Non-genetic factors affecting growth performance and carcass characteristics of two South African pig breeds

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Abstract

A study was conducted to establish non-genetic factors affecting growth and carcass traits in Large White and Landrace pigs. This study was based on 20 079 and 12 169 growth and 5 406 and 2 533 carcass data collected on performance tested pigs between 1990 and 2008 from Large White and Landrace breeds respectively. The traits analyzed were backfat thickness (BFAT), test period gain (TPG), lifetime gain (LTG), feed conversion ratio (FCR), age at slaughter (AGES), lean percentage (LEAN), drip-free lean percentage (DLEAN), drip loss (DRIP), dressing percentage (DRESS), carcass length (CRLTH) and eye muscle area (AREA). Significant effects were determined using PROC GLM of SAS. Herd of origin, year of testing and their interaction significantly affected all traits. Most traits were not affected by season of testing in both breeds, while all traits in both breeds were significantly affected by sex. Testing environment (station, farm) affected all growth traits except for LTG. Backfat thickness and AGES increased with increasing total feed intake, while other traits decreased as total feed intake increased. Improved test centre management did not compensate for pre-test underperformance. Castrates produced higher carcass yields of lower quality than females, while performance testing showed the best results when done at testing centres. This study showed the importance of adjusting for fixed effects when performing genetic evaluations in the two pig populations.

Keywords: Carcass traits, growth traits, environmental effects, Large White, Landrace, swine
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Introduction

The value of a meat animal is realized when its product is marketed and expressed relative to the input costs incurred. Growth and its associated traits in pigs reflect to a certain degree the value of the animal; hence live measurements can be used to evaluate an animal. Valuable pigs are the ones which, for each unit of food energy, waste least in such processes as digestion and physical activity, and retain most by favouring conversion of metabolizable energy to lean than conversion to fat tissue (Webster, 1977). This has desirable implications on enterprise profit, as feed constitutes a large portion (60 – 70%) of pig enterprise costs (Hoque *et al*., 2007). Thus, pig characteristics that are positive for profitability, are high growth rate, food conversion ratio and low carcass fatness (McPhee & MacBeth, 2000). Improvement has been achieved in some breeding programmes through selection for lean growth rate (McPhee *et al*., 1991; Cameron, 1994).

Success of these breeding programmes is facilitated by the variation that exits in growth and carcass traits in pigs. This variation can be partitioned into genetic and environmental components. Environmental variance, albeit not transferable from parent to offspring, plays an important part in the performance of livestock and their products. Knowledge of non-genetic factors helps in standardizing management of the

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breeding animals. Some non-genetic effects, such as farm, sex and age on growth and carcass traits have been reported in the literature for sheep (Cassady *et al*., 2004), pigs (Mungate *et al*., 1999; Serrano *et al*., 2008), goats (Maghoub *et al*., 2004) and cattle (Nephawe *et al*., 2006). It is therefore imperative that non-genetic factors be considered in livestock improvement programmes to accurately estimate breeding values.

Therefore, proper identification and estimation of non-genetic effects on growth and carcass traits being evaluated, is a necessity in pig improvement schemes. There is a paucity of information on non-genetic factors affecting carcass characteristics of centrally tested pigs in South Africa. The purpose of this study was to evaluate non-genetic effects on growth and carcass traits within the two major South African commercial pig breeds.

Materials and Methods

The South African Pig Performance Testing Scheme is conducted to extend and improve the National Pig Herd by means of scientifically founded and proven methods and practices. Performance testing occurred throughout the year on castrates and females, such that at any point in the year there were animals being tested. The animals were tested and slaughtered at three testing centres, namely Irene, Elsenburg and Cedara. Records available from performance testing are for Phases B and D of the Scheme. Phase B testing is the central boar and gilt performance and carcass quality test phase conducted at the testing centres named above. On the other hand, Phase D is the on-farm testing of pigs. Under the Phase B, each member submitted 44 pigs (22 boars and 22 gilts) for testing every year. These 44 pigs were to represent a minimum of five herd sires per breed or line, or 50% of the herd sires per breed or line. On arrival, pigs were treated for internal and external parasites and quarantined under the supervision of the responsible State veterinarian. All pigs were randomly selected at the test station for performance testing between 18 and 24 kg without considering representation of herds, sires or lines. The animals were individually penned and fed until they commenced testing at mean weights of 29.7 and 29.5 kg for the Large White and Landrace breeds respectively. Animals were kept on solid concrete floors. When testing commenced, the pigs were individually fed *ad libitum* using self feeders and water was also available *ad libitum* during the test period. Total feed intake from the beginning of the test to 86 kg body weight was calculated at the end of the test period. Parameters of growth rate, feed consumption and age at slaughter (86 kg) were measured on these animals. Backfat measurements were taken using a Backfat Scanner A100 probe at 77 kg and at slaughter (86 kg) at the T23 position, which was 6.5 cm from the midline between the second and third last rib. Weighing was done weekly during the test period, without any change in the feeding routine and performance testing was completed at a live weight of 86 kg. The Phase D scheme involves on-farm performance testing of boars and gilts, measuring growth rate, ultrasonic backfat measurements and, where possible, feed intake and feed conversion ratio.

Animals from the performance testing scheme (Phase B) were randomly selected for carcass evaluation. The animals were electrically stunned with 250 V for 7 – 10 sec. Animal ethics approval was obtained from the Agricultural Research Council Animal Ethics Committee. This was followed by the scraping and removal of the entrails. A State veterinarian or meat inspector performed the necessary inspection of the carcass after slaughtering. The carcasses were then hung for 24 h in a cold storage room for chilling. The carcases were then split vertically along the midline. A loin sample, approximately 2 cm thick and 15 cm long, was dissected at the T23 position. The average mass of the loin samples was recorded in grams. Each loin sample was placed in a nelton bag and tied accordingly to prevent the loin sample touching the bottom of the barrier bag or air coming into the barrier bag. The mass of each new empty and clean barrier bag was obtained in grams before placing in the loin sample. This parcel was stored in a refrigerator between 0 and 5 °C for 48 h, after which the loin sample in the nelton bag was removed from the barrier bag. The mass of the barrier bag, which included exudates collected as drip, was recorded in grams. Measurements for the T23 fat and muscle were taken using an ultrasonic probe at the T23 position.

The data incorporated 20 079 and 12 169 growth performance records and 5 406 and 2 533 carcass records for Large White and Landrace pig breeds, respectively. The growth performance data for Large White and Landrace were from 29 and 21 herds, respectively, while the carcass data were from 20 and 13 herds. These data were obtained from the Integrated Recording and Genetic Information Systems (INTERGIS) database. These animals were tested between 1990 and 2008 and carcass evaluated between 1993 and 2007. Carcass length and eye muscle area were evaluated between 1998 and 2007, hence they had 2 267 and 1 011 records, respectively, for Large White and Landrace pigs.

Table 1 Summary statistics of growth and carcass traits and covariates for Large White (above) and Landrace (below) pigs

	N	Mean	Min	Max	SD
BFAT (mm)	20079	12.3	7.0	24.0	2.9
	12169	15.6	6.0	27.0	2.9
TPG (g/day)	20079	1019.0	690.5	1327.0	107.3
	12169	941.4	654.8	1265.0	105.2
LTG (g/day)	20079	676.6	524.4	814.2	50.3
	12169	644.3	508.8	804.4	49.8
FCR	20079	2.08	1.41	3.12	0.31
	12169	2.32	1.63	3.04	0.19
AGES (days)	20079	127.7	106.0	164.0	10.2
	12169	107.0	134.3	169.0	10.2
LEAN (%)	5406	69.2	65.0	72.0	1.4
	2533	68.4	63.0	73.0	1.5
DLEAN (%)	5406	56.8	52.0	61.0	2.0
	2533	55.6	48.0	63.0	2.0
DRIP (%)	5406	3.08	0.29	5.46	2.03
	2533	3.96	1.00	6.30	1.97
DRESS (%)	5406	77.6	69.0	85.0	3.0
	2533	76.4	69.0	84.0	3.2
CRLTH (cm)	2267	77.2	65.0	85.0	2.1
	1011	78.2	70.0	85.0	2.2
AREA (cm^2)	2267	40.0	19.3	64.4	5.8
	1011	43.2	24.0	61.7	6.1
FEED (kg)	20079	140.1	95.5	185.5	15.0
	12169	144.1	99.5	198.5	17.3
AGEB (days)	20079	70.7	51.0	92.0	6.2
	12169	68.8	51.0	88.0	5.9
STWT (kg)	20079	29.7	25.0	32.0	1.8
	12169	29.5	27.0	32.0	1.7

N – number of records; SD – standard deviation; BFAT – backfat thickness; TPG – test period weight gain; LTG – weight gain from birth to slaughter; FCR – feed conversion ratio during test; AGES – age at slaughter; LEAN – lean percentage; DLEAN – drip-free lean; DRIP – drip loss; CRLTH – carcass length; DRESS – dressing percentage; AREA – eye muscle area; FEED – total test period feed intake; AGEB – age at the beginning of test period; STWT – weight at the start of the test period.

The growth traits analyzed were ultrasonic backfat thickness (BFAT), test period weight gain (TPG), lifetime weight gain (LTG), test period feed conversion ratio (FCR), which was computed as the amount of feed consumed to gain one kg body mass, and age at slaughter (AGES). Analysis of carcass traits were done on lean percentage (LEAN), drip-free lean percentage (DLEAN), drip loss (DRIP), dressing percentage (DRESS), carcass length (CRLTH) and eye muscle area (AREA). DRESS was calculated by expressing cold carcass weight (carcass weight after chilling) as a percentage of weight at slaughter. CRLTH was measured from the anterior edge of the first rib to the pubic bone using a measuring tape. AREA was determined using a square grid. The summary statistics for the traits analyzed are shown in Table 1. LEAN, DLEAN and DRIP were calculated using the following formulae (Equations 1 to 3), respectively (Bruwer, 1992).

$$\text{LEAN}\,(\%) = 72.5114 - (0.4618 \times \text{T23fat}) + (0.0547 \times \text{T23muscle}) \qquad [1]$$

$$\text{DLEAN}\,(\%) = 29.37 + (0.56 \times \text{LEAN}\,\%) - 3.1\sqrt{(\text{T23fat})} \qquad [2]$$

$$\text{DRP}\,(\%) = \left(\frac{(\text{combined drip (g)} + \text{bag weight (g)}) - \text{bag weight (g)}}{\text{weight of chop sample (g)}}\right) \times 100 \qquad [3]$$

where T23 fat and T23 muscle are fat and muscle thicknesses at the T23 position, respectively.

The original growth data contained 81 411 and 22 118 animal records for Large White and Landrace, respectively. Animals with missing feed intake and feed conversion records were removed, which amounted to 59 089 and 11 596 in Large White and Landrace, respectively. Original carcass data comprised of 5 492 and 2 585 records, respectively for Large White and Landrace pigs. These data were then edited to remove values that were greater or less than three standard deviations from the mean. The final data analyzed are shown in Table 1. Animals with missing birth and testing dates were also removed. The data were checked for normality. Seasons of testing were defined as season 1 (October – March) and season 2 (April – September). The significant effects of covariates on each trait were determined using PROC REG of SAS (SAS, 2003) by checking for independency and multicolinearity among covariates. Then the covariates which had significant effects on the response variable were taken to the GLM Procedures of SAS (SAS, 2003), where they were combined with class variables to get the final model for each trait. Effects of interactions between independent variables were also determined. Preliminary analyses showed no differences between growth or carcass traits due to test centre, suggesting uniformity in testing standards of the three testing stations. The following model equation (Equation 4) was used in the development of the models for all the traits:

$$y_{ijklm} = \mu + H_i + Y_j + S_k + SEX_l + \beta_0(TFI)_{ijklm} + \beta_1(AGEB)_{ijklm} + C_xC_y + e_{ijklm} \qquad [4]$$

where, y_{ijklm} is the observed trait, H_i is the effect of the i^{th} herd of origin, Y_j is the effect of the j^{th} year of testing, S_k is the effect of the k^{th} season of testing, SEX_l is the effect of the l^{th} sex of the animal, β_0 and β_1 are the regression coefficients of the observed trait on the respective covariate; $(TFI)_{ijklm}$ is the test period total feed intake, $(AGEB)_{ijklm}$ is the age at the beginning of the test period, C_xC_y is the interaction effects between each pair of effects and e_{ijklm} is the random error term.

Results and Discussion

Herd of origin affected (*P* <0.001) all growth and carcass traits in Large White and Landrace pigs. Table 2 shows the summary statistics of the Least Squares means for the growth and carcass traits in the two breeds. Differences in growth performance and carcass characteristics in pigs were attributable to the birth and rearing environment (Gentry *et al*., 2004). Herd performance differences may suggest carry-over effects from pre-test performance differences, which are a result of different environmental conditions. Growth performance is determined by muscle fibre characteristics (Larzul *et al*., 1997), which are programmed during the prenatal period (Foxcroft *et al*., 2006). Furthermore, muscle fibre type percentages are influenced by environmental factors (Gentry *et al*., 2004; Petersen *et al*., 1997). Bee (2004) observed the effect of gestation feeding on carcass quality of progeny. Thus, pre-test environment has an effect on growth and carcass attributes (Beattie *et al*., 2000; Gentry *et al*., 2002; 2004; Hansen *et al*., 2006). These results suggest that differences in growth performance may be due to differences in management practices applied on different farms. Management at different farms should be optimised to produce pigs that perform well during the growth period and produce desirable carcasses.

All growth and carcass traits in the two breeds were affected (*P* <0.001) by year of testing. The Least Square means for the effect of year of testing on growth and carcass traits for the two breeds are shown in

Table 2 Summary statistics of herd least squares means for growth and carcass traits for Large White (above) and Landrace (below) pigs

Traits	No Herds	N	Overall Mean (± SE)	n	Min Mean(± SE)	n	Max Mean (± SE)
BFAT (mm)	29	20079	12.3 ± 0.01	100	10.3 ± 0.21	521	15.4 ± 0.09
	21	12169	12.5 ± 0.02	154	11.7 ± 0.18	221	14.4[c] ± 0.15
TPG (g/day)	29	20079	1010.4 ± 0.58	757	893.1 ± 3.60	5133	1059.1 ± 1.78
	21	12169	987.4 ± 0.69	225	918.9 ± 5.72	154	1013.2 ± 7.28
LTG (g/day)	29	20079	661.7 ± 0.21	757	569.8 ± 1.58	5133	704.7 ± 0.78
	21	12169	664.4 ± 0.25	225	606.4 ± 2.58	154	697.7 ± 3.28
FCR	29	20079	2.19 ± 0.001	100	2.13 ± 0.02	854	2.43 ± 0.01
	21	12169	2.13 ± 0.001	132	2.04 ± 0.02	393	2.34 ± 0.01
AGES (days)	29	20079	131.2 ± 0.06	5133	122.3 ± 0.16	757	150.7 ± 0.32
	21	12169	130.2 ± 0.05	154	124.1 ± 0.66	255	143.6 ± 0.52
LEAN (%)	20	5406	68.6 ± 0.02	220	67.4 ± 0.11	345	69.5 ± 0.09
	13	2533	68.4 ± 0.03	22	67.3 ± 0.36	98	69.7 ± 0.19
DLEAN (%)	20	5406	56.0 ± 0.03	220	54.3 ± 0.15	345	57.3 ± 0.12
	13	2533	55.5 ± 0.04	22	54.0 ± 0.50	98	57.7 ± 0.25
DRIP (%)	20	5406	3.59 ± 0.02	8	2.19 ± 0.66	106	4.81 ± 0.19
	13	2533	4.04 ± 0.05	13	2.48 ± 0.66	98	6.94 ± 0.27
DRESS (%)	20	5406	77.0 ± 0.03	355	75.5 ± 0.15	260	79.3 ± 0.18
	13	2533	76.5 ± 0.05	70	75.6 ± 0.34	70	77.7 ± 0.24
CRLTH (cm)	7	2267	77.3 ± 0.04	220	75.9 ± 0.45	8	78.7 ± 0.79
	4	1011	78.3 ± 0.08	231	77.0 ± 0.16	98	79.9 ± 0.32
AREA (cm^2)	7	2267	40.4 ± 0.11	8	35.4 ± 1.87	345	43.7 ± 0.48
	4	1011	43.3 ± 0.16	157	36.3 ± 0.51	307	48.5 ± 0.59

SE – standard error; BFAT – backfat thickness; TPG – test period weight gain; LTG – weight gain from birth to slaughter; FCR – feed conversion ratio during test; AGES – age at slaughter; LEAN – lean percentage; DLEAN – drip-free lean; DRIP – drip loss; CRLTH – carcass length; DRESS – dressing percentage; AREA – eye muscle area.

Figures 1a to 1e and 2a to 2f. Generally, growth traits in the two breeds followed similar trends. The reduction in backfat thickness from 1990 to 2008 is desirable for consumers who prefer lean meat (Webb *et al*., 2006). There were decreasing trends for age at slaughter that favours farmers as fewer days to slaughter translate to less feed consumed. Feed cost constitutes about 60 – 70% of pig enterprise costs (Hoque *et al*., 2006). There were increases in both test period and lifetime weight gains from 1990 to 2000 as well as general increases in lean and drip-free lean from 1993 to 2007. Drip loss decreased in both breeds from 1993 to 1998, after which there was no discernible trend. A general decline in carcass yield was observed, depicted by a decreased carcass length in the Landrace breed and a reduced eye muscle area in the Large White breed. The jumps observed in drip loss and dressing percentages may be attributed to the amount of data collected that were not consistent (not presented) over the years. Since drip loss can only be determined in laboratories, there may have been inconsistent calculation of drip loss in some or all the testing centres. This may also be due to correlated responses to selection on different traits during different periods, when emphasis on traits might have varied. Although these animals were in total confinement, carry-over effects from their respective herds of origin may explain the observed differences during the years, as shown by the significant herd effect and its interaction with year of testing on growth and carcass traits (Cassady *et al*., 2004). These trends may also suggest changes due to selection and/or management practices. Growth traits have been reported to be heritable (Johnson *et al*., 1999; Nguyen & McPhee, 2005; Oh *et al*., 2005; Chimonyo & Dzama, 2007). Prenatal environmental influences may be exerted on growth and carcass characteristics (Foxcroft *et al*., 2006). Nilzen *et al*. (2001) and Gentry *et al*. (2002; 2004) observed the effect of birth and rearing environment on growth and carcass characteristics. These trends may also suggest response to selection on these or other correlated traits; hence improvement may be expected if the appropriate treatments are applied on them.

The effects of season of testing on growth and carcass traits for the two breeds are depicted in Table 3. Differences were observed in feed conversion ratio, with summer-tested pigs being more (P <0.001) efficient than winter-tested pigs in both breeds, which is consistent with the findings of LeDividich *et al*. (1987). They attributed this to the fact that pigs eat more feed in cold weather to compensate for the greater metabolic demand for heat production. No significant effect (P >0.05) of season of testing on backfat thickness, age at slaughter and weight gains in both breeds was observed. However, Chikwanha *et al*. (2007) reported an increase and decrease in body condition score in mature boars and lactating sows, respectively, due to season. Environmental temperature is known to affect the performance, voluntary energy intake and heat production of growing pigs (Close, 1987; Le Dividich *et al*., 1987; Bee, 2004). Landrace pigs tested in winter were leaner (P <0.001) than their summer-tested counterparts. Trezona *et al*. (2004) observed that

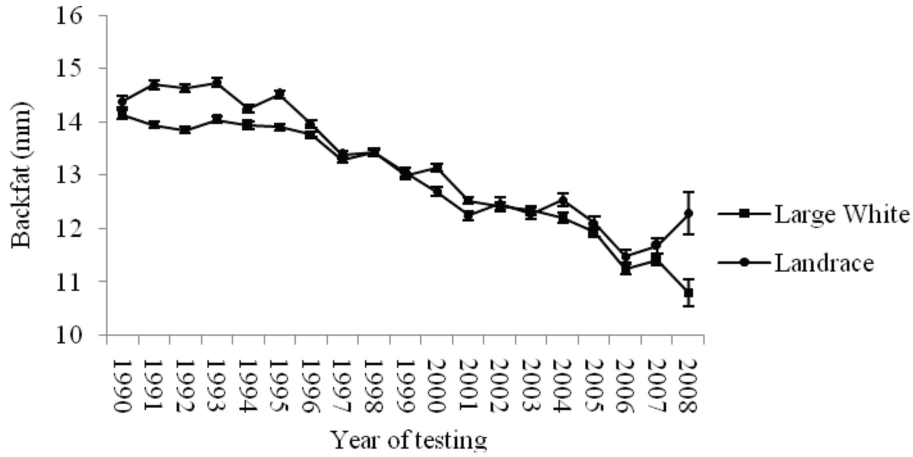

Figure 1a Phenotypic trend of backfat thickness in Large White and Landrace pigs.

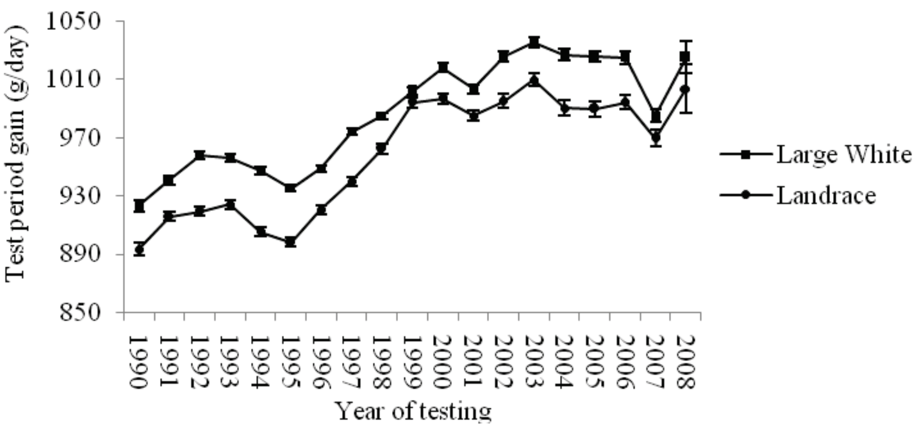

Figure 1b Phenotypic trend of test period weight gain in Large White and Landrace pigs.

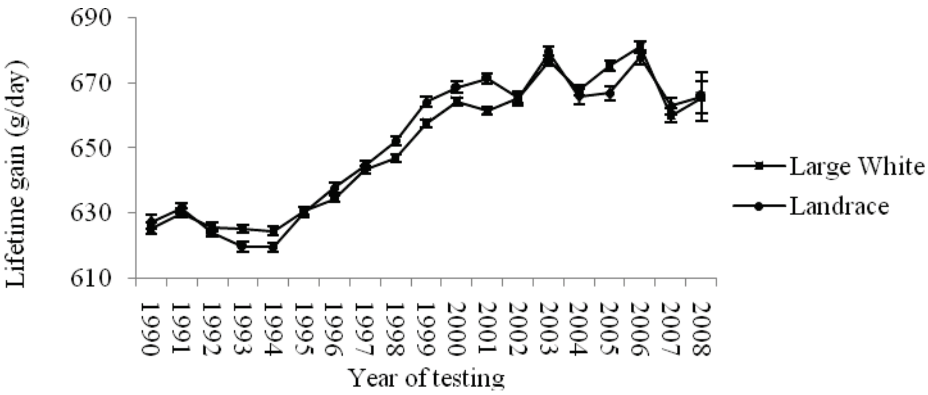

Figure 1c Phenotypic trend of lifetime weight gain in Large White and Landrace pigs.

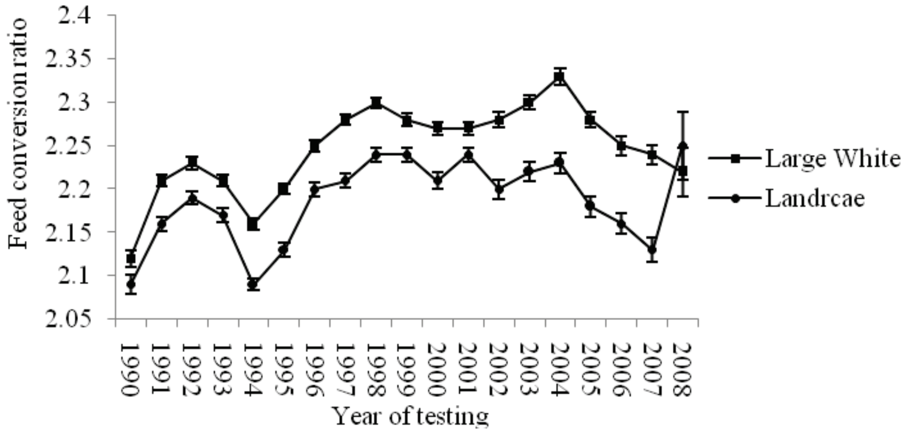

Figure 1d Phenotypic trend of feed conversion ratio in Large White and Landrace pigs.

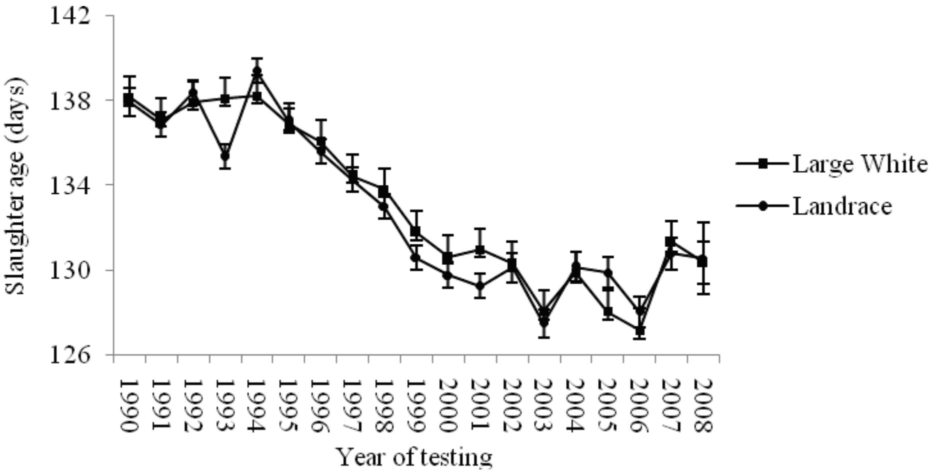

Figure 1e Phenotypic trend of age at slaughter in Large White and Landrace pigs.

pigs were fattest and leanest during spring and autumn, respectively. Winter-tested Large White pigs produced 0.28 cm shorter (P <0.001) carcasses than summer-tested pigs. Longer (P <0.01) Landrace carcasses were produced by pigs tested in summer compared to winter-tested pigs. The animals were brought to the testing station after weaning; hence the pre-test growth period for pigs tested in summer was in winter. During this season they consumed more feed to keep warm and had heavier weights (Rinaldo *et al*., 2000). Since these pigs were tested under similar conditions, the differences may be attributed to the carry-over effects of the pre-test rearing seasons. Such effects have been confirmed by Nilzen *et al*. (2001) and Gentry *et al*. (2002; 2004), who reported the effects of birth and rearing environment on carcass traits. The results from this study suggest that performance testing yielded best results when done in winter.

Table 4 shows the effects of sex on growth and carcass traits in the two breeds. Castrates had thicker (P <0.001) backfat than females. This may be attributed to the larger (P <0.001) quantities of feed consumed during the test period. Weight gains for castrates were less (P <0.001) compared to those of females in both breeds. These results are consistent with those in literature (Weatherup *et al*., 1998; Latorre *et al*., 2003).

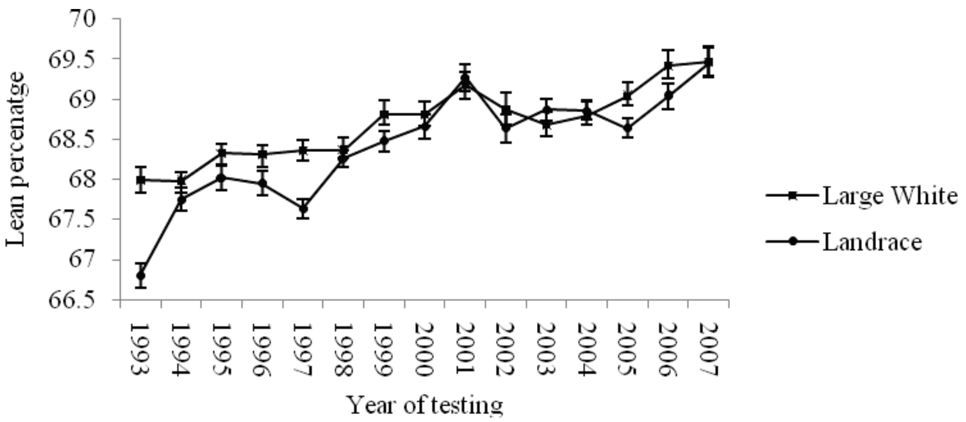

Figure 2a Phenotypic trend of lean percentage in Large White and Landrace pigs.

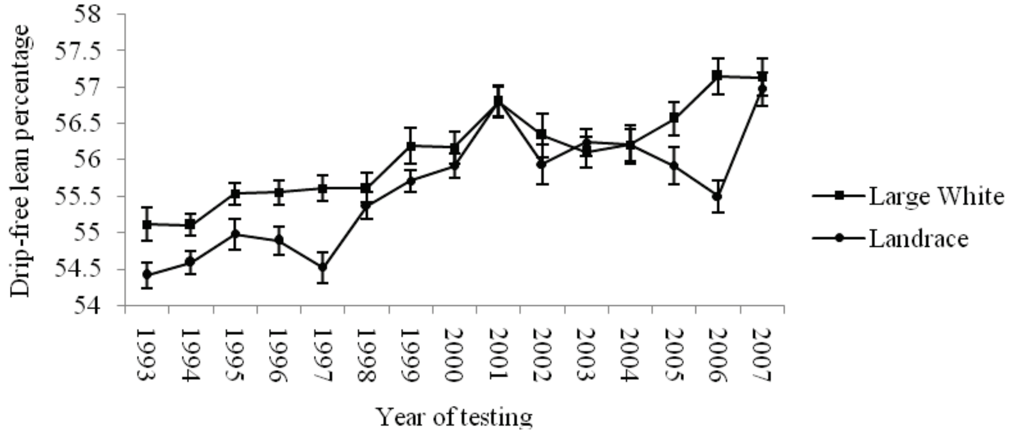

Figure 2b Phenotypic trend ofdrip-free lean percentage in Large White and Landrace pigs.

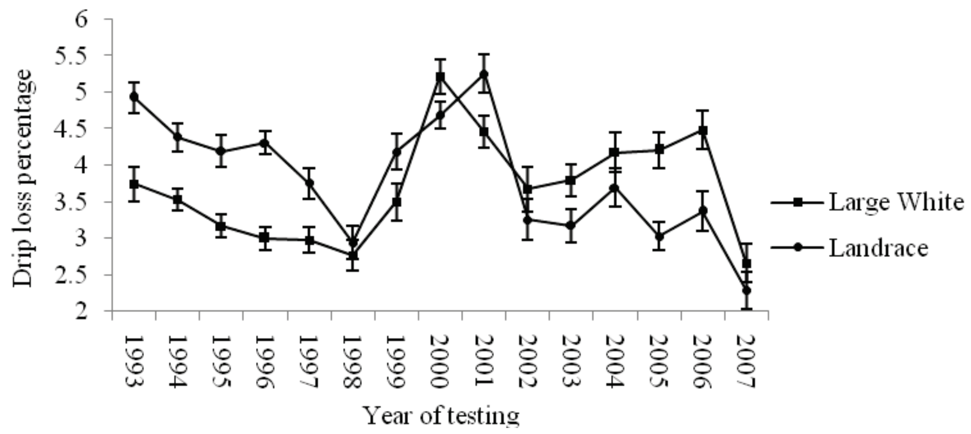

Figure 2c Phenotypic trend of drip loss percentage in Large White and Landrace pigs.

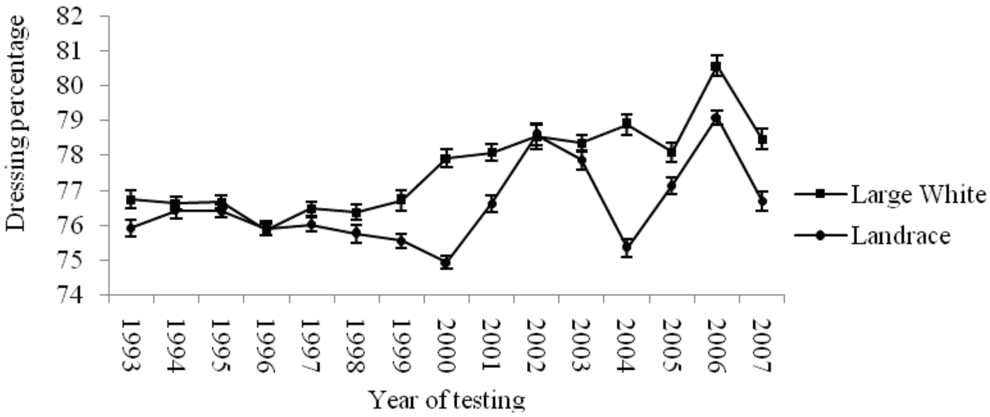

Figure 2d Phenotypic trend of dressing percentage in Large White and Landrace pigs.

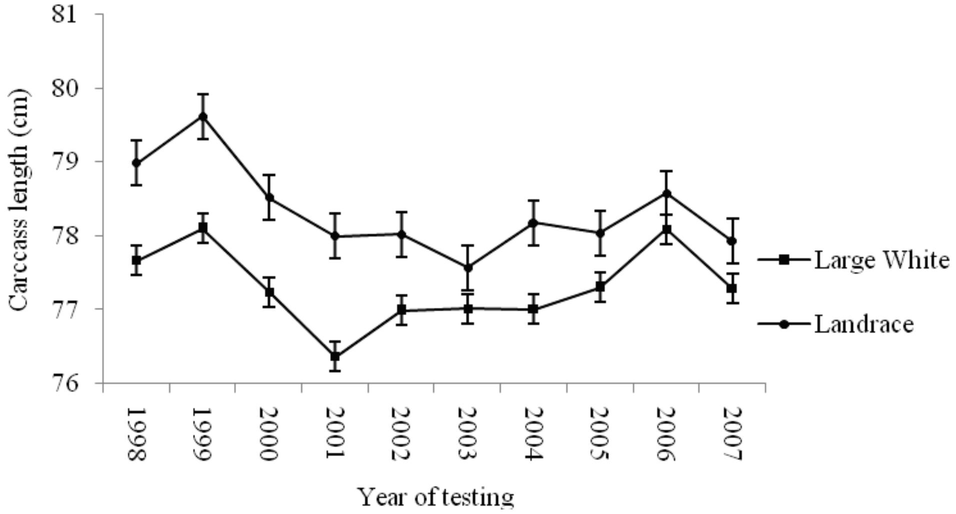

Figure 2e Phenotypic trend of carcass length in Large White and Landrace pigs.

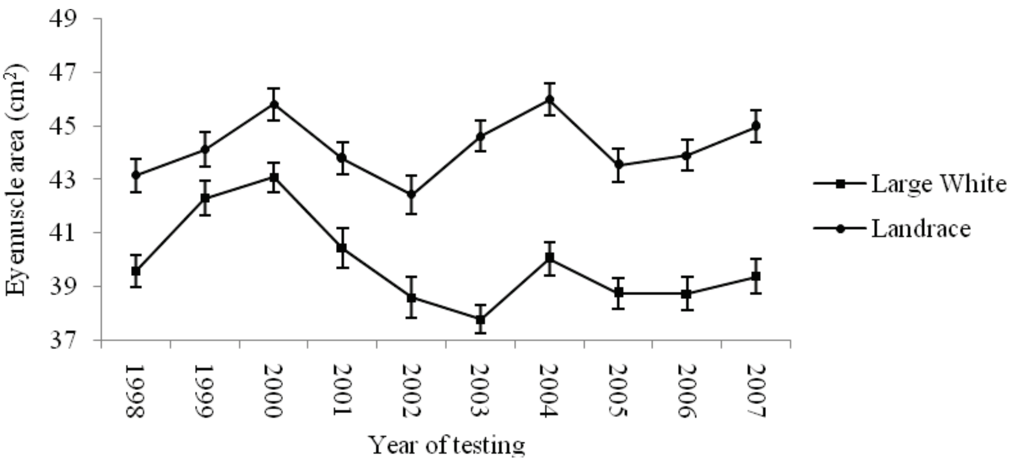

Figure 2f Phenotypic trend of eye muscle area in Large White and Landrace pigs.

Table 3 Least squares means (± SE) for the effect of season of testing on growth and carcass traits in Large White and Landrace pigs

	Large White				Landrace			
	N	Summer	N	Winter	N	Summer	N	Winter
BFAT (mm)	9195	$12.9^{a} \pm 0.03$	10884	$12.9^{a} \pm 0.03$	5538	$13.2^{a} \pm 0.05$	6631	$13.2^{a} \pm 0.05$
TPG (g/day)	9195	$989.1^{a} \pm 1.52$	10884	$983.9^{a} \pm 1.16$	5538	$958.9^{a} \pm 1.98$	6631	$957.6^{a} \pm 1.91$
LTG (g/day)	9195	$652.2^{a} \pm 0.67$	10884	$649.2^{a} \pm 0.64$	5538	$652.3^{a} \pm 0.89$	6631	$650.5^{a} \pm 0.86$
FCR	9195	$2.22^{a} \pm 0.01$	10884	$2.31^{b} \pm 0.01$	5538	$2.16^{a} \pm 0.01$	6631	$2.20^{b} \pm 0.01$
AGES (days)	9195	$132.8^{a} \pm 0.14$	10884	$133.4^{a} \pm 0.13$	5538	$132.9^{a} \pm 0.18$	6631	$133.3^{a} \pm 0.17$
LEAN (%)	1926	$68.7^{a} \pm 0.06$	3480	$68.7^{a} \pm 0.05$	852	$68.4^{a} \pm 0.09$	1681	$68.5^{b} \pm 0.08$
DLEAN (%)	1926	$56.1^{a} \pm 0.08$	3480	$56.1^{a} \pm 0.08$	852	$55.5^{a} \pm 0.12$	1681	$55.7^{a} \pm 0.11$
DRIP (%)	1926	$3.74^{a} \pm 0.07$	3480	$3.65^{a} \pm 0.06$	852	$3.88^{a} \pm 0.12$	1681	$3.78^{a} \pm 0.11$
DRESS (%)	1926	$77.7^{a} \pm 0.09$	3480	$77.5^{a} \pm 0.09$	852	$76.8^{a} \pm 0.13$	1681	$76.7^{a} \pm 0.12$
CRLTH (cm)	694	$77.5^{a} \pm 0.13$	1573	$77.2^{b} \pm 0.11$	342	$78.6^{a} \pm 0.19$	669	$78.1^{b} \pm 0.15$
AREA (cm^2)	694	$40.5^{a} \pm 0.30$	1573	$40.0^{a} \pm 0.27$	342	$44.2^{a} \pm 0.38$	669	$43.3^{b} \pm 0.31$

N – number of records; BFAT – backfat thickness; TPG – test period weight gain; LTG – weight gain from birth to slaughter; FCR – feed conversion ratio during test; AGES – age at slaughter; LEAN – lean percentage; DLEAN – drip-free lean; DRIP – drip loss; CRLTH – carcass length; DRESS – dressing percentage; AREA – eye muscle area.

Values with the same superscript within for breed and season are not significantly different.

Table 4 Least squares means (± SE) for the effect of sex on growth and carcass traits in Large White and Landrace pigs

	Large White				Landrace			
	N	Castrates	N	Females	N	Castrates	N	Females
BFAT (mm)	5417	13.3^{a} ± 0.04	14662	12.6^{b} ± 0.03	3404	13.5^{a} ± 0.05	8765	12.9^{b} ± 0.04
TPG (g/day)	5417	948.6^{a} ± 1.75	14662	1024.4^{b} ± 1.37	3404	922.7^{a} ± 2.24	8765	993.8^{b} ± 1.80
LTG (g/day)	5417	637.7^{a} ± 0.77	14662	663.7^{b} ± 0.60	3404	639.0^{a} ± 1.01	8765	663.8^{b} ± 0.81
FCR	5417	2.27^{a} ± 0.01	14662	2.24^{a} ± 0.01	3404	2.21^{a} ± 0.01	8765	2.23^{a} ± 0.01
AGES (days)	5417	135.7^{a} ± 0.16	14662	130.5^{b} ± 0.12	3404	135.6^{a} ± 0.20	8765	130.6^{b} ± 0.16
LEAN (%)	2557	68.6^{a} ± 0.06	2849	68.8^{b} ± 0.06	1232	68.4^{a} ± 0.08	1301	68.5^{a} ± 0.08
DLEAN (%)	2557	55.9^{a} ± 0.08	2849	56.3^{b} ± 0.08	1232	55.5^{a} ± 0.11	1301	55.7^{b} ± 0.11
DRIP (%)	2557	3.85^{a} ± 0.07	2849	3.54^{b} ± 0.06	1232	4.04^{a} ± 0.11	1301	3.62^{b} ± 0.11
DRESS (%)	2557	78.4^{a} ± 0.09	2849	76.9^{b} ± 0.09	1232	77.3^{a} ± 0.13	1301	76.3^{b} ± 0.13
CRLTH (cm)	1058	77.2^{a} ± 0.12	1209	77.4^{b} ± 0.12	488	78.1^{a} ± 0.17	523	78.7^{b} ± 0.17
AREA (cm^{2})	1058	41.6^{a} ± 0.28	1209	39.0^{b} ± 0.27	488	45.0^{a} ± 0.34	523	42.5^{b} ± 0.34

BFAT – backfat thickness; TPG – test period weight gain; LTG – weight gain from birth to slaughter; FCR – feed conversion ratio during test; AGES – age at slaughter; LEAN – lean percentage; DLEAN – drip-free lean; DRIP – drip loss; CRLTH – carcass length; DRESS – dressing percentage; AREA – eye muscle area.

Values with the same superscript within row for breed and sex are not significantly different.

Table 5 Least squares means (± SE) for the effect of testing phase on growth traits in Large White and Landrace pigs

	Large White				Landrace			
	N	Station	N	Farm	N	Station	N	Farm
BFAT (mm)	5890	13.9[a] ± 0.04	14189	11.9[b] ± 0.04	3152	14.8[a] ± 0.05	9017	11.6[b] ± 0.05
TPG (g/day)	5890	993.5[a] ± 1.62	14189	979.5[b] ± 1.63	3152	944.9[a] ± 2.13	9017	971.6[b] ± 2.06
LTG (g/day)	5890	654.7[a] ± 0.71	14189	646.7[a] ± 0.72	3152	648.1[a] ± 0.96	9017	654.7[a] ± 0.93
FCR	5890	2.33[a] ± 0.01	14189	2.18[b] ± 0.01	3152	2.32[a] ± 0.01	9017	2.12[b] ± 0.01
AGES (days)	5890	131.2[a] ± 0.15	14189	133.5[b] ± 0.15	3152	130.1[a] ± 0.19	9017	131.0[b] ± 0.19

BFAT – backfat thickness; TPG – test period weight gain; LTG – weight gain from birth to slaughter; FCR – feed conversion ratio during test; AGES – age at slaughter; values with the same superscript within row for breed and phase are not significantly different.

Table 6 Regression coefficients of feed intake and age at the beginning of test on growth and carcass traits

	Large White				Landrace			
	N	FEED (kg)	N	AGEB (days)	N	FEED (kg)	N	AGEB (days)
BFAT (mm)	21000	0.027 ± 0.001	21000	-0.014 ± 0.002	12169	0.030 ± 0.001	12169	-0.021 ± 0.003
TPG (g/day)	21000	-2.438 ± 0.044	21000	-0.984 ± 0.103	12169	-2.521 ± 0.052	12169	-0.763 ± 0.124
LTG (g/day)	21000	-0.436 ± 0.015	21000	-4.268 ± 0.036	12169	-0.523 ± 0.020	12169	-4.227 ± 0.046
FCR		ns		ns		ns		ns
AGES (days)	2100	0.141 ± 0.004		¥	12169	0.124 ± 0.004		¥
LEAN (%)	5406	-0.037 ± 0.001	5406	-0.021 ± 0.004	2534	-0.031 ± 0.002	2534	-0.028 ± 0.008
DLEAN (%)	5406	-0.051 ± 0.002	5406	-0.031 ± 0.006	2534	-0.043 ± 0.003	2534	-0.035 ± 0.010
DRIP (%)	5406	-0.010 ± 0.002		0.007 ± 0.003		ns		ns
DRESS (%)	5406	-0.065 ± 0.008		ns	2534	-0.031 ± 0.013		ns
CRLTH (cm)		ns		ns		ns		ns
AREA (cm^2)		ns		ns		ns		ns

N – number of records; BFAT – backfat thickness; TPG – test period weight gain; LTG – weight gain from birth to slaughter; FCR – feed conversion ratio during test; AGES – age at slaughter; LEAN – lean percentage; DLEAN – drip-free lean; DRIP – drip loss; CRLTH – carcass length; DRESS – dressing percentage; AREA – eye muscle area; FEED – total feed intake during test period; AGEB – age at the beginning of the test period; ns – effect not significant; ¥ – effect not included in the analysis.

Contrary to this, Augspurger *et al*. (2002) reported better growth rates in males and attributed it to their greater feed intake. Although there were no sex differences in feed conversion ratio in the current study, Nieuwhof *et al*. (1991), Friesen *et al*. (1994) and Latorre *et al*. (2003) observed poorer feed conversion efficiencies in males. Females were leaner (P <0.001) than castrates in both breeds, while smaller (P <0.01) eye muscle areas were observed in females. Serrano *et al*. (2008) observed that castrates produced more carcass yield, were fatter and had shorter carcasses. Castrates have a low capacity for protein deposition and a high rate of fat accretion (Campbell & Taverner, 1985). Mayoral *et al*. (1999) and Lattore *et al*. (2003) found no differences in carcass characteristics attributable to sex. These results may favour the testing of females.

The effect of the testing environment on growth traits is shown Table 5 where animals were tested at the central testing station (Phase B) and the farms (Phase D), respectively. Phase D animals were leaner (P <0.001) than Phase B animals in both breeds. Animals tested under Phase B had better (P <0.001) feed conversion ratios than Phase D animals. This may have resulted in higher (P <0.001) growth rates observed in Phase B animals which caused these animals to reach slaughter weight earlier (P <0.001). The differences in growth performance due to the testing phase may be attributable to differences between the two testing environments. Rearing environment has been reported to influence subsequent growth performance (Beattie *et al*., 2000; Gentry *et al*., 2004). The differences in performance between the phases show that central performance testing is more beneficial. The effect of testing phase may be confounded in the herd effect for Phase D animals, but not for those in Phase B. Although there are differences due to testing environment, data from both environments should be analyzed jointly. Traits from each testing environment can only be analyzed as different traits if they are genetically different.

The effect of feed intake on growth and carcass traits is shown in Table 6. Total test period feed intake was associated with reductions (P <0.001) in weight gains. Contrasting results showing increased weight gains with an increasing level of daily feed intake have been reported (Garcia-Valverde *et al*., 2008). This may suggest that animals consuming less feed under *ad libitum* conditions are more efficient. Increasing backfat thickness due to increased total test period feed intake observed in the current study is consistent with the observations of Garcia-Valverde *et al*. (2008). This can be attributed to the increased activity of lipogenic enzymes associated with increased energy intake (Daza *et al*., 2007). This observation suggests that there is an optimum feed intake to achieve the desired growth performance. Increasing total test period feed intake was associated with decreasing (P <0.001) lean percentage, drip-free lean percentage, drip loss and dressing percentage. These results are in agreement with earlier reports (Affentranger *et al*., 1996; Akdag *et al*., 2008). Nutrient digestibility increases with level of feed intake (Haydon *et al*., 1984) and the absorbed nutrients are used for maintenance and lean gain (Scharlach & Kleyn, 1996). When energy consumption exceeds requirements, the extra energy is converted to fat and stored (Scharlach & Kleyn, 1996). The differences may be attributed to the fact that total test period feed intake was used in the current study instead of average daily feed intake. Pigs that grow slowly have a longer test period and therefore require more total feed. On a daily basis, slow growth is associated with less daily feed intake.

Table 9 contains the effects of age at the beginning of the test on growth and carcass traits. Age at the beginning of the test period affected (P <0.001) backfat thickness, growth rates and lean percentages. Daza *et al*. (2007) reported contrasting results, where higher growth rates were observed in pigs that entered the test at an older age. They attributed this to compensatory growth whereby pigs that had shown slower growth rates during the pre-test period, had faster growth during test period. Average daily gain and carcass weight, as a consequence of older age at the beginning of the free-range fattening period have been previously reported (Daza *et al*., 2007). Variations in carcass characteristics due to age have been reported (Mayoral *et al*., 1999; Daza *et al*., 2005; 2007). Contrary to the present results, younger pigs at the beginning of the fattening period had inferior carcass characteristics in Iberian pigs (Daza *et al*., 2007). These results portray an unfavourable relationship between starting age and weight gains. An optimum age should be established for commencing testing in these pig populations. Observations from the current study may encourage the testing of younger animals at the beginning of the test.

The only interaction observed in this study was between herd of origin and year of testing, which affected (P <0.001) all growth and carcass traits in the two breeds. This suggests that there are inconsistent carcass characteristics in animals tested from different herds over the years. These results are consistent with those reported by Cassady *et al*. (2004). Wallenbeck *et al*. (2009) observed a herd-year-season interaction when they investigated the genotype × environment interaction in Hampshire boars. These results emphasize the influences of pre-testing period treatments on growth performance and carcass characteristics being carried over to slaughter, despite uniform treatment during the test period. Therefore, these effects may be combined during genetic evaluation to adjust for their effect on carcass traits.

Conclusion

There is a paucity of information on non-genetic factors affecting carcass characteristics of centrally tested pigs in South Africa. The purpose of this study was to evaluate the non-genetic effects on growth and carcass traits within the two major South African commercial pig breeds. These results point out that optimum management at farm level is a prerequisite for optimum growth performance and carcass quality and yield, which cannot be compensated for by on-test treatments. Castrates produce higher carcass yields, while females produce better carcass quality. If growth performance and carcass characteristics are to be improved, central performance testing should be done on females at a younger age in winter. Feeding the pigs *ad libitum* during testing may be counterproductive and separate genetic evaluation procedures for the two testing phases may be necessary. Younger pigs at the start of test may be preferable to improve carcass leanness and yield. The results discourage feeding pigs *ad libitum* if carcass quality is to be improved, but carcass yield is unaffected. Investigation of the effect of feed intake on growth and carcass traits in these pig populations may be improved by use of test-day data. These results underline the need to adjust for fixed effects when performing genetic evaluations in these pig populations.

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