis volume (cm^3)
Genotype 1	9.57	6.11	208.58 [ab]	200.35
	(0.39)	(0.27)	(17.77)	(16.91)
Genotype 2	10.35	6.65	256.55 [b]	243.45
	(0.45)	(0.32)	(20.77)	(19.77)
Genotype 3	9.82	6.43	222.92 [ab]	213.31
	(0.39)	(0.27)	(18.09)	(17.22)
Genotype 4	10.14	6.55	241.20 [ab]	229.75
	(0.42)	(0.29)	(19.19)	(18.26)
Genotype 5	9.48	6.14	198.20 [a]	189.60
	(0.42)	(0.29)	(19.19)	(18.26)

a - b: LSmeans in the same column with different superscript differ ($P \leq 0.05$); s.e. - standard error

Conclusions

It is acknowledged that the production of lean pig carcasses is beneficial to pig producers and consumers because lean meat yield is increased and carcass classification is generally more favourable. These results, however, suggest that the excessive emphasis on the selection for lean carcasses in commercial pig production systems may adversely affect the gonadal development of pigs. Gonadal measurements increased with age in both sexes as expected. The results of this study suggest that selecting against high backfat may delay sexual maturation, but the effects appear to be more pronounced in boars than in gilts. More research is required to make recommendations regarding appropriate selection programmes for South African pig genotypes that will ensure acceptable carcass quality without adverse effects on gonadal development and reproductive potential.

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