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Growth performance and carcass characteristics of progeny from different Topigs Tempo boars

by

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Declaration

I, Carla Rittonori, declare that this dissertation, which I hereby submit for the degree of MSc (Agric) Animal Science: Production Management at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at another university.

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"The creatures outside looked from pig to man, and from man to pig, and from pig to man again: but already it was impossible to say which was which." – *Animal Farm,* George Orwell.

"The only thing holding back a pig is its lack of opposable thumbs" – Kenny Fagan

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Abbreviations

SAPPO – South African Pork Producers' Organisations

PBS – The Pig Breeders' Society of South Africa

NPPPTS – National Pig Performance and Progeny Testing Scheme

ARC-AII – Agricultural Research Council – Animal Improvement Institute

SAMIC – South African Meat Industry Company

SADC – Southern African Development Community

ADG – Average daily gain

FCR – Feed conversion ratio

WCM – Warm carcass mass

CCM – Cold carcass mass

LMP – Lean meat percentage

CL – Carcass length

CC – Carcass compactness

BFT – Backfat thickness

P2-S – P2 backfat thickness at slaughter

BLUP – Best linear unbiased prediction

MAS – Marker assisted selection

EBV – Estimated breeding value

AI – Artificial insemination

G x E – Genetic by environment interaction

CASA – Computer assisted semen analysis

TSi – Topigs selection index

AEC – Animal ethics committee

GLM – General linear model

SD – Standard deviation

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Abstract

The current aim of the pig production industry is to improve production and reproduction efficiency while considering consumer satisfaction with the final product and the means of its production. The aim of this study was to evaluate and compare the growth performance and carcass characteristics of the progeny from a genetically improved, homospermic *Topigs Tempo*© boar with that of a standard, heterospermic *Topigs Tempo*© sire line. Parameters observed in the study included live body mass, P2 backfat thickness, average daily gain, warm carcass mass, cold carcass mass, lean meat percentage, carcass length and carcass compactness. As a sub-objective, the effect of the two methods of insemination on reproductive performance was analysed. The female progeny from the improved boar had heavier body weights ($P < 0.001$), greater average daily gains ($P < 0.01$), heavier warm and cold carcass mass, lower lean meat percentage and greater P2 backfat thickness ($P < 0.0001$) than the female progeny from the standard sire line. The male progeny from the improved boar line performed no better than the male progeny from the standard sire line except for greater warm and cold carcass mass and greater P2 backfat thickness ($P < 0.0001$). Between sexes, the male progeny from the standard sire line had heavier body weights ($P < 0.0001$) and greater average daily gains ($P < 0.01$) than their standard female counterparts while the male progeny from the improved boar performed no better than their improved female counterparts. No difference was observed for warm and cold carcass mass between the male and female progeny for both the standard sire line and improved boar. The female progeny were fatter than the male progeny from the improved boar and the male and female progeny from the improved boar were consistently fatter than the male and female progeny from the standard sire line. The study identified the genetically improved, homospermic *Topigs Tempo*© boar to affect the growth performance and carcass characteristics of its commercial offspring.

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Chapter 1

Introduction

The origin of the South African pig industry dates back to 1652 (Visser, 2004) and has since developed into a national economic industry with a gross producer value of ca. R3.49 billion and a gross consumer value of ca. R7.15 billion (Visser, 2014). South Africa contributes a mere 0.5% to world pig production (Visser, 2014). According to Visser (2004) the sub-optimal performance of the South African pig industry compared to the American, Danish and Taiwanese pig industries is the result of its relative small size, structure and limitations, exacerbated by export subsidies and the fluctuating exchange rate.

South Africa has 400 commercial pig producers and 19 stud breeders (DAFF, 2013) in possession of ca. 103 400 sows (of which a provincial distribution breakdown is shown in Figure 1) or 1572 million pigs in total at any one time (DAFF, 2013; Visser, 2014). Recently, North West and Limpopo provinces became the largest producers of pork, accounting for ca. 43% of South Africa's total pig production (DAFF, 2013). The National Agricultural Directory (2011) indicates that 79.85% of South Africa's pigs are distributed in commercial areas while the remaining 20.15% are found in developing areas.

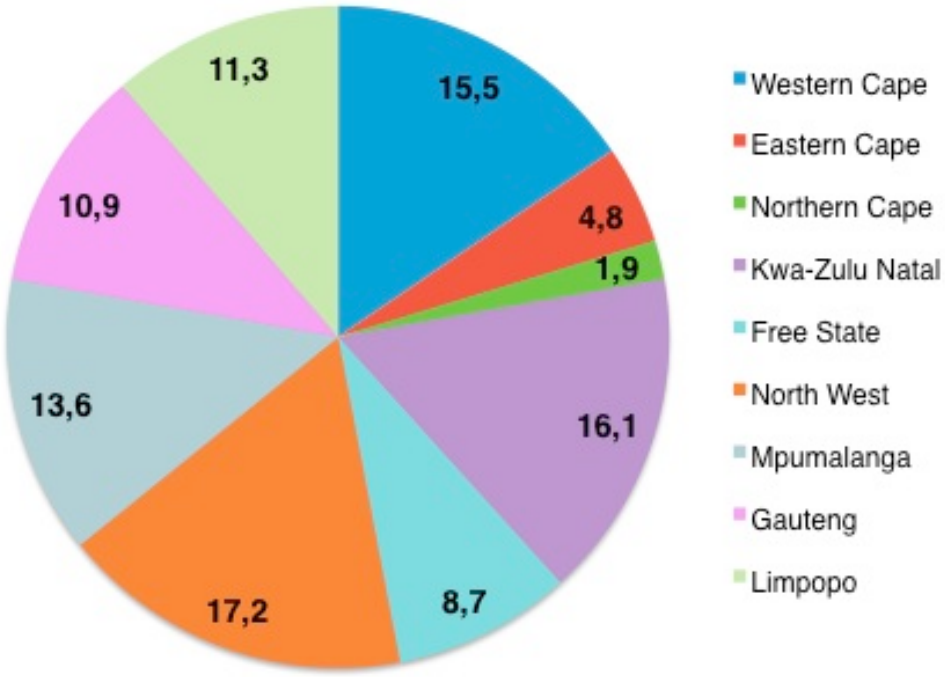

Figure 1 Diagrammatic representation of the distribution of commercial sows in South Africa (Visser, 2014).

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The South African pig industry may be structured as a pyramid (Figure 2) comprising of super nucleus, nucleus, multiplier, commercial and slaughter levels (Visser, 2004). Genetic selection can be implemented at all levels; however, selection at the super nucleus or nucleus level determines the rate of genetic improvement in the industry and should reflect the goals of the industry at the commercial level (Visser, 2004; Whittemore, 2008)

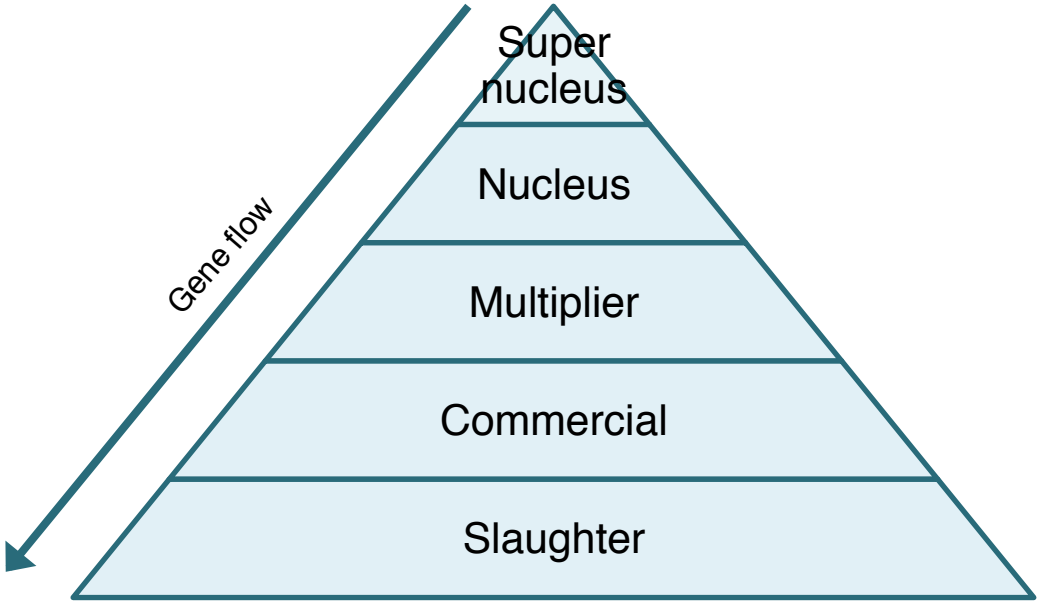

Figure 2 Diagrammatic representation of the pig industry structured as a pyramid where gene flow takes place from the top down.

Large breeding companies such as *TopigsSA*© make use of nucleus and multiplier herds (Visser, 2004). At the nucleus level, pure breeds are selected for specific traits and are subjected to genetic evaluation. From the purebred stock, lines with specific traits are developed and through the use of crossbreeding at the multiplier level, F1 hybrid gilts with high reproductive performance are produced (Dekkers *et al.,* 2011). At the commercial level these gilts are used in a terminal crossbreeding programme with a sire possessing the desired growth and carcass characteristics to produce pork for the market (Dekkers *et al.,* 2011). Genetic selection is therefore accomplished by evaluating the animals in the nucleus herds, providing unbiased estimates of their genetic potential, and improving market pig performance through selection and performance testing of seed stock populations (Whittemore, 2008; Dekkers *et al.,* 2011).

The environments under which these stud animals are evaluated differ from commercial environments. Within nucleus herds, animals may be penned individually instead of in large groups

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and may also be fed ad lib rather than in controlled amounts (Clutter, 2011). Through an astounding amount of effort, these animals are kept healthy and free of pathogens, benefiting from reduced phenotypic variance. Consequently, the genetic stock from nucleus herds perform more poorly in the commercial setting where the environment is below optimum for a nucleus herd (Mulder & Bijma, 2005; Clutter, 2011). Notwithstanding the difference in performance between the nucleus and commercial herds, genetic selection for increased lean muscle mass has brought about change in the average level of growth performance over all levels of production in the pig industry (Quiniou *et al.,* 2010).

Various structures and organisations are in place and serve to represent, unite, protect and promote the interests of commercial pig producers (Visser, 2004). Over time, many of these structures were withdrawn from the industry, leading Visser (2004) to describe the South African pork supply chain as uncoordinated due to its fragmented, individualistic and price-inconsistent nature. Among others, a few large organisations remain, including SAPPO (South African Pork Producers' Organisation), S.A. Stud Book, PBS (The Pig Breeder's Society of South Africa) and NPPPTS (National Pig Performance and Progeny Testing Scheme). SAPPO is a national organisation funded through voluntary membership fees and aims to equip its members with the necessary materials and knowledge to ensure efficient and profitable production (Visser, 2004). S.A. Stud Book represents almost 8000 stud breeders as well as other breeders' societies such as the PBS (The Pig Breeders' Society of South Africa). The PBS keeps records of the pedigrees of all registered boars and sows and participates in the National Pig Performance and Progeny Testing Scheme (NPPPTS) of the Agricultural Research Council – Animal Improvement Institute (ARC-AII). Apart from the pigs registered at PBS and participating in the activities of the NPPPTS, three popular breeding companies namely Kanhym-PIC, Dalland-Topigs and JSR practise their own performance testing. They are therefore full members of PBS but are not involved in the activities of the NPPPTS (Visser, 2004).

Breeding objectives in the pig industry may be classified into two categories namely, reproduction and production. Reproduction traits include the main components of sow productivity whereas production traits include production costs. Breeding programmes in South Africa make use of crossbreeding with breeds that show complementarities for specific traits (Ollivier, 2008; Dekkers *et al.,* 2011). Specific lines have separate genetic improvement programmes based on multi-trait selection, using a linear index, to predict breeding values. For dam lines, emphasis is placed on sow productivity while sire lines are selected for production performance (Dube *et al.*,

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2013). The most important breeding objective with regards to production is improvement of growth performance and product for the market (Ollivier, 2008; Dekkers *et al.,* 2011). The general trend in breeding objectives for the pig industry is a change from performance traits to carcass yield and quality (Van Wijk *et al*., 2005). More emphasis is being placed on meat quality and litter size with moderate emphasis on growth rate, feed conversion ratio and sow productivity (Ollivier, 2008; Dekkers *et al.,* 2011).

Slaughter weight has a great influence on growth performance of commercial pigs (Conte *et al.,* 2011) and the value of the pig at slaughter is determined by the input costs incurred (Dube *et al*., 2011). In the South African pork production industry, slaughter weight averages around 100kg live weight and producers are rewarded for the lean content of their carcasses based on the PORCUS carcass classification system (Conte *et al.,* 2011). The South African Meat Industry Company (SAMIC) is a national representative structure that regularly advises the pig industry on meat hygiene practices, abattoir practices, offal management and processing. Eskort, Enterprise, Renown, Roelcor and Spekenham are the main pork processors in South Africa, with ca. 53% of all fresh pork being sold through butcheries and the remaining 47% through retail chains. Registered abattoirs in South Africa slaughter ca. 85% of the 2.4 million pigs slaughtered annually (Visser, 2004; Visser, 2014). In 2012, South Africa imported 33 314 tons of pork at a value of R700 million and exported 1.5 tons of pork at a value of R30 million (DAFF, 2013; Visser, 2014). South Africa, therefore, remains a net importer of pork, especially pork ribs, and exports most of the country's pork to SADC (Southern African Development Community) countries within the continent. Even though South Africa is a net importer of pork, the country still produces more pork (2.08 million tons during the 2011/12 season) than its population consumes (239 000 tons during the 2011/12 season) and the DAFF (2013) describes South Africa as self-sufficient in terms of pork production.

Growth performance, carcass composition and sensorial meat characteristics are influenced by sex, and it is well known that gilts grow differently to intact males (Ellis *et al*., 1996; Candek-Potokar *et al*., 1998 and Lebret *et al*., 2001). Intact males are leaner and more efficient (Barton-Gade, 1987) compared to gilts and an increase in slaughter weight of intact males is associated with an increase in average daily (ADG) and gain:feed ratio (Desmoulin *et al*., 1982). Intact boars develop boar taint with age (Diestre *et al*., 1990) and show a 1.5mm increase in P2 backfat thickness as slaughter weight increases from a live weight of 85kg to 95kg, with no significant effect on lean gain (Conte *et al*., 2011). Gilts on the other hand, display a decrease in average

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daily gain (ADG) and gain:feed ratio as slaughter weight increases (Weatherup *et al.*, 1998; Desmoulin et al, 1982) with no real effect on carcass composition (Conte *et al.*, 2011).

When heterospermic insemination is performed, a female receives semen from multiple males within a short period of time near ovulation so that a mixture of spermatozoa is available for fertilisation (Dziuk, 1996). During homospermic insemination, the female is inseminated with semen from a single male. The heterospermic performance of a male is expressed as the percentage of offspring sired, while homospermic performance of a male is expressed as conception rate (Saacke, 1982). Sows in nucleus herds are homospermically inseminated (Mostert, 2014). The semen from the best boars are pooled together and sold to clients who then heterospermically inseminate their commercial herds (Mostert, 2014). It should be taken into account, however, that the benefits of using heterospermic insemination in a commercial herd is debatable and has been said to be of no practical value apart from allowing the spermatozoa from one boar to preferentially fertilise the ova over the spermatozoa from another boar (Beatty et al, 1969). Even so, heterospermic insemination may be useful in determining the most fertile male among a group of males that may otherwise perform similarly to each other. The study of heterospermic insemination may also aid in identifying the components of semen quality that contribute to fertility and in doing so, encourage the development of a semen evaluation test that more accurately determines the quality and fertility of ejaculates within and between boars (Dziuk, 1996; Stahlberg *et al.*, 2000; Holt & Van Look, 2004). This topic will be further elaborated upon in the literature review.

1.1 Aim of the study

The genetically improved *Topigs Tempo*© boar used in this study was classified as an outlier in terms of production performance. With a high average daily gain of 1.47kg, this specific boar was claimed to have superior growth performance and feed efficiency. Taking into consideration that the genetically improved boar was reared within a nucleus herd, as well as the fact that the offspring can only inherit 50% of a sire's genetic material, the aim of this study was to determine to which degree the performance of the male and female homospermic progeny from this genetically improved *Topigs Tempo*© boar could be compared to that of the boar itself, while comparing the growth of said progeny to that of the male and female heterospermic progeny of a standard, pooled semen sample where multiple *Topigs Tempo*© boars' semen samples were pooled together. Although not the main objective of this study, the effect of the different insemination methods on litter size was also analysed.

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To achieve the aim of the study the following main objectives were set:

1. Analysis of all data pertaining to the sows at farrowing (total born, born alive and parity)
2. Measure weight of progeny at 21 days old, 11, 13, 15, 17, 19 and 21 weeks old and slaughter weight of the heterospermic and homospermic treatments respectively.
3. Analysis of P2 backfat thickness of progeny every three weeks from 11 weeks of age onwards.
4. Analysis of carcass data obtained from the abattoir such as carcass length (CL), warm carcass mass (WCM), cold carcass mass (CCM), lean muscle percentage (LMP) and P2 backfat thickness.

Sub-objective:

1. Analyse the data collected pertaining to litter size.

1.2 Hypothesis

H_0: The genetically improved *Topigs Tempo*© boar has no beneficial effect on the growth performance and carcass characteristics of the resultant homospermic progeny compared to the growth performance and carcass characteristics of the heterospermic progeny from multiple standard *Topigs Tempo*© boars where the boars' semen was pooled together.

H_1: The genetically improved *Topigs Tempo*© boar improved the growth performance and carcass characteristics of the resultant homospermic progeny compared to the growth performance and carcass characteristics of the heterospermic progeny from multiple standard *Topigs Tempo*© boars where the boars' semen was pooled together.

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Chapter 2

Literature review

2.1 Introduction

Pigs belong to the order Cetartiodactyla (Novacek, 2001) and the genus *Sus,* with *Sus scrofa* being the fundamental ancestor of domesticated pigs (Groves, 1981) and a natural inhabitant of most parts of Europe and Asia. The species *Sus scrofa* consists of 16 subspecies and, as a consequence, exhibits great variability in the majority of its traits studied (Ruvinsky *et al.,* 2011). Genetic and phenotypic variation in the domesticated pig allows individuals to adapt to certain environmental conditions and enables the development of pig lines and breeds with distinct characteristics from which improvements in growth performance and carcass characteristics can be realised in the breeding industry (Groenen *et al.,* 2011).

Genetic improvement resulted in the development from the wild pig to the domestic pig of today. As time progressed, breeding focused more on the development of specific characteristics, specialised breeds and lines (Table 1). The development of genetics as a science introduced a more scientific approach to the original empirical methods of the genetic improvement of pigs (Dekkers *et al.,* 2011). Artificial insemination (AI) facilitated the dissemination of these genetic improvements across countries and from the nucleus to the commercial level (Visser, 2004).

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Table 1 Summary of the main events and breeding objectives in the pig industry since 1900 up to 2014 (Haley *et al.*, 1986; Knol, 1998; Meuwissen, 1998 and Visser & Hofmeyr, 2014)

Period	Event	Emphasis
1900-1950	Herdbook initiated in Europe	Docility
	Central testing initiated in Denmark	Colour
	Focus on purebred selection	Size
	Producers rewarded for fat and manure	Backfat thickness
	Selection indices introduced	Feed efficiency
		Daily gain
1950-1990	Cross-breeding	Backfat thickness
	Pig breeding companies established	Feed efficiency
	Separate sire and dam lines	Daily gain
	Index selection	Litter size
	Family selection in dam lines	
	Nucleus, multiplier and commercial farms established	
	Introduction of AI	
1990-1999	Genetic progress in sire and dam lines	Daily gain
	Best Linear Unbiased Prediction (BLUP) application	Feed efficiency
	Molecular genetics introduced	Litter size
	Strategies to overcome GxE interaction and inbreeding	Meat quality
		Piglet vitality
2000+	Breed for more efficient production	Daily gain
	High health herds	Feed efficiency
	Health of pigs more important	Litter size
	Quality of product more important	Meat quality
	Success of industry judged by consumer	Piglet vitality
	Animal welfare and integrity important	Sow longevity
	Consumer concern about housing	Disease resistance

This literature review aims to:

a. Discuss the genetic improvement of pigs through selection, breeding objectives and breeding programmes.
b. Discuss the fertility of boars in an artificial insemination centre and the use and effect of heterospermic and homospermic insemination on reproduction performance.
c. Give an overview of the main factors in this study that may affect growth performance in pigs.

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2.2 Genetic improvement of the pig

To achieve genetic improvement, breeding objectives reflecting the respective needs of the industry and the consumer are set (Dekkers *et al.*, 2011). The general trend in the breeding objectives of the pig industry is a change in focus on performance traits to carcass yield and quality (Van Wijk *et al.*, 2005). Initially, genetic improvement programmes in South Africa gave prominence to parameters such as feed conversion efficiency and feed intake. Driven by a need to change from a production oriented breeding programme to a programme that focuses on productivity and sustainability, the importance of sow productivity increased and is now included in selection indexes (Dube *et al.*, 2013).

Artificial selection is currently the most common form of selection for traits that are sex limited or have a low heritability. This selection process consists of a combination of visual appraisal, pedigree and performance records (best linear unbiased prediction (BLUP)), marker assisted selection (MAS) and progeny testing (Visser & Hofmeyr, 2014). Well-planned breeding objectives with appropriately allocated economic weights, a conscientiously selected breeding programme and procurement of genetically superior animals all determine the success of pig breeding (Visser & Hofmeyr, 2014). The selection of new animals to enter a breeding herd is crucial to the continued success of a breeding programme and selected animals should ideally perform better than the animals currently occupying the breeding herd. Selection for specific traits in a breeding herd is accomplished by genetic evaluation of the animal (Whittemore, 2006; Dekkers *et al.,* 2011). Such evaluation is dependant upon the heritability of the trait of interest and the number of observations for a specific sire or dam that in turn (Dekkers *et al.*, 2011), depends on observations based on records of parents, offspring and relatives such as half-sibs or full-sibs (Robinson & Buhr, 2005).

South African breeding programmes implement crossbreeding using specific sire and dam lines (Ollivier, 2008; Dekkers *et al.,* 2011; Dube *et al.*, 2013). Separate genetic improvement programmes exist for these specific lines and breeding programmes are used to predict estimated breeding values (EBV's) for the sires and dams included in a line (Dube *et al.*, 2013). Breeding objectives are defined respectively for the sire and dam lines. For dam lines, emphasis is placed on sow productivity (Dube *et al.*, 2013), including female reproduction traits such as age at puberty, conception rate, litter size, number weaned, piglet survival and weaning to oestrus interval (Dekkers *et al.*, 2011). Terminal sire lines are selected for production performance (Dube *et al.*, 2013) and traits such as growth rate, feed conversion, conformation, carcass quality and meat quality (Dekkers *et al.*, 2011).

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After genetic improvement at the nucleus level, genetic changes are disseminated to the multiplier and commercial levels by means of artificial insemination (AI) (Visser & Hofmeyr, 2014). Artificial insemination using fresh semen was developed for the pig industry during the late 1960's (Visser *et al.,* 2014). The development of AI enabled genetics to be disseminated across countries, creating an opportunity for the future establishment of multinational breeding programmes. Also, artificial insemination minimises the genetic lag between generations of pigs connecting the nucleus and commercial level (Dekkers *et al*., 2011).

2.2.1 Nucleus herds

Selection of boars and sows to enter a nucleus herd should be governed by the genetic potential of the pig, the heritability of a trait and a suitable selection strategy. Nucleus herds should formulate selection strategies based on the present and anticipated needs of their consumers. Such needs include those of the multiplier herds, commercial herds, meat processing companies and the buyer of the final product. On top of selection for production traits, a nucleus herd has to select for factors such as conformation, temperament, sperm quantity, quality and hardiness that will enhance its own efficiency. Ultimately, the nucleus herd should appraise genetic advancements made through selection strategies by reviewing its genetic evaluation results and progeny records (Robinson & Buhr, 2005).

Visual appraisal is an important means of artificially selecting an animal for a breeding programme in a nucleus herd and is an important attribute to the evaluation of a breeding animal. An animal that has excellent breeding values will not and should not reproduce if it displays any physical deformities. Table 2 shows the conformational characteristics taken into consideration when selecting animals based on visual appraisal (Visser, 2014).

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Table 2 Conformational characteristics taken into account during visual appraisal when selecting animals for breeding herds (Visser, 2014).

Characteristic	Appraisal
Skeletal soundness	Skeleton should support the animal.
Reproductive soundness	Gilts: Prolificacy, mothering ability and wean to conception interval. Boar: Semen production, quality and morphology. Libido, testis size, litter size and 21-day weight of daughters.
Mammary soundness	Sow: Number of teats and functional teats Boar: Trim, firm and straight underline
Body defects	Avoid animals with, or originating from animals with, genetic defects
Head and neck	Light head and neck, balanced and true to type
Shoulders and chest	Light in relation to hams with a wide chest
Middle	Depth of body, well sprung ribs for increased vigour
Back and loin	Wide, long, firm and well fleshed
Ham and rump	Wide, full and long with a high tail setting and good angle of the rump.

2.2.1.1 Sire lines

Nucleus herds define the breeding objectives for sire lines according to consumers' preference. Internationally, consumers buy pigs mostly for meat or replacement gilts, and so, sire lines are selected to produce offspring that will meet market demands for fast growth, improved efficiency and good quality meat. Different nucleus herds or artificial insemination (AI) stations in different countries may however, have different breeding objectives that reflect the emphasis of their specific product line or the economic position of the market their genetics is designed to supply (Robinson & Buhr, 2005). Robinson & Buhr (2005) are of the opinion that selection strategies for boars are universal. These strategies are based on genetic evaluations for the economically important traits for which the boars are selected. Traits of importance that are currently emphasised in sire lines (Visser & Hofmeyr, 2014) are as follows:

- High rate of lean tissue deposition
- Less feed required to deposit a unit of lean tissue (Feed conversion ratio (FCR))
- Low backfat thickness as measured with a P2 backfat meter
- Good lean meat percentage (LMP)
- Good dressing percentage

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- High libido
- Good and consistent semen quality and production
- Sound legs
- Masculine conformation and features
- Low stress levels
- Reproduction traits (minimal pressure)

Apart from measuring the phenotype and computing the estimated breeding value (EBV) of a boar, nucleus herds may also compute specialised indices reflecting the company's specific product line (Robinson & Buhr, 2005). Selection of a boar should, however, not be based on its EBV alone but also on its ranking compared to other boars within a herd. It follows that boars selected on the basis of their EBV's undergo screening to identify any other factors affecting their suitability for AI such as conformation, defects, health status and customer preference. Even though each nucleus herd has a different screening method, the general approach is to review the boars' EBV and test results for specific genes, perform a visual inspection of the boar and evaluate the nucleus herd's product line. This screening procedure assists in distinguishing between boars of close to equal genetic merit (Robinson & Buhr, 2005). Companies such as *TopigsSA*© make use of a TSi (Topigs selection index) as well as visual appraisal to select the best boars to enter the AI station. Lastly, the boars' semen quality is tested before entering the AI station (Mostert, 2014). In order to achieve maximum genetic progress in economically important traits, EBV indices should remain the focus during selection decisions on whether to include a boar in a nucleus herd or not. After entering the nucleus herd, a boar will then be replaced as soon as a younger boar with a superior EBV or index is available.

For companies such as *TopigsSA*©, a boar that meets all the abovementioned criteria enters the AI centre along with ca. 100 other boars. Its semen is collected every two weeks and upon collection, the semen is tested for concentration and motility using computer assisted semen analysis (CASA) (Mostert, 2014). The semen is then pooled with the semen from two to three other boars in the same sire line as the boar itself and sold to the client as a heterospermic semen sample (Mostert, 2014). Semen volume, concentration and gross morphology are considered to be the most important semenal traits to affect the profitability of an AI centre (Robinson & Buhr, 2005). Poor quality semen is one of the reasons an AI centre will cull a boar with valuable genetics. Robinson & Buhr (2005) stated that a boar's productivity depends on the number of spermatozoa it produces per week. Furthermore, the authors are of the opinion that fertility is of secondary

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importance since it only seems to become a hindrance when several clients complain about one boar's poor conception rates or small litter sizes.

2.2.1.2 Dam lines

Gilts for dam lines are selected in a similar manner to boars. However, the traits that are emphasised differ from that of the boar and are as follows (Visser & Hofmeyr, 2014):

- Fertility
- Mothering ability
- Milk production and pre-wean piglet growth
- Minimal loss of body reserves during lactation
- Short wean to conception interval
- Strong heat cycles
- Skeletal strength
- Sound legs
- Sound sex organs
- Temperament
- Level of stress
- High average daily gain (ADG), good feed conversion ratio (FCR) and lower P2 backfat thickness within realistic physiological restrictions

2.2.2 Breeding strategies

Nucleus herds have different breeding strategies in order to breed animals suitable for producing progeny that have all the desired traits to become a good quality carcass. A few of the crossbreeding systems in practice are the cross-breeding system using two breeds (criss crossing), the terminal cross-breeding system using three breeds or the rotational cross-breeding system using three breeds (Visser & Hofmeyr 2014).

Nucleus herds in South Africa, and probably world wide, such as Topigs, Kanhym and PIC mostly utilise the terminal crossbreeding system. Several purebred dam lines are crossed to produce a hybrid F1 gilt. Heterosis is further exploited by introducing a terminal sire breed or synthetic line. The F1 gilt is sold to the commercial pork producer along with the heterospermic semen sample from the sire line. The commercial pig producer then inseminates the sows to produce the three-way-cross market pig for slaughter (Mostert, 2014; Visser & Hofmeyr 2014).

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2.3 Selection of boars based on their semen characteristics and the use of heterospermic and homospermic insemination

2.3.1 Assessment of male fertility

The detection of differences in fertility between males is of importance to AI organisations, breeders and producers. Madsen *et al.* (1992) stated that the fertility between males differ in ways not exhibited by the male's libido or dominance. These differences are attributable to inherent variation and environmental effects (Dziuk, 1996). Customarily, male animals are selected based on their fertility, which is assessed by utilising a number of semen evaluation tests that take into consideration the various parameters believed to affect semen quality and fertility. Among others, these parameters include the motility and morphology of the spermatozoa, conception rate, litter size and *in vitro* penetration of the oocyte. Conventional *in vitro* evaluation of fertility to identify highly fertile boars is, however, inaccurate due to its high sensitivity to individual variation (Macedo *et al.*, 2006). The low correlation that exists between *in vitro* and *in vivo* performance (Dyck *et al.*, 2011) and the fact that these assessments of fertility are mostly subjective is because they are often made by gross and random observation of the candidate male (Dziuk, 1996). Litter size and conception rate on the other hand are considered by breeders and producers to be the pivotal standards by which to compare the fertility of males. Yet, Dziuk (1996) specified that these parameters are not reliable as the variation that exists between females; inseminators and managers may affect the measure of fertility within and between males.

A more accurate and objective means of assessing male fertility is through heterospermic insemination (Stahlberg *et al.*, 2000) which, also referred to as competitive fertilisation, pertains to the practice of mixing equal numbers of spermatozoa from more than one male into one insemination dosage (Saacke, 1982) (Dziuk, 1996). A female is then inseminated with this mixture within a timely manner approaching ovulation. Homospermic insemination on the other hand, refers to the practice of inseminating a female with the spermatozoa from a single male, also within a timely manner approaching ovulation (Saacke, 1982).

2.3.2 The use of heterospermic insemination in commercial herds

Most, if not all, commercial pig farms make use of heterospermic insemination to produce market pigs for slaughter. Commercial farmers and breeding companies alike reason that the use of heterospermic semen samples on a commercial level is beneficial since it compensates for individual differences in fertility between boars (Stahlberg *et al.*, 2000) and prevents a decrease in performance when conducted with stored semen (Haugen *et al.*, 2005). Heterospermic

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insemination is also believed to increase litter size, prevent commercial farmers from breeding their own lines and act as an insurance policy in case one boar, for whatever reason, performs below what is expected without detection (Mostert, 2014). Whether heterospermic insemination truly confers these benefits to a commercial herd is questionable. The use of heterospermic insemination in a commercial system results in anonymity of a piglets' paternity (Stahlberg *et al*., 2000). Consequently, subfertile boars in AI centres cannot be identified (Foxcroft *et al*., 2008) making the benefits of using heterospermic insemination debatable (Stahlberg *et al*., 2000).

Regardless, it has been confirmed in numerous research papers that heterospermic insemination may indeed have its uses at a nucleus level since it allows spermatozoa to naturally compete within one female and have an equal chance to fertilize the ovum (Dziuk, 1996). This makes heterospermic insemination the ideal method to assess male fertility and rules out any possible confounding effects brought about by factors affecting fertility results such as variation in females, season or inseminator skills (Stahlberg *et al*., 2000), and allows an opportunity to more clearly identify the components of semen quality (Saacke, 1982). In addition, males can be ranked based on their heterospermic performance using a heterospermic index of fertility (Beatty *et al*., 1969). Ferreira *et al*. (2014) proposed that homospermic insemination instead of heterospermic insemination be used on a commercial level since its use will increase the number of piglets sired by any individual boar, maximising the boars' contribution to herd composition.

2.3.3 The relationship between homospermic insemination, heterospermic insemination and reproduction performance

By studying the relationship between homospermic and heterospermic performance of boars, Martin & Dzuik (1977) found that boars that performed better homospermically, performed even better heterospermically. Stahlberg *et al*. (2000) performed a similar study in boars and found that when tested homospermically, the boars performed identically to one another, but when tested heterospermically, the one boar sired more offspring. Considering the results of the above-mentioned studies, Saacke (1982) and Dziuk (1996) concluded that heterospermic performance delineates a magnified homospermic performance.

Studies involving heterospermic inseminations, frequently resulted in a disproportionate number of offspring sired by each male included in the experiment (Saacke, 1982; Ferreira *et al*., 2014). In a study conducted by Overstreet & Adams (1971), the paternity of the offspring from heterospermic matings was in agreement with the proportion of spermatozoa from each male that

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fertilized the ova. They also found the spermatozoa from the male with the most offspring to be the predominant spermatozoa throughout all parts of the female reproductive tract. Ferrari & Graves (1972) performed a similar experiment on rabbits and concluded that the disproportionate amount of spermatozoa from each male at the site of fertilisation was due to the female reproductive tract preferentially promoting the retention and transport of one male's spermatozoa over another. Saacke (1982) stated that this effect of the female reproductive tract on a population of spermatozoa is not understood but that the assumption can be made that some form of selective transport occurs which would promote the preferential transport of morphologically normal spermatozoa. The author reckoned that the inherent feature of the female tract to retain or transport a portion of the spermatozoa could be considered to be the most important factor governing the heterospermic performance of males (Saacke, 1982).

These results suggest that heterospermic insemination provides information on sperm survival, competition and the timing of events pertaining to fertilisation in the female reproductive tract (Stahlberg *et al.,* 2000). Even though the detection of abnormal semen samples can be accomplished with computerized semen evaluation tests, Holt & Van Look, (2004) questioned why, when faced with two normal, fertile semen samples, one sample is apparently more capable of fertilising ova than the other.

Dziuk (1996) may have answered Holt & Van Look's question because he postulated that within an ejaculate, spermatozoa carrying different alleles would compete with one another. Beuhr & McLaren (1984) studied the progeny of a chimeric male. They found that the time interval from insemination to ovulation affected the number of progeny sired by each cell line within the male's ejaculate. Pre-ovulation, one cell line sired 80% of the offspring, while post-ovulation, the same cell line sired only 20% of the offspring. Taking this into consideration, reasoning may suggest that the motility of spermatozoa is not the only parameter influencing the heterospermic performance of a semen sample, but rather that the time of insemination, the female reproductive tract and the quality of the semen sample all play a role in determining the reproductive performance of a male.

Evolutionary biologists link the selection of spermatozoa to the inheritance of superior fitness traits (Holt & Van Look, 2004). It is assumed that the single spermatozoon that fertilises the ovum has to undergo a stringent selection process, and since the female cannot assess the spermatozoa's DNA quality, that the selection of spermatozoa has to be based on the phenotype and function of the spermatozoon. However, Yasui (1997) states that at least some females can

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choose a spermatozoon that will confer genetic benefits to the offspring and does so by assessing the genetic quality of each male. Zeh & Zeh (2001) proposed that this assessment is based on the major histocompatibility antigen and that females choose spermatozoa with immunologically compatible characteristics, while Wakimoto (1979) found the female newt's oocyte to select the best pronuclei based on its DNA quality. Pizzari & Birkhead (2002) suggested that the female may not be the only factor responsible for the selection process, but that sperm function and fertility are affected by 'fertilisation efficiency genes' that confer the required effects when needed, and therefore supply a certain male's spermatozoa with the necessary stimulus to achieve fertilisation.

Another astonishing consideration is that a single ejaculate is composed of several subpopulations of spermatozoa with each subpopulation reacting differently to external activators. These differences in reaction may be another reason for the reproductive skews detected in heterospermic inseminations. Holt & Harrison (2002) detected heterogeneous responses to external activators in pigs. They observed certain subpopulations to respond differently to bicarbonate in the female reproductive tract and concluded that these differences may well give certain subpopulations an advantage and are responsible for the disproportionate ratio of spermatozoa in the oviduct during heterospermic insemination. Also, Ferreira *et al*. (2014) observed boars with a high fertility index (as determined homospermically before entering the AI station), to behave as if they were subfertile when used heterospermically. They also found a negative, unfavourable correlation between in vitro penetration rate of the oocyte and percentage of a litter sired by the boar in question. They concluded that marginal differences in fertility not detected with homospermic insemination would be exacerbated with heterospermic insemination. Since paternity tests are unfeasible at a large-scale commercial level, it is unlikely, however, that these differences in fertility would be detected.

Furthermore, if only 10% of capacitated spermatozoa in the oviduct are responsive to chemotactic and thermotactic signals from the female reproductive tract (Eisenbach, 1999), then Holt & Van Look (2004) justifiably warned that, given the low percentage of spermatozoa in a single ejaculate that are functionally significant and capable of fertilisation, most spermatozoa are somehow functionally flawed. It becomes evident then that measures of fertility based on flagellar length, average path velocity and motility of the spermatozoa in a homospermic semen sample are poor, uninformative predictors of fertility, especially when semen is used heterospermically (Holt & Van Look, 2004).

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In conclusion, the value of heterospermically inseminating sows that produce terminal offspring has no clear practical application aside from providing an opportunity for the more fertile male of a pair to fertilise an ovum (Beatty *et al.*, 1969). Notwithstanding, heterospermic insemination may still be beneficial in a nucleus herd to assess the fertility of prospective breeding boars with superior genetic traits. Genetic selection for boars with superior heterospermic performance should benefit the conception rates and litter sizes in a commercial herd. Also, more consideration has to be given to subpopulations of spermatozoa in an ejaculate. Heterospermic insemination may allow a better understanding of the mechanism of naturally imposed selection on spermatozoa. A laboratory test that best fits the accurate assessment of the fertility of spermatozoa, within and between ejaculates, can then be created (Holt & Van Look, 2004). More recently, Ferreira *et al.* (2014) found that farrowing rate, total litter size and fertility index were similar for both artificial insemination (AI) methods and concluded that homospermic insemination can be used in routine farm conditions without any adverse effects on reproductive performance.

2.4 Growth and body composition changes

2.4.1 Changing the shape of the growth curve

The shape of the growth curve is intrinsic to each individual pig; however, genetic selection may change the shape of the curve within a population. Continued selection for increased lean tissue production results in an increase in the final weight and rate of gain of the population. Given the consequences of selection for increased lean tissue, it may be said that the pig industry is steadily increasing the size of pigs and delaying the attainment of maturity. Consequently, the nutritional and environmental requirements of the pig are in a perpetual state of change. Inevitably the industry continuously needs to adapt to these changes in requirements, which includes a higher maintenance requirement, larger space requirements, adjustments in optimum slaughtering weight and breeding practices to name a few (Whittemore & Kyriazakis, 2006).

2.4.2 Growth curves

Growth is defined as the process whereby animals increase in physical size and maturity, and is driven by the animal's current size or mass, age and nutrient supply. Growth can be measured by an animal's average daily gain (ADG), which is commonly used as a measure of the animal's efficiency (Whittemore & Kyriazakis, 2006).

When observing the differences between the growth curves of pigs with differing genetic potential (van Milgen *et al.*, 2012), genetically improved pigs selected for higher lean gain have

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larger final weights and higher growth rates than unimproved pigs. Since time at maturity and birth weight do not exhibit as much variation as final weight and growth rate, this leads to the conclusion that final weight and growth rate are positively correlated and selection for the latter will increase the former and vice versa (Whittemore & Kyriazakis, 2006).

The sigmoidal growth curve is more often than not interpreted incorrectly and the notion that achievable growth rate is related to body mass already attained is erroneous (Whittemore & Kyriazakis, 2006). Also, the much greater final weight of the improved pig can not only be attributed to a heavier birth weight but rather also to genetic improvement of the pig's growth potential (Whittemore, 2006). Owing to the fact that piglets fed ad lib gain weight at a rate above that which is possible from the sow's milk supply alone, the sudden increase in growth rate post-weaning may suggest that the animal has been released from a nutritionally limiting period. The potential growth rate of the pre-weaned piglet in an unlimiting environment has been shown to be 600g daily. However, the pig industry seems incapable of exploiting these growth rates and the steady decrease in growth of the piglet approaching weaning is evidence of a lack of feed supply and the inability of the sow's milk production to keep up with the requirements of her litter. This theory was substantiated when piglets at Edinburgh attained 12kg live weight at 28 days of age, seeing that the average 28-day weight for piglets in the commercial pig industry is a meager 8-9kg. (Whittemore & Kyriazakis, 2006)

2.4.3 Protein and lipid growth

Protein accretion is an efficient process, and the maximization thereof is of great consequence in the pig industry (van Milgen *et al*., 2012; Visser & Hofmeyr, 2014). The maximum amount of protein accretable in an individual pig is assumed to be attained when nutrition and environment is unlimiting. However, creating an unlimiting environment within commercial conditions is a challenging feat and, for the most part, whether the pig's nutrition and environment is truly unlimiting is up for debate (Whittemore & Kyriazakis., 2006).

Whittemore (1986) described a model to determine the forces that result in tissue growth. The model represents daily rates of lean and fat tissue growth in response to the animal's daily feed intake. As daily feed intake increases, lean tissue gain increases linearly at a lower, but fairly parallel, rate to fat tissue gain. When lean tissue gain plateaus, fat tissue gain continues to increase so the animal effectively becomes less efficient as they grow older. It is important to note that the point at which lean gain plateaus depends on the animal's genetic potential for lean gain.

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Before lean gain plateaus, animals are said to be nutritionally limited because most of the available energy is used for lean tissue deposition (Whittemore & Kyriazakis, 2006; van Milgen *et al*., 2012). This limitation is typical of scaled feeding systems, where animals are fed at a level that allows maximum lean gain but does not allow excessive fat tissue deposition beyond that which is recognized as physiologically normal. Feed intake is measured to meet the pig's daily requirement according to its weight and age. Scaled feeding can be achieved by adjusting the volume of the feed consumed on a daily or weekly basis, but for simplicity's sake, it is usually accomplished by adjusting the nutrient content of the feed. Ultimately, commercial systems make use of multiple diets, scaled to a common level and fed during different stages of growth to meet the requirements of the pig at that time in the growth curve (van Milgen *et al*., 2012; Viljoen, 2014).

After lean gain plateaus, animals become nutritionally unlimited because they consume energy beyond what is needed for maximum lean tissue gain. The additional energy is partitioned towards fat tissue gain and consequently, the animals grow less efficiently. This is typical of ad lib feeding systems where pigs are allowed to consume feed to appetite, which is much more than what is required for growth (Fowler *et al*., 1976 & Whittemore, 1986). High feed intakes, an imbalanced diet, or attainment of mature lean mass will result in increased fat deposition (Whittemore & Kyriazakis, 2006).

A pig carcass usually consists of 66% lean tissue, 23% fat and 10% bone. It is a fact that all animals become fatter as they grow and increase in size and tend to gain fat most rapidly before 28 days of age (Whittemore & Kyriazakis, 2006). However, the process of fattening may commence at different points along the growth curve, being dependent upon sex, level of nutrition and genotype of the animal, with the highest levels of fat seen in the unimproved castrate, followed by the female and lastly, the improved male. At any given weight, pigs of improved genotypes have less fat and more lean tissue. Genetic selection for increased lean tissue gain has resulted in the modern improved pig with the ability to attain a mature protein mass of 35 to 55kg. Fatness in the genetically improved pig is directly related to feed intake since pigs that are restricted in their daily feed intake can attain a carcass fatness of as little as 12 - 15% at 100 - 110kg, while unimproved males may achieve lipid levels as high as 25% at the same final weight (Whittemore & Kyriazakis, 2006).

Despite the universal ambition of the pig industry to achieve maximum lean gain, the optimum fat to lean ratio varies among world markets and presently, Europe, North America and

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South Africa prefer a lipid to protein ratio of 1:1 with a live weight of 80-110kg at slaughter, which may be realised in improved pigs. Other countries, such as Italy, prefer heavier and fatter pigs, with a lipid to protein ratio of 2:1, for ham production, which is typical of unimproved pigs.

It follows that growth is a dynamic process and the genetic merit for lean growth and the nutrient requirements for maximum lean gain may differ widely between two animals, depending on selection within the nucleus herd and the genetic potential for lean gain of the animal. The aforementioned is true for different sexes (Eissen, 2000), where boars may require more feed to achieve maximum lean gain, but can also be true among individuals of the same sex, breed or genetic strain (van Milgen *et al*., 2012). Therefore, it is important to include these differences within selection indices and breeding programs to improve genetic potential for lean gain and efficiency.

2.4.4 Growth response to feed supply

The energy requirements of the animal determine its feed intake and are dependent upon sex, genotype, environmental temperature and stocking density. The grower pig can only grow to its potential if energy supply is sufficient and if lysine is present in the correct ratio relative to the energy supply (Viljoen, 2014). These requirements change as soon as genetic improvements in the sire and dam lines are achieved. Knap (2005) states that advances in nutrition and management are required when the genetic potential of a pig increases; however, these advances are often overlooked.

The rate and maximum potential of protein deposition depends on the pig's genetic potential and sex, where males and genetically improved pigs naturally have higher daily protein deposition rates than females, castrates or unimproved pigs. Genetically improved pigs may require a higher feed supply in order to achieve maximum lean deposition in line with their genetic potential (Whittemore, 2006) and the differences in ability to deposit lean tissue needs to be taken into consideration when diets are formulated (Viljoen, 2014). It follows that in growth trials with the aim of determining a pig's growth potential, pigs need to be fed above requirement to determine whether it is indeed of an improved genotype with superior lean growth potential.

2.4.5 Feed additives

Two common feed additives used in the pig industry include Ractopamine hydrochloride and Tylosin. Ractopamine hydrochloride (more commonly known as Paylean) is a β-adrenergic agonist that directs nutrient usage away from fat gain and towards lean muscle gain. It follows that Paylean

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is included in commercial finishing rations during the last 28 to 35 days before slaughter and successfully improves live growth performance and carcass leanness (Watkins *et al.*, 1990; See *et al.*, 2004).

Tylosin (also known as Tylan) is a widely used antimicrobial growth promoter of the macrolide family and is included in pig grower and finisher rations at therapeutic doses. Concerns of antimicrobial resistance and the greater environmental impact of Tylosin residues in slurry and crops may result in the banning of this product in the future (See *et al.*, 2004; Marshall & Levy, 2011; Kim *et al.,* 2012).

2.4.6 Sex

Entire males deposit more lean tissue than gilts and castrates (Whittemore & Kyriazakis, 2006; De Lange *et al.*, 2012) and can maintain this rate for longer throughout the grower phase (de Lange *et al.*, 2012). The composition of gain is also affected by sex since castrates grow faster than females but have less lean gain. As animals grow older, fat deposition increases with females being fatter than entire males. Split sex feeding therefore has its merits and pigs are expected to utilize their feed more efficiently when fed according to sex (Viljoen, 2014).

2.4.7 Temperature

Feed consumption is commonly influenced by the effect of ambient temperature on the pig itself. Pigs in cold temperatures (12^{o}C) consume higher volumes of food within the limits determined by stomach capacity (Quiniou *et al.*, 2000; Viljoen, 2014). Pigs in hot temperatures (24^{o}C) consume less feed per meal and this response becomes more pronounced as the pigs grow heavier (Quiniou *et al.*, 2000; Viljoen, 2014). Growth rate and feed efficiency are both negatively affected by extremes in temperature and nutritionists need to consider the temperature extremes on a farm before formulating the feed (Viljoen, 2014).

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Chapter 3

Materials and methods

In this study, a progeny test was conducted using three groups of *Topigs-40*© sows inseminated with either heterospermic or homospermic semen samples from the same *Topigs Tempo*© boar line. It should be noted that even though *TopigsSA*© rank their boars according to EBV's, the exact EBV's of the boars used in this study could not be obtained. Consequently, it was assumed that the pooled semen samples were indeed from the two (occasionally three) best boars in the *Topigs Tempo*© line during the time at which this study was conducted. The homospermic semen sample came from a specific boar that is believed to exhibit outstanding growth performance of 1.47kg per day. The study was conducted at the request of *TopigsSA*© with the required ethics approval of the Animal Ethics Committee (AEC) of the University of Pretoria, project number: EC089-13.

The experiment was carried out at Walt Landgoed© piggery in Bela Bela during the summer time (September 2013 to January 2014). All activities pertaining to the *Topigs-40*© sows and progeny up to 21 days old were carried out at a farrowing unit at Walt Landgoed© piggery, Bela Bela, Settlers, Leeukuil. All activities pertaining to the progeny older than 21 days were carried out at a grower unit at Walt Landgoed© piggery, Bela Bela, Settlers, Meisjesvlei. Walt Landgoed maintains a high health herd and the animals in this study were housed, fed, medicated, vaccinated and transported according to commercial high health herd standards.

3.1 Materials

3.1.1 Animals

3.1.1.1 Boars

In this study, the *Topigs Tempo*© sire line, bred from the TOPIGS E-line (Large White type) was used. The semen was obtained by Walt Landgoed© from *TopigsSA*© where the semen from the 2 (occasionally 3) best boars in the AI centre were pooled together to create the standard *Topigs Tempo*© heterospermic semen sample. This is the same semen sample that is being sold to commercial pig producers for use on their farms. The semen from the specific boar was kept separate as a homospermic semen sample, and was not mixed with any other semen. Effectively, this study compared the growth performance of the progeny from this genetically improved *Topigs Tempo*© boar with that of the progeny from several standard *Topigs Tempo*© boar's semen pooled together. The *Topigs Tempo*© sire line is said to produce progeny that has excellent loins and tender meat as well as high disease resistance, feed intake and growth performance under

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challenging conditions. The *Topigs Tempo*© sire line is a popular choice in South African commercial pig farms due to the abovementioned attributes, as well as including qualities such as a high number of born-alive piglets per litter, and robust, uniform, fast-growing progeny suited for restricted- and liquid-feeding systems.

3.1.1.2 Sows

In this study the *Topigs-40*© dam line was used. These sows are F1 animals based on the A-line and B-line at the Topigs nucleus herds and are claimed to be robust, have a high feed intake capacity and number of parities per sow, are good in showing oestrus, and produce robust progeny with a good meat percentage. The *Topigs-40*© sows at Walt Landgoed© were randomly inseminated by the inseminator as per routine procedure. The sows were therefore either inseminated with the standard, heterospermic *Topigs Tempo*© semen sample, or with the homospermic *Topigs Tempo*© semen sample tapped from the single, genetically improved boar. After the gestation period, the sows were moved to the farrowing crates to farrow.

3.1.1.3 Selection of sows

It is important to note that the sows on this farm are divided into groups to facilitate an all-in all-out system. Each group occupies one farrowing house and the groups are inseminated, and therefore farrow, at two-week intervals. For the purposes of this study, three farrowing houses were used to select 42 sows from each house. Consequently, all the activities that were conducted on the first group of sows (Group 1) were repeated two weeks later on the second group (Group 2) and again, two weeks later on the third group (Group 3). In this chapter, the activities for Group 1 will be explained which will then be applicable to all three groups used.

From Group 1, 42 *Topigs-40*© sows were selected on the basis of parity and litter size (Table 3). Half of the sows from Group 1 (21 sows) were inseminated with the standard, heterospermic *Topigs Tempo*© semen sample, and the other half (21 sows) were inseminated with the homospermic *Topigs Tempo*© semen sample. After farrowing, only sows with a parity of up to five and a litter size between seven and 16 were included in the study. The progeny from these sows were tagged at birth to distinguish the standard, heterospermic *Topigs Tempo*© progeny from the genetically improved *Topigs Tempo*© progeny. The progeny from the selected sows were cross-fostered to eliminate sow effect within the house. Table 3 shows all the information pertaining to the litter sizes and parities of the sows in the three different farrowing houses.

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Table 3 Data pertaining to the litter sizes and parities recorded from the sows in the three respective groups

			Parity				Litter size			
Group	Boar used	Nr of sows	Ave	Min	Max	St. dev.	Ave	Min	Max	St. dev.
1	Improved	21	3.381	2	5	0.740	13.190	9	16	2.358
	Standard	20	3.450	2	5	0.826	12.750	10	16	1.888
2	Improved	21	3.286	2	5	1.056	13.762	10	17	2.143
	Standard	21	3.429	2	6	1.399	11.952	7	17	2.459
3	Improved	20	3.150	2	5	0.813	13.250	10	16	1.517
	Standard	20	2.100	1	6	2.024	11.889	6	16	2.632

3.1.1.4 Progeny included in the trial: pre-wean

The progeny from the selected sows included in the study were subjected to the same treatment (tail docking, iron injections and vaccinations) as all the other progeny from the remaining sows in the house. Teeth were not clipped and male piglets were not castrated, as these are not routine practices on the farm. The progeny from the 42 sows were weighed one day before weaning at 21 days old. At 21 days, the piglets were loaded onto a truck and transported to the grower farm at Meisjesvlei.

3.1.1.5 Progeny included in the trial: post-wean

Upon arrival at the grower farm, the pigs were moved into a weaner house. As mentioned earlier in this chapter, there were three groups of 42 sows and each group was inseminated and farrowed two weeks apart from each other. Therefore, three weaner houses were stocked with pigs at two-week intervals. The pigs remained in the weaner house for eight weeks or until they were 11 weeks of age (77 days). All pigs were subjected to the same treatment within the weaner house and were phase-fed three different standard commercial weaner rations ad lib according to age. After 11 weeks of age the pigs were moved from the weaner house to the grower house.

In summary, there were three groups of *Topigs-40*© sows inseminated two weeks apart from each other. Half of each group were inseminated with a standard, heterospermic *Topigs Tempo*© semen sample and the other half of each group were inseminated with the semen from a genetically improved, homospermic *Topigs Tempo*© boar. Each group of sows was housed in a separate farrowing house. The three groups farrowed two weeks apart from each other and so the progeny from the three houses were transported to the weaner houses and moved to the grower houses at two-week intervals. Figure 3 on the following page illustrates the steps followed.

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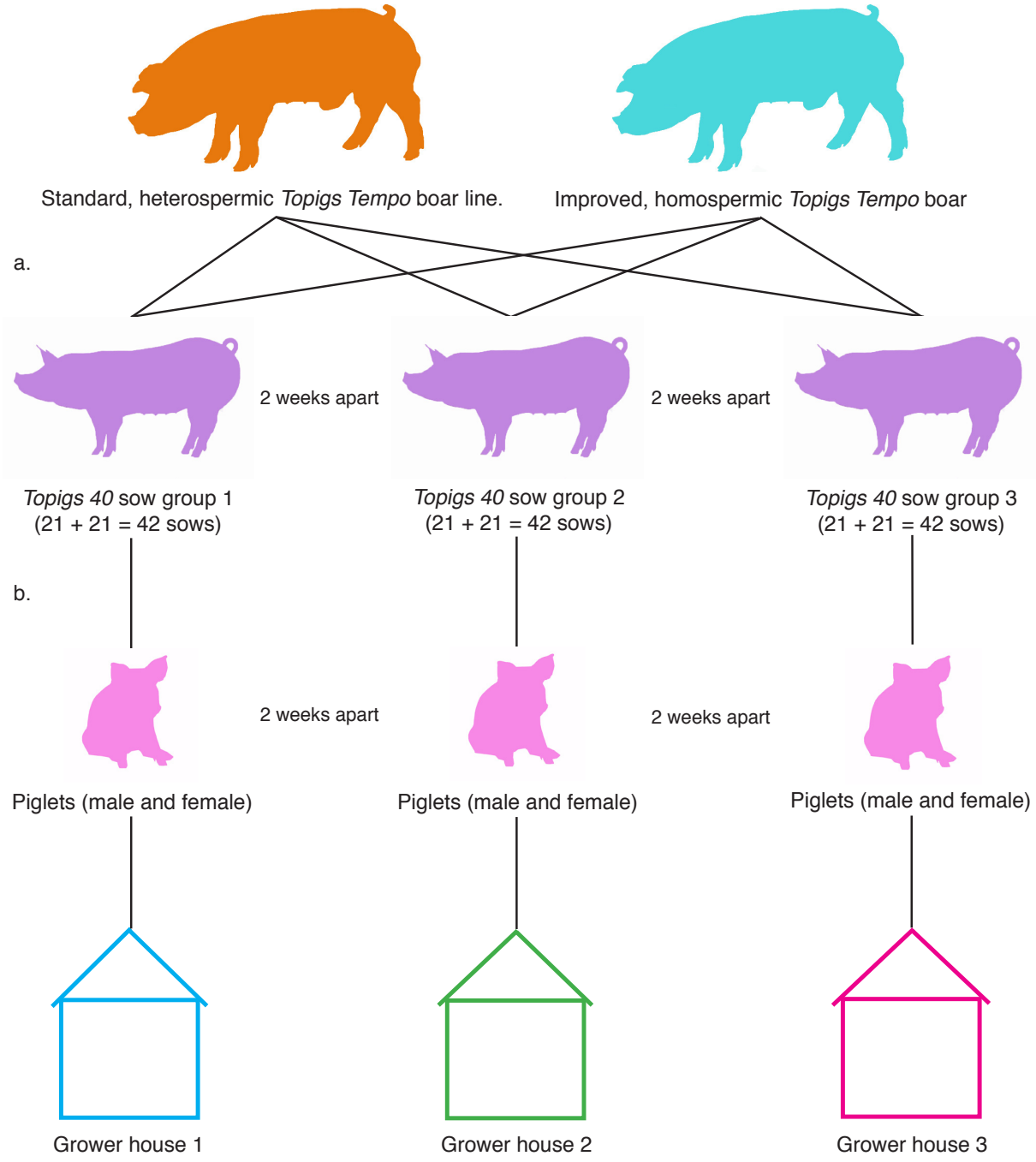

a. 21 sows per group inseminated using a standard, heterospermic *Topigs Tempo*© semen sample (treatment 1) and 21 sows per group inseminated with the semen from a genetically improved, homospermic *Topigs Tempo*© boar (treatment 2).

b. 21 sows per group gave birth to male and female heterospermic progeny and 21 sows per group gave birth to male and female homospermic progeny.

Figure 3 Diagrammatic representation of the animals used and the steps followed in the trial.

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3.1.2 Housing

3.1.2.1 Farrowing house

Sows were kept in farrowing crates on fully slatted floors. The farrowing house was environmentally controlled and the piglets were kept here with the sows for 21 days. At 21 days the piglets were moved to the weaner house.

3.1.2.2 Weaner house

Both the piglets from the standard, heterospermic *Topigs Tempo*© semen sample and the piglets from the genetically improved, homospermic *Topigs Tempo*© boar, were housed in a weaner house with other unmarked piglets from the same farrowing house. The weaner house was environmentally controlled, fully slatted, and the sexes were separated so that the male piglets were housed in one half of the house and the female piglets in the other half. All piglets were treated the same way and were fed ad lib of a standard commercial weaner diet.

3.1.2.3 Grower house

The animals were housed in three commercial, curtain-sided grower houses that were stocked two weeks apart from each other. The pigs were penned in fully slatted pens at a stocking density of 56 animals per pen with a space allowance of 0.9m^2 per animal. Each grower house had 14 pens of which eight pens were used for the study. Of the 56 pigs in each pen, only 15 pigs were included in the experiment, whilst the remaining 41 pigs were ignored and served only to create an environment similar to commercial group-housing conditions. In effect, each grower house housed up to 800 pigs of which 120 pigs per house were included in the experiment. All pigs were managed in the same way.

3.2 Methods

3.2.1 Selection of progeny and experimental design

The experimental phase of the study was conducted during the grower phase. Hence, all activities conducted and data collected within the farrowing phase was merely for preparation purposes and to assist in selection of the progeny that were used. It is therefore important to note that even though each farrowing, weaner and grower house contained ca. 800 progeny, only 120 of these pigs were actually included in the experiment.

Before entering the grower house, the tagged progeny that were born from the selected sows were weighed and penned according to sex (male and female), weight (above or below 35kg) and

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treatment (standard, heterospermic *Topigs Tempo*© sire line or genetically improved, homospermic *Topigs Tempo*© boar). As discussed previously in 3.1.2.3, only a number of the pigs in each pen were included in the experiment while the remaining pigs served for simulation purposes. The 15 pigs included in the experiment were selected based on weight, and any pig with visible abnormalities, abscesses, limps or an audible cough were not selected. Figure 4 on the following page illustrates the experimental design within each of the three houses. The study design was a 2x2x2x3 completely randomised factorial design, consisting of two sexes (male and female), two treatments (standard, heterospermic *Topigs Tempo*© sire line and genetically improved, homospermic *Topigs Tempo*© boar), two weight classes (above 35kg at 11 weeks of age and below 35kg at 11 weeks of age) and 3 houses (House 1, 2 and 3).

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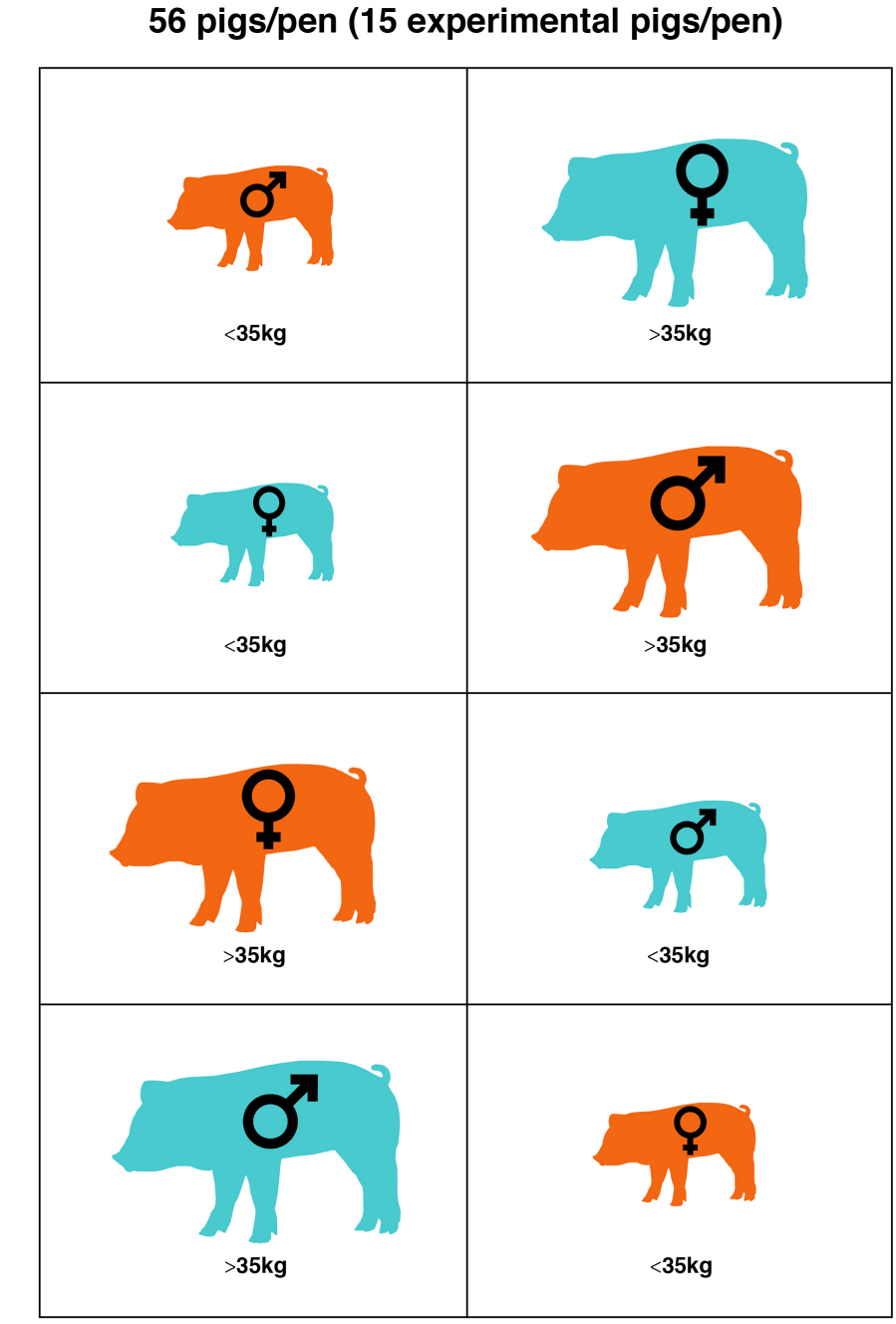

Figure 4 Diagrammatic representation of the experimental design (aerial view of pen layout).

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3.2.2 Feeding

During the farrowing and weaner phases, all pigs received the same feed routinely fed to the pigs on commercial farms that maintain a high health herd status. During the grower phase, pigs were fed a standard commercial pig diet ad libitum. The piggery where this experiment was conducted made use of phase feeding (also known as scaled feeding); hence, the diet was adjusted according to the pigs' requirements as they increased in weight (Table 4). Since the exact diet fed during the experiment could not be obtained, Appendix A provides an example of a boar grower diet once fed at Walt Landgoed.

Table 4 Different rations and additives fed during the experimental period (similar feeding regime followed by most commercial piggeries)

Week	Ration	Additive
11	Grower 1	Tylan[a]
12		Tylan
13	Grower 2	
14		
15		
16	Grower 3	Tylan
17		
18		Tylan
19	Grower 4	Paylean[b]
20		Paylean + Tylan
21		Paylean
22		Paylean

a. Tylan (Tylosin) is an antimicrobial growth promoter used in grower and finisher feeds.

b. Paylean (Ractopamine hydrochloride) is a β-adrenergic agonist that improves growth performance and carcass characteristics.

Each pen of 56 pigs had access to five CAWI© feeders, four cup-drinkers and five water lines attached to the feeders to facilitate wet feeding. Feeders were started each morning at 07h00 and each afternoon at 15h00. The feeders were not started at 15h00 the day before the pigs were loaded for slaughter; this was done to ensure that the feeders are empty once the pigs were loaded.

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3.2.3 General management and treatments

3.2.3.1 Health management

The piggery where this experiment was conducted maintains a high health herd status. The animals received all the standard vaccinations administered to all pigs at Walt Landgoed© piggery. During the experimental period (grower phase), the pigs were treated individually when they showed signs of illness. Some of the diseases encountered during the experiment included scours, glassers disease, and pneumonia. Group 1 showed symptoms of pneumonia and was suspected to have contracted mycoplasma. They were treated accordingly with Aivlosin and Amoxycillin at 12 weeks of age (2nd week of the experiment). Group 2 and 3 were treated with Amoxycillin for pneumonia-related symptoms at 12 weeks of age.

Group 1 had a single gilt from the homospermic progeny, heavy weight group who suffered from a rectal prolapse. This gilt was the heaviest and fattest gilt in the pen. The gilt was removed from the experimental group, kept in the alley of the house, treated, and later recovered completely. However, when the gilt was returned to its pen, it died of stress. Group 2 also had a case where a boar from the homospermic progeny, heavy weight class suffered from a rectal prolapse. The boar was removed from the experimental group, treated accordingly and recovered completely. It was not returned to its pen due to the potential risk of death and accordingly remained in the alley until slaughter.

3.2.3.2 Identification of pigs

The simplest method of identification was to tag each pig with a laser-printed tag at birth so that each pig was allocated its own number. Other than the tags, pigs selected to serve in the study were also marked on their backs with pink Wonder Ink© liquid ink markers. This was done to more easily and quickly identify the selected pigs from those not included in the study, all of which were also tagged at birth as candidates for selection. The marker ink also served as a practical means of identification for some of the pigs that had lost their tags during the study. Pigs had to be re-sprayed with marker ink every four days due to other pigs licking the ink of the selected pigs' backs. Alternatively the tags were sprayed with the ink to stain the selected pigs' tags with pink marker ink.

3.2.3.3 Pig mortalities and illness

Some of the pigs died during the study due to stress related problems such as too much human contact at the start of the study. As the pigs got used to the weighing routine, the mortalities

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decreased. Disease challenges were present in the grower houses and had to be treated accordingly as shown in Table 5. These disease challenges could have resulted in reduced growth.

Table 5 Disease challenges and the respective treatments administered during the grower phase of the study

House	Week	Challenge	Treatment
1	12	Redgut	Amoxicillin – 3 days
		Glässers	
	18	Redgut	Tylan in feed
2	12	Redgut	Amoxicillin – 3days
	17 - 21	Redgut	Tylan in feed on week 16, 18 and 20
3	12	Redgut	Amoxicillin – 3 days
		Glässers	Aivlosin – 3 days
		Mycoplasma	
	14	Redgut	Doxycillin – 3 days
		Glässers	
	20 - 21	Redgut	Tylan in feed on week 20

3.2.3.4 Missing pigs at weighing

A few pigs were sometimes missed during weighing sessions due to the difficulty of finding the 15 experimental pigs in a pen when all 56 pigs are milling around. Missing tags and marker ink that were licked off the pigs exacerbated the problem.

3.2.3.5 Feeder management

Approximately one feeder per pen became blocked every day during the grower phase. Feeders were unblocked twice a day; even so, growth performance could have been affected by the lack of feed due to a blocked feeder.

3.2.4 Parameters

3.2.4.1 Average daily gain (ADG)

The selected pigs (15 per pen) were weighed at two-week intervals to obtain 11, 13, 15, 17, 19 and 21-week weights. Weighing sessions started strictly at 06h00 to reduce heat stress and pens were weighed in the same order at each session. Weighing sessions took approximately two hours, where the selected pigs were removed from the pen of 56 pigs, placed in the alley, weighed

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one by one and immediately returned to their pens. Pigs were not starved before each weighing session due to the daily feeding schedule and feeder management. For optimum accuracy during weighing, the first highest weight displayed on the scale was recorded as the pig's true weight. This was done to limit the variance (ca. 3kg deviation from the first highest weight) in the displayed weight caused by pigs moving inside the crate and other pigs playing with the crate.

3.2.4.2 P2 backfat thickness (BFT)

Besides the weighing sessions, P2 measurements were taken on three occasions during the experiment, namely at 13, 17 and 21 weeks of age. Even though standard practice is to measure backfat thickness on the same day the animal is weighed, measurements were taken 2 days after each weighing session to minimize excessive human contact and subsequent stressing of the pigs after each weighing session. Also, taking the measurements on the same day would have resulted in the weighing session extending well into late morning hours – the time at which temperatures in this region start reaching their peak which would have resulted in further heat stress and unnecessary mortalities. Measurements were taken inside the respective pens at 13h00 during the hottest part of the day because no method of restraint was used and the animals preferred to lie down and sleep due to the heat and seemed more accepting of a human presence in their pens which allowed for more accurate P2 measurements. P2 measurements were taken using a Renco© P2 apparatus and liquid paraffin. Measurements were taken at a point over the last rib, approximately two finger's width from the spine.

3.2.5 Slaughter

At the end of the trial, the afternoon feeding was skipped so the feeders could empty overnight before the pigs were loaded at 06h00 the following morning. Pigs were transported with Walt Landgoed's specially designed transporting trucks to the Eskort© abattoir in Heidelberg and slaughtered the following morning at 06h00. Pigs were stunned in a stunning crate at 220V, 0.9-1.3 Amps for nine seconds. The ears of the carcasses were then notched for the purpose of later identification in the coolers since the plastic ear tags fell out during the dehairing process. The carcasses were then exsanguinated, dehaired, eviscerated and separated along the midline with the head still attached to the right half. The abattoir supplied the warm carcass mass, cold carcass mass, P2 backfat thickness measurements, lean muscle percentage and grading (PORCUS). Carcass length was measured afterwards in the coolers by measuring the carcass from the base of the tail, along the spinal cord to the point where the head was cut off.

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3.2.5.1 Calculation of carcass compactness

Carcass compactness was calculated using the following formula:

$$Carcass\ compactness = \frac{Cold\ carcass\ mass\ (kg)}{Carcass\ length\ (m)}$$

3.2.6 Data collection

Data were collected during the farrowing, grower and slaughter phase and consequently three data sets were compiled. The first data set consisted of all the data pertaining to the sires and dams of the progeny used in the study. Measurements in this data set included parity and litter size of the dam as well as treatment allocation to each dam. The second data set consisted of all the data pertaining to the progeny from the abovementioned dams. Measurements in this data set included, sex, weight class, sire line, 21-day weight during the farrowing phase, 11-, 13-, 15-, 17-, 19- & 21-week weight during the grower phase and P2 measurements. The third data set included all data collected at the abattoir. Measurements included warm and cold carcass mass, lean muscle percentage, P2 measurement and carcass length. Ultimately, the second and third data sets were combined so as to compare the measurements of the traits between the two sire lines.

3.2.7 Data analysis

Data were analysed statistically as a randomised block design with the General Linear Models (GLM) procedure (Statistical Analysis Systems, 2013) for the average effects over time. Repeated Measures Analysis of Variance with the GLM model was used for repeated week or period measures. Least square means and standard deviations were calculated for the different treatments, sexes, groups, houses and their interactions. Significance of difference ($P < 0.05$) between least square means was determined by Fischers test (Samuels, 1989)

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The two linear models used are described by the following equations:

Model 1, used to analyse the effect of the treatments on the variables measured across all three houses.

$$Y_{ijkl} = \mu + T_i + H_j + S_k + G_l + e$$

Where, Y = Variable studied during the period

μ = Overall mean of the population

T_i = Effect of the i^{th} treatment

H_j = Effect of the j^{th} house

S_k = Effect of the k^{th} sex

G_l = Effect of the l^{th} group (different weight classes)

e_{ijkl} = Error associated with each Y

Model 2, used to analyse the effect of the treatments on the variables measured within each of the three houses.

$$Y_{ij} = \mu + T_i + B_j + e_{ij}$$

Where, Y = Variable studied during the period

μ = Overall mean of the population

T_i = Effect of the i^{th} treatment

B_j = Effect of the j^{th} block

e_{ij} = Error associated with each Y

The results of these two models are presented in the following chapter of this dissertation.

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Chapter 4

Results

4.1 Descriptive and inferential statistics

Data was analysed using Statistical Analysis System (SAS Institute Inc., Cary, NC, USA. 2013). Tables were drawn up to provide a summary of the descriptive statistics (LSMeans ± standard deviations (SD)) and inferential statistics of each trait studied. In addition to these tables, graphs were constructed for the purpose of comparing the trends for the traits studied between the progeny of the two sire lines. These traits include body weight, backfat thickness, average daily gain and carcass characteristics such as warm carcass mass, cold carcass mass, backfat thickness, lean muscle percentage and carcass length.

4.1.1 Body weight

Table 6 provides a summary of the descriptive statistics of the body weights of the different treatment groups. The body weight of the selected pigs was measured every two weeks until slaughter. For the purpose of comparison, only the body weights corresponding with the weeks that P2 measurements were recorded are shown here. For the full table, refer to Addendum A.

Table 6 Extract from Addendum A, B & C: Descriptive statistics of the body weights recorded during the grower phase. Averages are given for the different groups.

Trait	Boar line	Sex	Nr of animals	Week	LSMean	Median	St. dev.	Min	Max
Weight	Standard	Female	78	13	48.43	48.30	± 0.378	27.40	63.60
				17	74.93	75.40	± 0.507	57.20	84.20
				21	103.06	103.90	± 0.730	77.40	119.00
	Improved	Female	80	13	48.80	50.20	± 0.376	37.20	60.60
				17	77.13	79.20	± 0.504	65.60	90.2
				21	107.44	108.60	± 0.727	87.60	122.2
	Standard	Male	81	13	48.49	47.20	± 0.382	34.60	57.60
				17	77.69	76.80	± 0.512	61.20	89.00
				21	105.34	104.00	± 0.521	85.20	127.4
	Improved	Male	84	13	49.72	51.40	± 0.366	30.00	61.20
				17	78.15	80.00	± 0.491	51.80	95.60
				21	108.20	110.20	± 0.708	86.20	126.20

Weight = Body weight (kg)

Table 7 provides a summary of the inferential statistics for Model 1, describing the significance of the effects of the independent variables (sources of variation) on the dependent variable (mass) for the duration of the grower phase.

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Table 7 Results for Model 1 to test the effects of boar lines, house, sex and weight class on mass during the grower phase of the study.

		Week				
		13	15	17	19	21
R^2 - value		0.688	0.682	0.596	0.542	0.472
Source of variation	DF					
Treatment (two boar lines)	1	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
House (1, 2 or 3)	2	<0.0001	<0.0001	<0.0001	<0.0001	0.0259
Sex (male or female)	1	ns	ns	0.0885	0.0025	0.0042
Weight class (heavy or lower)	1	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Treatment x House	2	0.0017	0.0022	0.0068	ns	ns
Treatment x Sex	1	0.0614	ns	ns	ns	0.0839
House x Sex	2	ns	ns	ns	ns	ns
Treatment x House x Sex	2	0.0073	ns	0.0701	ns	ns
Body weight at 11 weeks of age	1	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

ns = Sources of variation with no significant effect.

Figure 5 to 8 compare the trends for body weight between the sexes (male and female) and treatments (standard, heterospermic *Topigs Tempo*© sire line or genetically improved, homospermic *Topigs Tempo*© boar) for the grower phase of the study. The male progeny from the standard sire line (Figure 5) were heavier than their female counterparts at 15 weeks of age ($P < 0.01$) and became increasingly so from 17 to 21 weeks of age ($P < 0.0001$). The male progeny from the improved boar (Figure 6) were only heavier than their female counterparts at 19 weeks of age ($P < 0.01$).

Within sex, the female progeny (Figure 7) from the improved boar were heavier than the female progeny form the standard sire line at 15 weeks of age ($P < 0.001$) and maintained this advantage throughout the whole grower phase up to and including 21 weeks of age ($P < 0.0001$). The male progeny (Figure 8) from the improved boar however, were only heavier than the male progeny from the standard sire line at 13 weeks of age ($P < 0.05$) and the difference in weight approached significance again at 19 weeks of age ($P < 0.0618$).

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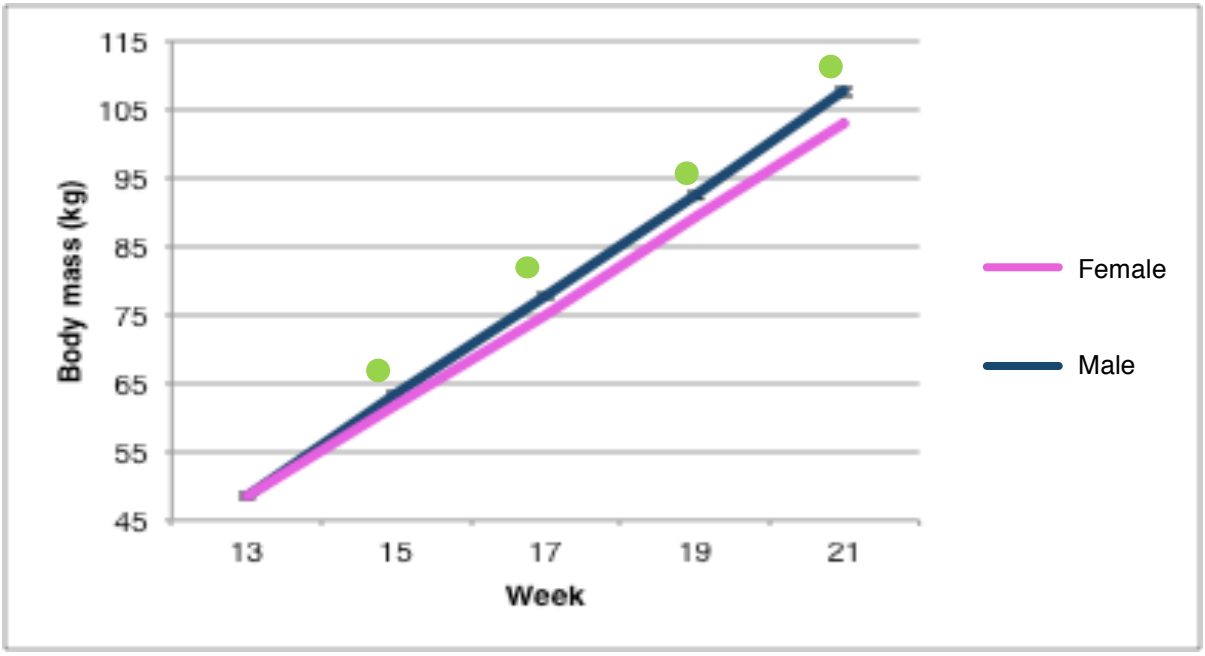
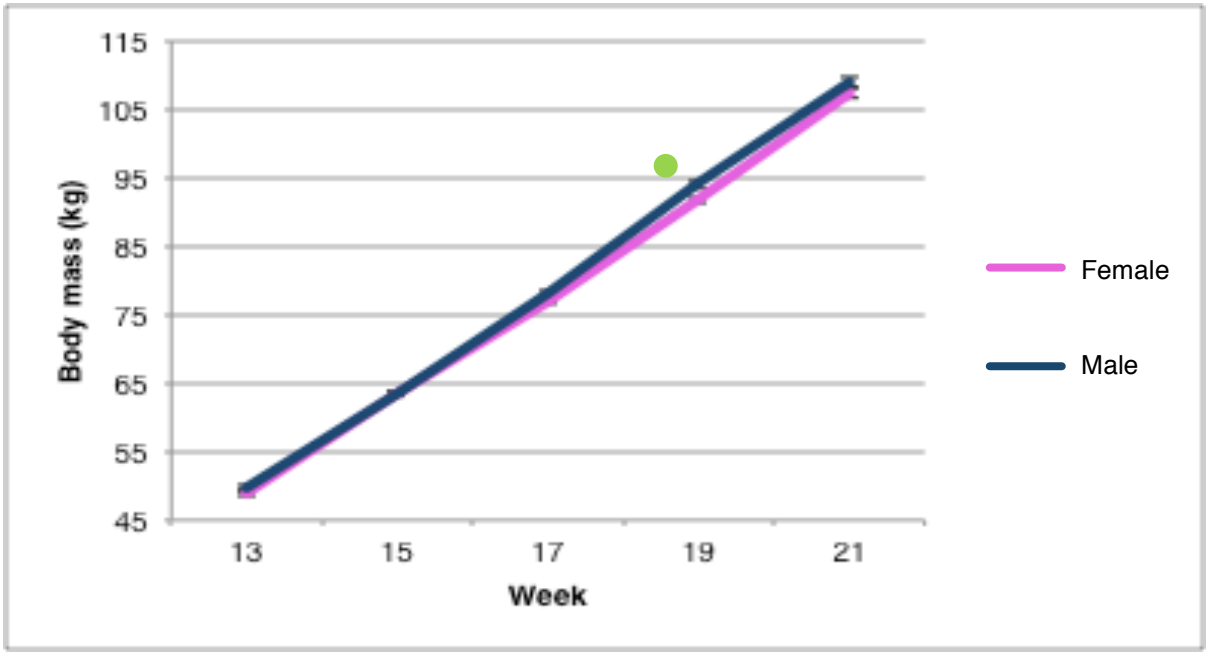


● significant differences (applies to all figures in this chapter)

Figure 5 Comparing the fortnightly body weights (kg) of pigs within treatment 1 (standard, heterospermic *Topigs Tempo*© sire line) between sexes (male and female).



● significant differences (applies to all figures in this chapter)

Figure 6 Comparing the fortnightly body weights (kg) of pigs within treatment 2 (genetically improved, homospermic *Topigs Tempo*© boar) between sexes (male and female).

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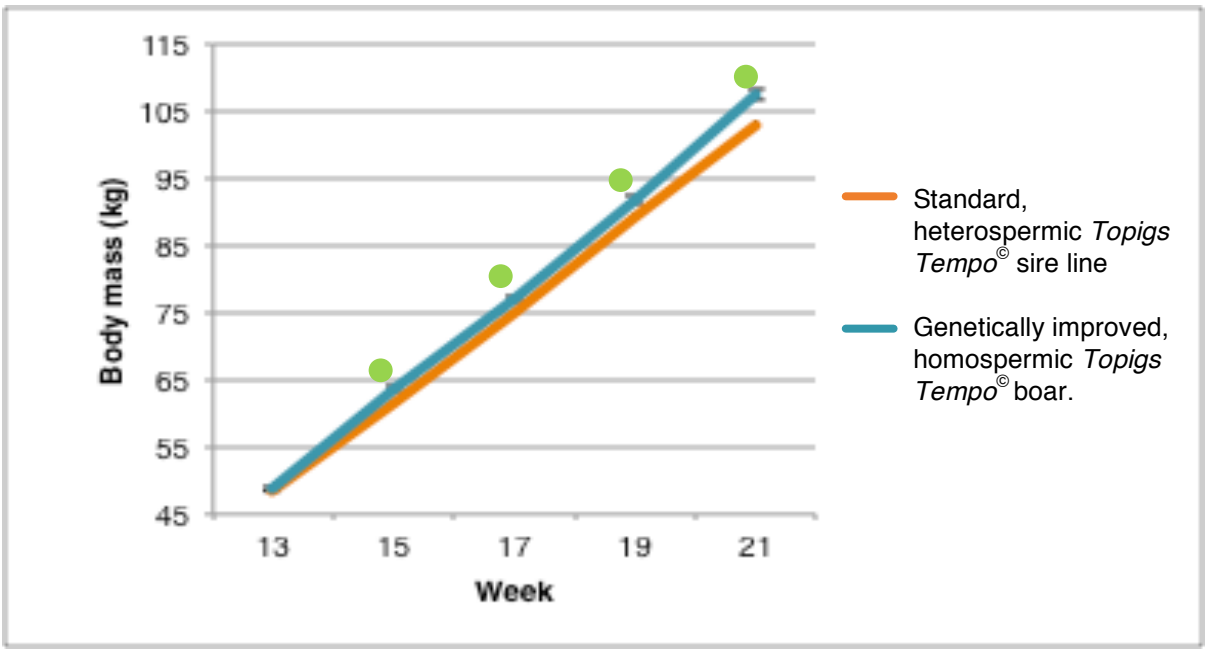

Figure 7 Comparing the fortnightly body weights (kg) of pigs within sex (female) between treatments (standard, heterospermic *Topigs Tempo*© sire line and genetically improved, homospermic *Topigs Tempo*© boar).

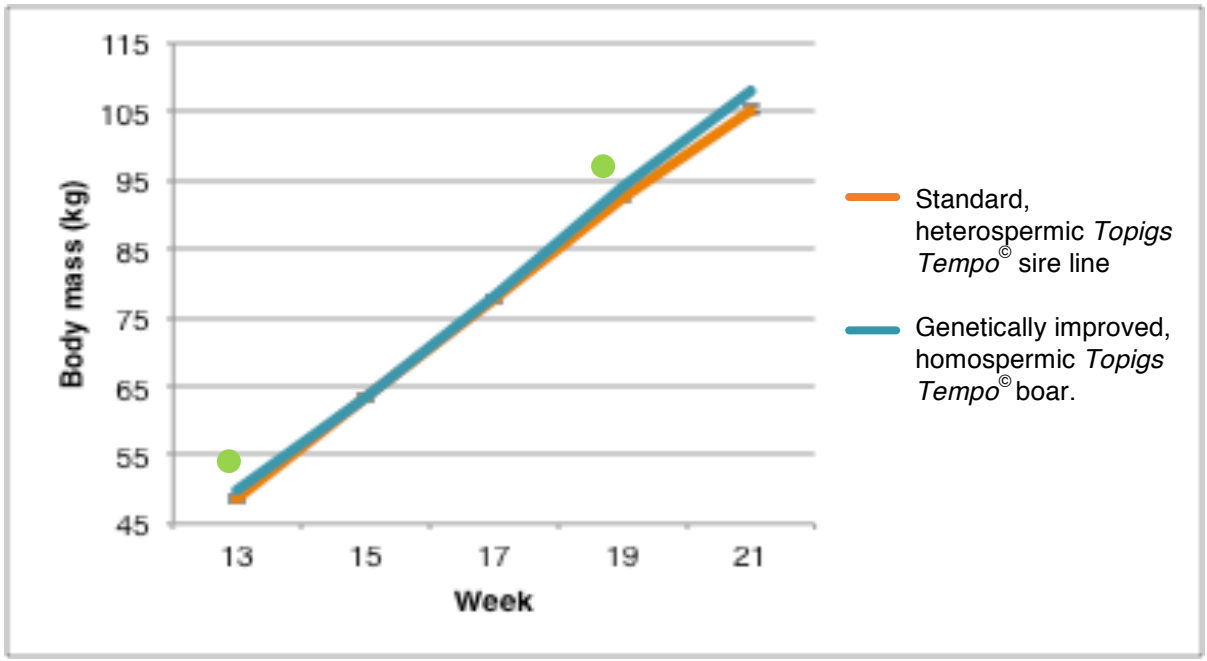

Figure 8 Comparing the fortnightly body weights (kg) of pigs within sex (male) between treatment (standard, heterospermic *Topigs Tempo*© sire line and genetically improved, homospermic *Topigs Tempo*© boar).

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4.1.2 Average daily gain

The average daily gain of the pigs was calculated from the body weights and Table 8 shows a summary of the average daily gain of the different groups of pigs during the weaner (3 - 11 weeks) and grower (11 - 21 weeks) phases.

Table 8 Summary of the descriptive statistics for the average daily gain of the different treatment groups of pigs during the weaner and grower phase.

				Period		
Trait	Boar line	Sex	Nr of animals	3-11 weeks	13-21 weeks	*11-21 weeks*
ADG	Standard	Female	78	0.483	0.900	*1.033*
	Improved	Female	80	0.508	0.962	*1.094*
	Standard	Male	81	0.462	0.965	*1.093*
	Improved	Male	84	0.497	0.976	*1.120*

ADG = Average daily gain (kg/day)

Adjusted values for the period 11-21 weeks indicated in italics

Table 9 provides a summary of the inferential statistics for Model 1, describing the significance of the effects of the independent variables (sources of variation) on the dependent variable (average daily gain) for the duration of the grower phase.

Table 9 Results for Model 1 for average daily gain during the grower phase of the study.

		Week			
		13 - 15	15 - 17	17 - 19	19 - 21
R-square		0.231	0.255	0.370	0.150
Source of variation	DF				
Treatment (two boar lines)	1	ns	ns	0.0859	0.0544
House (1, 2 or 3)	2	0.019	<0.0001	<0.0001	0.0708
Sex (male or female)	1	ns	0.0017	0.0115	ns
Weight class (heavy or lower)	1	ns	0.0773	ns	0.0003
Treatment x House	2	ns	ns	ns	0.0003
Treatment x Sex	1	0.0002	ns	ns	0.0162
House x Sex	2	0.0859	ns	0.0461	ns
Treatment x House x Sex	2	0.0008	0.0098	ns	ns
ADG from 11-13 weeks	1	<0.0001	0.0061	ns	ns

Sources of variation with no significant effect are indicated by means of an empty cell.

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The following figures (Figure 9, 10, 11 & 12) compare the trend for average daily gain between the sexes (male and female) and treatments (standard, heterospermic *Topigs Tempo*© sire line or genetically improved, homospermic *Topigs Tempo*© boar) for the grower phase of the study. The male progeny from the standard sire line (Figure 9) had higher average daily gains than their female counterparts from the start during the 13 - 17 and 19 - 21 weeks of age period ($P < 0.05$). They did not however, have higher average daily gains during the 17 - 19 weeks of age period. The male progeny from the improved boar (Figure 10) only had higher average daily gains than their female counterparts during the 17 - 19 weeks of age period ($P < 0.01$). This difference approached significance during the 15 - 17 weeks of age period ($P < 0.0594$). No difference was observed during the start and end of the grower phase.

Within sex, the female progeny (Figure 11) from the improved boar was heavier than the female progeny from the standard sire line during the start (13 - 15 weeks of age period) ($P < 0.0001$) and end (19 – 21 weeks of age period) of the grower phase ($P < 0.0046$). The male progeny (Figure 12) from the improved boar however, only had higher average daily gains than the male progeny from the standard sire line during the 17 – 19 weeks of age period ($P < 0.05$).

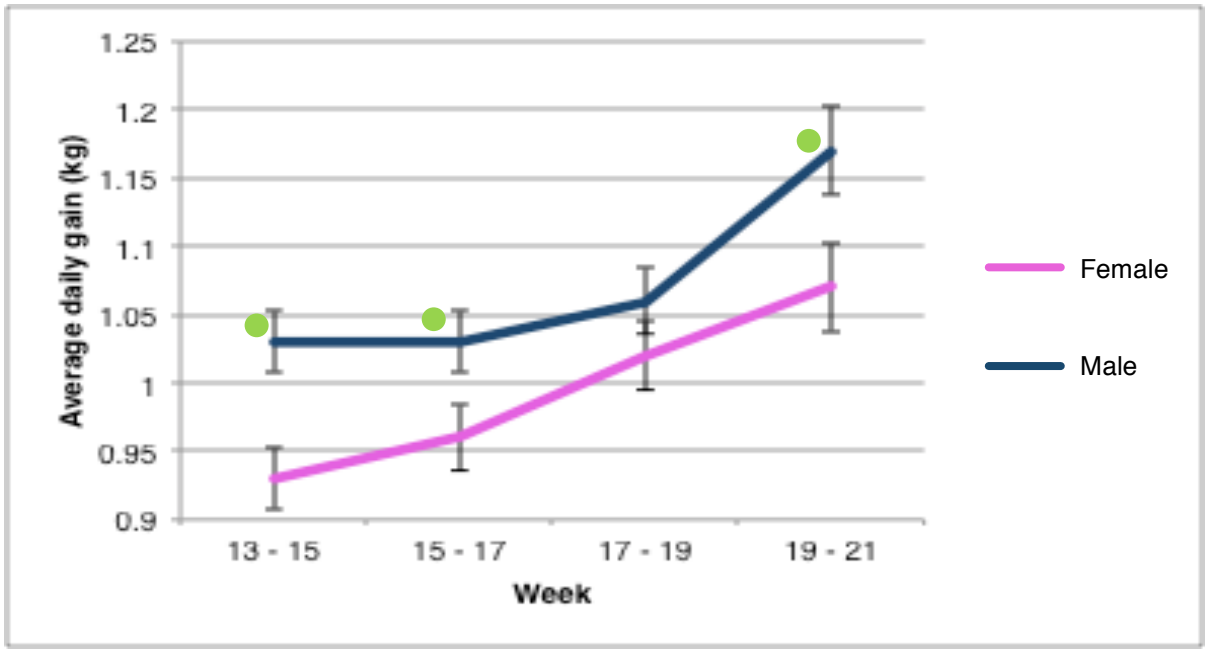

Figure 9 Average daily gain (kg) of pigs, compared within treatment 1 (standard, heterospermic *Topigs Tempo*© sire line) between sexes (males and females).

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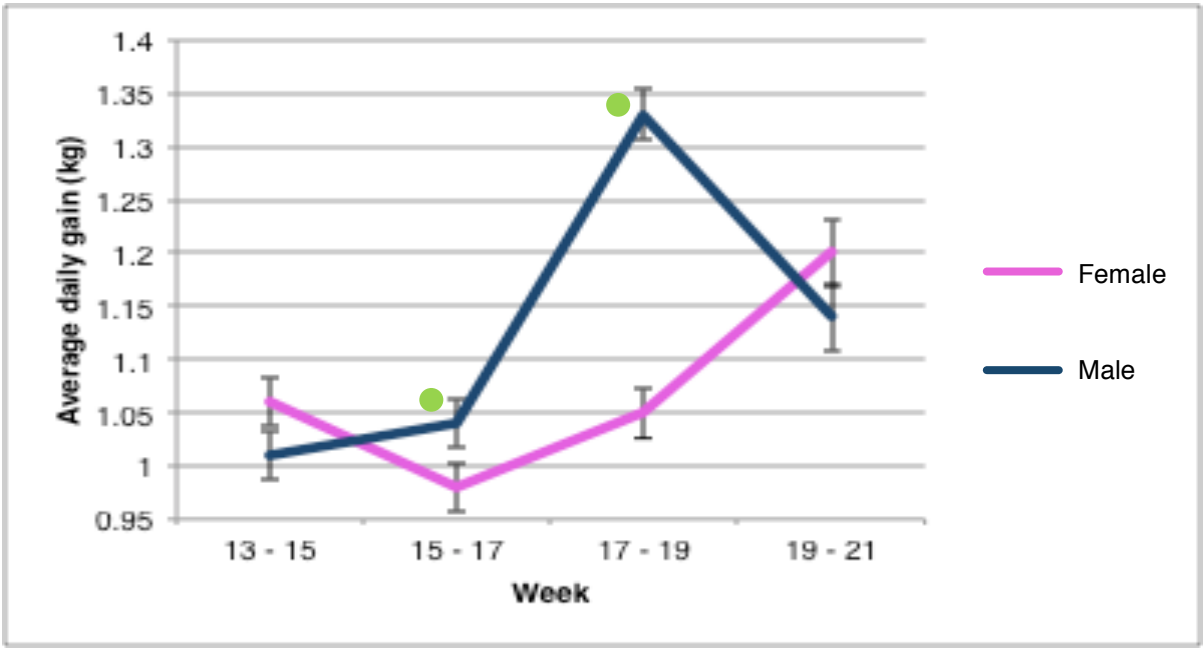

Figure 10 Average daily gain (kg) of pigs, compared within treatment 2 (genetically improved, homospermic *Topigs Tempo*© boar) between sexes (males and females).

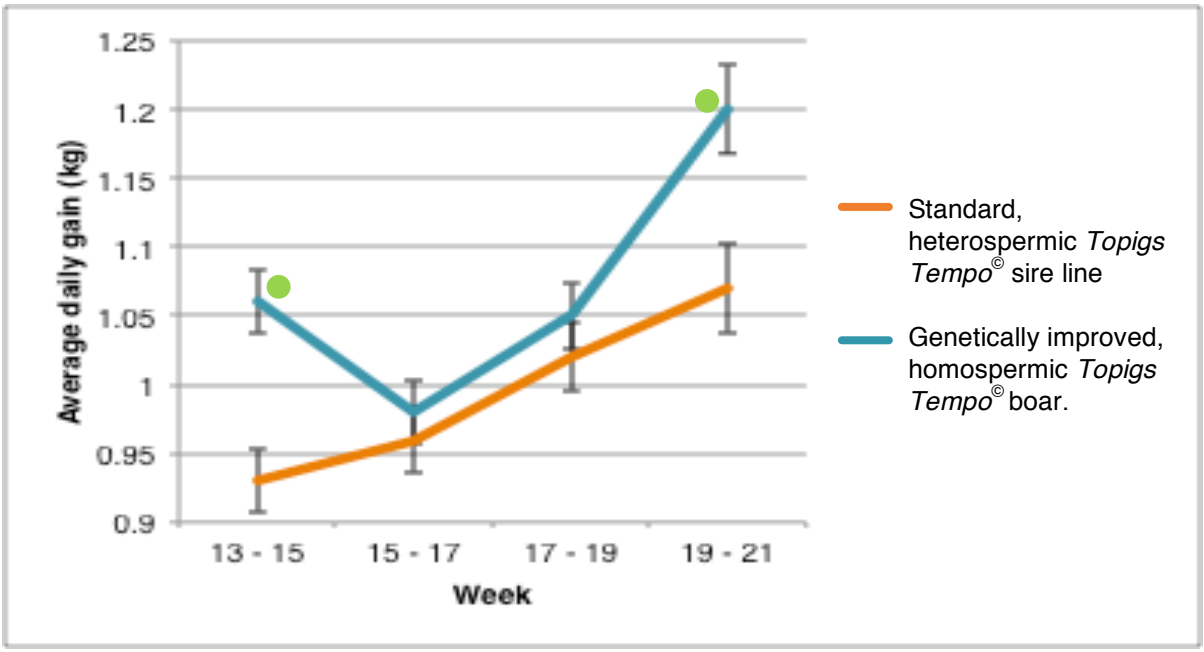

Figure 11 Average daily gain (kg) of pigs, compared within sex (female) between treatments (standard, heterospermic *Topigs Tempo*© sire line and genetically improved, homospermic *Topigs Tempo*© boar).

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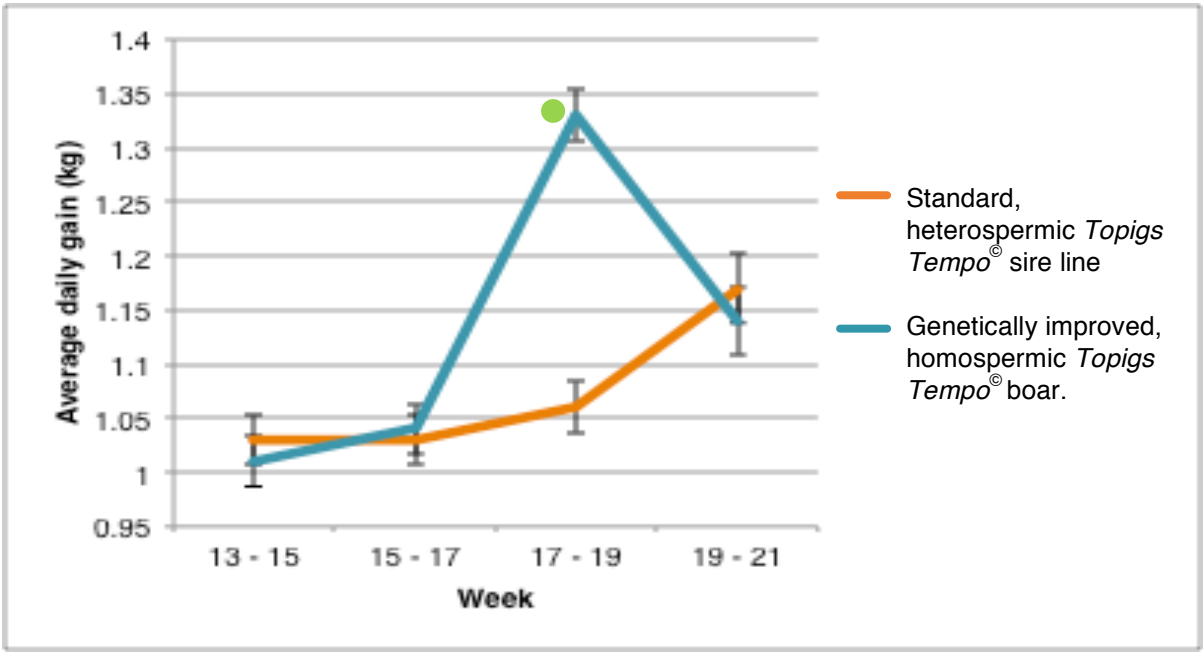

Figure 12 Average daily gain (kg) of pigs, compared within sex (male) between treatments (standard, heterospermic *Topigs Tempo*© sire line and genetically improved, homospermic *Topigs Tempo*© boar).

4.1.3 Backfat thickness

Backfat thickness was measured three times during the study at 13, 17 and 21 weeks of age using a Renco© P2 probe. Table 10 provides a summary of the descriptive statistics of the backfat thickness measured for the different groups of pigs.

Table 10 Extract from Addendum A, B & C: Summary of the descriptive statistics pertaining to the backfat thickness of different treatment groups measured during the study.

Trait	Boar line	Sex	Nr of animals	Week	LSMean	Median	St. dev.	Min	Max
P2	Standard	Female	78	13	6.58	7	± 0.100	4	9
				17	9.57	10	± 0.138	6	13
				21	11.90	12	± 0.183	9	16
	Improved	Female	80	13	7.77	8	± 0.100	6	12
				17	11.32	11	± 0.137	9	15
				21	13.06	13	± 0.182	9	19
	Standard	Male	81	13	6.65	7	± 0.100	6	9
				17	9.45	9	± 0.137	7	14
				21	11.68	12	± 0.182	9	17
	Improved	Male	84	13	6.86	7	± 0.100	4	9
				17	10.79	11	± 0.136	7	13
				21	12.46	12	± 0.181	9	16

P2 = Backfat thickness (mm)

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Table 11 provides a summary of the inferential statistics for Model 1, describing the significance of the effects of the independent variables (sources of variation) on the dependent variable (backfat thickness) for the duration of the grower phase.

Table 11 Results for Model 1 for backfat thickness during the grower phase of the study.

		Week			
		13	17	21	Slaughter
R-square		0.398	0.383	0.209	0.211
Source of variation	DF				
Treatment (two boar lines)	1	<0.0001	<0.0001	<0.0001	<0.0001
House (1, 2 or 3)	2	<0.0001	<0.0001	<0.0001	0.0038
Sex (male or female)	1	<0.0001	0.0176	0.0170	0.0008
Weight class (heavy or lower)	1	<0.0001	<0.0001	0.0020	0.0015
Treatment x House	2	-	-	0.0070	-
Treatment x Sex	1	<0.0001	-	-	-
House x Sex	2	-	-	-	-
Treatment x House x Sex	2	-	-	-	-

Sources of variation with no significant effect are indicated by means of an empty cell.

Figures 13 to 16 compare the trends for backfat thickness between the sexes (male and female) and treatments (standard, heterospermic *Topigs Tempo*© sire line or genetically improved, homospermic *Topigs Tempo*© boar) during the grower phase of the study. No difference in backfat thickness was observed between the male progeny from the standard sire line and their female counterparts for the duration of the grower phase (Figure 13). At slaughter however, the females were found to be slightly fatter than the males ($P < 0.05$). The female progeny from the improved boar was always fatter than their male counterparts (Figure 14) with the greatest difference observed at 13 weeks ($P < 0.0001$), a slightly smaller difference was maintained throughout the rest of the grower phase including slaughter ($P < 0.01$).

Within sex, the female progeny (Figure 15) from the improved boar were consistently fatter than the female progeny form the standard sire line throughout the whole grower phase including slaughter ($P < 0.0001$). The male progeny (Figure 16) from the improved boar followed the same trend as the female progeny ($P < 0.0001$) except for the fact that no difference between the treatments was observed at 13 weeks of age.

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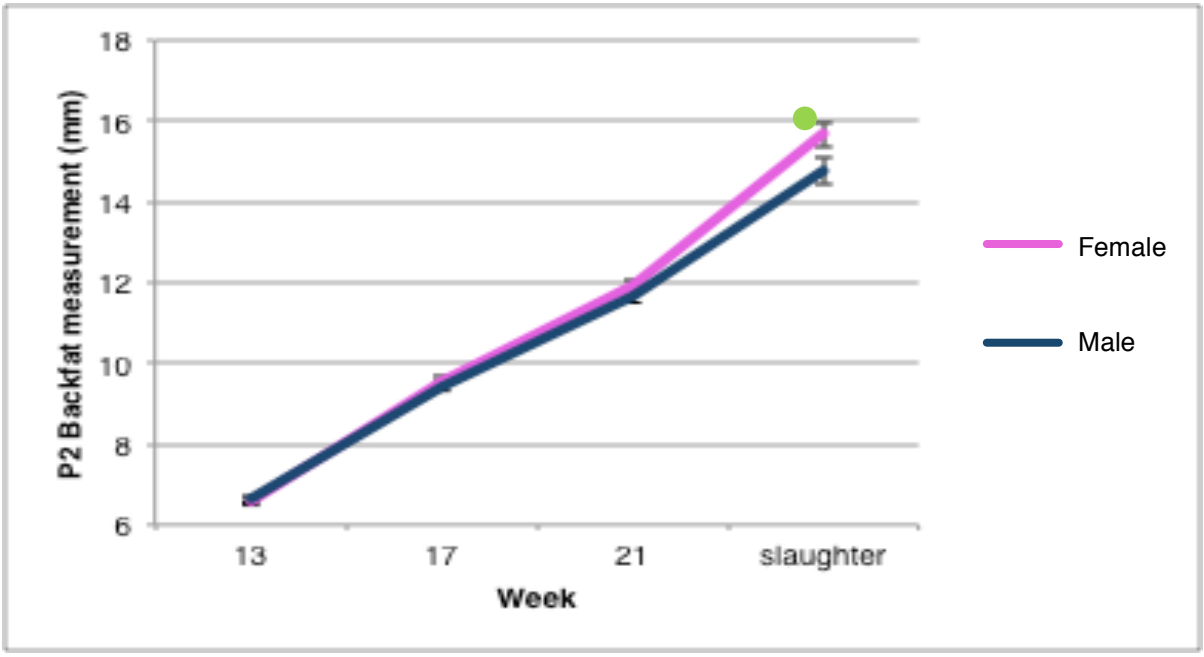

Figure 13 P2 backfat thickness of pigs measured every four weeks compared within treatment 1 (standard, heterospermic *Topigs Tempo*© sire line) between sexes (male and female).

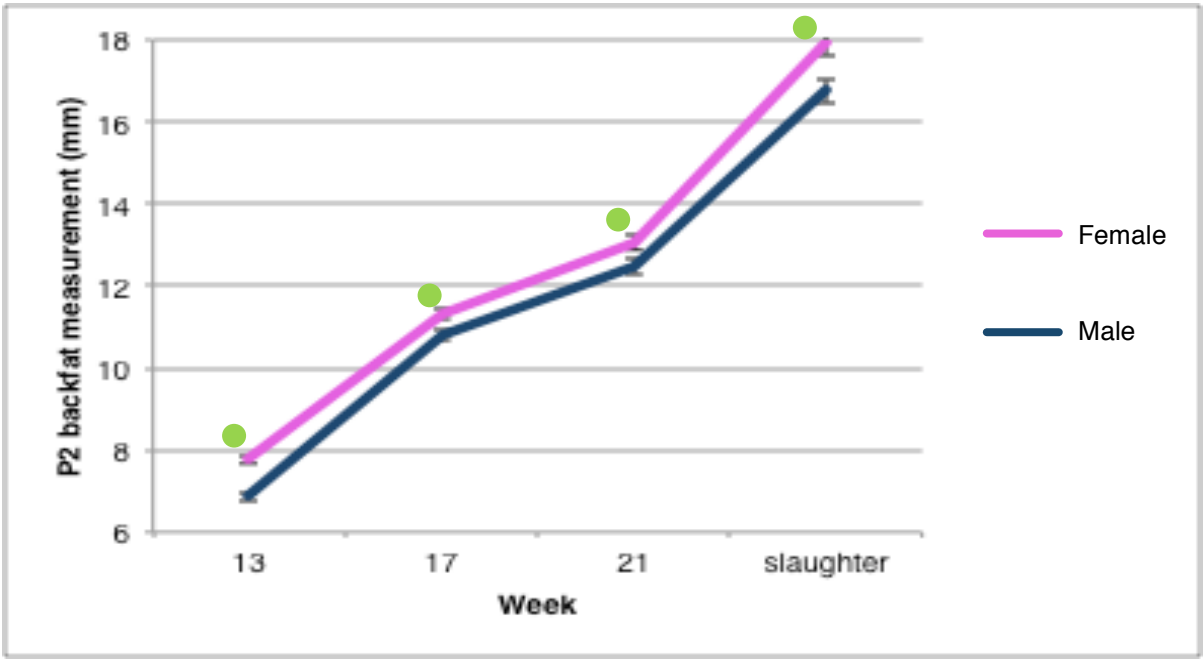

Figure 14 P2 backfat thickness of pigs measured every four weeks compared within treatment 2 (genetically improved, homospermic *Topigs Tempo*© boar) between sexes (male and female).

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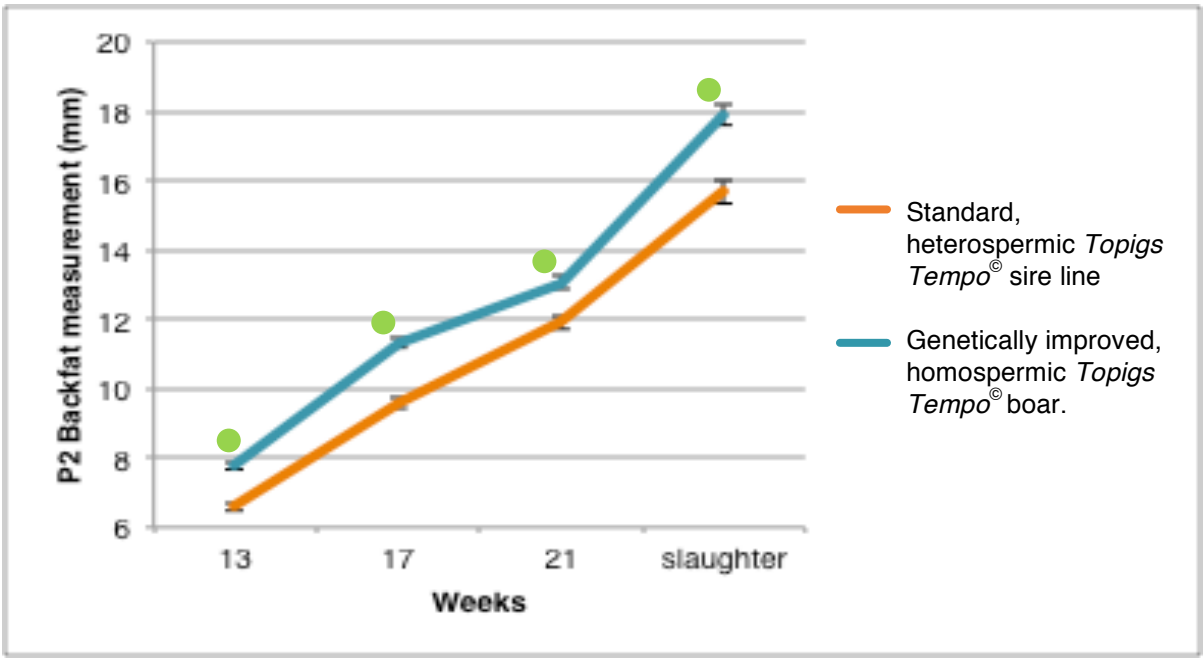

Figure 15 P2 backfat thickness of pigs every four weeks compared within sex (female) between treatments (standard, heterospermic *Topigs Tempo*© sire line and genetically improved, homospermic *Topigs Tempo*© boar).

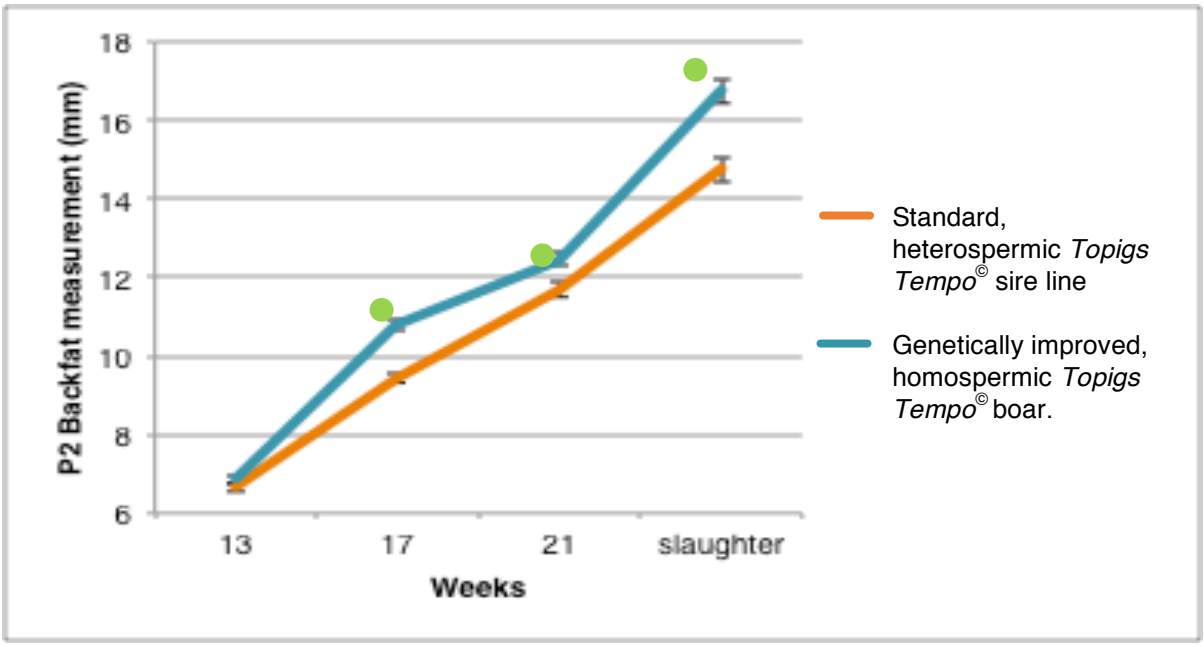

Figure 16 P2 backfat thickness of pigs every four weeks compared within sex (male) between treatments (standard, heterospermic *Topigs Tempo*© sire line and genetically improved, homospermic *Topigs Tempo*© boar).

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4.1.4 Carcass characteristics

After slaughter, carcass characteristics such as carcass mass, carcass length and lean muscle percentage were measured. Table 12 gives a summary of the descriptive statistics of the carcass characteristics measured for each group of pigs.

Table 12 Summary of the descriptive statistics for all carcass traits measured after slaughter.

Trait	Boar line	Sex	Nr of animals	LSMean	Median	St. dev.	Min	Max
WCM	Standard	Female	78	86.06	86.5	± 0.680	69.4	108.2
	Improved	Female	80	89.12	90.4	± 0.676	70.6	102.4
	Standard	Male	81	86.06	85.4	± 0.680	67.8	99.2
	Improved	Male	84	88.67	89.9	± 0.662	67.2	102.8
CCM	Standard	Female	78	83.56	84	± 0.680	67.4	105.7
	Improved	Female	80	86.62	87.9	± 0.675	68.1	99.9
	Standard	Male	81	83.64	82.9	± 0.667	65.8	96.7
	Improved	Male	84	86.18	87.4	± 0.662	65.2	100.3
LMP	Standard	Female	78	68.01	68.1	± 0.155	63.5	70.8
	Improved	Female	80	67.10	67.3	± 0.154	62.6	70.3
	Standard	Male	81	68.31	68.6	± 0.152	64.5	70.7
	Improved	Male	84	67.58	67.65	± 0.151	64.8	70.6
P2-S	Standard	Female	78	15.66	15.6	± 0.320	10.4	24
	Improved	Female	80	17.92	17.6	± 0.318	10.4	27.6
	Standard	Male	81	14.75	14.4	± 0.318	9.6	22.8
	Improved	Male	84	16.75	16.6	± 0.317	10.4	22.8
CL	Standard	Female	78	98.89	98.0	± 0.670	87	113.0
	Improved	Female	80	98.23	98.0	± 0.665	87	109.0
	Standard	Male	81	97.71	98.6	± 0.657	90.5	105
	Improved	Male	84	97.83	97.9	± 0.652	84	107.0
Compactness	Standard	Female	78	0.847	0.85	± 0.680	0.68	1.06
	Improved	Female	80	0.885	0.89	± 0.676	0.69	1.04
	Standard	Male	81	0.943	0.87	± 0.047	0.77	1.03
	Improved	Male	84	0.883	0.88	± 0.047	0.77	1.04

WCM = Warm carcass mass (kg); CCM = Cold carcass mass (kg); LMP = Lean muscle percentage (%); P2-S = Backfat thickness at slaughter (mm); CL = carcass length (cm); Compactness (kg/cm)

Table 13 provides a summary of the inferential statistics for Model 1, describing the significance of the effects of the independent variables (sources of variation) on the dependent variable (carcass characteristics) for the duration of the grower phase.

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Table 13 Results for Model 1 for carcass characteristics during the grower phase of the study.

		Carcass characteristic				
		WCM	CCM	LMP	CL	CC
R-square		0.227	0.228	0.151	0.328	0.044
Source of variation	DF					
Treatment (two boar lines)	1	<0.0001	<0.0001	<0.0001	-	-
House (1, 2 or 3)	2	-	-	-	<0.0001	-
Sex (male or female)	1	-	-	0.0110	-	-
Weight class (heavy or lower)	1	<0.0001	<0.0001	0.0037	<0.0001	-
Treatment x House	2	-	-	-	-	-
Treatment x Sex	1	-	-	-	-	-
House x Sex	2	-	-	-	-	-
Treatment x House x Sex	2	-	-	-	-	-

Sources of variation with no significant effect are indicated by means of an empty cell.

Figures 17 to 20 compare the carcass characteristics between the sexes (male and female) and treatments (standard, heterospermic *Topigs Tempo*© sire line or genetically improved, homospermic *Topigs Tempo*© boar) for the grower phase of the study. No difference was observed between the male progeny from the standard sire line and their female counterparts for all carcass characteristics studied (Figure 17). The male and female progeny from the improved boar followed the same trend (Figure 18) except for lean muscle percentage where the male progeny from the improved boar had a greater lean meat percentage than their female counterparts ($P < 0.05$).

Within sex, the female progeny (Figure 19) from the improved boar had a heavier warm and cold carcass mass than the female progeny form the standard sire line ($P < 0.01$). The female progeny from the standard sire line however, had a greater lean meat percentage than the female progeny from the improved boar ($P < 0.0001$). Similar to the females, the male progeny (Figure 20) from the improved boar had a heavier warm and cold carcass mass ($P < 0.01$) and once again the male progeny from the standard sire line had a greater lean meat percentage than the male progeny from the improved boar ($P < 0.001$).

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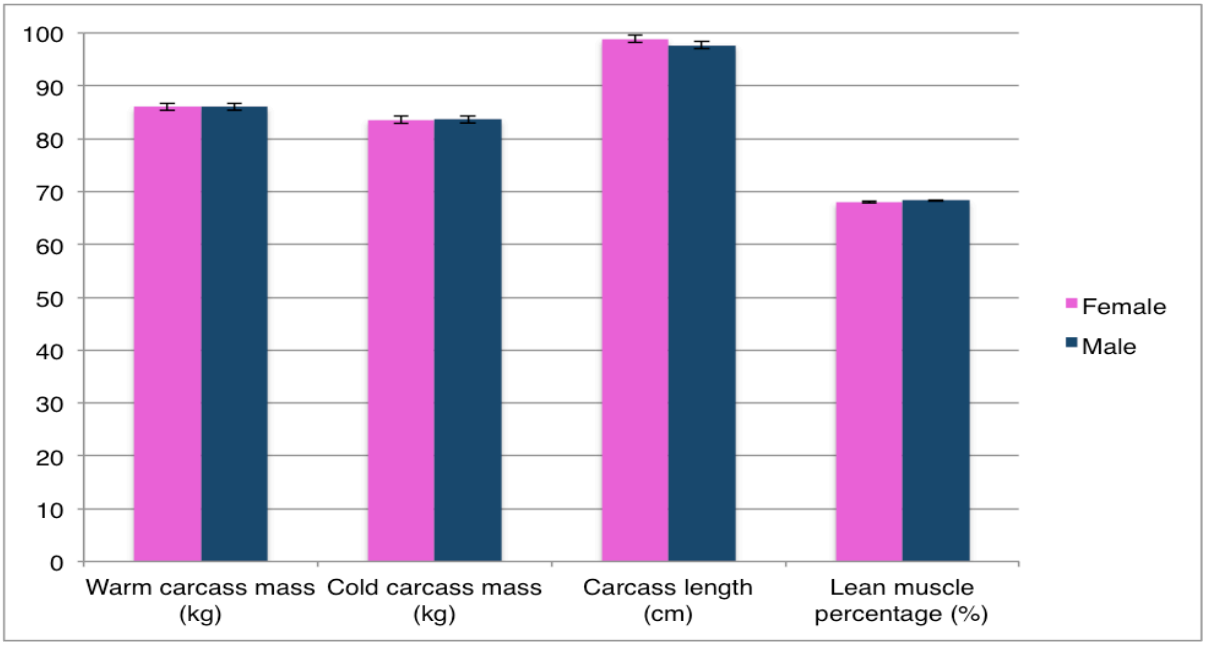

Figure 17 Carcass characteristics of pigs compared within treatment 1 (standard, heterospermic *Topigs Tempo*© sire line) between sexes (male and female).

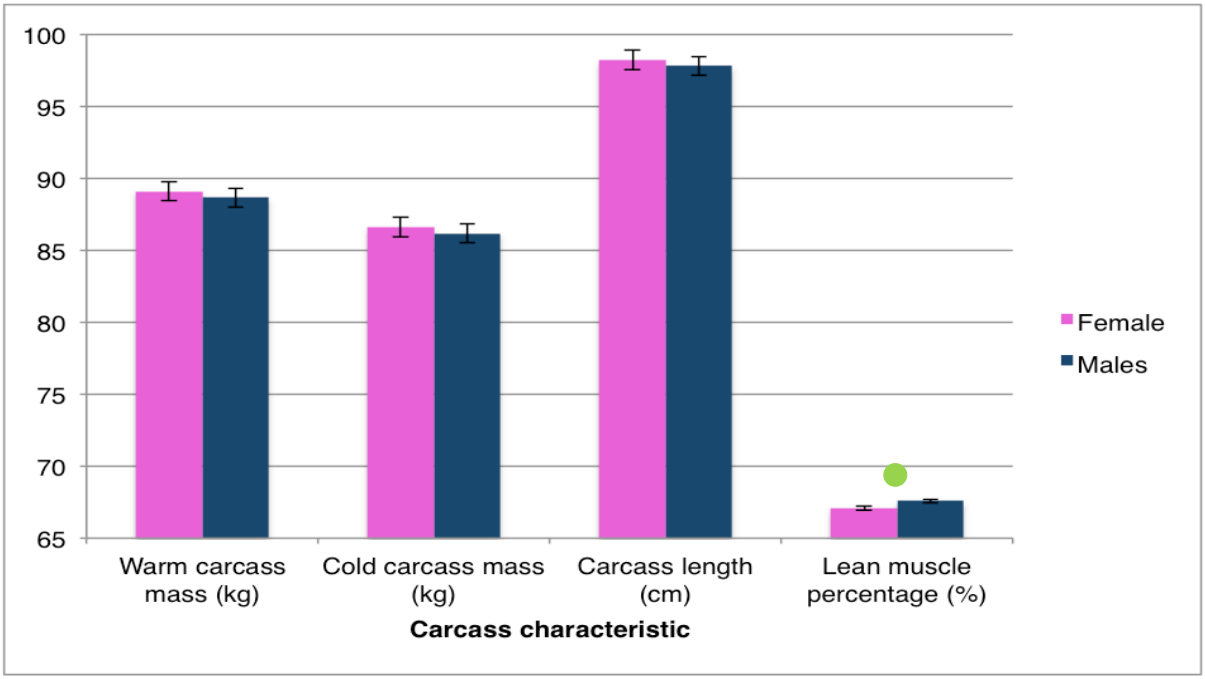

Figure 18 Carcass characteristics of pigs compared within treatment 2 (genetically improved, homospermic *Topigs Tempo*© boar) between sexes (male and female).

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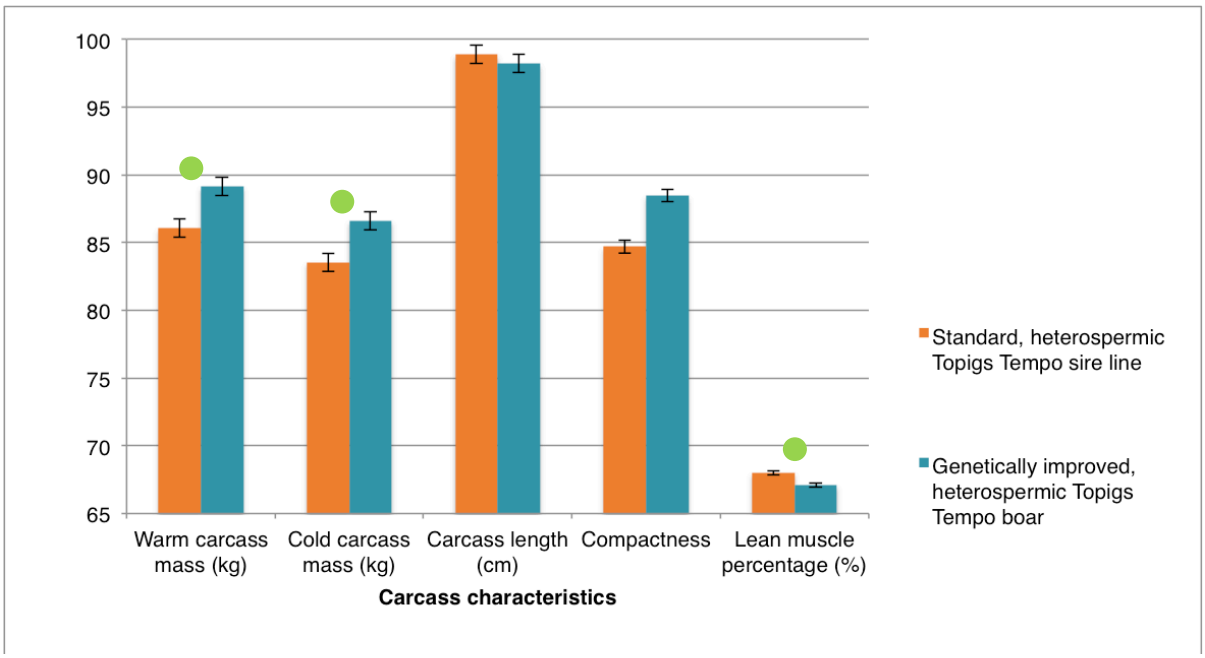

Figure 19 Warm carcass mass and cold carcass mass (kg) of pigs compared within sex (female) between treatments (standard, heterospermic *Topigs Tempo*© sire line and genetically improved, homospermic *Topigs Tempo*© boar).

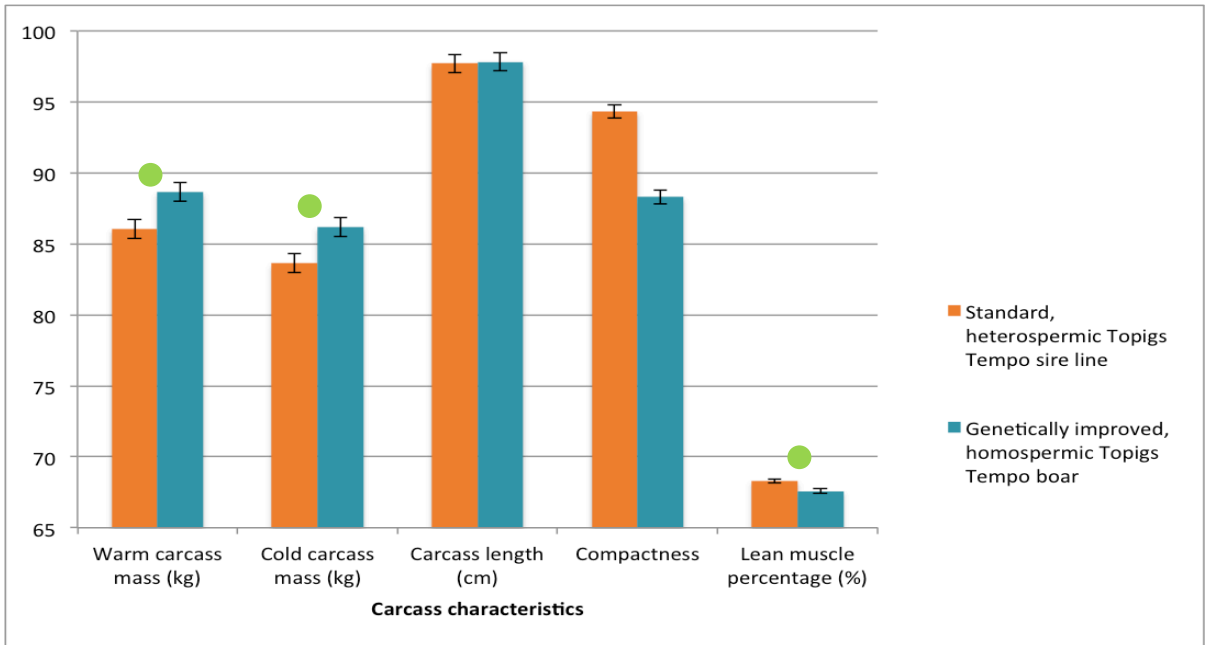

Figure 20 Warm carcass mass and cold carcass mass (kg) of pigs compared within sex (male) between treatments (standard, heterospermic *Topigs Tempo*© sire line and genetically improved, homospermic *Topigs Tempo*© boar).

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4.1.5 Litter size

The effect of the method of insemination (heterospermic or homospermic) was analysed as a sub-objective since the data was available. Table 14 gives a summary of the descriptive statistics of the litter sizes recorded for each group of sows.

Table 14 Summary of the descriptive statistics for litter size recorded for each group of sows.

Trait	Group	Insemination	N	LSMean	Median	St. dev.	Min	Max
Litter size	1	Heterospermic	20	12.73	13	± 0.496	10	16
		Homospermic	21	13.18	13	± 0.483	9	16
	2	Heterospermic	21	11.94	12	± 0.483	7	17
		Homospermic	21	13.75	14	± 0.481	10	17
	3	Heterospermic	20	11.95	13	± 0.559	6	16
		Homospermic	20	13.25	14	± 0.492	10	16

Figure 21 illustrates the difference in litter size between the homospermic and heterospermic treatments. Overall, homospermic insemination resulted in a greater litter size (13.39 piglets/litter) than the heterospermic insemination (12.21 piglets/litter) ($P < 0.01$). Between groups, only Group 2 had greater litter sizes for the homospermic insemination ($P < 0.01$). No difference was observed for Group 1 and Group 3, however the difference for Group 3 approached significance ($P < 0.083$).

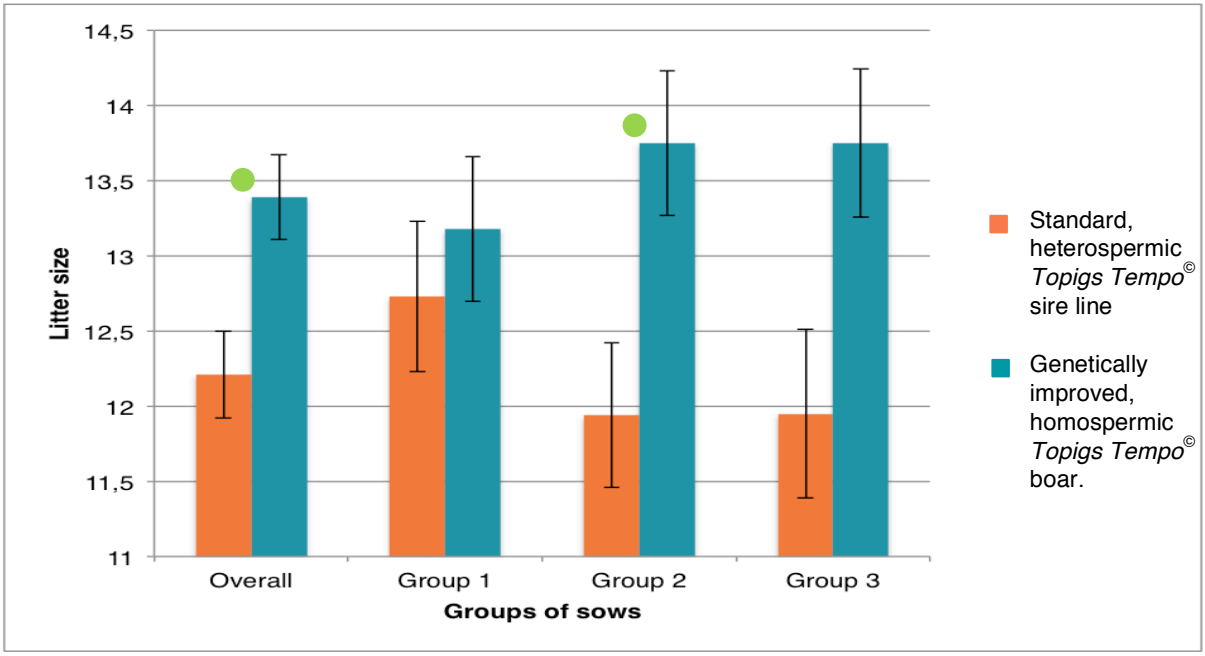

Figure 21 Litter sizes for each group of sows (Group 1, 2 & 3) for the different methods of insemination (heterospermic and homospermic).

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4.1.6 Effect of treatment within houses

Model 2 was constructed for the purpose of identifying whether the treatment had an effect within individual houses (House 1, 2 & 3). The results varied for each house and due to this, only the significant effects will be reported in this chapter of the dissertation and briefly discussed within the next.

4.1.6.1 Body weight within houses

The female progeny from the improved boar from House 1, 2 and 3 had heavier body weights than the female progeny from the standard sire line ($P < 0.05$). The male progeny from the improved boar from House 2 and 3 were heavier than the male progeny from the standard sire line ($P < 0.05$). Between sexes, the improved male progeny from House 1 were heavier than the improved female progeny ($P < 0.05$). The male and female progeny from House 2 & 3 did not differ as often as the progeny from House 1. The male progeny from the standard sire line were heavier than the female progeny from the standard sire line for House 1.

4.1.6.2 P2 backfat thickness within houses

Within sexes, the results for backfat thickness were straightforward and all three houses had backfat thickness measurements that were consistent with the results obtained across houses. These results showed the male and female progeny from the improved boar to be fatter than the male and female progeny from the standard sire line ($P <0.05$). Between sexes, however, the results were less clear and the female progeny from the improved boar were only fatter than the male progeny at 13 weeks of age. The female progeny from the standard sire line were only fatter than their male counterparts at slaughter ($P < 0.05$).

4.1.6.3 Carcass characteristics within houses

The carcass characteristics within House 2 & 3 were no different than the carcass characteristics across houses. Warm carcass mass, cold carcass mass and lean meat percentage were greater when comparing within sex, between treatments as well as between sexes, within treatments ($P < 0.05$).

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Chapter 5
Discussion

The aim of this study was to determine to which degree the performance of the male and female homospermic progeny from this genetically improved *Topigs Tempo*© boar could be compared to that of the boar itself, while comparing the growth of said progeny with that of the male and female heterospermic progeny of a standard, pooled semen sample where multiple *Topigs Tempo*© boars' semen samples were pooled together. The independent variables measured during the study were live body weight, P2 backfat thickness (live and at slaughter), carcass characteristics such as warm carcass mass, cold carcass mass, lean meat percentage and carcass length. Average daily gain and carcass compactness was subsequently calculated. All variables were analysed using a linear model.

The results pertaining to body weight indicated that treatment (standard, heterospermic *Topigs Tempo*© sire line or genetically improved, homospermic *Topigs Tempo*© boar), house (grower house 1, 2 and 3) and weight class (heavy and lower) significantly affected the body weight of the animal. From the results, all the progeny started off on the same 11-week body weight ($P > 0.05$), which had a significant effect on body weight during the whole grower phase. The effect of sex on body weight increasingly gravitated towards significance as the animals grew heavier. It is well known from literature that live male animals are heavier and have greater average daily gains than female animals. This male effect influenced the results pertaining to the differences between males and females in the standard sire line such that when comparing the trends for body weight between the male and female progeny of each treatment (standard, heterospermic *Topigs Tempo*© sire line or genetically improved, homospermic *Topigs Tempo*© boar), the male progeny from the standard sire line had heavier body weights ($P < 0.0001$) and greater average daily gains than the female progeny ($P<0.01$). However, the male progeny from the improved boar did not perform any better than their female counterparts. Despite the male effect, numerous literature studies support this finding that males may not always be significantly heavier than females, since body weight may be affected by numerous environmental factors. Gispert *et al*. (2010) compared the live weights between castrated males, entire males and females and found that the entire males did not have heavier live weights (111.64kg for entire males and 107.92kg for females) than the females ($P > 0.05$). Morales *et al*. (2010) conducted a similar study and also reported no difference ($P > 0.05$) in final weights for entire males and females (107.2 and 103.7kg respectively).

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When comparing the trends for body weight within each sex for both treatments (standard, heterospermic *Topigs Tempo*© sire line or genetically improved, homospermic *Topigs Tempo*© boar), the female progeny from the improved boar had heavier body weights than the female progeny from the standard sire line (P<0.01). Conversely, the male progeny from the improved boar performed no better than the male progeny from the standard sire line (P >0.05). A single study conducted by Morales *et al*. (2011), investigated the effects of sex and castration on growth performance of progeny from two Large White sire lines. The authors made use of the *Top York*© and *Tempo*© sire lines that were both from *Topigs*©. When reporting the differences between the sire lines, they concluded that the results were representative of the genetic background of the progeny and that the *Tempo*© line grew faster than the *Top York*©, resulting in heavier live (P <0.001) and carcass weights (P <0.01). Unfortunately, no research exists comparing the growth performance of the male and female progeny of two similar *Topigs*© lines.

From the results pertaining to average daily gain, house (grower house 1, 2 and 3) and sex (male and female) significantly affected the average daily gain of the pigs for the grower phase. The effect of treatment (standard, heterospermic *Topigs Tempo*© sire line or genetically improved, homospermic *Topigs Tempo*© boar) and weight class (heavy and lower) became more significant (in terms of significance level and F-values) closer to the end of the grower phase. When comparing the trends for average daily gain between the male and female progeny of each treatment (standard, heterospermic *Topigs Tempo*© sire line or genetically improved, homospermic *Topigs Tempo*© boar), the male progeny from the standard sire line had higher average daily gains than their standard female counterparts for the duration of the grower phase (P <0.01). Contrary to the standard sire line, the male progeny from the improved boar did not attain higher average daily gains than the female progeny from the improved boar (P >0.05), except for the sharp increase in average daily gain observed during the 17 – 19 week period (P <0.01). Morales *et al*. (2010) observed no difference in ADG between entire males and females during a 74-145 day age period. After 145 days, however, the authors did observe the females to have lower ADG than the entire males.

When comparing the treatments (standard, heterospermic *Topigs Tempo*© sire line or genetically improved, homospermic *Topigs Tempo*© boar), the female progeny from the improved sire line had higher average daily gains than the female progeny from the standard sire line at the start (13 - 15 weeks) and the end (19 – 21 weeks) of the grower phase. However, the average daily gains of the male progeny from the improved boar did not differ from the male progeny from

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the standard sire line, except for the sudden increase in average daily gain during the 17 – 19 week period. Morales *et al*. (2011) observed that the crossbred progeny from the Tempo sire line had better ADG than the crossbred progeny from the Top York sire line (P <0.001).

The results for backfat thickness indicates that treatment (standard, heterospermic *Topigs Tempo*© sire line or genetically improved, homospermic *Topigs Tempo*© boar), house (grower house 1, 2 and 3), sex (male and female) and weight class (heavy and lower) all influenced the backfat thickness of the pigs (P <0.01). Female animals are known to be fatter than male animals, but this trend was only observed for the progeny from the improved boar (P <0.01) since the female progeny from the standard sire line were no fatter than the male progeny from the standard sire line, except at slaughter (P <0.05). The female progeny from the improved boar however, were consistently fatter throughout the entire grower phase, including slaughter, than the male progeny from the improved boar. When comparing progeny within sex between the treatments (standard, heterospermic *Topigs Tempo*© sire line or genetically improved, homospermic *Topigs Tempo*© boar), the female progeny from the improved boar were fatter than the female progeny from the standard sire line (P <0.01). The male progeny from the improved boar and standard sire line followed the same trend as the females (P <0.01), except that the backfat thickness measurements for the males from both treatments were similar at 13 weeks of age. Morales *et al*. (2010) reported higher subcutaneous fat thickness at slaughter in females than in entire males (P <0.001). Morales *et al*. (2011) found no difference in backfat thickness measured in vivo between the *Tempo*© and *Top York*© sire lines. The fat deposition for all the pigs increased with age as expected from the literature. Overall, the progeny from the improved boar had higher backfat thickness measurements than the progeny from the standard sire line (P < 0.0001). This could suggest that the improved boar matures earlier than the standard sire line since animals that mature earlier also deposit adipose tissue reserves earlier. Another consideration is that the animals in this study were fed ad lib and could have become fatter due to the large amounts of feed consumed. As stated in Chapter 2 of this dissertation, Whittemore & Kyriazakis (2006) were of the opinion that genetically improved pigs deposit less fat than their unimproved counterparts. Exactly the opposite was observed in this experiment. However, it has to be noted that Whittemore & Kyriazakis (2006) furthered their explanation to include feed intake as a possible reason why the abovementioned phenomenon of less fat deposition in genetically improved pigs may not be observed. This correlates with the fact that the pigs in this experiment were fed ad lib.

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Carcass characteristics were analysed using a linear model and the results indicated that treatment and weight class had an effect on all the carcass characteristics ($P < 0.0001$) except for compactness. House influenced carcass length ($P < 0.0001$) and sex had an effect on lean meat percentage ($P < 0.01$). When comparing the trends for carcass characteristics between the male and female progeny of each treatment (standard, heterospermic *Topigs Tempo*© sire line or genetically improved, homospermic *Topigs Tempo*© boar). No difference was observed between the male progeny from the standard sire line and their female counterparts for all carcass characteristics studied. The male and female progeny from the improved boar followed the same trend, except for lean muscle percentage where the male progeny from the improved boar had a greater lean meat percentage than their female counterparts ($P < 0.05$).

When comparing the progeny within sex between the treatments, the female progeny from the improved boar had a heavier warm carcass mass and cold carcass mass than the female progeny from the standard sire line ($P < 0.0001$). The male progeny from the improved boar had a heavier warm carcass mass and cold carcass mass than the male progeny from the standard sire line ($P < 0.0001$). Morales *et al*. (2010) reported no difference in percentage lean or carcass weight between entire males and females. Gispert *et al*. (2010) found no difference in carcass weight, carcass length and carcass lean between entire females and males. The authors did however find the females to have higher subcutaneous fat levels in the ham as well as higher levels of flare fat. Morales *et al*. (2011) found the *Tempo*© sire line to have heavier carcass weights at slaughter than the *Top York*© sire line, however, there was no difference in backfat thickness or carcass lean percentage measured post mortem.

In summary, the progeny from the improved boar had heavier warm carcass and cold carcass mass as well as greater backfat thickness measurements than the progeny from the standard sire line. However, a significant observation was the fact that the male and female improved progeny had similar live body weights than the male progeny from the standard sire line. This similarity in live body weight between the treatments and sexes could be due to the fact that the males and females were fed the same commercial grower diet. The protein level of the diet fed during the experimental phase could possibly have restricted the male progeny from the improved boar to express their full genetic potential, resulting in a growth similar to that of the male progeny from the standard boar line. Literature supports the idea that males should be fed separately to maximise efficiency for the respective sexes. This may not have been a problem with the progeny from the standard sire line since the managerial aspects and the commercial diet fed during the

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study made provision for the expression of the genetic potential of the male progeny from the standard sire line. However, the genetic potential of the male progeny from the improved boar may not have been fully expressed and therefore they performed similar to their female counterparts.

When comparing the litter sizes between the two methods of insemination (heterospermic and homospermic) for each group of sows (Group 1, 2 & 3), the results indicate that Group 2 was the only group of sows to have greater litter sizes for the homospermic insemination treatment ($P < 0.01$). The difference between the two methods of insemination did however approach significance for Group 3 ($P < 0.083$) but no difference was observed for Group 1 ($P > 0.05$). Regardless, the overall results illustrated that homospermic insemination results in greater litter sizes than heterospermic insemination ($P < 0.01$). Ferreira *et al*. (2014) compared the effects of heterospermic and homospermic insemination on reproductive performance, including litter size. The authors found no difference between the two treatments for farrowing rate, total litter size and fertility index and concluded that homospermic insemination can be used in routine farm conditions without any adverse effects on reproductive performance.

When observing the effects of treatment within houses, the difference in backfat thickness and carcass characteristics between the groups of progeny within the houses were similar to the differences obtained across houses. The results for body weight varied more for House 1 & 2 performing close to the data obtained from across housing.

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Chapter 6
Conclusion and recommendations

Although pork is not as popular a choice as chicken and beef in South Africa, it remains the largest source of animal protein in the world. The current aim of the pig production industry is to improve production and reproduction efficiency while considering consumer satisfaction with the final product and the means of its production. The aim of this study was to evaluate and compare the growth performance and carcass characteristics of the progeny from a genetically improved, homospermic *Topigs Tempo*© boar with that of a standard, heterospermic *Topigs Tempo*© sire line. Parameters analysed from the data included, live body mass, P2 backfat thickness (live and at slaughter), average daily gain, warm carcass mass, cold carcass mass, lean meat percentage, carcass length and carcass compactness. The abovementioned parameters were measured using a randomised block design with the General Linear Models (GLM) procedure.

For the standard sire line, the male progeny had heavier body weights ($P < 0.0001$) and greater average daily gains ($P < 0.01$) than the females. For the improved boar, the male progeny were no heavier than the females ($P > 0.05$). The average daily gain did, however, differ for a part of the grower phase ($P < 0.05$). Carcass weights for both the standard sire line and improved boar were not affected by the male effect and no difference was observed between the sexes ($P > 0.05$). Despite the male effect, numerous literature studies support this finding that males may not always be significantly heavier than females, since body weight may be affected by numerous environmental factors.

Female animals are known to be fatter than male animals, but this trend was only observed for the progeny from the improved boar ($P <0.01$), since the male and female progeny from the standard sire line revealed no difference in their backfat thickness measurements ($P < 0.05$). Despite this, the fat deposition for all the pigs increased with age. Overall, the progeny from the improved boar had higher backfat thickness measurements than the progeny from the standard sire line ($P < 0.0001$). As discussed in Chapter five, this could suggest that the possible earlier maturation of the progeny from the improved boar, the ad lib diet fed during the experimental phase as well as the protein level of this diet may have influenced the abovementioned outcome.

The results from the effects between sire lines were less clear and due to the lack of published research on the growth performance and carcass characteristics of pigs in South Africa,

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no real comparisons with literature could be made. Despite this, the results from this study were consistent in reporting that the female progeny from the improved sire line performed better than the standard boar line and had heavier body weights ($P < 0.001$), greater average daily gains for part of the grower phase ($P < 0.01$), greater backfat thicknesses ($P < 0.0001$) and heavier warm and cold carcass weights as well as lean meat percentage ($P < 0.0001$). For the male progeny however, no difference was observed in the body weight and average daily gain between the progeny from the improved boar and the progeny from the standard sire line. Despite this, the progeny from the improved boar did display greater backfat thickness ($P < 0.0001$) as well as warm and cold carcass weights ($P < 0.0001$).

Due to the recent welfare concerns regarding castration, new methods of castration are being considered such as immunisation against the hormones (gonadotropin-releasing hormone) responsible for boar taint. There is a copious amount of current research comparing the growth of castrates and intact males or castrates and gilts, but not so much for comparing growth of intact males and gilts. Much of the research on the differences between intact males and females is dated, not to mention the scarcity of research from a South African perspective. This merits further investigation into the growth performance, reproductive performance and management of South African pigs on a commercial level.

No difference in litter size was observed between the two methods of insemination for two of the three houses ($P > 0.05$). This correlates well with the literature. However, homospermic insemination resulted in a greater litter size in one of the three houses ($P < 0.01$). In addition, the overall effect on litter size across all three houses was in favour of the homospermic insemination treatment ($P < 0.01$). Few studies compare the effects of homospermic and heterospermic insemination on reproductive performance and this warrants further research into this topic. Since the effect of method of insemination was not the main objective of the study, sample sizes may have been too small and greater variation may have existed between and within the groups of sows.

This study focused on the growth of pigs and therefore, neither the exact EBV's of the different boars, nor the precise composition of the diet fed was taken into consideration. Ideally, a regression analysis using a sire model that predicts the likelihood of the improved boar to perform in a similar fashion when subjected to similar conditions should be used. This model should include all the possible genetic and environmental interactions present in the study.

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In conclusion, the use of the genetically improved, homospermic *Topigs Tempo*© boar may have a beneficial effect on the growth performance and carcass characteristics of commercial grower and finisher pigs when reared under good managerial conditions and fed a diet that will allow the full expression of the sire line's genetic potential. Also, the use of homospermic inseminations will have no negative effects on litter size in a commercial herd.

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References

Barton-Gade, P.A., 1987. Meat and fat quality in boars, castrates and gilts. Livest. Prod. Sci. 16, 187-196.

Beatty, R.A., Bennett, G.H., Hall. J.G., Hancock, J.L. & Stewart, D.L., 1969. An experiment with heterospermic insemination in cattle. J. Reprod. Fert. 19, 491-502.

Beuhr, M. & McLaren, A., 1984. Interlitter variation in progeny of chimeric male mice. J. Reprod. Fertil. 72, 213-221.

Čandek-Potokar, M., Žlender, B. & Bonneau, M., 1998. Effects of breed and slaughter weight on *longissimus* muscle biochemical traits and sensory quality in pigs. Ann. Zootech. 47, 3-16.

Clutter, A.C., 2011. Genetics of performance traits. In: The genetics of the pig. 2nd ed. Eds. Rothschild, M.F. & Ruvinsky, A., CAB International, Wallingford, UK. pp. 325-354.

Conte, S., Boyle, L.A., O'Connell, N.E., Lynch, P.B. & Lawlor, P.G., 2011. Effect of target slaughter weight on production efficiency, carcass traits and behaviour of restrictively-fed gilts an intact male finisher pigs. Livest. Sci. 136, 169-174.

Dekkers, J.C.M., Mathur, P.K. & Knol, E.F., 2011. Genetic improvement of the pig. In: The genetics of the pig. 2nd ed. Eds. Rothschild, M.F. & Ruvinsky, A., CAB International, Wallingford, UK. pp. 390-425.

Department of Agriculture, Forestry and Fisheries, 2013. A profile of the South African pork market value chain.

Desmoulin, B., Bonneau, M., Frouin, A. & Bidard, J.P., 1982. Consumer testing of pork and processing meat from boars: the influence of fat androstenone level. Livest. Prod. Sci. 9, 707-715.

de Lange, C.F.M., Levesque, C.L. & Kerr, B.J., 2012. Amino acid nutrition and feed efficiency. In: Feed efficiency in swine. Ed. Patience, J.F., Wageningen Academic Publishers. pp. 81-100.

© University of Pretoria

Diestre, A., Oliver, M.A., Gispert, M., Arpa, I. & Arnau, J., 1990. Consumer responses to fresh meat and meat products from barrows and boars with different levels of boar taint. Anim. Prod. 50, 519-530.

Dube, B., Mulugeta, S.D., van der Westhuizen, R.R. & Dzama, K., 2011. Non-genetic factors affecting growth performance and carcass characteristics of two South African pig breeds. S. Afr. J. Anim. Sci. 41. No. 2, 161-176.

Dube, B., Mulugeta, S.D. & Dzama, K.. 2013. Evaluating breeding objectives for sow productivity and production traits in Large White pigs. Livest. Sci. 157, 9-19.

Dyck, M.K., Foxcroft, G.R., Novak, S., Ruiz-Sanchez, A., Patterson, J. & Dixon, W.T., 2011. Biological markers of boar fertility. Reprod. Domest. Anim. 46, 55-58.

Dziuk, P.J., 1996. Factors that influence the proportion of offspring sired by a male following heterospermic insemination. Anim. Reprod. Sci. 43, 65-88.

Eisenbach, M., 1999. Mammalian sperm chemotaxis and its association with capacitation. Dev. Genet. 25, 87-94.

Eissen, J.J., 2000. Breeding for feed intake capacity in pigs. PhD Thesis, Wageningen University, The Netherlands.

Ellis, M., Webb, A.J., Avery, P.J. & Brown, I., 1996. The influence of terminal sire genotype, sex, slaughter weight, feeding regime and slaughter-house on growth performance and carcass and meat quality in pigs and on the organoleptic properties of fresh pork. Anim. Sci. 62, 521-530.

Ferrari, L.S. & Graves, C.N. 1972. Sperm survival in the female tract following heterospermic insemination. J. Dairy. Sci. 55, 696 (Abstract).

Ferreira, C.E.R., Sávio, D.B., Gaurise, A.C., Flach, M.J., Gastal, G.D.A., Gonçalves, A.O., Dellagostin, O.A., Alonso, R.V., Bianchi, I., Corcini, C.D. & Lucia Jr. T., 2014. Contribution of

© University of Pretoria

boars to reproductive performance and paternity after homospermic and heterospermic artificial insemination. Reprod. Fert. Develop. Accepted February 2014.

Fowler, V.R., Bichard, M. Pease, A., 1976. Objectives in pig breeding. Anim. Prod. 23, 365-387.

Foxcroft, G.R., Dyck, M.K., Ruiz-Sanchez, A., Novak, S. & Dixon, W.T., 2008. Identifying useable semen. Theriogenology. 70, 1324-1336.

Gispert, M., Oliver, M.À., Velarde, A., Suarez, P., Pérez, J. & Font i Furnols, M., 2010. Carcass and meat quality characteristics if immunocastrated male, surgically castrated male, entire male and female pigs. Meat. Sci. 85, 664-670.

Groenen, M.A.M., Schook, L.B. & Archibald, A.L., 2011. Pig genomics. In: The genetics of the pig. 2nd ed. Eds. Rothschild, M.F. & Ruvinsky, A., CAB International, Wallingford, UK. pp. 179-194.

Groves, C., 1981. Ancestor for the pigs: taxonomy and phylogeny of the genus *Sus*. Technical Bulletin No. 3. Department of Prehistory, Research School of Pacific Studies, Australian National University, Canberra.

Haley, C.S., Avalos, E. & Smith, C. 1986. A review of selection for reproductive performance in the pig. 37th EAAP, Budapest.

Haugen, T., Reksen, O., Gröhn, Y.T., Gaustad, A.H. & Hofmo, P.O., 2005. A retrospective study on effects of storage time of liquid boar semen on reproductive performance in Norwegian swine. Theriogenology. 64, 891-901.

Holt, W.V. & Harrison, R.A., 2002. Biacarbonate stimulation of boar sperm motility via a protein kinase A-dependent pathway: between-cell and between-ejaculate differences are not due to deficiencies in protein kinase A activation. J. Androl. 23, 557-565.

Holt, W.V. & Van Look, K.J.W., 2004. Concepts in sperm heterogeneity, sperm selection and sperm competition as biological foundations for laboratory tests of semen quality. Reprod. 127, 527-535.

© University of Pretoria

Kim, H.B., Berewicz, K., White, B.A., Singer, R.S., Sreevatsan, S., Tu, Z.J. & Isaacson, R.E., 2012. Microbial shifts in the swine distal gut in response to the treatment with antimicrobial growth promoter, tylosin. PNAS. 109, 15485-15490.

Knap, P.W., 2005. Breeding robust pigs. Aust. J. Exp. Agr. 45, 763-773.

Knol, E., 1998. Genetic parameters of litter mortality and 6 related characteristics. Abstract ADSA and ASAS meeting. Denver.

Lebret, B., Juin, H., Noblet, J. & Bonneau, M., 2001. The effects of two methods of increasing age at slaughter on carcass and muscle traits and meat sensory quality in pigs. Anim. Sci. 72, 87-94.

Macaskill, C., 2011. The National Agricultural Directory. RainbowSA. pp. 408-414.

Macedo, M.C., Deschamps, Jr, J.C., Lucia, T., Bordignon, Jr, J., Serret, C.G., Rambo, G.,Pivato, I. & Schmitt, E., 2006. *In vitro* penetration of fresh and vitrified swine oocytes by homologous spermatozoa using different incubation systems. Anim. Reprod. Sci. 92, 334-348.

Madsen, T., Shine, R., Loman, J. & Häkansson, T., 1992. Why do female adders copulate so frequently? Nature. 355, 440-441.

Marshall, B.M. & Levy, S.B., 2011. Food animals and antimicrobials: Impacts on human health. Clin. Microbiol. Rev. 24, 718-733.

Martin, P.A. & Dziuk, P.J., 1977. Assessment of relative fertility of males (cockerels and boars) by competitive mating. J. Reprod. Fertil. 49, 323-329.

Meuwissen, Th., 1998. Risk management and the definition of breeding objectives. 6th WCGALP, Australia. 25, 347-354.

Morales, J., Gispert, M., Hortos, M., Pérez,J., Suárez, P. & Piñeiro, C., 2010. Evaluation of production performance and carcass quality characteristics of boars immunised against

© University of Pretoria

gonadotropin-releasing hormone (GnRH) compared with physically castrated male, entire male and female pigs. Span. J. Agric. Res. 8, 599-606.

Morales, J.I., Cámara, L., Berrocoso, J.D., López, J.P., Mateos, G.G. & Serrano, M.P., 2011. Influence of sex and castration on growth performance and carcass quality of crossbred pigs from 2 Large White sire lines. J. Anim. Sci. 89, 3481-3489.

Mostert, J.D., 2014. Personal communication. Manager of a Topigs multiplier unit in Bronkhorstspruit.

Mulder, H.A. & Bijma, P., 2005. Effects of genotype x environment interaction on genetic gain in breeding programs. J. Anim. Sci. 83, 49-61.

Novacek, M.J., 2001. Mammalian phylogeny: genes and supertrees. Curr. Biol. 11, R573-R575.

Ollivier, L., 2008. Genetic improvement of the pig. In: The genetics of the pig. Eds. Rothschild, M.F. & Ruvinsky, A., CAB International, Wallingford, UK. pp. 511-535.

Overstreet, J.W. & Adams, C.E., 1971. Mechanisms of selective fertilization in the rabbit: sperm transport and viability. J. Reprod. Fertil. 26, 219-231.

Pizzari, T. & Birkhead, T.R., 2002. The sexually-selected sperm hypothesis: sex-biased inheritance and sexual antagonism. Biol. Rev. 77, 183-209.

Quiniou, N., Courboulay, V., Salaün, Y., Chevillon, P., 2010. Impact of the non castration of male pigs on growth performance and behaviour-comparison with barrows and gilts. 61st Annual Meeting of the European Association for Animal Production, August 23rd-27th, 2010. Heraklion, Crete Island, Greece Session 17 "Symposium: Alternatives to castration in pigs".

Quiniou, N., Dubois, S. & Noblet, J., 2000. Voluntary feed intake and feeding behaviour of group-housed growing pigs are affected by ambient temperature and body weight. Livest. Prod. Sci. 63, 245-253.

© University of Pretoria

Robinson, J.A.B. & Buhr, M.M. 2005. Impact of genetic selection on management of boar replacement. Theriogenology. 63, 668-678.

Ruvinsky, A., Rothschild, M.F., Larson, G. & Gongora, J., 2011. Systematics and evolution of the pig. In: The genetics of the pig. 2nd ed. Eds. Rothschild, M.F. & Ruvinsky, A., CAB International, Wallingford, UK. pp. 1-10.

Saacke, R.G., 1982. Components of semen quality. J. Anim. Sci. 55, 1-13.

See, M.T., Armstrong, T.A. & Weldon, W.C., 2004. Effect of a ractopamine feeding program on growth performance and carcass composition in finishing pigs. J. Anim. Sci. 82, 2474-2480.

Stahlberg, R., Harlizius, B., Weitze, K.F. & Waberski, D., 2000. Identification of embryo paternity using polymorphic DNA markers to assess fertilizing capacity of spermatozoa after heterospermic insemination in boars. Theriogenology. 53, 1365-1373.

van Milgen, J., Noblet, J., Dourmad, J.Y., Labussière, E., Garcia-Launay, F. Brossard, L., 2012. Precision pork production: Predicting the impact of nutritional strategies on carcass quality. Meat. Sci. 92, 182-187.

van Wijk, H.J., Arts, D.J.G., Matthews, J.O., Webster, M., Ducro, B.J. & Knol., E.F., 2005. Genetic parameters for carcass composition and pork quality estimated in a commercial production chain. J. Anim. Sci. 83, 324-333.

Viljoen, H., 2014. Nutrition of the growing pig. In: Modern pig production. By Visser, D., Kejafa Knowledge Works. pp. 177-184.

Visser, D.P., 2004. Structuring of breeding objectives in the pork supply chain in South Africa. University of Pretoria, South Africa (Ph.D. thesis).

Visser, D., 2014. Pig breeds of South Africa. In: Modern pig production. By Visser, D., Kejafa Knowledge Works. pp. 59-63.

© University of Pretoria

Visser, D., Foss, S. & Labuscagne, A., 2014. Pig reproduction. In: Modern pig production. By Visser, D., Kejafa Knowledge Works. pp. 105-125.

Visser, D. & Hofmeyr, J., 2014. Breeding and genetics. In: Modern pig production. By Visser, D., Kejafa Knowledge Works. pp. 71-103.

Visser, D., Kirsten, J., Streicher, S. & Nyoka, Q., 2014. Overview of the South African pig industry. In: Modern pig production. By Visser, D., Kejafa Knowledge Works. pp. 33-48.

Wakimoto, B.T., 1979. DNA synthesis after polyspermic fertilization in the axolotl. J. Embryol. Exp. Morph. 52, 39-48.

Weatherup, R.N., Beattie, V.E., Moss, B.W., Kilpatrick, D.J. & Walker, N., 1998. The effect of increasing slaughter weight on the production performance and meat quality of finishing pigs. Anim. Sci. 67, 591-600.

Whittemore, C.T., 1986. An approach to pig growth modelling. J. Anim. Sci. 63, 615-621.

Whittemore, C.T., 2006. Development and improvement of pigs by genetic selection. In: Whittemore's science and practice of pig production. 3rd ed. By: Whittemore, C.T. & Kyriazakis, I., Wiley. pp. 184-262.

Whittemore, C.T., 2008. Development and improvement of pigs by genetic selection. In: Whittemore's science and practice of pig production. 3rd ed. By: Whittemore, C.T. & Kyriazakis, I., Wiley. pp. 184-262.

Whittemore, C.T. & Kyriazakis, I., 2006. Growth and body composition changes in pigs. In: Whittemore's science and practice of pig production. 3rd ed. By: Whittemore, C.T. & Kyriazakis, I., Wiley. pp. 65-100.

Yasui, Y., 1997. A "good-sperm" model can explain the evolution of costly multiple mating by females. Am. Nat. 149, 573-584.

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Zeh, J.A. & Zeh, D.W., 2001. Reproductive mode and the genetic benefits of polyandry. Anim. Behav. 61, 1051-1063.

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Appendix A

Table 1a Example of the ingredients used in a boar grower ration once fed at Walt Landgoed

Raw Material	Grower 1 (10-12 weeks) (kg)	Grower 2 (12-15 weeks) (kg)	Grower 3 (15-18 weeks) (kg)	Paylean 1 (kg)	Paylean 2 (kg)
Maize 7.5%	686	693	714	690	695
Soya oilcake 46%	185	160	133	170	150
Full-fat soya 36%	40	30	20		
Sunflower oilcake 36%	30	45	60	65	70
Wheat bran 15%	25	40	42	45	55
Feed lime 36	12,5	12,5	12,5	12	12
MCP 21	6	5	4	3	3
Salt	5	5	5	4,75	4,5
L-Lysine HCl	4,35	4	4	4,3	4,3
L-Threonine	1,65	1,4	1,35	1,75	1,55
DL Methionine	1,15	0,8	0,6	0,95	0,7
L-Tryptophan	0,45	0,35	0,3	0,3	0,275
MG T4 Grower	3	3			
MG T3 Pig Growth			3	3	3
Paylean				0,25	0,25

Table 2a Example of the nutritional composition of a boar grower ration once fed at Walt Landgoed

Nutrients	Grower 1 (10-12 weeks) (MJ/kg)		Grower 2 (12-15 weeks) (MJ/kg)		Grower 3 (15-18 weeks) (MJ/kg)		Paylean 1 (MJ/kg)		Paylean2 (MJ/kg)	
	Total	Avail	Total	Avail	Total	Avail	Total	Avail	Total	Avail
ME (pig) %	13,56		13,37		13,26		13,16		13,08	
Lysine %	1,18	1,05	1,09	0,97	1,01	0,90	1,10	0,97	1,05	0,94
Met+Cys %	0,72	0,64	0,67	0,59	0,64	0,56	0,69	0,61	0,66	0,58
Threonine %	0,80	0,70	0,75	0,64	0,70	0,61	0,77	0,67	0,74	0,64
Tryptophan %	0,24	0,21	0,22	0,19	0,20	0,17	0,21	0,19	0,20	0,18
Valine %	0,89	0,76	0,85	0,73	0,81	0,69	0,85	0,73	0,83	0,71
Crude protein %	17,19	14,73	16,42	14,01	15,53	13,23	16,50	14,07	16,05	13,70
Crude fibre %	3,50		3,79		3,97		4,10		4,23	
Crude fat %	3,77	3,26	3,66	3,17	3,54	3,09	3,16	2,75	3,19	2,77
Ca:P %	1,07		1,05		1,05		1,01		1,00	
Calcium (Ca) %	0,68		0,66		0,63		0,60		0,60	
Phosphorous (P) %	0,56	0,30	0,55	0,30	0,53	0,30	0,52	0,29	0,52	0,30
Sodium (Na) %	0,21		0,22		0,22		0,22		0,20	
dEB (meq/kg)	154		148		137		144		141	
Chloride (Cl) %	0,45		0,45		0,45		0,46		0,43	

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Addendum A Table indicating the average, standard deviation and significance of the measurements recorded for each parameter in the study. Measurements were compared within sexes (male and female) between treatments (standard, heterospermic *Topigs Tempo*© sire line and genetically improved, homospermic *Topigs Tempo*© boar).

		Males					Females				
Trait	Week	Control (N = 81)		Improved (N = 84)			Control (N = 78)		Improved (N = 80)		
		Ave	St. dev.	Ave	St. dev.	P	Ave	St. dev.	Ave	St. dev.	P
BW	13	48.49	± 0.382	49.72	± 0.366	0.0218	48.43	± 0.378	48.80	± 0.376	ns
	15	63.19	± 0.416	63.53	± 0.399	ns	61.59	± 0.412	63.55	± 0.410	0.0009
	17	77.69	± 0.512	78.15	± 0.491	ns	74.93	± 0.507	77.13	± 0.504	0.0024
	19	92.50	± 0.581	94.02	± 0.558	0.0618	89.23	± 0.576	91.79	± 0.573	0.0019
	21	105.34	± 0.521	108.20	± 0.708	ns	103.06	± 0.730	107.44	± 0.727	< .0001
P2	13	6.65	± 0.100	6.86	± 0.100	ns	6.58	± 0.100	7.77	± 0.100	< .0001
	17	9.45	± 0.137	10.79	± 0.136	< .0001	9.57	± 0.138	11.32	± 0.137	< .0001
	21	11.68	± 0.182	12.46	± 0.181	0.0025	11.90	± 0.183	13.06	± 0.182	< .0001
	Slaug.	14.75	± 0.318	16.75	± 0.317	< .0001	15.66	± 0.320	17.92	± 0.318	< .0001
ADG	13-15	1.03	± 0.023	1.01	± 0.003	ns	0.93	± 0.023	1.06	± 0.023	< .0001
	15-17	1.03	± 0.023	1.04	± 0.023	ns	0.96	± 0.024	0.98	± 0.023	ns
	17-19	1.06	± 0.024	1.33	± 0.024	0.0333	1.02	± 0.025	1.05	± 0.024	ns
	19-21	1.17	± 0.032	1.14	± 0.032	ns	1.07	± 0.033	1.20	± 0.032	0.0046
WCM	Slaug.	86.06	± 0.680	88.67	± 0.662	0.0059	86.06	± 0.680	89.12	± 0.676	0.0016
CCM	Slaug.	83.64	± 0.667	86.18	± 0.662	0.0072	83.56	± 0.680	86.62	± 0.675	0.0016
LMP	Slaug.	68.31	± 0.152	67.58	± 0.151	0.0008	68.01	± 0.155	67.10	± 0.154	< .0001
CL	Slaug.	97.71	± 0.657	97.83	± 0.652	ns	98.89	± 0.670	98.23	± 0.665	ns
CC	Slaug.	0.9434	± 0.047	0.8829	±0.047	ns	0.8471	± 0.048	0.8848	± 0.048	ns

BW = Body weight (kg), P2 = Backfat thickness measurement (mm), ADG = Average daily gain (kg/day), WCM = Warm carcass mass, CCM = Cold carcass mass, LMP = Lean meat percentage (%), CL = Carcass length (cm), CC = Carcass compactness, Slaug. = Slaughter, N = Number of animals, ns = Sources of variation with no significant effect.

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Addendum B Table indicating the average, standard deviation and significance of the measurements recorded for each parameter in the study. Measurements were compared within treatments (standard, heterospermic *Topigs Tempo*© sire line and genetically improved, homospermic *Topigs Tempo*© boar) between sexes (male and female).

		Control sire line					Improved boar				
Trait	Week	Male (N = 81)		Female (N = 78)			Male (N = 84)		Female (N = 80)		
		Ave	St. dev.	Ave	St. dev.	P	Ave	St. dev.	Ave	St. dev.	P
BW	13	48.49	± 0.382	48.43	± 0.378	ns	49.72	± 0.366	48.80	± 0.376	ns
	15	63.19	± 0.416	61.59	± 0.412	0.0065	63.53	± 0.399	63.55	± 0.410	ns
	17	77.69	± 0.512	74.93	± 0.507	0.0001	78.15	± 0.491	77.13	± 0.504	ns
	19	92.50	± 0.581	89.23	± 0.576	< .0001	94.02	± 0.558	91.79	± 0.573	0.0052
	21	105.34	± 0.521	103.06	± 0.730	< .0001	108.20	± 0.708	107.44	± 0.727	ns
P2	13	6.65	± 0.100	6.58	± 0.100	ns	6.86	± 0.100	7.77	± 0.100	< .0001
	17	9.45	± 0.137	9.57	± 0.138	ns	10.79	± 0.136	11.32	± 0.137	0.0072
	21	11.68	± 0.182	11.90	± 0.183	ns	12.46	± 0.181	13.06	± 0.182	0.0201
	Slaug.	14.75	± 0.318	15.66	± 0.320	0.0435	16.75	± 0.317	17.92	± 0.318	0.0096
ADG	13-15	1.03	± 0.023	0.93	± 0.023	0.0018	1.01	± 0.003	1.06	± 0.023	ns
	15-17	1.03	± 0.023	0.96	± 0.024	0.0216	1.04	± 0.023	0.98	± 0.023	0.0594
	17-19	1.06	± 0.024	1.02	± 0.025	ns	1.33	± 0.024	1.05	± 0.024	0.0119
	19-21	1.17	± 0.032	1.07	± 0.033	0.0226	1.14	± 0.032	1.20	± 0.032	ns
WCM	Slaug.	86.06	± 0.680	86.06	± 0.680	ns	88.67	± 0.662	89.12	± 0.676	ns
CCM	Slaug.	83.64	± 0.667	83.56	± 0.680	ns	86.18	± 0.662	86.62	± 0.675	ns
LMP	Slaug.	68.31	± 0.152	68.01	± 0.155	ns	67.58	± 0.151	67.10	± 0.154	0.0272
CL	Slaug.	97.71	± 0.657	98.89	± 0.670	ns	97.83	± 0.652	98.23	± 0.665	ns
CC	Slaug.	0.9434	± 0.047	0.8471	± 0.048	ns	0.8829	±0.047	0.8848	± 0.048	ns

BW = Body weight (kg), P2 = Backfat thickness measurement (mm), ADG = Average daily gain (kg/day), WCM = Warm carcass mass, CCM = Cold carcass mass, LMP = Lean meat percentage (%), CL = Carcass length (cm), CC = Carcass compactness, Slaug. = Slaughter, N = Number of animals, ns = Sources of variation with no significant effect.

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Addendum C Table indicating the descriptive statistics of the body weights and backfat measurements recorded for each group of pigs during the grower phase of the study.

Trait	Boar line	Sex	N	Week	Average	Median	St. dev.	Min	Max
Weight	Standard	Female	78	13	48.43	48.30	± 0.378	27.40	63.60
				15	61.59	62.20	± 0.412	41.60	72.4
				17	74.93	75.40	± 0.507	57.20	84.20
				19	89.23	89.60	± 0.576	71.8	101.4
				21	103.06	103.90	± 0.730	77.40	119.00
	Improved	Female	80	13	48.80	50.20	± 0.376	37.20	60.60
				15	63.55	65.20	± 0.410	50.00	78.40
				17	77.13	79.20	± 0.504	65.60	90.20
				19	91.79	93.20	± 0.573	72.80	105.0
				21	107.44	108.60	± 0.727	87.60	122.2
	Standard	Male	81	13	48.49	47.20	± 0.382	34.60	57.60
				15	63.19	62.20	± 0.416	46.00	73.00
				17	77.69	76.80	± 0.512	61.20	89.00
				19	92.50	90.80	± 0.581	75.80	108.0
				21	105.34	104.00	± 0.521	85.20	127.4
	Improved	Male	84	13	49.72	51.40	± 0.366	30.00	61.20
				15	63.53	63.80	± 0.399	45.40	74.60
				17	78.15	80.00	± 0.491	51.80	95.60
				19	94.02	94.80	± 0.558	72.20	106.2
				21	108.20	110.20	± 0.708	86.20	126.20
P2	Standard	Female	78	13	6.58	7	± 0.100	4	9
				17	9.57	10	± 0.138	6	13
				21	11.90	12	± 0.183	9	16
	Improved	Female	80	13	7.77	8	± 0.100	6	12
				17	11.32	11	± 0.137	9	15
				21	13.06	13	± 0.182	9	19
	Standard	Male	81	13	6.65	7	± 0.100	6	9
				17	9.45	9	± 0.137	7	14
				21	11.68	12	± 0.182	9	17
	Improved	Male	84	13	6.86	7	± 0.100	4	9
				17	10.79	11	± 0.136	7	13
				21	12.46	12	± 0.181	9	16

BW = Body weight (kg), P2 = Backfat thickness measurement (mm), ADG = Average daily gain (kg/day), N = Number of animals

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