CHAPTER IV

ESTIMATION OF GENETIC PARAMETERS FOR PRODUCTION AND CARCASS TRAITS IN THE SOUTH AFRICAN LARGE WHITE, LANDRACE AND DUROC PIG BREEDS

"A well balanced approach taking into account all opportunities, will remain essential in any future genetic improvement scheme"

- Louis Ollivier, 1998

4.1 INTRODUCTION

Selection for economically important traits in farm animals is normally based on the phenotypic records of the individual and it's relatives (Meuwissen, Hayes & Goddard, 2001). According to Ponzoni & Gifford (1990) response to selection for a multitrait objective depends not only on the economic- genetic variation, but also on the accuracy with which the breeding value of each trait is estimated, as well as the correlations (phenotypic and genetic) among traits.

Traits and models which are being used for genetic evaluation differ considerably between countries and states (Wolfova & Wolf, 1999). According to Goddard (1999) breeders wanting to stay in business must select those breeding animals with the highest estimated breeding values for profit. Furthermore, the estimation of genetic parameters for traits of economic importance calls for a high degree of accuracy in order to optimize the estimation of breeding values *per se* and that of breeding objectives and breeding schemes (Li & Kennedy, 1994: Tribout & Bidanel, 1999).

Carcass quality and meat quality have become increasingly important in modern day pig production (Lo, Mc Laren, Mc Keith, Fernando & Novakofski, 1992; Hovenier, 1993; Bidanel , Ducos, Guéblez & Labroue, 1994; Issanchou, 1996; Hermesch, Luxford & Graser, 2000). In South Africa the emphasis has been too long on input efficiency (growth rate, feed conversion and backfat on the live animal) and too short on output efficiency (carcass composition and meat quality traits).

This phenomenon was constituted by factors such as:

(i) the relative economic importance of growth rate and more specifically feed conversion ratio to pig producers in general

(ii) compensation of the end product, based on lean meat percentage and rectified indirectly at the breeding level through vigorous and sustained pressure on backfat thickness

(iii) the very low per capita consumption of pork (± 3,2kg per annum over the last three decades) linked to the immaturity of the pig supply chain and the consumer in general.

The objective of this chapter is to estimate genetic parameters for four production traits and for five carcass traits (for the first time) in the South African Large White, Landrace and Duroc pig breeds that are involved in the NPPTS. These traits were considered during 1988 to be the most important economic traits to the stud breeders participating in the NPPTS.

4.2 ESTIMATING GENETIC PARAMETERS FOR THE PRODUCTION TRAITS

4.2.1 Materials and Methods

4.2.1.1 Data Recording Procedures and Animals Involved

Production data was obtained from 5 631 <u>registered</u> Large White, 3 239 Landrace and 1 515 Duroc pigs, which were performance tested (and eventually slaughtered) at the three official pig testing centres in South Africa, namely: Irene, Elsenburg and Cedara. Tables 4.1, 4.2 and 4.3 indicate (i) the number of pigs that were performance tested per breed per year, (ii) the contribution (ratio) of males and females to the datasets and (iii) the number of pigs performance tested per breed per testing centre respectively. Data from these animals was used to determine heritabilities for four production traits.

These four production traits were: LADG[19] (lifetime average daily gain); TADG (test period average daily gain); TFI (total feed intake on test) and P_2 (backfat thickness). The data originated from the INTERGIS database of SA Studbook during the period 1989 – 2002. The number of stud herds involved in the database over the period, were 11, 17 and 24 for the Duroc, Landrace and Large White breeds respectively *(*Vide ANNEXURE XI *).*

[19] LADG refers to the average daily gain of test animals from birth to completion of the official performance test period

Table 4.1 The total number of pigs performance tested per breed per year (at the three central testing stations)

YEAR	**BREED**		
	DUROC	**SA LANDRACE**	**SA LARGE WHITE**
1989	19	84	141
1990	53	240	297
1991	127	414	387
1992	97	410	461
1993	80	357	553
1994	154	349	548
1995	144	356	630
1996	170	299	723
1997	95	204	528
1998	164	159	532
1999	142	99	287
2000	130	131	349
2001	123	116	159
2002*	17* (75)	21* (64)	36* (214)
TOTAL	**1 515**	**3 239**	**5 631**

* Not all pigs that were officially performance tested during 2002 were officially loaded onto the INTERGIS Database. Brackets ( ) indicating the total number of pigs that were officially performance tested, but not yet officially loaded onto the INTERGIS Database.

Table 4.2 The contribution (ratio) of males and females in the datasets of the three breeds

SEX	BREED			TOTAL
	DUROC	SA LANDRACE	SA LARGE WHITE	ALL BREEDS
Male	780 *(51.48)*	1 640 *(50.6)*	2 923 *(51.9)*	5 343 *(51.45)*
Female	735 *(48.52)*	1 599 *(49.4)*	2 709 *(48.1)*	5 042 *(48.55)*
TOTAL	**1 515**	**3 239**	**5 631**	**10 385**

(Brackets indicating the % representation)

Table 4.3 The number of pigs of each breed that were performance tested at each testing centre

TESTING CENTRE	BREED			
	DUROC	SA LANDRACE	SA LARGE WHITE	TOTAL
Elsenburg	336	1 495	2 641	4 472
Irene	371	472	1 641	2 484
Cedara	808	1 272	1 349	3 429
GRAND TOTAL	1 515	3 239	5 631	10 385

The total number of pigs that were performance tested per testing centre during the period were:

4 472, 2 484 and 3 429 for Elsenburg, Irene and Cedara respectively, amounting to a grand total of 10 385 pigs. All pigs were randomly selected from litters ranging from 4 to 20 pigs per litter (Vide Table 4.4). Selected pigs from these litters were submitted in litter pairs (one male and one female), representing a minimum of one and maximum of two litter pairs per litter. With random selection, each animal in the litter has the same opportunity to be selected for performance testing. This method of selection removes the bias of phenotypic or visual selection, where the preferred animal (in the eye of the beholder) is normally selected.

Table 4.4 **A summary of the number of centrally tested pigs selected from within the different litter size range(s) for the Large White, Landrace and Duroc pig breeds during the period 1989 – 2002.**

ACTUAL LITTER SIZE (NBA)	FREQUENCY DISTRIBUTION PER BREED		
	LARGE WHITE	LANDRACE	DUROC
4	-	4	2
5	6	6	6
6	22	13	27
7	279	226	196
8	499	388	248
9	732	540	313 * (20.66%)
10	928	630 * (19.45%)	274
11	1 016 * (18.04%)	513	220
12	860	447	126
13	637	294	61
14	293	106	26
15	234	49	14
16	81	10	-
17	27	2	2
18	11	11	-
19	-	-	-
20	6	-	-
TOTAL	**5 631**	**3 239**	**1 515**

* Numerically most pigs were selected for performance testing from litter sizes of 11, 10 and 9 for the Large White, Landrace and Duroc breeds respectively. If converted to percentages, these figures amount to 18,04%, 19,45% and 20,66% respectively for the three breeds.

Table 4.5 provides a summary of the number of sire and dam combinations per breed and per litter.

Table 4.5 A summary of the different sires, dams and sire dam combinations involved in the dataset for the Large White, Landrace and Duroc breeds.

COMBINATION	BREED		
	LARGE WHITE	LANDRACE	DUROC
Only sires	1 516	889	428
Only dams	3 571	1 952	979
Sire and Dams Combined (different litters)	4 810	2 712	1 332

The objective of the sampling method was to obtain a minimum of 22 ♂ and 22 ♀ pigs per breeder, representing at least 5 herd sires – the smallest number with which a good estimate of a stud herd's genetic merit can be obtained. Due to computational constraints pertaining to the production data (where seven traits were involved) only 2 generations of ancestors per animal for all three breeds were considered. (Vide Table 4.6 and Table 4.8). In the carcass data (where five traits were involved) 3 generations of ancestors per animal were considered for the Landrace and Duroc breeds and only 2 generations of ancestors per animal for the Large White breed (Vide Table 4.11 and Table 4.12).

Table 4.6 Description of the general data and statistical information of the covariants and four production traits for the three breeds.

TRAITS (BREED)	NUMBER OF RECORDS	MINIMUM	AVERAGE	MAXIMUM	S.D.
[LARGE WHITE]					
TADG (g)	5 631	590.52	949.76	1 466.70	111.07
LADG (g)	5 631	452.63	642.12	849.51	49.54
TFI (kg)	5 631	94.00	141.90	219.00	16.36
P_2 (mm)	5 631	5	16.04	35.00	4.16
Litter size	5 631	5	10.91	20.00	2.20
Start age (days)	5 631	40.00	66.39	98	6.78
Live mass 2 (kg)*	5 631	86.00	89.11	98.00	2.37
[LANDRACE]					
TADG (g)	3 239	599.14	893.37	1 445.70	106.04
LADG (g)	3 239	465.05	627.53	830.28	52.45
TFI (kg)	3 239	100.00	148.10	219.00	16.75
P_2 (mm)	3 239	6	17.27	35.00	4.18
Litter size	3 239	4	10.31	18.00	2.04
Start age (days)	3 239	41.00	64.86	103	6.73
Live mass 2 (kg)*	3 239	86.00	88.73	98.00	2.21
[DUROC]					
TADG (g)	1 515	534.88	960.54	1 384.60	113.59
LADG (g)	1 515	469.95	650.54	810.92	46.43
TFI (kg)	1 515	97.00	148.40	243.00	17.29
P_2 (mm)	1 515	7	16.82	30.00	3.76
Litter size	1 515	4	9.53	17.00	1.91
Start age (days)	1 515	42.00	65.41	93	6.78
Live mass 2 (kg)*	1 515	86.00	89.13	98.00	2.46

* Live mass 2 is the final mass of the test animal or mass when the test animal completes it's test ranging from ≥ 86kg to ≤ 99.9kg

All pigs were submitted for performance testing between 18 and 24kg. Pigs commenced their test period at ± 27kg (≥ 27 and ≤ 32kg) live mass, were penned individually, fed *ad lib*, weighed weekly and completed their test period at ± 86kg (≥ 86kg and ≤ 99,9kg). Table 4.7 gives an overview of the number of pigs that completed their test in each of the 1kg weight intervals between 86 and 98kg for the three breeds respectively. Backfat (P_2) measurements were taken on the live pigs at ±77kg (the second last weighing before completion of test or live mass 1) and again at ≥ 86kg (test completion date or live mass 2).

Table 4.7 The number of pigs that completed their tests in each of the 1 kg weight intervals between 86 and 98kg for the three breeds respectively.

	BREED					
	LARGE WHITE		LANDRACE		DUROC	
Weight intervals (kg)	Number per interval	Cumulative Percentage	Number per interval	Cumulative Percentage	Number per interval	Cumulative Percentage
86	903	16.03	602	18.58	263	17.35
87	821	30.61	567	36.09	211	31.23
88	802	44.86	502	51.59	217	45.61
89	787	58.83	421	64.59	190	58.15
90	754	72.22	428	77.80	194	70.96
91	581	82.54	333	88.08	179	82.77
92	452	90.57	203	94.35	103	89.57
93	291	95.74	106	97.62	81	94.92
94	152	98.44	47	99.07	44	97.82
95	51	99.34	15	99.53	14	98.74
96	27	99.82	9	99.81	14	99.67
97	9	99.98	4	99.94	4	99.93
98	1	100.00	2	100.00	1	100.00
TOTAL	**5 631**		**3 239**		**1 515**	

4.2.2 Statsitical Analysis

An animal model, which made provision for fixed, random and additive effects as well as genetic groups, (Vide ANNEXTURE XIII), was fitted to the data by using the VCE 4 (version 4.3.0) computer programme as indicated by Neumaier & Groeneveld (1998) [Vide Table 4.8].

Table 4.8 Fixed (F), random (R), additive (A) effects and the covariants (C) for the four production traits of the three breeds in the animal model.

FACTOR	EFFECT	FACTOR LEVELS PER BREED			TADG	LADG	TFI	BACK FAT
		LW	LR	D**				
YMT[#]	F	148	145	138	✓	✓	✓	✓
Herd	R (F)**	24	17	11	✓	✓	✓	✓
Test Centre	F	3	3	3	✓	✓	✓	✓
Sex	F	2	2	2	✓	✓	✓	✓
Dam parity	R	2 628	1 522	735	✓	✓	✓	✓
Animal	A	10 717	6 080	2 920	✓	✓	✓	✓
Litter size	C	1	1	1	✓	✓	✓	✓
Start age	C	1	1	1	✓	✓	✓	✓
Live mass 2	C	1	1	1	✓	✓	✓	✓

YMT indicates which herd(s) participated in which season of which year. Four seasons (1-4) were defined: 1 = Nov, Dec, Jan & Feb; 2 = March & April; 3 = May, June July & Aug.; 4 = Sept. & Oct.

✓ Indicates which factors were included for which traits

The animal model that was fitted to the data incorporated the *fixed effects* (sex, testing centre and year x season of test x herd interaction), the *random effects* (herd and dam parity) animal as an *additive effect* and the *covariants* (litter size, start age and live mass 2). The only difference in the model was the inclusion of herd as fixed effect** in the Duroc dataset. The reason being that the Duroc breed is numerically only the third most important pure breed in South Africa and not many breeders (eleven over thirteen years, Vide ANNEXTURE XI) were involved in the breeding / performance testing of this breed.

In practice and in almost any database, animals with unknown parents are common (Peškovičová, Groeneveld & Wolf, 2003). Genetic groups therefore represent the average genetic merit of the "phantom parents" that do not have records. Genetic groups were incorporated for the first time in the three datasets to adequately address the issue of semen imports from foreign countries during the period mentioned. The number of genetic groups fitted to the datasets of the Large White, Landrace and Duroc breeds were 57, 52 and 46 respectively. Ancestors without real (identified) parents were assigned to genetic groups based on year of birth, sex and country of origin (Vide ANNEXTURE XIII).

Table 4.9 Heritability estimates (h^2) for the four production traits of the Large White, Landrace and Duroc pig breeds

Trait	Large White	Landrace	Duroc
TADG	0.32 (0.013)	0.38 (0.026)	0.22 (0.051)
LADG	0.28 (0.016)	0.34 (0.026)	0.21 (0.048)
TFI	0.31 (0.017)	0.30 (0.030)	0.27 (0.064)
P_2	0.43 (0.015)	0.52 (0.040)	0.33 (0.058)

[( ) Brackets indicating the standard errors of h^2 – estimate]

4.2.3 Results and Discussions

In a previous study Visser, Delport, Voordewind & Groeneveld (1995) reported heritability estimates (h^2) of 0.26 and 0.35 for **TADG** (test period average daily gain) for the Large White and Landrace breeds respectively. In the present study the heritability (h^2) for TADG was 0.32; 0.38 and 0.22 for the Large White, Landrace and Duroc breeds respectively. These findings are partly in accordance with most literature cited. Johansson, Andersson & Lundeheim (1987) reported h^2 estimates of 0.26; 0.23 and 0.09 for daily gain for the Landrace, Yorkshire and Hampshire pig breeds, respectively from the Swedish pig testing stations during the period 1977 – 1981 involving data from 8 234 Landrace pigs, 4 448 Yorshire and 1 122 Hampshire pigs. Li & Kennedy (1994) [in a comprehensive Canadian study, (1989-1992) involving records of 47 360 Yorkshire pigs, 28 762 Landrace pigs and 14 020 Duroc pigs] reported h^2 estimates for growth rate (days to 100kg) of 0.31; 0.30 and 0.26 for the three breeds respectively. In an Australian study, involving 935 Large White and 767 Landrace boars, Mc Phee, Brennan & Duncalfe (1979) reported h^2 estimates of 0.4 and 0.25 for growth rate on tests (25kg – 80kg) for the Large White and Landrace breeds respectively. Wylie, Morton & Owen (1979) reported a h^2 estimate of 0.41 for daily gain in a study involving 1 357 Large White boars fed *ad libitum* on a performance testing scheme in the United Kingdom. Ducos, Bidanel, Ducrocq, Boichard & Groeneveld (1993) reported h^2 estimates of 0.3 and 0.34 for average daily gain in French Large White and French Landrace pigs respectively.

LADG (lifetime average daily gain) ranged from 0.21 for the Duroc breed to 0.28 for the Large White and 0.34 for the Landrace. Hermesch, Luxford & Graser (2000) indicated that: *"Average daily gain from 3 to 18 weeks is a different trait than average daily gain recorded during station testing between 18 and 22 weeks. A higher average daily gain prior to station testing is associated with an increased leanness, while a higher average daily gain in the latter part of the growing period will reduce leanness"* LADG is of particular importance in on-farm testing in South Africa. On-farm testing cannot be monitored precisely on all the farms under all circumstances. LADG therefore provides a guideline for lifetime potential on the farm, and a reliable on-farm method of selection.

Heritability estimates (h^2) for **TFI** (Total Feed Intake) of 0.31; 0.30 and 0.27 were recorded for the Large White, Landrace and Duroc breeds respectively. Clutter & Brascamp (1998) indicated a h^2 estimate of 0.29 for daily feed intake for 11 different studies with a range of 0.13 – 0.62. Wylie *et al* (1979) reported a h^2 estimate of 0.23 for Large White pigs and Mc Phee *et al* (1995) reported a h^2 estimate of 0.5 and 0.78 for feed intake in Australian Large White and Landrace pigs respectively.

Backfat thickness (P_2) is known as a highly heritable trait. In the 1995 South African study, Visser *et al* (1995) reported heritability estimates (h^2) of 0.50 and 0.537 for backfat thickness for the Large White and Landrace breeds respectively. In the present study the h^2 for backfat for the Large White and Landrace breeds was 0.43 and 0.52 respectively and that of the Duroc only 0.33. These estimates are in accordance with most literature cited. Mc Phee *et al* (1979) reported a pooled heritability estimate of 0.47 for backfat across Large White and Landrace breeds. Ducos *et al* (1993) reported h^2 estimates of 0.64 and 0.56 for backfat thickness in French Large White and Landrace pigs respectively. Lo, Mclaren, Mc Keith, Fernando & Novakofski (1992) indicated a h^2 estimate of 0.54 in Landrace and Duroc pigs in the USA. Clutter & Brascamp (1998) reported a h^2 estimate of 0.49 for backfat thickness under *ad lib* and *semi-ad lib* conditions and 0.31 for restricted feeding conditions.

4.3 ESTIMATION OF GENETIC PARAMETERS FOR THE CARCASS TRAITS

4.3.1 Materials and Methods

4.3.1.1 Data Recordings, Animals and Procedures

Carcass data of 5 631 registered Large White pigs, 3 239 Landrace pigs and 1 515 Duroc pigs, which were performance tested and slaughtered at the three official pig testing centres (Irene, Elsenburg and Cedara), were used to determine heritability estimates for five carcass traits. The carcass traits (Vide Table 4.11) were shoulder meat weight (SMW), shoulder bone weight (SBW), shoulder fat weight (SFW), loin sample (chop) weight (LSW) and drip loss (DL). The data originated from the INTERGIS database of S.A. Studbook covering the period: 1989-2002. All pigs were randomly selected and submitted for performance testing between 18 and 24 kg. Pigs commenced their test period at 27kg live mass, were penned individually, fed *ad lib*, weighed weekly and completed their test period at 86kg live mass. Pigs were slaughtered after completion of test.

4.3.1.2 Traits Analysed: Procedures

A detailed carcass (shoulder) dissection and evaluation was conducted on each pig's carcass. The left shoulder of each pig was severed by means of a cut running between the third and fourth ribs in a straight line through the junction of the third and fourth thoracic vertebrae and the junction of the caudal edge of the second rib with the sternum. The mass of each severed shoulder (Vide Table 4.1) from each pig, of each breed, was recorded. Thereafter each shoulder was deboned, the subcutaneous fat dissected and the mass of the meat, bone and fat recorded in kilograms (rounded off to 3 decimal figures). From the end of the carcass, where the back fat measurement (known as the P_2 –measurement which is found 6,5cm from the midline of the last rib) was obtained, a loin sample was cut off (approximately 2cm thick and 15cm long) by means of measuring along the surface of the back over the eye muscle. The average mass of the loin samples was recorded accurately in grams for the Large White, Landrace and Duroc breeds and amounted to 270, 282 and 280 grams respectively (Vide Table 4.10). The mass of each new, empty and clean barrier (plastic) bag was obtained in grams. Each loin sample was placed into a netlon bag and tied accordingly so as to prevent the loin sample from touching the bottom of the barrier bag or air coming into the barrier bag. This parcel was stored and hung in a refrigerator at between 0 and 5°C for 48 hours after which the loin sample in the netlon bag was removed from the barrier (plastic) bag. The mass of the barrier (plastic) bag, inclusive of the moisture (% drip*), was recorded in grams (rounded off to two decimals).

The average relative moisture or drip loss* (g moisture per unit loin sample over 48 hours) for the Large White, Landrace and Duroc breeds were 3,41%; 4,06% and 3,41% respectively [**Vide Results and Discussion].**

Table 4.10 The composition of shoulder mass and drip loss (expressed in percentage) for the three breeds

TRAITS	BREED		
	Large White	**Landrace**	**Duroc**
TSW (kg)**	8.322	8.008	8.412
SMW^a (kg) (SMW^a %)	5.583 (67.08)	5.406 (67.50)	5.587 (66.4)
SBW^b (kg) (SBW^b %)	1.238 (14.88)	1.179 (14.72)	1.248 (14.83)
SFW^c (kg) (SFW^c %)	1.501 (18.04)	1.423 (17.77)	1.577 (18.74)
LSW^d (g) (% Drip Loss*)	270 3.41	282 4.06	280 3.41

** TSW = Total Shoulder Weight

$$* \quad \text{\% drip loss} = \left[\frac{\text{combined drip + bag weight (g)} - \text{bag weight (g)}}{\text{weight of loin chop (g)}} \times 100 \right]$$

[a] SMW = Shoulder Meat Weight (after dissection and weighing)

[b] SBW = Shoulder Bone Weight (after dissection and weighing)

[c] SFW = Shoulder Fat Weight (after dissection and weighing)

[d] LSW = Loin Sample Weight (the average mass in grams of the loin sample that was cut off)

Table 4.11 **Description of the general data and statistical information with regard to the five carcass traits for the three breeds**

Traits (BREED: LARGE WHITE)	Number of records	Minimum	Average	Maximum	S.D.
SMW (kg)	5 631	3.41	5.58	8.70	0.52
SBW (kg)	5 631	0.43	1.24	2.43	0.20
SFW (kg)	5 631	0.69	1.50	4.80	0.32
LSW (g)	5 631	50.00	269.69	443.00	42.10
DL (g) *(% Drip loss) **	5 625	0.001	9.22 *(3.41)*	46.00 *(10.38)*	5.25
Traits (BREED: LANDRACE)	**Number of records**	**Minimum**	**Average**	**Maximum**	**S.D.**
SMW (kg)	3 239	3.81	5.41	7.37	0.48
SBW (kg)	3 239	0.69	1.18	2.40	0.22
SFW (kg)	3 239	0.75	1.42	2.28	0.28
LSW (g)	3 239	145.00	282.44	445.00	44.83
DL (g) *(% Drip loss) **	3 236	0.001	11.49 *(4.06)*	52.00 *(11.68)*	5.61
Traits (BREED: DUROC)	**Number of records**	**Minimum**	**Average**	**Maximum**	**S.D.**
SMW (kg)	1 515	3.99	5.59	7.29	0.48
SBW (kg)	1 515	0.73	1.25	2.01	0.20
SFW (kg)	1 515	0.68	1.58	2.73	0.29
LSW (g)	1 515	168.00	280.07	442.00	41.58
DL (g) *(% Drip loss) **	1 515	0.001	9.56 *(3.41)*	36.00 *(8.14)*	5.78

$$* \quad \text{\% drip loss} = \left(\frac{\text{combined drip + bag weight (g)} - \text{bag weight (g)}}{\text{weight of loin chop (g)}} \times 100 \right)$$

4.3.2 Statistical Analysis

An animal model, which made provision for fixed, random and additive effects as well as genetic groups, was fitted to the data by using the VCE 4 (version 4.3.0) programme of Groeneveld (1998). The animal model that was fitted to the data incorporated the *fixed effects* (sex, testing centre and breeder x year x season of test), the *random effects* (litter size, start age, dam parity and final mass at the end of test) and animal as an *additive effect* (Vide table 4.12). Genetic groups were incorporated to adequately address the issue of semen imports from foreign countries during the mentioned period. The number of genetic groups fitted to the datasets of the Large White, Landrace and Duroc breeds were 57, 31 and 24, respectively (Vide Annexure XIII). The same model was fitted to the dataset of each of the three breeds.

Table 4.12 Fixed (F), random (R), and additive (A) effects for the five carcass traits of the three breeds in the animal model

Factor	Effect	Factor levels per breed							
		LW	LR	D	SMW	SBW	SFW	LSW	DL
BYS#	F	375	249	138	✓	✓	✓	✓	✓
Sex	F	2	2	2	✓	✓	✓	✓	✓
Testing Centre	F	3	3	3	✓	✓	✓	✓	✓
Litter size	R	20	18	17	✓	✓	✓	✓	✓
Start age	R	98	103	93	✓	✓	✓	✓	✓
Final mass	R	100	98	98	✓	✓	✓	✓	✓
Dam parity	R	2 628	1 522	735	✓	✓	✓	✓	✓
Animal	A	10 717*	273 936**	92 797**	✓	✓	✓	✓	✓

\# Indicating which herd(s) participated in which season of which year.
Four seasons (1-4) were defined: **1** = Nov, Dec, Jan & Feb; **2** = March & April
3 = May, June, July & Aug; **4** = Sept &Oct.
✓ Indicates which factors were included for which trait
* Restricted pedigree (Vide description pp 100)
** Unrestricted pedigree (Vide description pp 100)

Table 4.13 Heritability estimates for the five carcass traits of the Large White, Landrace, and Duroc pig breeds.

Trait	Large White	Landrace	Duroc
SMW	0.18 (0.014)	0.28 (0.017)	0.33 (0.018)
SBW	0.13 (0.015)	0.13 (0.011)	0.29 (0.013)
SFW	0.25 (0.021)	0.25 (0.009)	0.25 (0.018)
LSW	0.04 (0.006)	0.06 (0.007)	0.06 (0.012)
DL	0.17 (0.012)	0.20 (0.008)	0.16 (0.012)

( ) Brackets indicating the standard errors of h^2-estimates

4.3.3 Results and Discussions

In a previous study, Visser *et al* (1995) reported heritability estimates (h^2) of 0.27 and 0.39 for % shoulder lean meat for the Large White and Landrace breeds respectively.

The heritability estimates (h^2) for shoulder meat weight (SMW) ranged from 0.18 (Large White) to 0.28 (Landrace) and 0.33 (Duroc) (Vide Table 4.13). These figures were lower than that reported for <u>lean meat content</u> by Cameron (1990) in a selection experiment with Duroc and halothane negative Landrace pigs and that of Knapp, Willam & Sölkner (1997) for Austrian Large White, Landrace and Pietrain pigs. The Austrian researchers reported heritability estimates of 0.53; 0.43 and 0.40 for the three breeds respectively. Sonneson, de Greef & Meuwissen (1998) reported a heritability estimate of 0.41 for the lean % in two selected lines of Large White pigs whilst Hermesch *et al* (2000) reported heritabilities for lean meat (of the entire back leg) of 0.27 and 0.59 in Australian Large White and Landrace pigs.

Heritability estimates for shoulder bone weight (SBW) could not be found in the literature. In the present study the h^2 for SBW ranged from 0.13 (Large White and Landrace) to 0.29 (Duroc) As indicated in Table 4.10 the % contribution of shoulder bone weight to total shoulder weight was very close to each other: 14.88%; 14.72%; and 14.83% for the Large White, Landrace and Duroc breeds respectively.

The heritability estimate for shoulder fat weight was surprisingly identical for all three breeds (h^2 =0.25). In the study of Cameron (1990) a heritability estimate of 0.54 was reported for subcutaneous fat weight [and 0.50 and 0.48 for intermuscular fat weight and backfat (P_2) respectively].

For drip loss the highest heritability estimate was recorded for the Landrace breed (h^2 = 0.20), followed by 0.17 and 0.16 for the large White and Duroc breeds, respectively. This is partly in agreement with most literature cited. Lo *et al* (1992) indicated h^2 estimates of 0.25 for American Duroc and Landrace pigs. Sonneson *et al* (1998) reported h^2 estimates of 0.08 and 0.19 for two water holding capacity traits in two lines of Large White pigs. Knapp *et al* (1997) reported estimated drip loss heritabilities of 0.21 and 0.10 for Large White and Landrace pigs respectively and Hermesch *et al* (2000) a heritability estimate of 0.23 for Large White and Landrace pigs in Australia.

In the present study, the relative moisture or drip loss (g moisture per unit loin sample over 48 hours) for the Large White, Landrace and Duroc breeds was 3.41%; 4,06% and 3,41% respectively (Vide Table 4.10 and Table 4.11)

4.4 CONCLUSIONS TO CHAPTER IV

The genetic response of those traits under selection, is dependent upon the accuracy with which genetic parameters are estimated, as well as the effectiveness of selection. The current dataset represents a much larger dataset (5 631 Large White records *vs.* 1 310 in 1995 and 3 239 Landrace records *vs.* 1 158 in 1995) as well as a better-structured and defined animal model.

The 1995 animal model fitted to the data had herd, sex, station and month of test as *fixed effects*, animal as an *additive effect* and litter as *random effect*. Genetic groups were also included in the datasets of all three breeds in the present study. The genetic parameters obtained from this study should therefore be more credible than in the past. Contributing factors were also the random submission of pigs for central testing, the ratio of males to females in the database (Vide Table 4.2) and the fact that every stud breeder of impact contributed to the dataset over some thirteen years (Vide Annexure XI).

The next real challenge is to harness the multi-trait estimates of both the carcass and production traits into a national genetic evaluation programme for pigs (a national BLUP). A national BLUP for pigs will make provision for animals in small studs, large studs, central test stations, on farm test stations, imported animals and/or semen, animals at auctions and offspring of boars in AI stations to be compared with each other simultaneously. This method will put the South African pig stud industry on a par with our counterparts in France, Belgium, The Netherlands, Denmark, Sweden, Norway, Austria and Switzerland.

Models as being described in this study were structured to best describe all possible variables and effects that could have an influence on the outcome of the genetic parameters. Status 1 runs were obtained for all models. Status 1 runs indicate that all the equations and iterations were successfully completed. Further analyses of the data of this study will include the estimation and reporting of genetic and phenotypic correlations as well as genetic and environmental trends.

Sustained selection for increased carcass lean weight and / or decreased carcass fat weight would ultimately be reflected in:

(i) decreased muscle pH (with a causal effect on other traits such as colour and water-holding capacity)

(ii) decreased intramuscular fat content

(iii) inferior eating quality (through reduced flavour, juiciness, tenderness and general acceptability)

Implications for the stud industry, which should be corrected through the right breeding objectives *a priori*, are the following:

(i) Divergent selection is conducive to acceleration of the desired genes within a preferred or selected line / genotype with a masking or inhibiting effect on other traits.

(ii) The causal relationship between different carcass and meat quality traits, within the genetic composition of an animal / population, is ultimately expressed in the end product as a result of positive or negative phenotypic and genetic correlations.

The very low h^2 values for loin sample weight (0.04 to 0.06) can be explained by the fact that expression of this trait is multifactorial and contained in the proportional meat, bone and fat ratios within the loin sample as well as the potential drip loss of the loin sample. Practical application of this trait in future breeding programs is limited. However, drip loss *per se* with real application as a meat quantity and meat quality trait, and which has a moderate heritability, is ascertained from this trait. Hovenier (1993) indicated that the economic value of a 1% drip loss is calculated to be equivalent to the loss of 1% lean meat.

Estimating genetic parameters for five carcass traits in the South African Large White, Landrace and Duroc breeds, was the first of its kind in South Africa. In future, breeding values for carcass traits can be determined more accurately for each of the three breeds. This research will serve as a directional departure point for further studies in this field as well as the possibility of determining breeding values for the efficiency of carcass composition and nutrient utilization.

The present carcass evaluation analysis, as being conducted by the National Pig Performance Testing Scheme, does not adequately address meat quality. Only drip loss (water holding capacity) is being measured. Extending this analysis to incorporate the essential meat quality traits such as pH or pH_u, marbling, tenderness and colour to eventually satisfy the consumer is recommended. These aspects will be dealt with in detail in the next chapter (Chapter V) where desired breeding objectives for the pig industry will be structured.