PRODUCTION PARAMETERS FOR BOER GOATS IN SOUTH AFRICA

by

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CHAPTER I

GENERAL INTRODUCTION

1.1 Goat production in South Africa

Goats are among the earliest animals to be domesticated and rank among important livestock species used for meat production around the world (Penn State, 2000; Galal, 2005). Although goats are found worldwide this small ruminant specie has been neglected in the livestock sector (Dubeuf *et al*., 2004).

It is estimated that there are 570 goat breeds distributed across the world, of which 89% are found in Africa. Although goats are found in all types of ecological zones, they are concentrated in the tropics, in dry zones and in developing countries (Galal, 2005). Due to their ability to adapt to different environments, goats exhibit large diversity as a result of natural selection under different conditions (Morand-Fehr *et al*., 2004).

The goat population has increased worldwide during the last three decades and is presently estimated at approximately 840 million head (Simela & Merkel, 2008), of which 95% are meat goats (Thompson, 2006). In 2005 approximately 95.8% of the total world goat population was found in developing countries: of these 43.6% were in Asia, 29.2% in Africa, 21.7% in China and 1.3% in Central America (Olivier *et al*., 2005). According to the National Department of Agriculture (2009), South Africa has approximately 6,495 million goats. This genetically diverse group of animals comprises of Boer goats, Savannah goats, Angora goats, Kalahari Red goats and other indigenous goats, generally owned by communal farmers (Braun, 1998). Only 36% of the total number of goats in South Africa is farmed on a commercial basis (Coetzee, 1998).

Goats are important for both commercial and subsistent farming systems in South Africa. Commercial farmers keep goats primarily for meat and fibre production, whereas subsistent farmers who cannot afford to keep cattle use them as a source of meat and milk, as well as cash for other expenses (Casey & Van Niekerk, 1988). Indigenous breeds such as Boer and Nguni goats have several advantages over the exotic breeds, due to their good mothering ability, adaptability, hardiness, and resistance to diseases under the harsh South African farming conditions (Casey & Van Niekerk, 1988; Barry & Godke, 1997).

Among the indigenous breeds in South Africa the Boer goat has numerous productive advantages over the rest and this has led to its popularity and demand worldwide. The adaptability of the breed, the quality of meat produced and their ability to perform well under extensive semi-arid climatic conditions, ranging from hot dry seasons to the extremely low temperatures of snow-clad mountainous regions, are among the advantages (Casey & Van Niekerk, 1988; Barry & Godke, 1997).

The demand for livestock is increasing significantly as a result of a fast growing world population, changes in lifestyle and food preferences (Delgado *et al*., 1999). South Africa, like most developing countries, is characterized by poverty, malnutrition and a growing human population with unequal distribution of wealth (Greyling *et al*., 2004). In developing countries people suffer from malnutrition, since food is scarce or unbalanced in terms of nutrients. Most of the diets consist of starchy grains and are lacking in proteins and essential nutrients for growth and body maintenance (Lasley, 1978).

In order to address this situation, alternatives in terms of sources of animal protein should be investigated. Animal products such as meat, milk and eggs are the main sources of protein for humans. One possibility is to use the goat as a source of protein to help feed and uplift these communities (Greyling *et al*., 2004).

1.2 Objectives of the study

The purpose of the study was firstly to evaluate the growth performance of Boer goat rams in the Northern Cape Veld-ram Club and secondly to estimate genetic parameters and -trends for two Boer goats studs in Northern Cape Province.

CHAPTER II

LITERATURE REVIEW

2.1 Origin and history of the Boer goat

The origin of the Boer goat is not precisely known, although it is believed that the ancestors of the Boer goat were probably kept by migrating tribes in Africa (Casey & Van Niekerk, 1988). According to Van Rensburg (1938), as cited by Campbell (2003) there are six types of goats recognized in South Africa: The *ordinary Boer goats,* animals with short hair, a number of colour patterns and good conformation; the *long hair Boer goats* that have coarse meat and heavy coats; the *polled Boer goats,* these animals have poor conformation and are hornless; the *white red-headed Boer goats,* the *brindle or briekwa goats* and the *mouse-eared and short-eared goats*. Animals that have been selected for good conformation, high fertility and fecundity, rapid growth and adaptability to varied environments are classified as the improved Boer goat.

The goat most commonly kept by small farmers in South Africa is the unimproved Boer goat, where "Boer" means "farmer" in Dutch (Casey & Van Niekerk, 1988). These traditional goats are similar to those found in many parts of Africa and Asia, being animals with long legs, lean bodies, and with a mixed array of colour patterns (Malan, 2000). The original work in the development of the present day Boer goats initiated in the early 1900's when breeders in the Eastern Cape region of South Africa started the selection of a meat type goat (Malan, 2000; Lu, 2001). Using the unimproved Boer goats of the region, these breeders obtained a compact, well proportioned short haired goat that still exists today (Casey & Van Niekerk, 1988). An exceptional characteristic of Boer goat breeding history is the fact that the breed was not created from two or more purebred breeds, but was established from selecting from all existing breeds of goats in South Africa, with the end result being the *improved Boer goat* that we see today (Malan, 2000).

The breed standards were first established when the South African Boer goat Breeders' Association was formed in 1959 (Malan, 2000).

2.2 Performance of the Boer Goat

The South African Boer goat is famous for its large mature size and fast growth which results in heavy muscled carcasses (Van Niekerk & Casey, 1988; Erasmus, 2000). A review of growth, development and carcass composition of 11 goat breeds from around the world showed that Boer goats had the highest mature weight (100-110 kg) and the fastest growth rate (McGregory, 1984 as cited by Hoover, 2000). The Boer goat is also known for its high fertility, with females having the ability to stay in production for long periods of time (Greyling, 2000; Malan, 2000). According to the National Department of Agriculture, Boer goat females under extensive conditions with a precipitation of 295 mm, have an average conception rate of 90%, kidding rate of 187%, fecundity (kids born/does kidded) of 210%, and weaning rate (kids weaned/doe mated) of 149% over a twenty year period (Malan, 2000). Casey & Van Niekerk (1988) reported mean litter size for Boer goat females of 1.93 kids per parturition. The litter size of Boer goat females varied from 15.2-24.5 % kids born as singles, 59.2-67.5% born as twins and 15.3-16.3% born as triplets (Erasmus, 2000; Greyling, 2000). In a study involving 826 Boer goat does ranging from 1.5 to 6.5 years old, 7.6% of the kids were born as singles, 56.5% as twins, and 33.2% as triplets

(Erasmus *et al*., 1985). Even though prolificacy is important and useful when looking at the maternal ability of the doe, the number of kids weaned per doe is of more practical significance when measuring reproductive efficiency.

Traits such as birth weight and weaning weight are important when considering growth potential and muscle development in meat goats. Weight gains of Boer goats have ranged from 139 g/day (Dreyer, 1975, as cited by Morris & du Toit, 1998) to over 200 g/day (Van Niekerk & Casey, 1988), depending on the feeding system. Average daily gains of Boer goat kids raised in Namibia averaged 240, 238 and 218 g/day for singles, twins and triplets, respectively (Barry & Godke, 1997). The corresponding rates in Germany were 257, 193, and 182 g/day (Lu, 2001). In the United States birth weight of Boer goat kids normally range from 3 to 4 kg, with males kids weighing about 0.5 kg more than females, while typical weaning weights range from 20 to 25 kg, depending upon weaning age (Lu & Potchoiba, 1988). The performance of Boer goats managed under extensive conditions in sub-tropical grass bush settings in South Africa showed average daily gains of 163 g/day from birth to weaning when weaned 100 days after birth (Aucamp & Venter, 1981 as cited by Van Niekerk & Casey, 1988). A study conducted by Almeida *et al*., (2006), in South Africa, reported average daily gains of 193 g/day and 131 g/day for supplemented and non-supplemented Boer goats respectively. Lehloenya *et al*., (2005) reported birth weights ranging from 2.3 to 2.5 kg for South African Boer goats following synchronization and artificial insemination.

2.3 Importance of performance recording

The genetic merit of the sire is of paramount importance in livestock production. The genetic and phenotypic characteristics of the sire are expressed in its offspring which have a significant impact when the characteristics have an economic value. Performance recording is an objective and systematic measurement of individual animal performance (Banga, 2002). The concept of performance recording relies on the fact that traits under investigation can be measured and are heritable (Kräusslich, 1974).

The testing of rams on natural grazing conditions is of great importance in evaluating growth traits. Growth rate under extensive conditions can be associated with some fitness traits such as resistance to tick born disease (Frisch, 1981). The selection of sires that perform well in performance tests does not only enhance the probability of obtaining increased growth and muscling, but also improves profitability.

For rapid genetic progress, breeding animals must be selected at an early age so that producers can incorporate these into their breeding programs as early as possible. The selection of sires in performance tests must be based on traits that will be needed in the progeny (Kräusslich, 1974).

2.4 The National Small Stock Recording and Improvement Scheme (NSSRIS)

Performance recording of Boer goats started in the early seventies under the South African Mutton and Goat Performance and Progeny Testing Scheme (Casey & Van Niekerk, 1988). This scheme records and evaluates the performance of goats and provides farmers with a selection tool with which the efficiency of goat meat production can be improved (Bergh, 1999; Ramsay *et al*., 2000).

There are four phases in the performance recording scheme: Phase A in which details of individual and group matings as well as birth, weaning weight and death events are recorded; this phase forms the basis of net production rate and total weight of lamb weaned per ewe; Phase B where records of weaning weight as well as post weaning weights (270 and 365 days of age), under natural production environment are taken in order to evaluate growth efficiencies and adaptability; Phase C which records traits in accordance with the economical importance of sheep and goat production systems such as fleece weights, fiber diameter, staple length, crimp frequency, coefficient of variation and clean yield; and Phase D where rams of different flocks are tested centrally under natural conditions with provisions for standardizing pre-test conditions like an appropriate adaptation period and minimum requirements for weight differences and growth rate.

In the veld-ram clubs, rams at weaning age are collected from different breeders and are performance tested as a group for 150 days on natural veld. On conclusion of the test period, when the rams are approximately 12 months of age, the animals are sold at a public auction. (Fourie, 1999 as cited by Fourie *et al*., 2000). By this means the buyer is purchasing a ram that has been selected for traits of economic importance and is adapted to the specific environment in which it is expected to perform.

Due to age and weight differences at the start of tests, the testing period must exceed 140 days, following an adaptation period of at least 14 days. In addition the difference in the initial live weights of all the males in a group is not allowed to exceed 12 kg and all animals must have been born within a 60-day period. The number of animals per test group must not be less than 20 and an average daily gain higher than 50 g has to be achieved over the entire test period. The starting weight, the final weight at the end of the test and three additional weights are recorded. These weights are used to calculate a regression of live weight and the average daily gain which depicts the growth of individual animals. A selection index is then calculated by combining the growth rate and final weight. At the end of the test the scrotal circumference is also measured and displayed as deviation from the mean (Olivier *et al*. 2005).

A study done by Fourie (1999), as cited by (Olivier, 2002), concluded that the information provided to potential buyers at a public auction of the veld rams had little effect on the sale price. Heavier rams generally fetched higher prices. This trend forced breeders to flush their rams before the testing period to ensure a higher body weight at intake and consequently also higher at the end of the test. In order to combat this practice a maximum intake weight of 50 kg was established for all tests (Olivier, 2002). The correlation between results in performance recording and progeny performance was found to be less than 2% in North American Suffolk sheep under feedlot conditions (Waldron *et al*., 1990). Comparing the progeny of three Dorper rams with a high selection index with three rams with a low index raised under extensive conditions, Olivier *et al*. (2005) noted that progeny of the high index rams were 2.14 kg heavier at weaning than progeny of the low index rams.

2.5 Traits investigated

2.5.1 Growth

Growth in animals is defined as a differentiation and increase in body cells (Bathaei & Leroy, 1996). Growth rate, body size and changes in body composition are of great economic importance for efficient production of meat animals. Berg & Walters (1983) reported that fast growing lean cattle breeds are more efficient in converting feed energy to lean tissue than the slow growing fatter breeds. According to Bathaei & Leroy (1996), animal growth can be expressed as the positive change in body weight per unit of time or by plotting body weight against age. The increase in body weight of farm animals is mainly a reflection of the growth of carcass tissues consisting of lean meat, bone and fat. Growth rate of lambs, particularly during the early stages of growth, is strongly influenced by breed, milk production, the environment under which the animals are maintained, including the availability of adequate feed supply in terms of both quantity and quality (Notter & Copenhaver, 1980; Burfening & Kress, 1993; Bathaei & Leroy, 1996).

Growth rate can be divided into two periods (Luginbuhl, 2002): pre-weaning average daily gain and post-weaning daily gain. The pre-weaning average daily gain period reflects the genetic potential of the growing animal and mothering ability of the ewe. Rapid growth is a crucial criterion for the improvement of meat production in goats (McGowan & Nurce, 2000). In some production systems, kids are sold at weaning and consequently pre-weaning average daily gain is an important production trait to be considered (Luginbuhl, 2002). Growth during the pre-weaning period is largely determined by milk production and competition for it amongst litter mates. The growth rate of kids is influenced by the energy level available offered to the ewe during lactation (Sibanda *et al*., 1999).

The growth rate of Boer goats is generally lower than that of sheep, but under good nutritional conditions, weight gains of more than 200 g per day can be obtained in goats, compared to maximum values of 176 g per day under extensive subtropical conditions (Van Niekerk & Casey, 1988). Results of Das & Sendalo (1990) working on meat goats in Malya, Tanzania, indicated that single born kids exhibited a higher growth rate than twins from birth to weaning. Males were significantly heavier and grew faster than females. Karua & Banda (1990) reported that male kids were heavier than female kids. Gebrelul *et al*. (1994) revealed that the sex of kids had a significant effect on weaning weight and pre-weaning average daily gain of Alpine, Nubian and crossbred single-born or multiple-born kids. Singles were heavier at weaning and grew faster in the pre-weaning average daily gain stage than multiple born and reared kids. Mourad & Anous (1998) demonstrated that type of birth in African and Alpine crossbred goats affected body weight and the average daily gain of kids. Montaldo *et al*. (1995) studied local goats in Mexico and demonstrated that goats with two or more kids at birth had higher milk production, efficiency and body weight than goats with only one kid.

Research done by Alexandre *et al*. (1999) on Creole goats showed that the daily weight gain from 10 to 30 days of age varied from 95 g for single kids to less than 70 g for multiples, and from 91 g for males to 86 g for females. Madibela *et al*. (2002), working on Tswana goats concluded that birth weight was positively correlated with growth rate. Singles and males had a higher average daily gain than twins and females (Osinowo *et al*. 1992). Inyangala *et al*. (1990) concluded that parity was a significant source of variation for growth rate. Age of dam had a significant effect on weaning weight and pre-weaning average daily gain of Alpine, Nubian and crossbred goats (Gebrelul *et al*., 1994). Ikwuegbu *et al*. (1995) showed in studies on African Dwarf goats under village conditions that the rate of gain and body weight up to weaning was affected by year, parity and birth type. Results of Osinowo *et al*. (1992) showed that pre-weaning average daily gain was significantly affected by parity, litter size and sex.

Lu (2001) reported that among all traits for goat meat production, heavier body weights and faster growth rates were the most important. Boer goats are known to have a higher growth rate compared to other goat breeds. Growth rate of the first 12 months can be 200 g/day or more under good pastoral conditions. Average growth rates in male goats were recorded as 291, 272, 245 and 250 g/day from birth to 100, 150, 210 and 270 days, respectively (Campbell, 1977; unpublished data as cited by Van Niekerk & Casey (1988). The corresponding rates were 272, 240, 204, and 186 g/day in females.

Under an extensive management system, Boer goat crosses (Alpine, Spanish and Tennessee stiff-legged goats used as maternal breeds) were heavier at 4, 8 and 12 weeks of age, compared to pure-bred Boer goats, although the advantage diminished with advancing age (Gebrelul & Iheanacho, 1997). However, a computer simulation done in the United States of America (Blackburn, 1995) suggested that Boer goats may not excel in growth and reproduction under extensive management conditions. Although performance of Boer goats under extensive management systems has not yet been well characterized, benefits in offspring performance with Boer goats used as a terminal sire breed under intensive management conditions are generally accepted (Luo *et al*., 2000). Jiabi *et al*. (2001) studied the improvement effect of crossbreeding Boer goats and Sichuan native goats and revealed that the crossbred F1 goats grew faster than local breeds with the advantages of better meat production, great potential for improvement in production, good mating ability and significant hybrid vigor. It is not always objective to relate growth rate with age. Factors such as weaning age, weaning stress and compensatory growth can affect growth rate (Lu & Potchoiba, 1988). One example is that growth rate of Boer goat kids can be substantially reduced in solitary confinement (Van Niekerk & Casey, 1988). The average daily gain was 62, 139, 182, and 194 g for birth-10 kg, 10-23 kg, 23-32 kg, and 32-41 kg body weight, respectively. Average daily gains were 240, 238, and 218 g/day respectively, for single, twin and triplet Boer kids raised in Namibia (Barry & Godke, 1997). The corresponding rates in Germany were 257, 193, and 182 g/day. Post weaning growth can be in excess of 250 g/day for Boer goats under extremely favourable conditions. This is substantially higher than the growth rate for dairy goats, which is 125-150 g/day from birth to weaning, and 115 g/day from 4 to 8 months of age (Lu & Potchoiba, 1988). Faster growth rates imply that Boer goats can potentially reach marketing weight earlier. However, desirable carcass quality should also be taken into consideration to capture maximum market return. Another important implication of faster growth rate is that Boer goats can reach breeding weight earlier. Continuous improvement in genetics, feeding methods and management systems may contribute to even faster growth rates in Boer goats as well as their crosses in the future.

2.5.2 Efficiency

As with all species of livestock, the feed conversion ratio is an integral component in goat selection and production. Goats are known to be more efficient in utilizing certain shrubs, brush, and other plant species for weight gain than other domestic livestock species; however, when fed in confined situations, feed conversion ratio is lower than the case would be with other livestock (Sheridan *et al*., 2003). There is much variation between performance and feed conversion ratio when comparing different breed types. Studies conducted in the United States of America have shown that Boer x Spanish goats offer improved feed conversion ratio ($P<0.05$) over that of purebred Spanish goats (Cameron *et al*., 2001).

Lewis *et al*. (1997) reported higher body weight (BW) and body weight gain for Boer goat crosses than for Spanish goats, although feed conversion ratio was similar. Koots *et al*. (1994) reported high negative genetic correlation estimates between feed conversion ratio (FCR) and growth rate and size. These correlations indicate that selection to reduce feed conversion ratio (FCR), and thus improve efficiency, would be accompanied by an increase in growth rate, and an increase in mature ewe size. Numerous studies have shown that feed conversion ratio (FCR) is highly negatively correlated with average daily gain (ADG). This implies that the selection for lower feed conversion ratio (FCR) would result in higher growth rate, or vice versa (Arthur *et al*., 2001; Nkrumah *et al*., 2004; Sainz & Paulino, 2004). Sheridan *et al*.(2003), in a study done in South Africa, concluded that the Boer goat performs better on a diet with a low metabolic energy level than the Mutton merino, and therefore can be finished off on these diets without reduction in performance.

2.5.3 Kleiber ratio

Unlike the case of animals in feedlots, it is virtually impossible to determine the feed intake (FI) of grazing goats. The relation of growth rate to metabolic weight (Kleiber ratio; KR) was developed as an alternative ratio to address this problem in rangeland animals (Arthur *et al*., 2001). The Kleiber ratio (KR) has been recommended to be a useful indicator of feed conversion and an important selection criterion for efficiency of growth (Köster *et al*., 1994). Recently, Arthur *et al*. (2001) showed that the Kleiber ratio (KR) is highly negatively correlated ($r = -0.81$) with feed conversion efficiency in beef cattle. Bergh (1994) indicated that Kleiber ratio (KR) is highly heritable ($h^2 = 0.50$) in beef cattle, which suggests that herd feed conversion could be improved through a selection process. The selection for Kleiber ratio (KR) is known to have fewer negative results than selection for average daily gain (ADG), since it has a lower correlation with other traits, such as birth weight, final weight, average daily gain per day of age (ADO), shoulder height and body length (Bergh, 1994).

In an experiment on young Charolais bulls, Arthur *et al.* (2001) reported a moderate heritability estimate for Kleiber ratio (KR) ($h^2 = 0.31$), but obtained a strong genetic and phenotypic correlation with FCR ($r=0.81$ and $r=-0.67$) and ADG ($r=0.82$ and $r=0.83$) respectively. Because of the fact that Kleiber ratio (KR) was lower correlated with most of the other measures of feed efficiency such as relative growth rate (RGR) and residual feed intake (RFI), it was concluded that Kleiber ratio (KR) be independently selected without compromising other feed conversion efficiency (FCE) traits (Arthur *et al*., 2001). Phenotypic and genetic correlations between average daily gain (ADG) and Kleiber ratio (KR) were reported to be 0.93 and 0.94 in Dormer sheep by Van Wyk *et al.* (1993). Van Niekerk *et al.* (1996) estimated a corresponding genetic correlation of 0.97 in Boer goats, using a sire model.

2.5.4 Scrotal circumference

Testicular traits are important variables directly associated with sperm features and animal fertility. The shape and content of the scrotum are associated with fertility parameters (Coulter & Foote, 1977). Scrotal circumference (SC) and testicular consistency (TC) have been extensively used in predicting the reproductive capacity of male domestic animals. This is because scrotal circumference is an indirect measurement of testicular weight and a reliable indicator of testicular growth and spermatogenic capacity of the testis (Daudu, 1984). Likewise, testicular weight (TW) is a reliable variable for estimating the sperm production capacity of males. Together with the other variables, it can be used to select males for testicular size at puberty (Coulter *et al*., 1975). Scrotal circumference (SC) is the most heritable component of fertility and should therefore be included in breeding soundness evaluations (Bailey *et al*., 1996). A number of studies have characterized the testicular traits of bulls (Coulter *et al*., 1975; Coulter & Foote, 1976). Animal size and traits such as birth weight (BW) are closely associated with testicular weight (Nsoso *et al*., 2004). However, the patterns of the growth and sperm production capacity of rams, as in other domestic animals, are influenced by factors such as nutrition, breed, age, season and health status (Roca *et al*., 1992; Karagiannidis *et al*., 2000). Bull reached puberty (50 x 10^6 sperm with a minimum of 10% motility) at an average scrotal circumference of 27.9 cm. Lunstra *et al.* (1982) reported a correlation of r=0.98 for the scrotal circumference of sires with age at puberty in heifers, amongst beef breeds. Genetic correlation estimates between scrotal circumference in yearling bulls and age at puberty in their half sib heifers of r=-0.71 and r=-1.07 have been reported by Brinks *et al*. (1978). Lunstra *et al.* (1982) stated that age at puberty and scrotal circumference are essentially the same trait. Toelle & Robison (1985) also reported that scrotal circumference was genetically positively related to several measures of female reproduction. The genetic and phenotypic correlations of scrotal circumference with measures of growth reported in the literature are generally positive.

2.5.5 Final weight

Buyers have always considered weight an important factor when purchasing an animal, because actual weight is an indicator of individual performance. Generally large rams fetch higher prices than smaller rams (Fourie *et al*., 2000). Final test weight is expected to have a positive correlation with price. This weight, recorded prior to the sale, is a close indication of the current sale weight of the rams. Buyers consider a high final weight as an indication of fast growth and early maturity (Price & Wallach, 1991).

CHAPTER III

THE RELATIONSHIP BETWEEN SELLING PRICE AND MERIT OF BOER GOAT RAMS IN THE NORTHERN CAPE VELD-RAM CLUB

3.1 Introduction

In South Africa most goat producers farm under extensive conditions, using the natural pastures as the main feed resource. The veld types of South Africa are extremely diverse in terms of botanical composition (Acocks, 1988) and therefore, also dry matter (DM) production potential (De Waal, 1994). Such diversity occurs due to the variation in rainfall and is reflected in animal performance. To perform in these environments the hardiness, adaptability and survival rates of the animals are of greatest importance. It was for these reasons that the Boer goat breed was developed (Olivier, 2002). The Boer goat, one of the hardiest breeds in the world can be reared in a great variety of climatic and pasture conditions (Casey & Van Niekerk, 1988).

For genetic improvement of locally farmed Boer goats, performance recording under extensive management conditions are carried out for young rams. The Northern Cape Veld-ram Club, located in the Northern Cape province of South Africa, records valuable data every year on the performance of young rams tested on the farm. The results of the test are supplied to farmers at the auctions. The breeders remain anonymous until the rams have been sold (Fourie *et al*., 2000). The basic idea is that animals from different farms receive the same treatment and thus prices are not influenced by the name or status of the breeder. The buyer can therefore consider all available information objectively in order to select the ram that best suits his/her production system.

The objective of this study was to investigate the relationship between selling price and traits measured during the test.

3.2 Material and Methods

3.2.1 Location of the experimental site

The performance test was conducted by the Northern Cape Veld-Ram Club, situated in the Postmasburg district, South Africa. The Northern Cape Veld-Ram Club is in the Griekwaland West region, situated at an altitude of 1304 m above sea level; longitude 23^{o} 15’ east and latitude 28^{o}51’ south.

Acocks (1988) classified the veld type that covers the Griekwaland West region as Kalahari Thornveld which consists of tall grass species such as *Themeda triandra, Cymbopogon plurinodis, Aristida difusa,* and dominant bush spieces, *Tarchonanthus camphorates*. The surface soil which covers most of the dolomite is calcareous. The summers are hot, while the winters are very cold and frosty with temperatures ranging from 6 to 40 ^{o}C. Rainfall distribution in the Postmasburg district is very erratic, with most rain occurring from January to March (Figure 3.1). The average annual rainfall received during the study period was 291 mm, with the highest (669 mm) recorded in the year 1991 and the lowest (85 mm) in 1992.

3.2.2 Performance recording procedure

Performance data of Boer goats collected from 1989 through 2007 were analysed to determine the relationship between sale price and the performance of animals in the veld-ram club. Each of the tests was conducted using the same procedure, and each year the test was conducted at the same farm. Male goats eligible for the performance tests were those of age at weaning (4-6 months). Kids were received from various breeders in the Northern Cape Province and were subjected to a two-week adaptation period before commencement of the performance test.

The performance test was conducted for a period of 160 days. Rams were kept on natural pastures at a stocking rate of 1.5 ha per small stock unit and received a concentrated lick at 14% CP, 6 MJ ME/kg DM and 10% fiber constituting about 20% of the animals' daily dry matter (DM) intake. This diet allowed a growth rate of approximately 70 g/day throughout the 160 day trial period.

During the grazing period all the rams were weighed at 28-days intervals. On the day of the weighing all animals were weighed at eight o'clock in the morning before grazing. All animals had free access to water throughout the grazing period. A salt-phosphate lick and protein lick was given during summer and winter respectively. After the conclusion of the grazing period only rams that showed outstanding performance in terms of weight were transferred to the feedlot to be prepared for the auction, while the rest were culled.

The following traits were recorded during and at the end of the testing period: final weight (FW); average daily gain (ADG); growth per day of age (ADO); Kleiber ratio (KR); auction weight (AW); scrotal circumference (SC); and sale price (SP). Sale catalogues were available to potential buyers prior to the sale. These catalogues included number of the animal, birth date, test group, scrotal circumference, Kleiber ratio (1989-1996), classification (1991, 1993-2007), selection index (1997-2007), final weight index (1992-1998) and growth per day of age index (1989, 1995).

The starting weight, the final weight at the end of the test and three additional weights were recorded and used to calculate a regression of live weight and the average daily gain. The selection index was calculated by placing equal economic weights on average daily gain and final weight.

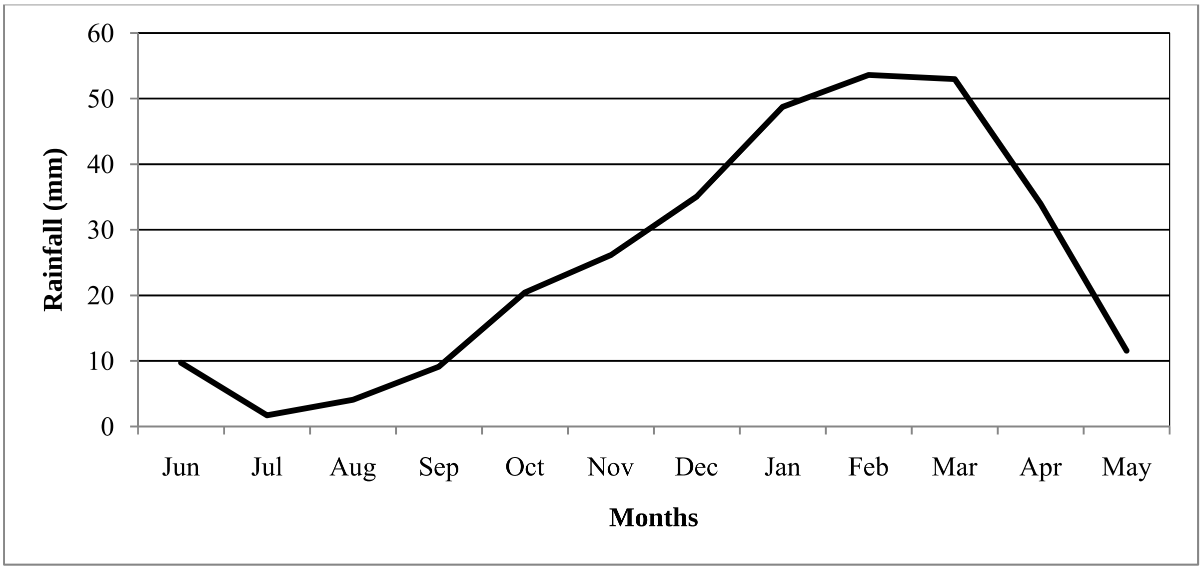

Figure 3.1 Average monthly rainfall distribution in the Northern Cape Veld-Ram Club during the study period from 1989-2007 (South African Weather Bureau, 2009).

Table 3.1 Definition of traits

Trait	Abbreviation	Definition	Formula
Initial weight	IW	Weight of animal at the start of the test period	
Final weight	FW	Weight of animal at the end of the test period	
Average daily gain	ADG	Average weight gain per day during the test	(Final weight-Initial weight)/days on test
Average daily gain index	ADGI	Ratio used to compare counterpart rams in a ram test	(ADG/breed-test groups ADG)*100
Kleiber ratio	KR	Weight gain per unit metabolic body weight	ADG/average test period $LWT^{0.75}$
Final weight index	FWI	Ratio used to compare counterpart rams in a ram test	Weight(Kg)/($height^2$)
Growth per day of age	ADO	Average weight gained each day while a ram is alive	Final weight/Final age in days
Growth per day of age index	ADOI	Ratio used to compare the growth rate	(ADO/breed-test group mean ADO)*100
Sale price	SP	Price paid for each ram sold on auction	
Selection index	SI	Comparative index of all the rams. Ranks all rams according to performance and measurements	I=ADG+FW
Scrotal circumference	SC	Circumference measured at the widest point of the scrotum (cm)	

LWT = Live weight

3.2.3 Statistical analysis

The general linear model (GLM) procedure of SAS (SAS, 2006) was used to identify independent factors that significantly influenced sale prices as a dependent variable. Sale prices were not normally distributed and therefore log transformed prices were used since this stabilizes the variances and results in a better distribution (Mendenhall & Sincich, 1989). This was followed by multiple regression analysis using the stepwise option of SAS to determine the contribution of each trait to selling price. Data from each year were evaluated separately in order to establish buyer trends over time as not all traits were measured or presented in the catalogue every year.

The traits that were not significant were removed from the model. The relationship between selling price and the performance traits was evaluated by calculating the correlation between price and each trait.

3.3 Results and discussion

A description of the data used in the analysis is presented in Table 3.2. Approximately 50% of the rams taken in between 1989 and 2007 were offered for sale on auction. Only 5% of the rams tested qualified as merit and 9% qualified as stud animals. Eight percent of all animals died, while 4% were culled on account of reproductive disorders and 6% on account of other diseases. Sale prices from year 2002 were not available.

Table 3.2 General statistics of Northern Cape Veld-Ram Club

		Culled (%) on		Rams sold as			
Year	Intake	performance	B Std	com(%)	stud(%)	merit(%)	total
1989	46		28				41
1990	40	13	30				55
1991	46	16	24	30		7	37
1992	38	15	28				58
1993	28	21	25	32	11	4	46
1994	40	28	23	30	10	5	45
1995	57	16	11	56	7		53
1996	55	16	25	35	4		33
1997	60	7	33	42	7	3	48
1998	59	5	19	53	5	3	53
1999	57	11	30	28	7	4	39
2000	48	4	38	33	10	4	46
2001	51	10	20	43	10	2	53
2002	70	11	20				
2003	34	6	6	68	12	6	68
2004	60	7	27	42	8		50
2005	65	10	24	31	8	12	46
2006	48	28	32	42	13	4	48
2007	63	3	24	38	17		56

B Std = Breed standard; com = commercial; blank = Not available

Means of traits by year for the data studied are presented in Table 3.3. The means are fairly constant from year to year. Average prices vary the most amongst years and in general have been in constant increase during the last 6 years. For example; the mean sale price (SP) increased from ZAR2, 624 in 2001 to as high as ZAR5, 997 in 2007, indicating an increase of 43.8%. The lowest year was 1990 and the highest 2007. Although the literature is of limited help in explaining these variations, the increase in price value from 2001 to 2007 could be associated with the increase of number of farmers at the auctions, which as a result increased the initial bidding price as reported in the Vrede Veld-bull Club (Mukuahima, 2007).

In 2002 there was an increase on agricultural product prices as a result of depreciation of the South African Rand against the USA Dollar (DoA, 2003). This feature could also influence the bidding price.

Table 3.3 Means of performance traits of Boer goats from Northern Cape Veld-Ram Club

Selling Year	Rams (units)	SP (Rand)	FW (kg)	WG (kg)	ADG (g/d)	ADOI (%)	KR (%)	AW (kg)	SC (cm)	SI (%)
1989	19	717	61.16	21.16	90	107.42	109.68		29.42	
1990	16	916	62.50	23.13	110		113.37		28.17	
1991	17	1559	56.24	20.47	110		120.06		28.71	
1992	22	1130	54.09	16.32	90		110.45		28.05	
1993	13	3150	58.92	18.77	110		115.23		28.46	
1994	18	2017	54.89	17.67	110		117.00		27.72	
1995	29	1517	54.34	15.34	110	102.03	109.62	77.59	27.86	
1996	18	1939	53.17	14.89	100		105.67		28.44	
1997	29	2059	49.24	14.34	80			73.00	28.48	103.97
1998	31	1990	42.97	12.23	70			74.16	27.94	102.52
1999	22	3618	50.73	19.91	80				28.14	
2000	22	2809	51.55	19.32	80				29.41	104.32
2001	27	2624	52.93	19.30	80				28.48	103.41
2003	23	2874	54.48	21.09	80			80.22	30.74	102.87
2004	30	4125	49.67	17.23	70			77.53	30.37	101.17
2005	30	4667	48.27	14.50	60			75.80	30.27	106.47
2006	23	4904	43.04	12.26	50			66.00	28.91	102.78
2007	35	5997	46.23	12.20	50				28.37	101.77

SP = Sale price; FW = Final weight; WG = Weight gain; ADG = Average daily gain; ADOI = Growth per day of age index; KR = Kleiber ratio; AW = Auction weight; SC = Scrotal circumference; SI = Selection index; Blank = Not measured

Correlation coefficients showing linear relationship between sale price and the various records studied are presented in Table 3.4. Simple correlation coefficients showed a positive relationship between sale price and most of the traits analysed. It is noted that negative correlations between traits and price were obtained in scrotal circumference (five out of eighteen years), average daily gain (three out of eighteen years), final weight (one out of eighteen years) and Kleiber ratio (one out of eight years). Furthermore, all of the negative correlations were fairly low and non significant, except average daily gain in one year, which was significant. No trend towards higher or lower correlations was found over the years in the correlation of price with the various traits as determined by examining the individual yearly coefficients for each trait.

Buyers tended to pay more for heavier rams as shown by positive correlations between price and auction weights in all seven years, only one of which was not significant. Most of correlations between auction weight and price were medium to high with a minimum of 0.38 and a maximum value of 0.75. Significant and positive correlations were obtained between final weight and price. These correlations ranged from 0.38 to 0.78. The final weight was significant ($P<0.05$) in ten out of eighteen years of records. Bisset *et al.*(2001) analyzing data from 50 Merino rams auctioned at public sales in South Africa have come to a similar conclusion, specifically that the prices paid were highly correlated with live weight ($P<0.0019$).

A similar tendency was shown for the selection index where positive correlations were obtained in all nine years, seven of which were significant. The correlations between sale price and selection index were also medium to high, ranging from 0.39 to 0.80. The significant correlation coefficient between sale price and the selection index indicate that buyers were placing emphasis on production traits such as average daily gain and final weight. Growth per day of age index (ADOI) was calculated only twice and had a moderate positive significant correlation with price in one year. Scrotal circumference had little influence on price during the period and was significantly correlated in only five out of eighteen years. It is evident that this measurement of a ram was not the most important variable in the pricing model, but its positive coefficient in some years does support the hypothesis that it was viewed favourably. Cassady *et al.* (1989) working with Brangus bulls in the United States, showed selling price to be correlated ($P<0.01$) with final index (0.48), average daily gain (0.39), weight per day of age (0.39) and scrotal circumference (r

= 0.13; P<0.05). The final index in this study was computed combining different emphasis on average daily gain ratio, growth per day of age ratio and feed efficiency.

Positive significant correlations occurred between sale price and average daily gain index in three out of the ten years during which the trait had been measured. Dustin (2002) reported simple correlation coefficients that showed average daily gain, average daily gain index, and scrotal circumference to be positively correlated with the sale price of Gelbvich and Angus bulls in the United States.

This research is also supported by Northcutt *et al.* (1995) who analysed performance data on 7428 bulls from 1981 to 1994 at the Oklahoma Beef Bull Test station and concluded that average daily gain and scrotal circumference were all positively correlated with the selling price.

Table 3.4 Correlation of log price with performance traits

Year	FW	FWI	ADG	ADGI	ADOI	KR	AW	SC	SI
1989	0.34		0.46	0.44	**0.53***	0.09		**0.62****	
1990	-0.16		**0.61***			**0.54***		-0.32	
1991	0.39		-0.07	0.18		0.05		0.26	
1992	**0.61****	**0.61****	**0.47***	**0.58****		**0.51***		**0.45***	
1993	0.49	0.22	-0.21	0.06		-0.02		-0.12	
1994	**0.55***	**0.56***	0.13	0.37		0.23		0.27	
1995	0.12	0.10	0.24	**0.39***	0.18	0.33	**0.38***	-0.04	
1996	0.12	0.22	**0.66****	**0.62****		**0.68****		-0.09	
1997	**0.38***	**0.46***	0.25	0.22			**0.67****	-0.17	**0.39***
1998	**0.41***	0.30	0.19	0.24			**0.72****	**0.42***	**0.39***
1999	0.13		0.02					**0.51***	
2000	0.38		**0.57****					0.28	**0.53***
2001	**0.44***		0.06					0.06	0.33
2003	**0.59****		**0.63****				0.37	0.19	**0.80****
2004	**0.78****		0.00				**0.75****	**0.45***	**0.65****
2005	**0.62****		0.06				**0.53****	0.25	**0.55****
2006	**0.58****		0.29				**0.44***	0.32	**0.48***
2007	**0.61****		**-0.34***					0.08	0.28

FW = Final weight; FWI = Final weight index; ADG = Average daily gain; ADGI = Average daily gain index; ADOI = Growth per day of age index; KR = Kleiber ratio; AW = Auction weight; SC = Scrotal circumference; SI = Selection index; Bold = Significance; * P<0.05; ** P<0.01; Blank = Not measured

A stepwise regression procedure was used to analyse which traits, if any, contributed significantly to the prediction of selling price per year. Only those traits that were significant at the 15% and higher level (P<0.15) were kept in the model to predict sale price. Contributions of each trait to selling price for each year were evaluated by obtaining partial regression coefficients for the traits. The column headed R^2 in Table 3.6 shows the proportion of the variation in price that can be explained by the performance traits indicated. In most of the years the performance traits did not explain more than half of the variation in selling price, except for years 1997, 1998, 2003, 2004 and 2006. It can be noted that in those years there is a strong contribution of auction weight, selection index or final weight to the sale price.

The amount of variation in sale price accounted for by the performance traits ranged from 15% in year 1991 to 65% in 1998 and 2004. It could be speculated that the remaining 35 to 85% was influenced by other factors such as sale order, availability of money, demand for rams and the physical appearance of the rams (Table 3.6).

Sale price was influenced significantly (P<0.15) by final weight, auction weight, selection index, average daily gain index, final weight index, scrotal circumference and Kleiber index. The effect of growth per day of age index was not significant in the variation observed in sale price.

Amongst all factors final weight was found to have the highest influence on price. It was significant in eight out of the eighteen years of recording. Final weight made the largest partial contribution to auction price in all years where it was significant. Auction weight is another variable which had an influence on price. It was not significant in three out of seven years it was measured. Auction weight made the largest contribution to auction price in three years out of four in which it was significant.

Rams that were heavier than the group average at the start of the test, maintained that status up to the conclusion of the test. Fourie e*t al*. (2000) found a proportionate increase in sale prices of Dorper rams at auctions with the increase in auction weight, coat type, Kleiber ratio, scrotal circumference and final weight index. Bisset *et al.* (2001) and Mukuahima (2007) came to a similar conclusion when they found that animals with higher auction weights were preferred by the buyers.

A selection index which combines final weight at the end of the test and average daily gain during the test was included in the catalogue during the last ten years of the study. The index had the largest influence ($P<0.0001$) on sale price in only one year out of three years in which it was significant. The R^2 contribution of selection index to the sale price ranged from 0.08 to 0.63 (Table 3.6). This indicates that between 8% and 63% of the variation in SP can be explained or accounted for by the SI.

Final weight index was significant in only two years out of six and average daily gain index in three years out of ten. Average daily gain index was placed in second position in terms of contribution in all years while final weight index experienced the first and second position in both years in which it was significant. Waldron *et al.* (1989) found that both average daily gain and final weight of a ram tend to be very important and account for a similar proportion of the variation in sale price. Each was, in turn more important in determining the value of the ram, than was birth type. This information was obtained by analysing the test performance and sale prices of 1563 Suffolk rams sold at public auction following central performance tests in the United States of America.

Scrotal circumference had the largest influence on price in two years and its influence on the sale price throughout the entire period was only significant in three years. The importance of Kleiber ratio for inclusion in a regression model to predict sale price was significant ($P<0.0018$) once and was the only trait found to be significant in 1996.

McPeake *et al*. (2000) as cited by Dustin (2002) revealed that scrotal circumference, along with sale year and adjusted weaning weight, were the top three factors ($R^2 = 0.54$) affecting selling price of the 365-730 days old Charolais bulls in the United States of America. This study also found scrotal circumference significantly affecting sale price ($P=0.0006$). In contrast, Northcutt *et al*. (1995) concluded in Angus bulls completing gain tests in the United States that scrotal circumference was correlated lower with auction price than average daily gain and growth per day of age.

Table 3.5 Ranking of performance traits according to their importance as contributors to sale price

Year	Performance traits								
	FW	FWI	ADG	ADGI	ADOI	KR	AW	SC	SI
1989	Ns		Ns	2^{nd}	Ns	Ns		1^{st}	
1990	Ns		1^{st}			Ns		Ns	
1991	1^{st}		Ns	Ns		Ns		Ns	
1992	1^{st}	Ns	Ns	Ns		Ns		Ns	
1993	1^{st}	2^{nd}	Ns	Ns		Ns		Ns	
1994	Ns	1^{st}	Ns	Ns		Ns		Ns	
1995	Ns	Ns	Ns	2^{nd}	Ns	Ns	1^{st}	Ns	
1996	Ns		Ns	Ns		1^{st}		Ns	
1997	Ns	Ns	2^{nd}	Ns			1^{st}	Ns	Ns
1998	Ns	Ns	Ns	2^{nd}			1^{st}	Ns	Ns
1999	Ns		Ns	Ns				1^{st}	
2000	Ns		1^{st}					Ns	2^{nd}
2001	1^{st}		Ns					Ns	Ns
2003	ns		Ns				Ns	Ns	1^{st}
2004	1^{st}		Ns				2^{nd}	Ns	Ns
2005	1^{st}		Ns				Ns	Ns	Ns
2006	1^{st}		Ns				Ns	2^{nd}	3^{rd}
2007	1^{st}		2^{nd}					Ns	Ns
Ranking	1^{st}	4^{th}	5^{th}	6^{th}	9^{th}	8^{th}	2^{st}	7^{th}	3^{nd}

FW = Final weight; FWI = Final weight index; ADG = Average daily gain; ADGI = Average daily gain index; ADOI = Growth per day of age index; KR = Kleiber ratio; AW = Auction weight; SC = Scrotal circumference; SI = Selection index; Ns = Not significant; Blank = Not measured

Table 3.6 Partial R^2 and probability (in brackets) contribution of traits to the prediction of log-auction price obtained from stepwise linear regression analysis of Boer goat data from 1989 to 2007 of Northern Cape Veld-Ram Club

Year	FW	FWI	ADG	ADGI	ADOI	KR	AW	SC	SI	R^2
1989	Ns		Ns	0.10 (0.0924)	Ns	Ns		0.38 (0.0047)		49 (0.0049)
1990	Ns		0.37 (0.0125)			Ns		Ns		37 (0.0125)
1991	0.15 (0.1250)		Ns	Ns		Ns		Ns		15 (0.1250)
1992	0.38 (0.0023)	Ns	Ns	Ns		Ns		Ns		38 (0.0023)
1993	0.24 (0.0869)	0.23 (0.0607)	Ns	Ns				Ns		48 (0.0392)
1994	Ns	0.32 (0.0149)	Ns	Ns		Ns		Ns		32 (0.0149)
1995	Ns	Ns	Ns	0.15 (0.0373)	Ns	Ns	0.19 (0.0101)	Ns		34 (0.0041)
1996	Ns	Ns	Ns	Ns		0.47 (0.0018)		Ns		47 (0.0018)
1997	Ns	Ns	0.10 (0.0250)	Ns			0.45 (<.0001)	Ns	Ns	55 (<.0001)
1998	Ns	Ns	Ns	0.13 (0.0029)			0.51 (<.0001)	Ns	Ns	65 (<.0001)
1999	Ns		Ns					0.26 (0.0156)		26 (0.0156)
2000	Ns		0.32 (0.0059)					Ns	0.10 (0.0867)	42 (0.0055)
2001	0.19 (0.0233)		Ns					Ns	Ns	19 (0.0233)
2003	Ns		Ns				Ns	Ns	0.63 (<.0001)	63 (<.0001)
2004	0.61 (<.0001)		Ns				0.03 (0.1286)	Ns	Ns	65 (<.0001)
2005	0.38 (0.0003)		Ns				Ns	Ns	Ns	38 (0.0003)
2006	0.34 (0.0038)		Ns				Ns	0.09 (0.0851)	0.08 (0.1223)	50 (0.0037)
2007	0.37 (0.0001)		0.10 (0.0197)					Ns	Ns	47 (<.0001)

FW = Final weight; FWI = Final weight index; ADG = Average daily gain; ADGI = Average daily gain index; ADOI = Growth per day of age index; KR = Kleiber ratio; AW = Auction weight; SC = Scrotal circumference; SI = Selection index; Pr = Probability in brackets; R^2 = Coefficient of determination; Ns = Not significant; Blank = Not measured

Ranking of the traits are presented in Table 3.5. These rankings were established according to the frequency and degree of significance (P<0.15). Three measures of performance (final weight, auction weight or selection index) had a fairly important effect on selling price. Based on the partial contribution (15-65%) it is clear that sale price is not exclusively influenced by the performance measurements. Selling the rams according to some performance index, highlights the rams that are superior, but it may also increase the price of the highest performing ram because of a desire to own the winner of the test. Certain rams have physical characteristics which can influence the behavior of a buyer at the time of auction. The extent to which visual appraisal was used to determine a ram's price is unknown.

3.4 Conclusions

The results revealed how the auction prices paid for test rams were affected by the performance data analysed at the Northern Cape Veld-ram Club.

It can be concluded that the information supplied to the buyers of rams at auction in Northern Cape Veld-Ram Club is responsible to certain extent for determining the variation in price.

Rams with higher weights at the end of the trial received better prices at auctions than lighter rams. Buyers were willing to pay more for those animals, irrespective of their performance in the other traits. This buyer preference for rams with higher final weight was a significant price determinant in almost every year the parameter was measured.

Since buyer place great emphasis on growth, final weight and the combination of the two as expressed in the selection index, it is recommended that additional performance traits such as scrotal circumference should also be included in the selection index.

CHAPTER IV

GENETIC AND NON-GENETIC FACTORS INFLUENCING PRODUCTION IN TWO BOER GOATS STUDS

4.1 Introduction

Meat is one of the primary incentives for goat husbandry in South Africa and the Boer goat is one of the most numerous goat breeds, accounting for about 30% of all commercial goats. The ability of Boer goats to produce under harsh environmental conditions (Malan, 2000), their natural immunity against diseases (Erasmus, 2000) and suitability as meat producers (Casey & Van Niekerk, 1988) have created interest in the breed amongst many breeders. In order to increase production, efforts must be directed at improvement in the feeding, breeding and management practices of these animals. Selection can only be successful when animals are compared on an equal basis to identify those that are superior. Growth is an extremely important trait for meat production and thus remains the main selection criterion for most breeders around the world (Archer *et al*., 1998; Olivier, 2002). Early growth is influenced by genes of the individual, environment provided by the dam and other environmental effects (Albuquerque & Meyer, 2001).

Identification and evaluation of factors that have an effect on production performance resulted in more accurate estimations of an animal's genetic potential (Van Wyk *et al*., 1993; Rashidi *et al*., 2008). Some of the factors known to affect production performance, include age of dam, herd, birth year, lamb's sex, birth type and season (Neser *et al*., 2001; Dixit *et al*., 2001; Abegaz *et al*., 2005; Rashidi *et al*., 2008). Maternal influences are strong in the early life of lambs, but dwindle with increasing age (Snyman & Olivier, 1996). Maternal influences can be due to the dam's own genotype for milk production and mothering ability (maternal additive genetic effects) and those that are consistent over lambings, but not genetic in origin, also referred to as maternal permanent environmental effects (Lewis & Beatson, 1999).

The objective of this research was to quantify the effect of some environmental factors on body weight of Boer goats under extensive conditions and to estimate genetic parameters for weaning and post-weaning weight, which are required for suitable selection and breeding plans.

4.2 Material and methods

4.2.1 Description of the location and origin of the data

The data set used in this study consisted of live weight records of registered Boer goats that kidded between 1998 and 2008. Data and pedigree information of these goats were obtained from two farms; one located in Prieska, latitude of 29^{o} 40' south and longitude of 22^{o} 44' east while the other one is located in Griekwastad at latitude of 28^{o} 50' south and longitude of 23^{o} 15' east. Acocks (1988) classified the veld type that covers the Griekwaland West region (in which the two farms are located) as Kalahari Thornveld which consists of tall grass species such as *Themeda triandra, Cymbopogon plurinodis, Aristida difusa,* and dominant bush spieces, *Tarchonanthus camphorates*. The surface soil which covers most of the dolomite is calcareous. The summers are hot, while the winters are very cold and frosty with average temperatures ranging from 6 to 40 ^{o}C. Rainfall distribution in the Northern Cape Province is very erratic, with most rain occurring from January to March.

4.2.2 Animals and management

Animals were raised under extensive conditions with some supplementation depending upon status and age category. Animals were released on pasture during the day and were kept indoors during the night. Breeding was not restricted to any particular season. Kidding peaked in autumn, indicating summer breeding season which coincides with optimum feed availability, Lambs suckled their mothers twice a day and were weaned on the veld at approximately four months of age (Webb & Mamabolo, 2004). Due to the extensive conditions ewes were mated for the first time at 18 months.

During the lambing season the following data were recorded for each lamb: Lamb ID, Dam ID, Sire ID, date of birth, sex and birth status of the lamb. Sires were selected based on phenotypic value according to body weight and body conformation.

4.2.3 Data and editing

Data editing consisted of checks for dates of birth; weighing-dates, records of individuals that appear earlier than those of parents and duplicate records for each animal. All animals without a sire or a dam or without any weight records were excluded from the analyses. Individuals that appear earlier than parents were re-numbered to give them a new identity; the re-numbering was done considering the date of birth of the animals and the digits of new identity not to exceed its offspring as parent. Sires with at least five progeny were used for this analysis. Duplicate records were deleted. Lambing occurred throughout the year. However, most of the lambing took place in ranges of March to April, June to July and September to October in all years. Seasons were then derived from the distribution of number of births per month. Weight data were grouped in two ranges according to the age as follow: 60 to 150 days for weaning weight and 151 to 274 days for post weaning weight.

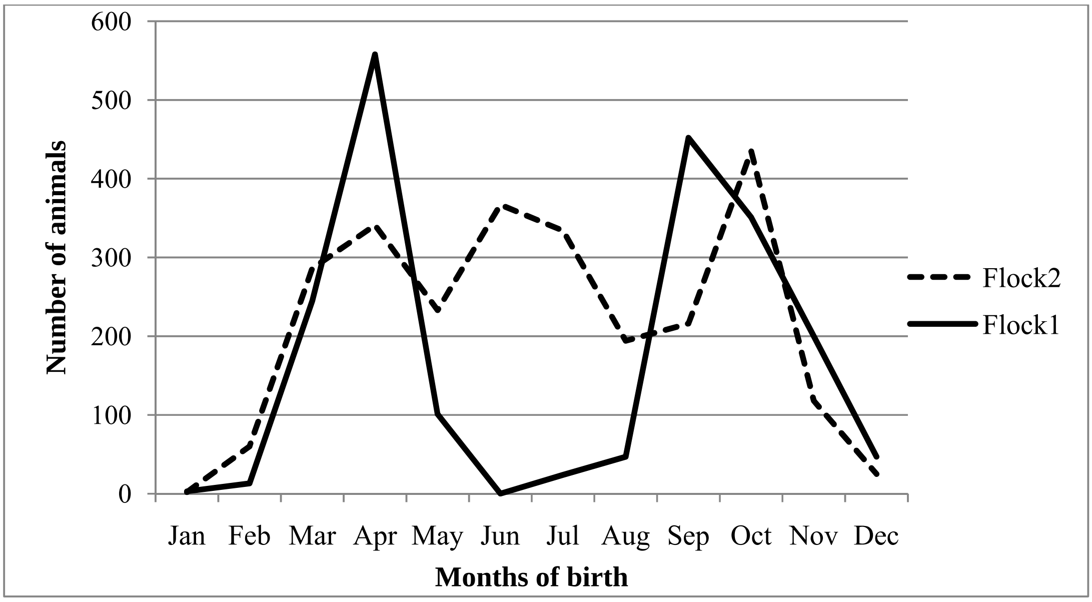

Figure 4.1 Distribution of number of births per month before editing

Figure 4.1 depicts the number of animals born in the respective months. Three distinct peaks could be distinguished: one in April, one in June and one in October. Based on this scenario, the seasons of lambing were finally classified as follows: January to May (1), June to July (2) and August to December (3). This was done because there were no distinct breeding seasons.

Data before editing consisted of 3855 individual records with 211 sires and 2242 dams. The edited data comprised of 3233 records for weaning and post weaning weights collected between 1998 and 2008. A summary of the data after editing is presented in Table 4.1.

Table 4.1 Description of the data used for analyses

	Weight traits	
	Weaning	Post-weaning
Number of records	2917	316
Number of sires	77	36
Number of dams	1227	249
Number of grand sires	34	3
Number of grand dams	538	7
Mean number of records per sire	37.9	8.8
Mean number of records per dam	2.4	1.3
Average age in days	108	274

4.2.4 Statistical analysis

4.2.4.1 Environmental effects

In order to determine which fixed effects should be included in the model, an analysis was carried out using the general linear model procedure (PROC GLM) of (SAS, 2006). The fixed effects considered important to be included in the genetic analysis were sex (male and female), age of dam at lambing (1, 2, 3 years), herd (1 and 2), year of birth (11 levels), season of birth (1, 2 and 3), type of birth (single, twin and triplets) and age of the lamb as a covariate for weaning weight (WW) and post-weaning weight (PW). The following model was fitted for WW and PW:

$Y_{ijklmnop} = \mu + S_i + Z_j + H_k + F_l + A_m + B_n + R_o + E_{ijklmnop}$

Where $Y_{ijklmop}$ = an observation of a trait on the i^{th} animal of the j^{th} sex of the k^{th} year of the l^{th} herd of the m^{th} season of the n^{th} age of the dam of the o^{th} birth status and of the p^{th} age.

μ = Overall mean,

S_j = fixed effects of the j^{th} sex ($_j$ = 1,2),

Z_k = fixed effects of k^{th} year ($_k$ = 1,2,3,… ,11),

H_l = fixed effects of l^{th} herd ($_l$ = 1,2),

F_m = fixed effect of the m^{th} season of born ($_m$ = 1,2,3),

A_n = fixed effect of the n^{th} age of the dam in years ($_n$ = 1,2,3),

B_o = fixed effects of the o^{th} birth status ($_o$ = 1,2,3)

U_p = fixed effects p^{th} age of the animal in days as a covariate

$E_{ijklmnop}$ = residual error variance.

4.2.4.2 Genetic analyses

(Co)variance components and genetic parameters were estimated using the software ASREML (Gilmour *et al.*, 2002) by fitting seven different single-trait animal models. The method aims to maximize the likelihood function given the data. Log likelihood ratio tests were used to identify the most suitable model for each trait by adding the random effect sequentially to the fixed model. The random effect was considered significant when its inclusion in the model caused a significant increase in the log likelihood. A chi square distribution for ($P<0.05$) and one degree of freedom were used as the critical test statistic (3.84) The effect was considered significant when -2 times the difference between log likelihoods were greater than the critical value.

Genetic correlations were estimated using bivariate trait analyses. The fixed effects included in the model were those in single trait analyses.

The variables included in the analyses for the single trait animal model were:

- Sex, year, herd, season, age of dam, birth status, as fixed effects and also age of lamb as a covariate;
- Direct and maternal effects for animals as random effects and
- Permanent maternal environmental effects of the dam as an additional random effect.

The models fitted were as follows:

Model 1 $y = X\beta + e$

Model 2 $y = X\beta + Z_1a + e$

Model 3 $y = X\beta + Z_1a + Z_3c + e$

Model 4 $y = X\beta + Z_1a + Z_2m + e$ with $cov_{(a, m)} = 0$

Model 5 $y = X\beta + Z_1a + Z_2m + e$ with $cov_{(a, m)} = A\sigma_{am}$

Model 6 $y = X\beta + Z_1a + Z_2m + Z_3c + e$ with $cov_{(a, m)} = 0$

Model 7 $y = X\beta + Z_1a + Z_2m + Z_3c + e$ with $cov_{(a, m)} = A\sigma_{am}$

Where:

y = vector of observations for weaning and post-weaning weights,

β = vector of fixed effects influencing growth,

a = vector of random direct genetic effects,

m = vector of random genetic maternal (dam) effects,

c = vector of random permanent environmental effects due to the dam,

e = is vector of residuals,

am = covariance between direct additive genetic and maternal genetic effects, and

X is the incidence matrix that relates to fixed effects. Z_1 and Z_2 relate the unknown random vectors of direct breeding value (a) and maternal breeding value (m), respectively, to y. The incidence matrix Z_3 relates the unknown additional random vector permanent maternal environment (c), to y.

Some assumptions and definitions were made: Additive direct and maternal effects were assumed to be normally distributed with mean 0 and variance $A\sigma^2_a$ and $A\sigma^2_{m,}$ respectively, where A is the additive numerator relationship matrix and σ^2_a and σ^2_m are additive direct and maternal variances, respectively. Permanent environmental effects of the dam and residual effects were assumed to be normally distributed with mean 0 and variances $I_d\sigma^2_{pe}$ and $I_n\sigma^2_e$, respectively, where I_d and I_n are identity matrices with orders equal to the number of dams and individual records, respectively, and σ^2_{pe} and σ^2_e are maternal permanent environmental and residual variances, respectively.

The following parameters were calculated from the estimated (co)variance statistics obtained from the analysis:

Heritability (h^2_a) for the direct additive genetic effects, as $h^2_a = \sigma^2_a/\sigma^2_p$,

Heritability (h^2_m) for the maternal additive genetic effects, as $h^2_m = \sigma^2_m/\sigma^2_p$,

Genetic correlation between direct and maternal effects, as $r_{am} = \sigma_{am}/(\sigma^2_a + \sigma^2_m)$, and

Permanent environmental variance, as $c^2_{pe} = \sigma^2_{pe}/\sigma^2_p$.

4.3 Results and discussion

4.3.1 Environmental effects

Overall means, standard deviations, test of significance, degrees of freedom of denominator and the proportion of variation explained by the fixed model (R^2) are given in Table 4.2. The fixed models explained 31% and 80% of the phenotypic variances in weaning weight and post-weaning weight respectively. The effects of sex, type of birth, age of dam, year of birth, herd, season and age of lamb, have been shown to be important sources of variation for both traits. Findings obtained from this research are in agreement with other results reported by Zhang *et al*. (2008, 2009), for Boer goats and Al-Shorepy *et al.* (2002), in Emirati goats, although the results reported by some authors indicated that the age of dam and type of birth effects would be expected to be less important for post-weaning traits (Gifford *et al*., 1990; Wenzhong *et al*., 2005), of Angora goats.

Table 4.2 Overall means (standard deviation) and test of significance for weaning and post-weaning weights

Fixed effects	Df	WW(kg)	PW(kg)
Overall mean		21.65 (4.36)	35.68 (5.45)
Age of lamb	1	**	**
Sex of lamb	1	**	**
Year of lambing	10[a]	**	**
Herd	1	**	*
Season	2	**	**
Age of dam	2	**	*
Type of birth	2	**	**
R^2(%)		31	80

Df = degree of freedom; WW = weaning weight; PW = post-weaning weight; a = 8 df for PW; * = P<0.05; ** = P<0.01

The year in which the lamb was born had a highly significant (P<0.01) influence on weaning weight, as well as post-weaning weight. The variation in the weight during different years may be due to differences in management, food availability, diseases, condition of climate and raising systems in different years. The maximum differences in weaning weight of the lambs born between the best year (2006) and the poorest year (2005) was 3.54 kg. The post-weaning weight of the lambs born in 2005 was significantly (P<0.01) lower than in all other years. Differences in the weaning weight due to year of birth were also reported by Schoeman (1990) who demonstrated that season and year of birth has a significant influence on weaning weight at 100 days in the Dohne Merino sheep.

The effect of herd of origin was also significant for both traits (P<0.01 and P<0.05 respectively). The difference among herds for the traits WW and PW can be explained by the differences in management and environmental conditions. The same results were shown by the researchers who investigated the effects of herd on body weight (Toplu & Altinel, 2008; Banh & Hafezian, 2009) in Ghezel sheep and hair goats respectively.

Lambs born in spring (August to December) were significantly (P<0.01) heavier at WW and had higher PW than their counterparts in autumn (January to May). The effect of season could be explained in part by the climatic conditions. Feeding practices in both seasons for dams and offspring were similar. Distinct influence of season on lambs' live weights has been reported in several breeds (Schoeman, 1990; Warmington & Kirton, 1990; Gebrelul *et al.*, 1994). The same explanation given for differences between years can be applied to season effects.

In contrast with results reported for alpine crossbred goats by Mourad & Anous (1998) the age of dam had significant effect on both traits. WW and PW means increased with the increasing of dam age from 1 to 3. This may be due to differences in maternal effects, nursing and maternal behaviour of dam in different ages. These results are in agreement with those reported by other authors (Dixit *et al.*, 2001; Zhou *et al.*, 2003; Behzadi *et al.*, 2007) in Bharat Merino sheep, Inner Mongolia goats and Kermani sheep respectively.

Single lambs were significantly (P<0.01) heavier at weaning and had a higher post-weaning weight than twins or triplets. The mean differences between lambs born as singles and twins were 3.14 kg and 7.11 kg for WW and PW respectively. The corresponding differences between singles and triplets were 2.27 kg and 16.88 kg respectively. In another Boer goat study single lambs weighed 16.9 kg at WW (90 days) compared to twins and triplets that weighed 14.6 kg and 14.1 kg respectively (Zhang *et al*., 2009). In the same study single lambs weighed 29.9 kg at PW (300 days) compared to twins and triplets that weighed 29.2 kg and 28.2 kg respectively. Limited uterine space during pregnancy for multiple birth lambs, nutrition of dam, particularly during last third of the pregnancy period, competition for milk suckling between the twins and triplet lambs during birth to weaning are some of the phenomena that can explain the above mentioned differences (Al-Shorepy *et al*., 2002).

These results indicate that the performance records for WW and PW should be corrected for the effects such as age of lamb, sex of lamb, year of lambing, herd, season, age of dam and birth status by including them as fixed effects in a mixed model when determining variance components and genetic parameters for these traits.

Table 4.3 Overall mean, number of observations (*n*), least squares means and standard error for weaning (WW) and post-weaning weight (PW)

EFFECT	WW			PW		
	n	LSMEAN	S.E.	n	LSMEAN	S.E.
Overall	2917	21.65	0.10	317	35.68	0.66
Sex						
Male	1345	21.57	0.19	162	36.07	0.94
Female	1572	20.03	0.18	155	29.10	0.94
Year						
1998	254	19.50	0.31	143	33.68	0.70
1999	203	20.71	0.34	49	41.70	0.92
2000	170	20.20	0.39	37	42.52	1.13
2001	235	22.03	0.33			
2002	167	21.71	0.39			
2003	268	20.76	0.32	25	32.07	1.32
2004	243	20.62	0.34	17	32.75	1.53
2005	308	19.17	0.30	28	26.42	1.19
2006	423	22.70	0.27	9	28.06	1.90
2007	287	19.26	0.32	8	27.04	2.11
2008	359	22.13	0.29			
Herd						
1	1355	19.95	0.22	149	32.20	1.04
2	1562	21.64	0.18	168	32.96	0.91
Season						
1	1158	21.35	0.15	186	35.62	0.60
2	663	21.70	0.19			
3	1096	21.93	0.15	130	35.82	0.73
Age of dam						
1	955	19.58	0.21	92	30.94	1.01
2	1667	21.30	0.18	176	32.74	0.92
3	295	21.52	0.28	49	34.06	1.12
Birth type						
Singles	1146	23.40	0.17	137	35.91	0.83
Twins	1628	19.95	0.16	164	31.89	0.87
Triplets	143	19.05	0.38	16	29.95	1.59

4.3.2 Genetic effects

4.3.2.1 Model selection

The (co)variance components and genetic parameter estimates using single-trait animal models are presented in Tables 4.4 and 4.5 with the most suitable model in bold. Although the log likelihood for WW indicate that Model 7 is the most appropriate to use it is not practical. The inclusion of the covariance between direct and maternal effects leads to a substantial and unrealistic increase of direct heritability. This situation can be ascribed to a poor pedigree structure, a small number of progeny per dam and limited information from the dam herself (Meyer, 1997; Lee *et al.*, 2000; Maniatis & Pollott, 2002, 2003).

It was therefore decided to use Model 6. The most appropriate model for WW included direct additive effects, maternal additive effects, as well as permanent maternal environmental effects. On the other hand the most appropriate model for PW was Model 3, which included direct additive effects and permanent maternal environmental effects. Numerous studies reported significant maternal effects on these traits for various species (van Niekerk *et al*., 1996; Schoeman *et al*., 1997 on Boer goats; Al-Shorepy *et al*., 2002 on Emirate goats; Abegaz *et al*., 2005 in Horro shep; Kariuki *et al*., 2009 in Dorper sheep; Shaat & Maki-Tanila, 2009 in Zaraibi goats; Zhang *et al*., 2009 in Boer goats).

Table 4.4 (Co) variance estimates, ratios calculated, log likelihoods and standard error (±SE) for single-trait models for weaning weight

	Model 1	Model2	Model 3	Model 4	Model 5	**Model 6**	Model 7
(Co) variance components							
σ^2_a		5.45	4.72	4.83	13.17	**4.74**	13.02
σ^2_m		-	-	1.86	7.77	**0.66**	4.44
σ^2_{pe}		-	2.63	-	-	**2.07**	2.87
σ_{am}		-	-	-	-8.991		-7.598
σ^2_e	19.03	13.95	12.15	12.97	8.70	**12.09**	7.73
σ^2_p	19.03	19.40	19.50	19.66	29.64	**19.55**	28.05
Variance ratios							
h^2_a		0.28 (0.04)	0.24 (0.04)	0.25 (0.04)	0.44 (0.06)	**0.24 (0.04)**	0.46 (0.06)
h^2_m		-		0.09 (0.02)	0.26 (0.03)	**0.03 (0.02)**	0.16 (0.03)
c^2_{pe}		--	0.14 (0.02)	-	-	**0.11 (0.03)**	0.10 (0.02)
r_{am}		-		-	-0.89 (0.07)		-0.99 (0.08)
Logl	-5773.08	-5690.67	-5668.97	-5675.17	-5642.33	**-5666.24**	-5629.30

σ^2_a = genetic direct variance due to the additive genetic effects of animals; σ^2_m = genetic maternal variance due to the additive genetic effects of dams of animals; σ^2_{pe} = variance of permanent environment due to the dam; σ_{am} = covariance between direct and maternal genetic effects; σ^2_e = variance due to residual; σ^2_p = total phenotypic variance; h^2_a = heritability for direct genetic effects; h^2_m = heritability for maternal genetic effects; c^2_{pe} = permanent environment due to the dam; r_{am} = genetic correlation between direct and maternal effects; Logl = Log likelihood.

4.3.2.2 Heritability and ratios

Heritability estimates vary substantially in this study. Heritability estimates fitting different models for WW and PW are presented in Tables 4.4 and 4.5 respectively. The estimate of direct heritability for WW (0.24) obtained in this study was within the range of results reported, ranging from 0.18 (Roy *et al*., 2008) in Jamunapari goats to 0.43 (Bosso *et al.,* 2007) in West African Dwarf goats. It is in agreement with that of 0.27 reported by Schoeman *et al*. (1997) in Boer goats, lower than those of 0.34 by Al-Shorepy *et al.* (2002) and 0.39 by Mourad & Anous (1998), but higher than that of 0.15 reported by Marquez *et al*. (2007) in Boer goat crosses. The estimate of direct heritability for PW (0.31) obtained in this study is within the range of those reported by other researchers. This result is in accordance with the 0.38 obtained by Thiruvenkadan *et al*. (2009) in Tellichery goats and higher than those of 0.10 reported by Zhang *et al.* (2009) and 0.19 by Zhang *et al.* (2008) in the Boer goat breed.

Direct heritability estimates for WW and PW with suitable models increased with age from 0.24 at weaning to 0.31 at post-weaning period. Meyer (1992) showed that models not accounting for maternal genetic effects could result in substantially higher estimates of additive direct genetic variance and, therefore, higher estimates of h^2. The increasing heritability at a later age indicates that environmental factors had more influence on weaning weight than on the weight achieved later at post-weaning stage (Mandal *et al*., 2006).

The maternal heritability estimate (0.03) for weaning weight in this study were lower than values reported by Maria *et al*. (1993); Neser *et al.* (2001); Roy *et al*. (2008) and Zhang *et al*. (2009), but are in agreement with those of 0.04 reported by Schoeman *et al.* (1997), 0.01 by McManus *et al*. (2008) and 0.00 by Al-Shorepy *et al*. (2002).

The permanent maternal environmental effect (c^2_{pe}) for WW was lower than the direct genetic effect (h^2). Neser *et al*. (2001) reported an estimate of 0.12 for pre-weaning weight in Dorper sheep, while Cloete *et al*. (2003) found an estimate of 0.08 for the permanent environmental effect of the dam for WW in Merino sheep. Both estimates are consistent with the results of this study of which the estimate was 0.10.

The permanent maternal environmental effect (c^2_{pe}) was still a significant source of variation in post weaning body weights, and in contrast to most of the literature findings (Maria *et al*., 1993; Tosh & Kemp, 1994) its relative importance increased from WW (0.03) to PW (0.44).

Table 4.5 (Co) variance estimates, ratios calculated, log likelihoods and standard error (±SE) for single-trait models for post-weaning weight

	Model 1	Model2	**Model 3**	Model 4	Model 5	Model 6	Model 7
(Co) variance components							
σ^2_a		21.22	**11.89**	16.05	20.72	11.92	8.18
σ^2_m				6.72	26.88	0.00	0.00
σ^2_{pe}			**13.08**			13.11	13.43
σ_{am}					-20.76		-0.03
σ^2_e	28.54	10.13	**5.63**	8.73	5.36	5.64	8.01
σ^2_p	28.54	31.35	**30.60**	31.50	52.96	30.67	29.61
Variance ratios							
h^2_a		0.54 (0.21)	**0.31 (0.19)**	0.45 (0.23)	0.36 (0.26)	0.31 (0.19)	0.25 (0.04)
h^2_m				0.18 (0.14)	0.47 (0.26)	0.00 (0.00)	0.00 (0.00)
c^2_{pe}			**0.44 (0.14)**			0.44 (0.13)	0.46 (0.09)
r_{am}					-0.89 (0.93)		-0.99 (0.00)
Logl	-682.01	-670.45	**-663.68**	-669.65	-667.69	-663.68	-663.75

σ^2_a = genetic direct variance due to the additive genetic effects of animals; σ^2_m = genetic maternal variance due to the additive genetic effects of dams of animals; σ^2_{pe} = variance of permanent environment due to the dam; σ_{am} = covariance between direct and maternal genetic effects; σ^2_e = variance due to residual; σ^2_p = total phenotypic variance; h^2_a = heritability for direct genetic effects; h^2_m = heritability for maternal genetic effects; c^2_{pe} = permanent environment due to the dam; r_{am} = genetic correlation between direct and maternal effects; Logl = Log likelihood.

4.2.2.2 Correlations among traits

The estimates of the correlation and genetic parameters from the bivariate analysis between WW and PW are given in Table 4.6. The effect of the bivariate animal models in comparison to the univariate on the magnitude of the estimates of genetic parameters is evident. As can be seen in Table 4.6 heritabilities are higher in comparison to that of the univariate analysis (Tables 4.4 and 4.5). There was a strong association between WW and PW as reflected by the high positive direct genetic correlation (0.89). The sign and size of this correlation were similar to those reported by Thiruvenkadan *et al*. (2009) for Tellicherry goats who found a correlation of 0.882 between six months and 12 months body weights. However the correlation obtained in this research was higher than the estimate of 0.590 reported by Gowane *et al*. (2009) in Bharat Merino sheep and than 0.57 obtained by Kariuki *et al*. (2009) for Dorper sheep. This result indicates that selection for one of these traits would result in ann increasing in other trait in live weight.

Table 4.6 (Co) variance estimates, ratios calculated, correlation and standard error (±SE) for two-trait analysis of weaning and post-weaning weight (WW and PW)

	WW	PW	WW/PW
(Co) variance components			
σ^2_a	4.91	13.43	
σ^2_m	0.58		
σ^2_e	12.59	12.92	
σ^2_{pe}	1.58	7.48	
σ^2_p	19.67 (0.60)	33.83 (3.74)	
Variance ratios			
h^2_a	0.25 (0.04)	0.40 (0.17)	
h^2_m	0.03 (0.02)		
c^2_{pe}	0.08 (0.02)	0.22 (0.09)	
r_a			0.85 (0.17)

σ^2_a = genetic direct variance due to the additive genetic effects of animals; σ^2_m = genetic maternal variance due to the additive genetic effects of dams of animals; σ^2_{pe} = variance of permanent environment due to the dam; σ^2_e = variance due to residual; σ^2_p = total phenotypic variance; h^2_a = heritability for direct genetic effects; h^2_m = heritability for maternal genetic effects; c^2_{pe} = permanent environment due to the dam; r_a = genetic correlation between direct and maternal effects; WW = weaning weight; PW = post-weaning weight

4.2.2.2 Direct and maternal genetic trends

The direct and maternal genetic trends for 11 years are presented in figures 4.2 to 4.4. An average genetic decrease of 0.1 kg of the genetic trend for weaning weight had taken place from 1998 till 2001(Figure 4.2).

The figure also indicate that weaning weight has increased in 2002, after which it decreased again as shown by the negative trend (2003-2008). It should be noted that this fluctuations in the trends could be due to the fact that no specific selection was placed on this traits as well as to the variation on the number of animals over the study period. A similar trend can be seen in Figure 4.3 which depicts the breeding values for post-weaning weight. This tendency is to be expected as the direct genetic correlation between the two traits was positive and high (r_{a12}=0.85). The maternal genetic trend for weaning weight followed a negative trend over the period with an annual average decrease of 0.02 kg (Figure 4.4)

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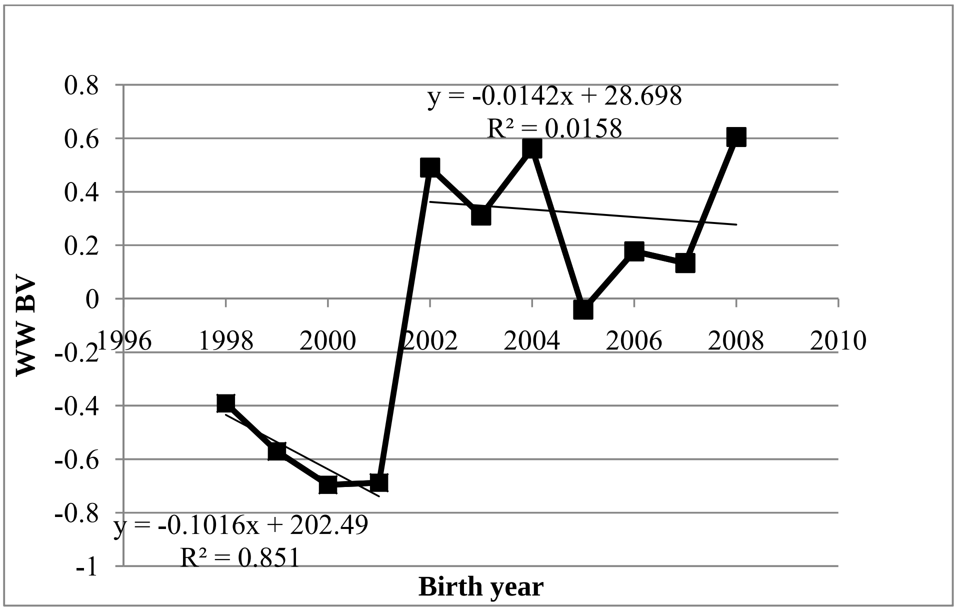

Figure 4.2 Annual mean direct breeding value estimates and genetic trend for weaning weight

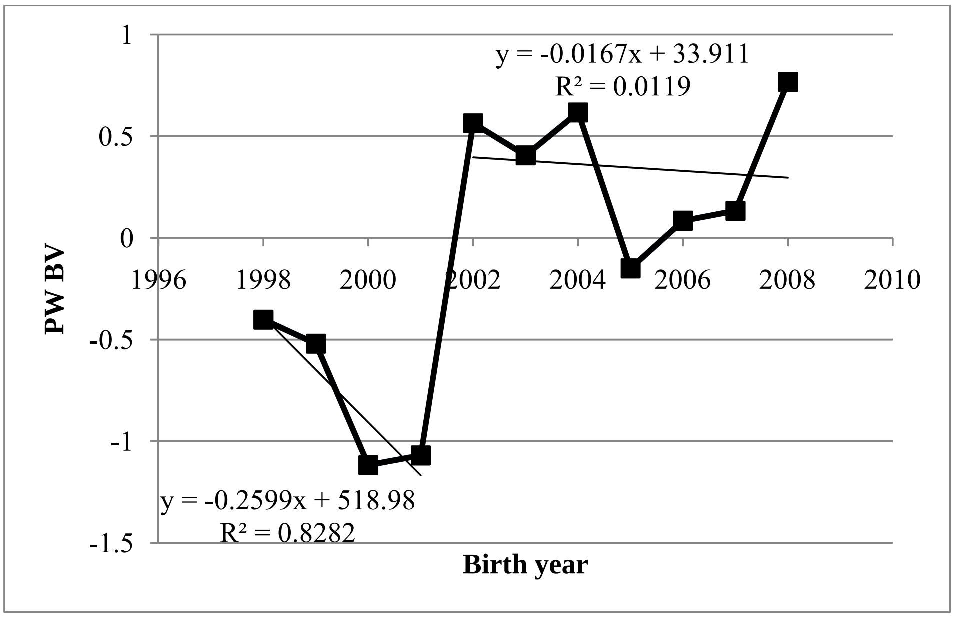

Figure 4.3 Annual mean direct breeding value estimates and genetic trend for post-weaning weight

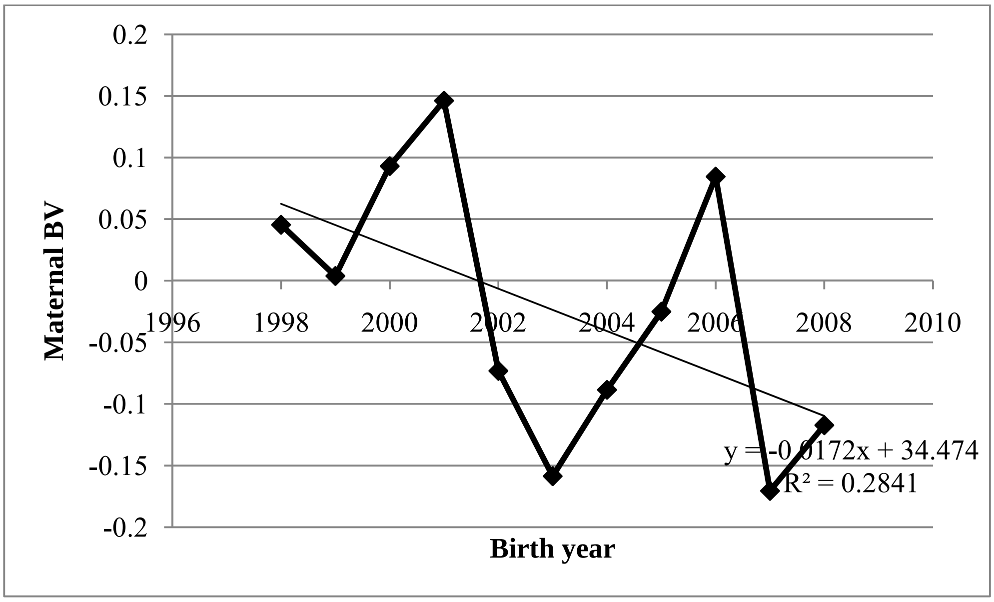

Figure 4.4 Annual mean maternal breeding value estimates and genetic trend for weaning weight

4.3 Conclusions

The results obtained in this study suggest that adjustment for effects of sex, type of birth, age of dam, year of birth, herd, season and age of lamb, need to be accounted for in the estimation of genetic parameters and prediction of breeding value for body weight in Boer goat. Furthermore the study indicated that direct and maternal additive genetic as well as maternal permanent environmental effects should be added to the models for weaning and post-weaning weights. The magnitude of heritability estimates for WW and PW indicated that these traits would respond to selection.

GENERAL CONCLUSIONS

Goat meat production in South Africa is mostly practiced under extensive conditions. The performance of any animal raised under these conditions is influenced by the environment prevailing in the region, its genetic merit and adaptation to the environment. In order to succeed in livestock production performance recording and identification of the effect of non-genetic sources of variation are of paramount importance. The purpose of performance recording is to identify superior animals to be parents in the next generations, while the identification of factors that have an effect on production performance resulted in more accurate estimations of an animal's genetic potential (Van Wyk *et al*., 1993, Rashidi *et al*., 2008).

This study analysed two data sets: one related to performance measurements and auction prices and the second data set comprised of records on weaning and post-weaning weights of Boer goat raised under extensive conditions. The purpose of the study was to identify the criteria by which farmers select breeding rams and to quantify the effect of some environmental factors on performance as well as to estimate the genetic parameters for growth traits which are required for suitable selection.

The information supplied to the buyers of rams at the auction in the Northern Cape Veld-Ram Club is responsible to certain extent for determining the variation in price.

The results indicated that buyers of stud rams put more emphasis on production traits, specifically body weight than on traits like scrotal circumference and Kleiber ratio.

Rams with heavier weights at the end of the trial received a better price at auction than lighter rams. Buyers were willing to pay more for those animals regardless of poor performance in other traits. This buyer preference for rams with a heavier final weight was a significant price determinant in almost every year the parameter was measured.

Weight of the Boer goat was significantly affected by the following non genetic effects: sex, type of birth, age of dam, year of birth, herd, season and age of lamb. These factors, as well as direct and permanent maternal environmental-(WW and PW), and maternal (WW) effects are necessary when estimating genetic parameters and breeding values for these traits in Boer goats.

The magnitude of the heritability estimates for weaning weight and post-weaning indicated that these traits would response to mass selection.

ABSTRACT

In the first study performance data from 465 Boer goat rams tested in a central performance test in the Northern Cape Veld-Ram Club from 1989 to 2007 were analysed to determine the relationship between performance and sale price. Rams were subjected to extensive management conditions on natural pastures for 160 days and finished-off in a feedlot for 50 days. Upon the conclusion of the entire test period, the rams were auctioned. Performance information was available for buyers for decision making. Traits analysed included final weight (FW), final weight index (FWI), average daily gain (ADG), average daily gain index (ADGI), growth per day of age index (ADOI), Kleiber ratio (KR), auction weight (AW), scrotal circumference (SC), selection index (SI) and sale price (SP). Stepwise regression analyses, using proc GLM of SAS were performed to identify variables that significantly influenced sale prices. Final weight was significant in eight out of eighteen years, auction weight was significant in six of the seven years measured and selection index influenced prices in seven out of ten years. Scrotal circumference, average daily gain, final weight index, average daily gain index and Kleiber ratio had little influence on sale price. Growth per day of age index did not show any influence on sale price.

Price was positively correlated ($P<0.05$) with many of the performance traits. All significant correlations were moderate to high and ranged from 0.37 to 0.80. The amount of variation in sale price accounted for by the performance traits ranged from 15% in year 1991 to 65% in 1998. The most important traits influencing sale price (SP) were final weight, auction weight, and selection index. The results indicated that buyers of stud rams put more emphasis on production

traits such as body weight and that they recognize the importance of performance data as shown by their preference for animals with high selection indices.

In the second study data consisting of 3855 records and collected from 1998 to 2008 were analysed to estimate genetic parameters for economic traits in two Boer goat flocks. The traits investigated were weaning weight and post-weaning weight. Least square analysis was used for estimation of environmental effects. Genetic parameters were estimated from single and bivariate trait analyses using ASREML software fitting animal models. By ignoring or including maternal additive genetic effects and their covariance and maternal permanent environmental effects seven different models were fitted for each trait. The fixed effects of sex, type of birth, age of dam, year of birth, herd, season and age of lamb, were all significant ($P<0.05$) for both traits. The direct heritability estimates varied from 0.24 for weaning weight to 0.31 for post-weaning weight. The corresponding maternal permanent environment due to the dam was 0.10 and 0.44 respectively. The maternal heritability (0.03) for weaning weight was lower than its corresponding direct heritability. Estimates of genetic parameters in this study confirmed that selection for weaning weight would result in genetic improvement of Boer goats.

OPSOMMING

In die eerste studie word data van prestasie eienskappe van 465 ramme getoets in ‘n sentrale prestasie toets by ‘n Noord-Kaap Veld-Ram Club vanaf 1989 tot 2007 ontleed om te bepaal wat die verhouding, indien enige, tussen die prestasie eienskappe en die verkoopprys is. Ramme is onderworpe aan ekstensiewe toestande op natuurlike weiding vir 160 dae afgerond in 'n voerkraal vir 50 dae. Na voltooiing van die afronding, was die die ramme opgeveil. Prestasie inligting was beskikbaar vir die koper vir besluitneming. Eienskappe ingesluit in die analiese was finale gewig (FW), finale gewig indeks (FWI), gemiddelde daaglikse toename (GDT), gemiddelde daaglikse toename indeks (ADGI), groei per dag van ouderdom-indeks (ADOI), Kleiber verhouding (KR), veiling gewig (AW), skrotumomtrek (SC), seleksie-indeks (SI) en verkoopprys (SP). Stapsgewyse regressie-analieses, met behulp van “proc” GLM van SAS is uitgevoer om te identifiseer watter eienskappe koopryse betekenisvol beïnvloed.

Finale gewig is betekenisvol in agt van die agtien jaar, veiling gewig was betekenisvol in ses van die sewe jaar gemeet en die seleksie-indeks beïnvloed pryse betekenisvol in sewe van die tien jaar. Skrotale omtrek, gemiddelde daaglikse toename, finale gewig indeks, gemiddelde daaglikse toename indeks en Kleiber verhouding het min invloed op die verkoop prys. Groei per dag van ouderdom-indeks toon nie enige invloed op die verkoop prys nie.

Prys was positief en betekenisvol gekorreleerd ($P<0,05$) met baie van die prestasie eienskappe. Alle betekenisvolle korrelasies was matig tot hoog (0.37-0.80). Die parsiëele bydrae van die prestasie eienskappe tot die verkoop prys was vanaf 15% in jaar 1991 tot 65% in 1998. Die belangrikste eienskappe wat verkoop prys beïnvloed was finale gewig, veiling gewig, en die seleksie-indeks. Die resultate dui daarop dat kopers van stoet ramme meer klem lê op die produksie eienskappe soos die liggaamgewig en herken die belangrikheid van die prestasie eienskappe soos aangedui deur ’n voorkeur vir diere met 'n hoë seleksie-indeks.

In die tweede studie is data versamel van 1998 tot 2008 ontleed om genetiese parameters te bereken vir twee van die ekonomiese produksie eienskappe speengewig en na-speengewig van Boerbokke. . Analises van kleinste kwadrate is vir die beraming van omgewing-effekte met SAS uitgevoer. Genetiese parameters van enkel eienskap modelle is met behulp van ASREML sagteware bereken. Sewe verskillende modelle is vir elke eienskap getoets. Die modelle het direk geneties en maternale effekte (in of uitgesluit) en permanente toevallige effekte met hul kovariansie (in of uitgesluit). Die vaste-effekte van seks, tipe van geboorte, ouderdom van ooie, jaar van geboorte, kudde, seisoen en die ouderdom van lam, was almal betekenisvol (P <0,05) vir beide speengewig en na-speengewig. Die direkte oorerflikheids beramings het gewissel van 0.24 vir speengewig tot 0.31 vir na-speengewig. Die ooreenstemmende permanente maternale omgewing as gevolg van die ooie is 0.10 en 0.44 onderskeidelik. Die maternale oorerflikheid (0.03) vir speengewig was laer as die ooreenstemmende direkte oorerflikheid. Beramings van genetiese parameters in hierdie studie bevestig dat seleksie vir speengewig, kan lei tot die genetiese verbetering van die Boerbok.

REFERENCES

Abegaz, S., Van Wyk, J.B. & Olivier, J.J., 2005. Model comparisons and genetic and environmental parameter estimates of growth and the Kleiber ratio in Horro sheep. S. Afr. J. Anim. Sci. 35(1), 30-40.

Acocks, J.P.H., 1988. Veldtypes of South Africa. 3rd ed. Memoirs of the Botanical Survey of South Africa, No 57. Botanical Research Institute, Department of Agriculture and Water Supply. Government Printer, Pretoria.

Albuquerque, L.G. & Meyer, K., 2001. Estimates of direct and maternal genetic effects for weights from birth to 600 days of age in Nelore cattle. J. Anim. Breed. Genet. 118, 83-92.

Alexandre, G., Aumont, G., Mainaud, J.C., Fleury, J. & Naves, M., 1999. Productive performances of Guadeloupean Creole goats during the sukling period. Small Rum. Res. 34, 155-160.

Almeida, A.M., Schwalbach, L.M., de Waal, H.O., Greyling, J.P.C. & Cardoso, L.A., 2006. The effect of supplementation on productive performance of Boer goat bucks fed winter veld hay. Trop. Anim. Health Prod. 38, 443-449.

Al-Shorepy, S.A., Alhadrami, G.A. & Abdulwahab, K., 2002. Genetic and phenotypic parameters for early growth traits in Emirat goat. Small Rum. Res. 45, 217-223.

Archer, J.A., Arthur, P.F., Parnell, P.F. & Van de Ven, R.J., 1998. Effect of divergent selection for yearling growth rate on female reproductive performance in Angus Cattle. Livest. Prod. Sci. 57, 33-40.

Arthur, P.F., Renand, G. & Krauss, D., 2001. Genetic and phenotypic relationships among different measures of growth and feed efficiency in young Charolais bulls. Livest. Prod. Sci. 68, 131-139.

Bailey, T.L., Monke, D., Hudson, R.S., Wolfe, D.F., Carson, R.L. & Riddell, M.G., 1996. Testicular shape and its relationship to sperm production in mature Holstein bulls. Theriogenology 46, 881-887.

Banga, C.B., 2002. Performance testing for the smallholder sector in South Africa. ARC–AII (Agricultural Research Council–Animal Improvement Institute), Irene, South Africa.

Banh, H. & Hafezian, S.H., 2009. Effects of environmental factors on growth traits in Ghezel sheep. Afr. J. Biotech. 12, 2903-2907.

Barry, D.M. & Godke, R.A., 1997. The Boer goat: the potential for cross breeding. http: //www.boergoats.com/godke.htm; accessed April 15, 2009.

Bathaei, S.S. & Leroy, P.L., 1996. Growth and mature weight of Mehraban Iranian fat-crossbred Blackbelly sheep. Small Rum. Res., 7, 61-66.

Behzadi, M.R.B., Shahroudi, F.E. & Van Vleck, L.D., 2007. Estimates of genetic parameters for growth traits in Kermani sheep. J. Anim. Breed. Genet. 124, 296-301.

Berg, R.T. & Walters, L.E., 1983. The meat animal: Changes and challenges. J. Anim. Sci. 57 (suppl. 2), 133-146.

Bergh, L., 1994. The Kleiber ratio as a measure of feed conversion efficiency in Phase D tests. National Beef Cattle Performance and Progeny Testing Scheme 1980-1992 Results. Ed. Bosman, D. J. Livestock Improvement Scheme, Irene. p. 13-14.

Bergh, L., 1999. The national beef cattle performance testing scheme. In: Breeding in South Africa. Commemorating 40 years of Beef catle performance testing. 1959-1999. Eds Scholtz, M.M., Bergh, L. & Bosman, D.J., Agricultural Research Council, Animal Improvement Institute, Irene. p. 81-82.

Bisset, S.A., Van Wyk, J.A., Bath, G.F., Morris, C.A., Stenson, M.O. & Malan, F.S., 2001. Phenotypic and genetic relationship amongst FAMACHA score, faecal egg count and performance data in Merino sheep exposed to *Haemunchus contortus* infection in South Africa. Proceedings of the fifth international sheep veterinary congress, 22-25 January 2001, Stellenbosch, South Africa.

Blackburn, H.D., 1995. Comparison of performance of Boer and Spanish goats in two US locations. J. Anim. Sci. 73, 302-309.

Bosso, N.A., Cisse, M.F., Van der Waaij, E.H., Fall, A. & Van Arendonk, J. A. M., 2007. Genetic and phenotypic parameters of body weight in West African Dwarf goat and Djallonke sheep. Small Rum. Res. 67, 271-278.

Braun, A., 1998. Progress and future of a cashmere industry in South Africa. Available: http://researchspace.csir.co.za/dspace/bitstream/10204/1197/Braun 1998.pdf

Brinks, J.S., McInerney, M.J. & Chenoweth, P.J., 1978. Relationship of age at puberty in heifers to reproductive traits in young bulls. Proc. West. Sect. J. Anim. Sci. 29, 28-30.

Burfening, P.J. & Kress, D.D., 1993. Direct and maternal effects on birth and weaning weight in sheep. Small Rum. Res. 10, 153-163.

Cameron, M.R., Luo, J., Sahlu, T., Hart, S.P. Coleman, S.W. & Goetsch, A.L., 2001. Growth and slaughter traits of Boer x Spanish, Boer x Angora, and Spanish goats consuming a concentrate-based diet. J. Anim. Sci. 79, 1423-1430.

Campbell, Q. P., 2003. The origin and description of Southern Africa's indigenous goats. S. A. Anim. Sci. 33(4), 18-22.

Cantet, R.J.C., Kress, D.D., Anderson, D.C., Doornbos, D.E., Burfening, P.J. & Blackwell, R.L., 1988. Direct and maternal variances and covariances and maternal phenotypic effects on pre-weaning growth of beef cattle. J. Anim. Sci. 66, 648-660.

Casey, N.H. & Van Niekerk, W.A., 1988. The Boer goat. I. Origin, adaptability, performance testing, reproduction and milk production. Small Rum. Res. 1, 291-302.

Cassady, J.A., Woody, H.D. & Young, A.W., 1989. Factors influencing performance and sale price of beef bulls. J. Anim. Sci. 67, 2498-2507.

Cloete, S.W.P., Olivier, J.J., Van Wyk, J.B., Erasmus, G.J. & Schoeman, S.J., 2003. Genetic parameters and trends for birth weight, birth coat score and weaning weight in Merino lines divergently selected for ewe multiple rearing ability. S. Afr. J. Anim. Sci. 33(4), 248-256.

Cloete, S.W.P. & Scholtz, A.J., 1998. Environmental effects, heritability estimates and genetic trends in a Western Cape Dohne Merino nucleus flock. S. Afr. J. Anim Sci. 28, 185-195.

Coetzee, R.J., 1998. Socio-economic aspects of sustainable goat production. In Webb, E.C. & Cronje, P.B., Research and Training Strategies for Goat Production Systems in South Africa. University of Pretoria, South Africa. p. 14-17.

Coulter, G.H., Larson, L.L. & Foote, R.H. 1975. Effect of age on testicular growth and consistency of Holstein and Angus bulls. J. Anim. Sci. 41, 1383-1389.

Coulter, G.H. & Foote, R.H., 1976. Effect of season and year of measurement on testicular growth and consistency of Holstein bulls. J. Anim. Sci. 42, 434-438.

Coulter, G.H. & Foote, R.H. 1977. Relationship of body weight to testicular size and consistency in growing Holstein bulls. J. Anim. Sci. 44, 1076-1079.

Das, S.M. & Sendalo, D.S., 1990. Comparative performance of improved meat goats in Malya, Tanzania. Proceedings of the First Biennial Conference of the African Small Ruminant Research Network, ILRAD, Nairobi, Kenya, p. 10-14 Dec.1990. http://www.fao.org/wairdocs/ilri/x5520b/x5520b19.htm

Daudu, C.S., 1984. Spermatozoa output, testicular sperm reserve and epididymal storage capacity of the Red Sokoto goats indigenous to northern Nigeria. Theriogenology 21, 317-324.

Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S. & Courbois, C., 1999. Food, agriculture and the environment, discussion paper 28, IFPRI, Washington, USA. www.ifpri.org.

De Waal, H.O., 1994. The effects of long-term variation in rainfall and dry matter production of veld on the financial position of beef weaner enterprise. S. Afr. J. Anim. Sci. 24(4), 113-118.

Dixit, S.P., Dhillon, J.S. & Singh, G., 2001. Genetic and non-genetic parameters estimates for growth traits of Bharat Merino lambs. Small Rum. Res. 42, 101-104.

DoA., 2003. Pricing monitoring committee. Final report. http/www.agric.za/docs/fpmc/default.html

Dubeuf, J.P., Monrand-Fehr, P. & Rubino, R., 2004. Situation changes and future of goat industry around the world. Small Rum. Res. 51, 165-173.

Dustin, T.D., 2002. Characterization of young bulls in a cooperative seedstock program for marketing and making decisions. MSc thesis, Texas Tech University, United States.

Erasmus, J.A., 2000. Adaptation to various environments and resistance to disease of the Improved Boer goat. Small Rum. Res. 36, 179-187.

Erasmus, J.A., Fourie, A.J. & Venter, J.J., 1985. Influence of age on reproductive performance of the improved Boer goat. S. Afr. J. Anim. Sci. 15, 5-7.

Fourie, P.J., Neser, F.W.C. & Van der Westhuizen, C., 2000. Relationship between performance measurements and sale price of Dorper rams in Northern Cape Veld-Ram club. S. Afr. J. Anim. Sci. 30(2), 128-131.

Frisch, J.E., 1981. Changes occurring in cattle as a consequence of selection for growth rate in a stressful environment. J. Agric. Sci. Camb. 96, 23-38.

Galal, S., 2005. Biodiversity in goats. Small Rum. Res. 60, 75-81.

Gebrelul, S., Sartin, L.S. &. Iheanacho, M., 1994. Genetic and non-genetic effects on the growth and mortality of Alpine, Nubian and crossbred kids. Small Rum. Res. 13, 169-176.

Gebrelul, S. & Iheanacho, M., 1997, The performance of Boer cross kids under extensive management system in Louisiana. J. Anim. Sci. 75 (Suppl. 1), 11.

Gifford, D.R., Ponzoni, R.W., Burr, J. & Lamp, R.J., 1990. Environmental effects on fleece and body traits of South Australian Angora goats. Small Rum. Res. 3, 249-256.

Gilmour, A.R., Cullis, B.R., Welham, S.J. & Thompson, R., 2002. ARSEML reference manual. N.S.W. Agriculture, Australia.

Gowane, G.R., Chopra, A., Prince, L.L.L., Paswan, C. & Arora, A.L., 2009. Estimates of (co)variance components and genetic parameters for body weights and first greasy fleece weight in Bharat Merino sheep. J. Animal. 3, 1-7.

Greyling, J.P.C., 2000. Reproduction traits in the Boer goat doe. Small Rum. Res. 36, 171-177.

Greyling, J.P.C., Mmbengwa, V.M., Schwalbach, L.M.J. & Muller, T., 2004. Comparative milk production potential of indigenous and Boer goats under two feeding systems in South Africa. Small Rum. Res. 55, 97-105.

Hoover, D.B., 2000. Effects of initial weight, scrotal circumference and breed on feedlot performance, loin eye area and final scrotal circumference of male kids goats. MSc dissertation, Angelo States University, United States.

Ikwuegbu, O.A., Tarawali, G. &. Rege, J.E.O., 1995. Effects of fodder banks on growth and survival of West African Dwarf goats under village conditions in subhumid Nigeria. Small Rum. Res. 17, 101-109.

Inyangala, B.A.O., Rege, J.E.O. & Itulya, S., 1990. Growth traits of the Dorper sheep I. Factors influencing growth traits. Proceedings of the First Biennial Conference of the African Small Rum. Res. Network, ILRAD, Nairobi, Kenya, 10-14 Dec. 1990.

Jiabi, P., Zegao, D., Taiyong, C. & Jiyun, G., 2001. Improvement effect of crossbreeding Boer goats and Sichuan Native goats. Proceedings of the 2001 Conference on Boer goats, Beijing, China, Oct. 20-25, 2001.

Karagiannidis, A., Varsakeli, S. & Karatzas, G., 2000. Characteristics and seasonal variations in the semen of Alpine, Saanen and Damascus goat bucks born and raised in Greece. Theriogenology 53, 1285-1293.

Kariuki, C.M., Ilatsia, E.D., Kosgey, I.S. & Kahi, A.K., 2009. Direct and maternal (co)variance components, genetic parameters and annual trends for growth traits of Dorper sheep in semi-arid Kenya. Trop. Anim. Health Prod.; published online on September 8th, 2009.

Karua, S.K. &. Banda, J.W., 1990. The performance of the Small East African goats and their Saanen crosses in Malawi. Proceedings of the Second Biennial Conference of the African Small Ruminant Research Network AICC, Arusha, Tanzania, 7-11 Dec. 1992. http://www.fao.org/wairdocs/ilri/x5472b/x5472b0i.htm.

Koots, K.R., Gibson, J.P. & Wilton, J.W., 1994. Analyses of published genetic parameter estimates for beef production traits. 2. Phenotypic and genetic correlations. Anim. Breed. Abstr. 62, 825-853.

Köster, E., Van der Westhuizen, J. & Erasmus, G.J., 1994. Heritability estimates for different Kleiber ratios obtained from growth performance data in a Hereford herd. S. Afr. J. Anim. Sci. 24, 71-72.

Kräusslich, H., 1974. General recommendations on procedures for performance and progeny testing for beef characteristics. Livest. Prod. Sci. 1, 33-45.

Lasley, J.F., 1978. Genetics of livestock improvement. 3rd Edition. Prentice-Hall. Inc., Englewood Cliffs. New Jersey. USA.

Lee, J.W., Waldron, D.F. & Van Vleck, L.D., 2000. Parameter estimates for greasy fleece weight of Rambouillet sheep at different ages. J. Anim. Sci. 78, 2108-2112.

Lehloenya, K.C., Greyling, J.P.C. & Schwalbach, L.M.J., 2005. Reproductive performance of South African indigenous goats following oestrous synchronization and AI. Small Rum. Res. 57, 115-120.

Lewis, S.J., May, B.J. & Engdahl, G.R., 1997. Feedlot performance and carcass traits of Boer goat crosses and Spanish male kids. J. Anim. Sci. 75 (Suppl. 1), 40.

Lewis, R.M. & Beatson, P.R., 1999. Choosing maternal-effect models to estimate (co)variances for live and fleece weight in New Zealand Coopworth sheep. Livest. Prod. Sci. 58, 137-150.

Lu, C.D. & Potchoiba, M.J., 1988. Milk feeding and weaning of goat kids. Small Rum. Res. 1, 105-112.

Lu, C.D., 2001. Boer goat production: progress and perspective. Proceedings of the 2001 Conference on Boer goats, Beijing, China, Oct. 20-25, 2001.

Luginbuhl, J.M., 2002. Breeds of goats for meat goat production and production traits. Department of Animal Science. www.cals.ncsu.edu/an /sci/extension/animal/meatgoat.

Lunstra, D.D., Ford, J.J. & Echternap, S.E., 1982. Influence of single-sire and multiple-sire natural mating on pregnancy rate of beef heifers. Theriogenology 18, 373-382.

Luo, J., Sahlu, T., Cameron, M. & Goetsch, A.L., 2000. Growth of Spanish, Boer x Angora and Boer x Spanish goats kids fed milk replacer. Small Rum. Res. 36, 189-194.

Madibela, O.R., Mosimanyana, B.M., Boitumelo, W.S. & Pelaelo, T.D., 2002. Effect of supplementation on reproduction of wet season kidding Tswana goats. S. Afr. J. Anim. Sci. 32(1), 1-22.

Malan S.W., 2000. The improved Boer goat. Small Rum. Res. 36, 165-170.

Mandal, A., Neser, F.W.C., Rout, P.K., Roy, R. & Notter, D.R., 2006. Genetic parameters for direct and maternal effects on body weights of Muzaffarmagari sheep. Anim. Sci. 82, 133-140.

Maniatis, N. & Pollot, G.E., 2002. Genotype by environment interactions in lamb weight and carcass composition traits. Anim. Sci. 75, 3-14.

Maniatis, N. & Pollot, G.E., 2003. The impact of data structure on genetic (co)variance components of early growth traits in sheep, estimated using animal model with maternal effects. J. Anim. Sci. 81, 101-108.

Maria, G.A., Boldman, K.G. & Van Vleck, L.D., 1993. Estimates of variances due to direct and maternal effects for growth traits of Romanov sheep. J. Anim. Sci. 71, 845-849.

Marquez, A.P., Saucedo, J.S., Montano, M. & Guerrero, J.N., 2007. Estimates of genetic parameters for weight in progeny of Nubian, French Alpine, Saanen, Toggenburgh and Spanish goats mated to Boer sires. Proc. American Society of Anim. Sci. 58, 113-115.

McGowan, C. & Nurce, G., 2000. Production factors affecting meat goat production. Dept. of Animal Science, Institute of Food and Agricultural Sciences, University of Florida. http://www.famu.org/stategoat/breeding4.html.

McManus, C., Filho, G.S., Louvandini, H., Dias, L.T., Teixeira, R.A. & Murata, L.S., 2008. Growth of Saanen, Alpine and Toggenburg goats in the Federal district, Brazil: Genetic and environmental factors. Cienc. Anim. Bra, 9(1), 68-75.

Mendenhall, W. & Sincich, T., 1989. A second course in business statistics, third edition. Dellen Publishers, San Francisco.

Meyer, K., 1992. Variance components due to direct and maternal effects for growth traits of Australian beef cattle. Livest. Prod. Sci. 31, 179-204.

Meyer, K., 1997. Estimates of genetic parameters for weaning weight of beef cattle accounting for direct-maternal environmental covariances. Livest. Prod. Sci. 52, 187-199.

Montaldo, H., Juárez, A., Berruecos, J.M. & Sánchez, F., 1995. Performance of local goats and their backcrosses with several breeds in Mexico. Small Rum. Res. 16, 97-105.

Morand-Fehr, P., Boutonnet, J.P., Devendra, C., Dubeuf, J.P., Haenlein, G.F.W., Holst, P., Mowlen, L. & Capote, J., 2004. Strategy for goat farming in the 21st century. Small Rum. Res. 51, 175-183.

Morris, C.D. & Du Toit, L.P., 1998. The performance of Boer goats browsing *Leucaena Leucocephala* in Kwazulu Natal, South Africa. Trop. Grass. 32, 188-194.

Mourad, M. & Anous, M.R., 1998. Estimates of genetic and phenotypic parameters of some growth traits in Common African and Alpine crossbred goats. Small Rum. Res. 27, 197-202.

Mukuahima, G., 2007. The performance of beef cattle bulls in the Vrede district of Mpumalanga, South Africa. MSc thesis, University of Pretoria, South Africa.

National Department of Agriculture. 2009. National Livestock statistics. Department of Agriculture and Land Affairs, Pretoria, South Africa.

Neser, F.W.C., Erasmus, G.J. & Van Wyk, J.B., 2001. Genetic parameter estimates for pre-weaning weight traits in Dorper sheep. S. Afr. J. Anim. Sci. 40, 197-202.

Nkrumah, J. D, Basarab, J. A., Price, M. A., Okine, E. K., Ammoura, A., Guercio, S C., Hansen, C., Li, C., Benkel, B., Murdoch, B. & Moore, S. S., 2004. Different measures of energetic efficiency and their phenotypic relationships with growth, feed intake, and ultrasound and carcass merit in hybrid cattle. J. Anim. Sci. 82, 2451-2459.

Northcutt, S.L., Franklin, B.L. & Buchanan, D.S., 1995. Relationships between performance traits, individual expected progeny differences and sale prices of centrally tested bulls. Dept.of Anim. Sci. Oklahoma State University, Stillwater.

Notter, D.R. & Copenhaver, J.S., 1980. Performance of Finnish Landrace crossbred ewes under accelerated lambing. II. Lamb growth and survival. J. Anim. Sci. 51(5), 1043-1050.

Nsoso, S.J., Podisi, B., Otsogile, E., Mokhutshwane, B.S. & Ahmadu, B., 2004. Phenotypic characterization of indigenous Tswana goats and sheep breeds in Botswana: continuous traits. Tropical Animal Health and Production 36, 789-800.

Olivier, J.J., 2002. The South African National Small Stock Improvement Scheme. Small Rum. Res. 60, 83-93.

Olivier, J.J., Cloete, S.W.P., Schoeman, S.J. & Muller, C.J.C., 2005. Performance testing and recording in meat and dairy goats. Small Rum. Res. 60, 83-93.

Osinowo, O.A., Abubakar, B.Y., Olayemi, M.E., Balogun, R.O., Onifade, O.S.,. Adewuyi, A.A., Trimmel, R. & Dennar, F.O., 1992. Preweaning performance of Yakansa sheep under semi intensive management. Proceedings of the Second Biennial Conference of the African, Small Ruminant Research Network, AICC, Arusha, Tanzania 7-11 Dec. 1992. http://www.fao.org/wairdocs/ilri/x5472b/x5472b0e.htm

Penn State, 2000. Agriculture alternatives: meat goat production. http://agalternatives.aers.psu.edu/livestock/meatgoat/meat goat.pdf.

Price, E.O. & Wallach, S.J., 1991. Development of sexual and aggressive behaviors in Hereford bulls. J. Anim. Sci. 69, 1019-1027.

Ramsay, K., Swart, D., Olivier, B. & Hallowell, G., 2000. An evaluation of breeding strategies used in the development of the Dorper sheep and the improved Boer goat of South Africa. ICAR technical series no 3.

Rashidi, A., Makhtari, M.S., Safi Jahanshahi, A. & Mohammad Abadi, M.R., 2008. Genetic parameter estimates of pre-weaning growth traits in Kermani Sheep. Small Rum. Res.74, 165-171.

Roca, J., Martinez, E., Vazquez, J.M. & Coy, P., 1992. Characteristics and seasonal variations in the semen of Murciano-Granadina goats in the Mediterranean area. Anim. Reprod. Sci. 29, 255-262.

Roy, R., Mandal, A. & Notter, D.R., 2008. Estimates of (co)variance components due to direct and maternal effects for body weights in Jamunapari goats. J. Anim. 2(3), 354-359.

Sainz, R.D. & Paulino, P.V., 2004. Residual feed intake. Sierra Foothill Research & Extension Centre.University of California http://0-repositories.cdlib.org.innopac.up.ac.za:80/ anrrec/sfrec/2004 residual feed intake

SAS, 2006. SAS institute Inc SAS procedures Guide , Cary, N.NC.

Schoeman, S.J., 1990. Production parameters for Dohne Merino under an accelerated intensive lambing system. S. Afr. J. Anim. Sci. 20(4), 174-179.

Schoeman, S.J., Els, J.F. & Van Niekerk, M.M., 1997. Variance components of early growth traits in the Boer goat. Small Rum. Res. 26, 15-20.

Shaat, I. & Maki-Tanila, A., 2009. Variation in direct and maternal genetic effects for meat production traits in Egyptian Zaraibi goats. J. Anim. Breed. Genet. 126, 198-208.

Sheridan, R., Ferreira, A.V. & Hoffman, L.C., 2003. Production efficiency of South African Mutton Merino lambs and Boer goat kids receiving either a low or high energy feedlot diet. Small Rum. Res. 50, 75-82.

Sibanda, L.M., Ndlovu, L.R. & Bryant, M.J., 1999. Effect of low plane of nutrition during pregnancy and lactation on the performance of Metebele does and their kids. Small Rum. Res., 32, 243-250.

Simela, L. & Merkel, R., 2008. The contribution of chevon from Africa to global meatproduction. Meat Sci. 80, 101-109.

Snyman, M.A. & Olivier, J.J., 1996. Genetic parameters for body weight, fleece weight and fiber diameter in South African Angora goats. Livest. Prod. Sci. 47, 1-6.

South African Weather Bureau, 2009. Personal communication.

Thiruvenkadan, A.K., Murugan, M., Karunanithi, K., Muralidharan, J. & Chinnamani, K., 2009. Genetic and non-genetic factors affecting body weight in Tellicherry goats. S. Afr. J. Anim. Sci. 39, (suppl1), 107-111.

Thompson, D., 2006. Meat goat breeds, breeding management and 4-H market goat management. http://www.extension.umn.edu/meatgoats/components.

Toelle, V.D. & Robison, O.W., 1985. Estimation of genetic correlations between testicular measurements and female reproductive traits in beef cattle. J. Anim. Sci. 60, 89-100.

Toplu, H.D.O. & Altinel, A., 2008. Some production traits of indigenous hair goats bred under extensive conditions in Turkey. 2nd communication: Viability and growth performances of kids. Arch. Tierz. 5, 507-514.

Tosh, J.J. & Kemp, R.A., 1994. Estimation of variance components for lamb weight in three sheep populations. J. Anim. Sci. 72, 1184-1190.

Van Niekerk, W.A. & Casey, N.H., 1988. The Boer goat II. Growth, nutrition requirements, carcass and meat quality. Small rum. Res. 1, 355-368.

Van Niekerk, M.M., Schoeman, S.J., Botha, E.M. & Casey, N., 1996. Heritability estimates for pre-weaning growth traits in the Adelaide Boer goat flock. S. Afr. J. Anim. Sci. 26(1), 6-10.

Van Wyk, J.B., Erasmus, G.J. & Konstantinov, K.V., 1993. Variance component and heritability estimates of early growth traits in the Elsenburg Dormer sheep stud. S. Afr. J. Anim. Sci. 23, 72-76.

Waldron, D.F., Thomas, D.L., Wickersham, T.W., Morrical, D.G.,Baertsche, S.R., Hudgens, R.E., Hirschinger, C.W. & Kemp. R.A., 1989. Central ram tests in the Midwestern United States: II. Factors affecting test performance and sale price of tested rams. J. Anim. Sci. 67, 1199-1207.

Waldron, D.F., Thomas D.L., Stookey, J.M., Nash, T.G., McKeith, F.K. & Fernando, R.L., 1990. Central ram testing in the mid-western Unites States: III Relationship between sire's central test performance and progeny performance. J. Anim. Sci. 68, 45-53.

Warmington, B.G. & Kirton, A.H., 1990. Genetic and non-genetic influences on growth and carcass traits of goats. Small Rum. Res. 3, 147-165.

Webb, E.C. & Mamabolo, M.J., 2004. Production and reproduction characteristics of South African indigenous goats in communal farming systems. S Afr. J. Anim. Sci. 34 (suppl1), 236-239.

Wenzhong, L., Zhang, Y. & Zhou, Z., 2005. Adjustment for non-genetic effects on body weight of size in Angora goats. Small Rum. Res. 59, 25-31.

Zhang, C., Yang, L. & Shen, Z., 2008. Variance components and genetic parameters for weight and size at birth in the Boer goat. Livest. Sci. 115, 73-79.

Zhang, C.Y., Zhang, Y., Xu, D.Q., Li, X., Su, J. & Yang, L.G., 2009. Genetic and phenotypic parameter estimates for growth traits in Boer goat. Livest. Sci. 124, 66-71.

Zhou, H.M., Allain, D., Li, J.Q., Zhang, W.G. & Yu, X.C., 2003. Effects of non-genetic factors on production traits of Inner Mongolia cashmere goats in China. Small Rum. Res. 47, 85-89.