Genetic parameter estimation and breeding plans for the South African dairy goat herd

by

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PHILOSOPHIAE DOCTOR

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DECLARATION

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and that I have not previously in its entirety or in part submitted it at any University for a degree.

Signature: ……..…………………………...   Date: …………………...

ABSTRACT

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Milk production records of all grade and registered Saanen dairy goats from the Milk Recording and Performance Testing Scheme of the Animal Improvement Institute of the Agricultural Research Council of South Africa and pedigree information of these animals from SA Studbook were analyzed to obtain specific genetic parameters. Records of goats with lactations exceeding 60 days in milk were used. A sufficient number of records only became available from 1985 onwards. Reproduction records were determined from milk recording data. The number of milk production records for the British Alpine and Toggenburg breeds was too small to warrant a genetic evaluation. In total, 3190 lactation records of 1413 Saanen does were available for the initial analysis. First and second parity records, 1190 and 775 records, respectively, were subjected to a separate genetic analysis. Milk production records (2319) of one commercial herd providing more than 70% of all the records in the national herd, were also subjected to a separate genetic analysis.

The fixed effects identified as having a significant ($P<0.05$) effect on all traits studied were production year, age of dam, lactation length, parity number, herds (owners) and year of birth. Although some significant interactions were found, they were ignored as their effects were very small.

Additive genetic variances and heritability estimates were obtained by ASREML procedures fitting three models. Estimates were generally in accordance with values found in the literature although estimates for fat and protein percentage were lower than expected when compared to dairy cow data. This could be explained by pedigree information lacking in the data set. The h^2 estimate for milk yield using all records, first parity records, second parity records and records from a commercial herd were 0.21±0.05, 0.32±0.08, 0.20±0.10 and 0.31±0.06, respectively. Heritability estimates for fat percentage showed a large variation and were 0.19±0.05, 0.67±0.08, 0.34±0.12 and 0.12±0.05, respectively for similar data sets as previously mentioned. In contrast to this protein percentage varied little between data sets and were 0.30±0.06, 0.32±0.00, 0.24±0.11 and 0.28±0.07, respectively.

Genetic and phenotypic correlations among production traits were positive and high for all data sets. As for dairy cows, milk fat and protein percentages were negatively related to milk yield. Genetic correlations between milk fat and protein percentages were positive and moderate to high. Increasing milk volume would have a negative effect on fat and protein percentages although it would increase fat and protein yields.

Reproduction parameters, i.e. age at first kidding (AFK), age at last kidding (ALK), productive life (PL) and number of lactations (NL) were derived from milk recording data. Mean values for these parameters were 457±171 days, 1046±718 days, 19.3±13.9 months and 2.24±1.37 kiddings, respectively. Kidding interval had no genetic basis and is controlled by management. Heritability estimates were in accordance with literature values and were 0.25±0.04, 0.28±0.04, 0.08±0.04 and 0.05±0.03 for AFK, ALK, PL and NL, respectively. The genetic correlation between AFK and ALK was as expected positive and high, i.e. 0.61±0.10, although the correlation between AFK and PL was negative indicating similar to dairy cows that PL is shortened by a later AFK.

The genetic trend for milk, fat and protein yield were positive, although it did not differ from zero. Large variations were observed between years (R^2 <0.13). Genetic trends for fat and protein percentages were positive and negative ($P<0.05$), respectively. These trends are in contrast to trends observed in other countries such as

France, The Netherlands and the USA where positive trends were generally observed. This may indicate a higher selection emphasis on milk yield parameters or more complete data sets in terms of pedigree information.

The dairy goat industry in South Africa should address some of the problems that were encountered in the analysis of the data. These include factors such as a large number of small herds, many short lactations, a large number of animals lacking production data linked to pedigree information, incomplete pedigrees, few does that have completed three or more lactations, little genetic ties between herds and a small number of progeny for bucks. Some organizational and logistic issues concerning pedigree and milk recording need to be addressed by the South African Milch Goat Society to enable the accurate estimation of the genetic merit of animals in the national herd.

OPSOMMING

Die beraming van genetiese parameters en teelplanne vir die Suid-Afrikaanse melkbokkudde

deur

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Melkproduksierekords van alle graad- en geregistreerde Saanen melkbokke in die Melkaantekening- en Prestasietoetsskema van die Diereverbeteringsinstituut van die Landbou-Navorsingsraad van Suid-Afrika en stambooominligting van SA Stamboek is vir die bepaling van kudde-spesifieke genetiese parameters gebruik. Rekords van ooie met laktasies langer as 60 dae in melk is gebruik. Voldoende rekords vir ‘n genetiese ontleding is slegs vanaf 1985 beskikbaar. Bepaalde reproduksieparameters is van melkaantekening inligting afgelei. Die aantal melkproduksierekords vir die Britse Alpine- en Toggenburgrasse was te min om ‘n genetiese ontleding te kon doen. In totaal was daar 3190 laktasierekords van 1413 Saanen melkbokooie vir die aanvanklike ontleding beskikbaar. ‘n Afsonderlike ontleding is gedoen met 1190 en 775 eerste en tweede laktasie melkproduksierekords. ‘n Kommersiële kudde met 2319 melkproduksierekords (meer as 70% van die rekords van die nasionale kudde) is ook aan ‘n soortgelyke genetiese ontleding onderwerp.

Die vaste effekte wat ‘n betekenisvolle ($P<0.05$) invloed op al die produksie-eienskappe gehad het was, produksiejaar, ouderdom van die ooi, laktasieperiode (aantal dae in melk) and geboortejaar. Hoewel ‘n aantal betekenisvolle interaksies

gevind is, is dit geïgnoreer aangesien hul invloed op die produksie-eienskappe baie klein was.

Additiewe genetiese variansies en oorerflikheidswaardes (h^2) is beraam deur die passing van die ASREML prosedure op die data. Genetiese parameters was met die uitsondering van oorerflikheidswaardes vir vet- en proteïenpersentasies oor die algemeen in ooreenstemming met waardes in die literatuur. Die oorerflikheid van vet- en proteïenpersentasies was laer as waardes in die literatuur, asook vir soortgelyke waardes vir melkkoei-ontledings. Dit kan waarskynlik toegeskryf word aan tekorte in stamboominligting in die datastel, asook bestuursverskille tussen produsente. Die h^2 waardes vir melkproduksie vir alle rekords, net eerste laktasierekords, tweede laktasierekords en rekords van 'n kommersiële kudde was onderskeidelik, 0.21±0.05, 0.32±0.08, 0.20±0.10 en 0.31±0.06. Die h^2 vir vetpersentasie het tussen die verskillende datastelle gevarieer en was onderskeidelik 0.19±0.05, 0.67±0.08, 0.34±0.12 en 0.12±0.05. In teenstelling hiermee het die h^2 vir proteïenpersentasie minder tussen datastelle gevarieer en was dit onderskeidelik 0.30±0.06, 0.32±0.00, 0.24±0.11 en 0.28±0.07.

Genetiese en fenotipiese korrelasies tussen eienskappe was hoog positief vir al die datastelle. Net soos by melkkoeie, is vet- en proteïenpersentasie negatief gekorreleer met melkproduksie. Genetiese korrelasies tussen vet- en proteïenpersentasie was matig tot hoog positief. Die verhoging van die volume melk geproduseer het dus 'n negatiewe effek op die vet- en proteïenpersentasies van die melk gehad. Ten spyte hiervan sal vet- en proteïenproduksies toeneem.

Reproduksieparameters, naamlik ouderdom met eerste lam (AFK), ouderdom met laaste lam (ALK), produktiewe leeftyd (PL) en aantal laktasies (NL) is afgelei van melkaantekeningrekords. Gemiddelde waardes vir hierdie parameters was onderskeidelik 457±171 dae, 1046±718 dae, 19.3±13.9 maande en 2.24±1.37 laktasies. Laminterval het geen genetiese basis gehad nie en word uitsluitlik deur bestuur beïnvloed. Oorerflikheidswaardes vir reproduksie-eienskappe was in ooreenstemming met waardes in die literatuur en was onderskeidelik 0.25±0.04, 0.28±0.04, 0.08±0.04 en 0.05±0.03 vir AFK, ALK, PL en NL. Die genetiese korrelasie tussen AFK en ALK was, soos verwag, hoog positief. Soos by melkkoeie is 'n negatiewe korrelasie tussen AFK en PL gevind.

Die genetiese tendense oor jare vir melk-, vet- en proteïenproduksie was positief, hoewel dit nie van nul verskil het nie. Groot variasies tussen jare is waargeneem (R^2 <0.13). Die genetiese tendens oor jare vir vet- en proteïenpersentasies was onderskeidelik positief en negatief ($P<0.05$). Hierdie veranderinge is in teenstelling met soortgelyke tendense in lande soos Frankryk , Nederland en die VSA waar die tendens vir produksie-eienskappe oor die algemeen positief is. Dit kan 'n aanduiding wees dat in hierdie lande 'n groter seleksiedruk op produksie geplaas word of dat daar meer volledige datastelle bestaan wat stamboominligting betref.

Die melkbokbedryf in Suid-Afrika behoort sekere van die probleme wat met die ontleding van die data ondervind is, aan te spreek. Hierdie faktore is onder andere 'n groot aantal klein kuddes, 'n groot aantal kort laktasies, 'n groot aantal diere met ontbrekende produksiedata tesame met stamboominligting, onvolledige stambome, 'n klein aantal ooie wat drie of meer laktasies voltooi het, min genetiese skakeling tussen kuddes en 'n klein aantal nageslag per ram. Bepaalde organisitoriese en logistieke probleme ten opsigte van stamboominligting en melkaantekening sal deur die Suid-Afrikaanse Melkboktelersgenootskap aangespreek moet word om die akkurate beraming van die genetiese meriete van die diere in die nasionale kudde moontlik te kan maak.

PREFACE

This dissertation is presented as four papers of which three are based on the genetic evaluation of the South African Saanen dairy goat herd using different sources of information, i.e. all dairy goat records, first and second parity records and records from a commercial herd comprising almost 65% of all the national herd's records. The fourth paper is based on reproduction parameters obtained from milk recording information pertaining to kidding dates, lactation periods and number of kiddings. Another article on a proposed breeding plan for the national herd is based on a literature review of different options available for dairy goat farmers. Because of the different analyses, it was inevitable that some repetition would occur. Presenting the dissertation in this format, however, presents the option of submitting the different papers for publication speedily.

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CONTENTS

CHAPTER 1

GENERAL INTRODUCTION

Goats are widely distributed in the world with 95% of them in less developed countries (Serradilla, 2001). Their distribution is usually associated with the arid, semi-arid, tropical and sub-tropical regions of the world. They often consist of heterogeneous populations as well as some well-defined specialist breeds for milk, meat and/or fibre production. Dairy goat breeds originated in the developed countries although today goats in these countries constitute only about 5% of the world goat population. Europe, specifically, produces 20.7% of the world goats milk while maintaining only 2.5% of the total goat population (Serradilla, 2001). Dairy type goats in developing countries generally have low individual milk yields. This is usually because of poor feed resources and/or animals of inferior genetic quality for milk yield. The lactation period is usually very short and seasonal, concurring with the available natural herbage and shrubs.

South Africa is, like most developing countries, characterized by a large human population combined with a poor distribution of food among rich and poor. First World standards apply in some areas while there are also highly populated, poorly developed areas. In these areas, a considerable number of people, especially children, suffer from malnutrition because of too little food or an unbalanced diet. Diets consist mostly of starchy grains that, although supplying sufficient energy, lack protein that is necessary for growth and the repair of body tissues (Lasley, 1978).

Animal products such as meat, milk and eggs are the main sources of high-quality protein for humans. On a worldwide basis, protein is unfortunately the nutrient in shortest supply. As the protein needs of humans increase because of population growth, there will be an increase in competition between humans and livestock for cereal grains. The dairy goat has for centuries been used to provide high quality protein to humans. This has been the case especially in the developing areas of the world, although the quantity of protein that goats could produce has always been low because of poor natural resources and varying genetic ability. Because dairy goats are browsers as well as foragers, they are less reliant on cereal grains for producing milk and meat protein compared to dairy and feedlot cattle. In some First World countries like Europe, dairy goat products have been used on a wide scale. In other parts of the world there is currently an increasing demand for milk products from dairy goat milk. These countries generally suffer from a lack of space, therefore farm animals need to be highly efficient in terms of production. Initially breeders paid a lot of attention to the type or body conformation of producing animals. However, with better evaluation of performance, it was realized that the correlation between type and performance for most farm animals is very low (Lasley, 1978). This means that selecting for good type will not automatically give good performance, while conversely, selecting for higher milk yields will not necessarily result in a deterioration of type. Performance testing was then initiated to improve livestock through breeding as the results from the show ring did not result in better performing animals.

Sustained improvement in production parameters has been observed over the last number of years mainly in the more intensive livestock industries (Cloete *et al.*, 2002). Improved feeding, management and disease control practices have been largely responsible for this. Selection and mating systems have also been developed over time. For breeders of farm livestock, it is a prerequisite to be able to distinguish between genetic or environmental improvements in a herd. It was observed very early that the limit to performance of animals is set by their own heredity or genetic merit and that the best possible environment will not enable individuals to exceed their inherent genetic potential (Lasley, 1978). To make the best possible use of superior breeding material, animals with the best genetic make-up have to be selected, as they possess more desirable genes or combinations of genes (Lasley, 1978). Superiority derived from favourable alleles is transmitted from the parents to the next generation.

Genetic evaluation programmes have been used in the dairy industry for many years (Van Raden, 1990). The phenotype (P) for a trait can be defined as the sum of an animal's genetic merit (G) for a specific trait and the influence of the environment (E) on the obtained record. Estimation of the heritabilities of production traits is required for the genetic evaluation of breeds. Heritability estimates refer to that portion of the phenotypic variance in a population that is due to genetic action (Lasley, 1978). Heritability estimates are concerned with the genetic differences between animals or groups of animals (families) and not with their absolute values. The previous two decades have been characterized by marked advancements in the computing abilities and software required for genetic evaluations. This has resulted in the development of much improved techniques for the genetic evaluation of the production parameters of livestock.

Initially the genetic merit of dairy animals was determined by a ratio based on the average yield of contemporaries of age groups within herds (Du Toit, 1994). Predicted breeding values of bulls were first determined by a contemporary comparison method. More recently the mixed model procedure such as the sire model of Henderson (1975) has been used to obtain Best Linear Unbiased Prediction (BLUP) of breeding values. An animal model, BLUP, is currently considered to be one of the best methods to predict the breeding value of replacement animals, as all available information from relatives are included and fixed effects are estimated simultaneously with breeding values (Bonaiti & Boichard, 1990; Uimari & Mäntysaari, 1993). The animal model furthermore allows simultaneous evaluation of male and female animals for additive genetic solutions, even for animals without records, but with adequate relationships (Henderson, 1977).

Breeding value estimation by the BLUP animal model was first used in the dairy industry in South Africa during 1990. Genetic evaluations of the different dairy breeds were conducted for Holsteins by Vermeulen (1991), for Ayrshires by Hallowell (1994) and for Jerseys by Du Toit (1994). The breeding values of dairy cows, bulls and heifers of the main dairy breeds in South Africa are now being estimated on a biannual basis and dairy farmers receive a genetic herd profile showing the average milk yield, milk composition and breeding values of cows and bulls for milk production parameters of the herd. Predicted breeding values of all heifers in the herd with known dam and sire identification are also provided. These parameters for individual herds are compared with those of the national dairy herds. From this the genetic and environmental trends for production parameters can be determined for each herd and compared with those of the national herd (Muller *et al*., 1998). No such information is presently available for the dairy goat industry in South Africa.

When the number of registered dairy goats and the number of does in milk recording are considered (Hallowell *et al*., 2000), it must be conceded that the dairy goat industry in South Africa is small compared to the dairy cow industry. This, however, is not a true reflection of the local dairy goat industry, as there is a large number of dairy type goats in the rural areas of South Africa. Unfortunately, information in terms of dam and sire identification and production of these animals is nonexistent.

There is currently a growing interest in the keeping of dairy goats in South Africa. Goat’s milk is regarded as a healthier food, with some people using it for medicinal reasons. People allergic to milk products from dairy cows use goat's milk without any problems. Furthermore, the government encourages food self sufficiency for the rural poor. Dairy goats are ideal for this purpose, and are being included in programmes for rural development. A cross-breeding project was started with pure bred dairy goat bucks on the local or indigenous goats to improve their milk yield capabilities while maintaining their resilience against endemic diseases like heartwater (Mullins, 1994). Further objectives of this programme are to introduce goat farming to more diverse areas, and to increase the milk yield of local goats that is often low. According to Donkin & Boyazoglu (2000), indigenous goats produce about 23 kg per lactation lasting on average 94 days. These goats, however, have to rely on natural resources while also rearing one or more kids during the lactation.

Dairy goat farmers, particularly those producing milk under intensive conditions, are in the same dilemma as dairy cattle farmers because they have been experiencing a reduced income because of higher production costs. It has therefore become necessary for them to increase the average milk yield of their does for a higher margin above feed costs. One way would be to improve the overall management level of their herds. This includes factors such as housing, feeding and milking procedures. It would also be important to have information on the genetic merit of animals in their herds. While the production environment of animals in different herds may vary, the genetic merit of any animal is fixed at conception. Animals then need a suitable environment to achieve milk yields equivalent to their genetic potential. The genetic merit of does in a dairy goat herd could, however, be affected either positively or negatively by the genetic merit of the bucks used in the breeding programme. Therefore the genetic change in a dairy herd depends on the parents chosen for the next generation. At present, dairy goat farmers in South Africa are using various information sources such as pedigrees, conformation traits and phenotypic performances to select bucks and does. With the available technology, it has become feasible to separate the environmental and genetic effects on production. This information would theoretically allow dairy goat farmers the opportunity to achieve a meaningful genetic improvement in their herds.

There is currently no information available on the genetic and phenotypic changes for milk yield parameters in the South African dairy goat herd, while the effect of environmental factors on production is also unknown. With the exception of body conformation traits that are determined by the breed society, it seems that most producers lack a definite breeding objective concerning milk yield or milk composition parameters. This is shown by the linear regressions of production parameters on production years for all breeds of dairy goats (Muller, CJC, unpublished data). There was no change in the milk yield, protein percentage of milk and protein yield of dairy goats in milk recording from 1981 to 2000. Fat percentage and fat yield on the other hand declined over the same period. The number of dairy goats in milk recording also varied to a great extent between years. Although these parameters are influenced by environmental factors, a lack of information concerning the genetic ability of bucks and does could have had a major effect on this situation.

Breeders of dairy goats in South Africa generally regard dairy goats as more efficient than dairy cows in terms of milk yield (Swart, 1997). No attempt has, however, been made to determine whether this is indeed the case. Vallerand (1996) found that the efficiency of milk production of dairy goats and sheep in an intensive system was about 10 and 20%, respectively, lower than that of dairy cows. Efficiency was expressed in terms of forage units for milk production and utilizable matter (total fat and protein) in milk. To do a study like this, information about the genetic quality of dairy goats should be known, as genetically comparable animals with regard to the mean for the breed should be used within animal type.

The genetic evaluation of a breed is relatively simple wherever accurate estimates of mean performances are available for the environment and production system. This is because the effects involved can be measured with high accuracy from data while some can be treated as fixed effects (Kinghorn, 1997).

The objectives of this study therefore were:

1) to determine a suitable model for the estimation of variances and prediction of breeding values;
2) to determine variance components and heritability estimates of production parameters evaluated to be used as inputs in BLUP breeding value estimations;
3) to determine genetic and environmental trends in production parameters in the national and individual dairy goat herds; and
4) to propose a breeding plan for the dairy goat industry.

The first genetic evaluation of a dairy breed is often controversial as the animals of some prominent breeders may be shown to be of inferior genetic merit in terms of milk yield or milk composition. The reason for this is that breeders often emphasize conformation traits instead of production traits in their selection programmes. Breed societies also tend to focus mainly on body conformation traits as described in the breed standards. However, some of these traits have little or no effect on the milk yield of animals.

It seems that among dairy farmers information about the breeding values of animals is not being used to a great extent in the culling of animals from the herd or when selecting animals for purchasing. The probable reason for this is that the estimated breeding value of an animal is a more abstract concept than actual milk yield. This makes the acceptance of information about breeding values more difficult. Although there seems to be a positive trend between breeding value and the purchase price for dairy cows, this trend is probably driven more by production performance and conformation traits of the animal on sale.

Estimated breeding values of animals will only be accepted by breeders once they realise that actual first lactation milk yields of cows (and does) add to the reliability of breeding values estimations. Breeding values of animals are not determined purely by actual milk yields. In some dairy herds it has been observed that the genetic trend for milk yield parameters could improve annually although there is a reduction in the actual milk yield of cows because of poor feeding. There is, however, ample evidence in the literature of the positive effects of using the breeding values of males and females in a national breeding programme. It only needs a change in attitude by farmers to accept the estimated breeding values of animals and to use this information in a structured breeding programme.

CHAPTER 2

HISTORY OF THE SOUTH AFRICAN DAIRY GOAT HERD

The many different modern goat breeds are probably all descended from *Capra aegagrus* found in most parts of the Middle East (Brown, 1955). Goats are among the oldest of the domesticated animals and their fossil remains have been found in the dwellings of Stone Age inhabitants of the present-day Switzerland. Goats were part of the migration of people southwards across the Mediterranean Sea and further south into Africa. More than 2000 years ago, goats had a great utility value to their owners, providing them with meat and milk, a rough type of cloth made from goat's hair and skins. Goats also provided dignity to some peoples. Hebrews, Assyrians and other related tribes used goats in their sacrificial ceremonies. Today, specialized goat breeds have been bred to produce either meat, milk or fibre.

The dairy goat industry in South Africa probably started long before the arrival of Europeans to this country. When Jan van Riebeeck and company surveyed the Cape interior in 1661, they encountered dairy goats among the Namaqua people in the vicinity of the Olifants River. These goats resembled those of Nubian or Egyptian origin. Barrow (1801), as cited by Hofmeyr (1962), noted that goats were used for the production of meat and milk. With their natural high fecundity, they were the most economical animals on early Boer farms.

During these early years, very little was done to improve the genetic merit of local dairy goats. In 1898, the Cape Agricultural Department imported three Saanen bucks and twelve does from (probably) Switzerland. Very little came of this small group of goats and it seems that they all died without progeny (Hofmeyr, 1965). Because of the large interest in dairy goats at that time, the Department of Agriculture of the Cape Province published an article in the Agricultural Journal of the Cape of Good Hope about the cost of importing dairy goats (Hofmeyr, 1959). About the same time 15 Saanen (also called Appenzel) does and two bucks were imported from Switzerland to the Graag-Reinet district. More Saanen, Toggenburg and British Alpine dairy goats were imported to South Africa after this. Some of the goats in these early years (after

1898) were very fertile with some does producing up to 10 progeny in less than three years.

The present-day Saanen dairy goats in South Africa probably originated from two bucks and 15 does that were imported from Switzerland in 1903. During the period 1906 to 1914, some 109 dairy goats were imported from Germany, 70 from Switzerland, 36 from the United Kingdom, three from France and eight from Italy (Hofmeyr, 1965). Until 1924 no official attempt was made to keep dairy goat breeds pure. At the time it was observed that the Swiss goats (probably Saanens) adapted poorly to local conditions, but that crosses with local goats thrived and were fairly good milk producers. It must be considered that these animals had to produce from the natural vegetation, which is of poor quality for most of the year. Brown (1955) already then observed that dairy goat production would be difficult in view of the extensive nature of South African agriculture and that it will only improve once intensive dairy goat farming becomes the norm.

Initially there was no organization specifically concerned with the breeding of dairy goats (Hofmeyr, 1965). It seems that all goats imported at that stage were interbred with local strains. An official Milch Goat Breeders' Society was established during 1924. It was affiliated with the British Goat Society in England and in 1926, also with the South African Stud Book Association. Many breeders registered their dairy goats. An appendix to the Register was opened for animals which did not qualify outright for registration but were descended from imported goats. From 1924 to 1939 a total of 464 dairy goats were registered or were included in the appendix by 47 different breeders. Most breeders kept only a few goats, i.e. 10 goats on average. The reason for this was the fact that most breeders were on smallholdings in the vicinity of major cities and also in small towns making it difficult for them to keep a large number of animals. They were also not fed commercial diets as these were probably not available then. Brown (1955) suggested that dairy goats could play a big role in parts of the country where small holdings are prevalent. At the time in Europe, dairy goat were referred to as “the poor man’s cow”. It was felt that dairy goats in South Africa could perform a similar function among the lower income groups living outside municipal areas.

During this time, four breeds of dairy goats were recognized in South Africa, i.e. Anglo-Nubian Swiss, British Alpine, Saanen and Toggenburg (Hofmeyr, 1965). The Saanen was the most prominent breed. By 1928 the Anglo-Nubian Swiss breed had disappeared. Problems arose within the Milch Goat Breeders' Society and after declining in membership from 1936 onwards, the Breeders' Society was dissolved in 1939. After this, all interest in the stud breeding of dairy goats in South Africa ceased. Only one breeder of Saanen goats continued to register animals directly with the South African Stud Book Association. This was done without a break from 1927. Animals of other breeds were not being registered at that time. From 1947 a new era of stud breeding dawned in the dairy goat industry (Hofmeyr, 1965). Two Saanen goats were imported from England in 1948 and interest in dairy goat breeding gradually increased again. A number of Saanen as well as British Alpine and Toggenburg goats were imported. At this stage there were in South Africa no registered British Alpines and Toggenburg goats. Through the enthusiasm of a few breeders, the South African Milch Goat Breeders' Society was established in 1957, with its headquarters in De Aar. The arranges all registrations of dairy goats with the South African Stud Book Association. The objectives of the Breeders' Society include the following: pure breeding and the improvement of various recognised dairy goat breeds, accurate recording of pedigrees and the performance of individual animals, and also supplying information about dairy goats.

The early Milch Goat Breeders' Society had persuaded agricultural societies to include classes for showing dairy goats at agricultural shows. Between 1920 and 1930, dairy goats were presented regularly at the Pretoria, Johannesburg and Port Elizabeth Agricultural Shows. During these years, milk production competitions were regular features at these shows. At the Witwatersrand Spring Show of 1929, there were 18 entries of dairy goats for the milk production competition. The highest milk yield in a 24 hour period by of one of these does was 5.3 kg. The average milk yield of the 18 goats was just over 3.6 kg/day (Hofmeyr, 1959). Higher yields were obtained at shows in 1931, i.e. 6.1 kg at Port Elizabeth and 8.1 kg at the Rand Show in Johannesburg. It was at that time already noted that while some dairy goats may actually produce a considerable amount of milk over a 24 hour period, the true proof of the value of a dairy goat is only shown over a lactation period of 300 days (Hofmeyr, 1959).

These recordings at the agricultural shows, although encouraging and emphasizing the potential of dairy goats in South Africa at the time, did not carry any official weight. Official milk recording by the Division of Animal Husbandry and Dairying of the Department of Agriculture and Technical Services commenced in 1957. Legal status of the Breeders' Society was acquired in 1958. By 1959 there were already 32 breeders registered with the Breeders' Society. Most of the breeders were situated in the Karoo and Eastern Cape.

For milk recording purposes, the milk yield of does was measured over a 300 day lactation period based on 10 monthly tests of the quantity of milk produced at two or more milkings per 24 hour period. Milk samples were collected at each milking from each doe and analysed for fat and protein percentages. Initially only the fat percentage of the milk was determined at these monthly tests.

Information on the milk production of dairy goats are available from the 1957/58-production year, when a number of mostly first parity does completed their lactations. Until the 1975/76 production year, a total of 1 001 does had lactation records based on lactation periods exceeding 120 days. This is approximately 80% of all does recorded from 1957/58 onwards, until 1975/76. However, only about 57% of all does had lactations longer than 240 days in milk. From 1976/77 to 1980/81 very few lactation records of dairy goats are available. For all practical purposes, the 1981/82-production year is regarded as the first year of milk recording for dairy goats. Presently the total milk produced (two or three milkings per day) over a 24 hour period is recorded. Milk samples are collected at each milking on the day of milk recording and analysed for the fat, protein and lactose percentage in the central laboratory of the Milk Recording Scheme. Milk recording is done every five weeks and eight tests are required for a lactation record of the milk, fat and protein yield as well as fat, protein and lactose percentage for each doe.

Between 1958 and 1985 almost 2 400 Saanen females were registered by the South African Stud Book Association. During the same time 530 Saanen males were also registered. From 1985 to 1991, a further 139 females and 42 males were registered. During 1998, the South African Milch Goat Breeders' Society had 432 Saanen females and 120 males registered in South Africa (Anonymous, 1998). There are, however, many more non-registered or grade dairy goats being milked in South Africa. These are various types of goats of mixed origin. These animals are adapted to survive and produce from the natural vegetation and are often maintained under poor management conditions.

Management practises for dairy goat farming have been provided to farmers in South Africa from an early period. Most of these practises are still applied. Brown (1955) noted that does generally conceive more readily from March to April to kid during spring and early summer. Young female goats can be bred from 7 to 8 months of age provided they are in good health and well grown out with a live weight of at least 30 kg. The gestation period is on average 150 days with an average reproduction rate of 1.8 kids per doe. Does in intensive systems are normally dried off after 10 months in milk. Recently, information on dairy goat farming is presented in the Small Farmer Section in popular farming magazines, i.e. Nicholas (1998) reported that young males are ready for mating as early as six months of age, while does reach maturity by two years of age. Of the three European breeds, only the fair skinned Saanen goats are sometimes affected by the sun which causes skin carcinoma of the udder. By manipulating daylight in July, it is possible to have a breeding season in spring in order to spread lactations more evenly around an all year production system (Boyazoglu, 1997).

There have been a large number of dairy goat breeders that have joined and left the South African Milch Goat Breeders' Society since its second inception in 1958. Because of this, many animals have also disappeared from the recording and registration data bases. This has hampered the growth of the industry causing it to be, with the exception of a few large producers, mainly a "hobby" industry that is being practised on the fringes of other farming activities or on small holdings close to cities. Articles on dairy goat production systems appear from time to time in the popular press, usually under the Small Farmer's section. Most of these small scale farmers do not do any official milk recording, resulting in a considerable loss of information. In the rural areas many goats are kept but this is mostly for household purposes. The milk yield of these animals is also not recorded.

The South African Milch Goat Breeders' Society today consists of 28 registered breeders with about 1 000 registered and grade goats. The three dairy goat breeds, i.e. Saanen, British Alpine and Toggenburg are all registered under the auspices of the SA Milch Goat Breeders' Society. Some dairy goat farmers often keep all three breeds under similar management conditions. The Breed Society provides practical information on the management of dairy goats.

Registered animals are evaluated and scored according to breed standards based on body conformation traits. Animals must show good dairy character with a fine head and a strong muzzle, a long and lean neck smoothly blending into the shoulders, a straight back with a slight break at the tip sloping towards the tail, a wide and deep barrel (body) with well arched ribs, a large and broad pelvis that is slightly sloped, strong, sturdy and straight legs with strong hoofs and a soft, wide and evenly hung udder that is well attached both front and rear.

In the past, dairy goats were mainly kept for household purposes in areas where it was difficult and usually not economical to keep dairy cows. The reason for keeping dairy goats, however, has largely changed. With the political changes in South Africa and with the increasing interest in the country, there are a number of dairy goat farmers producing goat milk products for specific niche markets. There is also a large demand for goat milk products for people with health problems. The general feeling among most producers is that the demand for goat milk products is still higher than the national supply. An increase in supply can be achieved by milking more animals or by increasing the production level of individual animals. For this, some genetic information of animals is urgently needed. A national selection and breeding programme should therefore be established. Various options could be considered such as using artificial insemination of frozen (local and/or imported) and fresh semen on a wider scale. Establishing one or more nucleus flocks to provide genetically superior bucks to the industry for natural mating or for progeny testing is also necessary.

Although the future of the production of dairy goat products in South Africa seems very positive, some actions should be put in place to improve milk recording as well as registering bucks and does to make a genetic evaluation of breeds and individual animals possible. At present data are lacking in this regard.

CHAPTER 3

DESCRIPTION OF THE MILK PRODUCTION DATA OF DAIRY GOATS IN SOUTH AFRICA

3.1 Introduction

The milk yield and milk composition of dairy animals are influenced by a large number of factors. Generally, these factors are based on environmental and genetic differences between animals. While the genetic potential of an animal is fixed at conception, environmental factors such as feeding and housing of the dam and the animal itself, determine whether this potential is attained. In South Africa, dairy goats produce milk under a wide range of climatic conditions. They originated in the Middle-East and in countries in the vicinity of the Mediterranean Sea. Climatic conditions in some parts of South Africa are similar to those in these countries. Dairy goats should therefore be well adapted locally. Dairy goats are both grazers and browsers making them well adapted to a wide range of production areas or environments. They can produce milk from the natural herbage under very extensive feeding conditions and also thrive under intensive feeding conditions such as a feedlot.

Sheep and goats are, next to dairy cattle, the most important group of milk producing animals in both the temperate and tropical environments of the world. The population of dairy goats in the world has increased over the last number of years. According to the FAO (2002), the world goat population increased from 677 million animals in 1995 to 720 million in 2000. Most (96%) of all animals were in developing countries producing more than 80% of the world's goat's milk. In South Africa there is currently a growing interest in the production of goat's milk both from a commercial and political perspective. The rich and sophisticated population in South Africa is increasingly demanding specialized dairy goat products. From the Government's point of view, dairy goats are seen as a way to provide a cheap source of high quality protein to rural people while also providing an income for the families of new and emerging farmers.

Except for a survey conducted by Hofmeyr (1962) concerning various aspects of registered dairy goats, little is known of the milk production potential of South African dairy goats. Hofmeyr (1962) established from a relatively small (125) number of records that the average milk yield of registered dairy goats of all breeds was on average 954 kg over an average lactation period of 276 days. The fat concentration of the milk of these dairy goats was 3.45%. Other information that was collected in this survey included birth weights, some body measurements, age at first kidding and season of kidding for all breeds of dairy goats. According to the South African Milch Goat Breeders' Society, dairy goats could produce up to 1200 kg of milk during a lactation period of 300 days provided that they are well fed. Donkin & Boyazoglu (2000) reported that Saanen goats produced more than 700 kg of milk over a lactation period of 288 days.

3.2 Lactation records

Lactation records of the three main dairy goat breeds, i.e. Saanen, British Alpine and Toggenburg have been available since 1956. The data sets consisted of milk production records of all grade and registered dairy goats participating in the official Milk Recording and Performance Testing Scheme of the Animal Improvement Institute of the Agricultural Research Council of South Africa. The minimum requirements for lactation records to be included in the analysis were as follows:

(a)	milk yield more than zero		
(b)	lactation period:	minimum number of days:	60 days
		maximum number of days:	305 days
(c)	lactation number:	1 to 8	
(d)	production year:	1956 to 2001	

The number of records conforming to these criteria, and available for analysis for the different dairy goat breeds is presented in Table 3.1. The number of milk production records for the British Alpine and Toggenburg breeds is very small in comparison to that of the Saanen breed. After removing data not conforming to the above criteria, only 354 and 463 usable records were available for the British Alpine and Toggenburg breeds, respectively. For the Saanen breed 10164 records were available. The data set of the Toggenburg and the British Alpine breeds have 372 and 174 lactation records, respectively, with no production figures. This constitutes 41 and 31% of all records. The number of usable records for the British Alpine and Toggenburg breeds is 63 and 51% of the original number of lactation records. Among the Saanens, 24% of all lactation records (3557 of 14688 does) had no production records. Almost 70% of the milk production records of Saanens conform to the required criteria.

Table 3.1 The number of records available for all production years and number of records removed from the data sets of the different breeds

Parameters	**Dairy goat breeds**		
	Saanen	**British Alpine**	**Toggenburg**
Initial number of lactation records	14688	560	900
Records removed:			
Milk = 0	594	25	50
Lactation period (> 304 days)	72	4	1
Lactation period (< 60 days)	262	2	12
Lactation number >8	33	1	2
No production figure	3558	174	372
Lactation record >2500 kg	5	-	-
Usable records	10164	354	463

3.3 Production year

For milk recording purposes, production years usually extend from the 1st of September of one year to the 31st of August of the following year. Therefore the termination date of a lactation normally determines the production year of a specific animal. For the genetic evaluation of dairy cattle, calving date is, however, generally regarded as a better option than termination date (Chauchan & Hayes, 1991; Harris *et al*., 1992). The number of records for Saanen, British Alpine and Toggenburg does within a production year as determined by kidding date is presented in Figure 3.1. Milk recording for all breeds started very early, i.e. in 1956 for Saanens, 1957 for British Alpines and 1959 for Toggenburgs. There were, however, only a few records available until 1980. For all breeds, milk recording stopped completely during the late 1970's. The reason for this is not known. Milk recording for the British Alpine and Toggenburg breeds only started again in 1998 although only with a small number of records. There was never more that 100 records per production year for the British Alpine and Toggenburg does. The number of Saanen does in milk recording is considerably higher. From a small start in 1980 with 213 records, the number of records for Saanen goats increased substantially from 1985 onwards. Almost 8700 records are available from 1985. Because of the small number of records in the earlier years, the 1981/82-production year is regarded as the first year of official milk recording (Hallowell, G.J., 2002: personal communication, Animal Improvement Institute, Irene).

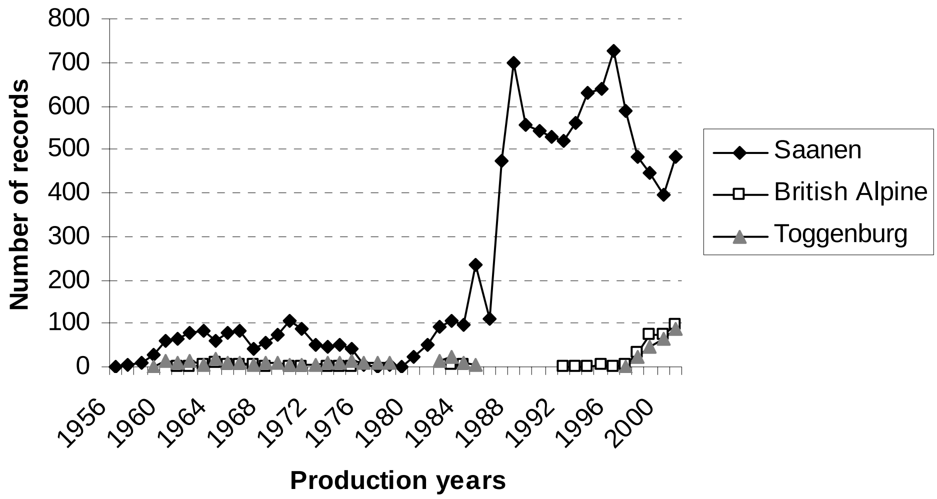

Figure 3.1 The number of milk production records within production year for dairy goats in the national herd.

Average production parameters for the different South African dairy goat breeds are presented in Table 3.2 (Saanen), Table 3.3 (British Alpine) and Table 3.4 (Toggenburg), respectively. Production parameters for Saanen, British Alpine and Toggenburg dairy goats are very similar although the average fat percentage of Saanen goat milk is lower than those of the other two breeds. The large variation in number of records between the different breeds and years makes comparisons very difficult. The owner-sampling method used in South Africa has resulted in a marked increase in the number of dairy goats participating in milk recording (Hallowell, 1994). There is, however, a large number of dairy goat herds that do not participate in the official Milk Recording Scheme because of various misconceptions, i.e. like milk recording being difficult and expensive.

Table 3.2 The number of does and unadjusted average milk production parameters for Saanen goats according to production year (year of kidding)

Production year	Number of does	Lactation period (days)	Milk yield (kg)	Fat yield (kg)	Protein yield (kg)	Lactose yield (kg)	Fat (%)	Protein (%)	Lactose (%)
1956	1	300	1100	44.0	-	-	4.00	-	-
1957	5	197	818	28.0	-	-	3.38	-	-
1958	9	268	907	30.4	-	-	3.38	-	-
1959	27	270	954	32.9	-	-	3.49	-	-
1960	60	220	801	26.7	-	-	3.41	-	-
1961	65	246	927	30.1	-	-	3.29	-	-
1962	77	257	1023	33.1	-	-	3.26	-	-
1963	83	244	922	27.9	-	-	3.51	-	-
1964	60	234	888	28.6	-	-	3.24	-	-
1965	78	226	795	25.0	-	-	3.52	-	-
1966	82	238	850	27.7	-	-	3.27	-	-
1967	40	239	943	30.5	-	-	3.29	-	-
1968	56	261	996	33.3	-	-	3.33	-	-
1969	73	239	886	28.8	-	-	3.36	-	-
1970	107	244	901	30.3	-	-	3.54	-	-
1971	86	248	833	28.5	-	-	3.43	-	-
1972	51	203	759	25.3	-	-	3.39	-	-
1973	48	229	679	21.6	-	-	3.20	-	-
1974	50	235	728	24.9	-	-	3.47	-	-
1975	41	270	850	27.2	-	-	3.21	-	-
1976	3	300	954	33.3	-	-	3.48	-	-
1977	2	288	835	30.5	24.5	-	3.55	2.82	-
1978	4	103	327	14.5	8.5	-	4.44	2.55	-
1979	0	-	-	-	-	-	-	-	-
1980	23	258	852	31.5	24.4	-	3.67	2.88	-
1981	50	265	889	29.1	24.9	-	3.33	2.84	-
1982	92	275	921	30.2	25.2	-	3.35	2.78	-
1983	107	230	758	26.1	21.0	-	3.44	2.79	-
1984	95	184	595	20.5	16.5	-	3.48	2.76	-
1985	236	218	592	20.0	16.4	-	3.42	2.81	-
1986	10	259	886	27.7	23.2	24.0	3.14	2.62	4.45
1987	475	269	786	23.7	21.2	-	3.07	2.72	-
1988	697	275	872	27.0	24.8	34.0	3.13	2.86	5.01
1989	555	283	915	26.7	26.3	42.0	2.94	2.87	4.59
1990	542	267	829	23.8	23.8	37.5	2.93	2.89	4.53
1991	530	267	756	22.2	20.8	33.6	2.96	2.75	4.48
1992	519	276	836	24.6	22.2	37.0	3.02	2.66	4.41
1993	562	268	850	26.3	21.8	36.2	3.14	2.58	4.27
1994	631	277	975	28.6	25.4	42.9	2.96	2.60	4.39
1995	641	277	930	29.5	24.5	40.6	3.19	2.63	4.36
1996	725	258	915	27.7	24.3	40.4	3.05	2.65	4.40
1997	588	281	991	30.2	27.9	43.6	3.06	2.81	4.39
1998	481	259	876	26.2	23.9	38.3	3.05	2.74	4.36
1999	447	268	869	25.4	23.4	37.9	2.94	2.70	4.36
2000	396	270	927	26.9	25.9	40.9	2.91	2.79	4.40
2001	483	256	890	27.3	24.8	39.0	3.11	2.76	4.38

Table 3.3 The number of does and unadjusted average milk production parameters for British Alpine goats according to production year (year of kidding)

Production year	Number of does	Lactation period (days)	Milk yield (kg)	Fat yield (kg)	Protein yield (kg)	Lactose yield (kg)	Fat (%)	Protein (%)	Lactose (%)
1961	1	298	986	33.0	-	-	3.35	-	-
1962	1	294	1169	40.0	-	-	3.42	-	-
1963	3	180	514	16.0	-	-	3.16	-	-
1964	8	175	564	17.8	-	-	3.18	-	-
1965	4	179	512	17.8	-	-	3.73	-	-
1966	6	184	598	19.5	-	-	3.35	-	-
1967	6	205	680	23.3	-	-	3.52	-	-
1968	1	254	885	32.0	-	-	3.62	-	-
1969	-	-	-	-	-	-	-	-	-
1970	1	116	392	12.0	-	-	3.06	-	-
1971	1	115	429	13.0	-	-	3.03	-	-
1972	-	-	-	-	-	-	-	-	-
1973	1	300	1171	36.0	-	-	3.07	-	-
1974	1	300	1192	38.0	-	-	3.19	-	-
1975	1	283	1279	41.0	-	-	3.21	-	-
1976	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-
1980	-	-	-	-	-	-	-	-	-
1981	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-
1983	4	156	434	16.0	13.0	-	3.53	3.02	-
1984	5	138	383	15.4	10.6	-	3.94	2.74	-
1985	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-
1992	1	288	984	27.0	25.0	45.0	2.74	2.54	4.57
1993	1	300	1201	36.0	28.0	50.0	3.00	2.33	4.16
1994	1	300	1510	39.0	37.0	66.0	2.58	2.45	4.37
1995	3	256	766	25.0	20.0	32.3	3.40	2.59	4.32
1996	2	279	772	23.5	20.0	34.5	3.09	2.60	4.49
1997	6	278	739	25.8	20.5	31.0	3.44	2.73	4.21
1998	33	281	1044	30.9	31.4	47.5	2.93	2.98	4.53
1999	72	248	821	29.1	24.2	35.8	3.70	2.88	4.38
2000	74	254	846	29.6	26.0	37.3	3.47	3.05	4.42
2001	96	246	762	28.2	23.8	33.5	3.78	3.05	4.36

Table 3.4 The number of does and unadjusted average milk production parameters for Toggenburg goats according to production year (year of kidding)

Production year	Number of does	Lactation period (days)	Milk yield (kg)	Fat yield (kg)	Protein yield (kg)	Lactose yield (kg)	Fat (%)	Protein (%)	Lactose (%)
1959	1	85	161	11.0	-	-	6.83	-	-
1960	12	253	511	18.9	-	-	3.71	-	-
1961	9	248	771	31.7	-	-	4.10	-	-
1962	12	274	1049	37.4	-	-	3.57	-	-
1963	5	245	575	21.0	-	-	3.70	-	-
1964	17	200	441	16.0	-	-	3.50	-	-
1965	9	278	901	35.0	-	-	3.82	-	-
1966	11	185	506	18.6	-	-	3.73	-	-
1967	5	299	1252	46.4	-	-	3.72	-	-
1968	9	282	919	37.1	-	-	4.09	-	-
1969	9	248	884	35.4	-	-	4.03	-	-
1970	5	228	882	33.4	-	-	3.75	-	-
1971	5	276	720	25.8	-	-	3.59	-	-
1972	5	279	944	35.0	-	-	3.77	-	-
1973	8	270	422	14.8	-	-	3.59	-	-
1974	11	292	694	26.2	-	-	3.86	-	-
1975	14	290	980	34.7	-	-	3.57	-	-
1976	11	279	924	32.5	-	-	3.51	-	-
1977	11	276	873	34.7	21.9	-	4.03	2.52	-
1978	9	111	313	14.3	8.0	-	4.51	2.59	-
1979	-	-	-	-	-	-	-	-	-
1980	-	-	-	-	-	-	-	-	-
1981	-	-	-	-	-	-	-	-	-
1982	13	264	731	25.6	19.4	-	3.46	2.65	-
1983	25	224	561	19.1	15.5	-	3.39	2.78	-
1984	8	254	739	25.4	19.3	-	3.39	2.63	-
1985	6	201	705	21.7	16.8	-	3.10	2.36	-
1986	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-
1997	1	300	1222	41.0	36.0	56.0	3.36	2.95	4.58
1998	21	248	721	23.8	20.0	30.3	3.32	2.78	4.22
1999	48	224	682	22.3	17.8	29.6	3.21	2.58	4.35
2000	66	222	646	22.8	17.6	27.5	3.51	2.71	4.23
2001	87	274	834	32.7	24.7	36.1	3.86	2.88	4.29

3.4 Parity

Milk yield parameters of dairy cows increase with parity and usually peak at fourth or fifth lactation. Increasing the number of animals that reach these lactation numbers will therefore have a positive effect on total farm income. Genetic improvement of dairy herds is dependent on replacing older animals in the herd. The total quantity of milk that is produced on a daily basis in a dairy herd is, however, reduced when a large proportion of the producing animals in that herd is in first lactation. The reason for this is the lower milk yield of first parity cows (or does) in comparison to multiparous cows. Although the milk yield of dairy cows (or does) usually decreases after fifth parity, these older cows still produce more milk than first parity cows. For dairy cows a longer herd life (a high average number of lactations per cow) reduces the need to rear all replacement heifers born in the herd to first calving. Alternatively, surplus replacement animals could be sold before first calving, adding to the income of the herd. Selecting higher genetic merit heifers to stay in the herd would at the same time have a positive effect on the genetic improvement of the herd. The number of milk production records for dairy goats in the different parities in the national herd is presented in Figure 3.2.

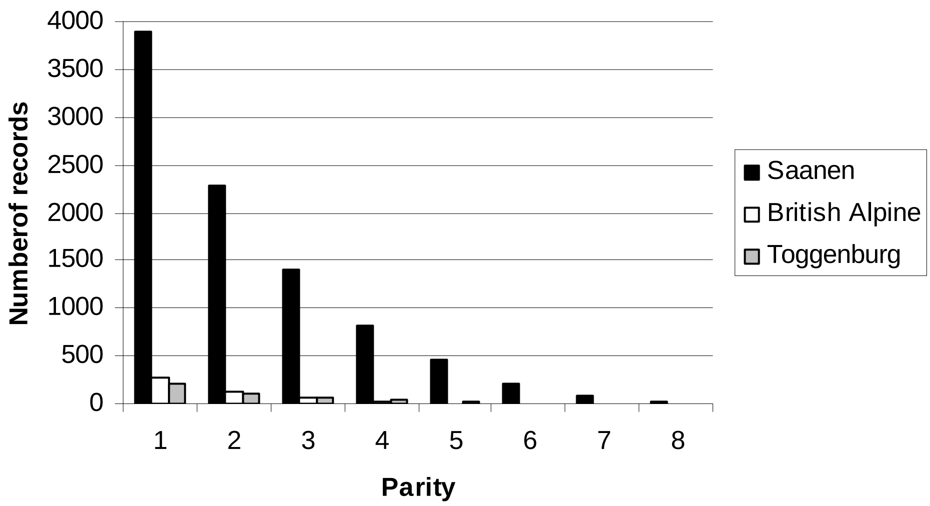

Figure 3.2 The number of milk production records within parity for dairy goats in the national herd

A similar situation as described above for dairy cows, would apply to dairy goat herds. Unadjusted milk yield parameters for dairy goats for all breeds within parity are presented in Table 3.5.

Table 3.5 Unadjusted average milk yield parameters for British Alpine, Toggenburg and Saanen dairy goats within parity

Breed	Parity	Lactation period (days)	Milk yield (kg)	Fat yield (kg)	Protein yield (kg)	Lactose yield (kg)	Fat (%)	Protein (%)	Lactose (%)
British Alphine	1	235	727	25.9	22.7	33.4	3.64	3.03	4.41
	2	247	874	30.6	27.9	41.0	3.54	3.02	4.42
	3	276	932	31.6	27.6	41.0	3.48	2.96	4.40
	4	240	743	24.1	22.2	32.8	3.26	2.81	4.29
	5	233	667	25.8	19.3	29.3	4.39	2.94	4.36
	6	290	792	26.9	23.1	35.0	3.45	2.90	4.41
Toggenburg	1	234	586	22.2	18.0	28.7	3.69	2.79	4.31
	2	249	798	29.1	20.1	32.5	3.63	2.73	4.13
	3	261	889	31.6	23.8	37.6	3.56	2.71	4.24
	4	265	907	33.1	23.4	38.0	3.62	2.69	4.17
	5	241	861	32.5	21.5	38.0	3.80	2.70	4.19
	6	265	854	30.8	24.0	44.5	3.59	2.58	4.30
Saanen	1	258	843	26.4	23.3	41.4	3.19	2.81	4.56
	2	271	852	25.4	22.7	37.5	3.02	2.67	4.40
	3	270	945	29.0	25.3	41.5	3.09	2.68	4.39
	4	265	885	26.4	24.2	38.6	3.01	2.73	4.36
	5	267	922	27.6	25.8	40.5	2.99	2.79	4.39
	6	261	917	26.4	25.2	40.1	2.93	2.74	4.38
	7	237	716	25.9	20.6	31.7	3.70	2.84	4.40
	8	228	679	28.1	20.2	30.6	4.32	2.98	4.51

The number of lactation records for all breeds decreases with increasing parity number with only a few does reaching sixth to eighth parity, i.e. 3 to 4% of the total number of production records. This is typical of the erosion rate of animals, as seen for dairy cows. For the British Alpine, Toggenburg and Saanen breeds, first and second lactation records accounted for 74, 66 and 63% of all the lactation records up to eighth parity. In comparison to this, first and second parity cows accounted for 57% of all Ayrshire lactation (Hallowell, 1994), and 58% of all Jersey lactation (Du Toit, 1994) records up to tenth parity. Almost 50% of all the lactation records for the British Alpine goats were first parity records. The average number of parities for British Alpine goats was lower than that for Toggenburg and Saanen goats, i.e. 2.02 vs 2.24 and 2.35, respectively. A similar pattern has been observed in other countries. Unadjusted milk yields of all breeds increased up to the third lactation. Saanen does maintained high milk yield levels until fifth lactation although the production of seventh and eight lactation does decreased substantially. This could be related to a smaller number of animals reaching these parities.

3.5 Regions

For the milk recording of dairy goats, South Africa was divided initially into eight geographical regions, namely:

Region 1	:	Western Cape - from Clanwilliam in the north to George in the east, including the hinterland area of the Klein Karoo
Region 2	:	Eastern Cape – the coastal area from George to East London and the hinterland area
Region 3	:	Free State (Bloemfontein)
Region 4	:	Transvaal (Irene)
Region 5	:	Natal
Region 6	:	-
Region 7	:	Northern Cape around Vryburg
Region 8	:	Queenstown

Presently the country is divided into 6 regions, namely the first five regions and Namibia as Region 6 (De Waal, H., 2003: personal communication, Animal Improvement Institute, Stellenbosch).

The distribution of herds in terms of the number of milk production records in the different regions is presented in Figure 3.3. Dairy goat herds in South Africa are found all over the country in conditions ranging from the arid regions of the Northern Cape Province to the sub-tropical areas of KwaZulu-Natal. The largest number of records was from Region 1. i.e. the Western Cape, and most records were from one herd only.

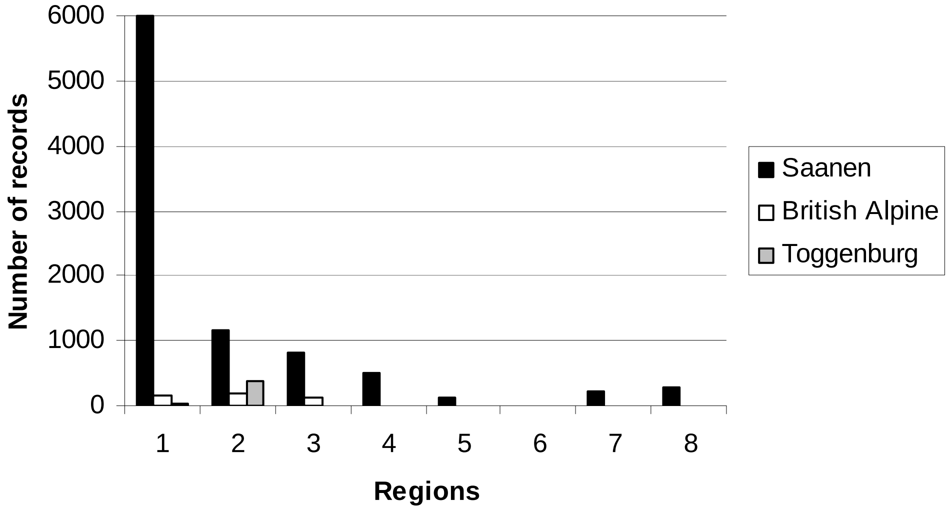

Figure 3.3 The number of milk production records according to geographical region for Saanen dairy goats in the national herd

Dairy goats are browsers as well as grazers and most natural shrubs have strong aromatic flavours that would affect the taste of milk. People not accustomed to the naturally strong taste of dairy goats' milk often dislike this strong aromatic taste, believing that the milk is of a poor quality. This usually results in reduced consumption. For this reason, natural herbage and shrubs are not generally used in commercial production systems. Another reason is the low feed quality and quantity available.

Herds on milk recording are therefore kept under relatively intensive feeding and housing conditions. A high quality roughage like lucerne hay is usually fed *ad libitum* with a concentrate mixture provided according to milk yield. Herds that are close to suburban areas often receive higher milk prices because of the large demand for milk for infant feeding. Lactating animals in these herds are then often fed a high quality complete diet, usually in a pellet form. Some herds are also kept indoors while others are kept in open camps or dry lots. The reason for this intensive level of management and feeding is the relatively small scale on which most operations are conducted.

3.6 Herds/Owners

The number of does and lactation records of does in Saanen herds with at least 40 does each in the national herd are presented in Figure 3.4. During the period from 1981 to 2001 some 65 dairy goat owners had animals with completed lactation records. Unfortunately, most (56%) of these herds were small with less than 30 lactation records each. Only 11 herds (17% of all herds) had more than 100 lactation records each. One herd had more than 5700 lactation records. More than 73% of all records were obtained from four herds only.

Unadjusted mean milk yield parameters for Saanen, British Alpine and Toggenburg dairy goats in a number of individual herds comprising of at least 60 does each are presented in Table 3.6. Some herds lacked data for protein yield and protein percentage. These herds were established and closed down or stopped doing milk recording before the 1977 production year when the routine analysis of protein percentage of milk was started. In the British Alpine and Toggenburg breeds there were only 11 and 8 herds, respectively. Of these, only two herds had more than 60 does each. Because of the small number of records, a genetic evaluation could not be contemplated for the British Alpine and Toggenburg breeds.

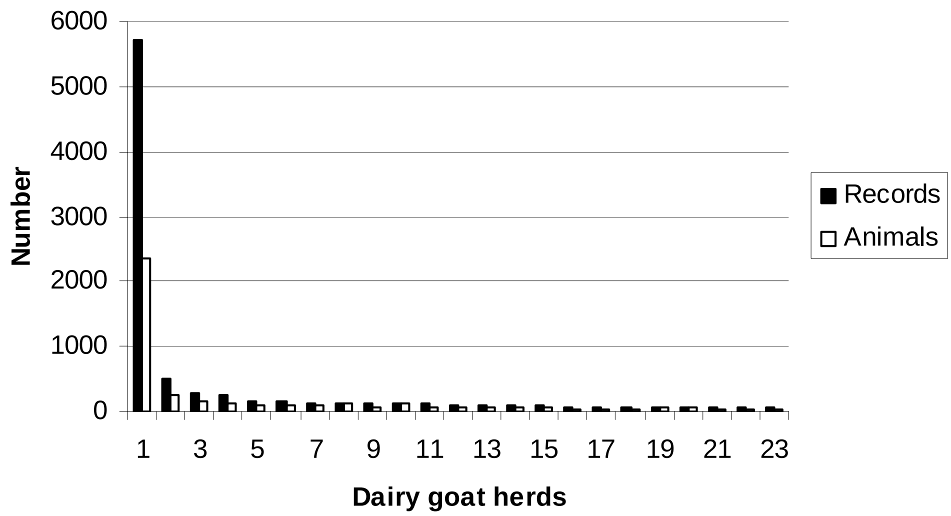

Figure 3.4 The number of does and milk production records for a number of Saanen dairy goat herds consisting of at least 40 does

Table 3.6 Unadjusted mean milk yield parameters for British Alpine, Toggenburg and Saanen dairy goats in herds with at least 60 does in the data set

Breed	Owner number	Number of does	Average number of lactations	Milk yield (kg)	Fat yield (kg)	Protein yield (kg)	Fat (%)	Protein (%)
Saanen	294721	2347	2.4	877	26.2	23.8	3.02	2.71
	35470	246	2.0	924	25.4	26.8	2.76	2.91
	20144	147	1.8	928	31.5	24.0	3.44	2.67
	454369	127	2.1	982	29.7	26.8	3.05	2.73
	50808	117	1.0	521	18.0	14.7	3.49	2.83
	512252	111	1.0	696	20.8	18.8	3.03	2.70
	20554	100	1.5	791	27.2	-	3.44	-
	20143	86	2.0	811	22.8	22.1	2.81	2.73
	345783	86	1.4	881	28.5	-	3.25	-
	397630	74	1.0	767	22.8	22.6	3.01	2.97
	30550	65	1.7	992	32.2	-	3.23	-
	384234	64	1.0	558	19.5	16.4	3.67	3.01
	504453	64	1.8	817	27.2	2.2	3.48	2.74
British Alpine	490806	80	1.5	985	32.7	30.4	3.35	3.05
	20144	60	1.7	805	25.6	-	3.24	-
Toggenburg	74686	101	1.6	705	26.1	19.6	3.67	2.74
	20630	85	1.9	706	26.5	15.7	3.78	2.55

There also seems to be very few genetic ties between the different herds. This indicates that mating with the same bucks in different herds was not done, as would be achieved through a mating system such as artificial insemination (AI). Very few bucks were also used for natural mating in different herds. This means that breeders most probably bred and reared their own bucks for use in their herds. This could increase inbreeding in specific herds. It was considered to estimate inbreeding in the national herd although the high frequency of missing pedigrees would probably have reduced the accuracy of the estimation. The data set specifically contained a large number of unknown bucks. Because most of the records in the national data base come from only a small number of herds, therefore meaning that a genetic evaluation of the Saanen dairy goat breed in South Africa would essentially be based on a few herds. Some efforts should be made by the industry to increase the number of does in milk recording as well as the number of does in individual herds. Increasing the number of does in herds is, however, dependant on economical factors such as an increasing market for dairy goat milk products.

3.7 Month of kidding

The number of milk production records of dairy goats kidding in different months of the year is presented in Figure 3.5.

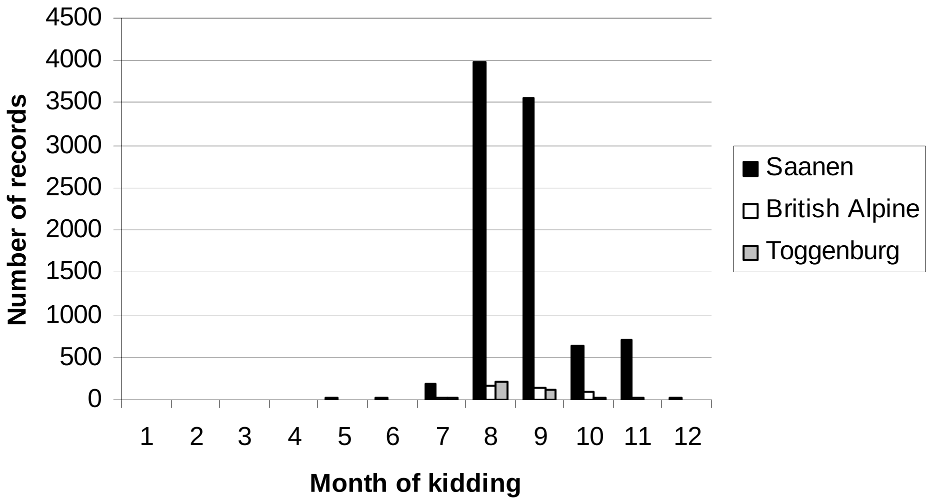

Figure 3.5 The number of milk production records within month of kidding for dairy goats in the national herd

Dairy goat milk production in South Africa is generally seasonal with most (82%) animals kidding in the spring (August to September). Kidding of commercial goats coincides with the natural pattern with the spring flush of pasture production. Hofmeyr (1962) noted that goats of all breeds kidded mainly from August to September. The seasonal production system creates some difficulty for dairy processors specializing in dairy goat products, as the retail industry demand a constant supply of products.

Little effort is currently being made by dairy goat farmers to maintain an even spread of goats kidding throughout the year. Hofmeyr (1962) also observed that seasonal kidding has a major negative effect on the dairy goat industry as it prevented farmers from having a constant year-round milk yield in their herds. In theory, additional lighting could be provided during

July to stimulate the reproductive system in dairy goats. Alternatively hormonal treatment could be used to stimulate the reproductive activity of dairy goats in the off-season.

3.8 Animal status (registered or grade animals)

There are both registered and grade animals in the national dairy goat herd. The number of milk production records for registered and grade dairy goat herds is presented in Figure 3.6.

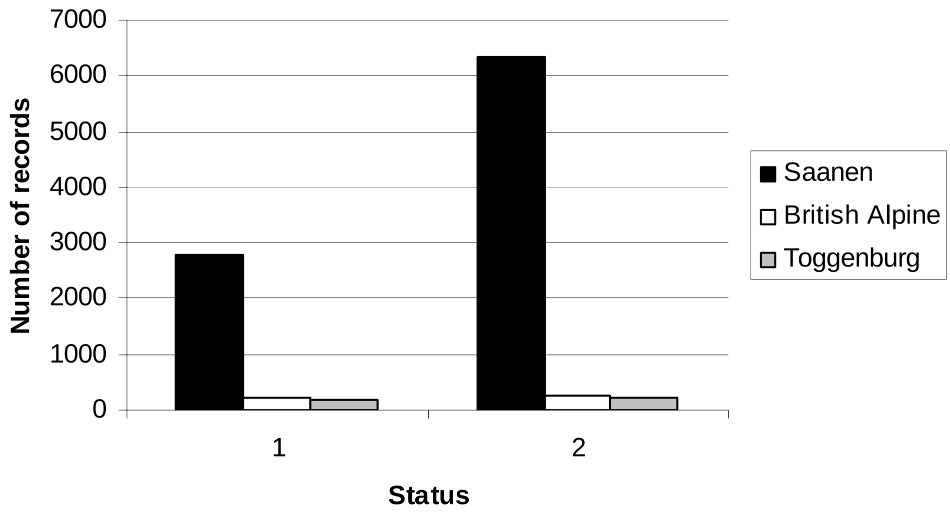

Figure 3.6 The number of milk production records for registered (status = 1) and grade (status = 2) dairy goats in the national herd

For dairy cows, milk yield parameters usually differ between grade and registered cows. Status is, however, not included as a fixed effect in the annual genetic evaluations for dairy cows (Hallowell, 1994 for Ayrshires and Du Toit, 1994 for Jerseys). The reason for this is that the status of the animals is usually confounded with herd. It is also assumed that no preferential treatment is given to registered over grade animals. For dairy goats, the small number of lactation records also does not allow the data to be analysed separately. Other researchers (Wickham & Henderson, 1976; Harris *et al*., 1992) have also combined grade and registered animals on the same assumption.

3.9 Times milked per day

Increasing the number of milkings from two to three increases the milk yield of dairy cows by 5 to 10%. For Holsteins, Vermeulen (1991) found that animals milked three times a day were mostly unique to certain herds and this effect was considered to be nested within herds. By using herds as a fixed effect, provision was made for three times a day milking *vs* twice a day milking. Dairy goats are normally milked twice a day for milk recording. In some cases goats may be milked only once a day especially when the milk yield is low or to prevent a loss in body condition because of poor feeding.

3.10 Age at first kidding

No limitations for a minimum and maximum age at first kidding have up to now been set for milk recording purposes (Hallowell, G.J., 2002, personal communication, Animal Improvement Institute, Irene). According to the South African Milch Goat Breeders' Society first kidding could be as early as 11 to 12 months of age. Goats kidding for the first time before 11 and after 24 months of age should probably not be included as first lactation records. A very early age at first kidding would have a negative effect on milk yield during first lactation while does older than 24 months of age that are being recorded as kidding for the first time, is probably incorrect as these animals should at least be in second lactation. They could, however, be recorded as a first lactation because there is no previous lactation recorded because of poor management, health reasons or the movement of animals from one farm to the other. Because the total number of available records would be reduced by excluding milk production records of does after 24 months of age, it was considered necessary for this first initial analysis to include all records up to 30 months of age as well. Hofmeyr (1962) found that first kidding for registered Saanen goats was between 12 to 14 months of age. Bagnicka & Lukaszewicz (2000) found that average age at first kidding for Polish dairy goats was 392 days (12.9 months). It is, however, greatly dependent on level of management and the environment.

3.11 Length of lactation period

Recorded lactation records of length of lactation of Saanen dairy goats varied from zero to 420 days. A lactation period of zero is highly unusual as although there are milk production records in the data set, the number of days in milk for these records is missing. Records of lactation periods less than 60 and exceeding 305 days were excluded from the original data set (see Table 3.1). The number of milk production records of dairy goats completing lactations of varying lactation periods is presented in Figure 3.7. In all breeds most lactation records exceeded 241 days in milk.

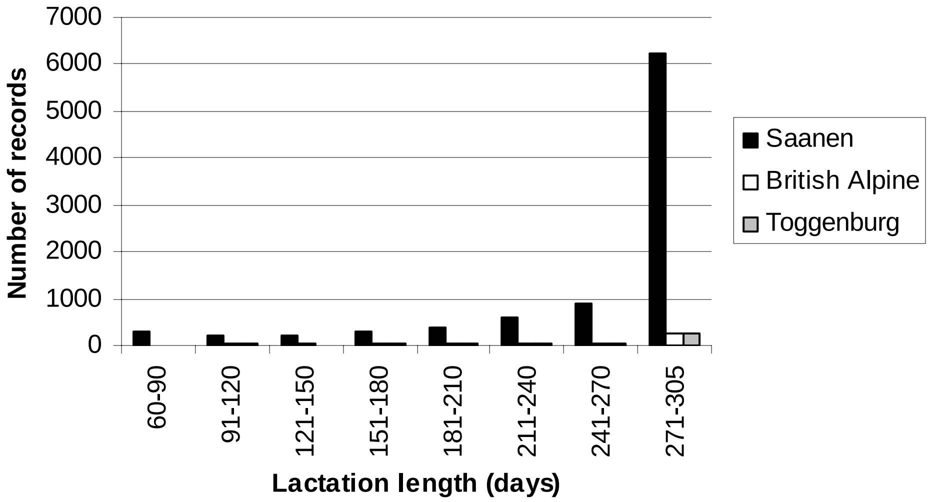

Figure 3.7 The number of milk production records of different lactation periods of Saanen dairy goats in the national herd

The general consensus is that all lactation records irrespective of number of days in milk should be included in an analysis to counter any bias in genetic evaluations that may occur (Norman *et al.*, 1985; Rege, 1991). The average number of days in milk for the Saanen data set was 246 ± 68 days. The coefficient of variation for days in milk exceeds 28%, showing a fairly large variation in number of days in milk. The reason for this is not clear but it could be related to low producing animals being culled before finishing a specific lactation. Short lactations could also occur because of some exchange of animals between breeders and owners or herds. Three standard deviation units from the average should normally include 99% (excluding 0.5% on each side) of all records. On this basis, normal lactation records of goats would be expected to be a minimum of 42 days in milk. Using 60 days in milk instead, resulted in using 98% of all available lactation records.

3.12 Bucks

The number of progeny of Saanen bucks and the number of herds in the national herd in which these bucks were used, are presented in Figure 3.8. From a total of 356 dairy goat bucks, only 38 had more than 40 progeny each. Two bucks with the largest number of progeny each were used in only 2 and 4 herds, respectively. A large proportion (23%) of all progeny resulted from bucks with no identification information.

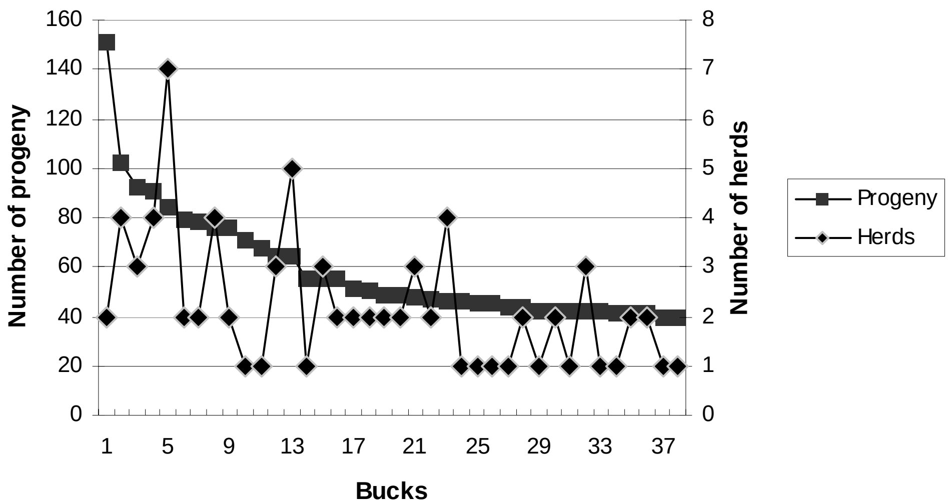

Figure 3.8 The number of progeny of individual Saanen dairy goat bucks and the number of Saanen herds in which these specific bucks were used

Dairy goat herds in which more than 10 bucks were used, and the number of their progeny are presented in Table 3.8. These herds (n = 11) represent almost 65% of all the progeny of Saanen bucks. With the exception of one herd, more than 90% of the progeny in the other herds could be positively identified with their sires.

The value of bucks in a dairy goat herd is much more than getting does pregnant and in production. They could result in an improvement or a deterioration of the genetic quality of a herd while also adding to the quality of data by establishing genetic ties. Bucks used in the last three generations of a herd have a genetic contribution of 87% in the current herd. At present there is no ongoing progeny testing of bucks for use through AI or natural mating for dairy goats in South Africa. Generally, local breeders evaluate the bucks to be used in their herds based on pedigrees and probably some production figures and/or conformation traits. There is no effort to evaluate bucks for wider use in different herds.

Table 3.8 Some herds that have used 10 bucks or more during the milk recording period and the number of their progeny in the different herds

Herd identification number	Number of bucks used	Number of progeny		
		With sire identification	Without sire identification	Total
35470	80	921	6	927
294721	58	1118	1156	2274
35957	40	186	8	194
345783	35	381	7	388
34276	27	87	5	92
409102	22	300	33	333
454369	18	267	14	281
124387	17	204	3	207
462686	16	175	2	177
116248	11	112	3	115
113065	10	27	5	32

Currently limited use of imported semen of bucks is allowed by the South African Milch Goat Breeders' Society. It seems that the interest in using imported semen in dairy goat herds varies from year to year and it seems to be related more to the efforts of semen distributors, than to the breeding and selection policies of individual breeders. This is in contrast to the dairy cow industry where dairy farmers actively search for specific sires to be used in their herds. Probably because of the size of the present market for imported dairy goat semen, importers also do not allocate an appreciable amount of time to the advertising and promotion of the use of dairy goat semen.

For Ayrshires, the progeny testing of young bulls was also not done on an acceptable scale until recently because of the limited number of Ayrshire cows in South Africa (Hallowell, 1994). The Breed Society has decided on a policy of promoting the use of imported semen of sires that have been progeny tested in their countries of origin. At present, however, the Ayrshires, together with the Guernseys, are participating in Young – Sire Programmes to supply locally progeny tested sires to the industry.

3.13 Conclusions

Various non-genetic factors affect the milk yield and milk composition of dairy goats. These factors should be considered when estimating variance components, heritabilities and breeding values of does and bucks. The number of usable production records for the British Alpine and Toggenburg breeds are too small for a genetic evaluation, as stated previously. Although milk recording for dairy goats started in 1956, an appreciable number of lactation records for Saanens became available only from 1985 onwards. Many lactations were short as the average lactation period was only 264 days. The erosion rate of dairy goats from the first to eighth lactation was high, similar to that for dairy cows. Eleven herds used more than 10 bucks each and the average number of progeny for bucks varied from 3.2 to 39.2. Although the data set lacks a considerable amount of pedigree information, a genetic evaluation for Saanen dairy goats in South Africa was conducted.

CHAPTER 4

ESTIMATION OF GENETIC PARAMETERS FOR MILK YIELD AND MILK COMPOSITION OF SOUTH AFRICAN SAANEN DAIRY GOATS

4.1 Introduction

Genetic improvement in dairy herds is achieved by selecting superior parents for the next generation. Identifying genetically superior animals depends on the accuracy of determining their genetic worth (Wiggans *et al.,* 1984). The improvement of production traits through selection is dependent on the effective utilization of the additive genetic variance. This is not likely to happen when animals of unknown genetic make-up are used in a breeding programme. A random combination of genes often results in a wide variation in phenotypic performances. There is presently no genetic information available for dairy goats in South Africa. Breeding and selection of dairy goats by local producers have been based on factors such as pedigrees, conformation traits and phenotypic performances. Genetic evaluations of does and bucks based on Best Linear Unbiased Predictions (BLUP) methods have been accepted widely in other countries (Weller *et al.,* 1987). This, however, requires that non-genetic factors affecting the accuracy of the predicted breeding values of the parents must either be controlled or eliminated. Thus factors such as lactation period, year and season of kidding, age at first kidding, status (grade or registered) of animals and different herds, owners or breeds must be included in a model if they have a significant effect on the breeding values of animals.

Models to determine breeding values for dairy cattle have been developed and the genetic evaluation of dairy breeds have become common practice in South Africa. Dairy farmers participating in milk recording now receive a profile of their herd's genetic status at least once a year. The option to receive this information twice a year is also available. This herd profile includes breeding values for all animals in the herd in relation to the national herd.

Heifers of cows in milk recording are included in the pedigree file making it possible to obtain an estimated breeding value (EBV) based primarily on parent averages although the production of other family members also contribute to the EBV's of heifers. With this information available, only heifers of a minimum predicted genetic quality could therefore be raised by the dairy farmer, therefore saving on the cost of replacement .

Genetic parameters are specific for a particular population. Reliable estimates of (co)-variance components and resulting heritabilities of production traits are needed to evaluate breeding programmes and to predict breeding values (Du Toit, 1994). Permission has been obtained from the South African Milch Goat Breeders' Society to merge pedigree records with production parameters to calculate genetic parameters for the national herd. The aim of this study was to develop an appropriate model to determine variance components, heritability estimates and breeding values for milk production parameters for Saanen dairy goats in the national herd. A genetic evaluation of the national dairy herd in South Africa has not been been done previously and with the small number of records available, it was considered necessary to include all available records of all dairy goats over all lactations in the analysis. This will provide a basis for a breeding and selection programme for dairy goat farmers with the aim of improving the milk yield and milk composition traits of dairy goats in South Africa.

4.2 Materials and methods

4.2.1 Data set

The data set used in this study consisted of milk production records of all grade and registered Saanen dairy goats that kidded between 1978 and 2001. Pedigree information of these goats was obtained from SA Studbook. Milk production records were from the South African National Dairy Animal Improvement Scheme of the Animal Improvement Institute of the Agricultural Research Council. Milk recording of dairy goats started in 1957, but only a small number (n = 100) of production records were available from that time until 1981. A larger number of records became available from the 1981/82-production year onwards.

Originally some 14167 lactation records of Saanen goats of all parities were available. A large number of these records (4171) had zero values in the data set while 5654 records were deleted because of no information about the owners' identification. Because of the small number of records before 1986, only records between 1987 and 2001 were used from owners that had more than 50 records each. Only seven owners had a sufficient number (more than 50) of lactation records. Furthermore, records had to comply with the following minimum requirements as well:

(a) lactation length : 60 – 305 days
(b) minimum age at first kidding : 11 months
(c) maximum age at first kidding : 36 months
(d) birth date recorded
(e) sire or dam identification number
(f) animal identification number
(g) lactation number 1 - 6
(h) milk yield higher than zero
(i) positive owner identification

After these requirements were met, between 3180 (for other traits) and 3190 (for milk yield) lactation records of 1473 Saanen does were available. These does were the progeny of 142 known sires and 757 known dams. A total of 1685 (53%) records lacked sire identification while dam information was not available for 1140 (36%) records. The comparatively large number of lactation records without complete pedigrees could be related to the lack of recording of pedigrees in the Fairview herd (also see Chapter 6). The full pedigree file was used, consisting of 8294 records. The pedigree files lacked information regarding the identification of sires and dams. Although some 6034 records had both dam and buck identification, there were some records with no buck and dam identification, i.e. 2171 and 1389, respectively. Although lacking some pedigree data, the full pedigree file was used to account for all known relationships. Ignoring relationships that may exist, may result in a reduction in REML estimates of genetic variance (Dong *et al.*, 1988). A total of 55 levels of herd-year effects was available.

4.2.2 Statistical analysis

The ASREML software package developed by Gilmour *et al*. (1999) was used for the estimation of the fixed effects, and also subsequently to derive variance components for the respective production traits in univariate analyses. Fixed effects that were considered included the herd-year effect, lactation number (1 – 6) and month of kidding with animal and doe permanent environment as random effects. Trends with regard to lactation number were modelled, using cubic splines (Verbyla *et al*. 1999). The splines initially consisted of three components, namely: a fixed linear component, random deviations from linearity following a smooth trend, and random deviations from linearity not conforming to a smooth trend. The latter effect was not significant ($P<0.05$) and was excluded from further analyses. Initial analyses involved fitting various combinations of fixed effects, random spline components and interactions between them to obtain an operational model. Lactation interval was included as a covariate in the analyses involving production and percentage traits, to account for the effect of the number of days in milk on the various production parameters. Effects found to be significant ($P<0.05$) in preliminary analyses were retained in subsequent analyses. Random terms were then added to the operational model, resulting in the following genetic models for analyses (in matrix notation):

$$y = Xb + Z_1c + e \qquad (1)$$

$$y = Xb + Z_2a + e \qquad (2)$$

$$y = Xb + Z_2a + Z_1c + e \qquad (3)$$

In these models, y was a vector of observations for production or percentage traits; b, a and c were vectors of fixed effects, direct genetic effects and doe permanent environmental effects; X, Z_1 and Z_2 were the corresponding incidence matrices relating the respective effects to y, and e the vector of residuals.

It was assumed that:

$V(a) = A\sigma^2_a$; $V(c_{PE}) = I\sigma^2$; $V(e) = I\sigma^2_e$,

with A being the numerator relationship matrix, I being an identity matrix; and σ^2_a, σ^2_c, and σ^2_e being the direct genetic variance, ewe permanent environmental variance and environmental (residual) variance respectively.

Log likelihood ratio (LRT) tests were conducted to determine the most suitable model for each trait in uni-trait analyses. The LRT's were based on testing twice the increase in Log likelihood resulting from adding random terms to the model of analysis as a Chi^2 statistic. Alternatively, for two models with the same number of random effects, and assuming identical fixed effect models, the one with the higher likelihood fits the data better. Subsequently, 2-trait animal models were fitted. These analyses allowed the calculation of all relevant direct genetic and doe permanent environment correlations between traits, together with their appropriate standard errors.

4.3 Results and discussion

The number of records available and the means for production parameters for Saanen dairy goats over all parities in the national herd are presented in Table 4.1. Yield parameters are higher than those reported by Hallowell (2002) for the national herd in that specific production year. The coefficients of variations (CV) for yield traits were high (exceeding 32%) while percentage traits varied less (18% for fat percentage and 9% for protein percentage). The coefficients of variation for yield traits were high because all lactations longer than 60 days were used.

Large variation in milk yield parameters of dairy goats seem to be common. Donkin & Boyazoglu (2000) reported that the average milk yield of a small group of Saanen goats (n = 157 does) in South Africa was 706±207 kg per lactation. Milk yields varied between 334 and 1404 kg per lactation with the CV almost reaching 30%. Fat and protein percentages were 3.43±0.53 and 2.88±0.34, respectively.

Table 4.1 The number of records and means (± standard deviation) for milk production traits for Saanen dairy goats in the national herd

Production parameters	Number of records	Mean ± SD
Milk (kg)	3190	930 ± 301
Fat (kg)	3180	28.1 ± 9.3
Protein (kg)	3180	25.2 ± 8.1
Fat (%)	3180	3.05 ± 0.56
Protein (%)	3180	2.71 ± 0.24

In Poland, Bagnicka *et al*., (2002) reported that over a 10 year period, average milk yield of dairy goats varied from 527 to 615 kg per lactation. Milk yield of does in the Polish study varied to a greater extent than fat and protein percentages, with the CV for milk yield reaching 37% while it was 17 and 10% for fat and protein percentage, respectively.

Factors affecting milk yield and milk component traits were lactation period or the number of days in milks (fitted as a linear co-variate), month of kidding and lactation number (Figures 4.1 – 4.4). The number of records from first to sixth lactation showed the typical erosion in the number of records as observed for dairy cows.

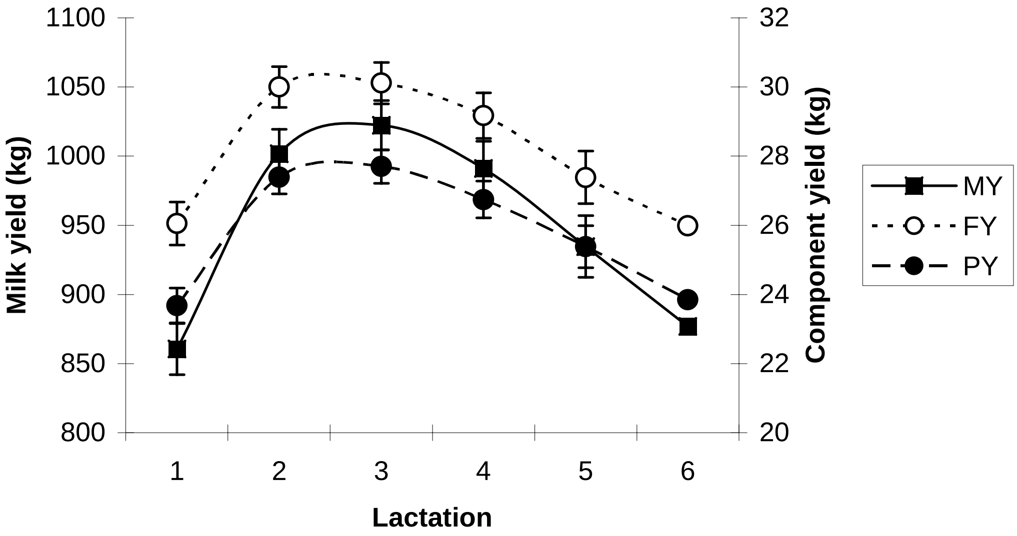

Figure 4.1 The change in milk (MY), fat (FY) and protein (PY) yields of Saanen dairy goats in the national herd as affected by lactation number

Phenotypically, lactation number influenced milk yield traits nonlinearly with production parameters increasing to third lactation and then declining. The milk yield of does increased from about 860 to 1020 kg per lactation from first to third lactation and then declined to sixth lactation. Fat and protein yields followed the same pattern. The sharp decline in yield parameters after third lactation is in contrast to that of dairy cows where milk yield only starts declining after fifth lactation while also not reaching such low levels in comparison to first lactation cows. Van der Linde & De Jong (2002) reported that the milk yield of dairy goats in The Netherlands increased from 852 kg in first lactation to 949 and 958 kg in second and third lactation, respectively. Corresponding figures for fat and protein yields were 34 and 28 kg in first lactation and 38 and 32 kg in third lactation.

Unusually, fat and protein percentages showed a downward trend from first to sixth lactation Figure 4.2). In contrast, Van der Linde & De Jong (2002) showed that while the fat percentage of dairy goat milk in Holland varied around 4.0% between first and third lactation, protein percentage showed a slight increase from 3.29% in first lactation to 3.34% in third lactation.

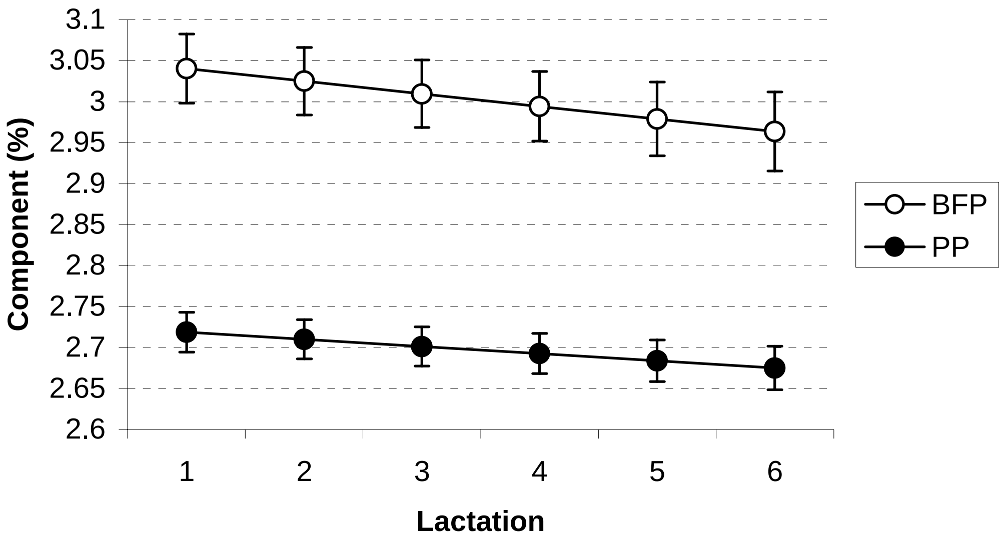

Figure 4.2 The fat (BFP) and protein (PP) concentration of the milk of Saanen dairy goats in the national herd as affected by lactation number

The reason for the lower fat and protein percentages in the milk of dairy goats in South Africa is not clear, although it is probably due to environmental and feeding differences. In this country, producers put a high emphasis on high milk volumes thereby contributing to low component levels because of the negative correlation of milk yield with fat and protein percentages. Milk is also mostly produced under intensive feeding conditions with relatively high levels of concentrate feeding. Dairy goats, like dairy cows, only need a minimum amount of roughage to keep their rumens healthy. These levels could however, be too low to produce milk of a high fat concentration. Milk pricing structures based on the volume of milk produced would also result in lower fat and protein percentages in milk. In general, on average, South African dairy cows also produce milk with lower fat and protein percentages than their European counterparts. This is also probably related to the local environment and feeding programmes.

Barillet *et al*. (1998) also noted that although goat's milk in Europe is used exclusively for cheese production, the protein content of the milk is often lower than that of sheep or even cow milk. Increasing the protein and fat concentration of milk through feeding and breeding, would result in a lower production cost of cheese (Muller & Robertson, 2004). The price of milk is usually based on prices paid per kg fat and protein. A volume bonus based on protein yield is often used to stimulate production. Fat and protein yields are determined by both the volume of milk produced and the fat and protein percentages in the milk. Dairy farmers increase milk income by higher milk yields per cow and/or milking more cows. This usually results in a decrease in the fat and protein percentages in the milk of dairy cows. The same principle probably applies in the dairy goat industry.

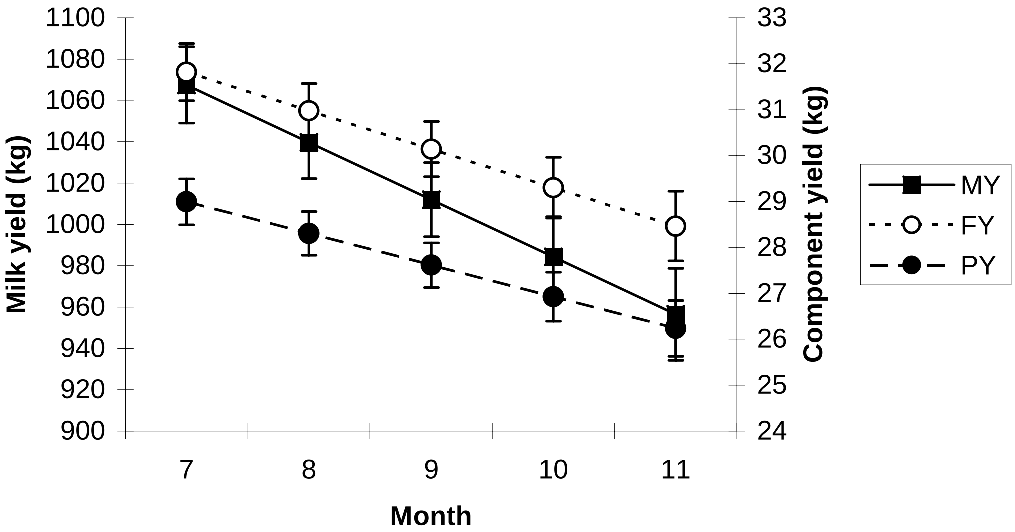

Figure 4.3 The milk (MY), fat (FY) and protein yield (PY) of Saanen dairy goats in the national herd as affected by month of kidding

Kidding of dairy goats in the South African national herd is mostly seasonal starting in July and ending in November. Most (82%) of all kiddings occur in August and September. All yield traits for goats kidding in August to November showed a downward trend (Figure 4.3). Milk yield declined from 1067 kg per lactation for does that kidded in August to 956 kg for those that kidded in November. The fat and protein yields of does likewise declined from 32 and 29 kg in August to 28 and 26 kg, respectively, in November. Fat and protein components varied little between months and tended to increase from August to November (Figure 4.4). Little comparative data of the effect of month of kidding are available in the literature.

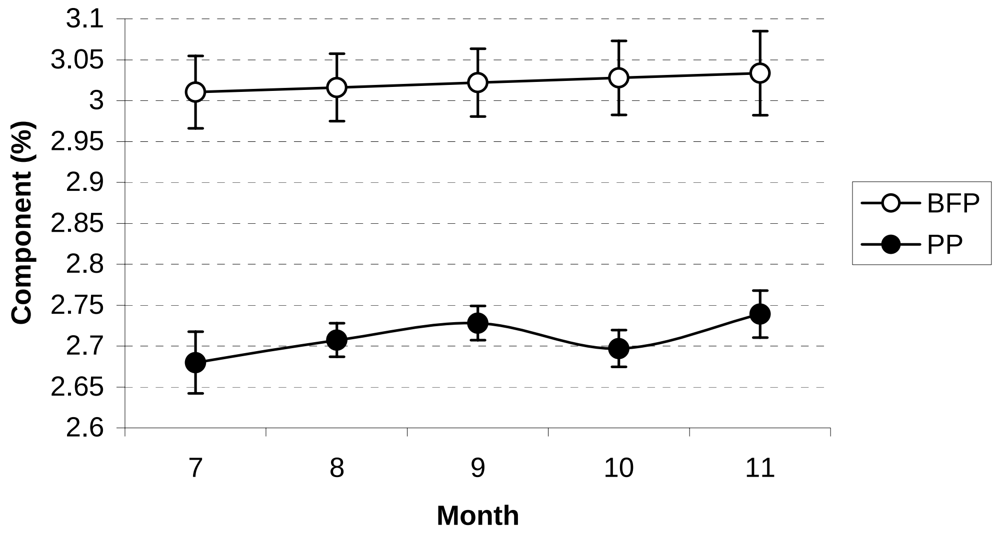

Figure 4.4 The fat (BFP) and protein concentration (PP) of the milk of Saanen dairy goats in the national herd as affected by month of kidding

For all milk production traits, the model that fitted the data best included direct additive and permanent environment effects (Table 4.2).

Table 4.2 Log likelihood ratios for milk production traits for Saanen dairy goats in the national herd under different models of analyis. The best model is indicated in bold figures

	Yield traits			Percentage traits	
Model fitted	**Milk**	**Fat**	**Protein**	**Fat**	**Protein**
Fixed effects	-18144.2	-7484.87	-6824.45	715.13	3194.08
$+h^2$	-17895.8	-7320.41	-6604.67	862.53	3536.94
$+c^2$	-17899.2	-7325.99	-6607.80	865.53	3533.05
$+h^2 + c^2$	**-17881.0**	**-7311.79**	**-6590.99**	**872.61**	**3550.43**

Random effects: h^2 = additive; c^2 = permanent environment

The additive and residual variances as well as heritability estimates for milk production parameters for Saanen goats of all parities are presented in Table 4.3. Heritability estimates for all yield traits (milk, fat and protein yield) and percentage traits were in the moderate range with protein percentage being the highest in absolute terms.

Table 4.3 Variance components and heritability (h^2) estimates of milk production parameters for Saanen goats in the national herd

Parameters	Yield traits			Percentages	
	Milk	Fat	Protein	Fat	Protein
Variance components					
σ^2_a	7580.22	8.0429	5.4912	0.0372	0.0132
σ^2_c	7353.36	6.9782	5.3670	0.0486	0.0121
σ^2_e	21491.30	26.8517	16.2562	0.1390	0.0211
σ^2_p	36424.88	41.8728	27.2562	0.2248	0.0464
Variance ratios					
h^2	0.21±0.05	0.19±0.05	0.20±0.05	0.17±0.05	0.28±0.06
c^2	0.20±0.04	0.17±0.04	0.20±0.04	0.22±0.05	0.26±0.05

σ^2_a : additive variance; σ^2_c : permanent environment variance;
σ^2_e : error variance; σ^2_p : phenotypic variance; c^2 : permanent environment

According to Montaldo & Manfredi (2002), on the organisation of selection programmes for dairy goats, most recent h^2 estimates for milk yield traits in dairy goats obtained from farm records and using an animal model-BLUP, are in the range of those obtained for dairy cows (0.20-0.40). Some estimates of h^2 for milk production have been higher (over 0.5). They have related this to deficiencies of data and methods of estimation to separate genetic from herd-year-season influences or artificially standardized environmental conditions of measurement in research stations. In most programmes, genetic values are predicted using an animal model-BLUP. In France evaluation programmes use univariate models for total milk, fat and protein production.

In Spain, Analla *et al.* (1996) analyzed traits with an animal model using repeated records in single-trait and multiple-trait options and found h^2 estimates of 0.18, 0.16 and 0.25 for milk yield, fat and protein percentages, respectively. An earlier study by Boichard *et al.* (1989) analyzing first lactation records of Saanen does from the French recording scheme using an animal model, reported h^2 estimates of 0.31 for milk yield, 0.47 for fat percentage and 0.41 for protein percentage. Iloeje *et al*. (1981) used a sire model and reported heritability estimates of 0.53, 0.48 and 0.62 for milk and fat yield and fat percentage of Saanen does, respectively. Kennedy *et al*. (1982) analyzing first lactation records of four breeds with a sire model, reported heritabilities for milk yield and fat percentage, respectively, of 0.68 and 0.54 for Alpine, Saanen and Toggenburg breeds. Sullivan *et al*. (1986) working with records of all lactations of Alpine, Saanen and Toggenburg breeds and using a model of doe nested within sire, obtained a heritability of 0.46 for milk yield.

In New Zealand, Morris *et al*. (1997) employed Restricted Maximum Likelihood procedures using the repeated records option of the animal model to estimate heritabilities. Heritability estimates for milk yield and fat plus protein yield for Saanen does were 0.23 ± 0.04 and 0.27 ± 0.04, respectively. Singireddy *et al*. (1997) used the software package PEST (Groeneveld *et al*., 1990) under a repeatability model to estimate genetic parameters in an across-breed genetic evaluation of New Zealand dairy goats. The heritability estimate for milk yield was 0.25. Using test day records, Breznik *et al.* (1999) found that the heritabilities of daily milk yield, fat and protein percentages were 0.21, 0.16 and 0.16, respectively.

The genetic and phenotypic correlations between production parameters for Saanen dairy goats are presented in Table 4.4. Correlations between yield traits were high and positive. Genetic and doe permanent environment correlations of milk yield with percentage traits were negative. Corresponding phenotypic and environmental correlations were lowly negative. Genetic and doe permanent environment correlations of milk yield with the percentage traits were negative, but exceeded twice their respective standard errors only for the genetic correlation between milk yield and fat percentage. Phenotypic and environmental correlations between milk yield and fat percentage and between milk yield and protein percentage were low and negative, but significantly different from zero ($P<0.01$).

The genetic correlation of fat percentage with fat yield was moderate and positive while the doe permanent environment correlation was high at 0.52.

Table 4.4 Estimates of correlations (±s.e.) among milk production traits for genetic, permanent environment, phenotypic and temporary environmental effects for Saanen dairy goats over all parities in the national herd.

Traits	**Correlations**			
	Genetic	**Doe permanent environment**	**Environmental**	**Phenotypic**
Milk yield x:				
Fat yield	0.75±0.07	0.76±0.07	0.78±0.01	0.80±0.01
Protein yield	0.92±0.02	0.80±0.03	0.93±0.00	0.95±0.00
Fat %	-0.34±0.16	-0.13±0.16	-0.14±0.02	-0.09±0.02
Protein %	-0.25±0.15	-0.18±0.14	-0.14±0.02	-0.08±0.02
Fat yield x:				
Protein yield	0.86±0.05	0.80±0.06	0.81±0.01	0.80±0.01
Fat %	0.35±0.15	0.52±0.14	0.43±0.02	0.43±0.02
Protein %	0.26±0.15	0.03±0.16	0.07±0.07	0.01±0.02
Protein yield x:				
Fat %	-0.07±0.18	0.06±0.16	-0.03±0.02	-0.04±0.02
Protein %	0.14±0.15	0.24±0.14	0.18±0.02	0.18±0.02
Fat % x:				
Protein %	0.72±0.11	0.72±0.11	0.30±0.02	0.11±0.02

The corresponding genetic and doe permanent evironment correlations between protein percentage and protein yield did not exceed twice the standard errors. The genetic and permanent environment correlations between percentage traits were moderate to high. Phenotypic correlations between milk yield and fat and protein yields were positive, and negative between milk yield and fat and protein percentages. This accords with other studies (Analla *et al*., 1996) although the magnitude in the present study was smaller, specifically for fat and protein content. Iloeje *et al*. (1981) found phenotypic correlations between milk yield and fat yield and between milk yield and fat percentage of 0.94 and 0.86, respectively. Genetic correlations between milk yield and fat yield and between milk yield and fat percentage were -0.04 and –0.24, respectively. Estimates of heritability of traits can vary considerably between studies because of models used, breed, population sampled, environmental conditions and random and systematic errors in the estimation process (Wiggans, 1989).

4.4 Conclusions

The partitioning of animal effects into genetic and permanent environment components was probably not optimal, owing to the incomplete pedigrees. Heritability estimates for production traits in this study were moderate and are in agreement with results reported in the literature. The heritability estimate for protein percentage was higher than for production traits. Phenotypic correlations between milk yield and fat and protein yields were positive, while a negative phenotypic correlation was found between milk yield and fat and protein percentages. Selection for fat and protein percentages would therefore have a negative effect on production parameters. As the current milk price structure is based on the quantity of fat and protein produced, this could have a negative effect on milk income.

CHAPTER 5

ESTIMATION OF GENETIC PARAMETERS FOR MILK YIELD AND MILK COMPOSITION OF SOUTH AFRICAN SAANEN DAIRY GOATS USING FIRST AND SECOND PARITY RECORDS

5.1 Introduction

Dairy goat breeders in South Africa have traditionally used information such as pedigrees, conformational traits and phenotypic performances of animals to select and cull animals. In most local breeding programmes, little effort has been made to select superior animals to be parents for the next generation. One reason for this is that most breeders do not have a clear breeding objective for their herd. A breeding objective gives a specific desired direction for genetic change (Kinghorn, 1997). It also implies that specific actions must be taken in an effort to attain the objective.

As for dairy cattle, a sustainable genetic improvement for primarily milk yield and milk composition parameters should be a long term objective for most dairy goat breeders. It is generally accepted that improving the genetic standard of a herd is the only way to increase the herd's efficiency and profitability. Improving production traits through breeding and selection is dependent on additive genetic variance (Kinghorn, 1997). This is difficult when animals of unknown genetic make-up are combined in a breeding programme as the random combination of genes often results in a wide variation of phenotypic performance. One way to overcome this, is to base the selection of parents for the next generation on the breeding value of animals. The breeding value (BV) gives an indication of the value of an animal as a parent. According to Kinghorn (1997), the BV of animals is estimated from three sources of information, i.e. the animal's pedigree, its production performance and the production performance of its progeny.

The dairy goat industry in South African had until now, no information on the genetic merit of animals for production traits. In Chapter 4, all lactation records of Saanen dairy goats over all lactations were used to obtain genetic parameters for production traits. For dairy cattle, first parity records of dairy cows were initially used to establish genetic parameters (Vermeulen, 1991 for Holsteins; du Toit, 1994 for Jerseys and Hallowell, 1994 for Ayrshires). The reason for this is that higher heritability (h^2) estimates are obtained from using first parity records in comparison to second parity records (Johannson, 1955). Freeman (1960) reported h^2 estimates of 0.36, 0.24 and 0.26 for first, second and third parity milk yield records, respectively. Molinuevo & Lush (1964) also found higher h^2 estimates with first parity records in comparison to second and third parity records. The reason for this variation in h^2 estimates is because second and third parity records are affected by additional sources of variation that are not applicable to first parity cows. This include the dry periods between first and second parity and between second and third parity. Using first parity records allows for early culling while it provides early information on the breeding value of sires through progeny testing for the artificial insemination (AI) industry. First parity does are usually the largest (more than 40% of all records for Saanen dairy goats) single group of dairy goats in a herd. Similarly as for dairy cows, there is a high erosion rate of does from first to third parity and often less than 40% of first parity does reach third parity. Using second and third parity records would, however, contribute to the estimation of more accurate breeding values for cows and does.

In this study, genetic parameters for milk yield and milk composition for first and second parity Saanen goats in the national dairy goat herd were estimated separately. This study was considered exploratory for the present data set and the outcome was uncertain. In the future with improved pedigree recording and a larger number of does in milk recording, a bivariate analysis comparing first and second parity lactation records could be used to confirm present results. This would also allow for the determination of the accuracy of the prediction of second parity records based on first parity records.

5.2 Materials and methods

5.2.1 Data set

Milk production records of all lactation records longer than 60 days were included in the analysis. A total of 1191 first lactation and 775 second lactation records of Saanen dairy goats in the national dairy goat herd was available. The pedigree file lacked information regarding the identification of some bucks and does. Although lacking some pedigree data, the full pedigree file was used to account for all known relationships. Ignoring relationships that may exist, may result in a reduction in REML estimates of genetic variance (Dong *et al.*, 1988). A total of 35 and 37 levels of herd-year effects was available for first and second lactation records, respectively.

5.2.2 Statistical analysis

The ASREML software package developed by Gilmour *et al.* (1999) was used for the estimation of the fixed effects, and also subsequently to derive variance components for the respective production traits in unitrait analyses. These analyses were conducted within lactation number, i.e. first and second lactation data were analysed separately. Fixed effects that were considered included herd-year of kidding (1988-2001). Lactation period (number of days in milk) was included as a covariate in analyses involving production and percentage traits, to account for the effect of the number of days in milk on the various production parameters. Effects found to be significant ($P<0.05$) in preliminary analyses were retained in subsequent analyses. The random term of animal was then added to the operational model, resulting in the following genetic model for analysis (in matrix notation):

$$y = Xb + Z_1a + e \qquad (1)$$

In this model, y was a vector of observations for production or percentage traits; b and a were vectors of fixed effects and direct genetic effects; X and Z_1 were the corresponding incidence matrices relating the respective effects to y, and e the vector of residuals.

It was assumed that:

$V(a) = A\sigma^2_a$; $V(e) = I\sigma^2_e$,

with A being the numerator relationship matrix, I being an identity matrix; and σ^2_a and σ^2_e being the direct genetic variance, and environmental (residual) variance, respectively.

Subsequently, pairwise 2-trait animal models were fitted. These analyses allowed the calculation of all relevant direct and doe permanent environment correlations between traits, together with their appropriate standard errors.

5.3 Results and discussion

The number of records available and means for milk yield parameters for first and second parity Saanen goats in the national herd are presented in Table 5.1.

Table 5.1 Number of records, means ± standard deviation (±SD) of production parameters for first and second parity Saanen dairy goats in the national herd

Production parameters	First parity		Second parity	
	Number of records	Mean ±SD	Number of records	Mean ±SD
Milk (kg)	1190	801±256	775	1011±288
Fat (kg)	1186	24.6±8.6	772	30.5±8.7
Protein (kg)	1186	21.9±7.3	772	27.6±7.7
Fat (%)	1186	3.07±0.6	772	3.05±0.5
Protein (%)	1186	2.73±0.2	772	2.73±0.2

There was, similar as for dairy cows, a substantial reduction in the number of dairy goat milk production records from first to second parity. The erosion rate in this case was about 35%. Milk yield parameters increased from first to second parity by at least 24%, while fat and protein percentages were similar. This large (26%) increase in milk yield from first to second lactation could be attributed to the effect of culling does at the end of first lactation because of low milk yields and/or reproductive problems. Some of the feed energy consumed during first lactation could also be channeled into growth instead of being used for the production of milk. This is often the case when does are too small at first kidding because of kidding at a too early age or a low growth rate until kidding. According to Hallowell (2002) the average milk yield for first parity dairy goats in milk recording in South Africa was 805 kg per lactation. Fat and protein percentages were 3.12 and 2.72%, respectively. Age at first kidding for both registered and grade dairy goats in milk recording was 14 months.

In dairy cattle, well grown out heifers reach live weights of at least 90% of their mature live weight at first calving at about 24 months of age, resulting in a smaller difference (<15%) between first and second parity milk yields. Percentage traits were similar for goats in both parities. The coefficients of variation for yield traits were high (exceeding 35% for first and 28% for second parity records). Percentage traits did not show such large variation, i.e. 19 and 16% for fat percentage and 7% for protein percentage, respectively.

Van der Linde & De Jong (2002) found that the average 305-day milk, fat and protein yields for first parity dairy goats in The Netherlands, was 852, 34 and 28 kg, respectively. In an across-breed genetic evaluation of goats in New Zealand, Singireddy *et al*. (1997) found that two-year-old does produced 150 litres extra milk compared to 1-year-old does. Milk yield of Saanen goats in Italy for all lactations averaged 477±188 litres (Moioli *et al*., 1995). Serradilla (2001), however, noted that it is difficult to compare the performance of dairy goats in different countries because of different production systems. Production systems are often not described very clearly. Higher milk yields are usually achieved in more intensive feeding systems.

In comparison to the data provided by Van der Linde & De Jong (2002), the fat and protein percentages in the milk of first and second parity dairy goats in the South African national herd seem quite low. Other authors (Bagnicka *et al*., 2002 in Poland) have also reported somewhat higher fat and protein percentages, i.e. 3.52 and 2.93%, respectively. The reason for the lower fat and protein concentrations in the milk of the local Saanen dairy goat herd is not clear as a substantial amount of goat's milk is used exclusively for cheese production. A higher protein percentage in milk would reduce the production cost of dairy products such as cheese. Cheddar cheese production from 100 kg of cow's milk increases from 9.5 to 13.7 kg with an increase in the fat and protein percentages in the milk from 3.5 and 3.0% to 5.5 and 4.2%, respectively (Muller & Robertson, 2004). A milk pricing structure based on a payment system for fat and protein yields actually favours an increase in volume production (Muller, 1994). Because of a large variation between animals, it would, however, be possible to improve this trait. Identification of high genetic merit does can be achieved through the use of breeding values.

The additive and residual variances and heritability estimates for first and second parity does for milk production parameters are presented in Table 5.2. Heritability (h^2) estimates for milk, fat and protein yield and protein percentage traits for first parity does were in the moderate range while the estimate was very high for fat percentage. All estimates were, however, lower for second parity does. The h^2 estimate for fat percentage was higher than estimates derived for yield traits.

Estimates of heritability of traits can vary considerably between studies because of breed, population sampled, environmental conditions and random and systematic errors in the estimation process (Wiggans, 1989). Estimates obtained in any study should be compared with those obtained in similar estimation methods (Analla *et al*., 1996). In the USA an animal model replaced the sire model for yield traits in 1987 (Wiggans *et al*., 1988).

Table 5.2 Variance components and estimates of heritability (h^2) of production and percentage (%) parameters for first and second parity Saanen dairy goats (SE = Standard error)

Parameters	Yield traits			%	%
	Milk	Fat	Protein	Fat	Protein
First parity					
σ^2_a	8394.9	12.647	6.822	0.1694	0.0149
σ^2_e	18049.7	21.494	14.670	0.0826	0.0320
σ^2_p	26444.6	34.141	21.492	0.2520	0.0469
h^2±SE	0.32±0.08	0.37±0.08	0.31±0.08	0.67±0.08	0.32±0.08
Second parity					
σ^2_a	7561.1	7.618	6.771	0.0618	0.0096
σ^2_e	30400.0	33.714	21.477	0.1216	0.0307
σ^2_p	37961.1	41.332	28.248	0.1834	0.0403
h^2±SE	0.20±0.10	0.18±0.11	0.24±0.10	0.34±0.12	0.24±0.11

σ^2_a : additive variance; σ^2_e : permanent environment variance; σ^2_p : phenotypic variance

Probably because of small numbers in available data sets, most studies reporting on h^2 estimates for milk production parameters for dairy goats were done considering all breeds and over all lactations. Kennedy *et al.* (1982), however, reported on the results of analyzing first lactation records of four breeds with a sire model. Heritability estimates for milk yield and fat percentage were 0.68 and 0.54, respectively, for Alpine, Saanen and Toggenburg breeds and 0.35 and 1.09 for Nubian goats. Boichard *et al.* (1989) also analyzed first lactation records of Saanen does from the French recording scheme with an animal model, and reported heritability estimates of 0.31, 0.47 0.41 for milk yield, fat percentage and protein percentage, respectively. All these estimates were larger than those obtained in the present study.

Recently in most genetic evaluation programmes, estimates are predicted by using an animal model-BLUP. In France, univariate models are used in evaluation programmes for total milk, fat and protein production. Montaldo & Manfredi (2002) showed that the h^2 estimates for milk yield traits in dairy goats obtained from farm records over all lactations and using an animal model-BLUP, are in the range of those obtained for dairy cows (0.20-0.40). Some estimates of h^2 for milk production have been higher (over 0.5). In Spain, Analla *et al.* (1996) analyzed traits with an animal model using repeated records in single-trait and multiple-trait options and found h^2 estimates of 0.18, 0.16 and 0.25 for milk yield, fat and protein percentages, respectively. Iloeje *et al.* (1981) used a sire model and reported heritability estimates of 0.53, 0.48 and 0.62 for milk and fat yield and fat percentage of Saanen does, respectively. Sullivan *et al.* (1986) working with records of all lactations of Alpine, Saanen and Toggenburg breeds and using a model of doe nested within sire, obtained a heritability of 0.46 for milk yield.

In New Zealand, Morris *et al.* (1997) employed Restricted Maximum Likelihood procedures using the repeated records option of the animal model to estimate heritabilities. Heritability estimates for milk yield and fat plus protein yield for Saanen does were 0.23 ± 0.04 and 0.27 ± 0.04, respectively. Singireddy *et al.* (1997) used the software package PEST (Groeneveld *et al.* 1990) under a repeatability model to estimate genetic parameters in an across-breed genetic evaluation of New Zealand dairy goats. The heritability estimate for milk yield was 0.25.

Presently in the USA, dairy goat owners participate in the same Dairy Herd Improvement Milk Recording Scheme that was developed for dairy cattle (Wiggans & Hubbard, 2001). The milk yield of dairy goats for only the first 305 days of each lactation is considered. Shorter lactation records are projected to a 305-d equivalent. Lactation records are also adjusted for age and season of kidding by standardizing yield to the equivalent of that for 3-year-old does that kidded from December to March in the USA (Finley *et al.*, 1984). Only information on the first six parities of does are included in the evaluation for computational convenience and because parities after the sixth contribute little additional information for the estimation of genetic merit (Wiggans, *et al.*, 1994). Milk, fat and protein yields are evaluated directly with an animal model across breeds. Evaluations for fat and protein percentages are calculated from yield evaluations. An economic index based on genetic merit for milk, fat and protein yields (MFP$) is calculated, based on economic values for dairy cattle.

Correlations among the yield traits for both first and second parity goats were high to very high (Table 5.3).

Table 5.3 Genetic (above the diagonal) and environmental (below the diagonal) correlations among production parameters for first and second parity Saanen dairy goats in the national herd.

Production parameters	Yield			Percentage	
	Milk	Fat	Protein	Fat	Protein
First parity					
Milk yield	-	0.61±0.10	0.91±0.03	-0.27±0.13	-0.16±0.19
Fat yield	0.81±0.03	-	0.82±0.06	0.58±0.10	0.47±0.15
Protein yield	0.93±0.01	0.79±0.03	-	0.05±0.15	0.22±0.18
Fat (%)	-0.07±0.11	0.43±0.09	-0.06±0.11	-	0.76±0.10
Protein (%)	-0.07±0.08	-0.001±0.09	0.25±0.07	-0.07±0.11	-
Second parity					
Milk yield	-	0.70±0.18	0.94±0.05	-0.53±0.32	-0.08±0.35
Fat yield	0.81±0.03	-	0.83±0.11	0.13±0.33	0.29±0.34
Protein yield	0.93±0.01	0.80±0.03	-	-0.30±0.31	0.23±0.31
Fat (%)	-0.04±0.10	0.50±0.08	0.05±0.11	-	0.45±0.26
Protein (%)	-0.17±0.09	-0.01±0.10	0.18±0.09	0.22±0.10	-

Fat and protein yields were positively related to milk yield. As for dairy cows, milk fat and protein percentages were negatively related to milk yield. The correlation between milk fat production and milk fat percentage was positive for both first and second parity goats. Genetically, the correlation between milk fat and protein percentages for first parity does was highly positive, i.e. 0.76. For second parity does this relationship was in the moderate range (0.45). Efforts to improve milk fat percentage would therefore have a positive effect on milk protein percentage. Other researchers found similar responses in terms of correlations among production traits. Barillet *et al*. (1998) found that milk yield and fat and protein yields were highly correlated (*c*. 0.8 to 0.9) while milk yield was negatively related to fat and protein percentages (-0.4 for protein percentage and –0.3 for fat percentage). Ilahi *et al*. (1998) also found negative correlations between milk yield and fat and protein percentages (-0.27 and -0.48 for fat and protein, respectively).

The negative genetic relationship between milk yield and percentage traits creates problems in the selection programme of some dairy herds as an increase in milk volume is associated with a reduction in the fat and protein percentage of milk. The production cost of milk products such as cheese is increased when milk with a lower solids content is used. Currently milk pricing systems are based on the amount of fat and protein produced. Higher fat and protein yields could be obtained from a higher volume of milk although at a lower fat and protein concentration or from milk at a higher fat and protein percentage in the milk. The selection objective for a herd producing milk for milk products should therefore be aimed at increasing fat and protein yields by increasing the percentage of fat and protein of milk while maintaining the volume of milk produced.

5.4 Conclusions

Heritability estimates for production traits for first and second parity dairy goats were in the range of estimates found in the literature. This indicates that selection for these traits would be effective. Heritability estimates for fat percentage for first and second parity goats were higher than for production traits while the h^2 estimate for protein percentage was similar to those of yield traits. Because of the negative correlations between milk yield and milk components, a compromise must be found to improve both fat and protein yields while maintaining or improving the fat and protein percentages in milk.

CHAPTER 6

GENETIC PARAMETERS, GENETIC AND PHENOTYPIC TRENDS FOR MILK PRODUCTION PARAMETERS IN A COMMERCIAL SAANEN DAIRY GOAT HERD

6.1 Introduction

A breeding objective for any herd has a desired direction for genetic change (Kinghorn, 1997). For most dairy goat herds a sustainable genetic improvement of primarily milk production parameters would be a long term breeding objective, however, the profitability of milk production is impaired by escalating input costs. One way to overcome this, is to improve the genetic merit of does in the herd to achieve a higher efficiency of production. Improving production traits through selection is dependent on additive gene variance. This is, however, very difficult when animals of unknown genetic make-up are combined in a breeding programme. A random combination of genes often results in a wide variation in phenotypic performances. Parents for the next generation should have alleles with the most beneficial effect on their progeny. This can only be done by selecting animals on the basis of their breeding values (Kinghorn, 1997). The breeding value (BV) of animals is an indication of the value of that animal as a parent. The BV of animals is estimated from three sources of information, i.e. the animal's pedigree, its own performance and the performance of its progeny (Kinghorn, 1997).

The national dairy goat herd in South Africa consist of only a few large herds with most (*c.* 80%) herds being small, i.e. fewer than 60 does in the herds over a 20 year period. This seems to be a worldwide trend. Iloeje *et al.,* (1981) also reported that dairy goat herds in the USA are small with only a few does per sire. The Fairview Saanen herd is the largest dairy goat herd in South Africa contributing almost 65% of all the milk production records to the national herd. The genetic merit of animals in this herd could therefore have a marked influence in the national Saanen herd. The genetic and phenotypic trends for milk production parameters in this herd would also affect trends in the national herd because of the large number of does in the Fairview herd. Although no information is available at present, it is probable that the herd is a mayor source of genetic material to the national dairy goat herd. Because the herd has to maintain a specific herd structure, a considerable number of surplus does and bucks would be available annually that could be sold to other breeders. At present breeders wanting to acquire these young animals for breeding purposes only have information on their pedigrees, conformation traits and phenotypic performances of their mothers.

A within herd genetic analysis of the Fairview herd was therefore considered necessary to provide information on the genetic merit of does and bucks in the herd. Breeders wanting to acquire animals for breeding purposes in their own herds could therefore use this information to identify animals of superior genetic merit. If the breeding programme of the Fairview herd is placed on a sound genetic basis, it could make a substantiable contribution to the national herd. Artificial insemination (AI) could for example be used to improve the genetic merit of the herd more speedily. Although through BLUP, the national herd could be considered to be a nucleus herd, consideration should be given of using the Fairview herd as a nucleus herd to provide bucks and does for breeding purposes in an effort to improve the genetic merit of the national herd. Dairy farmers initially find the concept of breeding values as too abstract and are generally reluctant to employ this concept in their breeding programmes. However, after seeing the results in their herds and in the national herd, the use of genetic information on sires and cows have become relatively common practice in the breeding and selection programmes of dairy herds. This has resulted in a marked improvement in the production performances of dairy cattle (Muller & Botha, 2003). In this study genetic parameters and genetic and phenotypic trends for milk production traits were estimated for the Fairview Saanen dairy goat herd.

6.2 Materials and methods

6.2.1 Data set

The Fairview herd is situated near Paarl in the winter rainfall region of South Africa. The farm is at an altitude of 185 m, longitude 18° 68’ and latitude 33° 48’. The Fairview herd was established in 1979 and milk from the herd has been used for the production of specialised cheese products. Milk recording has been done in the herd since 1980. Does are machine milked twice a day. For milk recording, the total daily milk yield of each doe that had been in milk for at least seven days was recorded every four weeks until 1998 and every five weeks since then (De Waal & Heydenrych, 2001). Milk samples of each doe were collected at the evening and following morning’s milking, composited and analysed for fat, protein and lactose content with a Milko Scan Infrared Analyser in the central laboratory of the South African Milk Recording Scheme.

All does are fed commercial pelleted total mixed rations according to the NRC (1981) requirements. Total mixed rations (TMR) consist mainly of oat and lucerne hay, wheat, maize, wheaten bran, cottonseed oil cake meal, fishmeal, feed lime and salt. The TMR is provided *ad libitum* from self feeders. Feed troughs are cleaned at least twice a week to prevent residues building up. Different diets are provided according to the level of milk production.

Initially very little attention was given to improve the average milk yield of ewes in the Fairview herd. Breeding for type to improve body conformation traits was the main emphasis during the early years after the herd was established. Artificial insemination of does has been done on a limited scale in the herd since 1998. Some effort has been made recently to improve udder traits in the herd by culling does with exceptionally poor udders. Does are serviced during March to April for kidding to take place during August and September.

Records from the Fairview herd of all lactations longer than 60 days to a maximum of 305 days in milk from the 1988 to 2001 milk recording years were included in the analysis. Age at first kidding age had to be more than 10 months while other information included kidding date, sire and dam identification. A total of 2288 lactation records from 967 does (2.38±1.44 lactation per doe) and sired by 68 bucks was available for the analyses. The pedigree file consisted of 2192 records. The data set lacked information regarding the identification of bucks and does. Only 548 animal records could be identified positively with both bucks and does. Some 1153 records had no information on bucks and 548 records had no information of the identification of does. Although lacking some pedigree data, the full pedigree file was used to account for all known relationships.

6.2.2 Statistical analysis

The ASREML software package developed by Gilmour *et al*. (1999) was used for the estimation of the fixed effects, and also subsequently to derive variance components for the respective production traits in unitrait analyses. Fixed effects that were considered included year of kidding (1987-2001) and lactation number (1-6). Trends with regard to lactation number were modelled, using cubic splines (Verbyla *et al*., 1999). The splines initially consisted of three components, namely: a fixed linear component, random deviations from linearity following a smooth trend, and random deviations from linearity not conforming to a smooth trend. The latter effect was not significant ($P<0.05$) and was excluded from further analyses. Initial analyses involved fitting various combinations of fixed effects, random spline components and interactions between them to obtain an operational model. Lactation period was included as a covariate in analyses involving production and percentage traits, to account for the effect of the number of days in milk on the various production parameters. Effects found to be significant ($P<0.05$) in preliminary analyses were retained in subsequent analyses. Random terms were then added to the operational model, resulting in the following genetic models for analyses (in matrix notation):

$$y = Xb + Z_1c + e \quad (1)$$

$$y = Xb + Z_2a + e \quad (2)$$

$$y = Xb + Z_2a + Z_1c + e \quad (3)$$

In these models, y was a vector of observations for production or percentage traits; b, a and c were vectors of fixed effects, direct genetic effects and doe permanent environmental effects; X, Z_1 and Z_2 were the corresponding incidence matrices relating the respective effects to y, and e the vector of residuals.

It was assumed that:

$$V(a) = A\sigma^2_a;\ V(c_{PE}) = I\sigma^2;\ V(e) = I\sigma^2_e,$$

with A being the numerator relationship matrix, I being an identity matrix; and σ^2_a, σ^2_c, and σ^2_e being the direct genetic variance, ewe permanent environmental variance and environmental (residual) variance, respectively.

Log likelihood ratio (LRT) tests were conducted to determine the most suitable model for each trait in uni-trait analyses. The LRT's were based on testing twice the increase in Log likelihood resulting from adding random terms to the model of analysis as a Chi^2 statistic. Alternatively, for two models with the same number of random effects, and assuming identical fixed effects models, the one with the higher likelihood fits the data better. Subsequently, 2-trait animal models were fitted. These analyses allowed the calculation of all relevant direct and doe permanent environment correlations between traits, together with their appropriate standard errors. Relative breeding values of individual animals were obtained from back solutions and averaged within birth year. The average breeding values were regressed on birth year to obtain genetic trends. Environmental trends were obtained from subtracting the average breeding values for the different production traits from the phenotypic values for production year.

6.3 Results and discussion

The number of records and means (± standard deviation) for production parameters for Saanen dairy goats in the Fairview herd are presented in Table 6.1. Yield parameters are higher than those reported by Hallowell (2002) for the national herd. The coefficients of variation for yield traits were high and exceeded 28% with the exception of fat and protein percentages. These production values accord to a large extent to those in Table 4.1 (Chapter 4) depicting production parameters for the national herd possibly shows the large effect of this herd on the national herd.

Table 6.1 The number of records and means (± standard deviation) for production parameters for Saanen dairy goats in the Fairview herd

Production parameters	Number of records	Means±SD
Milk (kg)	2288	943±281
Fat (kg)	2288	28.3±8.8
Protein (kg)	2286	25.1±7.6
Fat (%)	2288	3.02±0.46
Protein (%)	2286	2.67±0.21
Lactation period (days)	2288	275±50

SD: Standard deviation

Factors affecting milk yield traits were the length of the lactation (fitted as a linear covariate), year of kidding and parity. Phenotypically, the milk yield of does declined from about 1030 to 900 kg per lactation from 1988 to 1993 and then increased to about 940 kg per lactation in 2001 (Figure 6.1). Fat and protein yields followed the same general trend. All yield traits increased with parity, reaching a maximum at third lactation (Figure 6.2). Protein percentage declined from 2.84% in 1990 to 2.50% in 1993, increasing again to about 2.70% in the 2000 production year (Figure 6.3). Fat percentage varied around 3.0%. Fat and protein percentages showed generally a downward trend from first to sixth lactation (Figure 6.4).

Donkin & Boyazoglu (2000) found that the milk yield of Saanen dairy goats in South Africa was 706 kg per lactation over all lactations. Lactation periods, however, varied from 164 to 300 days. The milk yield of dairy goats over all breeds in Poland was 570 kg per lactation with a mean fat and protein content of 3.52 and 2.93%, respectively (Bagnicka *et al.*, 2002). In The Netherlands, the average 305-day yield for milk, fat and protein of first parity dairy goats were 852, 34 and 28 kg, respectively (Van der Linde & De Jong, 2002). Corresponding figures were 949, 38, 32 for second parity goats and 958, 38 and 32 kg for third parity goats. However, reviewing the performance of dairy goats in different countries is difficult because of different production systems. Often these are not described clearly (Serradilla, 2001). Generally higher production levels are achieved in more intensive systems.

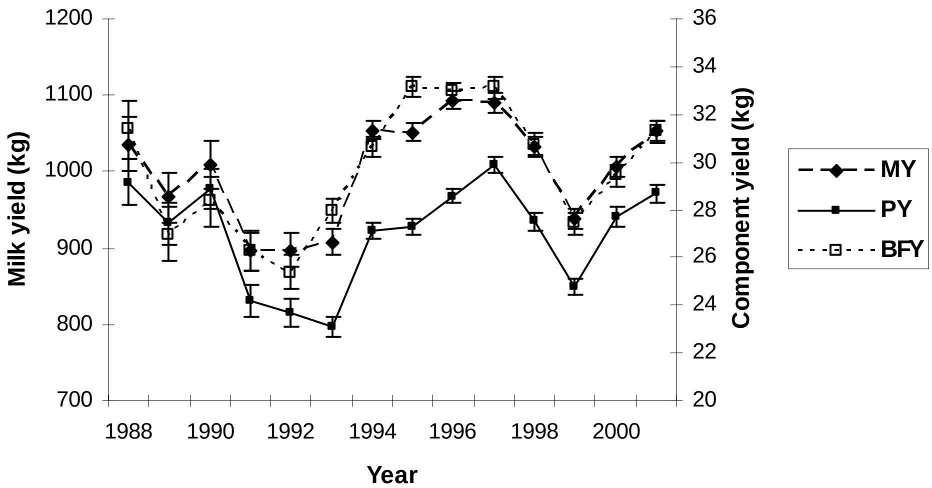

Figure 6.1 The change in phenotypic mean milk (MY), butterfat (BFY) and protein yield (PY) of Saanen dairy goats in the Fairview herd as affected by production year. Vertical bars about the mean indicate standard errors

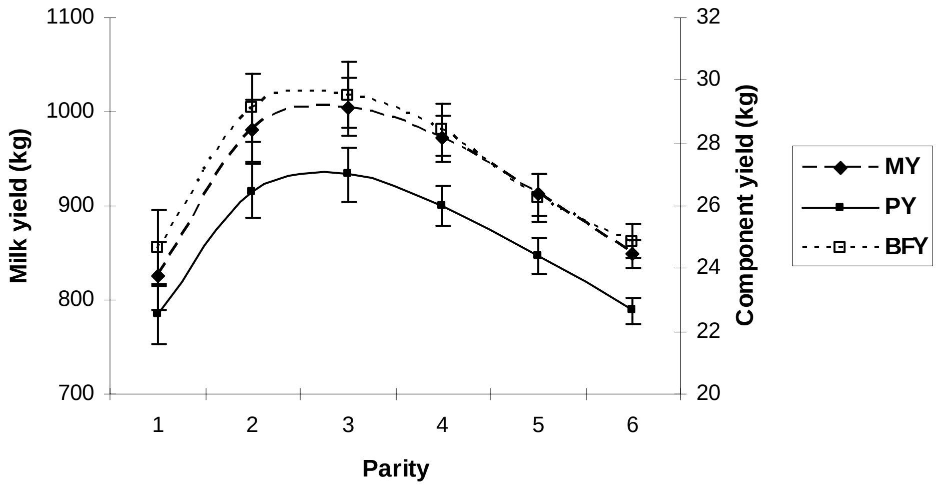

Figure 6.2 The change in phenotypic mean milk (MY), butterfat (BFY) and protein yield (PY) of Saanen dairy goats in the Fairview herd as affected by parity. Vertical bars about the mean indicate standard errors

According to Montaldo & Manfredi (2002) the milk yield in dairy goats varied to a greater extent than in dairy cows. This, combined with the shorter generation interval and higher reproductive efficiency, results in a higher biological potential to obtain a faster genetic progress for milk production traits.

Barillet *et al*. (1998) noted that, although goat's milk is used exclusively for cheese production, the protein concentration of goat's milk is often lower than that of sheep's or even cow's milk. To reduce the production cost of milk products such as cheese, the protein percentage of milk should be increased without reducing protein yield. This is should be achieved by increasing the volume of milk while maintaining the protein percentage in the milk.

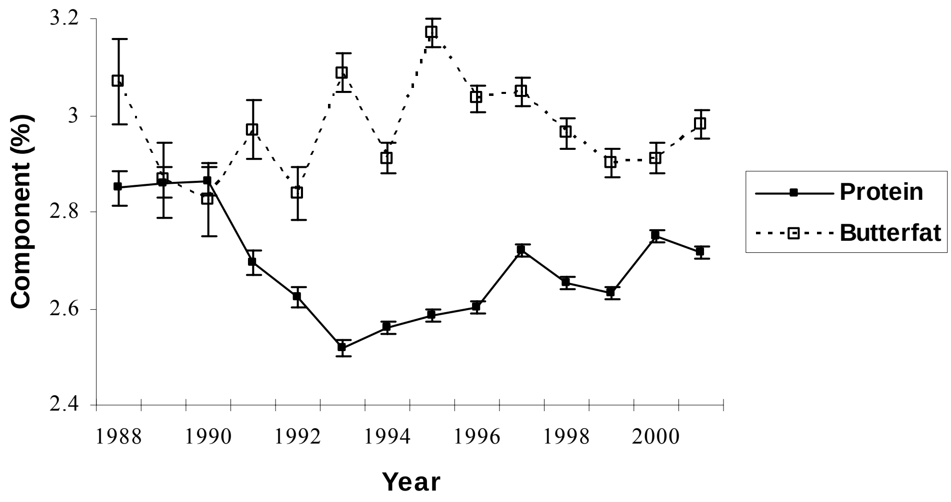

Figure 6.3 The change in phenotypic mean butterfat and protein percentages of the milk of Saanen dairy goats in the Fairview herd as affected by production year. Vertical bars about the mean indicate standard errors

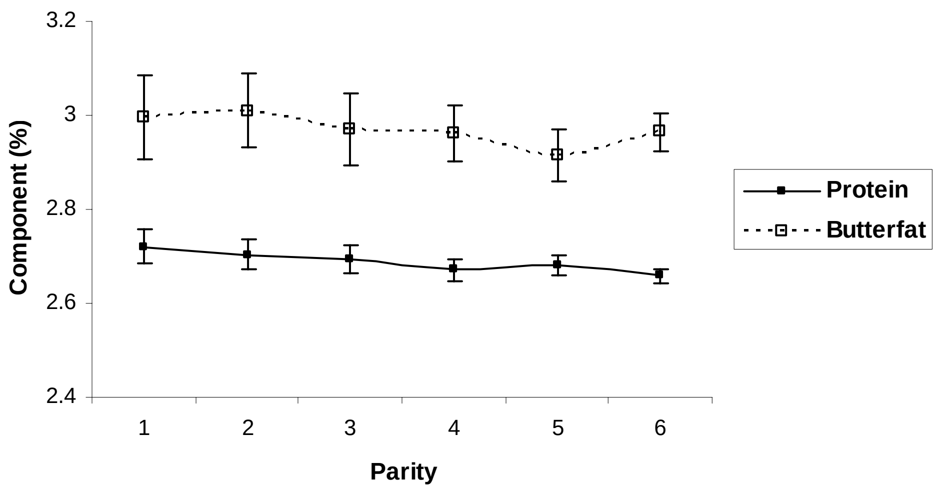

Figure 6.4 The phenotypic mean butterfat and protein percentages of the milk of Saanen dairy goats in the Fairview herd as affected by parity. Vertical bars about the mean indicate standard errors

The model of choice for all production parameters was model 3 that included the fixed effects, permanent environment and animal/additive effects (Table 6.1). According to Montaldo & Manfredi (2002) in most countries with a substantial number of dairy goats and reliable pedigree and recording systems, genetic values are predicted using an animal model for BLUP (Best Linear Unbiased Prediction) analyses. In France and the USA unitrait models are used for the prediction of breeding values for milk, fat and protein production.

Table 6.1 Log likelihood ratios for lactation period (days in milk) and milk production parameters for Saanen dairy goats in the Fairview herd under different models of analysis (Operational model = Fixed effects; Model 1 = Fixed effects + c^2 ; Model 2 = Fixed effects + h^2; Model 3 = Fixed effects + c^2 + h^2) The best model is indicated in bold figures.

Traits	Model fitted			
	Fixed effects	Fixed + c^2	Fixed + h^2	Fixed + c^2 + h^2
	Operational model	Model 1	Model 2	Model 3
Lactation period	-10006.6	-10006.6	**-10002.5**	-10002.5
Milk yield	-13088.4	-12883.2	-12863.2	**-12860.3**
Fat yield	-5335.73	-5203.76	-5194.34	**-5190.19**
Protein yield	-4828.13	-4657.04	-4636.20	**-4633.98**
Fat (%)	653.841	796.219	788.042	**800.782**
Protein (%)	2581.83	2880.92	2879.87	**2889.37**

Random effects: c^2 = permanent environment; h^2 = additive

Heritability (h^2) estimates for milk, fat and protein yield as well as protein percentage were in the moderate range while it was low for fat percentage (Table 6.2). This is in contrast to the very high h^2 estimate of 0.67±0.08 for fat percentage for first parity does in the national herd (Table 5.2). The h^2 estimate for fat yield in the Fairview herd was also lower than for fat yield for first parity does, i.e. 0.21±0.05 in comparison to 0.37±0.08.

A within herd genetic evaluation is not common probably because dairy goat herds are generally small consisting of only a few does. In Spain, most herds (77%) had less 100 does and only a few (5%) had more than 200 does

(Analla *et al*., 1996). However, often many organisational and logistic issues hamper the genetic evaluation of dairy goat breeds on a national scale. For single large dairy goat herds some of these issues are not relevant making a within genetic evaluation possible when a sufficient data set is available. In Brazil, Ribeiro *et al.* (2000) using an animal model, found that the h^2 estimate for milk yield of hand-milked Saanen does kept in a semi-confined housing system was 0.09, a value that is much lower than other estimates reported in the literature. The use of information from only one herd was probably not enough to get good estimates of genetic and phenotypic parameters. However, this estimate is regarded as very important as it is one of the first estimates obtained for the dairy goat population in Brazil. It should be considered as an indicator in the national breeding programme. The repeatability estimate for milk yield was 0.20 indicating that the effect of the permanent environment was more expressive than the genetic additive effect. The same situation almost applies in the State of Guanajuato in Mexico where the first genetic evaluation involving 12 herds and 1 045 animals was released using an animal model-BLUP for total milk production (Montaldo *et al*., 2001 as cited by Montaldo & Manfredi, 2002).

Montaldo & Manfredi (2002) in France using an animal model, found that h^2 estimates for milk, fat and protein yield in dairy goats from farm records were generally similar (ranging from 0.20 to 0.40), while h^2 of percentage traits were often higher or similar to those for yield traits. This was also reported by Du Toit *et al*. (1998), using an animal model, found that h^2 estimates for fat and protein percentages for Jersey cows were higher than similar estimates for yield traits, i.e. 0.45 to 0.65 for percentage traits and 0.25 to 0.35 for yield traits.

A key component of a sound genetic evaluation is correct pedigree and performance data as errors could bias predicted breeding values or limit the accuracy of breeding values (Betrand & Wiggans, 1998). In total, 56% of does in the present study did not have complete pedigree records. In Poland it was also found that 30% of dairy goats lacked data on their parents, while some bucks contributed less than 10 daughters each (Bagnicka *et al.,* 2002).

The lower h^2 estimate for fat percentage in the present analysis is probably also an indication of the large effect of the environment on the fat content of milk. Fat percentage is usually more affected by changes in the diet and other environmental conditions than protein percentage. Barillet *et al.* (1998) also found that using standard milk recording tests, genetic parameters on a total lactation basis for dairy traits in goats follow the same pattern as in dairy cattle. Heritability estimates for milk, fat and protein yields were moderate (~ 0.30), although smaller than for fat and protein percentages (~ 0.50 to 0.60). They also found the heritability estimate of fat percentage to be more variable than the estimate of protein percentage.

Table 6.2 Estimates of variance components and ratios for milk production traits in a commercial Saanen dairy goat herd (σ^2_a : additive variance; σ^2_c : doe permanent environment variance; σ^2_e : environment variance)

Variances and ratios	Yield traits			Percentages	
	Milk	Fat	Protein	Fat	Protein
<u>**Variances:**</u>					
σ^2_a	10692.3	8.1002	7.5319	0.0235	0.0101
σ^2_c	4047.4	5.4155	2.5538	0.0521	0.0096
σ^2_e	19890.5	24.8249	14.5261	0.1220	0.0164
<u>**Ratios:**</u>					
h^2	0.31±0.06	0.21±0.05	0.31±0.06	0.12±0.05	0.28±0.07
c^2	0.12±0.05	0.14±0.05	0.10±0.05	0.26±0.06	0.27±0.07

h^2 : heritability c^2: permanent environment

Correlations among the yield traits were high to very high at all levels of assessment (Table 6.3). As expected, yield parameters increased with lactation period, i.e. days in milk. Fat and protein yields increased with increasing milk yields. However, as for dairy cows, butterfat and protein percentages were negatively correlated to milk yield. Correlations of butterfat yield with butterfat percentage were positive. Genetically, the correlation between fat and protein percentage was highly positive. Changes in the fat percentage of milk would therefore also affect protein percentage. Barillet *et al*. (1998) also found that milk yield and fat and protein yields were highly related (~ 0.8 to 0.9), while milk yield was negatively correlated to fat and protein percentages (-0.4 for protein content and -0.3 for fat percentage).

Table 6.3 Estimates of genetic, permanent environment, environmental and phenotypic correlations for Saanen dairy goats in the Fairview herd

Traits	Correlations			
	Genetic	Permanent environment	Environmental	Phenotypic
Lactation interval x:				
Milk yield	0.48±011	-	0.75±0.01	0.67±0.01
Fat yield	0.60±0.12	-	0.68±0.01	0.63±0.01
Protein yield	0.53±0.11	-	0.75±0.01	0.68±0.01
Fat %	0.41±0.21	-	-0.21±0.03	-0.12±0.02
Protein %	0.13±0.14	-	0.14±0.03	0.11±0.02
Milk yield x:				
Fat yield	0.86±0.06	0.62±0.16	0.81±0.01	0.79±0.01
Protein yield	0.94±0.02	0.85±0.08	0.95±0.02	0.94±0.003
Fat %	-0.44±0.19	-0.17±0.22	-0.06±0.03	-0.15±0.02
Protein %	-0.15±0.16	-0.37±0.24	-0.07±0.03	-0.15±0.03
Fat yield x:				
Protein yield	0.93±0.04	0.66±0.15	0.80±0.01	0.81±0.01
Fat %	0.06±0.25	0.67±0.15	0.45±0.02	0.42±0.02
Protein %	0.27±0.18	-0.09±0.23	-0.01±0.03	0.05±0.03
Protein yield x:				
Fat %	-0.23±0.22	0.05±0.24	-0.03±0.03	-0.05±0.02
Protein %	0.27±0.18	-0.09±0.23	-0.01±0.03	0.05±0.03
Fat % x:				
Protein %	0.73±0.16	0.29±0.15	0.05±0.03	0.25±0.02

Ilahi *et al.* (1998) similarly found negative correlations between milk yield and milk component percentages (-0.48 and -0.27 for protein and fat, respectively) with a high correlation between protein and fat percentages.

The genetic trends for milk production parameters in the Fairview Saanen goat herd are presented in Figure 6.5. Genetic trends for milk, fat and protein yield, although positive, did not differ significantly from zero. Large variations between years (R^2 <0.13) were observed. More than 20% of does had estimated breeding values of zero for production traits probably because of missing pedigrees and/or production parameters. Relative breeding values for production traits declined from 1990 to 1995 and then increased until 1998. The extremely low average estimated breeding values for production traits during 1995 could be related to four bucks that resulted in almost 50% of does with negative estimated breeding values. Almost 70% of does in this year were descendants of two bucks.

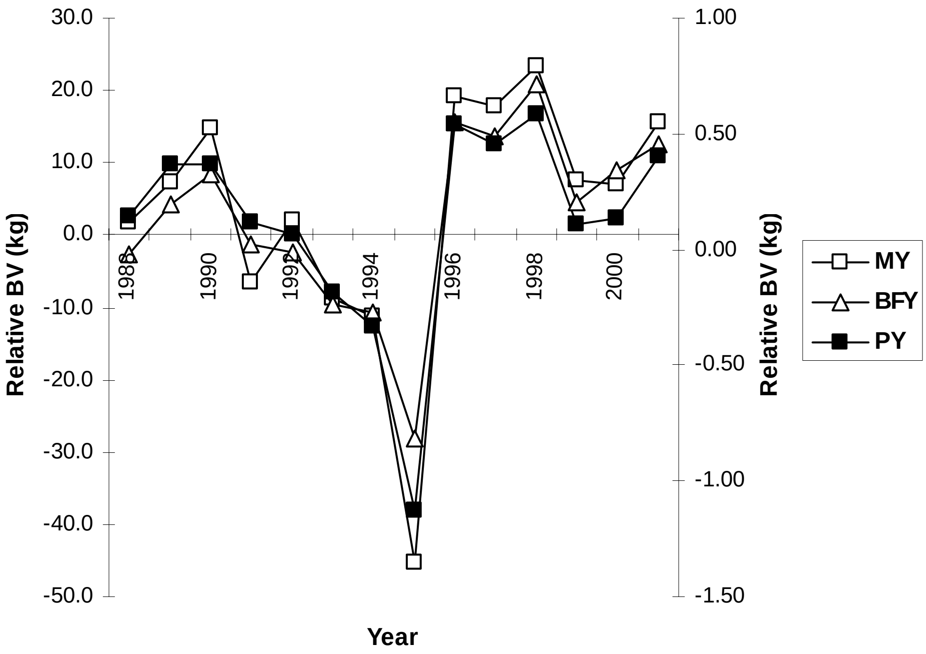

Figure 6.5 The change in relative breeding value (BV) for milk (MY), butterfat (BFY) and protein yield (PY) for Saanen dairy goats in the Fairview herd as affected by year of birth

The genetic trends for butterfat and protein percentages in the milk of Saanen dairy goats in the Fairview herd are presented in Figure 6.6. Genetic trends for fat and protein percentages were positive and negative ($P<0.05$), respectively. These trends probably occurred by chance. It would be very difficult to achieve this as there is normally a positive correlation between fat and protein percentage in the milk of dairy cows. In Table 6.3 the positive genetic and phenotypic correlations between fat and protein percentage are confirmed. It also makes no sense to have such a breeding policy as the Fairview herd is producing milk for cheese production, the aim of the breeding policy should be to improve the protein percentage in the milk in effort to reduce the production cost of cheese (Muller & Robertson, 2004).

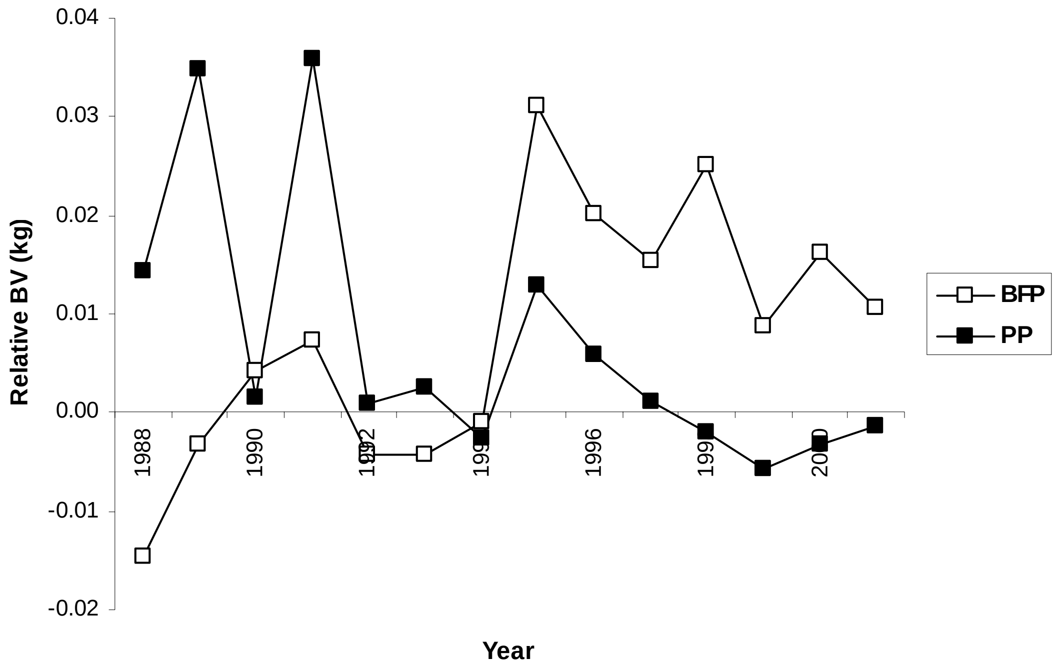

Figure 6.6 The change in relative breeding value (BV) for butterfat (BFP) and protein percentage (PP) of Saanen dairy goats in the Fairview herd as affected by year of birth

Clement *et al.* (2002) found that the annual genetic gain in milk yield for Saanen goats in France was 12.5 kg. In the USA the annual genetic increase in milk yield was 7.0 kg (USDA, 2001). In the USA, genetic gains for fat and protein yields were 0.32 and 0.23 kg per year while in France similar gains were 0.48 and 0.46 kg per year. In The Netherlands, Van der Linde & de Jong (2002) found a positive genetic trend for milk, fat and protein yield over an eight year period from 1992 to 2000. The average breeding values (kg) for

305-day yields of milk, fat and protein started at –22.2, -0.9 and -0.9 kg and increased to 40.0, 1.7 and 1.5 kg, respectively. Ribeiro *et al.* (1998) found that the breeding values for milk yield of Saanen does in Brazil showed a quadratic response over a 14 year period with a positive trend of 0.73 kg/year during the last 10 years.

An initial genetic evaluation of this kind should be regarded as a starting point for any breed. Even in the Netherlands, the dairy goat industry did not have the tools to improve the milk yield of does by selection until as recently as 2000 (Van der Linde & De Jong, 2002). Since then the genetic evaluation of dairy goats is routinely carried out twice a year in that country. For Dutch dairy goat farmers, the implementation of a genetic evaluation system is likely to improve current selection decisions. This should result in higher selection efficiencies within the Dutch dairy goat breeding programme.

In France, genetic improvement of dairy goats started in the 1960's. A selection programme was developed on a national scale for the Alpine and Saanen breeds (Clement *et al.,* 2002). The main selection objective has been the improvement of protein yield and protein percentage of milk to improve cheese yield. Genetic evaluations (for milk, fat and protein yield and fat and protein percentage) are performed three times per year. Similarly in Spain, a selection programme was started in 1990 in the two main milk producing regions of Andalucia and Murcia in more than 50 herds in each region and comprising of more than 10000 does. The selection objective for these farmers is to increase the total milk yield of their dairy goats while maintaining fat and protein percentages in the milk. These percentages are at present about 5 g of fat and 3 g of protein/100g of milk. An animal model with repeated records is used for the genetic evaluation of the animals (Analla, *et al*, 1996). In South Africa the Fairview herd provides an ideal opportunity to improve the genetic merit of the national dairy herd as the selection objective in that herd should be similar to that of the national herd. The number of dairy goats in milk recording should, however, be increased for an improved genetic evaluation. Genetic ties between herds should also be increased. This could be done by using a nucleus herd breeding system or by using AI of does with fresh or frozen semen more widely. Progeny testing of bucks in this country should also be considered to prevent having to rely on imported semen to improve the genetic quality of South African dairy goats.

6.4 Conclusions

Genetic parameters for yield traits in the Fairview herd are in accordance with values obtained in the literature although the heritability of fat and protein percentages were lower than expected. Genetic trends for yield traits were, although positive, not significant and showed large variation between years. Genetic trends for fat and protein percentages were positive and negative, respectively. A large number of animals lacked production data linked to pedigree information. Organizational and logistic issues concerning pedigree and milk recording need to be addressed to allow South African dairy goat producers access to complete and correct information regarding the genetic merit of individual animals on a national level.

CHAPTER 7

ESTIMATION OF GENETIC PARAMETERS FOR SOME REPRODUCTION PARAMETERS IN THE SOUTH AFRICAN SAANEN GOAT HERD

7.1 Introduction

The reproductive performance of dairy goats is one of the most important functional traits affecting the production cost of milk and genetic improvement of herds. The feeding cost of non-producing animals (young kids and non-lactation does) in a dairy herd is part of the production cost of milk. It is therefore clear that a larger number of such animals would increase the cost of milk production. On the other hand, a smaller number of progeny, i.e. kids per doe, would reduce the selection pressure in a herd. Various reproduction parameters may be used to define performance of does. For dairy cows, reproduction parameters such as age at first calving, number of lactations completed, productive life (the total number of months per lactation that a cow is in milk up to 10 months per lactation), intercalving period, number of inseminations per conception and longevity are routinely used. These parameters are at present not being recorded for dairy goats. Some reproduction parameters could be calculated from information such as birth and kidding dates normally recorded for milk recording purposes. These parameters include age at first kidding (AFK), age at last kidding (ALK), productive life (PL), kidding interval (KI), survival to next lactation and number of kiddings (NK).

Goats reach puberty as early as 4 – 6 months and full sexual maturity at 6 –8 months of age (Doney *et al*., 1982). The average AFK for Alpine, La Mancha, Nubian, Saanen and Toggenburg goats in the southern United States were 12.5, 12.5, 13.1, 12 and 12 months, respectively (Majid *et al*., 1993). According to the South African National Dairy Animal Improvement Scheme, AFK for registered and grade dairy goats in milk recording is 14 months (Hallowell, 2002). It is possible for goats to have a KI of 8 months although their pronounced seasonality of reproduction causes breeding to be mainly in the autumn months (Doney *et al*., 1982) resulting in little variation in KI. Kidding interval between first and second kidding for registered and grade dairy goats in South Africa was 345 and 466 days, respectively (Hallowell, 2002). The KI of various goat breeds in Poland was 363 days between first and second kidding (Bagnicka & Lukaszewicz, 2000).

There is no information about reproduction parameters other than AFK and KI for dairy goats in South Africa. No attempt has been made up to now to estimate heritability values for reproduction parameters for either dairy goats or dairy cows in South Africa. To estimate genetic parameters for reproduction traits is difficult as some parameters are described only as discrete values (i.e. 1 = pregnant and 0 = not pregnant), a large variation is shown among animals, it is measured late in an animal's life, it is sex-limited and little genetic variation is observed. This makes for computational difficulties. Producers have always used milk yields or conformation traits as a basis to cull or select animals. In this study genetic parameters, genetic and phenotypic trends and correlations among some reproduction traits were estimated for Saanen goats in the national dairy herd.

7.2 Materials and Methods

7.2.1 Data set

The data set used in this study consisted of pedigree information of all grade and registered Saanen goats of all parities that had started and completed a lactation or part of a lactation for production years between 1981 and 2001. The pedigree file consisted of 8294 records. The data set lacked information regarding the identification of bucks and does. A total of 2171, 1389 and 1300 records had no information on bucks, dams and both bucks and dams, respectively. Also in this analysis, although lacking some information, the full pedigree file was used to account for all known relationships.

Reproductive parameters, i.e. age at first kidding, age at last kidding, productive life and number of lactations were obtained from milk production records of these animals from the Animal Performance Scheme of the Animal Improvement Institute. Kidding intervals between lactations were calculated by subtracting the first kidding date from the second kidding date and repeating this calculation up to the fifth lactation. Productive life (in months) was calculated by adding all lactation periods (up to 305 days per lactation) and dividing the total by 365/12.

Although milk recording started as early as 1957, only a few records were available before 1980. Some 12430 records from 5492 goats were initially available. Only records of Saanen goats complying to the following minimum standards were, however, used:

(a) lactation length: 60 – 305 days
(b) minimum age at first kidding: 8 months
(c) maximum age at first kidding: 28 months
(d) maximum age at last kidding: 120 months
(e) birth date recorded
(f) animal identification
(g) lactation number
(h) owners with more than 75 records each

After these requirements were met, and depending on the trait considered, the number of records available for the analyses ranged between 3431 and 3771 records. There were only 10 owners that had 75 or more records indicating that herds in the national flock were generally small. Records from one owner (Fairview) comprised 55% of all records while for some owners there were no records for some years between 1981 and 2001.

7.2.2 Statistical analysis

The ASREML software package developed by Gilmour *et al.* (1999) was used for the estimation of the fixed effects, and also subsequently to derive variance components for the respective reproduction traits in univariate analyses. Fixed effects that were considered included year of birth and owner. Effects found to be significant ($P<0.05$) in preliminary analyses were retained in subsequent analyses. The random term of animal was then added to the operational model, resulting in the following genetic model for analyses (in matrix notation):

$$y = Xb + Z_1a + e \qquad (1)$$

In this model, y was a vector of observations for reproduction traits; b and a were vectors of fixed effects and direct genetic effects; X and Z_1 were the corresponding incidence matrices relating the respective effects to y, and e the vector of residuals.

It was assumed that:

$$V(a) = A\sigma^2_a; \; V(e) = I\sigma^2_e,$$

with A being the numerator relationship matrix, I being an identity matrix; and σ^2_a and σ^2_e being the direct genetic variance and environmental (residual) variance, respectively.

In the case of kidding interval, random direct additive genetic and permanent environment doe effects were fitted to the data. The fixed effects that were considered included year of kidding, parity number and owner. For traits other than KI, 2-trait animal models were subsequently fitted. These analyses allowed the calculation of all relevant direct and doe permanent environment correlations between traits, together with their appropriate standard errors.

7.3 Results and discussion

Reproductive parameters derived from milk recording records for Saanen dairy goats in the national herd are presented in Table 7.1. Reproductive parameters varied to a great extent with coefficients of variation for AFK, ALK, PL and NK being 37, 69, 72 and 61%, respectively. This was to be expected as the data set included all animals that had kidded at least once. ALK varied to a greater extent as a longer PL and NK resulted in a higher values for ALK.

Table 7.1 The number of records and reproductive parameters derived from milk recording information for Saanen dairy goats in the national herd

Traits	Number of records	Mean±SD
Age first kidding (AFK) (days)	3408	457±171
Age at last kidding (ALK) (days)	3771	1046±718
Productive life (PL) (months)	3143	19.3±13.9
Number of kiddings (NK)	3771	2.24±1.37
Kidding interval (KI) (days)	3601	365±49

SD: Standard deviation

The distribution of AFK for Saanen dairy goats in the national herd is presented in Figure 7.1. Mean AFK was 457 days (15 months) with most (54%) goats kidding between 350 and 400 days of age. The youngest AFK was below 300 days whereas the oldest AFK was in excess of 1225 days. It is unclear whether extremely late AFK in this data set is based on a deliberate management decision or poor data recording. Only AFK records below 1095 days were used.

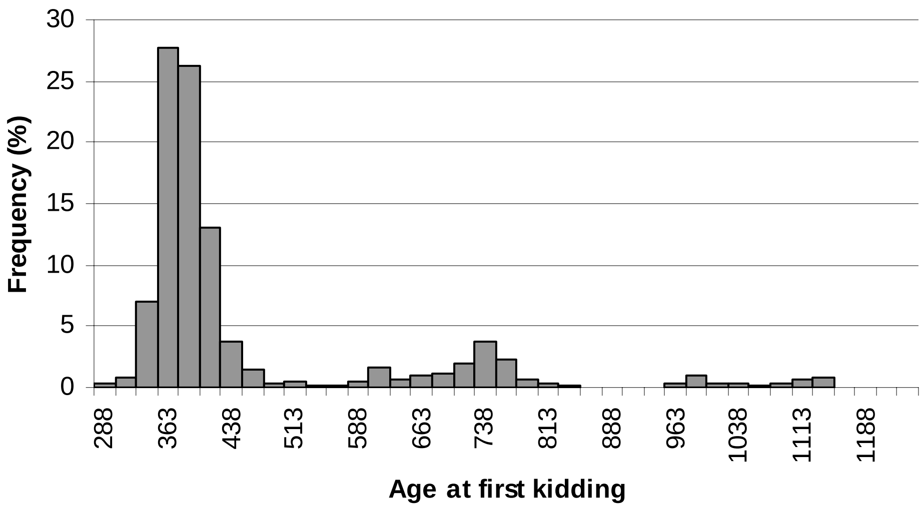

Figure 7.1 The distribution of age at first kidding (in days) for Saanen dairy goats in the national herd

Bagnicka & Lukaszewicz (2000) found that the average AFK of White Upgraded, Coloured Upgraded, Saanen and Alpine goats in Poland was 12.9 months. Ribeiro *et al*. (2000) found AFK in Saanen goats in Brazil to be 402 days with the youngest doe kidding at 252 days and the oldest at 732 days of age. Age at first kidding in the present study is similar to values reported by Wilson *et al*. (1989) and Galina *et al*. (1995). It is, however, lower than figures reported by other authors (Singh & Acharya, 1982) with estimates around 608 days (20 months) of age. Gonçalves *et al*. (1997) similarly found that average AFK for Brown Alpine, Saanen and Toggenburg goats in Brazil was 607 days. Age at first kidding was significantly affected by year and season of birth, i.e. 595, 611, 615 days, respectively for goats born in July – August, September – November and December – June. In Mexico, AFK was at 425±91 days of age (Silva *et al*., 1997).

According to Agraz (1984), as cited by Ribeiro *et al*. (2000), a very late AFK may lead to animals gaining weight because of excess fat deposition. This frequently results in poor fertility in young does. The main problem with a later AFK, however, is an increase in the rearing cost of young does, therefore adding to the total production cost of milk. This has a negative effect on farm income. An early AFK should, however, also be managed carefully as a low body weight at conception could result in does hurting themselves during kidding, with possible kidding problems and the loss of kids. Live weight at conception at 7 –8 months of age should be about 35 kg (Agraz, 1984, as cited by Ribeiro *et al*., 2000).

The kidding interval between successive kiddings for Saanen dairy goats in the national herd is presented in Figure 7.2. Kidding interval increased with age, i.e. 359 days between first and second kidding and 376 days between fourth and fifth kidding for Saanen goats.

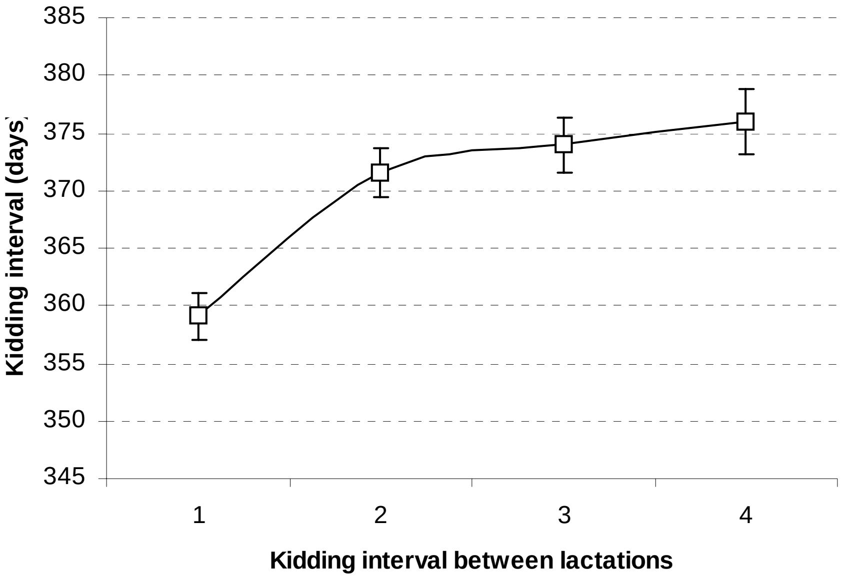

Figure 7.2 The effect of age on kidding interval for Saanen dairy goats in the national herd (Kidding interval = 1 represents the interval between first and second kidding dates)

According to Ribeiro *et al*. (2000) the KI of Saanen goats in Brazil was 328 days, while in Poland it was 363 days between first and second kidding for various goat breeds (Bagnicka & Lukaszewicz, 2000). Kidding interval depends on the herd management policy and may vary from 250 to 355 days (Kennedy *et al*., 1982).

The seasonality of reproduction is a common feature in dairy goat breeds originally from temperate latitudes, like Saanens. Photoperiod seems to be the key factor controlling reproduction. Under tropical conditions where the amplitude of photoperiodic changes is lower, some local breeds are either non-seasonal breeders or exhibit only a weak seasonality of reproduction (Simplicio, 1985 as cited by Lopes Junior *et al*., 2001). This might explain the lower KI observed by Ribeiro *et al*. (2000) although management practices to provide milk evenly through the year could have been adopted as well. According to Sarmento *et al*. (2003) the average (±SD) KI of crossbred dairy goats in Brazil was 276±61 days.

Kidding interval was affected by lactation length and a shorter KI would be obtained by better management. According to Gonçalves *et al*. (1997) the average (±SD) KI for Alpine goats in Brazil was 339±13 days. It was significantly affected by year and season of kidding while age and breed or sire had no effect on KI. Kidding interval for Alpine dairy goats in a semi-arid area of Mexico was 345±70 days, varying from 339±72 days in yearlings to 346±57 days in adults (Silva *et al*., 1997). In that study it was further found that season affected ($P<0.05$) KI with it being 324, 262, 481 and 364 days in spring, summer, autumn and winter, respectively. The mean KI for various goat breeds in the United States of America varied between 352 and 361 days (Ali *et al*., 1983). Minimum and maximum kidding intervals for these breeds were 181 and 510 days, respectively.

According to Leboeuf *et al*. (1998) the reproductive seasonality of dairy goats has some economic consequences in France as the concentration of kidding dates leads to the production of milk with a low solids content in spring and summer. This is mainly the result of the seasonality of the sexual activity of dairy goats. This usually starts at the end of summer and is the highest in autumn. The sexual activity of goats is stimulated by decreasing photoperiod. The market for dairy goat milk products demands a regular year long supply of milk with an adequate chemical composition. To overcome the problem of seasonality in dairy goats in France, artificial insemination (AI) of does was developed to accomplish two objectives, i.e. (1) to contribute to the optimization of breeding schemes and (2) to control kidding dates to satisfy cheese market demands.

With the exception of KI, very little information is available in the literature on other reproductive parameters for dairy goats. It is important to note the difference between PL and NK as reproductive parameters. PL reflects the number of days (or months) that a specific animal is in active production while number of lactations is an indication of the number of kiddings in that animal's lifetime. The advantage of a high average number of lactations (kiddings) for does in a herd could therefore be eroded if it is not supported by the maximum number of days in milk. In the present study, PL was 19.3 months, therefore indicating that the average Saanen doe in the national herd had only 1.93 completed lactations in her entire lifetime. This is in contrast to the 2.24 NK for the average doe. From Figure 3.7 in Chapter 3 it is clear that a considerable number of lactations were short. Only 58% of all lactation records of Saanen dairy goats in the national herd were longer than 290 days.

Variance components and h^2 estimates for reproductive parameters for Saanen dairy goats in the national herd are presented in Table 7.2.

Table 7.2 Variance components and heritability (h^2) estimates for some reproduction traits for Saanen goats in the national dairy herd

Traits	**Age at first kidding**	**Age at last kidding**	**Productive life**	**Number of lactations**
Variance components				
σ^2_a	3255.82	83564.2	12.348	0.0712
σ^2_e	9625.22	214829.0	139.262	1.4682
σ^2_p	12881.04	298393.2	151.610	1.5394
Variance ratios				
h^2±SD	0.25±0.04	0.28±0.04	0.08±0.04	0.05±0.03

SD : Standard deviation; σ^2_a : additive variance; σ^2_e : error variance; σ^2_p : phenotypic variance

Heritability estimates were 0.05 and 0.25 for number of lactations and AFK, respectively. Gonçalves *et al*. (1997) found h^2 estimates for AFK of 0.22 and

0.37, respectively when estimations were based on paternal half-sib correlations and Restricted Maximum Likelihood (REML) calculations. In contrast to this, Ribeiro *et al*. (2000) using an animal model with fixed effects being year of birth, season of birth, type of kidding at birth, and age of doe at kidding, found a h^2 estimate of 0.14 for AFK. The number of records in that study was, however, very small. The AFK data file had 284 observations from 108 does which were daughters of 14 bucks. From 9881 kiddings of 4944 dairy goats, Bagnicka & Lukaszewicz (2000) using REML animal model that included random effects of animal and herd-sire interaction, fixed effects of herd-year-season of kidding, year of birth, breed and regressions on age at kidding and litter size, found h^2 estimates for KI between first and second kidding and litter size of 0.13 and 0.15, respectively.

It is expected that AFK will be affected greatly by management decisions and the onset of reproduction. According to Ribeiro *et al*. (2000), animals in commercial herds rarely show their real genetic potential for early kidding. Management that allows does to grow out well and exposes them to males at an early age, will permit more reliable estimates of the genetic variability of this trait and the identification of the more sexually precocious does.

The effect of birth year on AFK is presented in Figure 7.3. Phenotypically, the trend for AFK of does increased from 1981 to 1989 by 3.3 days per year and then decreased to 2001 by 1.9 days per year. The genetic trend for AFK likewise increased by 6.9 days per year until 1992 and then declined by 8.6 days per year to 2001.

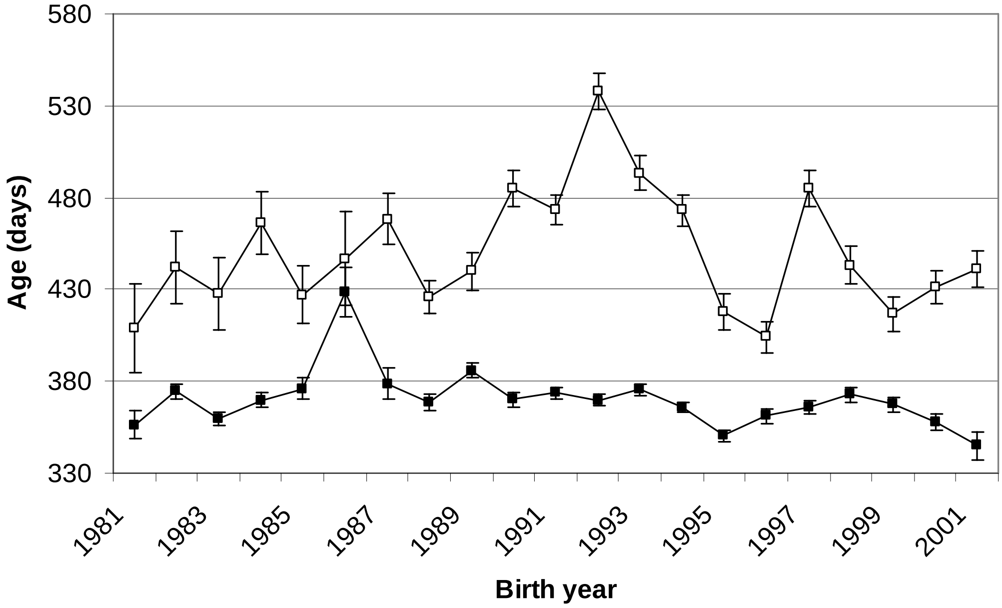

Figure 7.3 Phenotypic trends for age at first kidding (open squares) and kidding interval (filled squares) for Saanen dairy goats in the national herd as affected by birth year

Correlations among most reproduction traits were high to very high at all combinations of assessment (Table 7.3). As expected, PL and number of lactations were positively related to ALK. Likewise the genetic correlation between AFK and NK were positive, although not significant (P>0.05). The same applies for the negative genetic correlation between AFK and PL.

Table 7.3 Estimates of correlations among reproduction traits for genetic, environmental and phenotypic effects for Saanen dairy goats

	Correlations		
Parameters	**Genetic**	**Environmental**	**Phenotypic**
Age of first kidding x			
Age at last kidding	0.61±0.10	0.18±0.04	0.30±0.02
Productive life	-0.33±0.22	0.09±0.04	0.03±0.02
Number of lactations	0.30±0.29	-0.02±0.04	0.02±0.02
Age at last kidding x			
Productive life	0.49±0.09	0.91±0.01	0.79±0.01
Number of lactations	0.42±0.14	0.98±0.01	0.85±0.01
Productive life x			
Number of lactations	0.92±0.08	0.92±0.01	0.92±0.01

A recent study by Nilforooshan & Edriss (2004) similarly showed a negative phenotypic correlation of -0.093 between age at first calving and PL for Holstein cows in Iran. Although both the genetic correlation between AFK and PL in the present study and the phenotypic correlation between age at first calving and PL by Nilforooshan & Edriss (2004) for dairy cows were negative albeit not significant, it is still cause for concern as there is a general belief among dairy farmers that increasing age at first calving in dairy cows has a positive effect on herd life and therefore PL. Large variations between does probably resulted in a non-significant genetic correlation between these traits. Herd life is greatly affected by PL, the phenotypic correlation being 0.989 for Holsteins in Iran. In the present study the genetic and phenotypic correlations between PL and ALK were positive, i.e. 0.49 and 0.79, respectively.

Nilforooshan & Edriss (2004) noted that, when age at first calving for Holsteins exceeded 30 months, the period before first calving becomes greater than the average PL of cows. This means that the time of no income for cows (i.e. the period between birth and first calving) is greater than their productive period. For dairy goats in the national herd, the same situation almost applies as average AFK is late, i.e. 15 months of age and PL is short (19.3 months). This means that more attention should be given to getting dairy goats in production as early as possible. This is related to management decisions involving correct feeding diets and programmes. Lin *et al*. (1988) found that PL from first calving up to 61 months of age in dairy cows was longer for early-bred heifers than for late-bred heifers (623 *vs* 730 days of age), and that early calved heifers produced more milk in total (10693 *vs* 9218 kg) during the 61 month period. Ali *et al*. (1983) found that the phenotypic correlation between age at first kidding and KI was 0.12, indicating that factors associated with an increase in age at kidding are also associated slightly with prolonged intervals between kiddings.

It is generally believed that the variation in reproductive performance in dairy cattle is mainly environmental (Ali *et al*., 1983). This may also be the case for dairy goats, as they are seasonal breeders for most of the time. An understanding of factors contributing to seasonality of breeding in goats will be beneficial in explaining sources of variation in reproduction traits. In the present study, it was found that kidding interval had no genetic basis and that all variation in kidding interval was caused by other factors such as lactation number.

Kennedy *et al*. (1982) observed that although h^2 estimates could be determined for reproductive traits, estimates for traits such as age at first kidding, date of kidding and breeding year, were high, and in most cases exceeded the theoretical upper limit. They speculated that some breeding management practices and seasonality of breeding have contributed to making paternal half-sisters more alike in reproductive performance than has the genetic contribution of their sire. It was observed that within a herd, daughters of the same buck tend to be born at close to the same time. A possible reason for this is that some bucks may be used for only a part of the year to mate with as many does as possible. These bucks may be replaced later by other bucks. Because of seasonal breeding, kidding interval is further controlled by breeding management. Does not getting pregnant are probably culled, resulting in a loss in reproduction records.

In the South African dairy goat industry no effort has been made to improve the reproduction performance of dairy goats through breeding and selection. This has probably never been regarded as necessary, as goats normally have a high fertility (Knights & Garcia, 1997). In addition to this, goats have a shorter generation interval than cattle. Both these traits contribute to a higher reproductive efficiency. The fertility of goats is further enhanced by a high level of prolificacy. In some herds this was reported as 2.5 – 3.0 kids, although the average is generally 1.8 to 1.9 (Chemineau & Xande, 1982). Doney *et al*. (1982) also suggested that the fecundity of goats may vary from 100 to 400%, although averaging from 150 to 180% over all breeds.

Non-pregnant does at the end of a lactation are generally culled by producers. In dairy goats, as in the dairy cattle industry, profitability is affected by the efficiency of milk production and reproduction. The number of cows in milk expressed as a percentage of the total number of cows in the herd and the period from calving to conception (days open) are two factors that influence reproductive efficiency in dairy herds. It is unlikely that local dairy goat breeders have given any attention to any of these parameters in their breeding programmes.

In dairy cows, breeders have only recently started to give some attention to both milk yield and reproduction. This has to some extent been forced onto farmers as the reproductive rate of dairy cows has deteriorated over the last 20 to 25 years. In the United States the decline in the phenotypic trend for conception rate has been reported to be 0.45% per year between 1975 and 1997 (Beam & Butler, 1999 as cited by Pryce *et al*., 2000 and Butler & Smith, 1989). In the United Kingdom the decline in the phenotypic trend in conception rate was likewise 1% per year (Rogers *et al*., 1999). Most published genetic correlation estimates between milk yield and measures of fertility are unfavourable (Pryce *et al*., 2000).

As the genetic correlation between milk yield and reproductive performance of dairy cows is not unity, a selection index could be employed to improve both parameters or to maintain reproduction while improving milk yield. Although it is well known that the genetic effect on the reproductive performance of dairy cows is very small ($h^2 = 0.05$ for days open), there is a large variation among cows. The reproductive performance of dairy goats is also influenced by genetic and environmental effects and their interactions. Further studies are therefore needed to determine the reproductive performance of dairy goats and the genetic potential of does.

7.4 Conclusions

Age at first kidding for Saanen dairy goats was on average 457 days which is in agreement with other studies. A considerable portion (19%) of all dairy goats kidded for the first time beyond 500 days (16.4 months) of age. Heritability estimates for reproduction traits show that some parameters are largely affected by environmental conditions like management and factors such as seasonality of breeding. It was difficult to compare estimates between studies because of differences on breed, population sample, environmental and management factors. Other random and systematic errors may also affect estimates. More attention should be given to number of kiddings per doe and the productive life of does. A larger data set is needed to determine specific parameters for the South African dairy goat industry.

CHAPTER 8

A PROPOSED BREEDING PLAN FOR THE SOUTH AFRICAN DAIRY GOAT HERD

8.1 Introduction

The aim of breeding is to affect change in livestock to increase profitability, sustainability and ease of management at the production level (Kinghorn, 1997). This usually involves a large number of issues such as: breeding objectives to target, tools to use (i.e. performance and pedigree recording systems) and the design of a breeding programme. Other aspects include novel reproductive techniques, knowledge of population genetic parameters and genetic evaluations systems (Kinghorn, 1997).

It is difficult to formulate a national breeding programme for the dairy goat industry as, although individual farmers essentially provide the same product (white liquid), it is eventually used in a wide range of dairy products. The breeding programme for individual herds will therefore be influenced by the end product that the milk of a specific herd is intended for. In some countries like Spain, dairy goat farmers are being paid for the quantity of milk produced plus a bonus depending on fat content (Analla *et al*., 1996). However, this is an anomaly as the milk is used mainly for cheese making.

Fat or protein yield (and cheese yield) is affected by both the volume of milk and the percentage of fat and protein in the milk (Muller & Robertson, 2004). The cost of cheese production is reduced with an increase in the percentage of milk solids. Milk pricing structures should encourage the production of milk with a higher percentage of milk solids. For this reason the payment system in Spain has been revised to include a bonus for protein percentage (Analla *et al*., 1996). A selection programme was started for these farmers to increase the quantity of milk produced while maintaining the percentages of fat and protein in the milk. A breeding programme of this kind needs a genetic evaluation of the breed to provide estimated breeding values (EBV's) of animals for milk, fat and protein yield as well as for fat and protein percentages.

The heritability and repeatability estimates of production traits of dairy goats have been estimated (Muller *et al*., 2001 and Muller *et al*., 2002) and could be used for predicting EBV's of bucks and does in the South African Saanen dairy goat herd.

8.2 Breeding structures

Artificial insemination (AI) is a powerful tool to adapt milk production to market demands. It is widely being used by dairy farmers in South Africa to get cows pregnant. These herds therefore consist mainly of females (cows and heifers) of various ages with a few (one to four) bulls to be used on cows not conceiving through AI. For this reason there is still a considerable demand for bulls to be used in dairy herds. There are also breeders who rear bulls to be evaluated as possible candidates in the AI industry.

Dairy goat farmers in South Africa, on the other hand, do not as yet use AI in their breeding programmes to the same extent. If it is being used, it is on a varying scale. Natural mating (NM) is therefore mostly used for breeding purposes. Herds therefore consist of mainly female animals of various ages and a minimum number of breeding males. Depending on the status of the individual breeder, the dairy goat herd may have a varying number of young males that are being reared to be sold to other producers. The selection of these young males is based on phenotypic performances of the mother and other related females, pedigrees and conformation traits which are important to the individual farmer.

Phenotypically there has been no change in the average milk yield of dairy goats in milk recording in South Africa over the last 20 years while the fat and protein contents of the milk have declined somewhat (Muller, C.J.C., 2001, unpublished data). One of the reasons for this could probably be a lack of information concerning the genetic merit of animals used as parents for future generations. As the effect of the genetic merit of the males used in a herd is larger (> 80%) than that of the females, it is clear that the process of selecting males should preferably be based on factors such as breeding values for specific traits.

In France, AI of dairy goats plays an important role in intensive milk production systems to control reproduction (seasonality of kidding) as well as to improve the average milk yield in the national herd (Leboeuf *et al*., 1998). This is done in conjunction with the progeny testing of bucks. With frozen semen many progeny per male is produced in multiple environments. In the sire selection programme about 40 bucks per breed are put annually into the progeny test programme. Their estimated genetic values are based on the performance of at least 40 daughters in at least ten linked herds. The performances of other relatives are also taken into account by the animal model employed in the genetic evaluation.

Breeding in the beef industry can be used as an example of a breeding structure (Figure 8.1). A registered or stud breeder's bulls are sold to breeders (pedigree multipliers) with pure-bred or grade animals who in turn provide bulls to commercial breeders (pathway 1). In this way a downward flow of genetic material is created. In pathway 2 a commercial breeder buys directly

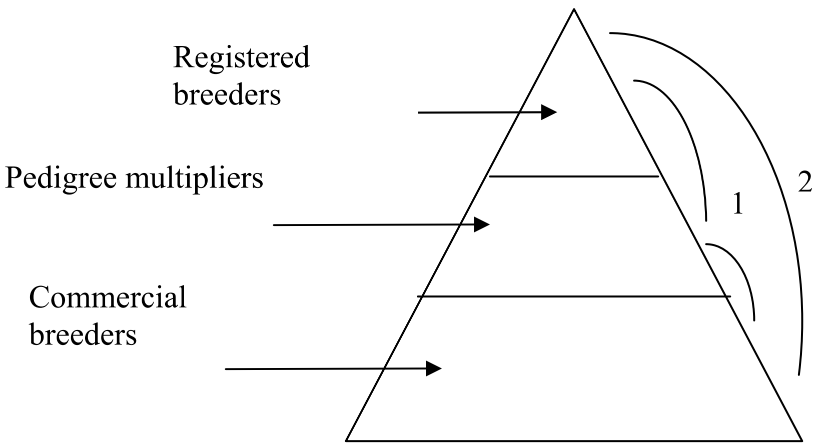

Figure 8.1 The typical flow of genes in the beef industry according to two pathways (Willis, 1998)

from the registered breeder, therefore shortening the flow of genes. The flow of genes in the dairy goat industry is based on a similar structure because of the limited use of AI and other methods such as multiple ovulation and embryo transfers (MOET).

A small number of animals in a breeding herd using natural mating limit genetic progress. Only in a herd with more than 75 breeding females, an independent breeding programme can be implemented (Rust *et al.,* 2002). This problem could, however, be reduced by using AI on a larger scale. Another way would be to participate in a co-operative group breeding scheme based on a nucleus herd. In this way the herd size is effectively enlarged (Rust *et al.,* 2002).

8.3 Breeding strategy

A breeding strategy may be used to improve conformation traits and/or milk yield. This can be done either in pure- or crossbreeding programmes (Barillet, 1997). Pure breeding is the method of choice in commercial dairy goat farming in South Africa. Crossbreeding of dairy and mutton type goats is generally practiced in the rural areas, although no information is available on the extent of the practice. If they have a market for milk, rural farmers rely on simple schemes and will use a dairy-type goat on their local or indigenous animals to upgrade their herds.

Because of a wide range of local production conditions, any definition of a breeding strategy needs to take into account not only milk yield merit but also conformation traits (Barillet, 1997). Information on the genetic ability of animals concerning specific traits is required before these animals can be used as parents in a breeding strategy for the national herd. For individual herds, local conditions i.e. feeding and management also need to be considered. It is also important to have a good idea of the expected genetic gain over a 10 year period in the case of direct selection for milk yield in the national herd.

8.4 Breeding objectives

A breeding objective indicate a desired direction for genetic change. It should be formulated in such a way that it allows its expression as part of a genetic evaluation system to enable ranking of animals based on genetic merit (Kinghorn, 1997). According to Kominakis *et al.* (1997) the definition of a breeding objective is aimed at the choice of traits to be genetically improved because they influence the producer's income. As market demands change over time, however, all breeding objectives are to some extent arbitrary. Breeding objectives are generally expressed as economic weights to be applied to each trait of commercial importance. These weights usually describe the economic gain associated with one unit change in each trait.

The income from dairy goats is based mainly on the sale of milk while some breeders may have the sale of male and female breeding stock to other herds as an additional source of revenue. For dairy cattle, milk sales usually account for more than 90% of all income with the sale of culled animals and animals intended for breeding purposes accounting for the rest (Burger, W.P., 2001: personal communication, George Study Group, Outeniqua Experimental Farm, George). Under such conditions, the market demand is to increase the milk yield potential of dairy animals. This should be combined with some conformation traits, i.e. feet and legs as well as udder traits. Selection for these traits is intended to sustain milk yield and longevity.

A breeding objective for most dairy goat farmers would therefore be based on an increased milk yield to improve milk income. Dairy cattle producers select for milk yield and/or fat and protein yield, as highest producing cows are usually the most profitable. Sullivan (2000) suggested that breeding objectives for dairy goats in Canada should be a higher milk yield per doe while maintaining or increasing fat and protein percentages. Some body conformation traits should, however, also be maintained or improved. It has been pointed out that extreme emphasis on selection for milk yield may have a negative effect on some linear type traits that contribute to overall fitness (De Groot *et al.,* 2002).

In the dairy cattle industry single trait selection for milk yield usually results in a reduction in the fat and protein concentrations of milk although with an increase in fat and protein production. Similar results would be obtained in dairy goat breeding, as genetic parameters show positive genetic and phenotypic correlations of milk yield with fat and protein yields. Negative correlations of milk yield with fat and protein percentages are often reported. Dairy farmers producing milk for a fluid market (i.e. fresh milk) should aim to increase milk yield while maintaining fat and protein percentages at or above minimum requirements set by the milk buyer. On the other hand, farmers that produce milk for a products market such as cheese should rather increase the concentration of fat and protein, i.e. percentages, without a reduction in the fat and protein yields.

8.5 Pyramidal management of a population

The most efficient breeding programme needs to progeny-test males born from assortative matings for AI purposes. This programme also requires on-farm milk recording of progeny, AI and possibly also a multiple ovulation and embryo transfer (MOET) programme as well as an accurate genetic assessment of the animals based on breeding values (Barillet, 1997). Artificial insemination of dairy goats can be done with fresh or frozen semen while oestrus can be induced. The diffusion potential of AI with fresh semen is multiplied by 10 to 20 in comparison to natural mating (NM). The diffusion potential of AI is even larger with frozen semen as is seen with dairy bulls (Barillet, 1997).

An official milk recording (recordings done every four to five weeks of daily milk yields) is the most popular method used in dairy cattle milk recording. However, the cost per animal relative to the income in the dairy goat industry is two to three times as much as for dairy cattle. A national breeding programme is complicated by this and a more cost effective way to do on-farm milk-recording of dairy goats needs to be found. Designing a breeding plan to improve the national herd would include methods such as a wider scale use of AI and MOET while the establishment of a nucleus herd should also be considered to test possible candidates for AI purposes.

For dairy sheep a pyramidal model of the management of the population is recommended (Figure 8.2). For dairy goats a similar model could be employed. In this model, breeders are divided into two groups, i.e. the breeders of the nucleus flock and the breeders for the commercial flock of the base population (Barillet *et al.*, 1998).

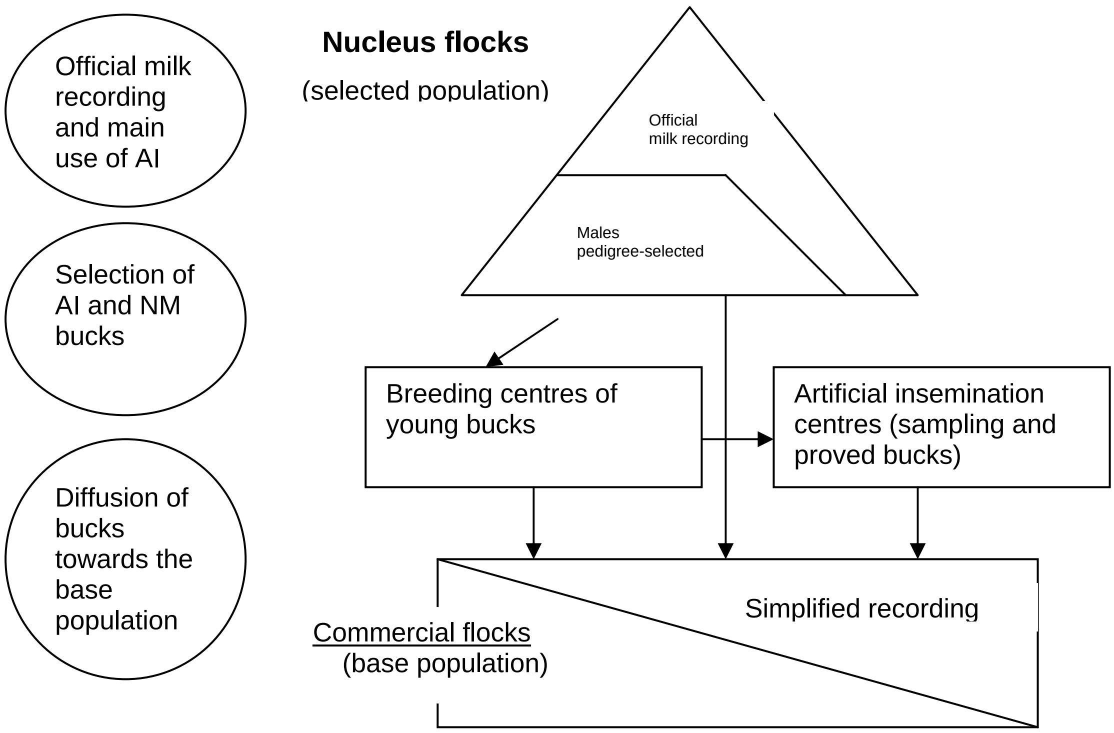

Figure 8.2. Pyramidal management of a population (AI = Artificial insemination and NM = Natural mating) (Barillet, 1997)

Official milk recording must be done in the nucleus flock while it is recommended for commercial flocks as well, particularly where NM is used on a large scale. Artificial insemination is primarily reserved for the nucleus flock but may be used elsewhere. Breeding centres where the young males born from the assortative matings in the nucleus flock are raised from weaning at 1 month of age to 8 months of age, must be set up. The breeding centre(s) could be managed by the breeders' association or another approved body/farmer/breeder. Thereafter, these males either join an AI centre for a subsequent progeny test or are sold to commercial flocks for natural mating. The gene flow from the nucleus herd to the base population is therefore based partly on AI and partly on NM bucks that were born in the nucleus herd, raised at the breeding centres and used in the base population.

Barillet (1997) cited several gene-flow studies based on similar pyramidal breeding programmes for the Lacaune dairy sheep demographics and genetic parameters (i.e. Elsen & Mocquot, 1974; Barillet & Elsen, 1979; Vallerand & Elsen, 1979 and Barillet *et al*., 1988). Although a programme like this is different from the usual dairy cattle programme, it may provide similar annual genetic gains. The main results for the nucleus herds include the following:

- The optimal size of the nucleus herd should range between 10 to 20% of the population.
- An asymptotic annual genetic gain can be expected from 10 to 15 years after starting the breeding programme. The annual gain is 50% higher when AI is used in the nucleus herd in comparison to NM.
- Dairy sheep rams seem to have a limited semen production in comparison to dairy bulls and therefore cannot be as strictly selected. The superiority of proven rams over young unproven rams is therefore lower than in dairy cattle. To maximize the annual genetic gain within these limits, a large number of males in the nucleus herd should be progeny tested.

The main results for commercial (or base population) dairy sheep flocks herds are as follows:

- The annual genetic gain is at equilibrium the same in the nucleus herd and the base population.

- Equilibrium is reached faster or more slowly depending on the diffusion rate of the rams from the nucleus herd to the base population.
- At equilibrium, the lag between the nucleus and base populations is limited to 5 to 10 years if the diffusion rate reaches 100%.

It has also been shown by Kominakis *et al.* (1997) that genetic improvement may be obtained without using AI. In an evaluation of the efficiency of alternative selection schemes in dairy sheep, however, to achieve a high rate of annual genetic gain in terms of profit and selection responses, the use of AI has to be introduced and diversified. With AI, selection activities like progeny testing and planned matings are adopted. Kominakis *et al.* (1997) found that higher genetic gains and economic efficiency levels were gained by employing progeny testing of rams and by using a nucleus herd.

8.6 Implementation of a breeding scheme

For the implementation of a national breeding scheme various requirements need to be met. These include on-farm milk-recording, AI and maintaining a nucleus herd combined with an accurate genetic evaluation of all the animals in the national herd. In South Africa, like in most other countries, the percentage of dairy goats in milk-recording is low. It is therefore recommended that milk-recording has to be simplified. Aspects that could be considered include fewer recordings during a lactation period, while individual milk recordings would also have to be less expensive if it is to be implemented on a wider scale.

Because of the higher prolificacy of dairy goats, the dam-daughter selection pathway is more valuable than in the case for dairy cattle. The most efficient pathway is, however, those for the dam-son, the sire-son and the sire-daughter. In small herds an efficient breeding programme cannot be maintained as only the dam-daughter and dam-son selection pathways can be followed. Under these conditions, AI is a powerful tool to affect increased genetic gains.

An annual genetic evaluation of animals in milk recording is the main tool for the implementation of an efficient breeding programme. The best linear unbiased prediction (BLUP) method based on an animal model is the best way to determine the genetic value of animals. In Canada, genetic evaluations of dairy goats are computed by the Canadian Centre for Swine Improvement for milk, fat and protein yields based on monthly test day records collected under the Canadian Goat Society (CGS) milk recording programme. Provincial dairy cattle milk testers do the milk recording, or alternatively, a group is formed with other breeders who then take turns testing each other's herds (Sullivan, 2000). All data collected under this programme are processed centrally by the Quebec Dairy Herd Analysis Service which is the organisation responsible for dairy cattle recording programmes in the province of Quebec, Canada. Genetic evaluations are computed using an animal model BLUP and individual test day records. Heritability estimates for milk, fat and protein yields are 0.29, 0.27 and 0.30, respectively. These estimates are similar to estimates based on full lactation yields over 305 days (Sullivan, 2000)

Chesnais & Sullivan, (1994), as cited by Sullivan (2000), reported that accuracy of doe evaluations for milk yield based on a single lactation record with an increasing number of test days is 0.29, 0.35, 0.37, 0.39, 0.40, 0.40, 0.41, 0.41, 0.42 and 0.42 for 1 to 10 test days, respectively. From this it is clear that evaluations based on just 3 test days are about 95% as accurate as those based on 10 test days. It is concluded that although fewer milk recording tests would result in a small loss in accuracy on individual animals, it would also reduce the cost of milk recording. This should entice more dairy farmers to participate in milk recording (Sullivan, 2000).

With the genetic information available, the genetic trend for milk production parameters for the national herd can be determined. A BLUP analysis of the national herd would identify genetically superior quality animals. A breeding centre consisting of the top 10% of bucks and does according to breeding values for milk yield parameters could be set up. The breeding centre could be managed by the breed society and/or individual breeders. The does at the breeding centre are then used as mothers of bucks to be evaluated in a progeny testing scheme using AI with either fresh or frozen semen. Does born from sire-mothers could be distributed back to the original owners or kept and mated at a breeding centre.

In private herds, high genetic quality does could be inseminated with semen of positive progeny tested bucks. The estimated breeding values of young bucks born in the herd could be used to identify bucks for AI. Fresh semen could be used on the does in the herd. Imported or home produced frozen semen could also be used in the herd. Does not conceiving through AI could also be serviced by bucks used for semen collection. After the initial selection of the young bucks based on their breeding values for milk production parameters, some of these bucks intended for progeny testing could be culled at a later stage in life (when growth and conformation traits are more noticeable), because of a poor growth rate and/or type traits.

8.7 Selection indices

Dairy goat selection in some European countries such as France has been oriented towards the improvement of milk yield and solids content (Manfredi *et al*, 2001). Current selection criteria include protein and fat yields, and protein and fat contents (Belichon *et al*., 2000). Clément *et al*. (2000) have shown that genetic trends have been positive for these traits and it is anticipated that new complementary traits may be included in the selection criteria. In South Africa, however, it seems that dairy goat breeders are generally hesitant to select on milk yield only as the general belief is that this has a negative impact on some body conformation traits and longevity. This perception is based on anecdotal observations only and no substantial evidence for this is currently available. De Groot *et al.* (2002) found, only a small genetic correlation between final score and yield traits in dairy cattle. Traits related to udder attachment had a negative genetic relationship with milk yield while udder capacity traits had a positive relationship with milk yield. While these estimates may suggest that selection for milk yield increased udder capacity while causing the fore udder attachment and udder cleft to weaken, the correlations between traits did not reach unity therefore high milk yields would not necessarily result in poor udder traits.

With this in mind, it is expected that some body conformation traits should be included in a dairy goat breeding programme. A new index combining production and type genetic evaluations was introduced in 1996 for the Canadian Goat Society (CGS) (Sullivan, 1996). The combined index gives 60% emphasis to production and 40% to type. The production index (PINDX) gives equal emphasis to milk and fat yield:

PINDX = 100 + 0.14*(milk EBV) + 4.4*(fat EBV)

Eight linear type traits are classified by classifiers of the CGS who visit breeder herds once a year during the summer. All first and second parity does must be classified while breeders have the option of classifying older does as well. At present (Sullivan, 2000), only the first classification on does is used in the genetic evaluation. Type traits are scored on a scale from 1 to 9, with 1 being extremely poor, 5 average and 9 ideal. The eight traits evaluated are: general appearance (GA), feet and legs (FL), dairy character (DC), body capacity (BC), medial suspensory ligament (SL), fore udder (FU), rear udder (RU) and teats (TE). The relative emphasis given to each of these traits as a percentage of the final score is: 23 for GA, 12 for FL, 15 for DC, 15 for BC, 15 for SL, 8 for FU, 8 for RU and 4 for TE. Genetic evaluations are computed for each of the eight linear traits using a BLUP animal model. A type index (TINDX) combines the type EBV's with the same emphasis as used in the calculation of the final score on the farm:

TINDX = 100 + (0.23*GA + 0.12*FL + 0.15*DC + 0.15*BC + 0.15*SL + 0.08*FU + 0.08*RU + 0.04*TE - 5) * 152

A combined production and type index (PTINDX) combines the above with 60% emphasis on production and 40% on type:

$$PTINDX = 100 + 0.832*(PINDX - 100) + 0.555*(TINDX - 100)$$

In the USA, the Department of Agriculture calculates annual genetic evaluations of dairy goats from yield data collected through the National Cooperative Dairy Herd Improvement Programme and from type and pedigree data supplied by the American Dairy Goat Association (ADGA) (Wiggans *et al*., 1999). Genetic evaluations are reported to the dairy goat industry as predicted transmitting abilities (PTA's). A PTA is half of breeding value and is the genetic merit that an animal is expected to contribute to its offspring. The sources of information that contribute to a PTA are as follows:

$$PTA = w^1(PA) + w^2(YD/2) + w^3[avg(2PTA^{kid} - PTA^{mate})],$$

where the w's are weights that add up to 1 and indicate how much emphasis should be placed on each source of information, PA is the animal's parent average, and YD is the doe's yield deviation. The PA indicates the contribution to the animal's evaluation from its parents and is the average PTA of its parents. A doe's own performance is represented by YD, which is the average of the doe's lactation yields minus the effects of management group, herd-sire interaction, and permanent environment weighted by factors dependent on lactation length. The contributions of offspring to an animal's evaluation are expressed by avg ($2PTA^{kid} - PTA^{mate}$), which is the average of the portion of offspring evaluations (PTA^{kid}) that can be attributed to the animal's genetic merit after adjusting for the genetic merit of mates (PTA^{mate}).

Evaluations for milk, fat and protein yields are combined into an economic index called milk-fat-protein dollars (MFP$). The economic values for milk production components used for calculating MFP$ for dairy cattle are also used for dairy goats:

MFP$ = $0.31(PTA milk) + $0.80(PTA fat) + $2.00(PTA protein)

Genetic evaluations for yield and type are combined into a production-type index (PTI) that represents the economic merit of the traits evaluated for the animal. Yield is represented by MFP$, and type is represented by PTA for final score. Two PTI's with differing weights are provided by ADGA to dairy goat producers: one with yield weighted twice as much as type and the other with type twice as much as yield (Wiggans *et al*., 1999).

Similar indices for production and type as well as production-type indices should be developed for dairy goats in South Africa. Type traits could be combined with breeding values for milk production parameters in a set ratio. Well-attached udders, strong feet and legs and a minimum stature are some conformation traits that could be included in a selection index.

Milk composition should also be considered in the breeding programme to prevent a reduction in fat and protein concentrations. Because of the negative correlation of milk yield with fat and protein percentages, however, emphasis should be on increasing milk fat and protein yields while maintaining or increasing fat and protein percentages. Increasing the fat and protein concentrations of milk reduces the production cost of milk products (Muller & Robertson, 2004). Other traits that need to be considered are factors such as milking ability and udder traits as well as reproduction parameters. Some of these traits, however, are not normally recorded by farmers. It will take time before a sufficient data base is compiled to enable calculation of breeding values for milk yield parameters. In the dairy cattle industry a combination of factors in a fixed ratio have been found to be the best selection method as various body conformation traits seem to have an affect on lifetime yield, which is a combination of milk yield and productive life.

8.8 Conclusion

Although a national breeding programme for South African dairy goats could be proposed, its acceptance and application by breeders could not be guaranteed. The main reason for this is the lack of information concerning the effect of different factors on the performance of does under practical farming conditions. From the breeders' society's point of view, body conformation traits are very important, with some breeders actually believing it being more important than the quantity of milk does produce. For dairy cattle, selecting for higher milk yield has generally not resulted in unwanted deterioration in most conformation traits. The genetic correlation between milk yield and body conformation traits is positive although low. Higher milk yields have, however, reduced the reproductive performance and productive life of dairy cows. A national breeding programme for dairy goats should therefore include (1) milk yield and milk composition (fat and protein percentages), (2) fertility traits such as age at first kidding and productive life and (3) conformation traits directly affecting milk yield and productive life. As the genetic correlation between fat and protein percentages is highly positive, only protein percentage need to be included in a selection index. The fecundity of does could also be considered as it is a highly heritable trait in comparison to other reproduction traits, and has been shown to respond readily to selection. A selection index that include all of these components of production should be developed for dairy goats in South Africa. As for dairy cattle, the selection index should emphasize optimum rather than maximum production per animal. At present, however, the recording of information to achieve this needs to be improved. These include aspects such as more animals and herds in milk recording and the correct identification of pedigrees. Ways to simplify milk recording of dairy goats should be found. This include the minimum number of recordings to obtain accurate genetic evaluations. The effect of conformation traits on production and productive life need to be assessed. It is generally accepted that the modern dairy industry does not allow the luxury of using fancy points in a breeding programme. Genetic improvement of the national herd for production traits could be improved substantially by AI, using fresh or frozen semen. This practice, however, might not be popular with breeders of long standing, since it could affect their income. Nucleus herds should also be considered to provide superior bucks and does to the general industry. Naturally, progeny testing of bucks then becomes a prerequisite.

CHAPTER 9

GENERAL CONCLUSIONS

The aim of breeding is to bring about change in livestock to increase profitability, sustainability and ease of management at the production level (Kinghorn, 1997). For dairy cattle, a higher milk yield influences profitability positively. Aiming for higher milk yields in dairy goats should have the same effect. The sustainability of higher milk yields should, however, be maintained. The performance of dairy goats is dependent on their genetic merit and environment in which they are kept.

No genetic information has been available for dairy goats in South Africa. To enable the improvement of an individual herd or the national herd, a starting point has to be established. With this study such a starting point has been established for the South African national Saanen dairy goat herd. From this point onwards, efforts that are made to bring about change in the local dairy goat industry could be monitored. Establishing this starting point was difficult as it was clear from the outset that certain restrictions apply to the data set.

The number of lactation records in the national dairy goat herd available for a genetic evaluation of this kind, was much smaller than for dairy cattle. While dairy goat farming has been practiced in this country for many years, even before the first Europeans arrived, it is only since 1985 that sufficient numbers of dairy goats (mainly Saanens) with at least a dam or sire identified to warrant a genetic evaluation, have been subjected to milk recording. Only a small number of herds had a sufficient number of lactation records each to be included in the evaluation. It seems that the bucks intended for breeding purposes in most dairy goat herds were selected and raised by the breeders themselves. This has resulted in poor genetic ties between herds, quite unlike the situation for dairy cows where many common sires are used with the aid of AI. The bucks used for breeding purposes therefore only had a small number of progeny in mainly individual herds. Eleven herds had used more than 10 bucks each and the average number of progeny with lactation records varied from 3.2 to 39.2 for individual bucks.

Many lactation records were short as the average lactation period of all dairy goats in milk recording was only 264 days. Only 58% of all lactation records were longer than 290 days. The erosion rate of goats from first to eighth lactation was high, similar to that of dairy cows. The number of usable records for the British Alpine and Toggenburg breeds is too small for a genetic evaluation.

The milk, fat and protein yield and fat and protein percentages of Saanen goats of all parities and over all production years in the data set were as follows: 930, 28.1 and 25.2 kg and 3.05 and 2.71%, respectively. These production figures were in some cases higher and in other cases lower than similar data from other countries. While it is difficult to compare production data between countries as production systems vary to some extent or are poorly described, it seems that fat and protein percentages in the milk of local dairy goats are lower than in most other countries. Production parameters increased from first to third lactation and then declined to sixth lactation. Fat and protein percentages declined linearly from first to sixth lactation and is negatively related to the volume of milk produced.

Heritability estimates for production traits using different data sources are presented in Table 9.1. Estimates were in the moderate range with estimates obtained from first parity records proving to be the highest.

Table 9.1 Heritability estimates for milk production traits of Saanen goats in the national herd as affected by source of information

Production parameters	All records	First parity records	Second parity records	Records from Fairview
Number of records	3190	1190	775	2319
Milk (kg)	0.21 ± 0.05	0.32 ± 0.08	0.20 ± 0.10	0.31 ± 0.06
Fat (kg)	0.19 ± 0.05	0.37 ± 0.08	0.18 ± 0.11	0.21 ± 0.05
Protein (kg)	0.20 ± 0.05	0.31 ± 0.08	0.24 ± 0.10	0.31 ± 0.06
Fat (%)	0.19 ± 0.05	0.67 ± 0.08	0.34 ± 0.12	0.12 ± 0.05
Protein (%)	0.30 ± 0.06	0.32 ± 0.08	0.24 ± 0.11	0.28 ± 0.07

Estimates for similar parameters were in accordance with values cited from the literature. All possible correlations between production traits were positive and high. Fat and protein percentages were negatively related to milk volume on a genetic level. Selection for fat and/or protein percentage would therefore have a negative effect on production parameters. As the current milk price structure is based on the quantity of fat and protein produced, this could have a negative effect on milk income. In contrast, selecting for yield parameters would lower the fat and protein percentage in milk, although it could increase milk income. Analyzing the data of one large commercial herd comprising 65% of all lactation records in the national herd, shows that genetic trends for yield traits were positive, although not significant. Large variation between years were found. Genetic trends for fat and protein percentages were positive and negative, respectively.

Reproduction parameters varied to a great extent with coefficients of variation exceeding 60%. Age at first kidding (AFK) was 457 days (15 months) with most goats (54%) kidding for the first time between 330 and 400 days of age. While the average number of lactations of dairy goats in the national herd was 2.24, productive life (PL) of the same animals was on average only 19.3 months. A large number of lactations were short i.e. 42% of all lactations were shorter than 290 days. Kidding interval (KI) increased with age as indicated by number of lactations, with KI between first and second kidding being the shortest. Kidding interval is influenced by breeding management practices and seasonality of breeding, while no additive variation was found. The genetic correlation between AFK and PL was moderate to high and negative. Similar results were obtained for dairy cattle. Heritability estimates for age at first kidding, age at last kidding, productive life and number of lactations were 0.25, 0.28, 0.08 and 0.05, respectively. These estimates show that some parameters are largely affected by environmental conditions like management and factors such as seasonality of breeding. Heritability estimates of traits may vary between studies depending on breed, population sampled, environmental and management conditions as well as random and systematic errors. Larger data sets are needed and information about specific parameters should be determined for the South African dairy goat industry.

Although a national breeding programme for South African dairy goats could be proposed, its general acceptability and application by breeders would be uncertain. The main reason for this is the lack of information concerning the effect of different factors on the performance of does under practical farming conditions. From the breeder's society's point of view, body conformation traits are very important with some breeders actually believing it to be more important than the quantity of milk does produce. For dairy cattle, selecting for higher milk yield has generally not resulted in a reduction in most conformation traits. The genetic correlation between milk yield and body conformation traits is favourable although low. Selection for higher milk yields have, however, reduced the reproductive performance and productive life of dairy cows.

A national breeding programme for dairy goats should therefore include (1) conformation traits directly affecting milk yield and productive life, (2) milk yield and milk composition (fat and protein percentages) and (3) fertility traits such as age at first kidding and productive life. A selection index that includes all of these aspects of production should be developed for dairy goats in South Africa. At present, however, sources of information in the industry need to be improved. These include aspects such as more animals and herds in milk recording and the correct identification of animals with complete pedigrees.

The effect of conformation traits on production and productive life needs to be assessed. It is clear that the modern dairy industry does not allow the luxury of improving fancy points in producing animals. For dairy cows it is clear that some conformation traits are favourably correlated with productive life. The effect of similar traits in dairy goats have not been evaluated. There is little advantage to include conformation traits that have no or little effect on production or productive life in a commercial breeding programme. Genetic improvement of the national herd could be improved substantially by AI using fresh or frozen semen. This practice, however, would not be popular with breeders of long standing as that could affect their income. Nucleus herds should also be considered to provide superior bucks and does to the general industry. Progeny testing of bucks then naturally becomes a necessity.

Notwithstanding the present high emphasis on conformation traits, the main aim of dairy goat farmers should be the improvement of milk yield in their herds. Single trait selection to improve either milk yield or fat and protein percentages is probably not appropriate for the dairy industry. Individual dairy farmers essentially provide the same product i.e. a white liquid, however, it is eventually used in a wide range of products. The end products of the milk of a specific herd should therefore influence the breeding programme of each herd. A national breeding programme for the dairy industry is therefore complex because of the negative relationship between milk volume and milk components as well as varying end products of the milk produced. For dairy goat farmers producing milk for liquid consumption, increasing the volume of milk produced while maintaining fat and protein percentages in milk would be breeding objective. The concentration of milk solids should be increased for farmers producing milk for processing. The breeding objective would be to increase fat and protein yields by increasing fat and protein percentages in milk without a reduction in the volume of milk produced.

Fat and protein yields (and therefore cheese yield) are affected by both the quantity of milk produced and fat or protein percentages in the milk. The cost of cheese production could be reduced by using milk containing higher protein and fat percentages. Milk pricing structures should therefore encourage the production of milk with higher solids concentrations. Milk payment systems have been revised and may include a bonus for higher protein percentages in some European countries. A selection programme has been started in France to assist dairy goat farmers to increase the total quantity or volume of milk produced while maintaining or increasing fat and protein percentages in milk. This is now possible in that country as the genetic evaluation of the breed started recently. Estimated breeding values (EBV's) of animals for milk, fat and protein yield as well as fat and protein percentages are now being determined on a regular basis. This information is being used in the selection or culling of animals.

To maintain the fat and protein percentages of milk while increasing volume, a selection index based on economic factors, as determined by the milk price, need to be constructed. For this purpose a milk pricing structure was obtained from a dairy producing milk to be processed and by varying the emphasis of selection, the response and weighting factors for each scenario was determined. In Table 9.2 the effect of selection emphasis on genetic gain for a specific milk pricing structure is presented. The h^2 estimates used to derive the indeces included both h^2 and c^2. This was accepted on the assumption that the lack of pedigree information would probably have impeded the partitioning of additive genetic and permanent environment effects. Changing the emphasis of the selection index from minimum to maximum volume, also changed the annual improvement of production parameters per lactation. i.e. from 0.15 to 79.6 for milk yield. When selecting for maximum protein production, the increase in milk yield increases although not to the same extent as for maximum volume production.

Table 9.2 The effect of different selection objectives on the annual improvement in production parameters and weighting factor for production parameters when payment is based on fat and protein yields (standard selection objective refers to improvement in the volume of milk produced)

		Selection objective		
Parameters	**Standard**	**Minimum volume**	**Maximum volume**	**Maximum protein**
Improvement/lactation				
Milk (kg)	63.41	0.15	79.6	68.0
Protein (kg)	2.06	1.04	1.82	2.09
Fat (kg)	2.36	1.87	1.55	2.19
Weighting factors				
Milk (kg)	-0.22	-87.5	61.2	-0.28
Protein (kg)	19.42	2717.0	-442.0	46.9
Fat (kg)	5.42	839.0	-280.0	2.7

Current milk pricing structure: 0.051 c/kg milk; R25.00/kg protein; R16.00/kg fat

The dairy goat industry in South Africa should be challenged to rectify some of the problems encountered in the analysis of data. These include factors such as many short lactations, a large number of animals lacking production data linked to pedigree information, incomplete pedigrees, few does that completed three or more lactations and few genetic ties between herds. Inseminating does with frozen or fresh semen from a national nucleus herd or through semen importation are options that could be considered to improve the genetic status of individual herds. The relative importance of factors such as length of lactation, herd and year and month of production and also lactation number should be taken into account in the evaluation of sires. Organizational and logistic issues concerning pedigree and milk recording need to be addressed to allow South African dairy goat producers access to complete and correct information regarding the genetic merit of individual animals on a national level.

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