PRODUCTIVITY AND DISEASES OF SAANEN, INDIGENOUS AND CROSSBRED GOATS ON ZERO GRAZING

by

EDWARD FRANCIS DONKIN

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Department of Animal Health and Production
Faculty of Veterinary Science
Medical University of Southern Africa

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Supervisor: PROFESSOR P.A. BOYAZOGLU

DECLARATION

I, EDWARD FRANCIS DONKIN, hereby declare that the work on which this thesis is based is original (except where acknowledgements indicate otherwise); and that neither the whole work nor any part of it has been, is being, or shall be submitted for another degree at this or any other university, institution for tertiary education, or professional examining body.

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E. F. DONKIN

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SUMMARY

Saanen and South African Indigenous goats were bred to kid at twelve months and annually thereafter. Milk production was recorded. Conception rates were generally more than 90 %, except for Indigenous goats in their first year. Few Indigenous goats (12 %) had twins at the first parturition, whereas 45% of Saanens had twins at 12 months of age. Twinning increased with age, and Saanen and Indigenous goats had kidding rates of 182% and 174% respectively in their third year, with Saanens later exceeding 200%. Triplets were infrequent, except in mature Saanens (9% of parturitions), and in Crossbreds (16%). Mean lactation yields were 579, 838, and 758kg for Saanens in first, second and third lactations, respectively. Lactation lengths were 283, 293 and 290 days respectively (excluding milk production beyond 300 days). Mean lactation yields for Crossbreds were 317, 446 and 438kg for first, second and third lactations. Lactation lengths were slightly shorter for Crossbreds than for the Saanens at 236, 248 and 257 days respectively. Indigenous goats were recorded at a mean milk yield of 23kg per lactation, and a mean lactation length of 94 days. Milk composition analyses for Saanens averaged 3.43, 2.88, and 4.49% for milk fat, protein and lactose, respectively. The analyses for Crossbred goats were 5.47, 3.88 and 4.81%, and for Indigenous goats were 9.33, 5.04 and 5.12%, respectively. These results showed that Crossbred goats gave less milk than Saanens, but significantly more than Indigenous goats. Milk production of Crossbred goats was found to be adequate for household requirements (subsistence purposes). In this way, the Crossbred goats were shown to be able to fulfil one of the objectives of the crossbreeding programme.

The main disease identified was coccidiosis, acccompanied by pneumonia, which caused unacceptably high mortality among goat kids: 31% of Saanen, 24% of Crossbred, 38% of Three-quarter Saanen and 28% of Indigenous female kids. It is believed that this problem is largely management related, and worsened by overcrowding and the consequent poor hygiene; but the presence of rotavirus might also be significant. These aspects warrant further investigation. The main disease problem identified in mature goats was mastitis, which caused deaths of goats from peracute cases. Another important problem which became apparent after four years of age, was the incidence of squamous cell carcinoma on the udders of Saanens. Reduced exposure to the sun, by the provision of adequate shade should alleviate this problem; but the crossbreeding programme was seen to be of benefit, since no cases occurred in Crossbred goats.

The experiment on heartwater aimed to assess resistance to this disease. Saanen, Indigenous and Crossbred goats were reared in a tick-free environment. In Year 1, eight goats of each type at eight months of age were given 5ml virulent heartwater blood of the Ball 3 stock. Temperatures and clinical sign were monitored. All eight Saanens were overcome by the disease, but only one Indigenous goat and two Crossbreds. In Year 2, Phase 1 of the experiment included six males and six females each of Indigenous and Crossbred goats at 11 months of age. Seven Crossbreds, but no Indigenous goats died. In Phase 2, nine Saanens were treated with tetracycline and compared to two untreated Saanens and nine untreated Three-quarter Saanen goats at 12 months of age. Both of the untreated and one of the treated Saanens died, and seven of the Three-quarter Saanens died. There were only small differences in temperature reactions; but Indigenous goats showed less clinical signs than other breeds. No differences of gender or year were apparent. These experiments indicated that Saanen goats show no genetic resistance, but that South African Indigenous goats appear to be genetically resistant to heartwater, and can transmit this resistance to a good proportion of Crossbred progeny.

It has been shown therefore that it is feasible to develop a dairy goat resistant to heartwater, which could contribute significantly to the reduction of human malnutrition in rural and peri-urban communities in Southern Africa.

Keywords: Milk, goats, crossbreeding, goat diseases, heartwater, complete feed

A PRAYER FOR THE MILCH GOAT PROJECT

(1989)

O Lord,
I want this work to be
for the sake of the little children;
Therefore please guide me on the way:
That they may have good food to eat
and grow strong and healthy.
Thank you for these wonderful goats.
By using them well,
and the milk that they give,
I want to show something
of how you provide for us,
If only we will work
and perceive what is there,
Waiting in the wealth of your creation:
That you may be glorified in our generation;
And the mouths of little children
Will give you thanks and praise.
Amen.

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"Cast your cares on the Lord, and he will sustain you" Psalm 55:22.

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INTRODUCTION

Goats have been used as a source of milk for a long time in the history of mankind:

> *"Look after your sheep and cattle as carefully as you can, because wealth is not permanent. Not even nations last for ever. You cut the hay and then cut the grass on the hillsides while the next crop of hay is growing. You can make clothes from the wool of your sheep and buy land with the money you get from selling some of your goats. The rest of the goats will provide milk for you and your family, and for your servant-girls as well."*
>
> *Proverbs: 27: 23 to 27*
> *[Good News Bible Translation]*

The rapidly growing population of Southern Africa will result in an increasing need for high-quality protein to reduce malnutrition, especially in children. Milk production from dairy goats is one source that should be developed. There are many advantages in the use of dairy goats rather than cows for subsistence production by householders and smallholder farmers.

Problems identified in developing the use of dairy goats include their scarcity and their susceptibility to disease.

* **Scarcity**

Millions of Indigenous goats are kept by subsistence farmers in developing areas, but not usually for milk production. Crossbreeding with male dairy goats may provide an economical means for the supply of suitable animals. This research project was aimed at measuring the effects of crossbreeding on milk production. Associated aspects such as the survival of young stock are also important, and were monitored.

* **Disease**

Indigenous goats are alleged to be resistant to diseases, especially heartwater, a tick-borne disease which is a problem in many developing areas. It was necessary to establish whether this resistance was a fact, and to determine if it could be inherited by Crossbred goats.

In summary, two main hypotheses were proposed:

Crossbreeding of Saanen and Indigenous goats will:

- ***be suitable for milk production;***
- ***result in resistance against heartwater.***

REVIEW OF LITERATURE

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1. MILK PRODUCTION FROM GOATS

1.1 The Place of Goats in the World Economy

Goats are kept in most countries of the world and estimates of numbers have been made by such organizations as the FAO (1986). They are kept for meat, hides, fibre and milk production. It was estimated that in 1985 there were 485 million goats, and that goat milk production totalled eight million tonnes. Of the total world population of goats, 94 percent are said to be found in developing countries, supplying 73 percent of the milk produced by goats (Devendra 1987a). Tropical Africa contains one-third of the world's goats, but "they have been neglected politically and scientifically" (Wilson 1988). In most circumstances goats are kept in small herds by poor people and may run with other animals such as sheep or cattle. They contribute a significant amount to the daily welfare of the very poor, even for the 123 million landless poor of India (Devendra 1992a). They are seldom kept for one type of production alone. For example, they may be mainly kept for meat production, but higher-yielding goats may be milked as the opportunity arises on a seasonal basis (Matthewman 1985).

Leather production from goats has become a major industry in India and other Asian countries in recent years (Saithanoo & Naidu 1996). Cashmere production is a significant contributor to small-farmer income, particularly in China (Youzhang 1996). Mohair production is important for commercial farmers (Laker 1996), especially in South Africa (van der Westhuysen *et al.* 1988). However, most production from goats is utilized in the small farm context, where its impact and value is often not measurable (Devendra 1996).

Variability in body size and in geographic distribution among breeds of goats exceeds that of any other farm animal (Shkolnik 1992). Goats are particularly well adapted to hot climates (Singh & Singh 1992). They are often unfairly accused of causing environmental deterioration and even desertification (Singh 1992); but they can form an important part in the ecology of rural areas (Acharya & Singh 1992), and can even be used to control bush encroachment (Allan & Holst 1996; Woldeghebriel *et al.* 1992). Goats are usually not of specific breeds in the formal sense, although many types can be distinguished. Some have a greater potential for milk production and are known to be kept primarily for this purpose (Gall 1975).

Goats are usually kept extensively and this may mean that there are severe nutritional constraints on their ability to produce milk. Such constraints may also apply in urban or peri-urban areas where "town goats" are kept under circumstances that are most unfavourable, especially in terms of the adequacy of nutrition. Many different systems of keeping goats occur in different parts of the world, and they may be both appropriate and efficient. However, improvements in productivity may be achieved by simple changes in methods of management, nutrition, disease prevention and health care (Mavrogenis & Narjisse 1992). Small holder goat production systems in Africa have been reviewed (Wilson *et al.* 1992).

Milk production from goats is substantial in many countries of Europe such as France (Sigwald & Lequenne 1985; Sopexa 1986), Germany (Geissler 1987), Great Britain (Mowlem 1988), Greece (Hatziminaoglu *et al.* 1982; Katsaounes 1986) the Netherlands (Boogaert 1982), Norway (Nygaard 1986), Spain (Ballester 1986), and Yugoslavia (Antic *et al.* 1986). However even in these countries most people who keep dairy goats keep a few for household use; and the commercial producers, while they may have large numbers of goats in their herds, are relatively few in number .

Goats are also kept for milk production in developed countries elsewhere, such as Australia (Rayner 1985), New Zealand (Horton & Dawson 1987) and the United States of America (Haenlein 1986). They have been reported to be a significant source of milk in many developing countries as well, including Brazil (Neto & Baker 1987), Central America (Stanton 1982), India (Saini & Khan 1986), Israel (Laor 1982), Mexico (Peraza 1986) and Thailand (Sarabol 1985). The difficulties commercial goat producers face include the need to manage successfully the whole spectrum of production, processing and marketing. This is because there may be no co-operative ventures or State controls over goat milk production, comparable to those that apply to the cow milk industry. Commercial ventures are also faced with problems of organization, inadequate facilities, and in particular, labour requirements, as a result of the large number of goats required to ensure economic viability. In few cases are the dairy goats the sole source of income (Mowlem 1988).

It is apparent that most people who keep dairy goats do so for a household supply of milk, with perhaps a surplus sold locally as milk or cheese. In France there are more than 80 recognised varieties of goat cheese (Le Jaouen 1982).

1.2 The Value of Goat Milk

Goat milk varies in quality in a way similar to that of cow milk (Le Jaouen 1986). For example, composition changes with breed, stage of lactation (Jenness 1980; Loewenstein 1982; Parkash & Jenness 1986), and feeding (Calderon *et al.* 1980; Morand-Fehr, Chilliard & Sauvant 1982; Morand-Fehr & Sauvant 1980). Disease, especially mastitis, can affect milk quality (Park & Humphrey 1986). If milk is produced unhygienically, it will be contaminated (Danielsson *et al.*

1982; Lewis 1988). Mineral content has also been documented (Park & Chukwu 1988). An example of the variability in compositional quality is given in the following Table (after Jenness 1980; Parkash & Jenness 1968):

Country	Breed	Total Solids (%)	Fat (%)	Protein (%)	Lactose(%)
Australia	Saanen	12.24	4.01	3.10	4.93
Germany	Fawn	12.43	3.92	3.52	4.48
India	Barbari	-	4.11	3.76	4.80
Nigeria	Saanen	12.15	3.41	3.07	4.54
Nigeria	Red Sokoto	15.28	4.86	4.38	4.72
Nigeria	Dwarf	17.87	7.10	4.71	5.58
UK	(various)	13.2	4.5	2.9	4.1
USA	(various)	13.5	4.6	3.6	4.7

Comparisons of milk yield should be made in such a way as to take account of compositional quality. A system similar to the Fat Corrected Milk (FCM) procedure for dairy cows may be used (Mavrogenis & Papachristoforou 1988; Van Zyl *et al.* 1988).

Analyses have been made of milk quality in Boergoats (Casey & Van Niekerk 1988), and the mean milkfat and protein analyses were 7.7% and 4.3% respectively. Milk from goats on the milk recording scheme in South Africa and registered with the Breed Society (n=263) had milkfat and protein contents of 3.16% and 2.65% respectively, for lactation yields of 981kg; milk from unregistered goats (n=281) had average analyses of 3.04% and 2.53% respectively for lactation yields of 986kg (RSA 1996). Indigenous goats in first lactations averaged 8.89% milkfat and 5.36% protein, which was three and two times respectively the concentration in milk from Saanens kept under the same circumstances (Donkin *et al.* 1990).

Goat milk differs from cow milk in the amino acid content and composition of the proteins (Addeo *et al.* 1987; Loewenstein 1982; Quiles *et al.* 1994) and therefore can have particular benefit in diets of children and adults who show sensitivity or allergic reactions to cow milk (Gorney 1982; Maree 1978). This is not to be confused with lactose intolerance reactions (Podleski 1992; Savaiano & Levitt 1987). Park (1994) reviewed the information available concerning the hypo-allergenic and therapeutic significance of goat milk. The incidence of allergy to cow milk in the United States is estimated at about 7% of children. Between 40% and 100% of patients allergic to cow milk proteins have been found to be tolerant to goat milk. Other advantages are the smaller fat globules, higher proportion of short and medium chain fatty acids and softer curd formation which are beneficial for digestibility and healthier lipid metabolism in comparison to cow milk.

Analyses indicate that one particular vitamin, folic acid, is deficient in goat milk (O'Connor 1994). Therefore, for infants relying on goat milk as the sole source of nutrients, a suitable supplement should be given to prevent anaemia (Davidson *et al.* 1984). However there is some evidence of a greater bioavailability of iron in goat milk than in cow milk (Park *et al.* 1986). In conclusion, it is clear that goat milk is a valuable source of nutrients and is in many ways comparable to cow milk. It is a potential resource that should be utilized.

1.3 A Place for Dairy Goats in Southern Africa

In Southern Africa goats are kept primarily for meat production (Donkin 1988) or for mohair production (Van der Westhuysen *et al.* 1988), and they are not a significant source of milk. There are probably only two or three thousand dairy goats of the recognised European breeds (Donkin 1988).

In any developing country a major problem is always posed by the rapid increase of the population and the large proportion of people with small incomes. Improved medical facilities and primary health care reduce infant mortality and there is a massive increase in the proportion of children in the society, as the parents still have large families. Mothers may reduce breast-feeding which can lead to a shorter interval between pregnancies (Morley & Lovel 1986). Very often the children are malnourished. This may be as a result of lack of food in sufficient quantity, or as a result of a lack of good quality food, or both, and has long-term consequences (Scrimshaw 1990). Milk is an ideal supplement to reduce any malnutrition (Davidson *et al.* 1984; Maletnlema 1987).

Families may not be able to buy fresh milk or milk powder because of the cost or because it is not available. The obvious solution for people in rural areas is for them to increase milk production from animals that are already available. Dairy cows, as the traditional source of milk, are expensive, require sophisticated feeding and management to be productive, and may produce more milk than required for the household. Beef cattle may be milked for the benefit of their owners (Tapson 1990), but yields are often so low that this will be to the detriment of the calf. In addition, fertility levels may be such that a calf is born only every two or three years, and milk is only sporadically available. The average livestock owner may keep very few cattle (Bembridge 1987). A study in Kenya has shown that the introduction of dairy cows was only feasible when farmers had access to credit and health and nutrition technology, and that cows were not desirable for smallholder farmers (Stotz 1982). In contrast, dairy goats are more appropriate to the needs of subsistence production and their use would be in harmony with the concept of the household economy (Low 1986). Goats are cheaper; require less food; produce appropriate quantities of milk; breed at a younger age; have multiple births; are more easily handled by women and children; represent a smaller loss in the event of death; and produce a carcase of appropriate size for a household's needs (Devendra & Burns 1983).

There is great potential for development of milk production from goats in the tropics (Sands & McDowell 1978), and in Southern Africa as well (Donkin 1988). Projects for this purpose have already been established in recent years in Kenya (Boor *et al.* 1987; Kitivo *et al.* 1982) and in Zimbabwe (Harrison 1988). In Kenya, Miller and Mwangi (1996) have reported the difficulties and benefits of goat milk production monitored with 1300 farmers. In Malawi, research projects have been concerned with evaluating milk production from indigenous goats (Cooper *et al.* 1994) and crossbred goats (Boylan *et al.* 1996). In Botswana, a survey has indicated that goat numbers have increased from 557 000 to over 2 million between 1979 and 1990. Goats are kept for milk as well as meat (Mrema & Rannobe 1996), even though milk production is only about 400ml/day (Mrema 1996).

2. FACTORS AFFECTING MILK PRODUCTION IN GOATS

2.1 Genetic Factors

2.1.1 Breed Differences and Selection

Some indication of breed differences has already been given in Section 1.2 (above). European breeds of dairy goats generally have a far higher potential for milk production than indigenous breeds that have not been selected for this attribute. This difference applies even when account is taken of the generally higher solids content of the milk of indigenous goats.

In countries such as France (Sopexa 1986) and the USA (Wiggans & Dickinson 1984) dairy goat sires are evaluated in a way similar to that applicable in dairy cattle. However, artificial insemination has been used successfully in goats only in recent years (Sopexa 1986), so that the effect of an outstanding sire is less widespread than for dairy cattle sires (Steine 1982).

A study of genetic parameters for milk production in dairy goats indicates good potential for improvement by selection (Ronningen 1966). Expected genetic gains in milk range from 3.0 to 3.8 percent per annum if a standard deviation of 300kg is assumed (Dentine & McDaniel 1982). Progress is also possible in non-dairy breeds such as the Beetal, although from a much lower initial level of milk production (130kg per lactation) (Singh & Acharya 1982). Unimproved types of goats may have low milk yields of up to 100 to 200kg in lactations of 140 to 180 days (DeGroot *et al.* 1992; Roy *et al.* 1992).

2.1.2 Inbreeding

Inbreeding is generally undesirable for the improvement of many traits because of the effects of homozygosity in allowing the expression of undesirable genes, resulting in inbreeding depression. This is usually greatest for characters associated with natural fitness such as viability and reproductive ability (Nicholas 1987). A general conclusion is that inbreeding should be avoided (De Lange 1989). It is possible that dairy goats in South Africa may be inbred to some degree because of the small population. Inbreeding should be assessed in case it affects productivity. Baker & de Souza Neto (1989) specified inbreeding as one of the main reasons for low productivity of crossbred goats in Brazil.

2.1.3 Crossbreeding

Crossbreeding results in heterosis (hybrid vigour) for certain characteristics. It is apparent when the average performance of crossbred progeny is superior to the average performance of the two parents. If this is a significant effect, the benefits may not persist with subsequent crossings or grading-up (Nicholas 1987). The main dairy goat breeds have been developed in Europe, and their yields generally far exceed those of indigenous breeds in other parts of the world (Mason 1981; Sahni & Chawla 1982). In a number of cases the milk yields of European breeds, such as Saanen, Alpine, Anglo-Nubian and Toggenburg goats, have been depressed to between 20 and 50 percent when they were kept in tropical countries. Such reductions were probably due to poor genetic potential, nutrition, disease or environmental stress (Steinbach 1987). Similar reports were recorded by Sands and McDowell(1978), except for goats in Israel and South Africa, where the environment and management were more favourable (Hofmeyr 1969). Yields of milk recorded goats in South Africa are similar to those of goats in Europe (RSA 1996; Shelton 1978).

Crossbreeding is a logical step to improve milk production of indigenous goats, and has been done in many countries (Galal 1987; Ricordeau 1981). Crossbreeding with European dairy goat breeds has in most cases resulted in large increases of milk production, even where environmental and management factors may not have been ideal. (See Table below: Sahni & Chawla 1982).

Country	Breeding	Milk Yield per Lactation (kg)		
		Native	F1 Crossbred	Three-quarter Bred
Korea	Saanen x Native	91	288	355
Puerto Rico	Saanen x Native	188	245	285
Turkey	Saanen x Kilis	261	710	718
Malaysia	Anglo-Nubian x Kambing Katjang	90	296	-
India	Saanen x Beetal	164	306	372
India	Saanen x Barbari	67	164	-

European dairy goat breeds (Alpine and Saanen) have been found to have lower milkfat and protein than crossbred and Indian Beetal goats. The crossbreds were intermediate in production. Stage of lactation and season had significant effects, even when goats were on uniform diets and systems of management (Bhatnagar *et al.* 1982; Chawla & Verma 1982). Similar results of crossbreeding European dairy goats with local breeds have been demonstrated in Turkey (Ozcan & Gursoy 1982); in Venezuela (Garcia, Bravo, Kennedy & Garcia 1982; Garcia, Garcia, Kennedy & Bravo 1982); in Chile (Hernandez-Naus *et al.* 1987); in China (Pu *et al.* 1987; Shongjia *et al.* 1992); in Malaysia (Mukherjee *et al.* 1985; Stemmer *et al.* 1996); in Mexico (Mellado *et al.* 1991); and Norway (Bakkene 1985). Little benefit of crossbreeding was found in India in an arid environment (Mittal 1992).

Crossbreeding has been carried out with Boergoats as well, in Kenya (Angwenyi & Cartwright 1987) and Germany (Schumacher *et al.* 1982), but mainly with the objective of improving meat production. Other experiments in crossing meat goats have been reported from Tanzania (Das 1992) and India (Panandan *et al.* 1992). Crossbreeding may be practised for a number of reasons, including the benefit of heterosis; as an initial stage of transition in establishing a breed ("grading-up"); or for the development of a new breed. The use of established dairy breeds for this purpose may be particularly relevant in unfavourable environments. Whether up-grading or the development of a new breed is the best policy will depend on the environment and level of management (Shelton 1986). The option of crossbreeding to introduce suitable genetic material for milk production is a much more rapid method than that of attempting to improve milk yield of local goat breeds by selection (Sands & McDowell 1978). The research reported by Rege *et* *al.* (1994) concerning crossbreeding with Jersey cattle in Africa has relevance, as the principles are the same. With Gudali x Jersey cattle, there was no significant advantage in increasing the proportion of Jersey genes beyond 0.5 for milk production traits. Heterotic effects were large and significant in improving milk production in Ghana Shorthorn crosses, although no heterotic effects were significant for reproductive traits. If this research has applicability with milk goats, then a third breeding option of producing first-cross females (F1) for milk production might be appropriate. The Crossbred females could be back-crossed to Indigenous males to produce progeny suitable for slaughter.

2.1.4 New Genetic Technology

Artificial insemination technology is now established for goats and can be expected to be used more widely in future (Greyling 1988). However, the value is limited by the effectiveness of systems for identifying outstanding sires, and by the generally small size of dairy goat herds (Mukherjee 1992). Nevertheless, this may be easier than in the past by using such analytical techniques as BLUP or REML (Hill & Meyer 1988). One recent factor that may inhibit the development of artificial insemination is that there is a risk of transferring Caprine Arthritis Encephalitis Virus (CAEV) in the process (Knowles *et al.* 1987).

Embryo transfers can be carried out in goats (Moore 1987), but are likely to have limited applicability (Foote *et al.* 1987; McKelvey & Bhattacharyya,1992). Ishwar & Memon (1996) have reviewed the technology for embryo transfer. *In vitro* production of embryos has had limited success (Poulin *et al.* 1996). Gene transfer technology (Memon & Ebert 1992) is also unlikely to have practical application for the forseeable future (Armstrong *et al.* 1987).

2.2 Physiological Factors

Many physiological factors can affect milk production, and will have to be assessed in relation to lactation yields measured. Mathematical models of lactation curves are useful to describe the essential characteristics of lactation during the lactation cycle. They can be used for predicting and comparing actual with expected milk production; for analysing data for the effects of factors such as genetic potential, stage of lactation, age and parity (lactation number); and assessing the effects of management, feeding practices and health care.

Wood (1969) established a method of fitting lactation curves for dairy cows. This method has also been used to fit curves to lactation data for East African goats (Wahome *et al.* 1994); for crossbred goats in Kenya (Ruvuna *et al.* 1995) and in Mexico (Montaldo *et al.* 1997); and to Comisana sheep in Italy (Portolano *et al.* 1996), US sheep breeds (Sakul & Boylan 1992), and Merino sheep in South Africa (Groenewald *et al.* 1995). Factors such as breed, season of kidding, lactation number (parity), and number of kids were found to be significant influencing factors. However, the papers of Williams (1993 a,b) critically evaluated the Wood models in comparison with other models proposed by Gipson & Grossman (1989) and Morant & Gnanaskathy (1990). Williams (1993a) indicated that the Wood model was less satisfactory than the Morant model, because it overestimated peak yields, underestimated mid-lactation yields, and over-estimated late lactation yields. In contrast, the linear Morant-4 model was adopted as the method of choice, because it was easy to use, relatively easy to fit, and there was little pattern of residuals after fitting the curves. Groenwald *et al.* (1995) also found the Morant models to be more satisfactory in describing the lactation curves of Merino sheep.

Some of the more important aspects influencing milk production are discussed here:

2.2.1. Age

Age is closely related to body size and parity (lactation number) as it affects milk production (Devendra & Burns l983). Body mass may increase up to six years of age and decrease there-after, and milk yield varies similarly, with peak milk yield at between four and eight years (Gall 1981). Factors can be calculated to adjust lactation records to a Mature Equivalent basis for comparative purposes (Wiggans 1984). However, Browning *et al.* (1995), working with Alpine goats, found the highest yields (960kg) in second lactations, and the lowest (634kg) in seventh lactations.

2.2.2. Seasonal Influence

Season of kidding can affect milk production (Gall 1981) and is often confounded with age effects. Adjustment factors can be calculated to correct for this bias (Wiggans 1984). Extremely cold weather can reduce milk production (Gall 1981; Mourad 1992). Goats producing milk are susceptible to heat stress in spite of heat resistant characteristics (Lu 1989).

2.2.3. Multiple Births

Mammary growth during gestation is said to be affected by the number of kids, and this has a subsequent effect on milk production which is independent of age, bodymass and season (Gall 1981; Mourad 1992). Milk production may also be increased in response to suckling stimuli, but this is not a factor in dairy goats if the kids are taken away and fed by hand (Devendra & Burns 1983). Williams (1993b) found no evidence of an effect of litter size on milk yield. However, Browning *et al.* (1995) found that Alpine does that had given birth to singles had a lower milk production (775kg) than does with twins (834kg) and triplets (903kg). This was despite the removal of kids at birth.

2.2.4. Length of Lactation and Dry Period

Some goat milk producers breed high yielding goats only every second year, to ensure continuity of milk production, with a resulting lactation of up to 22 months. However the more usual practice is to breed them annually, resulting in a lactation of ten months and a dry period of two months. Non-dairy breeds may not have a lactation this long, and then the dry period would be longer than two months (Devendra & Burns 1983). As with dairy cattle, it appears that a dry period is essential before a new lactation, to allow time for regeneration of secretory tissue. Short dry periods reduce subsequent milk yields (Schmidt & Van Vleck 1974). However, one experiment (with only four goats) showed no reduction of milk yield after the dry period was omitted, comparing milk production between halves of the udder (Fowler *et al.* 1991).

2.3. Milking Management

2.3.1. The Use of a Milking Machine

In small herds goats are milked by hand, but when goat numbers increase beyond 30 goats, consideration is given to the use of milking machines (LeJaouen 1981). A vacuum level of 45 to 52 kPa, pulsation ratio of 60:40 and a pulsation rate of 90 pulses/min appear to be optimal for machine milking of goats (Lu *et al.* 1991). Provolo *et al.* (1993) compared milk jars or milk meters for recording milk yields in Italy. They concluded that milk meters were liable to greater errors than milk recording jars, so that sampling had to be more frequent and precise compared to cow recording systems. The milking routine must ensure effective milk-letdown without stress, as adrenalin will reduce milk ejection and inhibit milk production. The structure of the goat mammary gland differs from that of the cow in that the volume of the cistern is greater in relation to total gland volume. This may mean that goats are less dependent on the milk letdown reflex for complete removal of milk than are cows (Gall 1981). Nevertheless, behavioural expression of temperament can be related to differences in the inhibition of milk ejection (Lyons 1989). This may be a factor reducing milk yield in indigenous goats. For example, some breeds of cattle will not show an effective milk ejection reflex without the presence of the calf (Alvarez *et al.* 1980). The release of milk (letdown) has been demonstrated to be important in one experiment with East African goats in Kenya. Milking in the presence of kids increased milk yield. However, as a consequence, too much milk was taken for human use, and there was little residual milk left to sustain adequate growth of the kids (Ruvuna *et al.* 1987).

Studies on milk letdown have been carried out with different breeds of indigenous goats in France (Sinapis *et al.* 1993); in Bulgaria (Ouzunov & Zounev 1993); and the Czech Republic

(Cumlivski & Stoural 1993). They showed that at least 80% of goats had no problems with milk letdown, provided they were adequately stimulated. The conclusion was that machine milking was acceptable for these breeds.

2.3.2. Milking Frequency and Milking Intervals

A reduction in the number of times a goat is milked per day will reduce milk yield. If goats are only milked once a day, then yield will be reduced by one third. If one milking is omitted on Sunday afternoons, yield will be reduced by 5 percent (Mocquot 1985). Secretion rate increases when milk is removed more frequently, as for example with thrice daily milking, especially for those goats that store a relatively high proportion of their milk in the alveoli compared to cisternal volume (Knight *et al.* 1989). It is well known that a greater frequency of milking increases milk production in cows, and conversely, that a build up of milk in the udder will reduce milk yield. Traditionally this was assumed to be a result of a build up of intra-mammary pressure (Schmidt & Van Vleck 1974), but more recent research has indicated that it is the effect of a fraction of whey protein (Wilde & Peaker 1990) which affects the proliferation and loss of secretory cells. Whatever the reason, dairy farmers try to keep the intervals between milkings to similar lengths of time. High-producing cows and heifers have been shown to give four to seven percent less milk if milking intervals were 16 and 8 hours (Bath *et al.* 1985). It is possible that uneven milking intervals will have less effect in goats than in cows (Mowlem 1988), because goats have a greater proportion of cisternal milk than cows (Dewhurst & Knight 1993; 1994). It may be necessary to adjust milk records either for long intervals or for increased milking frequency if these are factors in the management system.

2.4 Fertility Management

The productivity of dairy goats must be seen in the context of management of the whole herd. The effects of management, environment or disease on individual goats can have a wider effect on the efficiency and profitability of the whole herd or enterprise. For example, crossbreeding may affect breeding season, reproductive efficiency and kid mortality. Conversely, management decisions concerning such aspects as age at breeding and feeding strategy could have significant effects on the results obtained from a crossbreeding experiment (Shelton 1978). Some of these aspects will now be discussed.

2.4.1. Breeding Season

Oestrus can occur at any time during the year with most tropical breeds of goats although they may be affected by poor nutrition (Delgadillo & Malpaux 1996), but breeds developed in

temperate zones are seasonally polyoestrous (Walkden-Brown & Restall 1996). For both types there is a peak of sexual activity in autumn, associated with decreasing day-length (Devendra & Burns 1983), but often two peaks of activity are shown (Gonzalez-Stagnaro & Madrid-Bury 1982). Season of kidding may affect milk production, with peak production occurring in summer. This could be ascribed to nutritional effects (Kawas *et al.* 1992), but photoperiod is also important (Gall 1981). The effect of photoperiod has been reported by Chemineau (1992); by Chemineau *et al.* (1992); and Chemineau *et al.* (1996). There may be differences between male and female goats in their reaction to photoperiod changes (Debenedeth & Coll 1992).
Problems of marketing may arise if the breeding season is limited, because there will be a time during the year when the goats are in their dry period before the subsequent lactation. Manipulation of the lighting system can be an effective mechanism for inducing year-round breeding in dairy goats (Ashbrook 1982), and melatonin can be used to augment this method (Deveson *et al.* 1989). Other hormonal treatments have also been shown to be effective (Amoah & Gelaye 1990; Corteel *et al.* 1988; Holtz & Sohnrey 1992; Pendleton *et al.* 1992).

2.4.2 The Influence of Male Goats

The male goat is generally fertile if free from inherited defects, but a physical examination and assessment of the semen is desirable (Smith,M.C., 1992). Spermatogenesis in Black Bengal goats started at 4.5 months and was completed one month later (Majumdar 1992). Polled billy goats will produce hermaphrodite kids, and so horned males should always be used (Ricordeau 1981; Margetin 1992). The "male effect" can be used to synchronize oestrus, resulting from multisensorial, but mainly odour stimulation (Restall 1992); or in combination with other treatments such as light (Delgadillo & Malpaux 1996). Seasonality can be significant in male goats (Roca *et al.* 1991), but this can be successfully minimized by the use of photoperiodic cycles (Delgadillo *et al.* 1992). However, experiments in Mexico with does in either poor or good body condition, showed no benefit of stimulation with male goats prior to breeding (Mellado *et al.* 1994). Artificial insemination is used successfully in some countries (Leboeuf 1992; Mowlem 1992).

2.4.3 Age at First Breeding

If goat kids have grown well enough then they should be ready for breeding at seven or eight months of age, and will begin the first lactation at 12 months. However, in many circumstances kids will not be ready until they are 18 months old, and they will then give birth at two years of age (Chawla & Bhatnagar 1982). This wide variation is partly genetic and partly environmental in origin (Devendra & Burns 1983). Target mass before breeding will differ depending on the breed, and examples are 18 to 20 kg for the Katjang goat in Malaysia (Devendra & Burns 1983);

and 32 kg for dairy goats in France (Morand-Fehr, Hervieu, Bas & Sauvant 1982). The non-developed tropical breeds are said not to show much diversity from developed temperate breeds in age at first kidding (Aboul-Naga & Hanrahan 1992).

2.5 Kid Rearing

The number of kids born, kid mortality, system of rearing and incidence of diseases can affect growth rate and therefore breeding age. This in turn affects the number of young females entering the milking herd (to ensure continuity of production), and the level of milk production expected. Such parameters are affected by genetic (breeding) and environmental (management) policies and practices.

2.5.1 Prolificacy

Devendra and Burns (1983) have listed expected litter sizes for a wide variety of breeds of goats, ranging from 1.0 to 2.3. These statistics may sometimes become confused where goats are bred to give more than one litter a year (Ricordeau 1981). Some of the differences may be genetic, but age, bodymass and condition can also influence litter size (Constantinou 1989; Teh & Escobar 1987). One study showed year effects, but no influence of season of kidding or sire (Prakash & Khan 1987). The heritability of litter size is said to be low (Ricordeau 1981).

2.5.2 Kid Survival

Mortality among kids is a major factor determining the productivity of a herd (Sherman 1987). Neonatal deaths always make up a high proportion of total mortality, and may be caused by dystocia, cold, lack of food, and diseases (Devendra & Burns 1983). The influence of diseases, especially coccidiosis, is discussed elsewhere.

Differences in placentation can affect the growth and viability of lambs, and it would be reasonable to suppose that this would also apply in goats (McDonald *et al.* 1981). *In utero* infections can cause abortions and weak kids (Lefevre 1987b). Respiratory diseases (Ojo 1987) and gastrointestinal disease (Nagy *et al.* 1987) are major causes of kid mortality.

Kid survival has been shown to be dependent on birthmass. For example, a high mortality was shown by feral Australian kids of less than 2.5 kg, and poor nutrition of does resulted in a kid survival rate of 64 percent compared to 86 percent for those that were better fed (Bajhau & Kennedy 1990). Another study has shown that kids dying within 48h of birth were significantly lighter (2.3kg) than those that survived (2.9kg) (Allan, Holst & Hinch 1992). Up to 68% of peri-natal mortality was due to starvation (Allan, Hinch & Holst 1992). Birth weight, and not genetic factors, has been identified as the main determinant of kid survival in India, which were 79% from 3 to 6 months, and 82% from 6 to 12 months (Singh *et al.* 1991).

Immunoglobulin levels that result from adequate ingestion of colostrum are important (O'Brien & Sherman 1993a,b). Vihan (1988) has observed a 20% mortality in deprived kids, and reported the beneficial effects of vaccination with *E. coli* vaccine in prevention of colibacillosis (Vihan 1993). Artificial rearing of goat kids using an early-weaning (four week) system in England resulted in mortality of 33% post-weaning from starvation, compared to low levels when kids were weaned at eight weeks (Owen & de Paiva 1982).

Kid mortality has been reported to be higher for dairy goats (41.1 %) than for other breeds (average 33.8%) in India (Khera & Harbola 1982). Other reports indicated lower mortalities than these (approximately five percent), especially in extensive systems (Misra & Acharya 1987). In contrast, in Venezuela, mortalities of crossbred goats (European dairy goats crossed with native goats) varied from 26.5 to 47.5%, with no particular breed differences apparent (Garcia, Garcia, Kennedy & Bravo 1982). In Haiti, mortality of crossbred kids was lower (28%) than that of purebred Haitian kids (43%)(Martinez *et al.* 1992).

Mortality of Red Sokoto goats in Nigeria was 22.8% within the first month, due to abortion, dystocia, pneumonia, "starvation complex", *Haemonchus*, ectoparasites and predation. The major causes were pneumonia and "starvation complex", resulting from poor mothering ability (Ojo 1996). In Zimbabwe, pre-weaning losses of kids on communal grazing have been reported to be high (Ndlovu & Sibanda 1991). A further report from Zimbabwe stated that 19.4% of kids were lost before 180 days, either "lost" kids or from predation (Ndlovu & Simela 1996). Undernutrition of the female may result in inadequate intake of colostrum, as has been shown in sheep (Mellor & Murray 1985), which aggravates the adverse effects of low birth weight.

Morand-Fehr(1987) has indicated that mortality of kids can be kept at low levels by careful management during and after parturition, by ensuring adequate colostrum intake, by avoiding stress and by improving feeding of dams and kids.

2.5.3 Kid Rearing Systems

Many systems of rearing kids can be used, but will depend upon management capabilities and facilities. The objective should be to raise the kids economically, without increasing the likelihood of diseases or mortality, or of reducing growth rates from the economic optimum. The system of allocation of milk or milk substitute, time of weaning, and form of supplementary feeding can be significant. For example, one study (Greenwood 1993) showed that kids grew best when reared using cow colostrum, pasteurized goat milk at 1.6 litres/day and an ad libitum ration (with 12.3 MJ Me/kg and 252.5gCP/kg DM) until weaning at seven weeks, and a liveweight of 12.8kg. However, this system may well not be the most economical option. Milk feeding may be for as short a time as 4 to 5 weeks, or as long as several months. Milk replacers for calves or lambs can also be used for kids, but replacement of milk proteins by soya or fish proteins may reduce kid performance. Natural rearing is recommended for meat producing herds, and also for milk producing herds where the price of milk substitutes is high or management is poor. Individual feeding of milk from a small pail is suitable. Ad libitum teat feeding may save labour, but will increase consumption. Restricted milk feeding will enhance intake of other feeds and reduce the adverse effects of weaning (Havrevoll *et al.* 1991).

Weaning can be a time of great stress, and blood glucose levels have been shown to fall from 1.2g/litre to 0.68g/litre, mainly as a result of the energy deficit (Bas & Morand-Fehr 1992). The intake of Metabolizable Energy reached pre-weaning levels only 6 to 8 weeks after weaning at 4 to 8 weeks of age (Bas *et al.* 1991).

Post-weaning feeding is greatly affected by age at weaning and intensity of production. Intensive systems where female kids are bred at seven months must ensure that they are fed well to grow to the required size in the time available. This often includes the use of ionophores and cereal grains (Hadjipanayiotou, Economides, Morand-Fehr, Landau & Havrevoll 1991). Many factors may affect growth rate (Ruvuna *et al.* 1991).

2.6 Nutrition

2.6.1 Nutrient Requirements

Nutrition will have a major effect on production of milk, and careful planning of a feeding programme is essential, as with dairy cows, to ensure adequate intake of roughage (Sauvant, Morand-Fehr & Giger-Riverdin 1991) and concentrates, and a sufficient supply of all nutrients required. One problem arises from the fact that less research has been done on the nutrient requirements of goats than in other species (NRC 1981). However, more recently, significant research has been carried out on nutrient requirements (Ademosun *et al.* 1992) and digestion physiology (Tisserand *et al.* 1991; Sauvant 1992). Specific reviews have summarized progress in defining nutrient requirements in terms of energy for growing goats (Sanz Sempelayo *et al.* 1991), and for adult goats (Sauvant & Morand-Fehr 1991); protein for growing goats (Hadjipanayiotou, Brun-Bellut & Lindberg 1991), and for adult goats (Brun-Bellut *et al.* 1991); mineral nutrition (Haenlein 1992; Kessler 1991a); vitamins (Kessler 1991b); and water requirements (Giger-Reverdin & Gihad 1991).

Goats are renowned as fussy eaters (Mackenzie 1980) and this may be an expression of their ability to select food of high nutrient content when grazing or browsing (Harrington 1982; Lu 1988).

2.6.2 Feeding Systems

The feeding system used for dairy goats will depend on the resources available (Devendra 1987b), ranging from extensive grazing systems (Cunningham 1982), to intensive grassland systems (Alexandre *et al.* 1996; Coop 1982), to very intensive systems (Orskov 1982). Forage trees like *Leucaena* can also be used for milk goats (Shenkoru *et al.* 1996) although probably more often used for meat goats (Mtenga & Shoo 1990). However, for good yields of milk from dairy goats, intensive systems are essential, to provide enough good quality roughages and concentrates (Demment & Longhurst 1987; Morand-Fehr & Sauvant 1980). Excessive walking will increase the nutrient requirements (NRC 1981), and milk production of goats may be limited by their ability to ingest sufficient nutrients (Morand-Fehr & Sauvant 1980). The most cost-effective feeds should be used (Stark 1987). Knowledge about the mineral requirements of goats is limited (Haenlein 1980). Underfeeding of nutrients may be detrimental, but overfeeding can also be undesirable, especially if there is an imbalance of nutrients or a lack of roughage in the total diet, leading to reproductive difficulties, acetonaemia or laminitis (Slater 1987). Intensive feeding systems for dairy goats have become more prevalent in recent years (Devendra 1992b). Where roughage is limited, more concentrates are fed, and the animals are often confined (Giger-Riverdin & Sauvant 1991; Hadjipanayiotou & Morand-Fehr 1991). In contrast, indigenous goats generally have to survive and reproduce in harsh environments with extremes of environment and an erratic and insufficient food supply (Meuret *et al.* 1991; Ramsay & Smit 1987). It is reasonable to assume that nutrition is therefore a major constraint on their productivity. If dairy goats or crossbred goats are to be introduced successfully in Southern Africa, appropriate and economic feeding systems will have to be devised. These should make use of sources of feed that are available, and should be sufficient to allow the goats to express their genetic potential. They should also be appropriate to the socio-economic circumstances of the people keeping the goats (Boyazoglu & Morand-Fehr 1987).

The assertion has been made that goats need to select food of high nutrient content as they do not digest low quality roughage to the same extent as cattle, because of their smaller size (Illius & Gordon 1991). However, this view can be challenged by evidence presented by Tisserand *et al.*(1991), who stated:

" with forages low in nitrogen content and high in cell walls and not properly supplemented, goats have a better digestive efficiency than other ruminants......ascribed to the longer mean retention time of digesta, higher concentration of cellulolytic bacteria...... and their higher efficiency for recycling urea ."

It is likely that a major constraint to many dairy goat owners will be the provision of sufficient quantities of good quality roughage (Masson *et al.* 1991; Schwartz & Carles 1987). In addition, for efficient rumen function, dairy goats because they are high-producing animals, like dairy cows , will need an adequate *proportion* of total dry matter intake in the form of roughage (Kawas *et al.* 1991). One way of overcoming both these constraints would be the use of a complete feed (Morand-Fehr *et al.* 1996; Reddy & Raghavan 1992), as is used for dairy cattle (Poole 1986). This also has advantages experimentally in eliminating variation due to differences in availability and selection of browse or grazing. Goats in Italy have been shown to produce milk efficiently in a zero-grazing system (Bufano *et al.* 1996). Growth promotants such as ionophores improve average daily gain and feed conversion of growing kids, but have not yet been thoroughly researched in adult goats (Schmidely & Hadjipanayiotou 1991).

3. GOAT MEAT PRODUCTION

Meat is usually the most important product of goat farming, and can also be a significant source of income for fibre and milk production enterprises (Smith,G.C., 1992). It is an important source of protein in many developing countries of the world (Casey 1992), especially in Asia (Saithanoo & Huq 1992); but is less important in the USA (Smith,G.C., 1992) and in Europe (Morand-Fehr *et al.* 1992). Marketing systems are either non-existent or poorly developed and managed (Wilson 1992; Mandebvu 1991). Meat hygiene is often poor (Gill & Joshi 1992). The efficiency of goat meat production will depend on the reproductive rate achieved, and on the survival and growth rates of the kids, as well as the availablity of suitable feed sources. Goat meat production development programmes have been attempted, but with varying success on natural vegetation (Carles & Schwartz 1992; Riviere 1991); and also with intensive feeding (Mandebvu & Prasad 1991). Research has been carried out on the effects on carcasses of breed (Hogg *et al.* 1992; Ruvuna, Taylor, Okeyo, Wanyoike & Ahuya 1992); of rearing and feeding systems (Morand-Fehr *et al.* 1991); and of castration (Anous & Shahin 1993). Aspects of carcass evaluation include conformation (Prasad & Kirton 1992); by-products (Kumar & Issani

1992); minerals (Wahid *et al.* 1992); fatty acids (Zygoyiannis *et al.* 1992); and palatability (Griffin *et al.* 1992).

4. DISEASES IN GOATS

4.1 Incidence of Diseases in Goats

Any disease which affects the well-being of a dairy goat will reduce milk production, either directly through the effects on the individual animals, or indirectly through a reduction in fertility of the herd and therefore in the initiation of new lactations. (The wide range of diseases that can affect goats is illustrated below). The severity of the impact on milk production will depend on the severity and nature of the disease. Thus some diseases will have little effect on herd productivity, such as isolated cases of carcinoma (Rajan *et al.* 1982); or a more general effect, such as with pneumonia (Hidalgo 1987); or a specific effect on fertility, such as with toxoplasma (Dubey 1987); or an effect both on goats and humans, such as with brucellosis (Kolar 1987). However, seldom have the effects of these diseases been quantified in terms of a reduction of milk production. At times the effects are severe, as for example when a herd of 700 goats had to be destroyed in California because of an outbreak of mycoplasmosis (Damassa *et al.* 1987); or when a herd of dairy goats in Zimbabwe had to be slaughtered because they were infected with CAEV (Harrison 1988).

A wide range of diseases can affect goats, and dairy goats in particular (Williams 1981), and herd health programmes should be instituted to prevent these (Bliss 1984; Guss 1983; Lebbie *et al.* 1996). However, goats kept extensively in communal grazing areas may be remarkably free of internal parasites and diseases (Obwolo 1991). Management and husbandry are particularly important during kid-rearing in intensive systems (Morand-Fehr 1985).

This section of the review will only briefly consider various diseases.

4.1.1 Infectious Diseases

Many infectious diseases have been documented, including: brucellosis (Kolar 1987; Singh, Singh, Singh, Vihan & Lalwani 1992); tuberculosis (Bernabe *et al.* 1991); Johne's disease (Singh, Vihan, Singh & Gupta 1992); enterotoxaemia (Ayers 1984b; Harbola & Ratan 1992); mycoplasma (Damassa & Brooks 1987; Jones 1989; Wesonga *et al.* 1993); caseous lym-phadenitis (Dercksen *et al.* 1996; Gezon *et al.* 1991; Gonzalez & Tortora 1992; Olander & Brown 1987;); toxoplasmosis (Dubey 1987); pox (Mallick, Das, Goswami & Kishore

1992);foot-and-mouth disease (Shankar et al. 1992); pneumonia (Hidalgo 1987); mycosis (Chattopadhyay *et al.* 1992); coccidiosis (Smith 1984), and other diarrhoeal diseases (Ayers 1984a), such as colibacillosis (Singh, Vihan, Singh & Tiwari 1992; Vihan 1992a,b). Recent reviews have listed diseases affecting goats: bacterial (Sherman 1992); viral (Mallick, Shankar & Bansal 1992); protozoal and metazoal (Dubey 1992).

4.1.2 Coccidiosis

Coccidiosis is often considered to be a disease of intensification, affecting goat kids in particular (Vihan 1992b). However, it may also occur under more extensive conditions (Chhabra & Pandey 1992; Shrestha *et al.* 1992). One paper has reported cerebrocortical necrosis from treatment with amprolium (Lonkar & Prasad 1992). Monensin has been shown to reduce the effects of coccidiosis in lambs (Muwalla *et al.* 1994). Mortality rates of as high as 10% of does and 65% of kids have been reported (Sanchez *et al.* 1992). In another study, mortality from coccidiosis was 47% of a mortality rate of 9.9% of deaths from parasitic diseases (adults and kids), with most of the deaths occurring from three to six months of age (Sharma *et al.* 1992). It is possible that other infections may contribute to the effects ascribed to coccidiosis. In this regard, the identification of rotavirus in the MEDUNSA herd may be significant (DaCosta Mendes *et al.* 1994). Rotavirus has also been identified in goats in Spain (Munoz *et al.* 1994).

4.1.3 Caprine Arthritis Encephalitis (CAE)

Of particular note in recent years has been the extent and severity of Caprine Arthritis Encephalitis Virus (CAEV) (Adams *et al.* 1984). Although no reactors were reported from South Africa, one case was documented in Mozambique (Lopes Pereira *et al.* 1989), and in a research herd in Zimbabwe (Harrison 1988). Transmission appears to be through body fluids, primarily colostrum (East *et al.* 1993). This disease is very important in many countries of the world (Perrin & Polack 1992). Extension programmes have had some success in eradicating CAE (Greenwood 1992).

4.1.4 Tick-borne Diseases

Tick-borne diseases of importance in South Africa include anaplasmosis (Barry & Van Niekerk 1990) and heartwater (DuPlessis *et al.* 1983; Stewart 1987). These diseases are also important in other parts of Africa (Ilemobade 1982) and elsewhere (Matheron *et al.* 1987).

4.1.4.1 Heartwater

Heartwater is a disease caused by *Cowdria ruminantium*, transmitted by the tick *Amblyomma hebraeum* in South Africa (Walker & Olwage 1987). It affects cattle, sheep and goats in many parts of Southern Africa (van Winkelhoff & Uilenberg 1981) and elsewhere in the world (Matheron *et al.* 1987; Provost & Bezuidenhout 1987). Mortality has been reported to be high in Angora goats and Boer goats (Du Plessis *et al.* 1983; Du Plessis *et al.* 1986), but appears not to be well documented in other goat breeds in Southern Africa. Some degree of immunity can be induced by giving virulent heartwater blood and then blocking the disease with tetracycline when a temperature reaction is shown. However this procedure is risky, difficult to administer, and has a variable success rate (Poole,1962; Du Plessis *et al.* 1983). Immunity is difficult to assess serologically, and may be of limited duration (Stewart 1987).

The disease is characterized by a temperature reaction, and by clinical signs that can be associated with pain, fluid accumulation, and with damage to the nervous system (Prozesky 1987), leading to rapid death. The pathogenesis is not well understood (Du Plessis *et al.* 1987). Du Plessis (1985) proposed a "reaction index" to grade the degree of reaction between animals. However, the ideal would be to identify a marker or indicator that would be a good predictor of potential resistance, without the risk of mortality inherent in the present system of a direct challenge with the disease. Such a marker would make it possible to select resistant animals and study the mode of inheritance, thereby expediting the development of a resistant breed at greatly reduced costs in terms of animal suffering and mortality. There is some indication that resistance to heartwater may be linked to the presence of serum conglutinin in cattle (Du Plessis 1985; Du Plessis & Bezuidenhout 1979; Du Plessis & Malan 1987; Lachman 1967).

4.1.4.2 Anaplasmosis

Far less research has been carried out on anaplasmosis in goats in South Africa than on heartwater (Barry & Van Niekerk, 1990). This is presumably because it is perceived to be a less significant disease in goats than in cattle (FAO 1994).

4.1.6 Mastitis

Although mastitis is usually an infectious disease, its importance in dairy goats as in dairy cattle justifies listing it separately. It can affect milk production through sub-clinical as well as clinical infections (East *et al.* 1987; Guss 1984).

Losses are related, as with mastitis in dairy cows, to a reduction in milk production itself, as well as associated losses including the cost of treatment and the discarding of contaminated milk. However, such losses do not appear to have been quantified in dairy goat herds. Systems of controlling mastitis developed for dairy cows (Kingwill *et al.* 1979) should be applicable also to dairy goats. Diagnosis is in some ways different from mastitis in dairy cattle because of the unreliability of somatic cell counts (SCC) (Contreras *et al.* 1997; Lerondelle *et al.* 1992; Manser 1986; Park & Humphrey 1986).

Calfornia Mastitis Test (CMT), leucocyte counts, and lactose and chloride content were evaluated by Upadhyaya and Rao (1993) as measures of subclinical mastitis. The best correlation was between CMT and leucocyte count. Zeng and Escobar (1996) found no effect of breed of dairy goat or milking method on SCC. Over the whole lactation period, 51% of samples had more than one million cells/ml, but only traces of mastitis-related pathogens were found, which indicated that the high cell counts were not associated with mastitis infections. Wilson *et al.* (1995) also found that non-infected goats frequently had SCC greater than one million cells/ml, and suggested that an alternative measure of subclinical mastitis should be found for goats. Zeng (1996) has shown that the calibration of instruments used for measuring SCC had a significant effect on the results obtained, and this might be a reason for the apparently contradictory results reported. Other researchers have examined the different types of cells in goat milk. The proportion of polymorphonucleocytes increased during a lactation (Rota *et al.* 1993). Montaldo and Martinez-Lozano (1993) have shown a significant relation between udder conformation and mastitis incidence: globular udders and non-balloon-shaped teats were associated with lower levels of mastitis.

Vacuum level and pulsation rate used for dairy goats differ from those used for cows. Le Jaouen (1981) reported the requirement of levels of 38 to 44 kPa for goats compared to 50 kPa for cows; and 70 to 90 pulsations per minute for goats compared to 50 to 60 for cows. This means that a specialized milking machine that is effective is needed for goats, and Lu *et al. (*1991) have shown how effective milking is important for reducing somatic cell counts. Methods of treatment may also need to be different because of differences in udder function. For example, a report by Buswell *et al.* (1989) showed that the length of time that antibiotics may persist in milk can be longer than in cows. Selective dry period therapy might be all that is necessary if infected udder halves can be identified, as Fox *et al.* (1992) showed that there were few new infections during the dry period.

Causative organisms documented include *Mycoplasma* (Hasso *et al.* 1993); and Staphylococci (Maisi & Riipinen 1991). Bacilli, coliforms, micrococci, streptococci, corynebacteria and *Pseudomonas* have also been isolated from goat milk samples, but were not necessarily associated with clinical signs (Kalogridou-Vassiliadou 1991).

4.1.7 Internal Parasites

Internal parasites can have a significant effect on the productivity of goats, especially in intensive management systems (Anderson 1982; Cabaret *et al.* 1989; Schillhorn VanVeen 1982), but infestation is not necessarily always high (Chartier *et al.* 1992). Mortality has been reported to be as high as 20% from haemonchosis (Sharma *et al.* 1992). Coenurosis may be high in some areas in India (Gogoi *et al.* 1992). Some evidence of genetic resistance to internal parasites has been reported (Gill *et al.* 1991; Pomroy 1996); in some circumstances, different breeds of dairy goats have responded differently to treatment, as illustrated by the report of Richard & Cabaret (1992), documenting the variation in response to fenbendazole used to treat lungworm.

4.1.8 Nutritional and Metabolic Diseases

Nutritional diseases and metabolic disorders can be significant problems in goats (Dunn 1985; Lee & McIntosh 1982; Nelson 1984). These include ketosis resulting from high glucose demand and low availability, especially in late pregnancy. Parturient paresis may also occur, but is generally less of a problem than ketosis. These disorders can be prevented by correct feeding procedures (Sauvant, Chilliard & Morand-Fehr 1991). Abortion resulting from low blood glucose levels can be a particular problem in Angora goats (Wentzel 1982).

4.1.9 Other Diseases

Other diseases documented include those related to external parasites (Murray 1982); malignant melanoma (El-Hassan & Ramadan 1982);and ethmoid carcinoma (Rajan *et al.* 1982). Digital lesions and lameness can be significant (Mgasa & Arnbjerg 1993). Footrot can also be caused by *Bacteroides* and *Fusobacterium* (Duran *et al.* 1990).

4.2 Genetics and Disease Resistance

The significance of genetic effects on the ability of animals to resist various diseases is well documented (Nicholas 1987), but there appears to be little evidence of this recorded in goats.

Animal diseases are major factors limiting economic development in Africa (Jawara 1990), and the importance of developing breeds of animals that are resistant to diseases has been emphasised (Lefevre 1987a). This is especially so with diseases like trypanosomiasis (Griffin & Allonby 1979).

It is to be hoped that diseases like CAEV will never enter South Africa. However, there are many other diseases here that could be prevented if genetically resistant animals were available. For example, breed variations have been demonstrated in gastro-intestinal parasitism in Indian goats (Yadav & Sengar 1982); and resistance has been shown in the Kenya dual-purpose goat developed from crossbreeding (Ruvuna, Taylor, Davis, Mwandotto, Rurangirwa & McGuire 1992). Some Angora goats are genetically susceptible to abortions and should be culled (Wentzel 1982). Guadeloupe native goats have been shown to be resistant to heartwater (Matheron *et al.* 1987).

Ramsay & Smit (1987) reported on the adaptability of Indigenous goats in Southern Africa to survive in harsh environments when compared to Boergoats, particularly in an area where animals are liable to contract heartwater. The extent of any disease resistance should be established, and the effect of crossbreeding in relation to such disease resistance should be evaluated.

5. GOAT MILK PRODUCTION IN RURAL DEVELOPMENT

Small ruminant production systems in developing areas are usually associated with small-scale or subsistence production (Devendra 1996). The introduction of goats or the development of systems for improved production have to be carefully planned with the active co-operation of the people involved. Success has been achieved with milk goats in Tanzania (Mtenga 1992); but many difficulties have been encountered with a programme for meat production in Zimbabwe (Riviere 1991). Systems of production will vary depending on the people, the animals, environmental and economic factors.

5.1 The Farmers

Devendra and Coop (1980) outlined the characteristics typical of small-scale farmers and their livestock in many parts of the world:

* They are usually crop-oriented subsistence farmers with small land holdings (1 to 4 ha);

* Goats are kept because they involve little management, are a low-risk investment, and supplement income;

* The animals provide meat, milk, skins, fibre, manure, and by this diversification, provide insurance against crop failure;

* The animals make good use of crop by-products;

* Herd size is often very small (3 to 10 animals).

In addition to the products mentioned above, goats are kept as a source of supplementary income, provide some employment, have social, recreational and in some societies, religious functions (Devendra 1992a). Devendra and Coop(1980) identified the landless agricultural labourer as a further category of goat owner. Often the person who cares for the animals is a woman. This can result in problems of communication in countries where most of the extension agents are men, and there are social or religious barriers between them (Jiabi & Sinn 1992; Sinn & Wahyuni 1996). In addition, with the seemingly universal trend towards urbanization, there is a need to consider the potential of animal production in the peri-urban situation as well as in rural areas.

A major obstacle to progress in improving animal production among small-scale farmers is illiteracy and the low level of education. However, a study of the target population and their perceived needs will assist extension workers in developing appropriate programmes. Literacy is an asset but is not essential if the people are well motivated. The methods of agricultural extension are well known, and techniques can be used that are appropriate to particular circumstances. In essence, agricultural extension is a form of adult education, and can achieve results according to well-planned strategies, but the rate of change is often slow for whole communities, even though it may be rapid for specific individuals (Bembridge 1991).

5.2 The Animals

The existence of large scale commercial flocks of sheep has resulted in most of the research on small ruminants being applied to sheep. However, in the context of Africa, greater emphasis needs to be placed on goats (Donkin 1988), although sheep also have a significant contribution to make (Raats 1988). Devendra and Coop (1980) listed characteristics of goats that would influence their suitability for different environments and systems of production. Goats are resistant to dehydration, prefer a low rainfall environment and are usually found in the tropics; they have a preference for a variety of feeds, especially browse, and are very selective; they are usually kept for meat production, although milk production is a common secondary function (especially in temperate regions); and fibre is important for mohair and pashmina (cashmere) production. Goats have a greater susceptibility to exposure and stress than sheep, in part because they have hair coats, and because fat distribution is visceral rather than subcutaneous. They may be sensitive to pneumonia, gastroenteritis, parasites, and contagious ecthyma, but are said to be resistant to tsetse flies. In many developing areas the existing animals are probably well adapted to survival within the prevailing environment and social systems. There has been little attempt to breed animals with a specific purpose in mind, and those that were unable to adapt have died out. In these circumstances, low productivity, such as the absence of multiple births, may be beneficial. The prospects of genetic improvement by selection are negligible because of the small herd numbers, and the lack of control and records (Ricordeau *et al.* 1992). Many attempts have been made to crossbreed in order to introduce supposedly desirable characteristics to local breeds. (See Section 2.1.3). Breeding between crossbred animals will result in the development of a new breed, but large populations will be necessary, and selection will have to be sustained over a long period (Rae 1980). Unless the environment is improved in some way, by providing better control, nutrition and health care, there may be little benefit in breed improvement.

5.3 The Environment

The environment in its broadest sense consists firstly of natural constraints or advantages such as the climate and soils, vegetation and diseases; and secondly, the influence of the people, in how they organize their lives and those of their animals. The first category is one which can hardly be changed; but the second offers great hope, because the animals often have great potential for improved productivity following small changes in how things are done.

5.3.1 Forage Supply

Poor nutrition is often the greatest constraint to improved productivity, shown as a complete or seasonal shortage of energy, protein, macro-elements (such as phosphorus) or micro-elements (such as selenium). Shortages of protein or minerals can be remedied by the provision of a suitable supplement, if not too expensive; but a shortage of roughage is less easily solved.The smallholder farmer who keeps goats might well consider using trees and bushes, often referred to as "agroforestry". *Leucaena leucocephala* is one species that has been used in many parts of the world (Girdhar *et al.* 1991), but may have certain problems because of the toxin mimosine (Fernandez *et al.* 1992). This problem can be resolved by transferring to susceptible animals rumen microbes (*Synergistes jonesii*) which are capable of degrading mimosine to innocuous constituents (Jones 1981; Hammond 1995). A method of identifying and establishing suitable plants in Central America has been described by Benavides (1992). Some indications of the potential of indigenous fodder crops in Kenya have been given by Kihia (1992). In Africa and elsewhere in the world (Sheehy 1988; Singh 1992), major problems of environmental degradation have occurred because of the system of communal land tenure for grazing with the paradox of individual ownership of animals (Bembridge 1987); and also because of conflicting goals within communities (Russo & Spencer 1988). However it is possible to develop methods of livestock management including feeding, within mixed farming systems (Hardesty 1988).

Improved systems of production from goats will require an improvement in the supply of roughage. This process will involve some form of intensification as natural grazing becomes scarce (Smith,O.B., 1992). In very intensive systems such as those that apply in a peri-urban situation it is possible to use complete feeds, provided that they are cost-effective (Donkin 1991).

5.3.2 Fertility Management and Breeding

Management must involve some control. Problems with systems of communal grazing include the uncontrolled breeding that occurs. I am not aware of any studies that have demonstrated the extent of inbreeding in these situations, and it would be very difficult to measure. However, it is likely to be high where herds or flocks are small, the animals reach puberty at an early age, and many males are left uncastrated. A change in the system of management to allow the owner to exert control would require separation of the ram or billy goat from the female animals. This would imply confinement, and with that the provision of feed and water. A similar change in management would have to be applied by neighbours, and some social structure would be needed to ensure compliance. In situations where communal grazing is the traditional system, this would be a radical change. When male animals are separated, management procedures such as comparison between animals, culling, selection, breed improvement, the choice of the optimal breeding season, and uniform marketing become possible. The real difficulty may be the social problem of developing trust and understanding so that such mutual co-operation can take place.

5.3.3 Disease Control

Management systems for the control of diseases commonly encountered must be developed which are easily applied in the particular circumstances by the people concerned. These would normally involve vaccinations and the control of internal and external parasites. Management techniques such as the development of appropriate housing that is elevated and has slatted floors for the humid tropics (Appleman 1984) or simple shelters and energy supplementation for protection from bad weather may be needed (van der Westhuysen *et al.* 1988). The introduction or development of breeds with resistance to specific diseases may be required, as in the case of heartwater (Donkin *et al.* 1992).

5.3.4 Markets

While the primary aim may be to ensure self sufficiency in a subsistence economy, even the basic household economy has a need for some cash income (Low 1986). Local selling of animal products such as milk may generate some income, but it will be the rare entrepreneur that will develop a commercial enterprise. A marketing opportunity must be available, and sufficient resources at hand, such as feed supplies for the animals (Donkin 1991).

Government supported development of marketing opportunities may have a substantial effect in improving income for small-scale farmers, and also in developing secondary industries, as exemplified in the great progress made in the leather industry in India in the last few years (Rao & Rao 1992).

5.3.5 Support Services

Development can be stimulated by active programmes of animal and human health care, literacy, agricultural extension, marketing systems, financial services, communications, roads and other infrastructure. Priorities should be established according to local and national needs, but should always involve the willing participation of the communities themselves. A developed agricultural sector can be important in supplying some of the inputs for developing areas, such as improved breeding stock, technical expertise, and the vision and belief that improvements are not only necessary, but are also possible.

5.4 Economic Factors

The economics of development programmes must be evaluated within the context of the recipient community. A programme will not be adopted if it is not perceived to be of benefit and to be self-sustaining. The economy of the household, which involves family labour and time allocation as well as money, must be considered (Low 1986). Often a small input can develop to be a significant influence for improved prosperity and quality of life, as has been achieved in some projects of Heifer Project International (Jiabi & Sinn 1992). The importance of marketing in developing an enterprise from subsistence to a commercial venture has already been noted.

5.5 Complete Systems

Complete systems can be developed that will take account of all the factors required for success in a particular situation. Such systems will have to be formulated by development agencies, as the resources are not usually available to the small-scale farmer. Innovation is a risky business, and the chance of failure in introducing new techniques or systems is high. In the same way, the extension officer may risk losing credibility if the project is a failure. Therefore there is no substitute for careful research, imaginative "hands-on" practical experience, involvement of others in a multi-disciplinary approach, and above all, involvement of the people concerned on a sustained basis. Traditional "top-down" planning and implementation of development has seldom worked. Effective development is ultimately a development of the people, not only of the animals. Development should be planned to be as simple as possible, although complexity may follow. This approach is probably best seen in the programmes that use Farm Systems Research and Extension (FSR-E), such as the on-farm evaluation carried out in Kenya by Semenye *et al.*(1989). Potential areas for the promotion of development of small-scale farming must involve intensification, as the population pressures increase and resources become more limiting. This has already happened in countries like India where many goats do not graze or browse, but are confined and have their feed brought to them. A comprehensive and multi-disciplinary approach in development has been shown in the Small Ruminant Collaborative Research Support Program (SR-CRSP) in Kenya, Peru, Brazil, Indonesia, and Morocco (Raun 1989). Aspects of genotypes (Bradford *et al.* 1989); feeding (Johnson & Djajanegara 1989); animal health (Alexander *et al.* 1989); sociology (Nolan *et al.* 1989); and the on-farm evaluation of dual-purpose goat production systems in Kenya (Semenye *et al.* 1989) have been well documented.

MATERIALS AND METHODS

CONTENTS

1. RESEARCH PROTOCOLS

Research was initially carried out within the framework of two research protocols registered in the Faculty of Veterinary Science. These protocols are summarized as follows.

1.1 Research Project V3/88

The effect of crossbreeding of Saanen goats and Indigenous goats on milk production.

Materials: Breed 25 Saanen does and two bucks at Medunsa; 30 Indigenous does from Dept. of Development Aid

Use existing facilities at Medunsa.

Method:

* Breed does in April 1988 (to Saanen bucks)
* Measure lactations of pure Saanens and Indigenous does from 1988
* Rear Crossbred does to be bred in April 1989
* Measure Crossbred doe lactations from September 1989
* Compare lactations with those of Saanens from the same sires.

1.2 Research Project V4/91

A comparison of the genetic resistance to heartwater of Saanen, Indigenous and Crossbred goats.

* Goats : Rearing

Ten kids of Saanen, Indigenous and Crossbred (50:50) goats will be used. They will be removed from their dams at between one and two weeks, and weaned off milk at three months of age. They will be subject to normal rearing management including castration, dehorning, routine vaccinations and internal parasite control. They will be fed a complete feed incorporating hay from tick free pastures.

* Experimental Procedure

The goats will be inoculated at approximately seven months of age with Ball 3 heartwater.

* Temperatures will be measured twice daily for 30 days.
* Serology: The goats will be bled for serology on: days -7; 0; daily for the first 14days; and weekly thereafter. (The first test will show that all goats entering the trial will be free of antibodies to heartwater).
* Weighings: The goats will be weighed on day 0, and every two weeks thereafter.
* Evaluation: Response of the goats will be scored according to the severity of the reaction. The following facts will be recorded and points allocated at the completion of the trial:

a) Daily temperature.

b) Clinical signs e.g. anorexia, listlessness, nervous signs.

c) Duration of clinical signs.

d) Death.

* Brain biopsies: These will be carried out on all animals after they have shown an elevated temperature for more than 48 hours, to confirm that this is due to heartwater.

* Treatment: Animals will be treated when they show nervous signs for more than 24 hours. Animals *in extremis* with a hopeless prognosis will be euthanased.

* Actual Procedure

In 1991 three groups of eight goats each, Saanen, Indigenous and Crossbred were available. In 1992 larger groups were used consisting each of twelve goats, Saanen, Indigenous, Crossbred and Three-quarter bred, all equally divided between males and females. No brain biopsies were carried out, but *Cowdria* infection was confirmed post-mortem.

2. THE ANIMALS

What is planned and what is possible are not always the same; what actually happens is often different. This was apparent in the breeding policy applied. Over the years an attempt was made to maximize the opportunities for carrying out experiments with the goats. The primary aim was to generate enough lactations (mainly first and second) to compare the Saanens, Indigenous and Crossbreds. The female kids were reared to measure lactations in subsequent years. The male kids were used for other experiments (internal parasites; feeding experiments; heartwater experiments).

In addition the pressure to generate income has always been important, especially in recent years. This has been achieved by selling animals (alive or dead), and by developing a market for the milk.

Breeding was carried out at the same time each year to minimize seasonal differences. This policy was adhered to for the first four years. From the fifth year onwards the breeding season was altered to reduce kid mortality from coccidiosis and to facilitate an even production of milk for efficiency of marketing. (See Tables K3, K4 and K5). Growth patterns of Saanen, Indigenous and Crossbred female goats are shown in Figures M1 and M2.

3. FEEDING

The milking goats were fed uniformly throughout the years of the experiment using a complete diet containing 16 percent Crude Fibre (Table M1). Feed samples were analysed periodically to confirm the nutrient content. A small amount of dairy meal was fed to goats in milk while they were being milked. This quantity was not measured precisely, but was estimated at an average of about 200g per milking.

Kids were reared on different diets composed of different fibre levels. After the first few years they were fed the same diet as the lactating goats. The Indigenous goats initially were fed the same diet, but in later years spent extended periods in the veld camps, supplemented with hay and a lick as necessary.

4. BREEDING AND KIDDING PROGRAMME

The kidding programme is summarized in Tables K1 to K7 (pages 61 to 64).

Year 1 (1988) (K-goats born).

Twenty-five Saanen females born in September 1987 at Fairview Estate, Paarl, were purchased from Mr C. Back in early 1988. A group of 25 Indigenous goats of the same age were transferred from Delftzyl near Marble Hall. These goats were bred in April 1988 to two Saanen billy goats purchased from Mrs. T. Armitage near Standerton (L6 and L8). From this breeding 23 Saanens and 25 Indigenous goats kidded. Lactations were measured. The male kids born were used in a pilot study investigating resistance to internal parasites. The female kids were kept for breeding so that their lactations could be measured the following year.

Year 2 (1989) (J-goats born).

Two new billy goats (K12 and K43) were purchased from the same breeder, but they were not closely related to the first two. Additional Indigenous goats were transferred from Delftzyl.

The Saanens and Indigenous goats were divided into two groups (randomly), and each was bred to one of the two billy goats. From this breeding in April 1989, there were 23 older Saanens, 31 Indigenous goats; 10 younger Saanens and 9 Crossbred goats in their first lactations. The male kids born in 1989 were designated for the first feeding trial. The female kids were kept for breeding.

Year 3 (1990) (H-goats born).

The breeding groups of 1989 were used again in 1990, but the billy goats were interchanged. In addition, an Indigenous billy goat was used for the first time (Pegasus), bred to Indigenous and a few Saanen goats. A new Saanen billy goat (J81) was purchased from Mrs. C. Smit of Nylstroom, and used on the daughters of K12 and K43. From this breeding in April 1990, 22 older Saanens, 9 second lactation and 18 first lactation Saanens kidded. In addition, 9 second lactation and 12 first lactation Crossbreds kidded. There were 44 Indigenous goats. In addition two three-quarter bred Saanens kidded. The male kids were designated for the second year of the feeding trial. Some male kids and a few female kids were used in the first year of the heartwater experiment in 1991.

Year 4 (1991) (G-goats born).

A significant reduction in herd size was carried out in 1991. This was essential because the pens were overcrowded. At the same time goats were sold to other development agencies to assist them in establishing milk goat herds (Qwaqwa; Transkei). Limited use was made of K43, and K12 was sold. J81 and Kenny (also from Mrs. C. Smit) were the billy goats mainly used. From this breeding 29 Indigenous goats kidded; 15 older, 16 second lactation and 10 first lactation Saanens; 2 third lactation Crossbreds, 8 second lactation Crossbreds and 11 first lactation Crossbreds (including 4 reciprocal crosses) kidded. For the first time there was a group (8) of three-quarter bred Saanens in lactation. Male and female kids were used in the second year of the heartwater experiment in 1992.

Year 5 (1992) (F-goats born).

In 1992 it was considered that enough first and second lactations had been measured for the requirements of the crossbreeding experiment. The high kid mortality from coccidiosis and the need to improve milk sales led to the decision to split the herd. Half were bred in November to kid in autumn. A part of the herd was milked for much longer than the normal lactation of 10 months and the rest were bred in November. Therefore in July/August 1992 (earlier than previously), 8 older, 7 second lactation Saanens; 7 older Crossbreds and 15 second lactation Crossbreds; and 6 three-quarter bred Saanens kidded. The sires were again J81 and Kenny, but they were carefully placed with groups of females to avoid inbreeding. Thirty Indigenous goats kidded. New Saanen billy goats were purchased from Mrs. M. Jordaan near Bloemfontein for the breeding in November 1992. Goat kids born in 1992 were the first to be sold to smallholder farmers in the Winterveld area as part of the outreach research project in 1993, after they had been treated ("vaccinated") against heartwater.

Year 6 (1993) (D-goats born).

In autumn 1993, 33 Indigenous goats; 14 older Saanens, 4 second lactation and 5 first lactation Saanens; 4 older and 5 younger Crossbreds; and 6 Three-quarter Saanens kidded.

5. MEASUREMENT OF LACTATIONS

5.1 MILKING PROCEDURE

The goats were milked in an abreast milking parlour with space for six goats to be milked at one time. Initially there were three milking units (one for each pair of goats), but as numbers increased, an extra three milking units were installed. The milking machine was manufactured by Bodmin Nu-Pulse, a New Zealand-based company, with an agent in South Africa. Each milking unit was equipped with a Waikato Milk Meter. Although the estimation of milk yield with these milk meters has been alleged to be less accurate than other makes (Moore,1996), the effects of this were minimized, because the goats did not come into the milking stall in the same order each time, and so readings were taken from different meters at different milkings.

Milking took place twice a day, at about 07:30 and 14:30. It was not possible to get the workers to agree to milk in the afternoon at a later time, as is the normal situation on most dairy farms. Therefore it is likely that the milk yields measured would have been higher if the goats had been milked at more regular intervals. However, all goats were treated in the same way, so that any distorting effect on the comparison between breeds should have been of less consequence. This is assuming that accumulation of milk in the udder overnight would have had little effect. It was not possible to measure this. If there was an effect, it would have been likely to have depressed the milk production of the highest yielding goats.

Great difficulties were experienced with the milkers during the time of this experiment. South Africa was going through a turbulent time politically, and this affected the attitude of staff to their work. The credibility of the milk records could have been in question as a result. However, when the workers were on strike, the senior members of staff at the University had to milk the animals. This was a good opportunity that occurred regularly, to check on the completeness of milking and the accuracy of measurement. Little difference was detected.

Other factors ensuring that the milk records were a good reflection of actual milk yields included:

* Shift work meant that the less reliable milkers alternated with those more trustworthy.
* The milk yield of all goats was measured at every milking, twice a day.

Only a small proportion of the milk records were totalled by dairy staff; all the records were checked and added up by hand calculator.

5.2 MILKING THE INDIGENOUS GOATS

The Indigenous goats were difficult to milk, mainly because they were unused to the milking parlour. It was necessary to restrain them manually while they were being milked. In order to get a reliable sample of their milk, they were separated from their kids, and were fed and milked together with the other goats.

Three aspects were of concern:

5.2.1 *Milk Let-down*

Was milk let-down inhibited because the goats were being milked in the milking parlour?

The goats did not appear to have any problem with milk let-down. The milk flowed as expected. The udders were clearly seen to be empty after milking. It is common knowledge that these goats are milked in the rural areas by their owners, and therefore is is reasonable to expect that they will let down their milk. It does not appear to be necessary for the goat kids to be present, as has been documented with some cattle. (Alvarez *et al.*, 1980). However, in this experiment no provision was made to measure the amount of residual milk by extraction with oxytocin. The opinion of those working with the goats was that there would have been no greater proportion of residual milk after milking with the Indigenous goats than with the other breeds.

5.2.2 *Accuracy of the Milk Meters*

Milk yields were so small for the Indigenous goats that the reliability of the milk meters in measuring this accurately was questioned. Therefore, as an alternative to using the milk meters, milk was collected in an interceptor vessel (a "quarter milker") interposed in the milk line, between the cluster and the milk meter. This milk was measured accurately in a measuring cylinder, and the whole amount was used to collect the sample for milk compositional analysis.

5.2.3 *Effect of separating the goats from their kids*

It was possible that the separation of the goats from their kids might have affected the milk yields.

Therefore, in subsequent years, samples of milk produced by the Indigenous goats were collected intermittently during the lactations (Table M2). To achieve this, it was necessary to separate the goat kids for a day, and the mature goats were then milked out by hand. Too few goats were measured in detail in this way for statistical analysis, but the yields, the compositional analysis, and the lactation lengths were not obviously different from those of the Indigenous goats that had been milked with the rest of the herd.

5.3 ROUTINE MILK RECORDING

The milk samples were analysed for milkfat, protein and lactose by the laboratory of the Milk Recording Scheme at Irene, south of Pretoria. These analyses were always checked against a standard at the laboratory. The Milk Recording Scheme regulations at that time required that an accurate measurement of milk yield should be made, and a composite milk sample should be collected for each animal once a month. The composite milk sample was made up from milk collected at both the morning and the afternoon milking, the quantity of milk collected being proportional to the time between milkings. The total sample collected was 50ml of the milk produced thoughout the 24 hour period. Milking times were usually at 07:00 in the morning and at 14:00 in the afternoon. Since the long interval was 17 hours, and the short interval was 7 hours, the proportional fractions of milk collected were calculated as follows:

17/24 = 35ml from the morning milking;

and 7/24 = 15ml from the afternoon milking.

An analysis of some daily milk recordings showed that the morning yields were much higher than the afternoon yields, as would be expected. (Tables M3,M4,M5). This system of milk recording was devised for dairy cows. Each animal had to be sampled every month for the minimum length of a lactation. If less than the minimum number of samples was taken (six), or one sample was missed, or the lactation was too short, then the lactation was excluded from the Milk Recording Scheme. Many of the research goats did not reach the required number of samplings, and there were a number of reasons for this:

**** Labour disruptions***

Labour disruptions frequently meant that samples were not taken at the correct time, or that they were not delivered to the laboratory as required. (This was particularly bad in 1989/90).

**** Short lactations***

Many goats had lactations shorter than the standard cow lactation length of 300 days. All Indigenous goat lactations were very short; and there were goats in the other groups that had lactations shorter than 300 days. These goats could not be excluded from the research results, but were not acceptable for the Milk Recording Scheme. The result was that the Milk Recording Scheme administrators simply wiped large amounts of lactation information off the computer, as being irrelevant. When this was discovered, a request was made for the input information on milk compositional analyses to be supplied direct, to be used in our own data processing. Not all of the information was available, but the information that could be retrieved was used in the lactation analyses.

As a result of all these problems, the lactation data produced by the Milk Recording Scheme were not used, but all possible information from milk compositional analyses was incorporated with the actual milk yields recorded in the milking parlour.

5.4 CALCULATION OF MEAN MILK COMPOSITION

The Milk Recording Scheme rule that at least six consecutive monthly samples were essential for a lactation to be acceptable, was unattainable for a large proportion of the goat lactations, for the reasons indicated above. Therefore, a decision was made to include as many lactations as possible, provided that at least two samplings were made for compositional analysis. Sufficient numbers of lactations would mean that the indications for the broad comparisons between breed of goat would be valid. The large differences shown in the results have borne out this assumption as being correct.

Procedure:

An example of the individual record sheet for a goat is given in Table M7.

All analyses were recorded for each goat. Where three or more were available for a lactation, these were used to calculate mean analyses for the lactation, weighted according to the milk yield for the week of sampling. Similarly, weighted means were calculated over all lactations to give a mean milk analysis for the "lifetime" record of a goat. Where a lactation had only one or two analyses recorded, this sampling was considered to be an unreliable estimate of the analysis for the whole lactation. Instead of rejecting all the lactation information affected in this way, the mean "lifetime" milk analysis was used for that specific lactation. Most goats were affected during their time in the herd, and on average 22% of lactations had to be corrected for compositional analysis in this way (Table M6). The mean number of samplings for each lactation (where there were three or more per lactation) are shown in Table M8.

5.5 ACCEPTABILITY OF LACTATIONS FOR THE EXPERIMENT

5.5.1 Short lactations

Short lactations, unless caused by obvious reasons such as death, mastitis or some acute disease problem, were included in the analyses. Twelve lactations (out of 274) were excluded from the analysis for being short, because there were too few milk compositional analyses for them to be considered a reliable estimate. This was a very small proportion of the total number of lactations.

5.5.2 Variations in the starting date of lactations

Recording of lactations was not started at a uniform time after kidding. Where this was longer than 5 days after kidding, a graph was drawn of the lactation, and the unrecorded milk was estimated by extrapolation and smoothing the curve. This technique was also used to estimate the amount of milk taken by goat kid in early lactation. The time of removal of a kid from its mother was not standard. Estimates were made for each lactation. The data are summarized in Table M9.

5.5.3 Interpolation for missing milk records

In some cases interpolation was used to estimate milk yield within a lactation where the milk records had been lost by the milkers. This applied over the period from December 1989 to January 1990. This affected 19 first lactations and 23 second lactations. The loss of information was not critical: a normal milk recording scheme relies on measurement of yield every five weeks (Moore, 1996). The only adverse effect it might have had was to give a lower estimate of peak yield than the actual peak yield.

5.5.4 Day-to-day variations

It must be remembered that most milk recording schemes find it acceptable to record the milk yield only once a month, or every five weeks, and to use these recordings as an estimate of the yield from one month to the next. The variation in goat milk recorded from day to day in this experiment would have made such an extrapolation highly inaccurate. Some indication of the variation can be gauged from the sample of data presented in Tables M3, M4, and M5. Although not analysed statistically, the general variation from week to week appeared to be much less. It seems probable that day-to-day variations in the milk records were mainly related to incomplete milking; and only rarely were caused by mistaken identity.

5.6 FITTING LACTATION CURVES

As described in the Review of Literature, Williams (1993a) established that for the goat milk records he analysed, the linear Morant-4 model (Morant & Gnanaskathy, 1990) was the method of choice. This model was also used for deriving lactation curves in this research.

The linear Morant-4 model has four parameters A,B,C and D. (Williams,1993a):

Parameter A: This is the scale parameter, representing yield on Day 150.

Parameter B: This represents the rate of change after peak (percentage drop in yield on Day 150 of lactation), and is a measure of persistency.

Parameter C: This represents the change in rate of decline of yield with time after peak yield (changes in persistency), and it may be positive or negative. It is highly variable because it is manipulated to fit small differences between individual data sets. It has a relatively small effect on total yield, but a large influence on day of peak, and peak yield.

Parameter D: This describes the rate of increase in yield to peak, early in lactation.

The model is described by the following formula:

$$\log(y) = A + Bn' + Cn'^2 + D/n$$

where y = daily yield (kg)

n = day of lactation (post parturition)

$n' = (n-150)/100$

and the Parameters A,B,C, and D are as described above.

This model was fitted to some of the lactation data, and Analysis of Variance carried out to assess the significance of differences between breeds and parities.

5.7 COMPOSITION-CORRECTED MILK

It has long been recognized that if milk production is only measured by litres or kilogrammes, this will be an unfair criterion for comparison between animals or breeds that have milk differing significantly in compositional analysis. Therefore alternative criteria have been used to give a fairer comparison of the *nutrients* within the milk. The most commonly used has been Fat Corrected Milk (FCM), whereby the amount of milk measured or estimated is corrected to a standard percent analysis. An alternative method uses an estimate of the total quantity of milkfat or protein produced during the lactation, which is calculated by multiplying the total milk yield by the estimated mean nutrient percentage.

Four different criteria were used during the analysis of the data collected from the Milch Goat Project:

5.7.1 Fat Corrected Milk (FCM)

Fat corrected milk was the earliest criterion of this nature, used when milkfat was the only nutrient routinely measured. The standard chosen was 4.0% Fat Corrected Milk (FCM). All lactations were corrected to what they would have been if the milkfat analysis was 4%.

5.7.2 Protein Corrected Milk (PCM)

A comparison was made between lactations using protein as the criterion, correcting each lactation to a 3% protein equivalent.

5.7.3 Lactose Corrected Milk (LCM)

A comparison was made between lactations using lactose as the criterion, correcting each lactation to a 4.5% lactose equivalent.

5.7.4 Fat-Protein-Lactose Corrected Milk (FPLCM)

A comparison was made between lactations using all three criteria, namely milkfat, protein and lactose (at the percentages of 4%, 3% and 4.5% respectively), to give a composite criterion of "Fat-Protein-Lactose Corrected Milk", with lactations corrected to this level, an 11.5% FPL equivalent. Mineral analyses were not done on the milk samples. However, the literature indicates that mineral content is a relatively stable component, so that FPLCM is therefore a close approximation of Total Solids Corrected Milk.

6. STATISTICAL ANALYSES OF LACTATION DATA

1. Milk Records

Milk yields for each goat at every milking were recorded manually during milking, and later added using a hand calculator. Weekly totals were compiled, and collated into lactation yields. Corrections were made to compensate for milk lost or not recorded early in lactation (as discussed above). Weighted mean milk compositional analyses were computed manually. Composition corrected yields were calculated manually. The list of lactation data was scrutinized to eliminate any information that was considered to be unreliable. In the process, a few lactations were not included in the general analysis data set.

2. Lactation Curves

Dr F.D. Richardson assisted with the fitting of lactation curves using the linear Morant-4 model (Williams 1993a), and with the statistical analyses of comparisons using Analysis of Variance procedures. I am most grateful for his help.

3. Statistical analyses

Kidding and lactation data were analysed using the SAS System (SAS Institute,1989), with the assistance of Professor H.S. Schoeman and Dr R. Coetzer of the Agricultural Research Council. I am indebted to these people for their patience and generous help. Basic statistics were calculated for all the parameters measured and included in the analyses. Correlations were calculated between parameters including the main lactation parameters, and also for composition corrected milk. Analysis of Variance and Analysis of Covariance were carried out using the General Linear Models Procedure.

7. HEARTWATER EXPERIMENTS

The original Saanen goats were purchased from Paarl near Cape Town, where there is no risk of heartwater. Sires were obtained from different breeders. Indigenous goats were donated by the Department of Development Aid from the research herd at Delftzyl in the Northern Province of South Africa. This herd had been built up from goats collected from four different areas of South Africa. The goats were kept in pens at MEDUNSA and fed a complete feed. Saanen, Indigenous, Crossbred, and Three-quarter Saanen kids were born and reared in the same tick-free environment. Healthy kids of each breed were tested to ascertain the absence of specific antibodies against heartwater, and then were each given 5ml of virulent heartwater blood of the Ball 3 stock. Temperatures and clinical signs were monitored twice daily. Post-mortem examinations were carried out to confirm death due to heartwater.

Year 1: Eight kids were in each group: Saanen, Indigenous and Crossbred. Heartwater blood was given when the goats were eight months of age. A goat was designated as overcome by the disease when in lateral recumbency. It was then given treatment in a second experiment designed to assess therapy.

Year 2: This part of the experiment was carried out in two phases. More goats were available than in the previous year.

Heartwater blood was given when the goats were 12 months of age. Serum conglutinin levels were monitored (before and after infection) by Dr J.L. du Plessis at the Onderstepoort Veterinary Institute.

Phase 1: Indigenous and Crossbred goats

Six males and six females were allocated to both groups of Indigenous and Crossbred goats.

Phase 2: Saanen and Three-quarter Saanen goats

* **Saanens**: Eleven Saanens were available (5 males and 6 females). In view of the high mortality experienced in Year 1, it was decided to treat all Saanens with

tetracycline, except for two controls (one male and one female). This would provide an opportunity of monitoring response to the treatment. A goat was given liquamycin (10mg/kg) on the second successive day that the morning temperature was over 40°C. In an attempt to minimize mortality, a second treatment was given two days later if the morning temperature was not below 40°C by then. This policy has been followed for many years in general practice (Poole,1962). Eight out of the nine goats required the second treatment. Two male goats again showed an elevated temperature (above 40°C) on Day 21. They were re-treated with liquamycin (as before).

* **Three-quarter Saanens**: Ten Three-quarter Saanens were available (5 males and 5 females). One female was kept as a control. The remaining nine goats were given heartwater infected blood, but were not treated with tetracycline.

8. TABLES AND FIGURES RELATING TO MATERIALS AND METHODS

Table M1: Goat complete feed (total mixed ration): 16% fibre; 14% protein
[Half tonne mix]

Ingredient	Quantity (kg)
Yellow maize	160
Wheaten bran	45
Lucerne (milled)	100
Eragrostis hay (milled)	100
Sunflower oil cake meal	40
Fish meal	12.5
Limestone powder	2.5
Monocalcium phosphate	2.5
Molasses	35
Salt	2.5
Mineral/vitamin premix (sheep)	[one unit]
Taurotec	[100g]

Table M2: Indigenous goats: Milk production: Occasional samples (1991 and 1992)
[Note: Milk samples were frozen; milkfat analyses are unreliable].

Dates	No.	Milk (ml)	Milkfat (%)	Protein (%)	Lactose(%)
9/10/91	23	430 ± 190	2.82 ± 0.86	5.10 ± 0.42	5.34 ± 0.28
23/10/91	20	312 ± 157	3.12 ± 0.92	4.90 ± 0.49	5.46 ± 0.17
13/11/91	23	194 ± 78	-	-	-
means		314 ± 178	2.96 ± 0.89	5.01 ± 0.46	5.39 ± 0.24
31/8/92	23	-	2.71 ± 1.11	4.34 ± 0.59	5.53 ± 0.36
9/9/92	20	267 ± 106	3.84 ± 1.32	4.34 ± 0.41	5.39 ± 0.45
means	-	-	3.23 ± 1.32	4.33 ± 0.51	5.45 ± 0.41
9/9/92	86	304 ± 166	3.10 ± 1.13	4.67 ± 0.59	5.42 ± 0.33

Table M3: A comparison of morning and afternoon milk yields:
Year 1 (1988/89): First lactations. Saanen goats.
[Mean monthly milk yields; Ratio of afternoon to daily yield]

	October	January	March
Goat No. L217			
am	1.50 ± 0.24	1.57 ± 0.08	1.30 ± 0.11
pm	0.69 ± 0.13	0.66 ± 0.08	0.64 ± 0.09
daily	2.19 ± 0.31	2.22 ± 0.12	1.94 ± 0.14
Ratio	0.31	0.29	0.33
Goat No. L234			
am	1.85 ± 0.27	1.69 ± 0.13	1.22 ± 0.09
pm	0.77 ± 0.14	0.68 ± 0.11	0.57 ± 0.07
daily	2.62 ± 0.34	2.38 ± 0.17	1.79 ± 0.14
Ratio	0.30	0.29	0.32
Goat No. L481			
am	1.42 ± 0.33	1.66 ± 0.15	1.14 ± 0.10
pm	0.61 ± 0.17	0.67 ± 0.13	0.51 ± 0.06
daily	2.03 ± 0.45	2.33 ± 0.23	1.65 ± 0.13
Ratio	0.33	0.29	0.31

Table M4: A comparison of morning and afternoon milk yields:
Year 2 (1989/90): Second lactations. Saanen goats.
[Mean monthly milk yields; Ratio of afternoon to daily yield]

	November	February	April
Goat No. L217 am pm daily	 2.98 ± 0.43 1.07 ± 0.30 4.16 ± 0.60	 2.47 ± 0.30 0.99 ± 0.25 3.47 ± 0.33	 1.38 ± 0.17 0.61 ± 0.14 1.99 ± 0.24
Ratio	0.26	0.29	0.30
Goat No. L234 am pm daily	 3.36 ± 0.28 1.13 ± 0.31 4.50 ± 0.45	 2.76 ± 0.29 1.05 ± 0.13 3.81 ± 0.31	 2.20 ± 0.26 0.96 ± 0.14 3.16 ± 0.26
Ratio	0.25	0.28	0.30
Goat No. L481 am pm daily	 2.27 ± 0.28 0.79 ± 0.25 3.06 ± 0.33	 1.91 ± 0.21 0.81 ± 0.16 2.72 ± 0.25	 1.57 ± 0.21 0.67 ± 0.10 2.24 ± 0.25
Ratio	0.26	0.30	0.30

Table M5: A comparison of morning and afternoon milk yields:
Year 2 (1989/90): First lactations. Saanen and Crossbred goats.
[Mean monthly milk yields; Ratio of afternoon to daily yield]

	November	February	April
Goat No. K3(Sa) am pm daily	 1.62 ± 0.23 0.66 ± 0.12 2.28 ± 0.25	 1.54 ± 0.23 0.67 ± 0.14 2.22 ± 0.26	 1.51 ± 0.18 0.64 ± 0.18 2.16 ± 0.25
Ratio	0.29	0.30	0.30
Goat No. K23(Sa) am pm daily	 1.21 ± 0.22 0.49 ± 0.15 1.69 ± 0.27	 1.12 ± 0.18 0.47 ± 0.10 1.59 ± 0.19	 0.97 ± 0.20 0.37 ± 0.11 1.34 ± 0.24
Ratio	0.29	0.29	0.28
Goat No. K18(c) am pm daily	 1.01 ± 0.19 0.41 ± 0.07 1.42 ± 0.20	 1.06 ± 0.11 0.46 ± 0.12 1.52 ± 0.16	 0.99 ± 0.17 0.37 ± 0.06 1.36 ± 0.17
Ratio	0.29	0.30	0.27
Goat No. K28(c) am pm daily	 1.00 ± 0.19 0.41 ± 0.12 1.40 ± 0.28	 1.02 ± 0.23 0.49 ± 0.12 1.50 ± 0.27	 0.97 ± 0.21 0.38 ± 0.12 1.35 ± 0.26
Ratio	0.29	0.32	0.28

Table M6: Proportion of lactations corrected for compositional analysis by using mean "lifetime " analyses.

Breed	Total Lactations	Lactations corrected	Percent of total
Saanen	156	39	25%
Crossbred	71	16	23%
Three-quarter Saanen	20	2	10%
Totals	247	54	22%

TABLE M7: EXAMPLE OF AN INDIVIDUAL GOAT RECORD

GOAT No. L19 Sa (ZKFU 875)	Milk Date Fat Prot. Lac.
Birth:12/8/87 Sire:R11	
	1988/89
Bred: 5/88 Sire:L6;Age kidded:419d	18.9 16/11 2.62 2.32 4.58
Kidded: 4/10/88 Kids:88/37;K38 Sa	19.9 14/12 2.46 2.26 4.29
Lact: (1) start: 18/10/88	19.6 25/1 2.52 2.22 4.23
peak: 6/11; 3.1kg(30d)	18.9 22/2 2.23 2.18 4.16
dry:6/7/89	19.6 22/3 2.20 2.21 4.24
total:708kg;270d;2.6kg/d	959 2.41 2.24 4.30
[+15]	
Corrected:723kg;270d;2.68kg/d	
Dry period 65d	
Bred: April 1989 Sire: K12 Sa	1989/90
Kidded: 9/9/89 Kid: 89/23 Sa	
Lact:(2) start:(18d)27/9/89;KI=340d	27.9 3/90 3.23 2.37 4.30
peak: 28/1?; 4.97kg	
dry: 1/7/90	
total: 1122.5kg; 289d(=307d);3.88kg/d	
[+3 -4.2]	
Corrected:1121kg;305d;3.74kg/d	
Dry period 71d	
	1990/91
	32.3 11/90 2.55 2.58 4.43
	28.4 12/90 2.45 2.35 4.38
Bred: April 1990 Sire: K43 Sa	27.3 1/91*5.08 2.36 4.31
Kidded:10/9/90 Kids:H37;90/45 Sa	26.6 3/91 3.18 2.29 4.16
Lact:(3) start:(8d)18/9/90;KI=366d	25.3 4/91 3.30 2.48 4.03
peak: 15/11; 66d; 4.63kg	24.2 5/91 3.09 2.60 4.22
dry: 25/7/91	24.4 6/91 2.60 2.50 4.17
total: 1100.3kg; 309d(=31d);3.56kg/d	22.1 7/91 3.08 2.71 4.35
official:1221kg;2.86%fat;2.37%prot;300d	2106 2.87 2.48 4.26
[-28.9]	
Corrected:1078kg;305d;3.95kg/d	
Dry period 53d	
	1991/92
Bred: April 1991 Sire: K43	29.7 2/92 3.33 2.20 4.09
Kidded: 22/9/91 Kids:G52; G53 Sa	28.8 3/92 2.55 2.28 4.22
Lact:(4) start:(10d)2/10/91; KI=377d	24.8 4/92 2.74 2.25 4.23
peak: 10/11; 46d; 5.20kg	13.6 7/92 3.57 2.52 3.58
dry: not dry at 26/7/92	16.4 8/92 3.91 2.84 4.69
total: 1097.4kg;299d(=309d)+;3.67kg/d	18.8 9/92 3.80 2.88 4.12
	20.8 10/92 2.70 2.45 4.35
	12.9 2/93 3.48 2.52 4.15
	1658 3.17 2.44 4.19

[+ ? -8.8]
Corrected:1110kg;305d;3.70kg/d
Extra:516.6kg;225d;2.30kg/d
dried:8/3/93
Dry period 34d

Bred: November 1992 Sire: Gerry 1993/94
Kidded: 11/4/93 Kid: 93/42 Sa
Lact: (5) start:(8d)19/4/93 KI=567d 6.4 8/93 3.06 2.71 4.11
peak: 3/6/93; 53d; 2.97kg 5.6 12/93 3.05 2.35 4.06
dry: 22/12/93 120 3.06 2.54 4.09
total: 305.5kg; 248d(=256d);1.23kg/d
Corrected: 349kg;251d;1.39kg/d

Bred: February 1994 Sire: Gerry
Kidded:15/7/94 Kids:C13;94/15
Died 23/7/94 mastitis 5122 2.91 2.42 4.24

Table M8: Mean number of samples per lactation (excluding lactations with two or less samplings).

Breed	Number of goats	Samplings per lactation
Saanen	117	6.3 ± 2.1
Crossbred	55	4.7 ± 1.5
Three-quarter Saanen	18	3.8 ± 1.1
Totals	190	5.6 ± 2.1

Table M9: Corrections at the start of lactations.

Breed	Lact.	Day start recording	Correction to day	Correction (kg)	Percent lact. yield
Saanen	160	10 ± 7.2	20 ± 13.4	21 ± 17.4	3.2 ± 2.9
Crossbred	72	12 ± 9.5	30 ± 12.9	24 ± 17.2	6.2 ± 4.4
Three-quarter Saanen	23	15 ± 13.7	28 ± 18.7	27 ± 23.8	8.0 ± 7.0
Totals	255	11 ± 8.7	24 ± 14.4	22 ± 18.0	4.5 ± 4.2

Figure M1: Goat weights: Saanen and Indigenous females: 1988 to 1990
Mean monthly weights (kg)

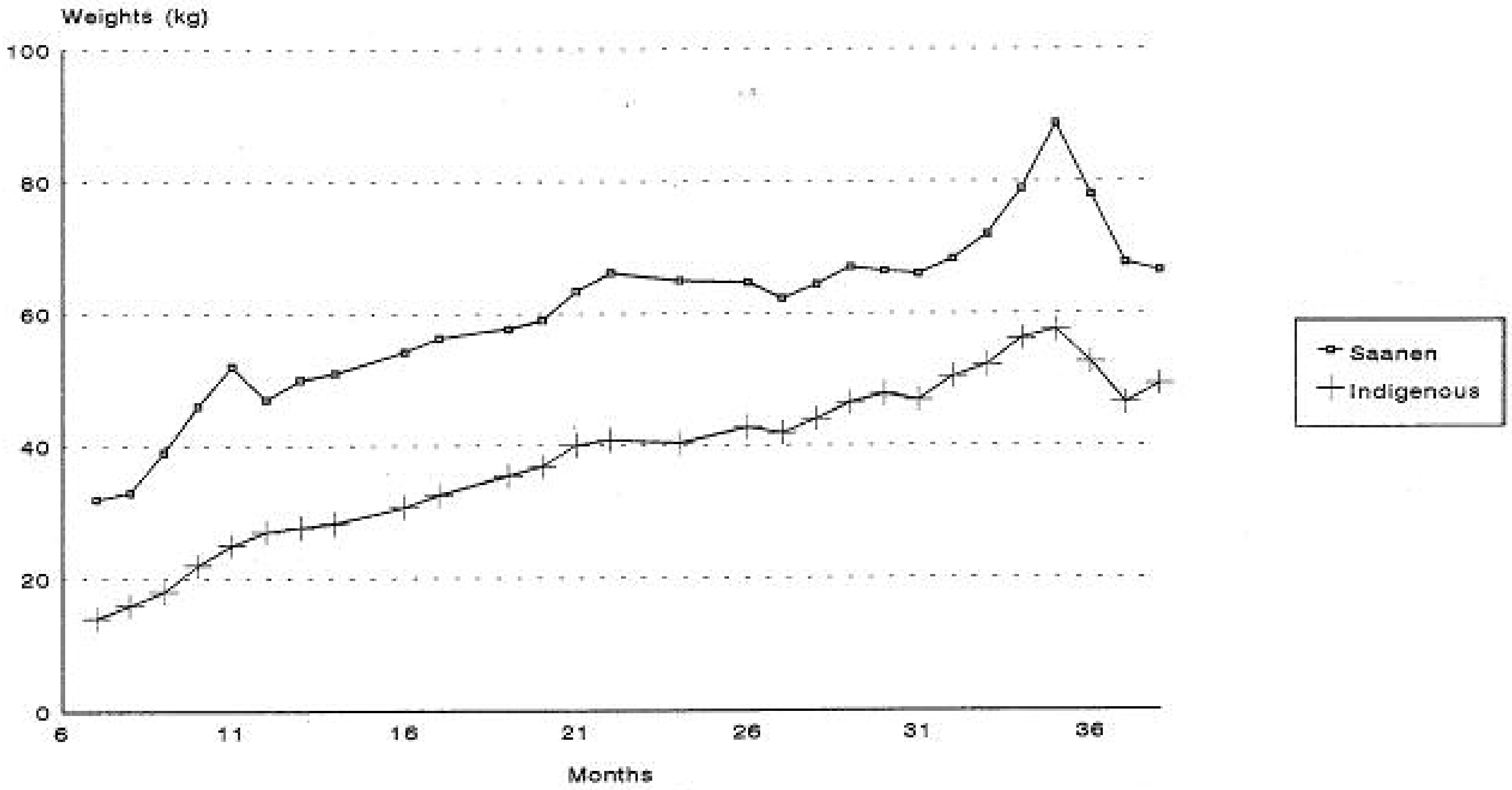
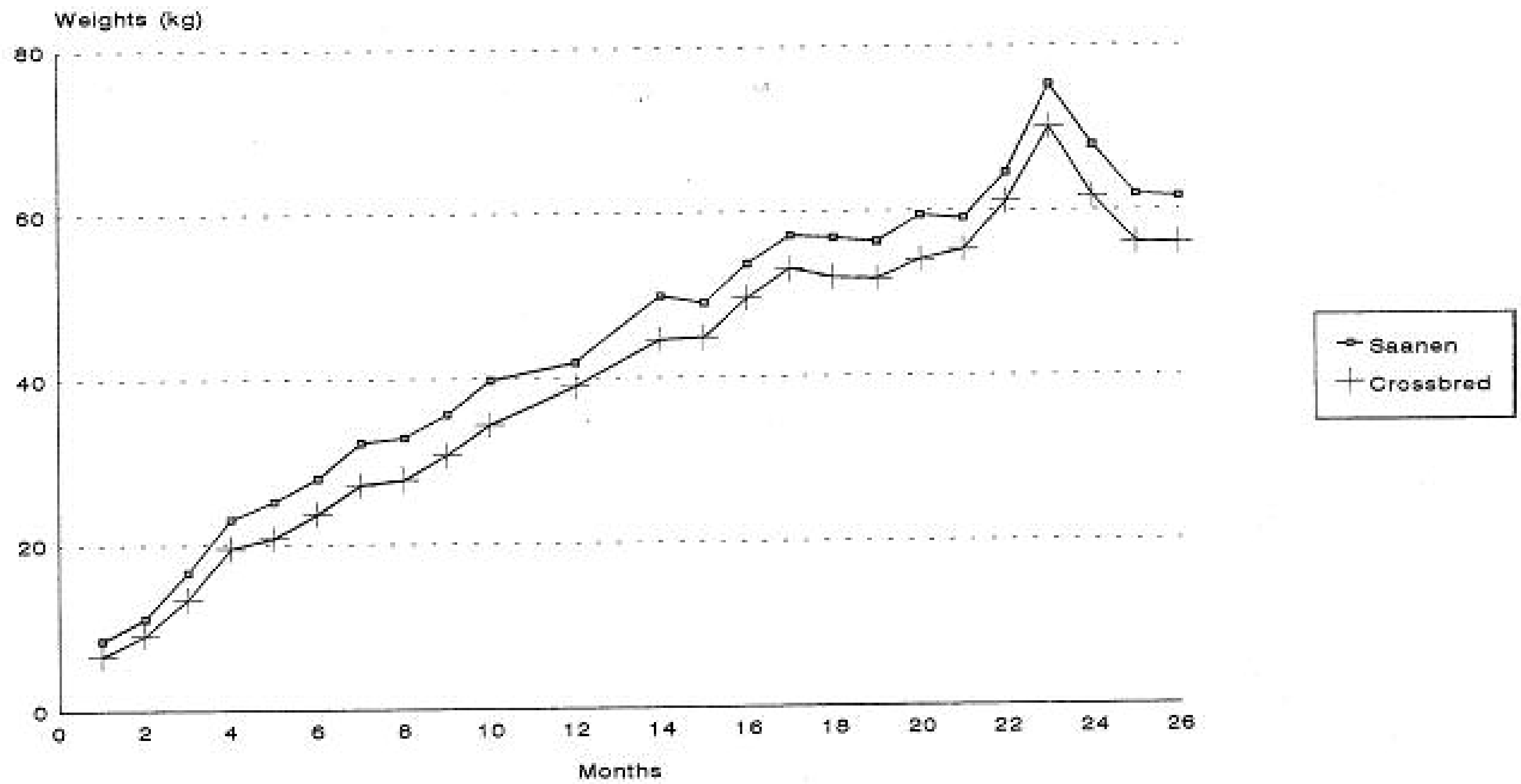


Figure M2: Goat weights: Saanen and Crossbred females:1988 to 1990
Mean monthly weights (kg)



RESULTS

CONTENTS

1. RESULTS: KIDDING

1.1 KIDDING OF GOATS

This section contains information about the fertility and fecundity of the goats:

* Parturition rate (number of parturitions per 100 females mated). This is important in a milk goat herd as it determines the number of goats in lactation.
* Reproductive rate (number of kids born per 100 females mated). This is important in a milk goat herd as it determines the number of replacement females in subsequent years, and the number of male goats for sale or slaughter.

Records of parturitions and kidding in the first three years of the experiment which were presented at the VI International Conference on Goats in Beijing (Donkin *et al.* 1996) are shown in Tables K1 and K2. Conception rates were high, except for first lactation Indigenous goats. The proportion of twinnings increased with age, but few goats had triplets. The numbers of kids born in the different categories are shown in Table K2. The lower proportion of twins among young Indigenous goats reduced their kidding percentage, but three-year old Indigenous goats had the same productivity as the Saanens (200 percent). The kidding percentage of Crossbred goats appeared to be intermediate, but fewer records were available for them in the first three years.

Details of the number of goats that were bred and subsequently kidded are shown in Tables K3 and K4. Conception rates were generally of a very high level, between 90% and 100%, except for the Indigenous goats in their first year, where many did not conceive during the first breeding season.

More detailed results are shown in the subsequent Tables K5 and K6, where information for all the years 1988 to 1994 are included. These data showed that Saanen goats achieved a high average kidding percentage of about 200% from the fourth kidding onwards, and that this was similar for Crossbreds and Three-quarter Saanens. However, the Indigenous goats did not achieve such high levels, and showed a decline after the third kidding. As a result, the average kidding percentage for Indigenous goats was 150%, compared to 165% for Saanens and Crossbreds. The apparently lower rates for Three-quarter Saanens was probably related to the fewer animals recorded. Saanens and Crossbreds had more multiple births (about 60% of parturitions) than Indigenous goats (about 50%). Three-quarter Saanens had a particularly low level at (about 36%); but it is fair to note that most of the kiddings recorded for these goats were first kiddings, and there were relatively few animals. Perhaps these proportions would have been different if the number of kiddings recorded for this group had been similar to the other groups. Indigenous goats hardly ever had triplets, whereas these occurred in 6% of Saanen kiddings and 10% of Crossbred kiddings.

The gender of goat kids born from 1988 to 1994 are shown in Table K7. The proportion was very close to 50% for each sex, except that Indigenous goats had an overall proportion of females of 47%. It seems unlikely that this is an important difference.

In 1992 the previously uniform system of breeding in autumn was altered, and a proportion of goats were given light treatment in the winter according to the method developed by Chemineau *et al.*(1992). The Indigenous goats were not included in the treatment, so that from this time onwards, the comparisons between breeds were not valid. The results of two years of this breeding policy are shown in Table K8. It was successful in 1992, but because of a power failure which dislocated the timing of the light treatment, it was a failure in 1993.

The results of these trials, which were not part of the original crossbreeding experiments, have been reported elsewhere (Donkin *et al.*, 1996b), and are summarised in Table K9.

1.2 TABLES RELATED TO KIDDING

Table K1: Parturitions of Saanen, South African Indigenous and Crossbred goats (first three years) (Donkin, *et al.* 1996).

Breed	Age (yr)	Bred No.	Kidded No.	Kidded (%)	Singles No.	Singles (%)	Twins No.	Twins (%)	Triplets No.	Triplets (%)
Saanen	1	55	51	93	31	61	20	39	0	0
	2	33	31	94	8	26	21	68	2	6
	3	22	21	95	5	24	11	52	5	24
	All	110	103	95	44	43	52	50	7	7
Indigenous	1	64	42	66	38	90	4	10	0	0
	2	44	44	100	15	34	29	66	0	0
	3	20	19	95	1	5	17	90	1	5
	All	128	105	82	54	51	50	48	1	1
Crossbred	1	23	22	96	17	77	5	23	0	0
	2	9	9	100	2	22	6	67	1	11
	All	32	31	97	19	61	11	36	1	3

Table K2: Kids born to Saanen, South African Indigenous and Crossbred goats (first three years) (Donkin, *et al.* 1996).

Breed	Age (yr)	Kiddings	Males	Females	Singles	Twins	Triplets	Kids born Total	Kids born (%)
Saanen	1	51	35	36	31	40	0	71	139
	2	31	28	28	8	42	6	56	181
	3	21	21	21	5	22	15	42	200
	All	103	84	85	44	104	21	169	164
Indigenous	1	42	20	26	38	8	0	46	110
	2	44	35	38	15	58	0	73	166
	3	19	19	19	1	34	3	38	200
	All	105	74	83	54	100	3	157	150
Crossbred	1	22	17	10	17	10	0	27	123
	2	9	9	8	2	12	3	17	189
	All	31	26	18	19	22	3	44	142

Table K3: Numbers of goats bred and kidding (1988 to 1991)

	Age (years)	1988		1989		1990		1991	
		Bred	Kidded No. %	Bred	Kidded No. %	Bred	Kidded No. %	Bred	Kidded No. %
Saanen	1 2 3 4	24	23 96	10 24	10 100 21 88	22 10 24	18 82 10 100 21 88	12 16 3 12	10 83 16 100 3 100 12 100
Indigenous	1 2 3 4	33	25 76	25 20	11 44 20 100	7 24 19	6 86 24 100 19 100	5 4 19 14	2 40 3 75 14 74 14 100
Crossbred	1 2 3			10	9 90	14 9	13 93 8 89	12 8 2	10 83 8 100 2 100
Three-quarter Saaanen	1					2	2 100	8	8 100

Table K4: Numbers of goats bred and kidding (1988 to 1991): Consolidated.

Breed	Age (years)	1988 to 1991	
		Bred	Kidded No. %
Saanen	1 2 3 4 All	68 50 27 12 157	61 90 47 94 24 89 12 100 144 92
Indigenous	1 2 3 4 All	70 48 38 14 170	44 63 47 98 33 87 14 100 138 81
Crossbred	1 2 3 All	36 17 2 55	32 89 16 94 2 100 50 91
Three-quarter Saaanen	1	10	10 100

Table K5: Parturitions (1988 to 1994)

Breed	Lact.	Parturitions	Kids born	Kidding (%)
Saanen	1st	77	101	131
	2nd	61	100	164
	3rd	39	71	182
	4th	29	59	203
	5th	13	25	192
	6th	5	11	220
	7th	6	12	200
	All	**230**	**379**	**165**
Indigenous	1st	55	63	115
	2nd	51	82	161
	3rd	39	68	174
	4th	34	53	156
	5th	23	35	152
	6th	21	33	157
	7th	7	10	143
	All	**230**	**344**	**150**
Crossbred	1st	50	68	136
	2nd	36	62	172
	3rd	22	46	209
	4th	12	27	225
	5th	3	3	100
	All	**123**	**206**	**167**
Three-quarter Saanen	1st	19	21	111
	2nd	8	14	175
	3rd	7	10	143
	4th	2	4	200
	All	**36**	**49**	**136**

Table K6: Multiple births: Number of parturitions (1988 to 1994)

Breed	Lact.	Singles	Twins	Triplets	Total Parturitions
Saanen	1st	53	24	0	77
	2nd	24	35	2	61
	3rd	11	23	5	39
	4th	4	20	5	29
	5th	1	12	0	13
	6th	0	4	1	5
	7th	1	4	1	6
	All	**94**	**122**	**14**	**230**
Indigenous	1st	48	6	1	55
	2nd	19	32	0	51
	3rd	11	27	1	39
	4th	15	19	0	34
	5th	11	12	0	23
	6th	9	12	0	21
	7th	4	3	0	7
	All	**117**	**111**	**2**	**230**
Crossbred	1st	33	17	0	50
	2nd	12	22	2	36
	3rd	3	14	5	22
	4th	2	5	5	12
	5th	1	2	0	3
	All	**51**	**60**	**12**	**123**
Three-quarter Saanens	1st	17	2	0	19
	2nd	2	6	0	8
	3rd	4	3	0	7
	4th	0	2	0	2
	All	**23**	**13**	**0**	**36**

Table K7: Gender of kids born (1988 to 1994)

Breed of Dam	Male	Female	Totals
Saanen	190	189	379
Indigenous	162	182	344
Crossbred	103	103	206
Three-quarter Saanen	23	26	49
All goats	478	500	978

Table K8: Parturitions in autumn and spring (1993 and 1994): two seasons.

Breed	Lact.	Autumn 1993	Spring 1993	Autumn 1994	Spring 1994	Totals
Saanen	1st	0	2	0	13	15
	2nd	5	1	0	1	7
	3rd+	18	9	0	21	48
Indigenous	-	30	4	16	16	66
Crossbred	1st	0	3	1	14	18
	2nd	1	2	0	2	5
	3rd+	8	6	0	12	26
Three-quarter Saanen	1st	0	4	0	7	11
	2nd	1	0	0	1	2
	3rd+	5	1	0	3	9
Seven-eighths Saanen	1st	0	1	0	4	5
	2nd	0	0	0	1	1
All goats	-	68	33	17	95	213

Table K9: The effect of supplementary light on kidding of milk goats (Donkin *et al.*, 1996b)

Breed and Year	Goats Bred	Goats Kidded	
	No.	No.	%
1992 - 1993			
Saanen	41	23	56
Crossbred	24	10	42
Three-quarter Saanen	9	6	67
All	**74**	**39**	**53**
1994 - 1995			
Saanen	39	24	62
Crossbred	27	19	70
Three-quarter Saanen	11	8	73
Seven-eighths Saanen	4	2	50
All	**81**	**53**	**65**

2. RESULTS: LACTATIONS

2.1 LACTATIONS OF GOATS

Information on the lactations is summarized in Tables L1 to L8, and selected lactation curves are illustrated in Figures L1 to L5.

Milk Production: All Goats, All Lactations (Table L1)

The data for mean milk production shown in Table L1 are not good examples of the average values because of the different proportions of lactation numbers in each group. Nevertheless, they show the broad differences between the breeds:

* Saanen goats had the highest yields, and lactation lengths of at least 300 days.
* Indigenous goats had very low yields and very short lactations.
* Crossbred goats produced less milk than Saanens, but considerably more than Indigenous goats; lactation lengths of Crossbreds were slightly shorter than those of Saanens.
* Three-quarter Saanens produced much the same amount of milk as Crossbreds. (However, there were too few lactations in the set of data to be sure that this would be generally true of all such goats.)

Lactation Yields: All Breeds and Lactations (Table L2)

Saanen Goats

The mean lactation yields as shown for each lactation number in this Table are more accurate indicators of the productivity of the Saanen goats than the averages in Table L1. These data show that the peak yield of Saanens occurred in the second lactation at a mean of 838 ± 177kg in 300 days. First lactation yields were 70% of second lactations; third lactation yields were reduced by 10%. Milk production declined slightly in the third and fourth lactations, but dropped to 60% in the fifth lactation, compared to yield in the second. Peak daily milk production was approximately 140% of average daily production per lactation, and the peak occurred at about 70 days. Peak daily milk production was approximately 0.5% of total lactation yield (i.e. a factor of 200 x peak daily milk yield).

Indigenous Goats

As stated previously, milk production from Indigenous goats was difficult to measure. Mean daily yield was only 250ml, and lactation length varied from two to four months. Only the first lactations were accurately measured. Intermittent measurements in subsequent years indicated similar production levels for second and third lactations.

Crossbred Goats

Milk production of Crossbred goats was highest also in the second lactation (466 ± 118kg). The higher yields shown for fourth lactation are not representative: this was a small and biased sample. The production of first lactation goats was approximately 70% of the yield in second lactation. Peak daily milk production was approximately 140% of average daily production per lactation, and the peak occurred at about 80 days. Peak daily milk production was approximately 0.57% of total lactation yield (i.e. a factor of 175 x peak daily milk yield).

Three-quarter Saanens

Milk production of Three-quarter Saanens was remarkably similar to that of Crossbred goats, but it is important to take note of the relatively small number of goats in the sample.

Dry periods (Table L3)

Mean lengths of dry periods were very similar for all goats (except Indigenous goats), and averaged about two months. In the case of Indigenous goats, the very short lactations meant that dry periods were very long.

Actual Lactation Lengths (Table L4)

Traditional analysis of lactations according to standard milk recording procedure makes comparisons only between lactations of 300 days or less. In fact many goats had lactations longer than this, as shown in Table L4. Where a goat was not bred during the normal breeding season of March to May (by intent), the better Saanen goat was capable of continuing milk production for twice as long as normal.

Milk Composition: All goats (Table L5)

The data for mean milk composition as measured by fat, protein and lactose percentage showed a high variability within breeds, apart from the distinctive differences between breeds. Although Indigenous goats had short and small lactations, their milk was extremely concentrated. Crossbred goats had milkfat and protein percentages approximately 1% higher than those of Saanens. The milk of Three-quarter Saanens was only slightly less rich in comparison to that of the Crossbred goats.

Kidding Intervals (Table L6)

Although not strictly a part of milk production *per se*, the interval between kiddings is an important measure for indicating continuity of milk production. Kidding interval averaged about 380 days for both Saanen and Indigenous goats, but with a greater range about the average for Indigenous goats. It is interesting that both Crossbred and Three-quarter Saanens had much shorter kidding intervals on average. It must of course be remembered that management decisions had a great influence on kidding interval. The breeding season was from March to May in all years until 1992. Even so, decisions about which group of goats should be bred at a particular time varied from year to year.

Milk Yields and Composition in the Early Years (Tables L7 and L8)

Milk production in the early years of the Milch Goat Project perhaps gave a better indication of breed and lactation number differences than did the means over all the years. Table L7 contains data presented at the VI International Conference on Goats in Beijing in 1996. It shows milk production from selected lactations, where the ages of goats were similar, and year effects were eliminated. Milk composition for these specific lactation comparisons are shown in Table L8. The variation between years is indicated, for example, in the comparison of milkfat and protein percent of first lactation Saanens in 1988 and 1989. Nevertheless, for both lactation yields and composition, the detailed analyses are similar to the breed averages shown in Tables L1 and L2.

2.1.1 Graphs of Lactations

These graphs illustrate the actual lactation curves of goats. Examples are taken of the curve for the highest-yielding goat (total lactation), the lowest yielding goat (total lactation), and for the mean of the lactations in each particular group. [Thus it happened that the initial yield recorded for the highest yielding Indigenous goat (Table L1) was the same as for the average of all Indigenous goat lactations at that time. Other goats had higher yields initially, which raised the average yield, but they did not give as high a production measured over the whole lactation. A similar apparent anomaly is also shown in Figure L4.]

These graphs should be compared with those derived statistically using the linear Morant-4 model. (Figures G1 to G3).

Figure L1: Lactations: Saanen and Indigenous Goats: 1988/89
First Lactations: Mean daily milk production (kg)

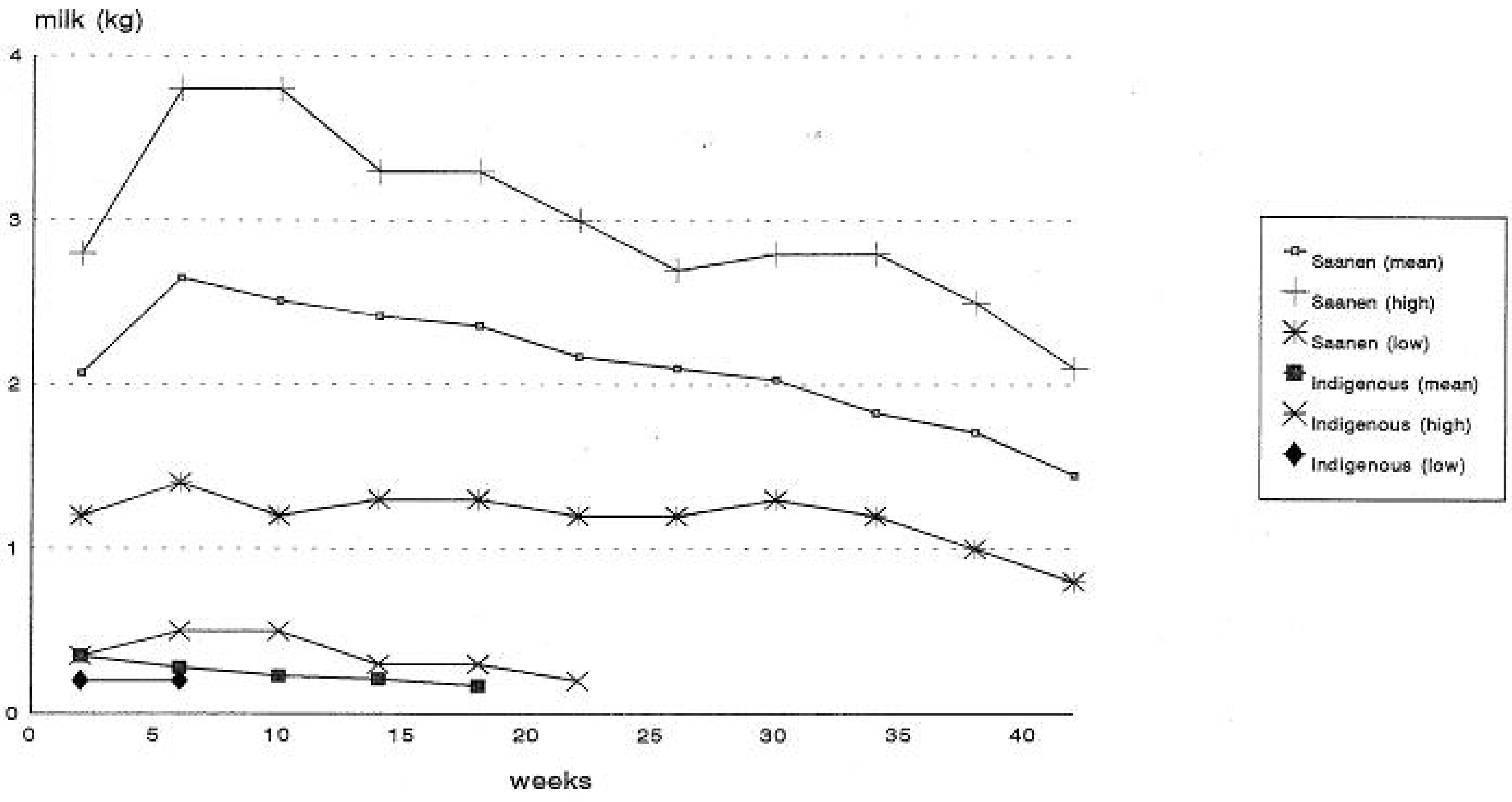


Figure L2: Lactations: Saanen and Crossbred goats: 1989/90
First Lactations: Mean daily milk production (kg)

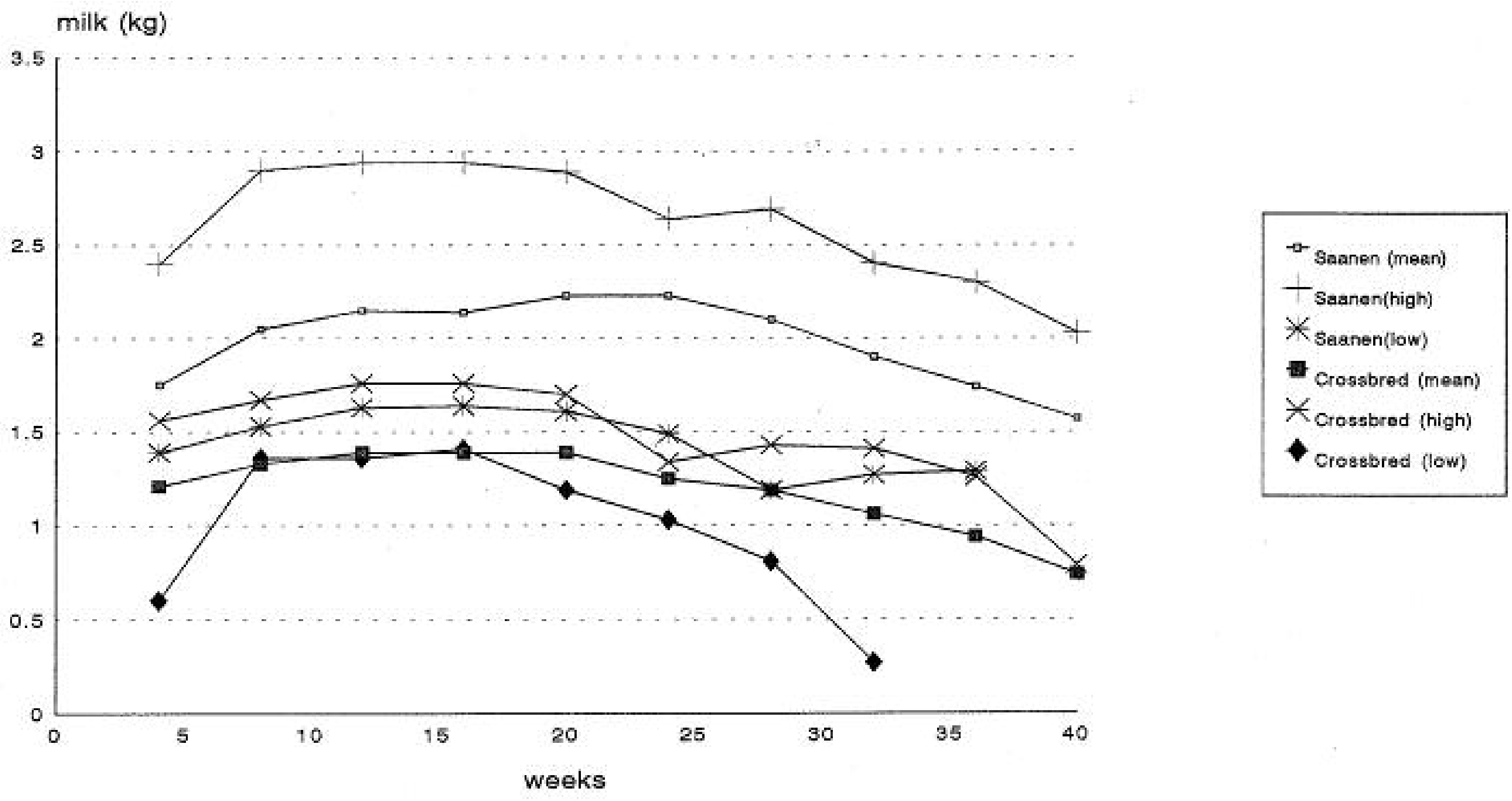


Figure L3: Lactations: Saanen goats: 1989/90
Second Lactations: Mean daily milk production (kg)

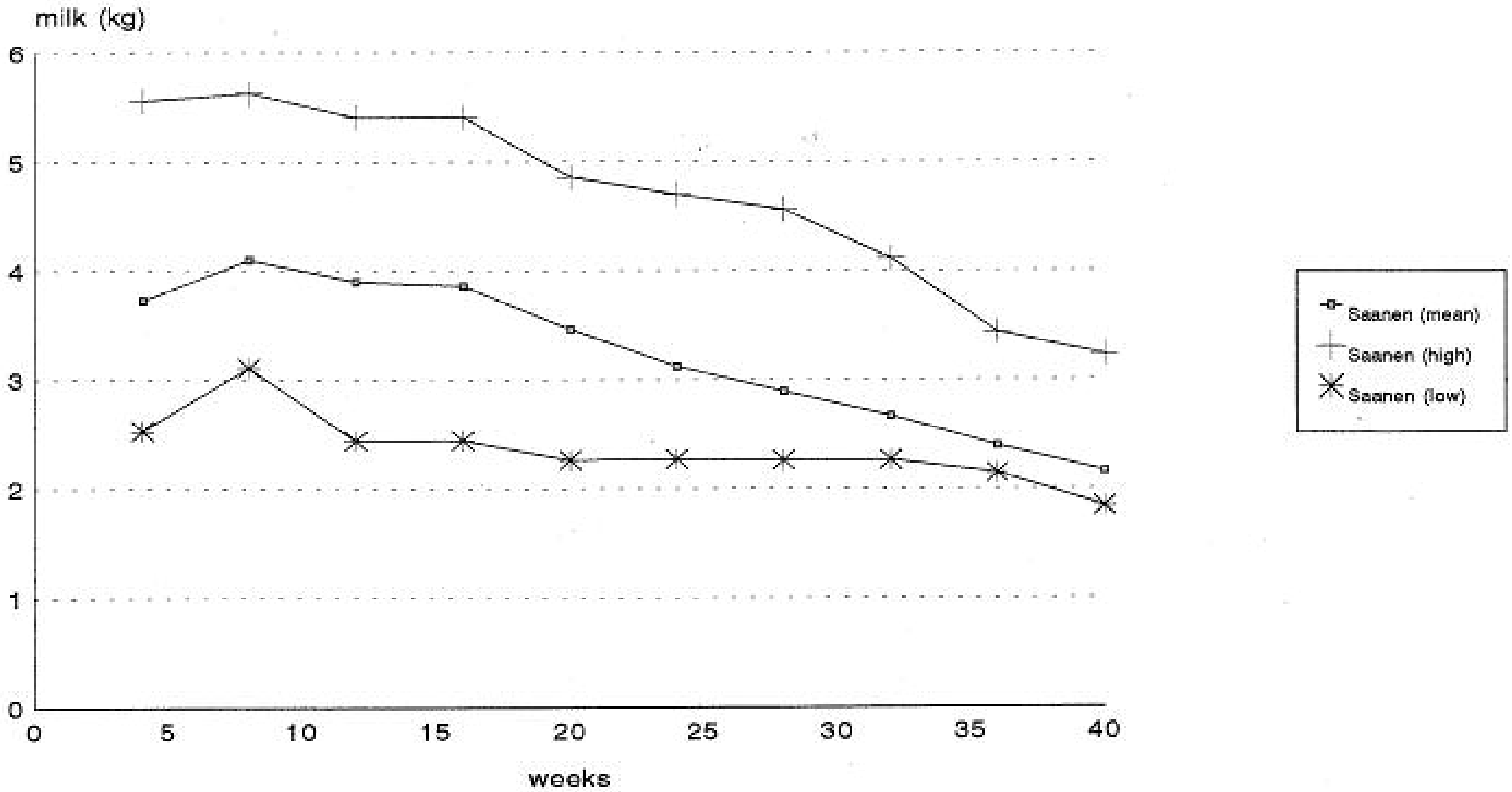


Figure L3: Lactations: Saanen goats: 1989/90
Second Lactations: Mean daily milk production (kg)

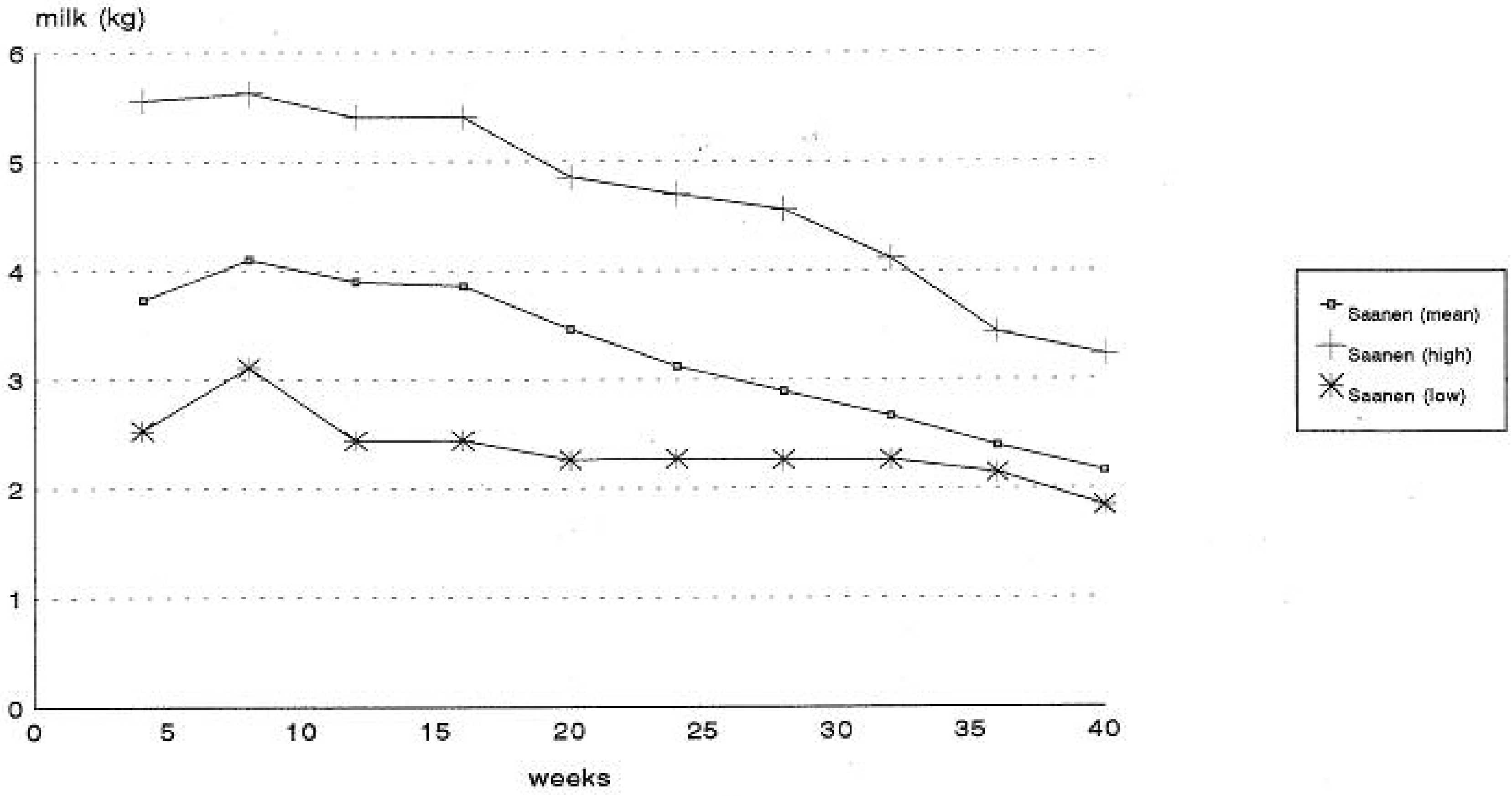


Figure L4: Lactations: Saanen and Crossbred Goats: 1990/91
First Lactations: Mean daily milk production (kg)

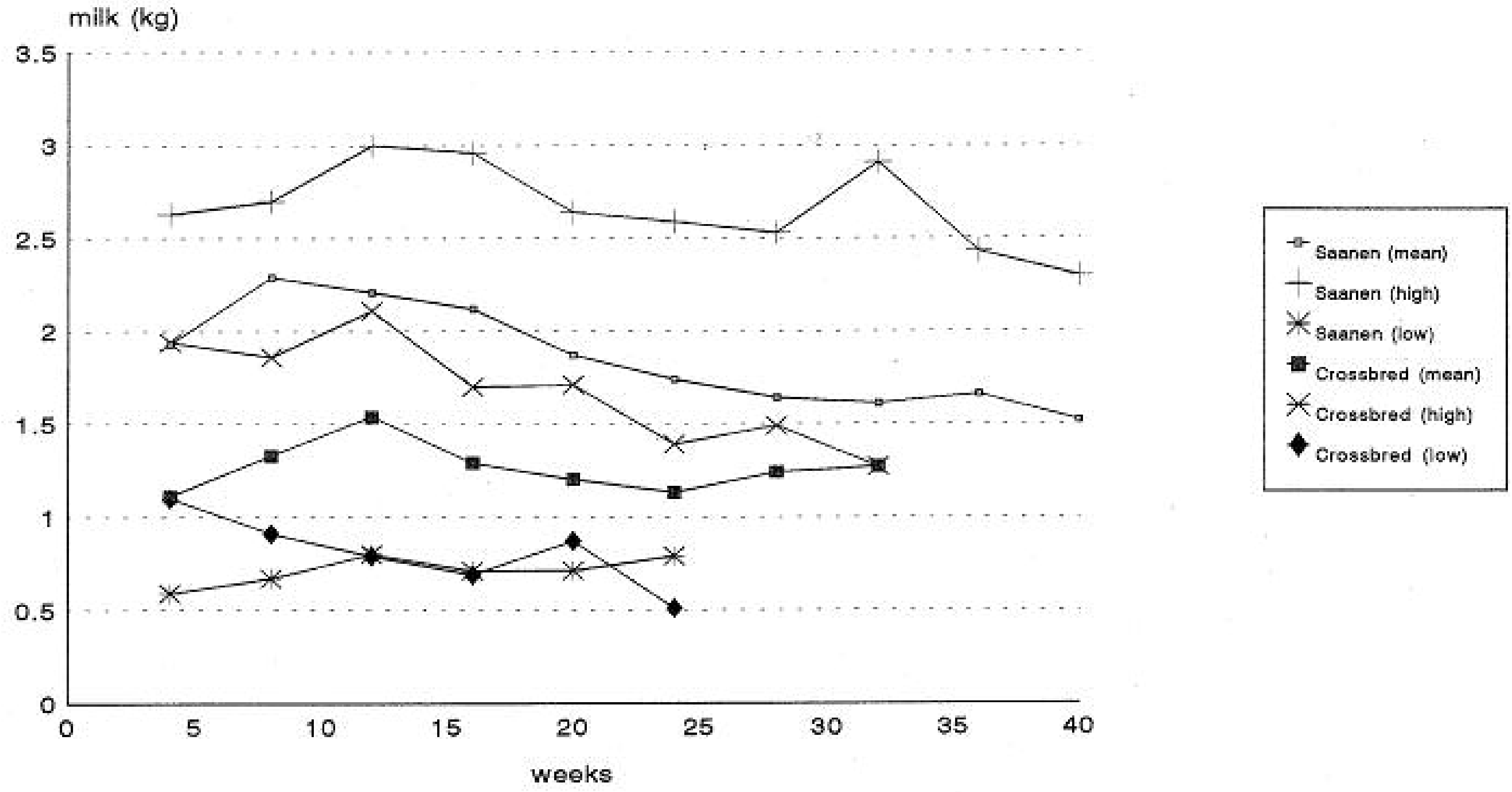
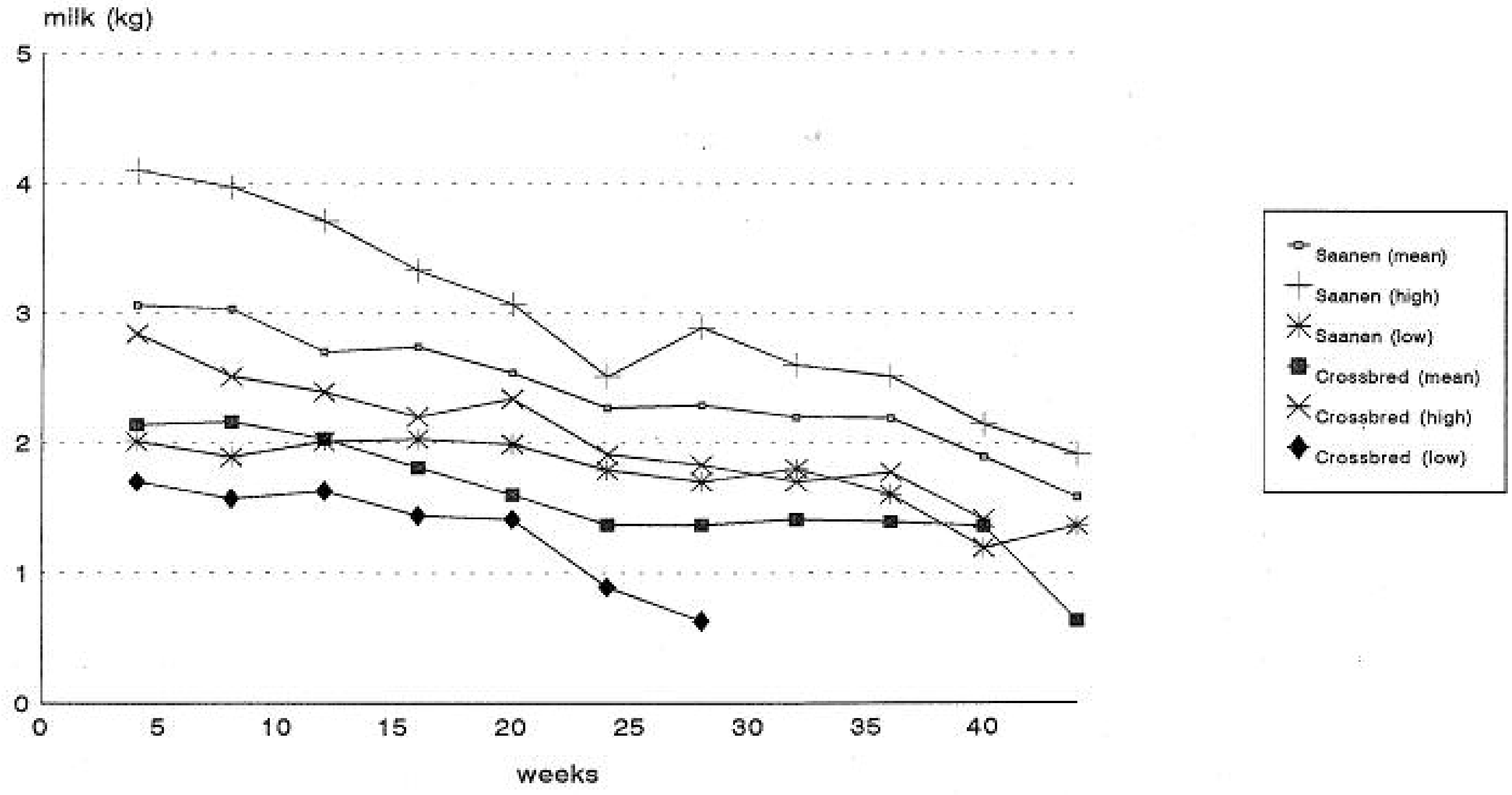


Figure L5: Lactations: Saanen and Crossbred Goats: 1990/91
Second Lactations: Mean daily milk production (kg)



2.1.2 Tables of Lactation Data

Table L1: Milk Production: All Goats, All Lactations

Breed	Lactation Yield (kg)*			Days of Lactation *		Mean Daily Milk (kg)
	No.	Mean ± SE	Min. Max.	Mean	Min. Max.	Mean ± SE
Saanen	156	706 ± 207	334 1404	288	164 300	2.45 ± 0.67
Indigenous	21	23 ± 13	6 57	94	30 155	0.25 ± 0.06
Crossbred	73	392 ± 13	56 828	245	69 300	1.58 ± 0.41
Three-quarter Saanen	22	390 ± 161	82 677	250	109 300	1.51 ± 0.41

[* Milk Production beyond 300 days not included]

Table L2: Goat Lactation Yields: Breeds and Lactation Numbers

Breed and Lactation	No.	Milk Yields (kg) Mean ± SE	Mean Lactation Lengths (days)*	Peak Daily Yields		Mean Daily Yields kg/d ± SE
				kg/d ± SE	Days ± SE	
Saanen						
1	59	579 ± 130	283	2.74 ± 0.55	78 ± 42	2.04 ± 0.42
2	48	838 ± 177	293	3.93 ± 0.85	69 ± 30	2.86 ± 0.57
3	28	758 ± 208	290	3.68 ± 0.58	68 ± 25	2.60 ± 0.66
4	15	764 ± 242	286	3.81 ± 1.10	67 ± 30	2.68 ± 0.78
5	6	503 ± 111	281	2.75 ± 0.56	55 ± 12	1.79 ± 0.37
Indigenous						
1	21	23 ± 13	94 ± 39	0.40 ± 0.11	16 ± 12	0.25 ± 0.06
Crossbred						
1	32	317 ± 102	236	1.83 ± 0.41	94 ± 38	1.33 ± 0.31
2	24	446 ± 118	248	2.55 ± 0.45	56 ± 21	1.80 ± 0.31
3	12	438 ± 120	257	2.39 ± 0.48	67 ± 18	1.69 ± 0.37
4	5	504 ± 227	265	2.76 ± 0.86	73 ± 31	1.85 ± 0.61
Three-quarter Saanen 1	12	320 ± 166	232	1.75 ± 0.62	82 ± 28	1.33 ± 0.43
2	5	438 ± 115	260	2.49 ± 0.43	83 ± 20	1.67 ± 0.24
3	5	509 ± 109	284	2.68 ± 0.35	59 ± 13	1.79 ± 0.27

[* Note: Milk production beyond 300d not included]

Table L3: Goat Lactations: Dry Periods: Days Dry Following Lactations

Breed	Previous Lactation	Number	Days Dry Mean ± SE
Saanen	1	49	73 ± 56
	2	29	62 ± 35
	3	15	55 ± 39
	4	6	65 ± 29
Indigenous	1	18	272 ± 190
	2	2	363 ± 236
	4	3	527 ± 328
Crossbred	1	23	95 ± 46
	2	12	58 ± 26
	3	5	52 ± 14
Three-quarter Saanen	1	5	75 ± 77
	2	4	37 ± 28

Table L4: Goat Lactations: Actual Lactation Lengths
[Including lactations >300 days]

Breed	Lactation	Number	Days Mean ± SE	Min.	Max.
Saanen	1	59	296 ± 58	231	662
	2	49	344 ± 98	108	574
	3	29	346 ± 108	174	717
	4	15	422 ± 146	220	673
	5	6	301 ± 51	230	359
Indigenous	1	21	98 ± 39	35	159
	2	2	46 ± 4	43	49
	4	3	54 ± 5	48	58
Crossbred	1	32	248 ± 62	73	412
	2	25	253 ± 51	137	336
	3	12	268 ± 53	203	333
	4	5	302 ± 66	235	406
Three-quarter Saanen	1	12	263 ± 95	118	424
	2	5	275 ± 60	194	339
	3	5	383 ± 132	224	574

Table L5: Milk Composition: All Breeds of Goats

Breed	Fat		Protein		Lactose	
	No.	Mean ± SE	No.	Mean ± SE	No.	Mean ± SE
Saanen	153	3.43 ± 0.53	153	2.88 ± 0.34	153	4.49 ± 0.20
Indigenous	26	9.33 ± 1.84	74	5.04 ± 0.82	74	5.12 ± 0.56
Crossbred	71	5.47 ± 0.67	71	3.88 ± 0.29	71	4.81 ± 0.18
Three-quarter Saanen	19	5.10 ± 0.64	19	3.50 ± 0.41	19	4.73 ± 0.17

Table L6: Kidding Intervals for Goats (days)

Breed	Number	Mean ± sd	Min.	Max.
Saanen	99	380 ± 88	174	693
Indigenous	148	384 ± 165	220	1276
Crossbred	42	329 ± 51	202	461
3/4 Saanen	9	304 ± 30	242	353

Table L7: Milk yields of Saanen, South African Indigenous and Crossbred goats
[Donkin, *et al.*(1996)]

	No.	Lactation (kg)		Days^{A}		Daily milk (kg/d)	
Category	mean	se	mean	se	mean	se	
First lactations 1988							
Saanen	23	614	142	285	-	2.16	0.48
Indigenous	21	23	13	94	39	0.25	0.07
First lactations 1989							
Saanen	10	558	87	290	-	1.92	0.30
Crossbred	9	337	63	282	-	1.19	0.16
Second lactations 1990							
Saanen	9	743	118	300	-	2.48	0.39
Crossbred	9	463	122	266	-	1.72	0.30

(^{A} milk production beyond 300 days not included)

Table L8: Milk composition analysis of Saanen, South African Indigenous and Crossbred goats
[Donkin, *et al.*(1996)]

	No.	Milk fat (%)		Protein (%)		Lactose (%)	
Category	mean	se	mean	se	mean	se	
First lactations 1988							
Saanen	23	2.88	0.31	2.63	0.26	4.61	0.20
Indigenous	21	9.06	1.84	5.44	0.69	4.64	0.44
First lactations 1989							
Saanen	9	3.91	0.40	3.15	0.26	4.47	0.14
Crossbred	9	5.31	0.61	3.77	0.28	4.82	0.12
Second lactations 1990							
Saanen	9	3.73	0.40	3.12	0.28	4.47	0.16
Crossbred	9	5.13	0.63	3.77	0.26	4.82	0.12
All Saanens	41	3.29	0.58	2.85	0.37	4.55	0.19
All Crossbreds	18	5.22	0.61	3.77	0.27	4.82	0.12

2.2 FITTING LACTATION CURVES

The model chosen for the fitting of lactation curves was the linear Morant-4, as described in the section on Materials and Methods. These curves were fitted to lactation data for goats that kidded in 1988 and 1990.

The Parameters (A,B,C and D) for each lactation are shown in Tables G1, G2, and G3.

2.2.1 STATISTICAL ANALYSIS OF LACTATION CURVES

Comparison of Lactations: Saanen and Indigenous Goats in 1988 (First Lactations) [Table G4]

All Parameters were significantly different in the comparison between Saanen and Indigenous goats in first lactation: Parameters A and D ($P<0.001$); Parameters B and C ($P<0.05$). This analysis shows that the lactation curves were totally different in all aspects.

Comparison of First Lactation Saanens in 1988 and 1990 [Table G5]

The comparison of Saanen first lactations in 1988 and 1990 showed no significant effect of year on Parameters A and D, but a significant ($P<0.05$) difference in Parameters B and C. This means that there was no difference in the scale of the lactation curves, but that there were significant ($P<0.05$) differences in the rate of decline (persistency) for Saanen first lactations between the years 1988 and 1990.

Comparison of Lactations: Saanen and Crossbred Goats in 1990 [Table G6]

The comparison of Saanen and Crossbred lactations in 1990 showed a significant ($P<0.001$) difference in Parameter A (scale of lactation) for first lactations, and a lesser significance ($P<0.01$) for second lactations. This was the most important difference between groups. In contrast, there was little difference between groups in the "shape" parameters B and C. There were no significant differences in Parameter B. Parameter C showed a significant ($P<0.05$) difference only for second lactations. There were no significant differences for Parameter D in lactations 1 and 2, but a significant ($P<0.001$) breed x parity interaction. In Saanens the negative value of Parameter D decreased between parities 1 and 2, but the reverse was true for Crossbreds.

2.2 2 LACTATION CURVES: Figures G1, G2, G3.

*** Figure G1: Goat Lactation Curves 1990: Saanen and Crossbred: Lactations 1 and 2**.
These graphs relate to the data shown in Table G5.

*** Figure G2: Goat Lactation Curves: Saanens, First Lactations: 1988 and 1990**.
These graphs relate to the data shown in Table G4. The differences in persistency are clear, but the apparent difference of scale (at 150 days) was found to be not significant.

*** Figure G3: Goat Lactation Curves: Indigenous Goats: First Lactations**.
Lactation curves of Indigenous goats proved to be greatly variable in both scale and shape, and it was considered unrealistic to attempt to fit curves of average values. Therefore, three individual lactation curves were selected to illustrate the different types. The Wood model was used in these cases because it was more appropriate than the linear Morant-4 model.

Table G1: Morant Parameters for Lactation Curves of Goats: Saanens (1990)

Goat	Weeks	Parameter A	Parameter B	Parameter C	Parameter D	R-squared
1st Lact.						
0S1JO4	43	0.7139	-0.3459	0.0026	-9.3283	0.7009
0S1J06	42	0.7439	-1.1973	-0.0238	-8.6478	0.7514
0S1J11	42	0.8208	-0.2805	-0.0309	-9.0153	0.8621
0S1J21	41	0.7965	-0.2009	0.0315	-6.6768	0.6763
0S1J22	34	0.6123	-0.4139	-0.3107	-5.9161	0.7510
0S1J27	34	0.4421	-0.6216	-0.1929	-7.4457	0.7997
0S1J31	32	0.4279	-0.5026	-0.0638	-10.3434	0.8269
0S1J32	42	1.0067	-0.1271	-0.0652	-7.9446	0.7333
0S1J33	41	1.0437	-0.1197	-0.0136	-5.1633	0.5113
0S1J35	40	0.1742	-0.2521	-0.2668	-10.6366	0.3368
0S1J40	40	0.8309	-0.4318	-0.0459	-9.1974	0.8824
0S1J41	40	0.7374	-0.3594	0.0070	-7.1647	0.8469
0S1J44	41	0.7221	-0.3619	-0.0435	-8.7359	0.8827
0S1J46	35	0.8015	-0.4046	-0.1213	-8.7203	0.8638
2nd Lact.						
0S2K04	43	0.6950	-0.0999	-0.1295	0.9339	0.8689
0S2K23	46	0.8661	-0.2952	-0.0409	-11.6818	0.9131
0S2K30	46	0.9648	-0.0540	-0.0092	-0.8133	0.1185
0S2K31	44	0.9093	-0.2739	-0.1180	-9.9999	0.7103
0S2K35	43	1.1874	-0.2268	-0.1001	-5.0333	0.7345
0S2K40	44	0.8386	-0.2053	-0.0087	-3.6240	0.5954
0S2K43	47	1.0991	-0.3295	-0.0073	-7.4107	0.9167
0S2K45	46	1.1895	-0.2883	-0.0121	-6.0256	0.8921
0S2K50	43	0.9617	-0.2791	-0.0848	-10.4736	0.7372
0S2L276	42	1.1024	-0.1491	-0.0965	-0.5985	0.5606
3rd Lact.						
0S3L019	44	1.4498	-0.2356	-0.0008	-14.9629	0.7708
0S3L184	43	0.9268	-0.3806	-0.0360	-12.9887	0.8277
0S3L197	43	1.0524	-0.4112	0.0937	-11.5641	0.6057
0S3L199	43	1.0114	-0.2850	-0.0431	-10.8586	0.8674
0S3L205	46	0.9376	-0.2705	-0.1524	-8.2963	0.9446
0S3L217	36	1.0546	-0.5451	-0.4534	-3.5946	0.9167
0S3L314	38	0.7912	-0.4243	-1.0025	-7.7879	0.8497
0S3L341	46	1.5872	-0.1900	-0.1133	-3.6241	0.9278
0S3L410	15	1.6429	0.2933	0.2885	-6.9992	0.5453
0S3L429	47	1.2820	-0.1134	-0.0371	-6.8979	0.5842
0S3L436	32	0.9063	-1.0115	-0.8218	-1.9805	0.7230
0S3L449	45	1.1999	-0.4001	-0.3221	-4.5138	0.9058
0S3L454	45	0.8628	-0.1919	-0.0833	-5.0713	0.6989
0S3L466	47	1.4668	-0.1381	-0.0880	-9.0259	0.7652
0S3L481	45	0.9094	-0.4576	0.0290	-9.2677	0.8699
0S3L492	45	1.0909	-0.3597	-0.0291	-6.0572	0.8683
0S3L607	44	0.8457	-0.1911	-0.2120	-6.8036	0.8064
0S3L676	40	1.4478	-0.1614	-0.1476	-1.9844	0.7519

Table G2: Morant Parameters for Lactation Curves of Goats: Crossbreds (1990)

Goat	Weeks	Parameter A	Parameter B	Parameter C	Parameter D	R-squared
1st Lact.						
0C1J03	42	0.4949	-0.0175	-0.2345	-1.0253	0.5469
0C1J07	34	0.4858	-0.5465	-0.1650	-8.5388	0.8590
0C1J08	27	0.4057	-0.9702	-0.6327	4.6580	0.5206
0C1J12	34	0.3210	-0.3215	0.1178	-2.3898	0.6049
0C1J13	29	0.0599	-0.5249	-0.1470	-6.0280	0.6727
0C1J14	33	0.3615	-0.3195	0.1576	-9.0297	0.8223
0C1J18	29	0.0723	-0.4476	-0.4892	2.7099	0.5374
0C1J25	28	-0.0675	-0.1764	-0.1443	1.1638	0.0167
0C1J28	24	0.4530	-0.2932	0.0526	-7.9215	0.5773
0C1J39	12	-2.0772	-3.7680	-1.7882	2.3319	0.3298
2nd Lact.						
0C2K18	46	0.8571	-0.3694	0.0221	-12.5702	0.7139
0C2K28	33	0.3849	-0.2944	0.1657	-6.2509	0.7747
0C2K33	36	0.2880	-0.5345	0.1113	-10.4522	0.9002
0C2K44	32	0.4800	-0.3271	0.1476	-10.0944	0.8221
0C2K48	32	0.1834	-0.6652	-0.2013	-5.0700	0.8688
0C2K51	36	0.5142	-0.3054	0.1114	-3.3051	0.8885
0C2K53	45	0.8823	-0.3233	-0.0464	-8.7874	0.7661
0C2K57	43	0.4453	-0.2504	0.0130	-1.4311	0.7653
0C2K60	45	0.6448	-0.4610	0.0786	-11.3841	0.7868

Table G3: Morant Parameters for Lactation Curves of Goats: Saanen and Indigenous: First lactations (1988)

Goat	Weeks	Parameter A	Parameter B	Parameter C	Parameter D	R-squared
Saanen						
8S1L019	39	1.0513	-0.1847	-0.0464	-6.3470	0.7628
8S1L184	39	1.0639	-0.3178	-0.0399	-7.4547	0.9144
8S1L197	39	0.9164	-0.2147	-0.0815	-3.9781	0.4022
8S1L199	40	0.6019	-0.4010	-0.0228	-6.9475	0.8677
8S1L205	39	0.5785	-0.2360	-0.0812	-2.7201	0.7178
8S1L217	40	0.7821	-0.2507	-0.0032	-8.3467	0.8600
8S1L234	41	0.8068	-0.3418	0.0447	-9.2866	0.9005
8S1L257	39	1.0113	-0.3381	0.0490	-7.6988	0.9291
8S1L314	41	1.1548	-0.3153	0.1075	-12.1593	0.9144
8S1L341	40	1.1267	-0.2887	-0.0895	-6.7794	0.9295
8S1L410	41	0.9651	-0.2861	0.0486	-7.5197	0.6395
8S1L429	39	0.9635	-0.1022	-0.1151	-2.0917	0.7683
8S1L436	40	0.4130	-0.1708	0.0156	-4.9815	0.1561
8S1L449	38	0.8517	-0.2183	0.1171	-9.6178	0.4743
8S1L450	41	0.7045	-0.2601	-0.0224	-9.2969	0.8363
8S1L454	37	0.5594	-0.0530	-0.2001	-0.9158	0.6067
8S1L466	40	0.7051	-0.1618	-0.0814	-0.7622	0.7642
8S1L476	39	0.7329	-0.2324	-0.0901	-8.1727	0.8025
8S1L478	42	0.7960	-0.4888	0.0986	-13.1713	0.9035
8S1L481	42	0.7719	-0.3158	0.0819	-9.5331	0.8619
8S1L492	40	0.5937	-0.3095	0.0021	-4.1105	0.8932
8S1L607	42	0.2533	-0.2160	0.0088	-6.3893	0.6223
8S1L676	41	1.1978	-0.1746	-0.0453	-11.8381	0.9310
Indigenous						
8I17410	6	-1.7378	3.7699	1.0940	0.4761	0.9999
8I17313	15	-5.3367	-8.3127	-4.4559	11.7344	0.7614
8I17409	18	-1.7504	1.1008	0.9283	7.5253	0.2848
8I17410	16	-3.7568	3.9561	1.7867	9.0662	0.7284
8I17414	8	-5.8524	-7.7838	-3.5595	3.8036	0.0252
8I17416	9	-11.5113	-1.7392	-8.0416	9.6731	0.5694
8I17419	16	-1.7442	-1.9531	-1.5286	14.6419	0.0622
8I1746D	8	7.7034	15.6174	7.0711	-4.7555	-
8I17502	8	-2.1969	-1.6141	-1.1984	13.6993	0.7422
8I17503	7	-31.0701	-50.0363	-21.1264	13.5869	0.9675
8I17504	4	-	-	-	-	-
8I17506	22	-1.3427	-0.3427	0.5342	-14.7645	0.7085
8I17507	10	-1.9462	-0.4529	-0.1289	4.9155	0.8002
8I17508	16	-1.1311	4.8938	4.8888	-26.5440	0.7026
8I17509	-	-	-	-	-	-
8I17510	20	-1.5393	0.4245	-0.0606	13.5858	0.4826
8I17602	16	-3.4849	-4.5691	-2.4896	8.1851	0.6336
8I17603	10	-11.0127	-17.2253	-7.6174	9.2350	0.7114
8I17606	20	-3.4524	-3.1175	-1.0937	2.7330	0.8227
8I17613	8	-23.9691	-40.1356	-18.4570	21.3574	0.1025
8I1795D	12	-5.3480	-7.0191	-3.1293	6.8001	0.7709

Notes: 1. Goat No. 8I17504: No variance in yield.
2. Goat No. 8I17509: Too few observations.

Table G4: Comparison of Lactations: Saanen and Indigenous Goats in 1988 (First Lactations)

	Breed	n	Means	SD	ANOVA	df	MS	F
Parameter A	Saanen Indigenous	23 18	0.80877 -6.56528	0.242895 8.297502	Breed Error	1 39	549.0701 30.0442	18.27 ***
Parameter B	Saanen Indigenous	23 18	-0.25557 -7.23089	0.096178 14.8415	Breed Error	1 39	491.2978 96.0201	5.1166 *
Parameter C	Saanen Indigenous	23 18	-0.01500 -3.53636	0.079692 6.719143	Breed Error	1 39	125.2096 19.6829	6.3613 *
Parameter D	Saanen Indigenous	23 18	-6.96166 6.09504	3.416135 11.10427	Breed Error	1 39	1721.405 60.331	28.532 ***

Table G5: Comparison of First Lactation Saanens in 1988 and 1990

	Year	n	Means	SD	ANOVA	df	MS	F
Parameter A	1988 1990	23 14	0.80877 0.70528	0.242895 0.230695	Year Error	1 35	0.09320 0.05685	1.6395NS
Parameter B	1988 1990	23 14	-0.25557 -0.40138	0.096178 0.267666	Year Error	1 35	0.18501 0.03242	5.7057*
Parameter C	1988 1990	23 14	-0.01500 -0.08124	0.079692 0.104634	Year Error	1 35	0.038180 0.008058	4.7380*
Parameter D	1988 1990	23 14	-6.96166 -8.20966	3.416135 1.585516	Year Error	1 35	13.35451 8.26913	1.6391NS

Table G6: Comparison of Lactations: Saanen and Crossbred Goats in 1990

	Parity	Saanen	Crossbred	Means	Source of Variation	df	MS	F
Parameter A	1 2 Means	0.7053 0.9814 0.8203	0.0515 0.5200 0.2734	0.4329 0.7628 0.5787	Breed Parity Breed x Parity Error	1 1 1 39	3.2510 1.4494 0.0968 0.1730	18.794*** 8.379 ** 0.559 NS
Parameter B	1 2 Means	-0.4014 -0.2201 -0.3259	-0.7385 -0.3923 -0.5745	-0.5419 -0.3017 -0.4357	Breed Parity Breed x Parity Error	1 1 1 39	0.6782 0.7274 0.0711 0.3060	2.216 NS 2.376 NS 0.232 NS
Parameter C	1 2 Means	-0.0812 -0.0607 -0.0727	-0.3273 0.0447 -0.1511	-0.1838 -0.0108 -0.1073	Breed Parity Breed x Parity Error	1 1 1 39	0.0517 0.4027 0.3229 0.0821	0.630 NS 4.9038 * 3.932 NS
Parameter D	1 2 Means	-8.2097 -5.4725 -7.0692	-2.4069 -7.7049 -4.9165	-5.7919 -6.5300 -6.1180	Breed Parity Breed x Parity Error	1 1 1 39	33.3222 17.1436 168.7747 14.5771	2.286 NS 1.176 NS 11.578**

[Note: The means are unadjusted]

Figure G1: Goat Lactation Curves 1990: Saanen and Crossbred: Lactations 1 and 2
Mean curves derived from the linear Morant-4 Model

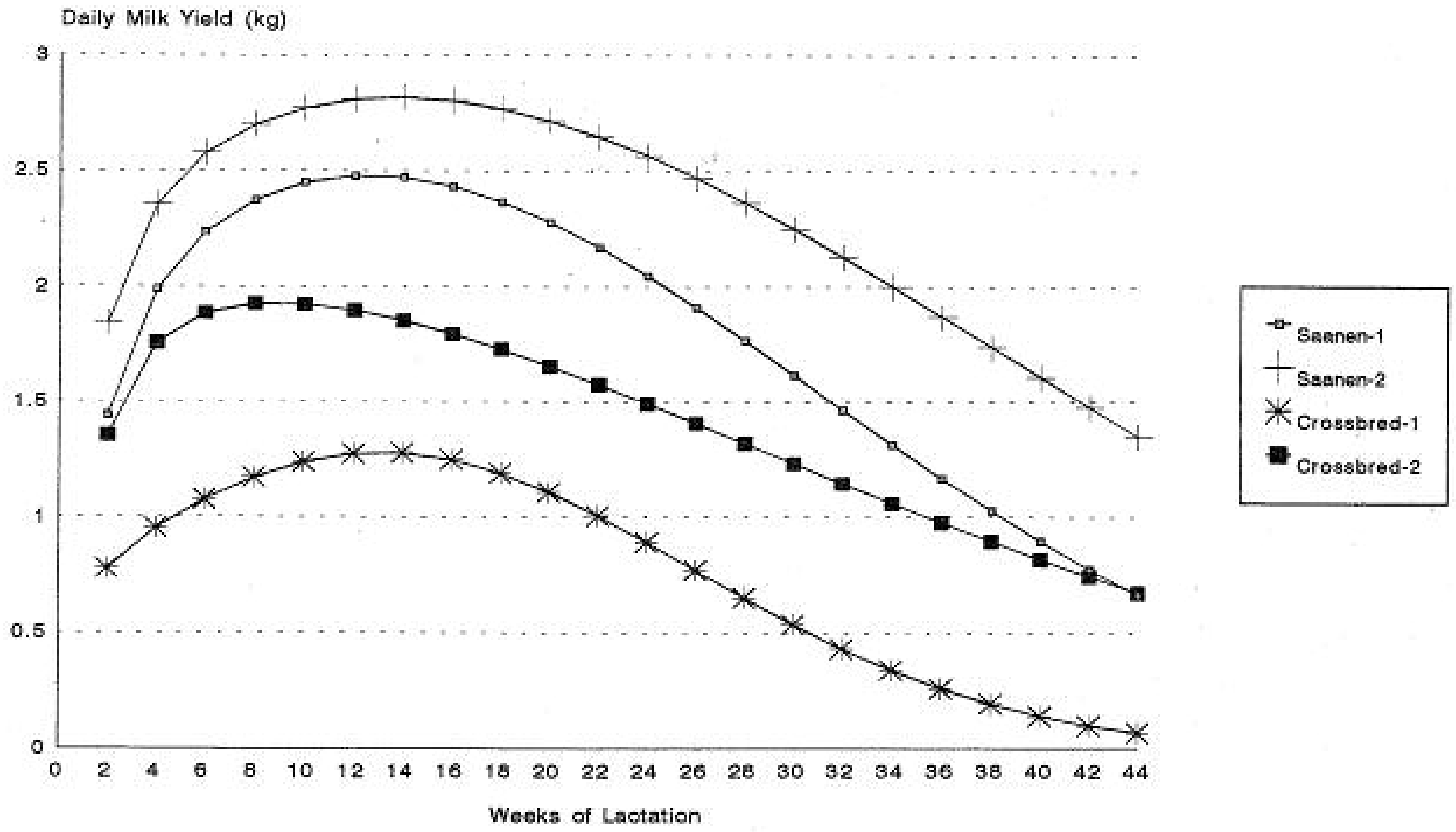


Figure G2: Goat Lactation Curves: Saanens, First Lactations:1988 and 1990
Mean curves derived from the linear Morant-4 Model

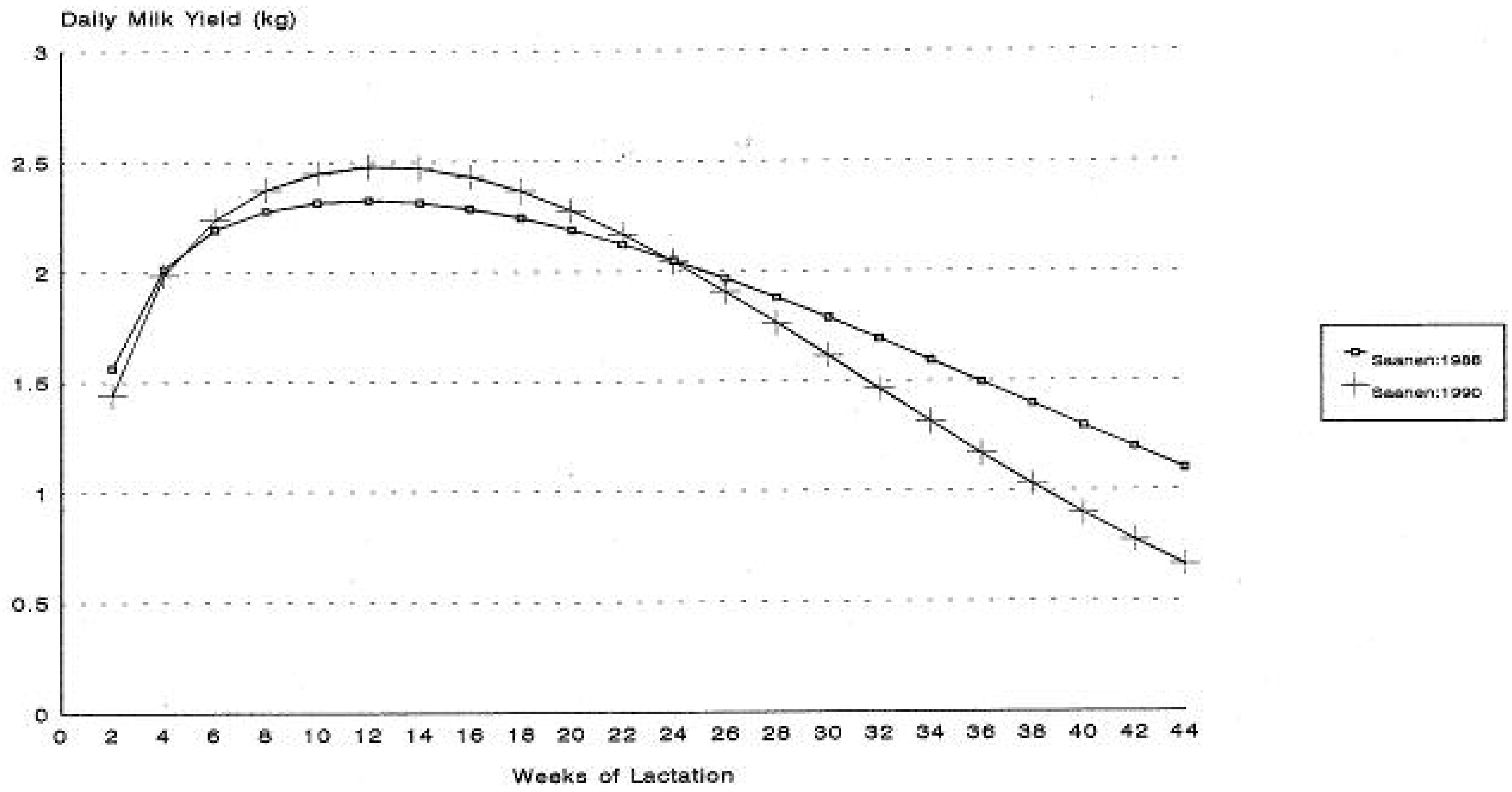
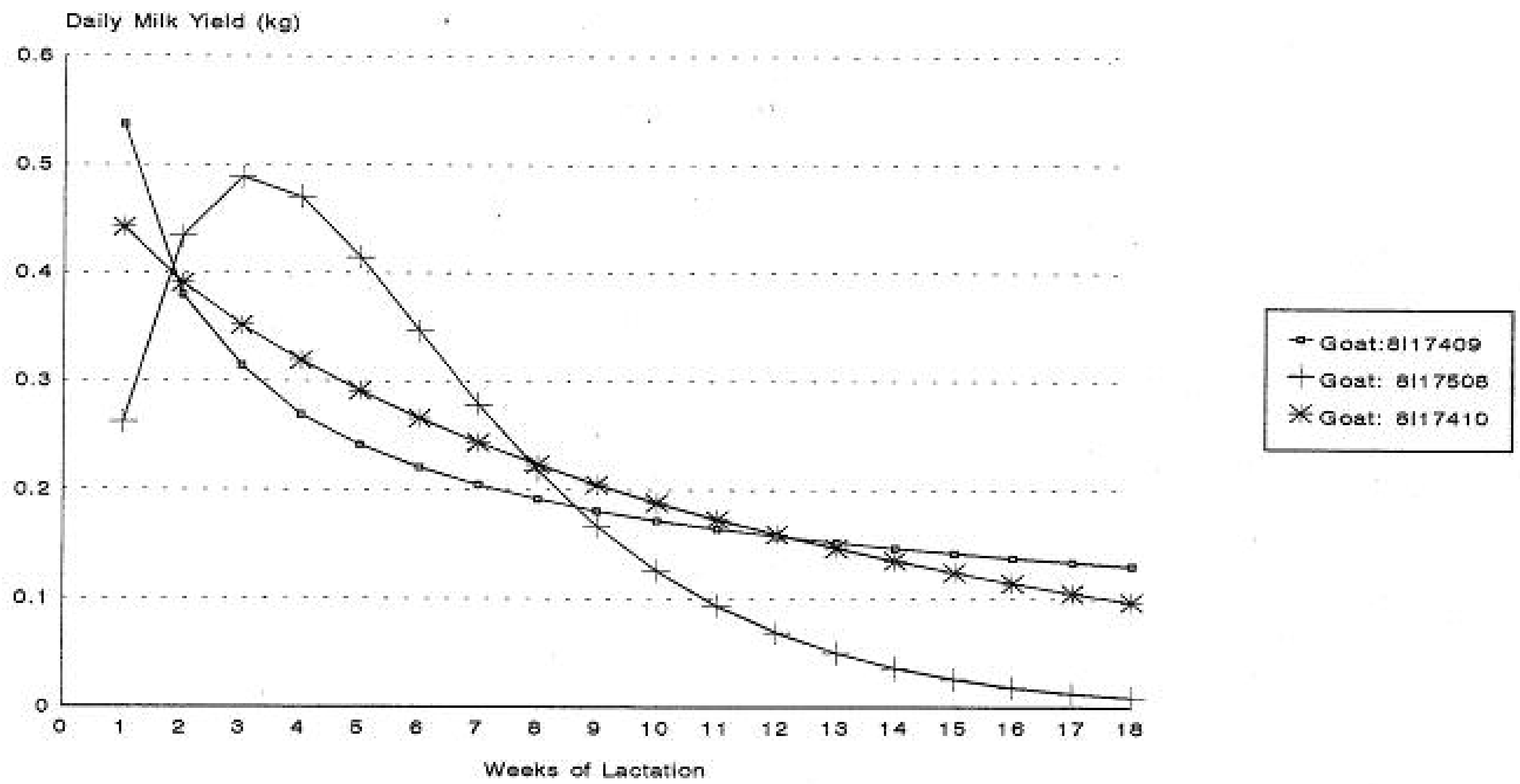


Figure G3: Goat Lactation Curves: Indigenous Goats: First Lactations
Curves derived from Wood Model



2.3 COMPOSITION CORRECTED MILK

The wide variation of milk composition analysis (as shown for example in Table L2) raised the question of the adequacy of comparing milk yields on the basis of litres of milk alone. The traditional system of correcting milk yields to a standard equivalent of 4% Fat Corrected Milk was originally used because milkfat was the only criterion measured at that time. Since routine milk recording analyses now also include protein and lactose percentages, additional composition corrected milk estimates were added to the list of criteria to be assessed in the analyses:

* Fat Corrected Milk (FCM) [corrected to 4%]
* Protein Corrected Milk (PCM) [corrected to 3%]
* Lactose Corrected Milk (LCM) [corrected to 4.5%]
* Fat, Protein, Lactose Corrected Milk (FPLCM) [corrected to 11.5%]

Summaries of these for lactation number and for breed are shown in Tables L9 to L12.
Full details of the corrected lactation yields are listed in Tables L13 to L31 (Appendix A).
Probably the most meaningful Tables are those which included data for the first three lactations for each breed: Tables L14 to L17 (Appendix A). Composition corrected yield estimates for Indigenous goats increased greatly because of the high percentage of nutrients in the milk. Those for Saanen goats decreased compared to the uncorrected milk yields, because Saanens generally had milk composition analyses lower than those used for the correction factors. In contrast, composition corrected yields for Crossbred and Three-quarter Saanen goats were increased, because their milk composition analyses were generally higher than those used for the correction factors. Nevertheless, even after correction for composition, yields of Saanens were still higher than those of Crossbreds and Three-quarter Saanens. Further details of statistical analyses of these lactations are shown in the subsequent Tables in the sections concerning correlations and multiple regression analyses.

2.3.1 COMPOSITION-CORRECTED MILK: Tables L9 to L12

Table L9: Fat Corrected Milk Yields of Goats: All Breeds; All Lactations
Table L10: Protein Corrected Milk Yields of Goats: All Breeds; All Lactations
Table L11: Lactose Corrected Milk Yields of Goats: All Breeds; All Lactations
Table L12: Fat-Protein-Lactose Corrected Milk Yields of Goats: All Breeds; All Lactations

[Note: Detailed Tables of Composition Corrected Milk Yields are shown in Appendix A].

Table L9: Fat Corrected Milk Yields of Goats (kg):
All Breeds: All Lactations.

Breed and Lactation	No.	Mean ± SE	Min.	Max.
Saanen 1	56	487 ± 116	215	770
2	48	716 ± 148	375	1130
3	28	644 ± 158	425	1030
4	15	643 ± 191	382	966
5	6	427 ± 115	254	558
Indigenous 1	19	53 ± 22	24	107
Crossbred 1	30	452 ± 133	256	923
2	24	612 ± 159	339	1022
3	12	593 ± 141	353	850
4	5	658 ± 208	495	913
Three-quarter Saanen 1	9	476 ± 147	291	730
2	5	542 ± 114	391	648
3	5	649 ± 198	407	894

Table L10: Protein Corrected Milk Yields of Goats (kg):
All Breeds: All Lactations.

Breed and Lactation	No.	Mean ± SE	Min.	Max.
Saanen 1	56	548 ± 127	297	850
2	48	801 ± 165	404	1284
3	28	721 ± 163	498	1166
4	15	717 ± 179	445	999
5	6	483 ± 107	282	602
Indigenous 1	19	43 ± 20	20	97
Crossbred 1	30	434 ± 111	261	826
2	24	573 ± 160	373	1086
3	12	559 ± 149	291	770
4	5	649 ± 295	398	1071
Three-quarter Saanen 1	9	461 ± 168	268	749
2	5	476 ± 103	333	560
3	5	570 ± 154	406	774

Table L11: Lactose Corrected Milk Yields of Goats (kg):
All Breeds: All Lactations.

Breed and Lactation	No.	Mean ± SE	Min.	Max.
Saanen 1	56	585 ± 132	334	883
2	48	836 ± 182	488	1376
3	28	745 ± 203	501	1278
4	15	743 ± 228	440	1129
5	6	489 ± 107	329	596
Indigenous 1	19	26 ± 15	9	63
Crossbred 1	30	357 ± 86	154	617
2	24	476 ± 128	287	810
3	12	467 ± 124	244	631
4	5	528 ± 229	337	865
Three- 1	9	402 ± 149	214	613
quarter 2	5	455 ± 114	314	578
Saanen 3	5	527 ± 123	378	707

Table L12: Fat-Protein-Lactose Corrected Milk Yields of Goats (kg):
All Breeds: All Lactations.

Breed and Lactation	No.	Mean ± SE	Min.	Max.
Saanen 1	56	541 ± 117	301	823
2	48	785 ± 156	454	1254
3	28	704 ± 169	482	1162
4	15	701 ± 197	421	1030
5	6	466 ± 103	290	584
Indigenous 1	19	40 ± 18	17	87
Crossbred 1	30	410 ± 106	220	778
2	24	549 ± 143	339	956
3	12	535 ± 134	294	714
4	5	605 ± 238	408	935
Three- 1	9	444 ± 152	255	689
quarter 2	5	491 ± 108	367	589
Saanen 3	5	581 ± 153	395	789

2.4 CORRELATIONS: LACTATION DATA

2.4.1 CORRELATIONS: Lactation Yields and Milk Composition

Tables C1.1 to C1.19 (See Appendix B) summarize the results of analyses carried out to assess the correlations between milk production per lactation and milk composition analysis for each breed and lactation number.

All Goats; All Breeds (Tables C1.1, C1.2)

Fat percent, protein percent and lactose percent were all highly significantly (P<0.0001) negatively related to milk yield, when all goats and breeds were included in the analyses. Fat percent was also significantly (P<0.0001) related to protein percent; and lactose percent was significantly (P<0.0001) related to protein percent, but less so (P<0.05) to fat percent. However, more detailed analyses within breeds showed that not all these broad relationships held true for all the analyses. For example, lactose percent was not significantly related to fat percent, when *only the first three lactations* of all goats were considered (Table C1.2). ***Saanen Goats*** (Tables C1.3 to C1.8)

Protein percent was significantly (P<0.0001) related to fat percent for first and second lactations of Saanens, was less significantly related in third and fourth lactations (P<0.01 and P<0.05 respectively), but not significantly for the small group of fifth lactations (six goats; Table C1.7). Milk fat percent was significantly (P<0.0001) negatively related to milk yield per lactation for the first lactations, was less significantly negatively related(P<0.05) for second and third lactations, but was not significantly related for fourth and fifth lactations. However, when the first three lactations were considered together, there was a significantly (P<0.01) negative relation between milkfat percent and lactation yield (Table C1.8). Protein percent was only significantly negatively related to milk yield per lactation for third and fourth lactations (P<0.01 and P<0.05 respectively) (Tables C1.5 and C1.6), but was clearly so (P<0.01) when the first three lactations were considered (Table C1.8).

Indigenous Goats (Tables C1.9 and C1.10)

The results of this group must be interpreted carefully, because of the short lactations and therefore the relatively small number of analyses carried out. Lactations were closely monitored in the first year, but in subsequent years they were sampled for yield and compositional quality at intervals. In addition, many of these further samplings gave distorted results for milkfat analyses, because the samples were frozen before analysis. The milkfat analyses were therefore excluded; but the protein and lactose percentages did not appear to be affected, and were included in the analyses.

Milkfat and protein percent were significantly (P<0.05) negatively related to milk yield per lactation, but lactose percent was positively related (P<0.01). Lactose percent was negatively related to fat and protein percent (P<0.05 and P<0.001 respectively). Fat and protein percent were significantly positively related to each other (P<0.01).

Crossbred Goats (Tables C1.11 to C1.15)

In contrast, Crossbred goats in first and second lactations had no significant correlations between the criteria considered, except for the positive correlation (P<0.01) between fat and protein percent in first lactations (Table C1.11). However, significant (P<0.05) negative correlations were observed in third and fourth lactations (Tables C1.13 and C1.14) between fat percent and milk production per lactation. The only significant (P<0.0001) correlation observed when the first three lactations were considered (Table C1.15) was between fat percent and protein percent. I have no explanation for the lower number of correlations between these criteria for Crossbred goats in comparison to those for Saanen goats.

Three-quarter Saanens (Tables C1.16 to C1.17)

Goat numbers were small for all three lactations. The only significant (P<0.05) negative correlation observed was between fat percent and milk production per lactation for first lactation goats; and a positive correlation (P<0.01) between fat percent and protein percent for the same group. This latter relationship (P<0.01) was also observed when data were analysed for all Three-quarter Saanens together (Table C1.19).

Summary

Most lactations showed a significant correlation (at least P<0.05) between fat percent and protein percent. A significantly (at least P<0.05) negative correlation between fat percent (and sometimes also between protein percent), and milk production per lactation was observed for Saanen goats and Indigenous goats; but not for Crossbreds and Three-quarter Saanens. There were no significant correlations between lactose percent and milk production per lactation, except for a positive (P<0.01) correlation for the Indigenous goats.

TABLES: CORRELATIONS: Lactation Yield and Milk Composition

(SEE APPENDIX B)

2.4.2 CORRELATIONS:

Composition Corrected Yield: Lactation Yield and Milk Composition

Tables C2.1 to C2.18 summarize the results of analyses carried out to assess the correlations between composition corrected milk and milk production per lactation and milk composition analysis for each breed and lactation number.

All Goats; All Breeds (Tables C2.1 and C2.2)

When all lactations, and the fat, protein and lactose percentages were grouped, then all measures of composition corrected milk were significantly ($P<0.001$) related to them, except for the relation between lactose percent and Fat Corrected Milk. The correlations were positive with milk production per lactation, and negative with fat, protein and lactose percent. The highest correlation (99%), was between milk yield per lactation and Lactose Corrected Milk (LCM), presumably because lactose was the component that varied the least. Fat Corrected Milk (FCM) had the lowest correlation with milk yield per lactation (84%), since fat percent was more variable than protein or lactose percent. The correlations with Protein Corrected Milk (PCM) were intermediate. Lactose percent had a negative correlation with composition-corrected milk, but it was not significant for FCM. However, more detailed analyses within breeds showed that not all these broad relationships held true for all the analyses.

Saanen Goats (Tables C2.3 to C2.8)

Milk Yield per lactation was significantly ($P<0.001$) positively related to all categories of composition corrected milk, except for the small sample of goats in fifth lactation (Table C2.7). Fat percent was significantly ($P<0.05$) correlated with FCM in the first and second lactation (Tables C2.3 and C2.4), but not in subsequent lactations. It was negatively correlated ($P<0.05$) with LCM in first lactations. Protein percent was significantly ($P<0.05$) positively correlated with FCM and PCM but only in first lactations (Table C2.3). It was negatively correlated ($P<0.05$) with LCM in third and fourth lactations, and in all three lactations when the data were grouped together (Table C2.8).

Indigenous Goats (Table C2.9)

Milk yield per lactation was significantly ($P<0.001$) positively correlated with all measures of composition corrected milk for Indigenous goats. Correlations ranged from 99% for LCM to 88% for FCM; a similar pattern to that observed for Saanen goats. Fat percent and protein percent were negatively ($P<0.05$) related to LCM. Lactose percent was positively ($P<0.05$) correlated to PCM, LCM and FPLCM.

Crossbred Goats (Tables C2.10 to C2.14)

Milk yield per lactation was significantly ($P<0.0001$) correlated with all categories of composition corrected milk in a similar way to the correlations for Saanen goats, but with a higher range of correlations (89% to 99%). Fat percent was significantly ($P<0.01$) correlated (*positively)*, with FCM, but only for first lactations (Table C2.10), although the same trend was apparent when the first three lactations were considered as a group. It was negatively ($P<0.05$) correlated to LCM, but only in the third and fourth lactations (Tables C2.12 and C2.13); and to PCM ($P<0.05$), but only for fourth lactations (Table C2.13). Protein percent and lactose percent were not significantly correlated with any of the composition corrected milk parameters.

Three-quarter Saanens (Tables C2.15 to C2.18)

Goat numbers were small for all three lactations, which may have affected the reliablilty of the estimates as representing Three-quarter Saanens in general. Milk yield per lactation was significantly ($P<0.05$) correlated with all composition corrected milk parameters, except for FCM in second lactations. The only significant ($P<0.05$) negative correlation observed was between fat percent and LCM, but only for first lactations (Table C2.15). Protein percent and lactose percent were not significantly correlated with any of the composition corrected milk parameters.

Summary

Milk yield per lactation was significantly ($P<0.05$) positively correlated with all measures of composition corrected milk for all but a few of the comparisons (which had a small number of goats in the group). Fat percent was significantly ($P<0.05$) correlated with FCM for some, but not all of the analyses. Fat percent was also correlated (negatively) ($P<0.05$) with LCM for some of the analyses. Protein percent was significantly ($P<0.05$)positively correlated with FCM and PCM but only in first lactations, and only for Saanen goats. It was negatively ($P<0.05$) correlated with LCM in third and fourth lactations, and in all three lactations when the data were grouped together, but again, only for Saanens.

TABLES: CORRELATIONS (C2):(SEE APPENDIX B)

2.4.3 CORRELATIONS: Composition Corrected Yield: Breed and Lactation Number

Tables C3.1 to C3.18 (see Appendix B) summarize the results of analyses carried out to assess the correlations between the different criteria of composition corrected milk; for the goat breeds and lactation numbers.

The correlations between different criteria of composition corrected milk (i.e. FCM; PCM; LCM; and FPLCM) were all significantly ($P<0.05$) correlated. The only exception was the small group of Saanen goats (five goats) in their fifth lactation.
The correlations varied from a low of 71.8% between LCM and FCM for Saanen goats in their first lactations (Table C3.3); to a high of 99.9% between PCM and LCM for Crossbred goats in their fourth lactations (five goats) (Table C3.13). Most correlations were over 90%. This would seem to imply that there were not many differences between the composition corrected milk criteria. However, there were some differences that were apparent from other analyses carried out. (See later: Multiple Regression Analyses).

TABLES: CORRELATIONS (C3)

(SEE APPENDIX B)

2.5 RESULTS: ANALYSIS OF LACTATION DATA:

2.5.1. Multiple Regression Analyses

INTRODUCTION

The SAS General Linear Models Procedure (SAS Institute 1989) was used to carry out Multiple Regression Analysis, and Analysis of Variance and Covariance. Analyses were carried out for the different sets of data:

* Total milk production per 300-day lactation
* Fat percent
* Protein percent
* Lactose percent
* Fat Corrected Milk (FCM)
* Protein Corrected Milk (PCM)
* Lactose Corrected Milk (LCM)
* Fat-Protein-Lactose Corrected Milk (FPLCM)

Within each item, analyses were done comparing selected criteria between breeds.
In general, comparisons were only made between first lactations; or between the data from Lactations 1,2 and 3.

First lactations were compared for two reasons:

* Indigenous goats had effective milk records only for the first lactation;
* First lactations are usually the primary standard of comparison between cows, such as for progeny testing, because other potentially complicating factors such as fertility management are avoided. Nevertheless, second and third lactations were also used in comparisons, to assess longer-term effects than those shown for first lactations only. The number of goats with records of the first three lactations was adequate for the tests, whereas records of fourth and fifth lactations were relatively few.

Multiple Regression Analysis is a technique where a mathematical model is derived to fit the data of the particular comparison. The Least-Square Means (LSM) calculated are specific to that particular comparison. (LSM tables have been included for some of the comparisons.) The model is then used to perform an Analysis of Variance and Covariance. A summary of the salient facts relating to the Analysis of Variance is included in the Table for each test. Details of the significance of interactions have also been tabulated for some of the comparisons.

The Analysis of Variance was done in two forms: Type I SS and Type III SS (Sum of Squares). The effects of Breed were significant ($P<0.05$) in nearly all cases of Type I SS tests. Type I SS analysis was the appropriate method for this test. The Type III SS tests were found to be unreliable when compared to the Type I tests, and often gave contradictory results.

Terminology

One aspect of the terminology used in the Tables requires clarification:

* "**Days**" refers to the number of days in a lactation, within the limitation of a 300-day lactation.
* "**Lactation Length**" refers to the actual lactation length, which may or may not be more than 300 days.

THE ANALYSES

The analyses carried out are listed in the Contents page for the Tables of this section, and are summarized in Tables A1.1 to A8.4.

Comments on the results follow according to the sub-headings listed above.

TOTAL MILK PRODUCTION (Tables A1.1 to A1.5)

These tests refer to total milk production per standard lactation.

Indigenous Goats: Lactation 1 (Table A1.1)

The only factor shown to affect total milk production per lactation for Indigenous goats in Lactation 1 was lactation length. The longer the lactation, the more milk was produced! (This was identical to Days of lactation for Indigenous goats, since all Indigenous goat lactations were short, and considerably less than 300 days).

Saanen and Indigenous Goats: Lactation 1 (Table A1.2)

The main factor was breed differences, but after that, Days of lactation was significant ($P<0.0001$), and there was a significant ($P<0.01$) interaction with breed. In other words, total milk production was dependant mostly upon breed, and length of the lactation; but Indigenous goats had much shorter lactations than Saanens.

Saanen and Crossbred Goats: Lactation 1 (Table A1.3)

The main factor was breed differences, but after that, Days of lactation was significant ($P<0.0001$), and there was a significant ($P<0.01$) interaction with breed. In other words, total milk production was dependant mostly upon breed, and length of the lactation; but Crossbred goats had shorter lactations than Saanens.

Saanen and Crossbred Goats: Lactations 1,2,3.

(Tables A1.4.1, A1.4.2)

Table A1.4.1 shows the Analysis of Variance. Table A1.4.2 shows the Least Square Means for the model used in analysis, and the significance of interactions. Note that the 5% level of significance for Table 1.4.2 (as shown beneath the Table) is different from the usual levels of probability because of the nature of the tests carried out.

Table A1.4.1 indicates that, in addition to breed effects, total milk production per lactation was significantly affected by lactation number, (with the highest yield in Lactation 2, as shown in

Table 1.4.2). There was a significant interaction between breed and lactation number. These relations are shown in detail in Table A1.4.2. Saanen first lactations were significantly less than second ($P<0.01$) and third ($P<0.05$) lactations. Saanen second lactations were not significantly different from third lactations (Table 1.4.2).

The only other interactions found ***not*** to be significant were between Saanen first lactation and second and third Crossbred lactations; and between Crossbred third lactations and Crossbred first and second lactations. This is probably due to the relatively low number of Crossbred third lactations included in this analysis.

Considering the results shown in Table A1.4.1, total milk production per lactation was dependant upon Days of lactation (i.e. within the standard 300 days length), but not upon actual lactation length (including production beyond the standard of 300 days). This is an anomaly that is difficult to explain. However, for each of these factors, there was a significant ($P<0.01$) interaction with breed. The number of kids was not significantly related to total milk production per lactation.

Saanen, Crossbred and Three-quarter Saanens: Lactation 1,2,3

(Tables A1.5.1 and A1.5.2)

The analyses shown in these Tables are similar to those of Tables A1.4.1 and A1.4.2 discussed above for Saanen and Crossbred goats. Table A1.5.1 shows the Analysis of Variance. In addition to the breed differences shown, total milk production per lactation was significantly related to lactation number, to lactation length and the number of kids born. It is not clear why the association between number of kids and total milk production should be significant ($P<0.001$) in this test, whereas it was not significant for the test reported in Table A1.4.1. The only suggestion could be that first lactations (lower yields) were associated with a lower rate of twinning when compared to subsequent lactations.

Table A1.5.2 shows the Least Square Means for the sample of data fitted to the mathematical model, and interactions between breed and lactation number. The significant ($P<0.05$) interactions between lactations of Saanen and Crossbred goats was the same as reported in Table A1.4.1 (but the size of the Table has meant that the level of significance was not measured as precisely). Apart from these interactions between Saanen and Crossbred goats, these results show that, although first lactations of pure Saanens were not significantly different from Three-quarter Saanen first, second or third lactations; second and third lactations of Saanens were significantly different ($P<0.05$) from all of them. No Crossbred lactations were found to be significantly ($P<0.05$) different from those of any of the groups of Three-quarter Saanens.

FAT PERCENT

These tests refer to the weighted mean fat percentage per lactation.

Indigenous Goats: Lactation 1 (Table A2.1)

Fat percent was found not to be significantly related to the factors considered (of which four are shown).

Saanen and Indigenous Goats: Lactation 1 (Table A2.2)

The difference in fat percent between Saanens and Indigenous goats in first lactation was highly significant ($P<0.001$).

Saanen and Crossbred Goats: Lactations 1,2,3. (Table A2.3)

Fat percent was significantly different ($P<0.001$) between Saanen and Crossbred goats. It is difficult to see how fat percent was related to lactation length itself, except that Crossbreds had shorter lactations than Saanens. The non-significance of the interaction between Days of lactation (within 300 days) is in contrast to the significance ($P<0.01$) when the actual length of lactations (i.e. beyond 300 days) was considered.

All Goats: Lactations 1,2,3. (Tables A2.4.1, A2.4.2 and A.2.4.3)

These Tables show the significant breed differences in fat percent. The Analysis of Variance result is shown in Table A2.4.1 and the Least Square Means are listed in Table A2.4.2 with the interactions between breeds. These indicate that all breeds were found to be significantly different ($P<0.01$); except that the fat percent of Crossbred goats was found ***not*** to be significantly different from that of Three-quarter Saanens. The significance ($P<0.01$) of lactation number shown in Table A2.4.1 is not a fair indication as a general statement, because of the varying numbers of lactations in each category for each breed. A further test (Table A2.4.3) showed no significant effect of lactation number when all lactations were considered.

PROTEIN PERCENT

These tests refer to the weighted mean protein percentage per lactation. Least Square Means for the model used in analysis are shown in Table A3.5.2.

Indigenous Goats: Lactation 1 (Table A3.1)

Protein percent was significantly ($P<0.05$) related to lactation length. It is difficult to explain this finding. The finding that there was a significant relation between protein percent and days to peak daily yield is also of dubious value. The sample of Indigenous goats was relatively small, the lactations were short, and the variation from day to day was small. In fact it was probably not valid to assign a particular day as representing the peak of lactation, because of the variable nature of the lactation curves for Indigenous goats in comparison to that shown by the milk goats: daily milk yield did not change much during the lactation. In addition, the opportunity for obtaining milk samples (at the usual interval of once a month) was limited because the lactations were short.

Saanen and Indigenous Goats: Lactation 1 (Table A3.2)

Breed differences in protein percent were found to be highly significant ($P<0.001$), as was expected. The significance with days to peak of lactation is again hard to explain, but the reasons discussed above are presumed to apply here as well.

Saanen and Crossbred Goats: Lactation 1 (Table A3.3)

Breed was the only factor found to influence protein percent ($P<0.001$) in this comparison.

Saanen and Crossbred Goats: Lactations 1,2,3. (Table A3.4)

This analysis also showed the significance ($P<0.001$) of breed differences in protein percent.

All Goats: Lactations 1,2,3. (Tables A3.5.1 and A3.5.2)

Again, breed difference was the main factor identified as being significant ($P<0.001$). The marginal level of significance ($P<0.05$) shown for days to peak yield should be interpreted as for the test reported in Table A3.1. The interaction analysis in Table A3.5.2 shows that the differences were significant ($P<0.01$) between all breeds.

LACTOSE PERCENT

These tests refer to the weighted mean lactose percentage per lactation.

Indigenous Goats: Lactation 1 (Table A4.1)

Lactose percent was significantly (P<0.01) related to length of lactation. As with protein percent, it is difficult to explain this finding. The same reasons as those proposed above apply in this case as well.

Saanen and Indigenous Goats: Lactation 1

(Tables A4.2.1 and A4.2.2)

Breed differences were not shown to be significant according to the Type I SS analysis. This was even though Saanen lactations were much longer than those of Indigenous goats, and a significant (P<0.01) relation was found between lactose percent and lactation length for Indigenous goats. There was also a significant (P<0.05) breed x lactation length interaction. It is difficult to explain such findings. Perhaps an error was made. Table A4.2.2 shows the Least Square Means for the model used in this comparison.

Saanen and Crossbred Goats: Lactation 1

(Tables A4.3.1 and A4.3.2)

These analyses show the significant (P<0.001) breed differences in lactose percent between Saanen and Crossbred goats for the first lactation.

Saanen and Crossbred Goats: Lactations 1,2,3.

(Tables A 4.4.1 and A4.4.2)

Breed differences were highly significant (P<0.001) in this comparison. The analysis of the interactions in Table A4.3.2 shows *no* significant differences between lactose percent of Saanen lactations 1, 2 or 3. However they were significantly (P<0.01) different with those of all Crossbred lactations. Similarly, the differences between Crossbred lactations were not significant.

Saanen, Crossbred and Three-quarter Saanens: Lactations 1,2,3.

(Tables A4.5.1 and A4.5.2)

Breed differences were the main factors found to be significant (P<0.001) in affecting lactose percent in this larger group of lactations. No significant interaction was shown between Days of lactation (within 300 days) and Breed; but there was a significant (P<0.05) interaction between breed and days dry. Lactose percent of Saanen goats was significantly (P<0.001) different from that of Crossbreds and Three-quarter Saanens. However, no significant difference was apparent between Crossbreds and Three-quarter Saanens (Table A4.5.2).

FAT CORRECTED MILK (FCM)

FCM refers to 4% Fat Corrected Milk per lactation.

Indigenous Goats: Lactation 1 (Table A5.1)

FCM was significantly ($P<0.01$) related to lactation length. As with total milk production, the longer the lactation, the more FCM was produced. These lactations were short in comparison to those of all other breeds of goats studied.

Saanen and Indigenous Goats: Lactation 1 (Tables A5.2.1 and A5.2.2)

In this comparison, FCM was significantly ($P<0.001$) related to breed and lactation length. The Least Square Means for the model used in this analysis are shown in Table A5.2.2.

Saanen and Crossbred Goats: Lactations 1,2,3. (Tables A5.3.1 and A5.3.2)

FCM was significantly different according to breed ($P<0.01$), lactation number ($P<0.001$), number of kids born ($P<0.05$), and lactation length ($P<0.01$). In addition, there was a significant ($P<0.05$) interaction between breed and lactation length. The Least Square Means for the model used in this analysis are shown in Table A5.3.2.

Saanen, Crossbred and Three-quarter Saanens: Lactations 1,2,3.

(Tables A5.4.1 and A5.4.2)

This test was similar to that shown in Table A5.3.1, but with the addition of Three-quarter Saanens. FCM was significantly affected by breed ($P<0.05$), lactation number ($P<0.001$) and lactation length ($P<0.01$). There was a significant ($P<0.001$) interaction between breed and lactation length. The Least Square Means for the model used in this analysis are shown in Table A5.4.2.

PROTEIN CORRECTED MILK (PCM)

PCM refers to 3% Protein Corrected Milk per lactation.

Indigenous Goats: Lactation 1(Table A6.1)

PCM was significantly ($P<0.001$) related to lactation length.

Saanen and Indigenous Goats: Lactation 1 (Tables A6.2.1 and A6.2.2)

In this comparison, PCM was significantly (P<0.001) affected by breed, and related (P<0.001) to Days of lactation (within 300 days), but not to lactation length. However, there was a significant (P<0.01) interaction between breed and lactation length. Least Square Means for the model used in this analysis are shown in Table A6.2.2.

Saanen and Crossbred Goats: Lactation 1 (Tables A6.3.1 and A6.3.2)

In this analysis, PCM was shown to be significantly (P<0.001) affected by breed. The other factor having a significant effect was Days of lactation (within the 300 day standard lactation length); but actual lactation length was not significant.

Saanen and Crossbred Goats: Lactation 1,2,3

(Tables A6.4.1, A6.4.2 and A6.4.3)

The results reported in Table A6.4.1 showed significant (P<0.001) differences of PCM according to breed, lactation number and lactation length. There was a significant (P<0.001) interaction of breed and lactation length, related to the fact that Crossbreds had shorter lactations than Saanens. When the lactations were considered across all parities (lactation number), the Saanens were not shown to be significantly different from the Crossbreds. (This is an apparent contradiction of the result in Table A6.4.1, but may have arisen because of the unequal numbers of goats in in the first, second or third lactation groups for each breed. The interactions of lactation number are shown in Table A6.4.3 (without taking breed into account). First lactations were significantly (P<0.05) different from second and third lactations; but second lactations were not significantly different from third lactations.

Saanen, Crossbred and Three-quarter Saanens: Lactations 1,2,3.

(Tables A6.5.1 and A6.5.2)

The Analysis of Variance in Table A6.5.1 shows that breed, lactation number, days in milk and lactation length were all significantly (P<0.001) related to PCM. There were significant (P<0.001) interactions between breed and lactation number, breed and lactation length, but not breed and days of lactation (within 300 days). The interactions between breed and lactation number are shown in Table A6.5.2, with the Least Square Means calculated for the model used in the analysis. This Table should be compared to Table A1.5.2, the comparison for total milk production per lactation (uncorrected). The correction to PCM had a number of effects in the significant relations identified.

Saanen first lactations were significantly ($P<0.05$) different from second and third lactations. Saanen second lactations were not significantly different from Saanen third lactations. (These results were no different from the tests in Table A1.5.2). In contrast, whereas Saanen first lactations were significantly different from Crossbred first lactations in Table A1.5.2, this was not the case in this comparison; instead the difference here was with Crossbred second lactations. Similarly, in this Table comparing PCM, Saanen second lactations were significantly ($P<0.05$) different from Crossbred first lactations, and from all Three-quarter Saanen lactations, but not from Crossbred second and third lactations. Saanen third lactations were shown to be significantly different from Crossbred and Three-quarter Saanen first lactations, but not from the second or third lactations of these other breeds. (This was a change from the data shown in Table A1.5.2). Crossbred first lactations were significantly different ($P<0.05$) from Crossbred second lactations, but not from Crossbred third lactations.

LACTOSE CORRECTED MILK (LCM)

LCM refers to 4.5% Lactose Corrected Milk per lactation.

Indigenous Goats: Lactation 1 (Table A7.1)

LCM was significantly ($P<0.001$) related to lactation length. LCM increased significantly ($P<0.001$) as the length of lactation increased.

Saanen and Indigenous Goats: Lactation 1 (Table A7.2)

LCM was shown to be significantly ($P<0.001$) affected by breed and Days in milk (within the standard 300 day lactation), and there was a significant ($P<0.01$) interaction between Days and breed.

Saanen and Crossbred Goats: Lactations 1,2,3 (Table A7.3)

This analysis showed a significant ($P<0.001$) effect of breed, lactation number and Days of lactation, with significant ($P<0.001$) breed interactions for these factors.

Saanen, Crossbred and Three-quarter Saanens: Lactations 1,2,3.

(Tables A7.4.1 and A7.4.2)

Significant ($P<0.001$) effects were identified for all the parameters included (Table A7.4.1). This analysis should be compared to that for total milk production per lactation (uncorrected) (Table A1.5.2). The only *difference* in the factors found to be significant were in the relation between Saanen third lactations and Crossbred second and third lactations. For these factors, the relationship was significantly different ($P<0.05$; Table A1.5.2) in the case of uncorrected lactation yield, whereas the differences were not significantly different for LCM. In addition, no significant difference was found between first and third lactation LCM yields for Saanens. The fact that there were very few differences as shown in these two Tables, is probably because lactose did not vary as much as the other milk composition components analysed.

FAT-PROTEIN-LACTOSE CORRECTED MILK (FPLCM)

FPLCM refers to milk production per lactation corrected to 4% for fat, 3% for protein and 4.5% for lactose.

Indigenous Goats: Lactation 1(Table A8.1)

FPLCM was significantly ($P<0.001$) related to lactation length. As with the other measures of milk production per lactation, the longer the lactation, the more milk produced.

Saanen and Indigenous Goats: Lactation 1 (Table A8.2)

FPLCM was shown to be significantly ($P<0.001$) affected by breed, and Days in milk (within the standard 300 day lactation), and there was a significant ($P<0.01$) interaction between lactation length and breed. Indigenous goats had much shorter lactations than Saanens. Why the test should show the relation of FPLCM to lactation length (actual) to be non-significant is inexplicable, since the lactations of all Indigenous goats were short and therefore identical with Days of lactation (shown to be significantly ($P<0.001$) different between the breeds). Perhaps there was an error in the analysis.

Saanen and Crossbred Goats: Lactations 1,2,3 (Table A8.3)

This analysis showed a significant ($P<0.001$) effect of breed, lactation number and Days of lactation, with no significant breed interaction identified.

Saanen, Crossbred and Three-quarter Saanens: Lactations 1,2,3.

(Tables A8.4.1 and A8.4.2)

Significant ($P<0.001$) effects were identified for breed, lactation number, Days of lactation, and Number of kids ($P<0.01$). The interaction between breed and lactation number was significant ($P<0.01$), as was the interaction between breed and lactation length ($P<0.001$). The anomaly of a non-significant effect of lactation length, whereas the effect of Days of lactation was significant ($P<0.001$) was apparent in this test also. (See comments above concerning Table 8.1). This analysis should be compared to that for total milk production per lactation (uncorrected) (Table A1.5.2).

The process of correcting milk yield for all three factors (to FPLCM) changed the significance of relationships for many parameters. Saanen first lactations were significantly different from Saanen second ($P<0.01$) and third ($P<0.05$) lactations (as before), but were not found to be significantly different from any of the Crossbred or Three-quarter Saanen lactations. Saanen second lactations were only significantly ($P<0.01$) different from Crossbred first lactations, and from Three-quarter Saanen first and second lactations. Saanen third lactations were only significantly ($P<0.01$) different from Crossbred first lactations. Crossbred first lactations were only significantly ($P<0.01$) different from Crossbred second lactations. It must be borne in mind that there were relatively few third Crossbred lactations, and relatively few Three-quarter Saanen lactations compared to the other categories, and this could have had an effect on the results of the analyses.

2.5.2 Tables of Multiple Regression Analyses

CONTENTS

Tables of Multiple Regression Analyses

A1. TOTAL MILK PRODUCTION

Table A1.1: Total Milk Production: Indigenous Goats: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Lact. Length	1	82.1776	82.1776	257.11	0.0001	***

Table A1.2 Total Milk Production: Saanen and Indigenous: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	1058.1109	1058.1109	1480.64	0.0001	***
Days	1	15.6827	15.6827	21.95	0.0001	***
Days x Breed	1	8.0054	8.0054	11.20	0.0013	**

Table A1.3: Total Milk production: Saanen and Crossbred: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	228.9042	228.9042	210.18	0.0001	***
Days	1	64.3106	64.3106	59.05	0.0001	***
Days x Breed	1	7.6996	7.6996	7.07	0.0085	**

Table A1.4.1: Total Milk Production: Saanen and Crossbred: Lactations 1,2,3
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	228.9042	228.9042	340.02	0.0001	***
Lactation No.	2	79.8478	39.9239	59.30	0.0001	***
Breed x Lact. No.	2	10.6443	5.3222	7.91	0.0005	***
Days	1	10.3639	10.3639	15.39	0.0001	***
Days x Breed	1	43.4600	43.4600	64.56	0.0001	***
No. of Kids	1	2.5961	2.5961	3.86	0.0511	NS
Lact. Length	1	0.1782	0.1782	0.26	0.6075	NS
Lact. Length x Breed	1	6.5715	6.5715	9.76	0.0021	**

Table A1.4.2: Total Milk Production: Saanen and Crossbred: Lactations 1,2,3
Interaction between breed and lactation number:[Test: Ho: LSMEAN(i)=LSMEAN(j)]

			Saanen		Crossbred		
Breed	Lact	LSM	Lact 2	Lact 3	Lact 1	Lact 2	Lact 3
Saanen	1	559.7	-7.852 0.0001 **	-3.221 0.0015 *	6.216 0.0001 **	2.111 0.0362 NS	2.159 0.0322 NS
	2	779.0	-	2.024 0.0445 NS	11.901 0.0001 **	8.169 0.0001 **	7.404 0.0001 **
	3	691.7	-	-	6.677 0.0001 **	4.313 0.0001 **	4.240 0.0001 **
Cross-bred	1	406.8	-	-	-	-3.419 0.0008 *	-2.126 0.0349 NS
	2	496.9	-	-	-	-	0.427 0.6697 NS
	3	481.1	-	-	-	-	-

[Note: 5% level of significance is at P <0.05 ÷ (5x6) = 0.0017]

Table A1.5.1: Total Milk Production: Saanen, Crossbred, Three-quarter Saanen: Lactations 1,2,3
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	2	238.7049	119.3525	183.67	0.0001	***
Lactation No.	2	85.6438	42.8219	65.90	0.0001	***
Breed x Lact. No.	4	12.6557	3.1639	4.87	0.0009	***
No. of Kids	1	10.4789	10.4789	16.13	0.0001	***
Days	1	55.0484	55.0484	84.71	0.0001	***
Days x Breed	2	2.7943	1.3971	2.15	0.1192	NS
Lact. Length	1	0.2722	0.2722	0.42	0.5183	NS
Breed x Lact. Length	2	6.6902	3.3451	5.15	0.0066	**

Table A1.5.2: Total Milk Production: Saanen, Crossbred, Three-quarter Saanen: Lactations 1,2,3
Interaction between breed and lactation number:[Test: Ho: LSMEAN(i)=LSMEAN(j)]

			Saanen		Crossbred			Three-quarter Saanen		
Breed	Lact	LSM	Lact 2	Lact 3	Lact 1	Lact 2	Lact 3	Lact 1	Lact 2	Lact 3
Saanen	1	551.6	-8.050 0.0001 *	-3.308 0.0005 *	5.941 0.0001 *	1.870 0.0629 NS	1.967 0.0507 NS	2.936 0.0037 NS	2.308 0.0220 NS	1.763 0.0795 NS
	2	772.1	-	2.062 0.0405 NS	11.761 0.0001 *	8.006 0.0001 *	7.282 0.0001 *	7.018 0.0001 *	6.691 0.0001 *	5.836 0.0001 *
	3	684.7	-	-	6.637 0.0001 *	4.224 0.0001 *	4.160 0.0001 *	4.627 0.0001 *	4.228 0.0001 *	3.674 0.0003 *
Cross-bred	1	404.8	-	-	-	-3.523 0.0005 *	-2.202 0.0289 NS	-0.234 0.8153 NS	-0.896 0.3715 NS	-1.211 0.2273 NS
	2	496.0	-	-	-	-	0.429 0.6684 NS	1.576 0.1167 NS	1.026 0.3060 NS	0.584 0.5597 NS
	3	480.3	-	-	-	-	-	1.172 0.2426 NS	0.648 0.5176 NS	0.266 0.7904 NS
Three-quarter Saanen	1	416.0	-	-	-	-	-	-	-0.501 0.6168 NS	-0.784 0.4341 NS
	2	446.4	-	-	-	-	-	-	-	-0.292 0.7705 NS
	3	465.3	-	-	-	-	-	-	-	-

[Note: 5% significance level is at P <0.05 ÷ (9x8) = 0.0006]

A2. FAT PERCENT

Table A2.1: Fat percent: Indigenous goats: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Days	1	3.8305	3.8305	4.49	0.0525	NS
Days to Peak Yield	1	0.3677	0.3677	0.43	0.5222	NS
Lact. Length	1	0.7137	0.7137	0.84	0.3759	NS
Age at Kidding	1	1.1411	1.1411	1.34	0.2669	NS

Table A2.2: Fat percent: Saanen and Indigenous: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	173.1589	173.1589	173.16	0.0001	***

Table A2.3: Fat percent: Saanen and Crossbred: Lactations 1,2,3
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	405.1691	405.1691	428.82	0.0001	***
Days	1	0.7488	0.7488	0.79	0.3745	NS
Lact. Length	1	8.3467	8.3467	8.83	0.0034	**

Table A2.4.1: Fat Percent: All Goats: Lactations 1,2,3
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	3	661.9027	220.6342	222.58	0.0001	***
Lactation No.	2	13.6740	6.8370	6.90	0.0012	**

Table A2.4.2: Fat Percent: All Goats: Lactations 1,2,3
Breed Interactions:[Test: Ho: LSMEAN(i)=LSMEAN(j)]

	LSM (fat %)	Indigenous	Crossbred	Three-quarter Saanen
Saanen	3.46	-16.0151 0.0001 **	-20.1248 0.0001 **	-10.6505 0.0001 **
Indigenous	9.45	-	10.4667 0.0001 **	10.8353 0.0001 **
Crossbred	5.47	-	-	1.9787 0.0491 NS
Three-quarter Saanen	5.13	-	-	-

[Note: 5% level of significance is at P < 0.05 ÷ (4x3) = 0.004]

Table A2.4.3: Fat Percent: All Goats: Lactations 1,2,3
Interactions of Lactation No.:[Test: Ho: LSMEAN(i)=LSMEAN(j)]

	Lact. 2	Lact. 3
Lact. 1	-0.5089 0.6113 NS	-1.1618 0.2466 NS
Lact. 2		-0.7253 0.4690 NS

[Note: 5% level of significance is at P < 0.05 ÷ (3x2) = 0.008]

A3. PROTEIN PERCENT

Table A3.1 Protein Percent: Indigenous goats: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Lact. Length	1	3.7547	3.7547	6.34	0.0228	*
Days to Peak Yield	1	2.9949	2.9949	5.06	0.0390	*

Table A3.2: Protein Percent: Saanen and Indigenous: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	224.5461	224.5461	282.05	0.0001	***
Lact. Length	1	0.0174	0.0174	0.02	0.8828	NS
Breed x Lact. Length	1	3.9336	3.9336	4.94	0.0295	*
Days to Peak Yield	1	10.0946	10.0946	12.68	0.0007	***
Breed x Days to Peak	1	2.2462	2.2462	2.82	0.0975	NS

Table A3.3: Protein Percent: Saanen and Crossbred: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	427.3342	427.3342	436.73	0.0001	***
Lact. Length	1	0.8924	0.8924	0.91	0.3409	NS
Breed x Lact. Length	1	0.8138	0.8138	0.19	0.6653	NS
Days to Peak Yield	1	2.7545	2.7545	2.81	0.0951	NS
Breed x Days to peak	1	2.5996	2.5966	2.66	0.1049	NS

Table A3.4: Protein Percent: Saanen and Crossbred: Lactations 1,2,3
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	427.3342	427.3342	430.64	0.0001	***

Table A3.5.1: Protein Percent: All Goats: Lactations 1,2,3
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	3	592.1899	197.3966	204.37	0.0001	***
Days to peak Yield	1	3.8385	3.8385	3.97	0.0475	*
Breed x Days to Peak	3	6.2741	2.0914	2.17	0.0931	NS

Table A3.5.2: Protein Percent: All Goats: Lactations 1,2,3
Breed Interactions:[Test: Ho: LSMEAN(i)=LSMEAN(j)]

	LSM (%)	Indigenous	Crossbred	Three-quarter Saanen
Saanen	2.88	-5.2272 0.0001 **	-21.1506 0.0001 **	-6.1887 0.0001 **
Indigenous	6.90	-	3.9531 0.0001 **	4.5681 0.0001 **
Crossbred	3.85	-	-	5.9383 0.0001 **
Three-quarter Saanen	3.37	-	-	-

[Note: 5% level of significance is at P < 0.05 ÷ (4x3) = 0.004]

A4. LACTOSE PERCENT

Table A4.1: Lactose Percent: Indigenous goats: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Lact. Length	1	1.6619	1.6619	15.05	0.0012	**

Table A4.2.1: Lactose Percent: Saanen and Indigenous: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	0.4969	0.4969	0.57	0.4519	NS
Days	1	0.1844	0.1844	0.21	0.6464	NS
Breed x Days	1	6.0162	6.0162	6.93	0.0104	*

Table A4.2.2: Lactose Percent: Saanen and Indigenous: Lactation 1: Least-square Means

	Least-square Means (Lactose %)
Saanen	4.52
Indigenous	4.80

Table A4.3.1: Lactose Percent: Saanen and Crossbred: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	100.4007	100.4007	97.46	0.0001	***
Days	1	0.3180	0.3180	0.31	0.5792	NS
Breed x Days	1	0.0001	0.0001	0.00	0.9921	NS

Table A4.3.2: Lactose Percent: Saanen and Crossbred: Lactation 1
Breed Interactions:[Test: Ho: LSMEAN(i)=LSMEAN(j)]

	Lactose LSMEAN (milkfat %)	TEST
Saanen	4.52	-8.203 0.0001 ***
Crossbred	4.80	-

Table A4.4.1: Lactose Percent: Saanen and Crossbred: Lactations 1,2,3
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	100.4007	100.4007	98.38	0.0001	***

Table A4.4.2: Lactose Percent: Saanen and Crossbred: Lactations 1,2,3
Breed and Lactation Number Interactions:[Test: Ho: LSMEAN(i)=LSMEAN(j)]

			Saanen		Crossbred		
Breed	Lact	LSM	Lact 2	Lact 3	Lact 1	Lact 2	Lact 3
Saanen	1	4.54	1.103 0.2715 NS	1.969 0.0506 NS	-4.494 0.0001 **	-4.393 0.0001 **	-4.415 0.0001 **
	2	4.49	-	0.921 0.3585 NS	-5.217 0.0001 **	-4.562 0.0001 **	-4.921 0.0001 **
	3	4.43	-	-	-5.671 0.0001 **	-5.383 0.0001 **	-5.253 0.0001 **
Cross-bred	1	4.82	-	-	-	-0.095 0.9242 NS	0.109 0.9134 NS
	2	4.83	-	-	-	-	0.219 0.8272 NS
	3	4.81	-	-	-	-	-

[Note: 5% level of significance is at P < 0.05 ÷ (5x6) = 0.0017]

Table A4.5.1: Lactose Percent: Saanen, Crossbred, Three-quarter Saanen: Lactations 1,2,3
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	2	77.1371	38.5685	41.88	0.0001	***
Days x Breed	3	4.3148	1.4383	1.56	2.2037	NS
Dry Days x Breed	3	10.7065	3.5689	3.88	0.0116	*

Table A4.5.2: Lactose Percent: Saanen, Crossbred, Three-quarter Saanen: Lactations 1,2,3
Breed Interactions:[Test: Ho: LSMEAN(i)=LSMEAN(j)]

	LSM	Crossbred	Three-quarter Saanen
Saanen	4.47	-7.1167 0.0001 ***	-6.1723 0.0001 ***
Crossbred	4.78	-	0.2030 0.8396 NS
Three-quarter Saanen	4.77	-	-

[Note: 5% level of significance is at P < 0.05 ÷ (2x3) = 0.008]

A5. FAT CORRECTED MILK (FCM)

Table A5.1: Fat Corrected Milk: Indigenous goats: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Days in milk	1	57971.4199	57971.4199	314.72	0.0012	**

Table A5.2.1: Fat Corrected Milk: Saanen and Indigenous: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	714.4844	714.4844	869.15	0.0001	***
Days	1	13.8125	13.8125	16.80	0.0001	***

Table A5.2.2: Fat Corrected Milk: Saanen and Indigenous: Lactation 1: Least Square Means
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

	Least Square Means (FCM)
Saanen	462.4
Indigenous	124.9

Table A5.3.1: Fat Corrected Milk: Saanen and Crossbred: Lactations 1,2,3
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	5.9734	5.9734	7.78	0.0059	**
Lactation No.	2	89.6040	44.8020	58.36	0.0001	***
No. of Kids	1	4.0163	4.0163	5.23	0.0234	*
Days	1	34.3268	34.3268	44.72	0.0001	***
Lact. Length	1	5.3485	5.3485	6.97	0.0090	**
Breed x Lact Length	1	3.2936	3.2936	4.29	0.0398	*

Table A5.3.2: Fat Corrected Milk: Saanen and Crossbred: Lactations 1,2,3: Least Square Means
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

	Least Square Means (FCM)
Saanen Crossbred	588.3 627.8
Lactation 1 2 3	515.6 685.3 623.3

Table A5.4.1: Fat Corrected Milk: Saanen, Crossbred, Three-quarter Saanen: Lactations 1,2,3
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	2	6.6599	3.3299	4.59	0.0113	*
Lactation No.	2	88.5714	44.2857	61.03	0.0001	***
Breed x Days	3	46.7543	15.5848	21.48	0.0001	***
Lact. Length	1	5.2088	5.2088	7.18	0.0080	**
Breed x Lact. Length	2	10.9012	5.4506	7.51	0.0007	***

Table A5.4.2: Fat Corrected Milk: Saanen, Crossbred, Three-quarter Saanen: Lactations 1,2,3:
Least Square Means
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

	Least Square Means (FCM)
Saanen Crossbred Three-quarter Saanen	579.8 654.7 553.1
Lactation 1 2 3	495.0 671.8 620.8

A6. PROTEIN CORRECTED MILK (PCM)

Table A6.1: Protein Corrected Milk: Indigenous goats: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Lact. Length	1	4458.2768	4456.2768	31.22	0.0001	***

Table A6.2.1: Protein Corrected Milk: Saanen and Indigenous: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	824.7700	824.7700	1107.46	0.0001	***
Days	1	14.5208	14.5208	19.50	0.0001	***
Lact. Length	1	0.1638	0.1638	0.22	0.6405	NS
Breed x Lact. Length	1	6.1833	6.1833	8.30	0.0053	**

Table A6.2.2: Protein Corrected Milk: Saanen and Indigenous: Lactation 1: Least Square Means
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

	Least Square Means (PCM)
Saanen Indigenous	428.3 92.0

Table A6.3.1: Protein Corrected Milk: Saanen and Crossbred: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	59.1757	59.1757	51.54	0.0001	***
Days	1	52.4052	52.4052	45.64	0.0001	***
Lact.Length	1	8.1056	8.1056	7.06	0.0086	**
Breed x Lact.Length	1	0.4196	0.4196	0.37	0.5463	NS

Table A6.3.2: Protein Corrected Milk: Saanen and Crossbred: Lactation 1
Breed Interactions:[Test: Ho: LSMEAN(i)=LSMEAN(j)]

	PCM LSMEAN (kg)	TEST
Saanen	612.9	1.92723 0.0555 NS
Crossbred	558.1	-

Table A6.4.1: Protein Corrected Milk: Saanen and Crossbred: Lactations 1,2,3
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	59.1757	59.1757	71.04	0.0001	***
Lactation No.	2	81.7335	40.8668	49.06	0.0001	***
Lact. Length	1	18.4164	18.4164	22.11	0.0001	***
Breed x Lact Length	1	18.0354	18.0354	21.65	0.0001	***

Table A6.4.2: Protein Corrected Milk: Saanen and Crossbred: Lactations 1,2,3
Breed Interactions: [Test: Ho: LSMEAN(i)=LSMEAN(j)]

	LSM (PCM) (kg)	Crossbred
Saanen	668.2	2.1831 0.0303 NS
Crossbred	615.4	-

[Note: 5% level of significance is at P < 0.05 ÷ (1x2) = 0.025]

Table A6.4.3: Protein Corrected Milk: Saanen and Crossbred: Lactations 1,2,3
Lactation Number Interactions: [Test: Ho: LSMEAN(i)=LSMEAN(j)]

	LSM (PCM)(kg)	Lact. 2	Lact. 3
Lact. 1	536.9	-8.732 0.0001 *	-4.070 0.0001 *
Lact. 2	734.8	-	2.570 0.0110 NS
Lact. 3	653.8	-	-

[Note: 5% level of significance is at P < 0.05 ÷ (2x3) = 0.008]

Table A6.5.1: Protein Corrected Milk: Saanen, Crossbred, Three-quarter Saanen: Lactations 1,2,3
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	2	66.0152	33.0076	47.07	0.0001	***
Lactation No.	2	76.2043	38.1022	54.34	0.0001	***
Breed x Lact. No.	4	13.9458	3.4865	4.97	0.0008	***
Days	1	45.9906	45.9906	65.59	0.0001	***
Breed x Days	2	1.2089	0.6044	0.86	0.4240	NS
Lact. Length	1	1.0847	1.0847	1.55	0.2151	NS
Breed x Lact. Length	2	13.8906	6.9453	9.90	0.0001	***

Table A6.5.2: Protein Corrected Milk: Saanen, Crossbred, Three-quarter Saanen: Lactations 1,2,3
Breed and Lactation Number Interactions:[Test: Ho: LSMEAN(i)=LSMEAN(j)]

			Saanen		Crossbred			Three-quarter Saanen		
Breed	Lact	LSM	Lact 2	Lact 3	Lact 1	Lact 2	Lact 3	Lact 1	Lact 2	Lact 3
Saanen	1	524.0	-8.672 0.0001 *	-4.290 0.0001 *	-0.393 0.6948 NS	-3.865 0.0002 *	-2.643 0.0089 NS	1.049 0.2955 NS	0.027 0.9787 NS	0.592 0.5548 NS
	2	752.8	-	2.413 0.0168 NS	6.740 0.0001 *	2.066 0.0402 NS	2.333 0.0207 NS	5.334 0.0001 *	4.972 0.0001 *	3.803 0.0002 *
	3	666.7	-	-	3.519 0.0005 *	-0.033 0.9739 NS	0.488 0.6264 NS	3.481 0.0006 *	2.878 0.0045 NS	2.499 0.0133 NS
Cross-bred	1	534.8	-	-	-	-3.904 0.0001 *	-2.436 0.0158 NS	1.201 0.2314 NS	0.259 0.7958 NS	0.728 0.4678 NS
	2	668.1	-	-	-	-	0.529 0.5977 NS	3.370 0.0009 NS	2.766 0.0062 *	2.460 0.0148 NS
	3	641.7	-	-	-	-	-	2.691 0.0078 NS	2.052 0.0415 NS	2.005 0.0464 NS
Three-quarter Saanen	1	471.8	-	-	-	-	-	-	-0.830 0.4073 NS	-0.144 0.8856 NS
	2	522.9	-	-	-	-	-	-	-	0.487 0.6268 NS
	3	483.4	-	-	-	-	-	-	-	-

[Note: 5% level of significance is at P < 0.05 ÷ (9x8) = 0.0006]

A7. LACTOSE CORRECTED MILK (LCM)

Table A7.1: Lactose Corrected Milk: Indigenous goats: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Lact. Length	1	2465.6726	2465.6726	28.13	0.0001	***

Table A7.2: Lactose Corrected Milk: Saanen and Indigenous: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	972.6140	972.6140	1322.87	0.0001	***
Days	1	13.4043	13.4043	18.23	0.0001	***
Lact. Length	1	0.0898	0.0898	0.12	0.7277	NS
Breed x Lact. Length	1	8.0398	8.0398	10.94	0.0015	**

Table A7.3: Lactose Corrected Milk: Saanen and Crossbred: Lactations 1,2,3
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	204.2540	204.2540	271.81	0.0001	***
Lactation No.	2	69.0132	34.5066	45.92	0.0001	***
Breed x Lact. No.	2	10.7274	5.3637	7.14	0.0010	***
Days	1	33.5399	33.5399	44.63	0.0001	***
Breed x Days	1	2.1525	2.1525	2.86	0.0923	NS
Lact. Length	1	0.0580	0.0580	0.08	0.7816	NS
Breed x Lact. Length	1	11.4962	11.4962	15.30	0.0001	***

Table A7.4.1: Lactose Corrected Milk: Saanen, Crossbred, Three-quarter Saanen: Lactations 1,2,3
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	2	208.0199	104.0099	150.83	0.0001	***
Lactation No.	2	68.4380	34.2190	49.62	0.0001	***
Breed x Lact. No.	4	14.1524	3.5381	5.13	0.0006	***
Days	1	41.9466	41.9466	60.82	0.0001	***
Breed x Days	2	3.1230	1.5615	2.26	0.1067	NS
No. of Kids	1	9.5432	9.5432	13.84	0.0003	***
Lact. Length	1	0.5921	0.5921	0.86	0.3553	NS
Breed x Lact Length	2	9.8414	4.9207	7.14	0.0010	***

Table A7.4.2: Lactose Corrected Milk: Saanen, Crossbred, Three-quarter Saanen: Lactations 1,2,3
Breed and Lactation Number Interactions:[Test: Ho: LSMEAN(i)=LSMEAN(j)]

			Saanen		Crossbred			Three-quarter Saanen		
Breed	Lact	LSM	Lact 2	Lact 3	Lact 1	Lact 2	Lact 3	Lact 1	Lact 2	Lact 3
Saanen	1	569.5	-7.446 0.0001 *	-2.872 0.0045 NS	5.473 0.0001 *	1.025 0.3065 NS	1.345 0.1801 NS	2.845 0.0049 NS	1.854 0.0652 NS	1.683 0.0941 NS
	2	784.8	-	2.343 0.0202 NS	11.214 0.0001 *	6.774 0.0001 *	6.388 0.0001 *	6.896 0.0001 *	6.006 0.0001 *	5.238 0.0001 *
	3	685.0	-	-	6.007 0.0001 *	3.259 0.0013 NS	3.352 0.0010 NS	4.307 0.0001 *	3.552 0.0005 *	3.227 0.0015 NS
Cross-bred	1	439.5	-	-	-	-3.592 0.0004 *	-2.245 0.0259 NS	-0.040 0.9680 NS	-0.893 0.3727 NS	-0.649 0.5171 NS
	2	536.9	-	-	-	-	0.458 0.6476 NS	1.883 0.0612 NS	1.075 0.2836 NS	1.023 0.3077 NS
	3	518.7	-	-	-	-	-	1.411 0.1598 NS	0.671 0.5028 NS	0.680 0.4975 NS
Three-quarter Saanen	1	441.3	-	-	-	-	-	-	-0.664 0.5076 NS	-0.517 0.6060 NS
	2	481.9	-	-	-	-	-	-	-	0.084 0.9329 NS
	3	475.9	-	-	-	-	-	-	-	-

[Note: 5% level of significance is at P <0.05 ÷ (9x8) = 0.0006]

A8. FAT-PROTEIN-LACTOSE CORRECTED MILK (FPLCM)

Table A8.1: FPLCM: Indigenous goats: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Lactation Length	1	34199.9358	34199.9358	317.96	0.0001	***

Table A8.2: FPLCM: Saanen and Indigenous: Lactation 1
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	963.0428	963.0428	1312.00	0.0001	***
Days	1	14.9418	14.9418	20.36	0.0001	***
Lact. Length	1	0.0348	0.0348	0.05	0.8282	NS
Breed x Lact. Length	1	6.6415	6.6415	9.05	0.0037	**

Table A8.3: FPLCM: Saanen and Crossbred: Lactations 1,2,3
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	1	72.0733	72.0733	90.17	0.0001	***
Lactation No.	2	88.6339	44.3169	55.44	0.0001	***
Days	1	40.1048	40.1048	50.17	0.0001	***
Lact. Length	1	1.6536	1.6536	2.07	0.1521	NS
Breed x Lact. Length	1	2.2527	2.2527	2.82	0.0950	NS

Table A8.4.1: FPLCM: Saanen, Crossbred, Three-quarter Saanen: Lactations 1,2,3
(SAS General Linear Models Procedure: Multiple Regression Analysis: Analysis of Variance and Covariance)

Source of Variation	DF	Type I SS	Mean Square	F Value	P > F	Signif.
Breed	2	76.5089	38.2544	56.45	0.0001	***
Lactation No.	2	86.2294	43.1147	63.63	0.0001	***
Breed x Lact. No.	4	12.4965	3.1241	4.61	0.0014	**
Days	1	46.5895	46.5895	68.75	0.0001	***
Breed x Days	2	1.5092	0.7546	1.11	0.3305	NS
No. of Kids	1	6.6012	6.6012	9.74	0.0021	**
Lact. Length	1	1.9342	1.9342	2.85	0.0928	NS
Breed x Lact. Length	2	10.6510	5.3255	7.86	0.0005	***

Table A8.4.2: FPLCM: Saanen, Crossbred, Three-quarter Saanen: Lactations 1,2,3
Breed and Lactation Number Interactons:[Test: Ho: LSMEAN(i)=LSMEAN(j)]

			Saanen		Crossbred			Three-quarter Saanen		
Breed	Lact	LSM	Lact 2	Lact 3	Lact 1	Lact 2	Lact 3	Lact 1	Lact 2	Lact 3
Saanen	1	529.7	-8.181 0.0001 **	-3.524 0.0005 *	0.818 0.4143 NS	-2.867 0.0046 NS	-1.847 0.0663 NS	1.143 0.2543 NS	0.125 0.9007 NS	0.241 0.8098 NS
	2	733.9	-	2.411 0.0169 NS	7.455 0.0001 **	2.940 0.0037 NS	3.086 0.0023 NS	5.280 0.0001 **	4.489 0.0001 **	3.214 0.0015 NS
	3	648.5	-	-	3.756 0.0002 **	0.524 0.6012 NS	0.947 0.3451 NS	3.208 0.0016 NS	2.411 0.0168 NS	1.876 0.0623 NS
Cross-bred	1	508.9	-	-	-	-3.837 0.0002 **	-2.422 0.0164 NS	0.637 0.5246 NS	-0.324 0.7461 NS	-0.069 0.9448 NS
	2	626.2	-	-	-	-	0.522 0.6023 NS	2.793 0.0058 NS	1.996 0.0474 NS	1.569 0.1182 NS
	3	603.5	-	-	-	-	-	2.185 0.0301 NS	1.437 0.1525 NS	1.201 0.2313 NS
Three-quarter Saanen	1	478.6	-	-	-	-	-	-	-0.761 0.4477 NS	-0.460 0.6460 NS
	2	524.1	-	-	-	-	-	-	-	0.131 0.8962 NS
	3	513.7	-	-	-	-	-	-	-	-

[Note: 5% level of significance is at P <0.05 ÷ (6x5) = 0.0016]

3. RESULTS: DISEASES OF GOATS

3.1 DISEASES

3.2 MORTALITIES AND POST-MORTEMS

3.1 DISEASES

In the routine management of the Milch Goat Project, many goats developed diseases and were treated for them. Goats that died were sent to the Pathology Department, and post-mortems were carried out. No accurate statistics of disease incidence are available, because the required records were not kept fully, and are therefore incomplete and inadequate. Mortalities of adult goats are shown in Table D4, and mortalities of goat kids for the first three years are shown in Tables D5 to D9. Accurate and complete information about kid mortality in subsequent years is not available. The results of post-mortems are accurate and are discussed separately (Tables P1 to P3). Although this is also not a complete record, it is a representative sample.These diseases which were recorded as post-mortem reports were the most important, and had the greatest impact on the productivity of the goat herd. Neither of the two sets of data (mortalities and post mortem records) is complete, and they contain some data which is duplicated, because it is not possible to identify all individual goats. The data sets should therefore be seen as complementary. Other diseases occurred which did not result in death, and it is important to record observations about them also. A summary of the incidence of these diseases from the inadequate information available is recorded in Table D1. This gives some idea of the relative importance of the main disease problems.

3.1.1 DISEASES OF GOAT KIDS

1.1 Coccidiosis

Most of the disease problems relating to the kids were not recorded, as the diarrhoea/coccidiosis/pneumonia complex was the main and overriding problem.

1.2 Rotavirus

Rotavirus was isolated from the faeces of goat kids in 1990, and reported in 1994 (DaCosta Mendes *et al.*,1994). This was believed to be the first report of rotavirus in goats in southern Africa. Further attempts to isolate the virus in other years have been unsuccessful.

1.3 Pasteurella

No outbreaks of *Pasteurella* were recorded, but the herd is now routinely vaccinated.

1.4 Broken legs

In the early years, broken legs were a problem with young kids; but the incidence was generally low. Exact statistics were not recorded, but were of the order of two to four kids a year (Table D1).

1.5 Orf (Vuilbek)

In the early years of the Milch Goat Project, orf did not appear. However, since then outbreaks occurred in kids of about three months of age, most recently in 1996. The lesions contributed to mortality, by making the drinking of milk or eating of other food difficult. Generally the problem cleared up after a few weeks. It was not a major problem.

3.1.2 DISEASES OF ADULT GOATS

2.1 Mastitis

2.1.1 Clinical Mastitis

The goats were subject to a normal milking routine, involving standard hygiene and mastitis control practices, and mastitis occurred in the herd periodically. The problem on occasions reached alarming proportions with outbreaks of peracute cases. On one occasion in 1991 this was traced specifically to a *Pseudomonas* infection that was transmitted by the milking machine. The peracute cases ("blue udder") resulted in deaths, or in the loss of one half of the udder. The recording of 28 cases of clinical mastitis (including the peracute outbreaks) in a period of six years indicated a relatively moderate level of infection.

2.1.2 Subclinical Mastitis

In the years 1990/91 milk samples were taken regularly to monitor subclinical infections.

The results are presented in Tables D2 and D3. The incidence of subclinical mastitis as indicated by growth of bacterial colonies was generally low, and infections identified did not often persist. The main organism identified was *Staphylococcus epidermidis*, infecting 109 of the 1032 udder halves sampled (10.6%). It is likely that this organism was an environmental contaminant, and not a true mastitis-causing organism. The other bacteria were few in comparison (27 of 1032 udder halfsamples = 2.6%), and consisted primarily of *Staphylococcus aureus* (23 of 27 colonies = 85%). *Pasteurella haemolytica* and *Streptococcus sp.* were each identified once, and *Escherichia coli* twice.

As was expected, the Somatic Cell Counts (SCC) were an unreliable indication of subclinical mastitis (Table D3). These values would be considered to indicate severe infections if they were measured in samples of cow milk.

2.2 Dystocia

Dystocia, and the resultant metritis, occurred in a surprisingly low number of goats: only 11 of these cases were identified in the six year period.

2.3 Abscesses (Caseous lymphadenitis)

Abscesses occurred in the herd every year, but generally without any deleterious effects. The characteristic group was the dry goat group, and the abscesses developed in the winter months. When the abscess was swollen, it was opened, the caseous matter was cleaned out, the wound was treated with wound spray, and an antibiotic given. Healing occurred in a short time. The incidence was low enough (up to ten cases a year; see Table D1) that the disease was not perceived as a major problem, and no attempt was made at vaccination.

2.4 Eye Infections

Serious eye infections were generally not a problem, and seldom occurred (Table D1).

2.5 Pneumonia

Six cases of adult goats with pneumonia were recorded. (See Table D1 and Table P1). This was relatively low, compared with the high incidence in kids.

2.6 Squamous Cell Carcinoma

Approximately half of the original herd of pure Saanens (out of 24) developed squamous cell carcinoma on the skin of the udder from the fourth lactation onwards. This condition proved to be uncurable, and these goats were culled. No cases were reported in the Crossbred goats. The new goat shed was constructed which provided more complete shelter from the sun than the original pens, and the problem has abated.

2.7 "Sore Feet"

Foot problems occurred only occasionally in goats where the hoofs had not been trimmed regularly. Hoof trimming should have been done every three months, but this procedure was often treated as a low priority. Some goats' hoofs grew so long that the feet became deformed; although it appeared that a small proportion of goats had a genetic weakness, making them susceptible to foot deformities, especially if they became overweight. A few showed what appeared to be laminitis, and spent a proportion of their time kneeling. This may have resulted from the high energy diet that was fed even when the goats were not lactating.

2.8 Caprine Arthritis Encephalitis Virus (CAEV)

This disease was not recorded, and appears **not** to exist in South Africa. On two occasions, samples were collected from goats that had swollen joints, but the laboratory tests were negative.

2.9 Internal Parasites

Apart from the problem with coccidiosis in the kids discussed above, internal parasites did not cause much of a problem in the adult goat herd. The goats kept in the goat pens or shed seldom showed any evidence of internal parasites. Levamisole was included with the vaccination Ovivax® given annually to adult goats during the dry period. Indigenous goats were dosed with various anthelmintics once or twice a year. A small trial to assess resistance against *Haemonchus* was attempted with the first group of male goat kids born. However, the number of goats was too small to be able to draw general conclusions.

2.10 External Parasites

The only external parasites that caused any problems were lice. These became apparent at various times, about twice a year. The goats would rub themselves against fences or walls. In general they were only of nuisance value, but may occasionally have contributed to kid debility. A simple dipping of the goats (a synthetic pyrethroid was used) solved the problem; at least for a time. The goats that spent some time outside the goat pens in the veld paddocks ran a high risk of tick infestation. Saanen or Crossbred goats generally were not left in the veld because they deteriorated in body condition and were at risk of tick-borne diseases. In contrast, Indigenous goats appeared to be resistant to tick infestation. Tick populations on the Indigenous goats were generally low, affecting areas under the tail and between the hoofs. The latter sometimes caused lameness.

3.1.3 TABLES OF GOAT DISEASES

Table D1: Records of Goat Diseases
(In addition to those reported as post-mortems: See Table P3).

	1989	1990	1991	1992	1993	1994
Kids						
Diarrhoea	2	21	15	-	2	-
Respiratory	1	4	-	-	-	-
Broken legs	4	2	2	-	1	-
Adults						
Mastitis	1	7	4	2	2	4
Dystocia, etc.	-	2	1	-	1	4
Abscesses	-	7	10	-	1	-
Eye infections	-	-	3	-	-	-
Pneumonia	-	-	1	-	-	-

Table D2: Subclinical Mastitis Survey: 1990/91: Bacterial growth.

Date	Udder halves sampled	No growth	Growth of bacterial colonies				% Growth	% Growth*
			Totals	*Staph. epidermidis*	*Staph. aureus*	Other		
18/9/90	76	73	3	2	1	0	3.9	1.3
2/10/90	114	106	8	5	2	1	7.0	2.6
16/10/90	140	129	11	10	1	0	7.9	0.7
6/11/90	132	113	19	14	4	1	14.4	3.0
27/11/90	126	106	20	11	9	0	15.9	7.1
5/2/91	118	99	19	17	1	1	16.1	1.7
12/3/91	120	100	20	18	1	1	16.7	1.7
16/4/91	121	98	23	19	4	0	19.0	3.3
14/5/91	85	72	13	13	0	0	15.3	0.0
Totals	1032	896	136	109	23	4	13.2	2.6

[* Excluding *Staph. epidermidis*]

Table D3: Subclinical Mastitis Survey: 1990/91: Mean Somatic Cell Counts (SCC)

Date	Somatic Cell Counts (cells x 1000/ml)	
	No growth mean SCC ± SE	**Growth** mean SCC ± SE
18/9/90	1687 ± 2866	1222 ± 1080
2/10/90	1042 ± 1712	2334 ± 3989
16/10/90	1194 ± 2500	1022 ± 1100
6/11/90	508 ± 614	670 ± 696
27/11/90	527 ± 1020	1344 ± 2214
5/2/91	864 ± 1171	696 ± 525
12/3/91	825 ± 1362	671 ± 726
16/4/91	831 ± 1242	954 ± 590
14/5/91	839 ± 1795	1313 ± 855

3.2 MORTALITIES AND POST-MORTEMS

3.2.1 MORTALITIES

3.2.1.1 Mortality of Adult Female Goats

Records of deaths of adult femle goats are summarized in Table D4 for the years 1988 to 1993. There were few deaths in the early years, but the incidence increased as the animals became older, and as the size of the herd increased. The overall rates of 10% for Saanens and 15% for Crossbreds was surprisingly high, compared with equivalent percentages for a dairy cow herd of about 3%. Perhaps the "turn-over" in a goat milk herd is higher than a dairy cow herd, not only because of the more rapid reproductive rate. The data for Three-quarter Saanens are unrepresentative, because of the small number of animals of this type. In contrast, the overall percentage for Indigenous goats was much lower at 4%.

3.2.1.2 Mortality of Goat Kids

Mortality of goat kids is shown in Tables D5.1 to D9. Little effect of gender was apparent (Table D8.1); nor was there any obvious effect of whether the kids were from multiple births (Table D8.2). About one third of kid deaths occurred within the first month, but deaths continued until past the age of four months (Table D9).

The reasons are discussed in the section about post-mortems.

3.2.2 TABLES OF MORTALITY OF GOATS

3.2.2.1 MORTALITY OF ADULT GOATS

Table D4: Mortality of adult female goats: 1988 - 1993.

Year	Saanen		Crossbred		Three-quarter Saanen		Indigenous	
	No.	%	No.	%	No.	%	No.	%
1988:	25		-		-		33	
deaths	1	4.0	-	-	-	-	-	-
1989:	24		-		-		33	
deaths	-	-	-	-	-	-	1	3.0
1990:	34		9		-		44	
deaths	5	14.7	-	-	-	-	6	13.6
1991:	48		21		2		40	
deaths	4	8.3	7	33.3	-	-	1	2.5
1992:	41		22		8		48	
deaths	4	9.8	2	9.1	4	50.0	2	4.2
1993:	41		21		9		49	
deaths	9	22.0	2	9.5	1	11.1	1	2.0
Averages: 1988 - 1993:	35.5		18.2		6.3		41.2	
deaths	3.8	10.7	2.7	15.1	1.7	27.0	1.8	4.4

3.2.2.2 MORTALITY OF GOAT KIDS

Table D5.1: Mortality of Goat Kids Born 1988: Gender

	Male No.	Male %	Female No.	Female %	Totals No.	Totals %
Saanen	2	11.1	6	37.5	8	23.5
Crossbred	3	25.0	5	35.7	8	30.8
Totals	5	16.6	11	36.7	16	26.7

Table D5.2: Mortality of Goat Kids Born 1988: Multiple Births

	Singles No.	Singles %	Twins and Triplets No.	Twins and Triplets %	Totals No.	Totals %
Saanen	4	28.6	4	20.0	8	23.5
Crossbred	6	27.3	2	50.0	8	30.8
Totals	10	27.8	6	25.0	16	26.7

Table D6.1: Mortality of Goat Kids Born 1989: Gender

	Male No.	Male %	Female No.	Female %	Totals No.	Totals %
Saanen	11	39.3	6	21.4	17	30.4
Crossbred	7	30.4	9	39.1	16	34.8
Three-quarter Saanens	5	71.4	2	50.0	7	63.6
Totals	23	39.7	17	30.9	40	35.4

Table D6.2: Mortality of Goat Kids Born 1989: Multiple Births

	Singles No.	Singles %	Twins and Triplets No.	Twins and Triplets %	Totals No.	Totals %
Saanen	2	20.0	15	32.6	17	30.4
Crossbred	8	50.0	8	26.7	16	34.8
Three-quarter Saanen	4	57.1	3	75.0	7	63.6
Totals	14	39.7	26	30.9	40	35.4

Table D7.1: Mortality of Goat Kids Born 1990: Gender

	Male No.	Male %	Female No.	Female %	Totals No.	Totals %
Saanen	12	40.0	1	33.3	23	36.5
Crossbred	4	11.8	6	17.1	10	14.5
Three-quarter Saanens	5	26.3	5	35.7	10	30.3
Indigenous	4	28.6	5	27.7	9	28.1
Totals	25	25.5	27	26.7	52	26.1

Table D7.2: Mortality of Goat Kids Born 1990: Multiple Births

	Singles No.	Singles %	Twins and Triplets No.	Twins and Triplets %	Totals No.	Totals %
Saanen	6	46.1	17	34.0	23	36.5
Crossbred	8	50.0	8	26.7	16	34.8
Three-quarter Saanen	3	17.6	7	13.5	10	14.5
Indigenous	7	63.6	3	13.6	9	28.1
Totals	14	39.7	26	30.9	40	35.4

Table D8.1: Mortality of Goat Kids Born: Three Years (1988 to 1990): Gender

	Male No.	Male %	Female No.	Female %	Totals No.	Totals %
Saanen	25	32.9	23	29.9	48	31.4
Crossbred	14	20.3	20	27.8	34	24.1
Three-quarter Saanens	10	38.5	7	38.9	17	38.6
Indigenous	4	28.6	5	27.8	9	28.1
Totals	53	28.5	55	29.6	108	29.0

Table D8.2: Mortality of Goat Kids Born: Three Years (1988 to 1990): Multiple Births

	Singles No.	Singles %	Twins and Triplets No.	Twins and Triplets %	Totals No.	Totals %
Saanen	12	32.4	36	31.0	48	31.4
Crossbred	17	30.9	17	19.8	34	24.1
Three-quarter Saanen	11	61.1	6	23.1	17	38.6
Indigenous	2	28.6	7	28.0	9	28.1
Totals	42	35.3	66	26.1	108	29.0

Table D9: Age of Goat Kids at Death: Three Years (1988 to 1990)

Age at death (days)	1988	1989	1990	Three Years		
				10-day	30-day	%
0 to 10	3	8	17	28		
11 to 20	1		4	5		
21 to 30	4			4	37	36.3
31 to 40	2	1	1	4		
41 to 50	5	2		7		
51 to 60		4		4	15	14.7
61 to 70		4		4		
71 to 80		4	4	8		
81 to 90		3	1	4	16	15.7
91 to 100		2	5	7		
101 to 110	1	5	4	10		
111 to 120		3	2	5	22	21.6
121 to 130		2	3	5		
131 to 140		1	1	2		
141 to 150		1	1	2	9	8.8
151 to 160			1	1		
161 to 170			2	2		
171 to 180					3	2.9
Totals	16	40	46	102	102	100

3.2.3 POST-MORTEMS OF GOATS

Since the start of the Milch Goat Project, it was a standing instruction that all goats that died should be sent to the Department of Veterinary Pathology. This was to ensure that the reasons for death were correctly identified, and to provide teaching material for the students. However, because of management and labour difficulties, not all dead animals were delivered to the Department; some arrived too late for post-mortems to be done; and others were not done because there were too many with the same problem, as happened when many kids were dying from coccidiosis at the same time.

Nevertheless, records are available for 182 post-mortems, from 1988 to 1994. These probably represent a good sample of the animals that died within this period. The details are shown in Table P3 (Appendix C), and the results are summarized in Table P1.

* **GOAT KIDS**:

The overwhelming reasons for the death of goat kids were coccidiosis and pneumonia, usually occurring together. If the diagnosis "enteritis" is also taken to be indicative of coccidiosis, and "cachexia" is the logical consequence before death, then there is no doubt that this was the major problem in the herd. Pneumonia also occurred separately from coccidiosis, and this was probably the final reason for death of goat kids that had not received enough colostrum.

An important proportion of kids were lost in the early days after being born, probably as a result of poor mothering ability, pendulous udders, overcrowding, and lack of close attendance by the staff responsible.

In the list of goats in Table P3 (Appendix C), two distinct groups were discerned:

* Kids that died soon after being born. In this group, those that died from pneumonia before 35 days after being born, on average died at two to three weeks (range: 1 to 33 days).

* Kids that died from coccidiosis and its complications, at about two to four months of age. The different groups distinguished are shown in Table P2. In most cases, the pneumonia diagnosed as the cause of death was a complication arising from the debilitating effects of earlier coccidiosis.

* **ADULT GOATS**:

The 32 post-mortems recorded are summarized in Table P1. Few deaths of adult goats (older than six months) occurred in the first years. Some of the reasons for death that warrant specific comment are as follows:

* **Mastitis**

Mastitis was not perceived to be a problem generally in the herd, but on specific occasions there were a few goats that died from acute mastitis ("blue udder"), usually caused by *Staphylococcus aureus*. On one occasion the causative organism was identified as *Pseudomonas*, spread as a result of inadequate cleaning of the milking machine.

* **Pneumonia**

Pneumonia was diagnosed as the cause of death for five adult goats, but this may have been the final complication to other disease problems.

* **Hepatic cirrhosis**

The two cases recorded here occurred in Indigenous goats that were brought into the herd from elsewhere.

* **Plastic bags in the rumen**

This was seldom a problem with the goats kept in the goat pens. However, it was a hazard for the Indigenous goats that spent time in the veld paddocks elsewhere on campus. Littering is endemic, and the older goats, when slaughtered often had tangled masses in the rumen. These obstructions restricted the flow of ingesta, and contributed to deaths by weakening the animals.

* **Squamous cell carcinoma**

Approximately one half of the foundation Saanen goats developed squamous cell carcinoma on the skin of their udders from the fourth lactation onwards (more than five years of age). This progressed to unhealable wounds, and would have led to death, except that in most cases the goats were culled before the problem became extreme. In later years this was not a problem, probably because the new goat shed provided adequate shade. No cases of squamous cell carcinoma were recorded in Crossbred or Indigenous goats.

* **Ketosis**

Ketosis developed in a few goats that were grossly overweight and were put on a low energy diet of roughage and a lick. The majority of overweight goats were Crossbred goats that had dried off, but had been left on the complete feed designed for the goats in milk. A shortage of energy that was associated with later pregnancy was usually the cause of the ketosis. In this regard, goats should be treated like sheep, rather than like dry cows, because of the energy demand for multiple pregnancies.

*** Heartwater**

Only two cases of heartwater were recorded during this period (1988 to 1994), one of which was from a goat kept in the goat pens. How the tick managed to reach the goat is difficult to imagine, but it could have been transported via guinea fowl that fly in to eat spilled goat feed in the pens, or it could have been carried in by an Indigenous goat that had been in the veld. Because of the risk of heartwater, Saanen and Crossbred goats were seldom sent out to the veld paddocks.

3.2.4 TABLES OF POST-MORTEMS OF GOATS

Table P1: Goat post-mortems: 1988 to 1994: Summary (n = 182)

Aetiology	Number
Adult goats (32 post-mortems):	
mastitis	8
ketosis	5
pregnancy toxaemia	1
pneumonia	5
peritonitis	3
metritis	2
dystocia	1
uterine prolapse	1
hepatic cirrhosis	2
heart failure	1
Heartwater (cowdriosis)	1
plastic bags in rumen	1
squamous cell carcinoma	1
nephrosis/renal calculi	1
Corynebacterium abscesses	1
Goat kids (150 post-mortems):	
pneumonia	54
coccidiosis	53
enteritis/diarrhoea	9
cachexia	15
septicaemia	8
E.coli	3
born dead	4
born weak	5
hypothermia	1
cerebrocortical necrosis	1
Vitamin E/ selenium deficiency	1
myocarditis	1
pericarditis	1
ataxia	1
renal dysplasia	1
arthritis	1
pyogenic bacterial embolism	1
Monezia	1
"concentrate overload"	2
asphyxiation (stuck in feed bin)	2

Table P2: Goat kid mortality: age at death

Group	No.	Days (mean ± SE)
Coccidiosis	53	86 ± 79
Coccidiosis with pneumonia	14	94 ± 28
Pneumonia (<35 days)	18	13 ± 11
Pneumonia (>35 days)	13	102 ± 30
Pneumonia (> 35 days; incl. coccidiosis)	27	95 ± 31

4. RESULTS OF HEARTWATER EXPERIMENT

4.1 RESULTS OF HEARTWATER EXPERIMENT

Preliminary results for the first year of the experiment have already been reported at the Fifth International Conference on Goats (Donkin *et al.* 1992). These have been consolidated in this report with the information from the second year.

4.1.1 TEMPERATURE REACTIONS

Temperature reactions are illustrated in Figures H1 to H4. The similarity is readily apparent. The detailed analyses of these reactions are given below.

4.1.1.1 Pre-febrile temperatures

Morning and afternoon mean pre-febrile temperatures are listed in Table H1. It is apparent that any differences between groups are small. On average, afternoon temperatures were approximately 0.5°C higher than morning temperatures. As the morning temperatures were taken at a more consistent time than for those in the afternoon, the morning temperatures were used in all further analyses.

4.1.1.2 Temperature reactions:

Temperature reactions are shown in Tables H2 to H6. On average, the pre-febrile temperature was 39°C (Table H2). The characteristic rise in temperature above 40°C occurred on Day 10, with a mean temperature of 40.6°C. Peak temperature occurred on Day 12, at a mean of 41.7°C; and for those goats that survived, temperature fell below 40°C again on Day 16. The mean temperature rise was 2.7°C. The mean time from temperature rise to drop was 5.3 days, and the mean time from peak to drop was 3.6 days. Death, if it occurred was on average on Day 15.

4.1.1.3 Breed Differences

Breed difference effects were analysed, and the results are shown in Tables H7 to H18 :

* H7: Mean temperatures before heartwater reaction
* H8: Mean temperatures at day of rise in temperature
* H9: Day of temperature rise above 40°C
* H10: Peak temperatures
* H11: Peak temperatures for goats that died
* H12: Day of peak temperature
* H13: Degrees rise in temperature
* H14: Degrees rise in temperature for 1992 only
* H15: Day of temperature drop

* H16: Days from peak to temperature drop

* H17: Days from temperature rise to drop

* H18: Day of death

All these tests were not significant, except for the three shown in Tables H7, H10 and H13.

** Table H7: Mean temperature before heartwater reaction:*

The mean temperature before temperature rise was significantly ($P<0.05$) different only between Saanen (39.87°C) and Three-quarter Saanen goats (39.19°C). This is difficult to interpret, as the temperatures are very similar; it seems likely that the difference would not have been significant if there had been more Three-quarter Saanen goats.

** Table H10: Peak temperatures:*

Peak temperatures did not differ significantly between the breeds Saanen, Indigenous and Crossbred. However, the peak temperature of the Three-quarter Saanens was significantly ($P<0.05$) higher than those of goats of the three other breeds. This is difficult to account for, and the mean difference was approximately 0.5°C. It is possible that the small number of goats might have contributed to the significance, and the fact that the Three-quarter Saanens were only included in the experiment in Year 2.

** Table H13: Degrees rise in temperature:*

The difference in degrees rise in temperature was not significant between Saanen goats and Three-quarter Saanens. However, it was significantly ($P<0.05$) different when Indigenous and Crossbred goats were compared to Three-quarter Saanens. This difference was not significant when the test was done again (Table H14), including only goats in Year 2. This suggests that there might have been a year effect, or that the difference in the number of goats could have caused the effect. This influence would not have been apparent if there had been more Three-quarter Saanen goats in the experiment, and if they had been in both years.

4.1.1.4 Differences between survivors and those that died:

Temperature reactions in terms of rising and peak temperatures are shown in Tables H19 to H22. The relatively low number of male goats that died was related to the fact that most of the Saanen goats were females, and this group had the highest mortality. In spite of this discrepancy, there were no significant differences between the parameters measured.

4.1.1.5 Year effects

The only groups that could be compared between years were the Crossbred and Indigenous groups (Table H23). There were no significant differences.

4.1.1.6 Saanens treated or not treated with tetracycline

These data are shown in Table H24 to H29. The only nearly-significant difference was in the slightly later timing of the rising temperatures of treated goats. No explanation can be given of this, and it was unrelated to whether goats were treated or not, as it occurred before treatment was given.

4.1.2 CLINICAL SIGNS

Clinical signs have been grouped into four categories, relating to general behaviour, the effects of fluid accumulation, nervous signs, and those associated with collapse and death. Observation periods consisted of about one hour each morning and afternoon. Some signs might therefore have been missed, such as convulsions, if they did not occur during the specific observation periods. Other signs, such as anorexia, might have not been noted because they were a negative occurrence. Observation periods were generally shared by two people, and four observers were involved altogether. Death was not often observed, and when it was seen, the progression through lateral recumbency and convulsions was mercifully swift. In the first year, goats in lateral recumbency were used for an experiment on emergency resuscitation procedures, but very few goats survived long enough for a drip to be inserted. Because of the uncertainties concerning the validity of incidence of observed signs, it was not considered appropriate to attempt to carry out statistical analyses of these data.

4.1.2.1 Breed differences:

The incidence of clinical signs noted for the different breeds is indicated in Table H30. All Saanens, approximately half of the Crossbreds, and approximately three-quarters of the Three-quarter Saanens died. Although all breeds showed a range of clinical signs, the incidence and severity appeared to increase with the increasing proportion of Saanen genetic influence.

The general impression was that Indigenous goats showed less clinical signs, and those signs that were noted appeared to be less severe than in the other groups.

4.1.2.2 Gender differences:

These are shown in Table H31. The relatively low proportion of males that died is a breed effect, resulting from the low number of male Saanens included. It would be difficult to attempt to distinguish any differences in the incidence of clinical signs between males and females, for the reasons discussed above. For example, more male goats showed diarrhoea, but a higher proportion of female goats died.

4.1.2.3 Differences between Saanen goats that were treated or not:

These are shown in Table H32. The small number of goats in this comparison make it difficult to draw any general conclusions. However, the treated goats did not show many of the more severe nervous signs that were shown by the untreated goats in the final stages of the disease.

4.1.2.4 Differences between those goats that survived or died:

These are shown in Table H33. *No apparent differences* were obvious between these groups in regard to general behavioural signs and those associated with fluid accumulation. Apparently these goats could survive in spite of showing the same clinical signs. Although more nervous signs were shown by goats that died compared to those that survived, nevertheless many of the survivors showed licking of lips, grinding of teeth, and tremors.

4.1.3 CONGLUTININS

Serum conglutinin titres are listed in Tables H34 to H37.

In Year 1, conglutinins were only measured after the experiment, and as all the Saanens had died, samples were taken from a group of other Saanens in the herd. These few results seemed to indicate that there might be a difference between breeds.

Therefore, in Year 2, conglutinin levels were measured before and after the experiments. The data shown in Tables H34 and H36 were not numerous enough in each cell to ensure the validity of the Chi-squared tests. Therefore the data were consolidated into Tables H35 and H37 respectively, to ensure validity of the Chi-squared tests. No significant effect was evident of the level of conglutinin before heartwater on survival of the goats (Table H35). Although conglutinins were at a lower level before than after heartwater, there was no significant relationship between the levels before and after.

These results gave no indication that conglutinin titres were a predictor of the goats' ability to survive heartwater.

4.1.4 DEATH OR SURVIVAL

The incidence of deaths from heartwater among goats, from animals treated or untreated is shown in Table H38. A more detailed summary including the differences between Year 1 and Year 2, is shown in Table H39. The deaths recorded in untreated goats are shown in Table H40. It can be seen that all ten Saanens died, only one of the twenty Indigenous goats died, 55% of Crossbred goats survived, and 22% of Three-quarter Saanens survived. The proportion of goats that survived from the different breed groups was similar to the proportion of genetic inheritance from the Indigenous goats.

The statistical analysis is shown in Tables H41.1, H41.2 and H41.3. The Fisher Exact Chi-squared Test showed that the death rate between the different breeds was significantly ($P<0.05$) different, except between Three-quarter Saanens and pure Saanens. It was also not significantly different between Three-quarter Saanens and the Crossbred goats. This was probably because of the small number of goats in the Three-quarter Saanen group.

The relation between gender and survival from heartwater is shown in Table H42. No significant effect of gender was determined.

4.1.5 WEIGHTS

Weights and ages of goats are shown in Table H43. The differences in weights between the Indigenous goats and those of the other breeds are apparent. A reduction in weight was not always observed, and no general trend was discernible. It was concluded that weight change was not a reliable parameter in these experiments.

4.2 GRAPHS OF TEMPERATURE REACTIONS

Figure H1: Heartwater in Goats: 1991: Saanen, Indigenous and Crossbred Goats

Figure H2: Heartwater in Goats: 1992: Phase 1: Indigenous and Crossbred Goats

Figure H3: Heartwater in Goats: 1992: Phase 2: Saanen and Three-quarter Saanen Goats

Figure H4: Heartwater in Goats: 1992: All Goats

Figure H1: Heartwater in Goats
1991: Saanen, Indigenous and Crossbred Goats

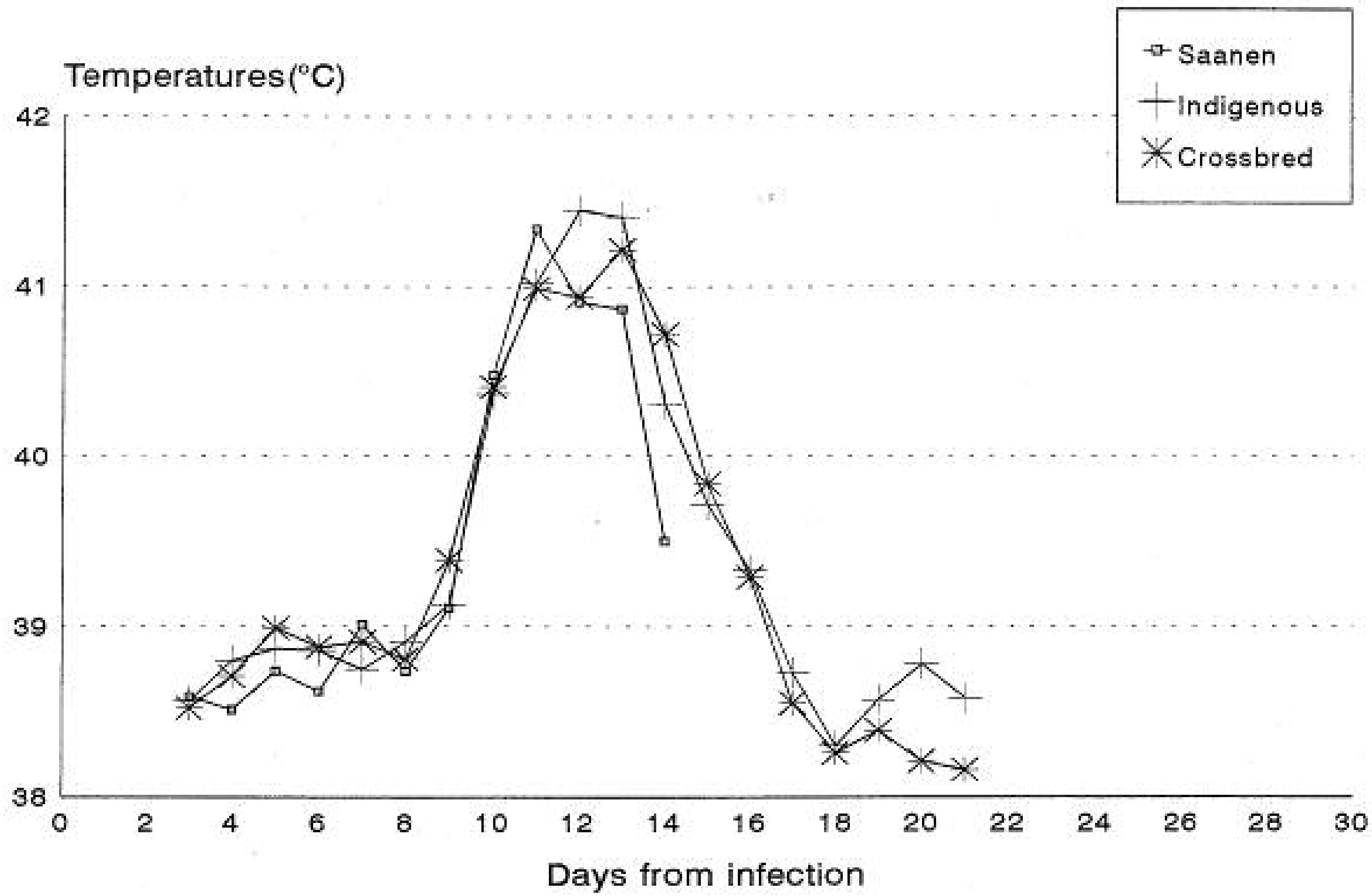


Figure H2: Heartwater in Goats
1992: Phase 1 : Indigenous and Crossbred Goats

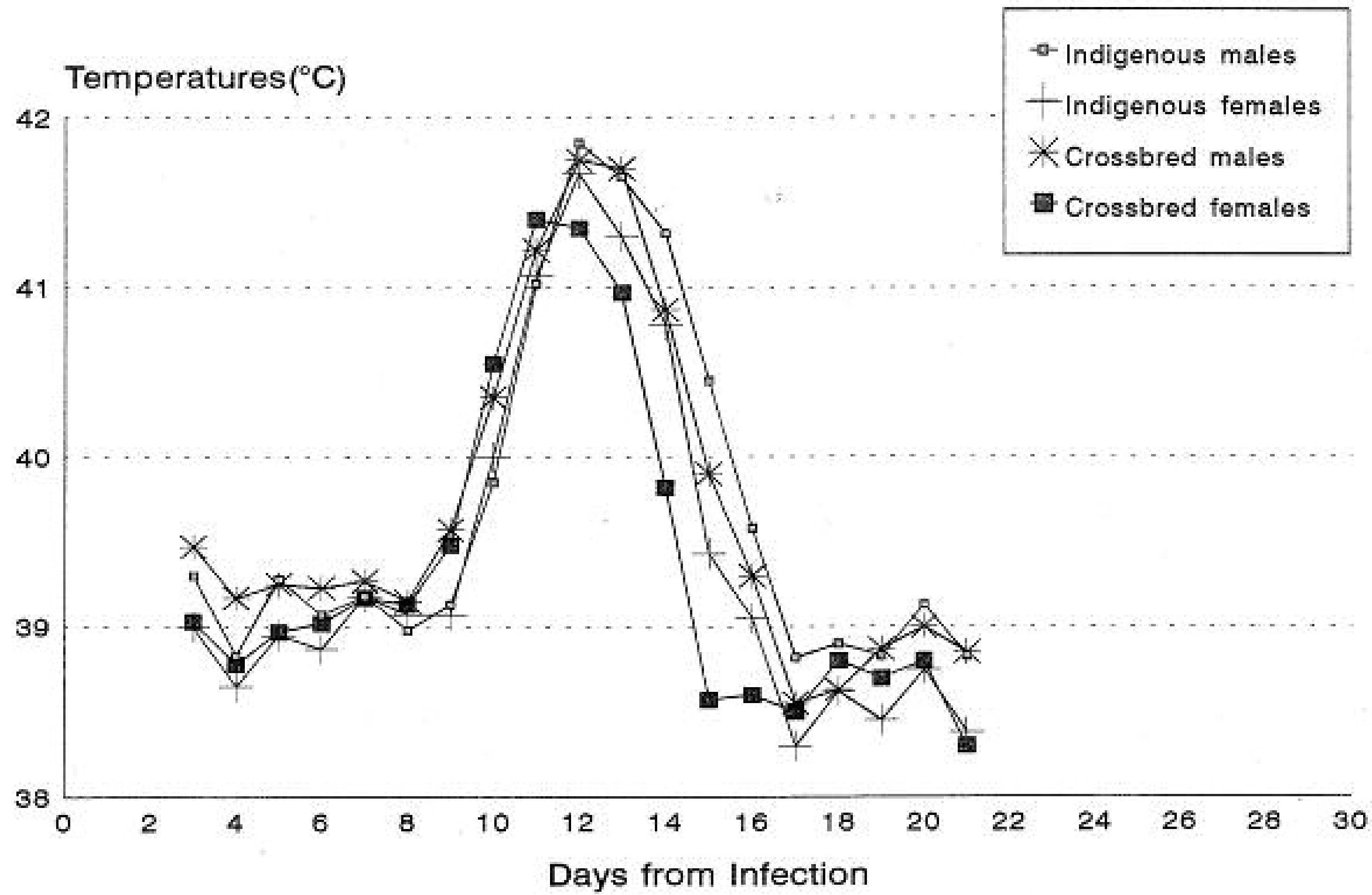


Figure H3: Heartwater in Goats
1992: Phase 2 : Saanen and Three-quarter Saanen Goats

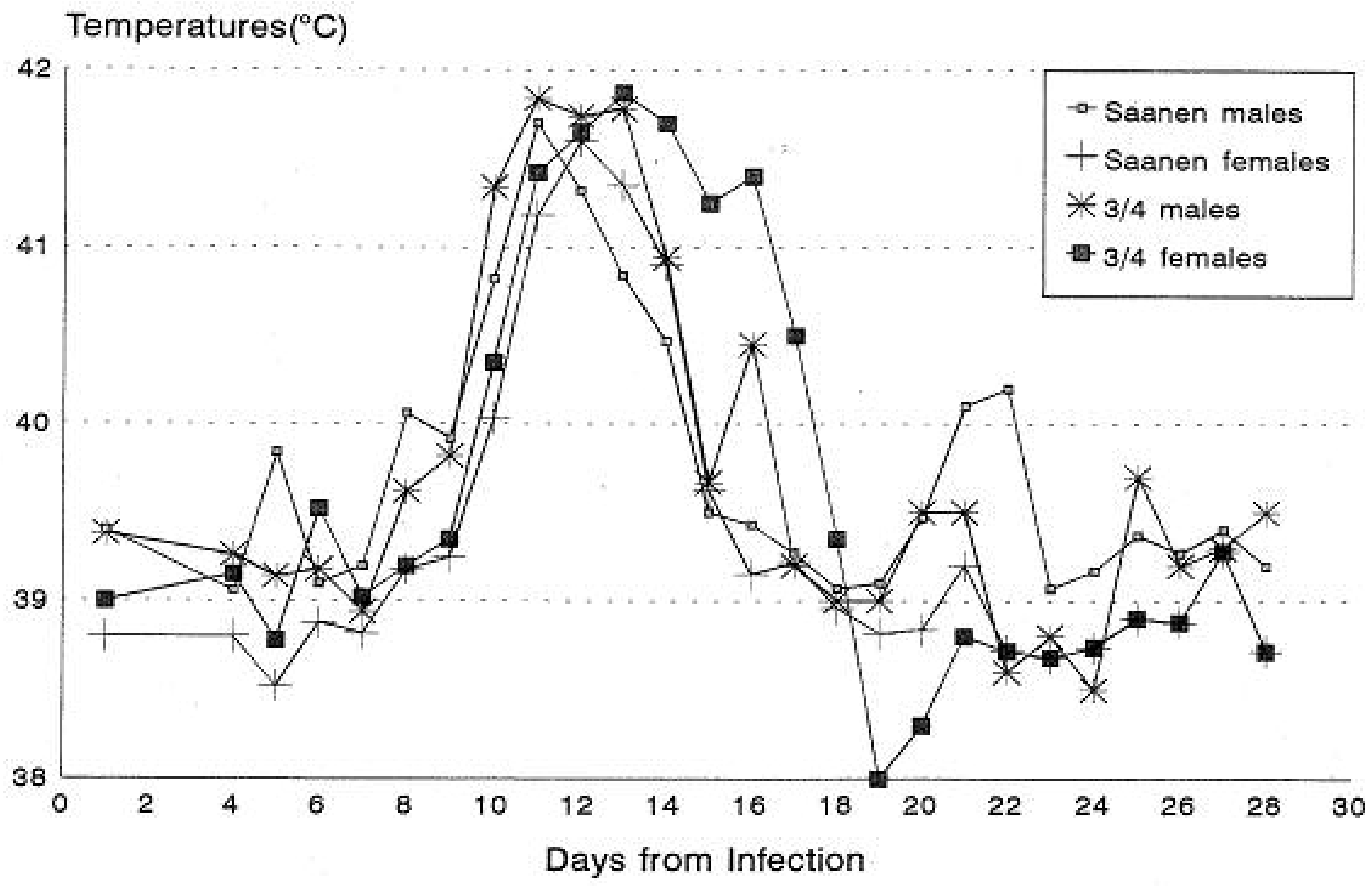
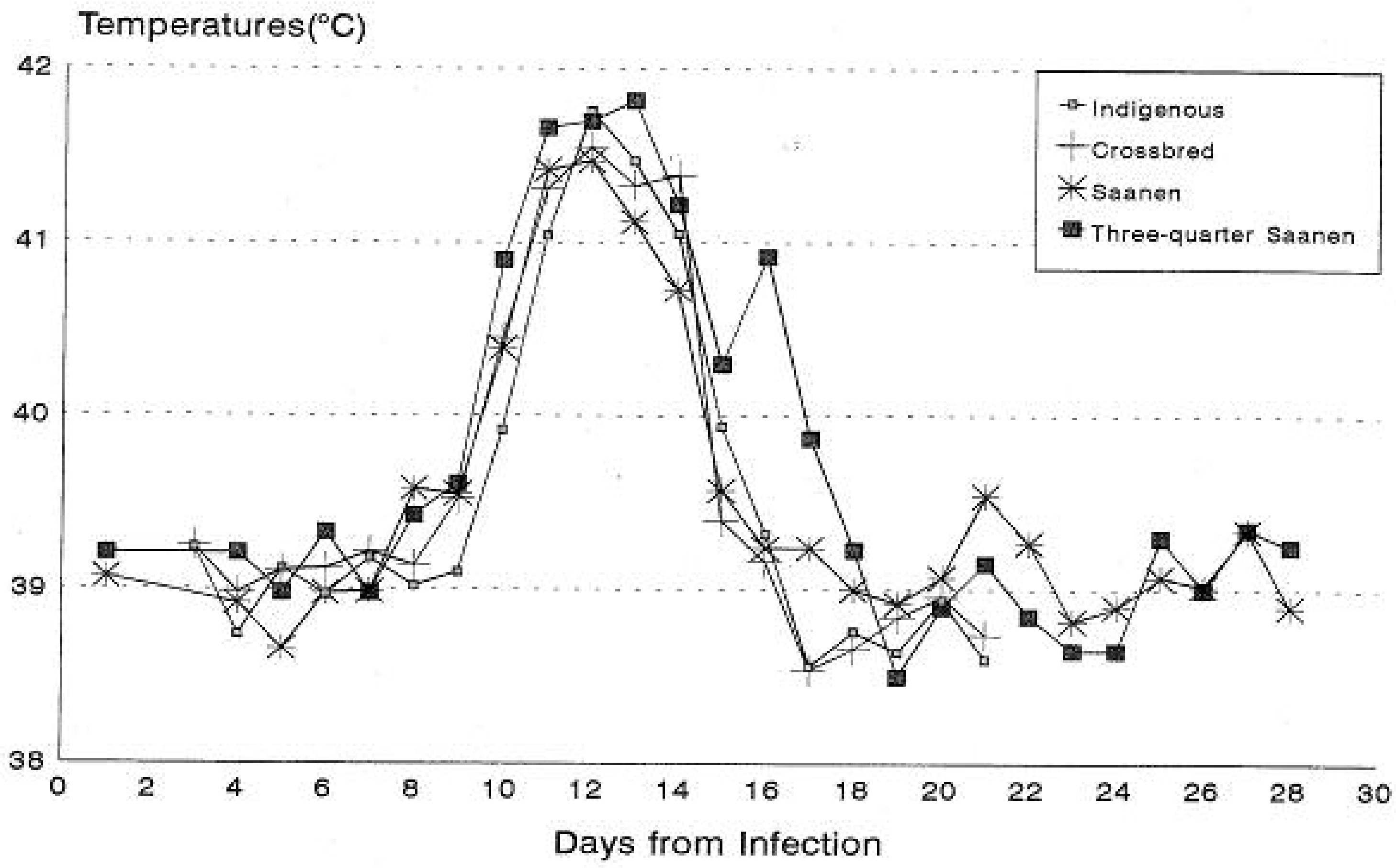


Figure H4: Heartwater in Goats
1992: All Goats



4.3 TABLES OF HEARTWATER EXPERIMENT

<u>Note: Tables H1 to H29 are in Appendix D</u>

Table H30: Incidence of clinical signs: goats with heartwater: breed comparisons
[Number of goats for which a clinical sign was recorded]

	Saanen		Indigenous		Crossbred		75% Saanen	
Number of goats	10		20		20		9	
GENERAL:	No.	%	No.	%	No.	% 4	No.	%
Anorexia	6	60	0	0	20		0	0
Listlessness	9	90	7	35	13	65	9	100
Recumbency	0	0	0	0	4	20	3	33
Diarrhoea (mild)	4	40	15	75	17	85	8	89
Diarrhoea (severe)	0	0	1	5	4	20	2	22
FLUID ACCUMULATION:	No.	%	No.	%	No.	%	No.	%
Oedema: facial	0	0	0	0	7	35	0	0
Oedema: abdominal	0	0	0	0	0	0	1	11
Nasal discharge	0	0	7	35	10	50	3	33
Cough	1	10	2	10	8	40	4	44
Respiratory distress	1	10	10	50	10	50	5	56
NERVOUS SIGNS:	No.	%	No.	%	No.	%	No.	%
Licking of lips	0	0	3	15	8	40	3	33
Chewing movements	2	20	0	0	0	0	0	0
Grinding teeth	0	0	9	45	5	25	4	44
Tremors	1	10	3	15	5	25	6	67
Ataxia/ unsteady gait	4	40	1	5	2	10	0	0
Stance: wide-based	1	10	1	5	0	0	0	0
Head-pushing	1	10	0	0	1	5	0	0
Hyperaesthesia	6	60	1	5	4	20	1	11
COLLAPSE:	No.	%	No.	%	No.	%	No.	%
Recumbency (lateral)	6	60	1	5	1	5	1	11
Convulsions (if seen)	4	40	1	5	1	5	0	0
Extensor rigidity	1	10	0	0	0	0	0	0
DEATH:	10	100	1	5	9	45	7	78

Table H31: Incidence of clinical signs: goats with heartwater: Gender comparison.
[Number of goats for which a clinical sign was recorded].

	Males		Females		All goats	
Number of goats	25		34		59	
GENERAL:	No.	%	No.	%	No.	%
Anorexia	2	8	8	24	10	17
Listlessness	18	72	20	59	38	64
Recumbency	4	16	3	9	7	12
Diarrhoea (mild)	23	92	21	62	44	75
Diarrhoea (severe)	6	24	1	3	7	12
FLUID ACCUMULATION:	No.	%	No.	%	No.	%
Oedema: facial	5	20	2	6	7	12
Oedema: abdominal	1	4	0	0	1	2
Nasal discharge	14	56	6	18	20	34
Cough	9	36	6	18	15	25
Respiratory distress	15	60	11	32	26	44
NERVOUS SIGNS:	No.	%	No.	%	No.	%
Licking of lips	8	32	6	18	14	24
Chewing movements	0	0	2	6	2	3
Grinding teeth	8	32	10	29	18	31
Tremors	7	28	8	24	15	25
Ataxia/ unsteady gait	1	4	6	18	7	12
Stance: wide-based	0	0	2	6	2	3
Head-pushing	0	0	2	6	2	3
Hyperaesthesia	4	16	8	24	12	20
COLLAPSE:	No.	%	No.	%	No.	%
Recumbency (lateral)	2	8	7	21	9	15
Convulsions (if seen)	1	4	5	15	6	10
Extensor rigidity	0	0	1	3	1	2
DEATH:	9	36	18	53	27	46

Note: Excluding Saanen goats that were treated with tetracycline.

Table H32: Incidence of clinical signs: goats with heartwater: Comparison of Saanen goats treated or untreated with tetracycline.

[Number of goats for which a clinical sign was recorded].

	Untreated		Treated	
Number of goats	10		9	
GENERAL:	No.	%	No.	%
Anorexia	6	60	0	0
Listlessness	9	90	9	100
Recumbency	0	0	0	0
Diarrhoea (mild)	4	40	3	33
Diarrhoea (severe)	0	0	0	0
FLUID ACCUMULATION:	No.	%	No.	%
Oedema: facial	0	0	0	0
Oedema: abdominal	0	0	0	0
Nasal discharge	0	0	1	11
Cough	1	10	0	0
Respiratory distress	1	10	4	44
NERVOUS SIGNS:	No.	%	No.	%
Licking of lips	0	0	0	0
Chewing movements	2	20	0	0
Grinding teeth	0	0	1	11
Tremors	1	10	0	0
Ataxia/ unsteady gait	4	40	0	0
Stance: wide-based	1	10	0	0
Head-pushing	1	10	0	0
Hyperaesthesia	6	60	0	0
COLLAPSE:	No.	%	No.	%
Recumbency (lateral)	6	60	0	0
Convulsions (if seen)	4	40	1	11
Extensor rigidity	1	10	0	0
DEATH:	10	100	1	11

Table H33: Incidence of clinical signs: goats with heartwater: Comparison of goats that survived or died.
[Number of goats for which a clinical sign was recorded].

	Died		Survived	
Number of goats	27		32	
GENERAL:	No.	%	No.	%
Anorexia	7	26	3	9
Listlessness	22	81	16	50
Recumbency	4	15	3	9
Diarrhoea (mild)	18	67	26	81
Diarrhoea (severe)	3	11	4	12
FLUID ACCUMULATION:	No.	%	No.	%
Oedema: facial	3	11	4	12
Oedema: abdominal	1	4	10	31
Nasal discharge	7	26	13	41
Cough	10	37	5	16
Respiratory distress	12	44	14	44
NERVOUS SIGNS:	No.	%	No.	%
Licking of lips	8	30	6	19
Chewing movements	2	7	0	0
Grinding teeth	5	19	13	41
Tremors	9	33	6	19
Ataxia/ unsteady gait	6	22	1	3
Stance: wide-based	2	7	0	0
Head-pushing	1	4	1	3
Hyperaesthesia	10	37	2	6
COLLAPSE:	No.	%	No.	%
Recumbency (lateral)	7	26	0	0
Convulsions (if seen)	6	22	0	0
Extensor rigidity	1	4	0	0
DEATH:	27	100	0	0

Table H34: Effect of conglutinin level before heartwater on death or survival of goats.

Conglutinin (dilution)	Goats died	Goats survived	Totals
< 20	2	1	3
20	5	9	14
40	4	6	10
80	2	1	3
160	1	1	2
Totals	14	18	32

Note: None of the tests showed significance. However, the Chi-squared tests were not valid because too many of the cells had expected counts of less than 5. Therefore, the data were consolidated into smaller groups:

Table H35:
Consolidated Table: Effect of conglutinin level before heartwater on death or survival of goats.

Conglutinin (dilution)	Goats died	Goats survived	Totals
20 or less	7	10	17
40 or more	7	8	15
Totals	14	18	32

Comment: No significant effect was evident of the level of conglutinin before heartwater on survival of the goats.

Table H36: Conglutinin levels in goats before and after heartwater.

Conglutinin (before)	Conglutinin (after)						
	< 20	20	40	80	160	320	Totals
< 20	0	0	0	1	0	0	1
20	1	2	3	1	1	1	9
40	0	2	1	1	2	0	6
80	0	0	0	0	1	0	1
160	0	0	0	1	0	0	1
Totals	1	4	4	4	4	1	18

Comment: There are too few expected counts in each cell for the Chi-squared test to be valid. Therefore, the Table was consolidated into smaller categories.

Table H37: Consolidated Table: Conglutinin levels in goats before and after heartwater.

Conglutinins (before)	Conglutinins (after)		
	40 or less	80 or more	Totals
20 or less	6	4	10
40 or more	3	5	8
Totals	9	9	18

Comment: Although conglutinins were at lower levels before than after heartwater, there was no significant relationship between the levels before and after.

Table H38: Deaths from Heartwater: Breeds 1 to 4; Treated and Untreated: Consolidated for both years.

Group	Died No.	Died %	Survived No.	Survived %	Totals
Saanen:					
Untreated	10	100	0	0	10
Treated	1	11	8	89	9
Indigenous:					
Untreated	1	5	19	95	20
Crossbred:					
Untreated	9	45	11	55	20
Three-quarter Saanens:					
Untreated	7	78	2	22	9

Table H39: Deaths from Heartwater: Breeds 1 to 4; Treated and Untreated:
Years 1991 and 1992.

Group	Died No.	Died %	Survived No.	Survived %	Totals
Saanen:					
Untreated: 1991	8	100	0	0	8
1992	2	100	0	0	2
Treated: 1992	1	11	8	89	9
Indigenous:					
Untreated: 1991	1	12	7	88	8
1992	0	0	12	100	12
Crossbred:					
Untreated: 1991	2	25	6	75	8
1992	7	58	5	42	12
Three-quarter Saanens:					
Untreated: 1992	7	78	2	22	9

Table H40: Deaths from Heartwater: Breeds 1 to 4; Untreated goats only: Consolidated for both years.

Group	Died		Survived		Totals
	No.	%	No.	%	
Saanen	10	100	0	0	10
Indigenous	1	5	19	95	20
Crossbred	9	45	11	55	20
Three-quarter Saanens	7	78	2	22	9

Table H41.1: Heartwater experiments: Statistical analysis of breed differences between those goats that survived or died: Chi-squared test: pairwise comparisons: Fisher exact test.

Breed	Died	Survived
1: Saanen	10	0
2: Indigenous	1	19
3: Crossbred [50:50]	9	11
4: Three-quarter Saanen [75:25]	7	2

Table H41.2: Pairwise comparisons: Fisher exact test (Chi-squared test: $p < 0.05$)

Comparison	P value	Significance
1 vs 2	0.0000	***
1 vs 3	0.0041	***
1 vs 4	0.2105	NS
2 vs 3	0.0084	***
2 vs 4	0.0002	***
3 vs 4	0.1296	NS

Table H41.3: Summary of tests of significance

Breed	Indigenous	Crossbred	Three-quarter Saanen
Saanen	p = 0.0000 ***	p = 0.0041 ***	p = 0.2105 NS
Indigenous	-	p = 0.0084 ***	p = 0.0002 ***
Crossbred	-	-	p = 0.1296 NS

Table H42: A comparison of the effect of gender on the resistance of goats to heartwater. [Fisher exact test]

	Male	Female
Died	9 (36%)	18 (53%)
Survived	16 (64%)	16 (47%)

p= 0.29 ; no significant difference.

Table H43: Ages and weights of goats in heartwater experiment.

Groups	Age	Weight (pre-infection)		Weight (post-infection)	
	months	No.	kg ± SE	No.	kg ± SE
1991: Saanen	7 to 8	8	24.5 ± 3.5	0	-
Crossbred	7 to 8	8	22.1 ± 4.0	6	23.7 ± 4.2
Indigenous	7 to 8	8	14.0 ± 1.7	7	14.4 ± 2.0
1992: Indigenous	11 to 12	12	29.1 ± 4.5	5	27.0 ± 3.4
Crossbred	11 to 12	12	39.2 ± 7.3	12	34.8 ± 8.2
1992: Saanen (treated)	12	9	40.9 ± 4.4	8	-
Three-quarter Saanen	12	9	39.5 ± 7.5	2	-

DISCUSSION OF RESULTS

1. CROSSBREEDING OF SAANEN AND INDIGENOUS GOATS: THE EFFECTS ON PRODUCTIVITY

2. CROSSBREEDING OF SAANEN AND INDIGENOUS GOATS: DISEASES (ESPECIALLY HEARTWATER)

DISCUSSION OF RESULTS

The results of this research project will be assessed in the context of the original objectives set; and in comparison with similar research done elsewhere. In addition, there are areas that require further research, which have been identified during the course of the project.

The project can be divided into two main categories:

* the effects of crossbreeding on productivity;
* the effect of crossbreeding on disease.

(The disease selected for specific study was heartwater).

1. CROSSBREEDING OF SAANEN AND INDIGENOUS GOATS: THE EFFECTS ON PRODUCTIVITY

The productivity of Crossbred goats was assessed in comparison to that of Saanen and Indigenous goats. The main categories considered in this section included:

* fertility
* multiple births
* milk production

1.1 Fertility

Reproductive rate is important in the context of crossbreeding of goats for milk production, in that sufficient female kids must be born from the Indigenous goats to supply Crossbreds for milk production as well as replacements for the Indigenous goat herd; and the Crossbreds themselves must reproduce in order to initiate new lactations. An additional source of income for the milk producer should also arise from the sale of surplus animals, and this too depends on an efficient reproductive rate.

The results from this research at MEDUNSA indicated that there were no major problems in regard to fertility for Saanen, Indigenous or for Crossbred goats. The proportion of goats that kidded was in excess of 90 percent, except for the first kiddings of Indigenous goats at the age of about 12 months (Table K8). This was related to the phenomenon of late maturity of Indigenous goats in comparison to the Saanens. No such limitation was apparent for the Crossbred goats, which were very similar to the Saanens in this respect. Kidding percentages in subsequent years were good for all breeds considered. Sands & McDowell (1978) reported kidding intervals of approximately 12 to 13 months across a wide range of breeds of goats, with in some cases a reduction of kidding interval for crossbreds. It must be remembered that in the first few years of the research at MEDUNSA, all goats were on the same diet, which supplied adequate quantites of nutrients. Nutritional limitations might well have an effect under normal circumstances if the goats were to rely only on natural vegetation. Little information seems to have been published about the reproductive rate of Indigenous goats subsisting on natural vegetation without supplementation in the developing areas of South Africa. However, Wilson *et al.*(1989) reported a high reproductive performance of Indigenous goats in Mozambique and Rwanda, which could be improved from existing levels on the farms by applying better management practices. Mrema (1996) in Botswana reported an average of 1.5 kids per female goat each year, which would indicate a good reproduction rate. At MEDUNSA in 1991, a reduction in adequacy of nutrition was probably the cause of the reduction in percentage of Indigenous goats that kidded (Table K7), by which time they had spent a portion of the year on the veld, and were not entirely dependent on the complete diet, as in the early years of the research. This aspect was not specifically assessed in this research.

1.2 Multiple Births

The percentage of kids born for each lactation number is shown in Table K3. In general, the Saanens were more prolific than the Indigenous goats, and Crossbred goats were similar to the Saanens. The Indigenous goats had very few triplets (Table K4). These results are similar to those summarized by Devendra & Burns (1983), ranging from 1.0 to 2.3 kids per parturition. This was in agreement with the data reported by Sands & McDowell (1978), with a range of 1.0 to 2.0. Small litters may be important for Indigenous goats to survive the rigours of climatic extremes in Southern Africa, where droughts occur frequently, and rainfall is often erratic within a rainy season.

1.3 Milk Production

1.3.1 Fitting Lactation Curves

The linear Morant-4 model proved to fit well to most Saanen and Crossbred lactations. (Tables G1, G2 and G3). The mean values for each group of goats were used to draw lactation curves shown in Figures G1 and G2. However, because the lactation curves for Indigenous goats were found to be so variable in shape, curves fitted to the average values of the parameters were unrealistic. Therefore, in Figure G3, curves have been plotted, using the Wood model (Wood 1969), for three typical lactations of Indigenous goats. These curves were very different from those of the Saanen and Crossbred goats (Tables G4, G5 and G6) and warrant further research, with greater numbers of lactations and more precise measurement of milk yields. Wahome *et al.* (1994) studied the lactation curves of Small East African goats using the Wood model. Their lactation curves were very similar to the one for Goat No. 8I17508 shown in Figure G3. They rose to a peak at about three weeks, but their lactation lengths were longer: up to 31 weeks. Montaldo *et al.* (1997) used the Wood model to document differences in lactation curves between various crossbreeds of Alpine, Saanen and Toggenburg goats crossed with local Mexican goats. These were compared to those for Granadina and Nubian crosses with local Mexican goats. The former group had greater values for maximum production and persistency. Young goats (2 and 3 years old) had flatter lactation curves and higher persistency. There were also seasonal effects. The production levels of the crossbred goats were of the same order as those in the MEDUNSA herd. Ruvuna *et al.* (1995) used the Wood model for lactations of straightbred East African and Galla goats and their crosses with Toggenburgs and Anglo Nubians. They documented many differences in the parameters of the lactation curves between all these combinations of breeds. Seasonal effects were significant for nearly all the lactation curve parameters, the season of kidding having a major effect on the shapes of the curves. The four-way cross (all breeds: the Kenyan Dual Purpose Goat) had a superior level of production. These levels of production appeared to be lower than those of the Crossbreds in the MEDUNSA herd. Some of this effect might be attributed to the generous feeding of the complete feed, compared to the feeding systems practised by smallholders in Kenya.

1.3.2 Milk Yields per Lactation

Milk yields of Saanen goats were on average less than those achieved by goats on the Milk Recording Scheme in South Africa. No details of the effect of parity have been published in the Milk Recording results in South Africa, but the mean lactation yield has varied between 900 and 1000 kg per lactation (RSA 1996). Average yields for Saanens in England and the USA have been quoted as 1188kg and 979kg respectively (Shelton 1978). [Although these results were reported a long time ago, it is likely that yields are still of the same order of magnitude, because sire selection is generally not carried out rigorously, as with dairy cattle.] A comparison of the milk yields of MEDUNSA Crossbred goats (Table L2) with those of crossbred goats from other breeds elsewhere in the world (see Review of Literature, page 13), shows that the yields of MEDUNSA Crossbred goats were higher. Mean yields were reported to have ranged from 164kg to 306kg (except for the Saanen x Kilis goats in Turkey). These results might have been because of less favourable nutrition than that provided for the goats at

MEDUNSA. In contrast, the same research reported *higher* milk yields for Three-quarter-bred goats than for the Crossbred goats. However, it seems probable that the relatively poor production of MEDUNSA Three-quarter Saanen goats may have been related to the small number of goats milked in this category.

The lower recorded milk yields of Saanens in the MEDUNSA herd compared to others in South Africa were probably because of a combination of factors:

*** Sires**

The sires used in the herd were not selected for exceptional production. Good average sires were used, from parents with good milk records. However, the sires were representative of average breed production, rather than the best.

*** Unselected Goats**

Goats were not culled from the herd. In the first few years, no goats were removed from the herd because of low milk production. This was to try to ensure that the experimental groups were representative of the real genetic worth of the goats studied, and not a biased sample. In a normal commercial or stud herd, the low yielding goats would not have been tolerated.

*** Complete Feed**

Goats show characteristics of grazing behaviour and diet selection which give them an advantage compared to other livestock. Most goat owners will make use of natural vegetation (Lu 1988), but more intensive feeding systems are needed to maximize milk production (Hadjipanayiotou & Morand-Fehr 1991). The goats at MEDUNSA were fed a complete feed, with a small supplement of dairy meal fed during milking. This was chosen to give a standard diet for all milking groups, to facilitate comparisons of genetic potential, with the minimum of variation resulting from feed differences. A complete feed was chosen also to be a reliable system of ensuring the goats would be adequately fed in spite of labour disruptions. The supplement of dairy meal might have been inadequate for the highest yielders resulting in a shortage of energy at peak milk production, with a consequent reduction in total lactation yield. This would be in spite of the fact that higher milk yields result in greater feed intake (Randy *et al.* 1988). Nevertheless, the complete feed diet chosen was of great value in ensuring that all goats had access to the same level of nutrition, eliminating feed effects as far as possible between breeds. In contrast, in a commercial or stud herd the economic incentive would have encouraged the farmer to feed a goat according to her individual needs and to maximize production.

Complete feeds are apparently not commonly used for milk goats, but have been used in some circumstances (Morand-Fehr *et al.* 1996; Reddy & Raghavan 1992). They were not mentioned in an review by Hadjipanayiotou & Morand-Fehr in 1991. Kawas *et al.* (1991) reported on the effects of different forage-to-concentrate ratios for diets of goats in Mexico, and found no effect of varying proportions. However, the milk yields for the Crossbred goats in the experiment were relatively low at about 0.5 litres per day.

*** Unequal Milking Intervals**

The large difference in the time between morning and afternoon milkings may well have had a depressing effect on lactations because of the build-up of milk overnight in high-yielding goats early in lactation (Wilde & Peaker 1990). Rischkowsky & Steinbach (1997) measured milk production of Crossbred goats (Saanen x Malawi Indigenous goats) at only 104 kg per lactation compared to a potential of 130 kg. Apart from feed inadequacies, one factor that suppressed milk production was the irregularity of milking. Initially the goats were milked once a day, but five years later, only a few were milked as often as four times a week.

*** Summary**

In summary, the broad differences between breeds in milk yield per lactation in the MEDUNSA herd were:

* Saanens had the highest yields, with lactation lengths of at least 300 days;

* Indigenous goats had very low yields, and very short lactations;

* Crossbred goats produced less milk than the Saanens, but far more than the Indigenous goats. Lactation length was slightly shorter than that of the Saanens. Strong hybrid vigour (heterosis) effects made milk production of Crossbred goats much closer to that of the Saanens than the Indigenous goats.

- Three-quarter Saanens produced a quantity of milk similar to that of the Crossbreds. Presumably any relative reduction in hybrid vigour was offset by the closer relationship to the pure Saanens.

1.3.3 Lactation Length and Dry Periods

The lactation lengths of Saanens were at least 300 days, and in many lactations milk production continued for a longer time than this. In one year a proportion of goats was left without being mated at the normal breeding season (March to May), and these goats continued in their lactations for up to double the normal length. However, not all goats were capable of continuing for the full length of these extended lactations. Lactation length and breeding policy determined the length of the dry period. Saanen and Crossbred goats had similar dry period lengths of about two months. The Indigenous goats had short lactations of two to four months, and therefore had very long dry periods, since they were also bred to kid every 12 months. Sands & McDowell (1978) reported mean lactation lengths of 270 to 300 days for most dairy breeds, but much shorter lactations for Indigenous breeds in India, Africa and Central America, ranging up to about 200 days. Crossbred goats had intermediate lactation lengths.

1.3.4 Milk Composition

Milk samples were analysed only for milkfat, protein and lactose percentages. It was not possible to analyse milk composition in more detail in this research herd. This is an area that warrants further research, particularly in the light of the beneficial nutritional and anti-allergenic properties reported about goat milk (Park 1994).

The mean analyses (Table L5) should be compared to the results reported by Jenness (1980). [See Review of Literature, page 9]. Saanen milk proved to have a broad compositional analysis similar to that of cows. Indigenous goats had milk that was very concentrated. No comparative information from this type of goat is available even though milk yields of similar goats have been measured (Cooper *et al.* 1994). The milk of Crossbred goats was approximately two percentage points higher for milk fat, and one percentage point higher for protein than that of Saanen goats. The analysis of milk from Three-quarter Saanens was similar to that of the Crossbred goats, rather than that of the pure Saanens. This means that although Crossbred and Three-quarter Saanens had lower total milk production per lactation than pure Saanens, the production of Total Solids in the milk was not as low, because of the higher percentages. This relationship was examined in the statistical analyses involving composition corrected milk (FCM,PCM, LCM, and FPLCM).

1.3.5 Composition Corrected Milk

Fat Corrected Milk has traditionally been a fairer means of comparison between lactations than straight milk yield, when the comparison is between cows producing milk of very different compositional analysis, such as between Holstein and Jersey cows (Schmidt & Van Vleck 1974). Since milkfat percent is susceptible to variations because of feeding and sampling, other criteria might be more reliable. Therefore, in this study, total milk production was corrected for fat, protein, lactose and also for all three criteria together (Fat-Protein-Lactose Corrected Milk).

Composition corrected yield estimates for Indigenous goats increased greatly because of the high percentage of nutrients in the milk. Those for Saanen goats decreased compared to the uncorrected milk yields, because Saanens generally had milk composition analyses lower than those used for the correction factors. In contrast, composition corrected yields for Crossbred and Three-quarter Saanen goats were increased, because their milk composition analyses were generally higher than those used for the correction factors. Nevertheless, even when milk production was corrected for these factors, the composition corrected yields of Saanens were still higher than those of Crossbreds and Three-quarter Saanens.

Fat-Protein-Lactose Corrected Milk yields of Crossbreds varied between 0.70 and 0.76 of the yields of Saanens of the same parity (Table L12). However, the mean bodyweights of Crossbreds was generally not much less than that of the Saanens, as is illustrated in Figure M1 (in the section "Materials and Methods"). It is unlikely that the differences of milk production between these breeds was affected significantly by differences in bodyweight. In contrast, the weights of Indigenous goats were considerably less (Figure M2), but their milk yields were dramatically lower that those of Saanens or Crossbreds, even when corrected for milk composition.

1.4 Factors Affecting Milk Production

Many of the factors that normally affect milk production, such as management differences, feeding systems and seasonal effects, were not relevant in this research because of the management systems that were applied. Until 1992, the breeding season was the same (autumn); natural breeding was practised, using a variety of billy goats; feeding was uniform, using one type of complete feed, with a small supplement of dairy meal in the milking parlour; and goats were bred to kid for the first time at about 12 months of age. Therefore, comparisons between breeds were more valid than they would have been in a less controlled situation.

Breed differences had the greatest influence on milk production and milk composition. Saanen goats had the highest yields, but the milk with the lowest concentration of nutrients. The Indigenous goats had very short lactations with low yields, but very high concentrations of nutrients in comparison. The Crossbred goats showed an effect of heterosis, not only in terms of milk yield, but also for milkfat and protein percentage.

Lactation number was significant ($P<0.05$), especially when first and subsequent lactations were compared. This result was similar to many other reports (e.g. Browning *et al.* 1995). Lactation length was significantly ($P<0.05$) different between breeds, and this was a major factor in determining the total lactation yield. The number of kids born was assessed as a significant ($P<0.05$) factor associated with lactation yield in a few of the comparisons. This was most likely because of breed differences in the incidence of multiple births, and due to the fact that the incidence of twinning increased with lactation number; and not because of an inherent effect of the number of kids born *per se*. However, Montaldo *et al.* (1991) reported in crossbred goats in Mexico that only 7% of variation in litter size was associated with parity: litter sizes increased from 1.5 to 1.8 (first to fourth kidding). No correlation was reported with milk production, although the milk yields were low (121kg in first lactation; 171kg in fourth lactation).

No attempt was made to assess the effect of disease on milk production. Direct effects were of course apparent, such as with mastitis, but indirect effects such as those arising from high kid mortality and the effects on replacement rate or sales of animals were not estimated.

1.5 Milk Production: The Benefits of Crossbreeding

Computations to estimate heterosis have not been done in this research, because of the limited data, and because information is not available on the performance of reciprocal crossbreds. Nevertheless, first lactation Crossbreds produced much more FPLCM than the average of the two parent breeds at this parity. This is a good indication of the benefit of heterosis. The lactations of Three-quarter Saanens were disappointing in comparison, but interpretation should be tempered by an awareness of the small number of lactations of these goats. They may well not be a representative sample. Table L12 (page 91) lists the mean standardized milk yields for Fat-Protein-Lactose Corrected Milk (FPLCM).

The benefits of crossbreeding among these goats are comparable to those reported by Rege *et al.* (1994) in cattle crossed with Jerseys. They found a strong effect of heterosis in terms of milk yields with the F1 Crossbred cows, but there was no benefit of back-crossing to produce a Three-quarter Jersey cow. This agreed with the results reported by Syrstad (1990). These results indicate that the option of crossbreeding is probably the most suitable method for introducing milk production potential to local goat breeds (Sands & McDowell 1978): using local breeds to produce Crossbred females; and to repeat the process for replacement animals. The suggested alternative of up-grading may show little benefit; and the development of a new (adapted) breed would be a solution only with a long-term programme of development (Shelton 1986). A few studies have shown an equal or improved performance of the Three-quarter (up-graded) breeds of goat for milk production (Sahni & Chawla 1982); but this was not shown in the research herd at MEDUNSA.

Other researchers have reported similar benefits of crossbreeding to form "new" or "synthetic" breeds. Horst (1997) reported that the Jermasia synthetic breed improved milk production to 250kg per lactation compared to 45kg for Kambing Katjang goats in Malaysia.

Baker & de Souza Neto (1989) reported low productivity of dual-purpose goats in Brazil, which gave a total of only 107kg in a lactation of 134 days. The main reasons suggested for the low milk yields were inbreeding and poor nutrition.

The most thoroughly studied programme in Africa has been in Kenya, where a dual-purpose goat has been developed (Semenye *et al.* 1989). This research was carried out thoroughly, has been accepted, and is part of the lives of many people: the report by Miller & Mwangi 1996 concerned 1300 milk goat owners. In contrast, a crossbreeding project in Malawi has not proved to be sustainable (Rischkowsky & Steinbach 1997), although the reasons were not due to the goats, but were socio-economic. Among these were the design and administration of the project: goats were "loaned" to people, and many were subsequently sold; the programme was not sustained for a long enough duration; and "the motivation for the acceptance or rejection of goat milk production was hard to clarify, as the farmers were never completely frank when giving their reasons."

2. CROSSBREEDING OF SAANEN AND INDIGENOUS GOATS: DISEASES (ESPECIALLY HEARTWATER)

The occurrence of diseases in the goat herd was monitored; and a large number of goats that died were evaluated by post-mortem examination. In addition, heartwater, the widespread and devastating tick-borne disease in South Africa, was assessed for its effects on the different breeds of goats.

2.1 Occurrence of Diseases

Record-keeping of the incidence of diseases in the herd was not consistent or satisfactory, so that a complete record is not available. A detailed analysis of post-mortems examinations was carried out, which represents a good sample of the incidence of fatal diseases. However, there were other diseases, which though not fatal, were also important in the herd.

2.1.1 Kid Mortality

In the MEDUNSA herd, no breed effects were apparent in the ability of goat kids to survive. This was similar to the finding of Rischkowsky & Steinbach (1997) who reported losses of 24.0% and 22.8% of local Malawi goats and F1 crossbreds (with Saanens) on smallholder farms. Kid mortality can be much higher, as for example reported among West African Dwarf goats in Ghana, where 55 percent of kids died within three months, mainly as a result of starvation and pneumonia (Oppong & Yebuah 1981). Losses can be severe even for animals kept under extensive management systems, as reported by Ndlovu & Sibanda (1991) in

Zimbabwe. The reasons for kid mortality have been reported to be usually respiratory and gastrointestinal diseases (Nagy *et al.* 1987). This was true for the MEDUNSA goat herd. The mortality of kids was unacceptably high at 29 percent on average (Table D8.2, page 141).

The major disease problem among goat kids at MEDUNSA was, without doubt, the loss of goat kids as a result of coccidiosis. This has been described as a disease of intensification (Vihan 1992b). A proportion of goat kids was lost soon after being born, related to inadequate colostrum intake, poor mothering ability, and overcrowding. It is well known (O'Brien & Sherman 1993a,b) that immunoglobulin levels are important for the survival of neanatal goat kids. Vihan (1988) reported a loss of 20 percent mainly arising from this reason. However, the great losses at MEDUNSA occurred later in the lives of the kids, at about the age of two to four months. Diarrhoea quickly spread through the group of kids. A timely treatment with Vecoxan® was usually effective in stopping the diarrhoea, but by then the damage had been done. Affected goat kids usually died, if not from diarrhoea, then from pneumonia. The few kids that were saved often took months to recover, and some remained stunted and had to be culled. In addition to treatment with Vecoxan®, preventative measures included the addition of an ionophore to the feed, either Romensin® or Taurotec®. Such compounds have a coccidiostatic effect. This was at first thought to be ineffective, because kids with coccidiosis stopped eating anyway, which reduced the intake of coccidiostat. However, in one year the feed mill supervisor, for no apparent reason, omitted the ionophore, and a devastating outbreak of coccidiosis occurred, even though the kids had been born in autumn (a better time of the year). This unintended and undesirable change in the feeding policy illustrated clearly the importance of including the ionophore in the kids' diet. Monensin has been shown to reduce the effects of coccidiosis in lambs (Muwulla *et al.* 1994). In the first three years, kids were taken from their mothers and kept in groups of up to ten in nursery pens with slatted floors. They were there fed 0.5 litre milk twice a day, and had free access to the complete feed. Research by Greenwood (1993) has indicated that a high protein diet (18.7% Crude Protein in the Dry Matter) resulted in a higher growth rate of kids compared to those fed a diet containing 14.4% CP in the DM. The complete feed given the the goat kids at MEDUNSA was at the level of approximately 14% CP. Further research is warranted to determine not only if a high protein diet would result in better growth rates, but also improve survival rates of goat kids. Systems of kid rearing have been well documented by researchers in France (Simon *et al.* 1986), but techniques need to be adapted to South African conditions.

The system of kid rearing that was initially used had to be abandoned because of labour difficulties, and the uncertainty whether there would be anyone available to feed the kids.

Therefore, in subsequent years, the kids were allowed to run with their mothers until about six weeks of age. This system, although more similar to the method likely to be used by farmers in the developing areas, was inefficient. It meant that less milk was available for sale, and inevitably resulted in poorer control and management. It cannot be recommended, but the use of it in the MEDUNSA herd should be seen in the context of the turbulent political situation in South Africa at that time. An improvement in hygiene and in careful husbandry of the kids in recent years has made a great difference in reducing the effects of coccidiosis in the kids, but it is still the most important problem in the herd, and warrants further research.

2.1.2 Mortality of Adult Goats

A wide range of diseases resulted in the deaths of adult goats. The most important of these identified from post-mortem examinations were mastitis, ketosis and pneumonia. Both mastitis and ketosis are management related diseases; and pneumonia was probably the end result of other diseases or general debilitation. Few cases of dystocia were recorded, but some goats were lost as a result of uterine infections and peritonitis, sometimes following dystocia. Some goats suffered from pregnancy toxaemia, and some of the cases of ketosis were clearly related to the increased demand for energy late in gestation. In this regard, it is important to supply a diet with sufficient energy, especially where there are multiple births. Some goats suffered from ketosis when they had gained too much weight; these were usually Crossbred goats. There is therefore a need to supply a complete feed or diet for dry goats that is different from that fed to lactating goats, particularly if the dry period is expected to be longer than two months. Indigenous goats, in later years when they were not fed a complete feed continuously, showed a good ability to survive severe changes in the quality and quantity of feed. However, in general, the incidence of diseases causing deaths of adult goats could not be said to differ between breeds.

2.1.3 Mastitis

Kalogridou-Vassiliadou (1991) reported high levels of mastitis organisms in goat herds in Greece, but stated:

> *"no mastitis control measures ... have been adopted by farmers"*
>
> (Kalogridou-Vassiliadou *et al.* 1991).

The basic control measures for mastitis prevention and control are well established (Dodd & Neave 1970; Kingwill *et al.* 1979) and include hygienic practices in the milking routine (washing and drying the udder; stripping foremilk to test for mastitis; teat disinfection after milking); prompt antibiotic treatment of clinical cases; intramammary therapy in the dry period to control sub-clinical infections; and strategic culling of chronically infected animals. These procedures were carried out routinely in the MEDUNSA goat herd, except that intramammary dry period therapy was discontinued after the third year because of management difficulties. Further research should be carried out to determine the need for and the potential benefits of dry period intramammary therapy in goats. Subclinical mastitis appeared to be low, but a full survey was carried out in only one year. Losses from peracute mastitis have been quantified (Tables D1 and P1). A few goats lost half udders as a consequence. The recording of only 28 cases of clinical mastitis in a period of six years indicated a relatively moderate level of infection in the herd.

2.1.4 Internal Parasites

Internal parasites were not a problem in the Milch Goat Project, but might well be in other circumstances especially where goats are kept on pastures (Cabaret *et al.* 1989). Some work on resistance to haemonchosis in Saanen goats has been reported from New Zealand (Gill *et al.* 1991). Dosing with anthelmintics may lead to resistance (Pomroy 1996), as demonstrated with *Haemonchus contortus* in goats in Sri Lanka (Van Aken *et al.* 1989). This is an area that warrants further research, particularly as Indigenous goats appear to show some resistance.

2.1.5 External Parasites

Lice were the only external parasites of note among the goats kept in the pens or shed. Ticks occurred on the Indigenous goats (which were kept in the veld after the first few years on zero grazing), but did not seem to cause major problems. Tick resistance was not studied in this research project, and is an area that warrants further study, particularly as Indigenous goats appeared to be more resistant than the other breeds. The report of the FAO First Expert Consultation (FAO 1994) indicated that although tick-borne diseases were of great significance in Africa,

> *" tick control was of little value, because of the complexity of most situations, the expense and the experience of many failures."*

2.2 Heartwater

The FAO (1994) report stated:

> *" Heartwater is one of the major constraints to ruminant livestock industries in most of Sub-Saharan Africa, and has spread to the Caribbean where it is a severe threat to the livestock industries of America."*

Matheron *et al.* (1987) reported low levels (25%) of genetic resistance to heartwater in Guadeloupe native goats. The value of genetic resistance to disease has been recognized as a general principle, especially for trypanotolerance, where it has been reported to be higher in Indigenous breeds of sheep and goats compared to exotic breeds (Griffin & Allonby 1979). No research has been reported on genetic resistance to heartwater in goats in South Africa, apart from the preliminary report on the MEDUNSA research (Donkin *et al.* 1992). After the goats had been given heartwater blood, they all showed the same temperature reaction, which indicated that none was completely resistant. This was in contrast to research on cattle, where some showed no reaction at all (Du Plessis & Bezuidenhout, 1979; Du Plessis, 1985). The temperature reactions also confirmed that the goats had not been previously exposed to heartwater. The similarity of temperature reaction between breeds was not reflected in the incidence of clinical signs, which were more severe in Saanens and in the Crossbred goats. Mortality was highest in the Saanens, and less in Crossbred goats, apparently in proportion to the contribution of Saanen genes. The Indigenous goats had a resistance to heartwater, but still showed a typical temperature reaction and some clinical signs, though less than shown by the Saanens. They appeared to be able to transfer this resistance to a good proportion of Crossbred goats (approximately half).

No effect of gender was apparent in resistance to heartwater, in contrast to that found in Guadeloupe (Matheron *et al.* 1987). The male goats were all castrated, but it seems unlikely that this would have made a difference. No differences were noted in temperature reactions or the incidence of clinical signs (except for those directly associated with death) between those goats that survived or those that died, even though there were substantial differences between genotypes in the proportions that survived or died.

Serum conglutinin levels were no apparent indication of potential resistance. This was in contrast to the findings reported for cattle (Du Plessis 1985; Du Plessis & Malan 1987). Therefore, at this stage, the only indicator of the ability to survive heartwater is the positive result to a direct challenge with the disease. This would make any attempt to select for resistance an expensive procedure, involving considerable suffering by both resistant and susceptible goats. However, as the resistance to heartwater shown by these Indigenous goats can be incorporated in goats that are kept for milk production, then it is possible to use these goats as a source of milk to alleviate human malnutrition in areas affected by heartwater.

2.3 Diseases: The Benefits of Crossbreeding

This research has demonstrated a benefit of crossbreeding in transferring genetic resistance to heartwater from Indigenous to Crossbred goats. In any situation it is difficult to separate genetic from other influences, especially managerial and environmental effects. For example, no clear benefit of crossbreeding was apparent in reducing kid mortality in this herd. Nevertheless, further research should be carried out to assess benefits of crossbreeding for resistance to other diseases and against internal and external parasites.

CONCLUSIONS

The main objectives as set out in the original research protocols have been achieved:

1. CROSSBREEDING FOR MILK PRODUCTION

Crossbreeding Saanen and South African Indigenous goats to achieve adequate levels of milk production for subsistence purposes was successful. Although the Crossbreds produced less milk than pure Saanens, the amount of milk and the duration of lactation was much closer to that of Saanen than of Indigenous goats. The average daily yields were adequate for the needs of householders and subsistence farmers. Upgrading by breeding Crossbred goats to a Saanen male resulted in Three-quarter Saanens which had yields similar to those of the Crossbreds.

2. CROSSBREEDING FOR RESISTANCE TO HEARTWATER

South African Indigenous goats were shown to have a genetic resistance to heartwater, and this resistance was transmitted to a large proportion of Crossbred goats (about half). These results give hope that the Crossbred goats can be used for small-scale milk production in areas where heartwater is an important disease.

3. CROSSBRED GOATS FOR MILK PRODUCTION IN SOUTH AFRICA

This study has shown that Indigenous female goats can provide the basis for milk production by householders or small-scale farmers in developing areas by crossing them with Saanen males to produce female Crossbred milk goats. This would make it possible to develop goat milk production schemes rapidly and economically, using resources already available in these areas. Further upgrading towards the pure Saanen would probably be a disadvantge, especially in view of the low resistance to heartwater of the Three-quarter Saanen. The development of a new synthetic breed might not be necessary if Indigenous goat herds can provide a source of females for crossbreeding.

4. MANAGEMENT OF MILK GOATS IN SOUTH AFRICA

Many aspects of management were developed which will have application to the success of a wider introduction of milk goats in South Africa. In the process, many aspects were identified which require further research. These include the following:

* 4.1 Kid mortality

This was the most significant disease problem affecting the goats. Further research is needed to identify the causes and develop management strategies to eliminate the problem.

Although lack of colostrum and poor mothering ability contribute to kid mortality, the greatest problem identified was diarrhoea. This was presumed to be caused by coccidicosis, but this has not been proved, and the possibility of other causative agents cannot be excluded. For example, the role of rotavirus in diarrhoea of goat kids needs to be examined more thoroughly.

* 4.2 Heartwater

The proof of genetic resistance to heartwater is only the first step. The programme should be extended to develop a resistant breed of milk goats. This would require facilities and resources beyond those available at present.

* 4.3 Resistance to Parasites

The resistance of South African Indigenous and Crossbred goats to inernal and external parasites should be measured. It seems likely that these goats will be a valuable source of genetic material that could be used to contibute traits of hardiness like these to other breeds.

* 4.4 Mastitis

Mastitis is recognised as one of the most important diseases of dairy cows. A thorough examination of the incidence of clinical and subclinical mastitis is needed, to establish levels of infection, and to assess if the established methods of mastitis control for dairy cows are appropriate for milk goats. There are recognised differences, for example in the levels of Somatic Cell Counts (SCC) (Contreras *et al.* 1997), and an indication that mastitis treatments may behave differently in goats compared to cows (Buswell *et al.* 1989).

* 4.5 Out-of-Season Breeding

Marketing goat milk is a specialized activity, since the biggest demand for fresh milk is from people or children who have allergic reactions to cow milk. To supply this market, a year-round production of milk is essential. The seasonal breeding of milk goats is a handicap to the establishment of a commercial milk goat operation. Work done in France promises to make the manipulation of breeding season feasible and sustainable (Chemineau *et al.* 1996). These techniques need to be assessed and adapted if necessary to South African conditions.

* 4.6 Alternative Feed Sources

Alternative feed sources must be assessed and developed which will be appropriate and suitable for the different agro-ecological regions of South Africa, with particular application to the small-scale farmer.

* 4.7 Application of Development to Small-Scale Farmers

Systems need to be developed , preferably by using such techniques as Farming Systems Research and Extension (FSR-E), so that the concept of using milk goats can be promoted and adopted by the people of South Africa who are in greatest need of such a source of high quality protein. An aspect that was not studied was the acceptability of goat milk by the people perceived to be likely to benefit from keeping milk goats. However, many communities have clearly stated that the drinking of goat milk is, or has been traditional. The introduction of Crossbred milk goats to a limited number of farmers through pilot outreach programmes has resulted an enthusiastic response.

* 4.8 Nutritional Value of Goat Milk

The nutritional value of goat milk needs to be evaluated in relation to normal nutritional parameters. In addition, its benefits to adults and children who are allergic to cow milk should be assessed more precisely than has been done.

* 4.9 Small-Scale Milk Processing Methods

Methods of processing milk hygienically must be developed which are appropriate for the small-scale producer. This should include fermented milk products, considering the relatively high proportion of the adult population that develops lactose intolerance with maturity.

APPENDIX A

COMPOSITION-CORRECTED MILK

COMPOSITION CORRECTED LACTATIONS

Table L13: Lactations Corrected for Fat, Protein and Lactose:
All Breeds: All Lactations.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	272	543 ± 275	6	1404
Fat (%)	269	4.66 ± 1.95	2.17	13.62
Protein (%)	317	3.65 ± 0.99	2.23	7.80
Lactose (%)	317	4.72 ± 0.41	3.47	6.16
Fat Corrected Milk (kg)	262	541 ± 216	24	1130
Protein Corrected Milk (kg)	262	572 ± 239	20	1284
Lactose Corrected Milk (kg)	262	562 ± 263	9	1376
FPL Corrected Milk (kg)	262	557 ± 233	17	1245

Table L14: Lactations Corrected for Fat, Protein and Lactose:
All Breeds: Lactations 1,2 and 3.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	246	531 ± 276	6	1404
Fat (%)	243	4.75 ± 2.00	2.17	13.62
Protein (%)	269	3.62 ± 1.00	2.23	7.80
Lactose (%)	269	4.69 ± 0.35	3.47	5.80
Fat Corrected Milk (kg)	236	535 ± 217	24	1130
Protein Corrected Milk (kg)	236	563 ± 241	20	1284
Lactose Corrected Milk (kg)	236	553 ± 265	9	1376
FPL Corrected Milk (kg)	236	550 ± 235	17	1254

Table L15: Lactations Corrected for Fat, Protein and Lactose:
Saanen Goats: Lactations 1,2 and 3.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	135	708 ± 202	334	1404
Fat (%)	132	3.43 ± 0.54	2.17	4.76
Protein (%)	132	2.88 ± 0.33	2.23	3.60
Lactose (%)	132	4.51 ± 0.20	3.97	5.00
Fat Corrected Milk (kg)	132	604 ± 172	215	1130
Protein Corrected Milk (kg)	132	677 ± 188	297	1284
Lactose Corrected Milk (kg)	132	710 ± 201	334	1376
FPL Corrected Milk (kg)	132	664 ± 180	301	1254

Table L16: Lactations Corrected for Fat, Protein and Lactose:
Indigenous Goats: Lactations 1,2 and 3.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	21	23 ± 13	6	57
Fat (%)	26	9.33 ± 1.84	5.13	13.62
Protein (%)	52	5.21 ± 0.83	3.83	7.80
Lactose (%)	52	4.96 ± 0.57	3.47	5.80
Fat Corrected Milk (kg)	19	53 ± 22	24	107
Protein Corrected Milk (kg)	19	43 ± 20	20	97
Lactose Corrected Milk (kg)	19	26 ± 15	9	63
FPL Corrected Milk (kg)	19	40 ± 18	17	87

Table L17: Lactations Corrected for Fat, Protein and Lactose:
Crossbred Goats: Lactations 1,2 and 3.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	68	384 ± 126	56	753
Fat (%)	66	5.47 ± 0.67	4.11	7.16
Protein (%)	66	3.88 ± 0.30	3.29	4.87
Lactose (%)	66	4.81 ± 0.18	4.07	5.12
Fat Corrected Milk (kg)	66	536 ± 162	256	1022
Protein Corrected Milk (kg)	66	507 ± 151	261	1086
Lactose Corrected Milk (kg)	66	421 ± 123	154	810
FPL Corrected Milk (kg)	66	483 ± 141	220	956

Table L18: Lactations Corrected for Fat, Protein and Lactose:
Three-quarter Saanen Goats: Lactations 1,2 and 3.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	22	390 ± 161	82	677
Fat (%)	19	5.10 ± 0.64	4.01	6.22
Protein (%)	19	3.50 ± 0.41	2.76	4.49
Lactose (%)	19	4.73 ± 0.17	4.50	5.07
Fat Corrected Milk (kg)	19	539 ± 163	291	894
Protein Corrected Milk (kg)	19	494 ± 150	268	774
Lactose Corrected Milk (kg)	19	449 ± 138	214	707
FPL Corrected Milk (kg)	19	492 ± 146	255	789

Table L19: Lactations Corrected for Fat, Protein and Lactose:
Saanen Goats: First Lactations.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	59	579 ± 130	334	885
Fat (%)	56	3.41 ± 0.57	2.34	4.58
Protein (%)	56	2.86 ± 0.34	2.23	3.60
Lactose (%)	56	4.56 ± 0.18	4.24	5.00
Fat Corrected Milk (kg)	56	487 ± 116	215	770
Protein Corrected Milk (kg)	56	548 ± 127	297	850
Lactose Corrected Milk (kg)	56	585 ± 132	334	883
FPL Corrected Milk (kg)	56	541 ± 117	301	823

Table L20: Lactations Corrected for Fat, Protein and Lactose:
Saanen Goats: Second Lactations.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	48	838 ± 177	487	1404
Fat (%)	48	3.44 ± 0.50	2.17	4.59
Protein (%)	48	2.89 ± 0.33	2.35	3.60
Lactose (%)	48	4.49 ± 0.20	3.97	4.92
Fat Corrected Milk (kg)	48	716 ± 148	375	1130
Protein Corrected Milk (kg)	48	801 ± 165	404	1284
Lactose Corrected Milk (kg)	48	836 ± 182	488	1376
FPL Corrected Milk (kg)	48	785 ± 156	454	1254

Table L21: Lactations Corrected for Fat, Protein and Lactose:
Saanen Goats: Third Lactations.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	28	758 ± 208	487	1295
Fat (%)	28	3.46 ± 0.55	2.37	4.76
Protein (%)	28	2.90 ± 0.32	2.36	3.60
Lactose (%)	28	4.43 ± 0.19	4.10	4.90
Fat Corrected Milk (kg)	28	644 ± 158	425	1030
Protein Corrected Milk (kg)	28	721 ± 163	498	1166
Lactose Corrected Milk (kg)	28	745 ± 203	501	1278
FPL Corrected Milk (kg)	28	704 ± 169	482	1162

Table L22: Lactations Corrected for Fat, Protein and Lactose:
Saanen Goats: Fourth Lactations.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	15	764 ± 242	435	1165
Fat (%)	15	3.41 ± 0.46	2.69	4.63
Protein (%)	15	2.88 ± 0.34	2.44	3.57
Lactose (%)	15	4.39 ± 0.16	4.11	4.73
Fat Corrected Milk (kg)	15	643 ± 191	382	966
Protein Corrected Milk (kg)	15	717 ± 179	445	999
Lactose Corrected Milk (kg)	15	743 ± 228	440	1129
FPL Corrected Milk (kg)	15	701 ± 197	421	1013

Table L23: Lactations Corrected for Fat, Protein and Lactose:
Saanen Goats: Fifth Lactations.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	6	503 ± 111	349	657
Fat (%)	6	3.41 ± 0.67	2.54	4.39
Protein (%)	6	2.90 ± 0.50	2.42	3.86
Lactose (%)	6	4.38 ± 0.27	4.08	4.81
Fat Corrected Milk (kg)	6	427 ± 115	254	558
Protein Corrected Milk (kg)	6	483 ± 107	282	602
Lactose Corrected Milk (kg)	6	489 ± 107	329	596
FPL Corrected Milk (kg)	6	466 ± 103	290	584

Table L24: Lactations Corrected for Fat, Protein and Lactose:
Indigenous Goats: First Lactations.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	21	23 ± 13	6	57
Fat (%)	20	9.09 ± 1.80	5.13	13.62
Protein (%)	23	5.39 ± 0.74	3.93	7.40
Lactose (%)	23	4.77 ± 0.51	3.52	5.67
Fat Corrected Milk (kg)	19	53 ± 22	24	107
Protein Corrected Milk (kg)	19	43 ± 20	20	97
Lactose Corrected Milk (kg)	19	26 ± 15	9	63
FPL Corrected Milk (kg)	19	40 ± 18	17	87

Table L25: Lactations Corrected for Fat, Protein and Lactose: Crossbred Goats: First Lactations.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	32	317 ± 102	56	575
Fat (%)	30	5.41 ± 0.68	4.11	6.74
Protein (%)	30	3.91 ± 0.35	3.29	4.87
Lactose (%)	30	4.81 ± 0.20	4.07	5.08
Fat Corrected Milk (kg)	30	452 ± 133	256	923
Protein Corrected Milk (kg)	30	434 ± 111	261	826
Lactose Corrected Milk (kg)	30	357 ± 86	154	617
FPL Corrected Milk (kg)	30	410 ± 106	220	778

Table L26: Lactations Corrected for Fat, Protein and Lactose: Crossbred Goats: Second Lactations.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	24	446 ± 118	271	753
Fat (%)	24	5.53 ± 0.71	4.29	7.16
Protein (%)	24	3.86 ± 0.27	3.34	4.33
Lactose (%)	24	4.80 ± 0.19	4.21	5.12
Fat Corrected Milk (kg)	24	612 ± 159	339	1022
Protein Corrected Milk (kg)	24	573 ± 160	373	1086
Lactose Corrected Milk (kg)	24	476 ± 128	287	810
FPL Corrected Milk (kg)	24	549 ± 143	339	956

Table L27: Lactations Corrected for Fat, Protein and Lactose: Crossbred Goats: Third Lactations.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	12	438 ± 120	219	600
Fat (%)	12	5.52 ± 0.58	4.83	6.46
Protein (%)	12	3.85 ± 0.24	3.61	4.31
Lactose (%)	12	4.82 ± 0.14	4.52	5.01
Fat Corrected Milk (kg)	12	593 ± 141	353	850
Protein Corrected Milk (kg)	12	559 ± 149	291	770
Lactose Corrected Milk (kg)	12	467 ± 124	244	631
FPL Corrected Milk (kg)	12	535 ± 134	294	714

Table L28: Lactations Corrected for Fat, Protein and Lactose: Crossbred Goats: Fourth Lactations.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	5	504 ± 227	311	828
Fat (%)	5	5.48 ± 0.76	4.41	6.37
Protein (%)	5	3.86 ± 0.02	3.83	3.88
Lactose (%)	5	4.74 ± 0.12	4.56	4.87
Fat Corrected Milk (kg)	5	658 ± 208	495	913
Protein Corrected Milk (kg)	5	649 ± 295	398	1071
Lactose Corrected Milk (kg)	5	528 ± 229	337	865
FPL Corrected Milk (kg)	5	605 ± 238	408	935

Table L29: Lactations Corrected for Fat, Protein and Lactose: Three-quarter Saanens: First Lactations.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	12	320 ± 166	82	569
Fat (%)	9	5.13 ± 0.60	4.01	6.01
Protein (%)	9	3.68 ± 0.47	2.76	4.49
Lactose (%)	9	4.76 ± 0.20	4.50	5.07
Fat Corrected Milk (kg)	9	476 ± 147	291	730
Protein Corrected Milk (kg)	9	461 ± 168	268	749
Lactose Corrected Milk (kg)	9	402 ± 149	214	613
FPL Corrected Milk (kg)	9	444 ± 152	255	689

Table L30: Lactations Corrected for Fat, Protein and Lactose: Three-quarter Saanens: Second Lactations.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	5	438 ± 115	300	584
Fat (%)	5	5.09 ± 0.63	4.43	6.01
Protein (%)	5	3.33 ± 0.19	3.04	3.56
Lactose (%)	5	4.74 ± 0.10	4.60	4.86
Fat Corrected Milk (kg)	5	542 ± 114	391	648
Protein Corrected Milk (kg)	5	476 ± 103	333	560
Lactose Corrected Milk (kg)	5	455 ± 114	314	578
FPL Corrected Milk (kg)	5	491 ± 108	367	589

Table L31: Lactations Corrected for Fat, Protein and Lactose: Three-quarter Saanens: Third Lactations.

Variable	No.	Mean ± SE	Min.	Max.
Milk Yield (kg)	5	509 ± 109	378	677
Fat (%)	5	5.04 ± 0.84	4.14	6.22
Protein (%)	5	3.33 ± 0.37	2.79	3.81
Lactose (%)	5	4.64 ± 0.17	4.50	4.91
Fat Corrected Milk (kg)	5	649 ± 198	407	894
Protein Corrected Milk (kg)	5	570 ± 154	406	774
Lactose Corrected Milk (kg)	5	527 ± 123	378	707
FPL Corrected Milk (kg)	5	581 ± 153	395	789

APPENDIX B

APPENDIX B

TABLES: CORRELATIONS: Lactation Yield and Milk Composition

Table C1.16: Correlations: Lactation Yield and Milk Composition: Three-quarter Saanens: First Lactations

Table C1.17: Correlations: Lactation Yield and Milk Composition: Three-quarter Saanens: Second Lactations

Table C1.18: Correlations: Lactation Yield and Milk Composition: Three-quarter Saanens: Third Lactations

Table C1.19: Correlations: Lactation Yield and Milk Composition: Three-quarter Saanens: Lactations 1,2,3

TABLES: CORRELATIONS (C1)

Table C1.1: Correlations: Lactation Yield and Milk Composition: All Goat Breeds: All Lactations.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.72987 0.0001 262	-0.73410 0.0001 262	-0.36080 0.0001 262
Fat(%)		0.93674 0.0001 269	0.14095 0.0208 269
Protein(%)			0.37235 0.0001 317

[In each cell is listed: correlation; significance; number of lactations]

Table C1.2: Correlations: Lactation Yield and Milk Composition: All Goat Breeds: Lactations 1,2,3.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.74533 0.0001 236	-0.74847 0.0001 236	0.34476 0.0001 236
Fat(%)		0.93850 0.0001 243	0.09595 0.1358 243
Protein(%)			0.27829 0.0001 269

[In each cell is listed: correlation; significance; number of lactations]

Table C1.3: Correlations: Lactation Yield and Milk Composition: Saanen Goats: First Lactations.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.30546 0.0221 56	-0.23194 0.0854 56	-0.14747 0.2781 56
Fat(%)		0.75770 0.0001 56	-0.00090 0.9947 56
Protein(%)			0.10926 0.4228 56

[In each cell is listed: correlation; significance; number of lactations]

Table C1.4: Correlations: Lactation Yield and Milk Composition: Saanen Goats: Second Lactations.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.32138 0.0259 48	-0.28098 0.0530 48	0.03172 0.8305 48
Fat(%)		0.59609 0.0001 48	0.16926 0.2501 48
Protein(%)			-0.05866 0.6921 48

[In each cell is listed: correlation; significance; number of lactations]

Table C1.5: Correlations: Lactation Yield and Milk Composition: Saanen Goats: Third Lactations.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.38306 0.0442 28	-0.53944 0.0031 28	-0.12378 0.5303 28
Fat(%)		0.49723 0.0071 28	0.23972 0.2192 28
Protein(%)			-0.01878 0.9244 28

[In each cell is listed: correlation; significance; number of lactations]

Table C1.6: Correlations: Lactation Yield and Milk Composition: Saanen Goats: Fourth Lactations.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.31376 0.2548 15	-0.61422 0.0148 15	-0.29799 0.2807 15
Fat(%)		0.63592 0.0108 15	0.14921 0.5956 15
Protein(%)			0.05445 0.8472 15

[In each cell is listed: correlation; significance; number of lactations]

Table C1.7: Correlations: Lactation Yield and Milk Composition: Saanen Goats: Fifth Lactations.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.93946 0.8595 6	-0.21843 0.6776 6	-0.09024 0.8650 6
Fat(%)		0.72246 0.1049 6	0.54500 0.2634 6
Protein(%)			0.14970 0.7771 6

[In each cell is listed: correlation; significance; number of lactations]

Table C1.8: Correlations: Lactation Yield and Milk Composition: Saanen Goats: Lactations 1,2,3.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.24605 0.0045 132	-0.23363 0.0070 132	-0.15966 0.0675 132
Fat(%)		0.65000 0.0001 132	0.09771 0.2650 132
Protein(%)			0.00505 0.9542 132

[In each cell is listed: correlation; significance; number of lactations]

Table C1.9: Correlations: Lactation Yield and Milk Composition: Indigenous Goats: First Lactations.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.55803 0.0130 19	-0.50744 0.0266 19	0.59241 0.0075 19
Fat(%)		0.66604 0.0013 20	-0.49451 0.0267 20
Protein(%)			-0.64967 0.0008 23

[In each cell is listed: correlation; significance; number of lactations]

Table C1.10: Correlations: Lactation Yield and Milk Composition: Indigenous Goats: Lactations 1,2,3.*

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.55803 0.0130 19	-0.50744 0.0266 19	0.59241 0.0075 19
Fat(%)		0.72594 0.0001 26	-0.59502 0.0013 26
Protein(%)			-0.69008 0.0001 52

[In each cell is listed: correlation; significance; number of lactations]
[* Note: Extra analyses were available for protein and lactose from other lactations]

Table C1.11: Correlations: Lactation Yield and Milk Composition: Crossbred Goats: First Lactations.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	0.07928 0.6771 30	-0.12276 0.5181 30	0.12396 0.5140 30
Fat(%)		0.56760 0.0011 30	-0.13649 0.4720 30
Protein(%)			-0.10937 0.5651 30

[In each cell is listed: correlation; significance; number of lactations]

Table C1.12: Correlations: Lactation Yield and Milk Composition: Crossbred Goats: Second Lactations.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.20130 0.3456 24	-0.05994 0.7808 24	0.06735 0.7545 24
Fat(%)		0.33094 0.1142 24	0.22884 0.2821 24
Protein(%)			-0.07540 0.7262 24

[In each cell is listed: correlation; significance; number of lactations]

Table C1.13: Correlations: Lactation Yield and Milk Composition: Crossbred Goats: Third Lactations.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.69024 0.0130 12	-0.37851 0.2250 12	-0.48199 0.1126 12
Fat(%)		0.64449 0.0237 12	0.54177 0.0688 12
Protein(%)			0.30103 0.3417 12

[In each cell is listed: correlation; significance; number of lactations]

Table C1.14: Correlations: Lactation Yield and Milk Composition: Crossbred Goats: Fourth Lactations.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.91825 0.0277 5	0.82163 0.0880 5	-0.74102 0.1519 5
Fat(%)		-0.61813 0.2665 5	0.63331 0.2514 5
Protein(%)			-0.67933 0.2072 5

[In each cell is listed: correlation; significance; number of lactations]

Table C1.15: Correlations: Lactation Yield and Milk Composition: Crossbred Goats: Lactations 1,2,3.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.11761 0.3474 66	-0.16154 0.1950 66	-0.00924 0.9413 66
Fat(%)		0.47806 0.0001 66	0.07983 0.5240 66
Protein(%)			-0.05301 0.6725 66

[In each cell is listed: correlation; significance; number of lactations]

Table C1.16: Correlations: Lactation Yield and Milk Composition: Three-quarter Saanens: First Lactations.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.74007 0.0226 9	-0.37481 0.3203 9	-0.04990 0.8986 9
Fat(%)		0.87438 0.0020 9	0.43057 0.2473 9
Protein(%)			0.63580 0.0657 9

[In each cell is listed: correlation; significance; number of lactations]

Table C1.17: Correlations: Lactation Yield and Milk Composition: Three-quarter Saanens: Second Lactations.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.49392 0.3977 5	-0.57327 0.3123 5	0.48504 0.4076 5
Fat(%)		0.29735 0.6271 5	0.36575 0.5449 5
Protein(%)			0.14911 0.8109 5

[In each cell is listed: correlation; significance; number of lactations]

Table C1.18: Correlations: Lactation Yield and Milk Composition: Three-quarter Saanens: Third Lactations.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	0.40133 0.5031 5	0.35377 0.5591 5	0.52846 0.3599 5
Fat(%)		0.63191 0.2528 5	0.39716 0.5080 5
Protein(%)			0.84935 0.0686 5

[In each cell is listed: correlation; significance; number of lactations]

Table C1.19: Correlations: Lactation Yield and Milk Composition: Three-quarter Saanens: Lactations 1,2,3.

	Fat(%)	Protein(%)	Lactose(%)
Milk Yield (kg)	-0.35429 0.1367 19	-0.35286 0.1384 19	0.00056 0.9982 19
Fat(%)		0.63825 0.0033 19	0.38970 0.0991 19
Protein(%)			0.65251 0.0025 19

[In each cell is listed: correlation; significance; number of lactations]

TABLES: CORRELATIONS (C2)

TABLES: CORRELATIONS (C2)

Table C2.1: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:
All Goat Breeds: All Lactations (n = 262).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.84361 0.0001	-0.47882 0.0001	-0.50651 0.0001	-0.11631 0.0601
Protein Corrected Milk (kg)	0.93472 0.0001	-0.62974 0.0001	-0.57793 0.0001	-0.24059 0.0001
Lactose Corrected Milk (kg)	0.99403 0.0001	-0.72146 0.0001	-0.72581 0.0001	-0.27618 0.0001
FPL Corrected Milk (kg)	0.96071 0.0001	-0.64115 0.0001	-0.63813 0.0001	-0.22418 0.0003

[In each cell is listed: correlation; significance]

Table C2.2: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:
All Goat Breeds: Lactations 1,2,3. (n = 236).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.84298 0.0001	-0.50621 0.0001	-0.53373 0.0001	-0.10902 0.0947
Protein Corrected Milk (kg)	0.93763 0.0001	-0.65103 0.0001	-0.60325 0.0001	-0.22795 0.0004
Lactose Corrected Milk (kg)	0.99441 0.0001	-0.73869 0.0001	-0.74180 0.0001	0.26373 0.0001
FPL Corrected Milk (kg)	0.96131 0.0001	-0.66322 0.0001	-0.66067 0.0001	0.21296 0.0010

[In each cell is listed: correlation; significance]

Table C2.3: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:
Saanen Goats: First Lactations (n = 56).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.73872 0.0001	0.39760 0.0024	0.31847 0.0168	-0.14970 0.2708
Protein Corrected Milk (kg)	0.86031 0.0001	0.08480 0.5343	0.28060 0.0362	-0.09242 0.4981
Lactose Corrected Milk (kg)	0.98382 0.0001	-0.31270 0.0190	-0.21695 0.1083	0.02836 0.8356
FPL Corrected Milk (kg)	0.93164 0.0001	0.02435 0.8586	0.09482 0.4870	0.06624 0.6276

[In each cell is listed: correlation; significance]

Table C2.4: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:
Saanen Goats: Second Lactations (n = 48).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.76605 0.0001	0.33651 0.0194	0.12967 0.3797	0.16565 0.2605
Protein Corrected Milk (kg)	0.84702 0.0001	0.01407 0.9244	0.25887 0.0756	0.03101 0.8343
Lactose Corrected Milk (kg)	0.97686 0.0001	-0.27742 0.0563	-0.27219 0.0613	0.23989 0.1005
FPL Corrected Milk (kg)	0.93560 0.0001	-0.00785 0.9578	-0.00751 0.9596	0.16938 0.2498

[In each cell is listed: correlation; significance]

Table C2.5: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:
Saanen Goats: Third Lactations (n = 28).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.83034 0.0001	0.18858 0.3365	-0.27180 0.1618	0.00739 0.9702
Protein Corrected Milk (kg)	0.92418 0.0001	-0.21683 0.2677	-0.18355 0.3498	-0.14724 0.4546
Lactose Corrected Milk (kg)	0.98832 0.0001	-0.35118 0.0669	-0.54257 0.0029	0.02523 0.8986
FPL Corrected Milk (kg)	0.96642 0.0001	-0.15816 0.4215	-0.38946 0.0405	-0.02266 0.9089

[In each cell is listed: correlation; significance]

Table C2.6: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:
Saanen Goats: Fourth Lactations (n = 15).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.93123 0.0001	0.05014 0.8592	-0.40223 0.1372	-0.26507 0.3397
Protein Corrected Milk (kg)	0.93698 0.0001	-0.13316 0.6361	-0.30700 0.2657	-0.33305 0.2251
Lactose Corrected Milk (kg)	0.99289 0.0001	-0.30894 0.2625	-0.62069 0.0135	-0.18513 0.5089
FPL Corrected Milk (kg)	0.98287 0.0001	-0.15380 0.5842	-0.48806 0.0649	-0.25210 0.3647

[In each cell is listed: correlation; significance]

Table C2.7: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:

Saanen Goats: Fifth Lactations (n = 6).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.74047 0.0923	0.59058 0.2171	0.23430 0.6550	0.32714 0.5268
Protein Corrected Milk (kg)	0.79684 0.0577	0.35187 0.4940	0.41432 0.4141	0.00593 0.9911
Lactose Corrected Milk (kg)	0.94931 0.0038	0.06285 0.9058	-0.18619 0.7239	0.22663 0.6659
FPL Corrected Milk (kg)	0.89219 0.0168	0.35316 0.4923	0.13030 0.8057	0.22389 0.6698

[In each cell is listed: correlation; significance]

Table C2.8: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:

Saanen Goats: Lactations 1,2,3. (n = 132).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.85426 0.0001	0.27205 0.0016	0.11392 0.1934	-0.09663 0.2703
Protein Corrected Milk (kg)	0.91515 0.0001	0.00928 0.9159	0.16319 0.0615	-0.15267 0.0805
Lactose Corrected Milk (kg)	0.98735 0.0001	-0.23249 0.0073	-0.23115 0.0077	-0.00677 0.9386
FPL Corrected Milk (kg)	0.96253 0.0001	-0.00745 0.9324	-0.01782 0.8393	-0.07800 0.3740

[In each cell is listed: correlation; significance]

Table C2.9: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:
Indigenous Goats: First Lactations (n = 19).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.88123 0.0001	-0.14574 0.5516	-0.27240 0.2592	0.44630 0.0554
Protein Corrected Milk (kg)	0.97226 0.0001	-0.43083 0.0655	-0.33800 0.1570	0.49696 0.0304
Lactose Corrected Milk (kg)	0.99219 0.0001	-0.59211 0.0076	-0.54494 0.0158	0.66640 0.0018
FPL Corrected Milk (kg)	0.97168 0.0001	-0.37177 0.1170	-0.38336 0.1052	0.54255 0.0164

[In each cell is listed: correlation; significance]
[Note: This is the same Table as for Lactations 1,2,3 for Indigenous goats]

Table C2.10: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:
Crossbred Goats: First Lactations (n = 30).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.90482 0.0001	0.48692 0.0064	0.14335 0.4498	0.06828 0.7200
Protein Corrected Milk (kg)	0.93436 0.0001	0.27086 0.1477	0.22987 0.2217	0.13514 0.4765
Lactose Corrected Milk (kg)	0.98899 0.0001	0.06516 0.7323	-0.11229 0.5547	0.26074 0.1640
FPL Corrected Milk (kg)	0.96453 0.0001	0.30892 0.0967	0.09120 0.6317	90.15025 0.4281

[In each cell is listed: correlation; significance]

Table C2.11: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:
Crossbred Goats: Second Lactations (n = 24).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.89011 0.0001	0.26017 0.2196	0.11343 0.5977	0.15953 0.4565
Protein Corrected Milk (kg)	0.96615 0.0001	-0.10240 0.6340	0.18902 0.3764	0.05276 0.8066
Lactose Corrected Milk (kg)	0.99240 0.0001	-0.17178 0.4222	-0.06500 0.7629	0.18864 0.3774
FPL Corrected Milk (kg)	0.97333 0.0001	0.01068 0.9605	0.07709 0.7203	0.14304 0.5049

[In each cell is listed: correlation; significance]

Table C2.12: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:
Crossbred Goats: Third Lactations (n = 12).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.92131 0.0001	-0.36529 0.2430	-0.16164 0.6157	-0.34766 0.2682
Protein Corrected Milk (kg)	0.97635 0.0001	-0.56767 0.0542	-0.17611 0.5840	-0.43886 0.1535
Lactose Corrected Milk (kg)	0.99542 0.0001	-0.66157 0.0191	-0.36330 0.2457	0.39797 0.2001
FPL Corrected Milk (kg)	0.97896 0.0001	-0.53655 0.0721	-0.24115 0.4502	-0.39761 0.2006

[In each cell is listed: correlation; significance]

Table C2.13: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:
Crossbred Goats: Fourth Lactations (n = 5).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.98140 0.0001	-0.84604 0.0708	0.84943 0.0685	-0.82977 0.0821
Protein Corrected Milk (kg)	0.99998 0.0001	-0.91699 0.0283	0.82467 0.0858	-0.74027 0.1526
Lactose Corrected Milk (kg)	0.99908 0.0001	-0.92320 0.0253	0.81586 0.0922	-0.71205 0.1773
FPL Corrected Milk (kg)	0.99893 0.0001	-0.90186 0.0364	0.83356 0.0794	-0.76115 0.1350

[In each cell is listed: correlation; significance]

Table C2.14: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:
Crossbred Goats: Lactations 1,2,3. (n = 66).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.91767 0.0001	0.27318 0.0265	0.03296 0.7928	0.03370 0.7882
Protein Corrected Milk (kg)	0.96652 0.0001	0.00613 0.9610	0.08586 0.4931	0.00244 0.9845
Lactose Corrected Milk (kg)	0.99374 0.0001	-0.10404 0.4058	-0.15580 0.2116	0.09703 0.4383
FPL Corrected Milk (kg)	0.97678 0.0001	0.07587 0.5449	-0.01524 0.9024	0.04752 0.7048

[In each cell is listed: correlation; significance]

Table C2.15: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:
Three-quarter Saaanens: First Lactations (n = 9).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.95235 0.0001	-0.50472 0.1650	-0.10191 0.7942	0.11126 0.7757
Protein Corrected Milk (kg)	0.92293 0.0004	-0.43422 0.2429	-0.00104 0.9979	0.17382 0.6547
Lactose Corrected Milk (kg)	0.99328 0.0001	-0.67263 0.0471	-0.28092 0.4640	0.05250 0.8933
FPL Corrected Milk (kg)	0.96879 0.0001	-0.55515 0.1208	-0.14418 0.7113	0.10711 0.7039

[In each cell is listed: correlation; significance]

Table C2.16: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:
Three-quarter Saaanens: Second Lactations (n = 5).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.87186 0.0540	-0.05164 0.9343	-0.33731 0.5788	0.80496 0.1003
Protein Corrected Milk (kg)	0.93385 0.0202	-0.42535 0.4752	-0.25403 0.6801	0.64148 0.2434
Lactose Corrected Milk (kg)	0.98851 0.0015	-0.42981 0.4701	-0.46494 0.4301	0.58010 0.3052
FPL Corrected Milk (kg)	0.95469 0.0115	-0.29892 0.6251	-0.37785 0.5306	0.69084 0.1965

[In each cell is listed: correlation; significance]

Table C2.17: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:
Three-quarter Saaanens: Third Lactations (n = 5).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.88995 0.0431	0.77359 0.1248	0.56489 0.3211	0.55483 0.3317
Protein Corrected Milk (kg)	0.92805 0.0229	0.55652 0.3299	0.67641 0.2099	0.75708 0.1384
Lactose Corrected Milk (kg)	0.99156 0.0009	0.42213 0.4789	0.45379 0.4427	0.63367 0.2510
FPL Corrected Milk (kg)	0.95563 0.0111	0.62878 0.2558	0.57548 0.3100	0.64855 0.2365

[In each cell is listed: correlation; significance]

Table C2.18: Correlations: Composition Corrected Milk with Lactation Yield and Milk Composition:
Three-quarter Saaanens: Lactations 1,2,3. (n = 19).

	Milk Yield(kg)	Fat(%)	Protein(%)	Lactose(%)
Fat Corrected Milk (kg)	0.90888 0.0001	0.05269 0.8034	-0.09577 0.6965	0.13877 0.5710
Protein Corrected Milk (kg)	0.91627 0.0001	-0.11594 0.6365	0.02995 0.9031	0.23374 0.3355
Lactose Corrected Milk (kg)	0.99226 0.0001	-0.29476 0.2205	-0.25723 0.2877	0.10121 0.6802
FPL Corrected Milk (kg)	0.96085 0.0001	-0.11894 0.6277	-0.12418 0.6125	0.15318 0.5313

[In each cell is listed: correlation; significance]

TABLES: CORRELATIONS (C3)

TABLES: CORRELATIONS (C3)

Table C3.1: Correlations: Composition Corrected Milk Yields: All Goats: All Lactations (n = 262).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.93807 0.0001	0.86184 0.0001	0.95362 0.0001
Protein Corrected Milk (kg)		0.94259 0.0001	0.98620 0.0001
Lactose Corrected Milk (kg)			0.97125 0.0001

[In each cell is listed: correlation; significance]

Table C3.2: Correlations: Composition Corrected Milk Yields: All Goats: Lactations 1,2,3. (n = 236).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.93865 0.0001	0.86066 0.0001	0.95306 0.0001
Protein Corrected Milk (kg)		0.94494 0.0001	0.98730 0.0001
Lactose Corrected Milk (kg)			0.97135 0.0001

[In each cell is listed: correlation; significance]

Table C3.3: Correlations: Composition Corrected Milk Yields: Saanen Goats: First Lactations (n = 56).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.89861 0.0001	0.71772 0.0.0001	0.91608 0.0001
Protein Corrected Milk (kg)		0.85310 0.0001	0.96934 0.0001
Lactose Corrected Milk (kg)			0.92931 0.0001

[In each cell is listed: correlation; significance]

Table C3.4: Correlations: Composition Corrected Milk Yields: Saanen Goats: Second Lactations (n = 48).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.84397 0.0001	0.77953 0.0.0001	0.92005 0.0001
Protein Corrected Milk (kg)		0.83640 0.0001	0.94214 0.0001
Lactose Corrected Milk (kg)			0.94688 0.0001

[In each cell is listed: correlation; significance]

Table C3.5: Correlations: Composition Corrected Milk Yields: Saanen Goats: Third Lactations (n = 28).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.85515 0.0001	0.83787 0.0.0001	0.93357 0.0001
Protein Corrected Milk (kg)		0.91032 0.0001	0.95687 0.0001
Lactose Corrected Milk (kg)			0.97087 0.0001

[In each cell is listed: correlation; significance]

Table C3.6: Correlations: Composition Corrected Milk Yields: Saanen Goats: Fourth Lactations (n = 15).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.93526 0.0001	0.92470 0.0001	0.97494 0.0001
Protein Corrected Milk (kg)		0.92674 0.0001	0.96924 0.0001
Lactose Corrected Milk (kg)			0.98138 0.0001

[In each cell is listed: correlation; significance]

Table C3.7: Correlations: Composition Corrected Milk Yields: Saanen Goats: Fifth Lactations (n = 6).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.83035 0.0407	0.81683 0.0473	0.94944 0.0038
Protein Corrected Milk (kg)		0.76870 0.0741	0.91026 0.0117
Lactose Corrected Milk (kg)			0.93569 0.0061

[In each cell is listed: correlation; significance]

Table C3.8: Correlations: Composition Corrected Milk Yields: Saanen Goats: Lactations 1,2,3. (n = 132).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.91380 0.0001	0.85232 0.0001	0.95111 0.0001
Protein Corrected Milk (kg)		0.90599 0.0001	0.97058 0.0001
Lactose Corrected Milk (kg)			0.96464 0.0001

[In each cell is listed: correlation; significance]

Table C3.9: Correlations: Composition Corrected Milk Yields: Indigenous Goats: First Lactations (n = 19).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.93710 0.0001	0.84184 0.0001	0.96600 0.0001
Protein Corrected Milk (kg)		0.94476 0.0001	0.98924 0.0001
Lactose Corrected Milk (kg)			0.94891 0.0001

[In each cell is listed: correlation; significance]
[Note: This Table is the same for Lactations 1,2 and 3]

Table C3.10: Correlations: Composition Corrected Milk Yields: Crossbred Goats: First Lactations (n = 30).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.93648 0.0001	0.89126 0.0001	0.97627 0.0001
Protein Corrected Milk (kg)		0.93424 0.0001	0.97940 0.0001
Lactose Corrected Milk (kg)			0.96220 0.0001

[In each cell is listed: correlation; significance]

Table C3.11: Correlations: Composition Corrected Milk Yields: Crossbred Goats: Second Lactations (n = 24).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.90910 0.0001	0.89441 0.0001	0.96493 0.0001
Protein Corrected Milk (kg)		0.95799 0.0001	0.97869 0.0001
Lactose Corrected Milk (kg)			0.97527 0.0001

[In each cell is listed: correlation; significance]

Table C3.12: Correlations: Composition Corrected Milk Yields: Crossbred Goats: Third Lactations (n = 12).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.95454 0.0001	0.93100 0.0001	0.97827 0.0001
Protein Corrected Milk (kg)		0.97599 0.0001	0.99099 0.0001
Lactose Corrected Milk (kg)			0.98408 0.0001

[In each cell is listed: correlation; significance]

Table C3.13: Correlations: Composition Corrected Milk Yields: Crossbred Goats: Fourth Lactations (n = 5).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.98149 0.0030	0.97313 0.0053	0.98906 0.0014
Protein Corrected Milk (kg)		0.99910 0.0001	0.99898 0.0001
Lactose Corrected Milk (kg)			0.99644 0.0003

[In each cell is listed: correlation; significance]

Table C3.14: Correlations: Composition Corrected Milk Yields: Crossbred Goats: Lactations 1,2,3. (n = 66).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.93849 0.0001	0.91758 0.0001	0.97605 0.0001
Protein Corrected Milk (kg)		0.96371 0.0001	0.98445 0.0001
Lactose Corrected Milk (kg)			0.97817 0.0001

[In each cell is listed: correlation; significance]

Table C3.15: Correlations: Composition Corrected Milk Yields:
Three-quarter Saanens: First Lactations (n= 9).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.99158 0.0001	0.97420 0.0001	0.99666 0.0001
Protein Corrected Milk (kg)		0.95447 0.0001	0.98856 0.0001
Lactose Corrected Milk (kg)			0.98767 0.0001

[In each cell is listed: correlation; significance]

Table C3.16: Correlations: Composition Corrected Milk Yields:
Three-quarter Saanens: Second Lactations (n = 5).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.90826 0.0329	0.92115 0.0263	0.96791 0.0069
Protein Corrected Milk (kg)		0.97334 0.0052	0.97765 0.0040
Lactose Corrected Milk (kg)			0.98707 0.0018

[In each cell is listed: correlation; significance]

Table C3.17: Correlations: Composition Corrected Milk Yields:
Three-quarter Saanens: Third Lactations (n = 5).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.92014 0.0268	0.89367 0.0409	0.97323 0.0052
Protein Corrected Milk (kg)		0.96178 0.0089	0.97917 0.0036
Lactose Corrected Milk (kg)			0.96895 0.0065

[In each cell is listed: correlation; significance]

Table C3.18: Correlations: Composition Corrected Milk Yields:
Three-quarter Saanens: Lactations 1,2,3. (n = 19).

	PCM (kg)	LCM (kg)	FPLCM (kg)
Fat Corrected Milk (kg)	0.93580 0.0001	0.92956 0.0001	0.97818 0.0001
Protein Corrected Milk (kg)		0.95152 0.0001	0.97837 0.0001
Lactose Corrected Milk (kg)			0.98105 0.0001

[In each cell is listed: correlation; significance]

APPENDIX C

POST-MORTEM RECORDS

APPENDIX C

Table P3: Goat post-mortem Records

Date	pm No.	Number	Sex	Breed	Age	REASON
20/9/88	2450	n/n bl	m	i	?2wk	no milk
3/10/88	2475	L418	f	Sa	1y	uterine prolapse
11/10/88	2494	13	f	c	26d	pneumonia
20/10/88	2515	27	m	c	19d	pneumonia
24/10/88	2521	n/n	m	?Sa	?mth	pneumonia
24/10/88	-20	f	Sa	33d		pneumonia
27/10/88	2528	17	m	Sa	40d	*E.coli*
29/10/88	2537	n/n	?	?Sa	?	pneumonia
31/10/88	2542	38	f	Sa	27d	pneumonia
6/11/88	2552	22	f	Sa	45d	pneumonia
30/12/88	2655	n/n	m	?Sa	?7mth	CCN

14/4/89	2820	88/622	f	i	7mth	hepatic atrophy
5/9/89	3027	89/2	m	Sa	3d	emaciation
7/9/89	3032	89/13	m	3q	2d	pneumonia
7/9/89	3033	J10	f	c	1d	pneumonia
12/9/89	3044	89/26	m	c	2d	inanition
16/9/89	3045	J43	f	c	3d	pneumonia
19/9/89	3053	J42	f	Sa	6d	pneumonia
17/10/89	3098	89/15	m	Sa	41d	diarrhoea
18/10/89	3098	89/4	m	Sa	46d	bacterial enteritis
28/10/89	3115	J51	f	c	23d	VitE/Se deficiency
29/10/89	3114	89/5	m	Sa	57d	malnutrition
11/11/89	3136	J15	f	3q	65d	pneumonia
12/11/89	3141	89/41	m	c	61d	diarrhoea
13/11/89	3260	J47	f	Sa	54d	coccidiosis
21/11/89	3161	n/n	m	?	?3mth	cachexia
29/11/89	3181	J19	f	c	81d	coccidiosis
2/12/89	3193	J52	f	c	52d	coccidiosis
6/12/89	3201	89/53	m	c	70d	coccidiosis
12/12/89	3210	n/n	f	?Sa	kid	coccidiosis
14/12/89	3213	n/n	f	?Sa	?	pneumonia + coccidiosis
25/12/89	3229	89/28	m	c	106d	coccidiosis
26/12/89	3228	89/54	m	3q	90d	coccidiosis
28/12/89	3232	89/48	m	Sa	105d	coccidiosis
29/12/89	3233	89/56	m	c	60d	pneumonia + coccidiosis
29/12/89	3234	n/n	f	?Sa	?2mth	pneumonia + coccidiosis
30/12/89	3235	89/18	m	3q	113d	poor condition
31/12/89	3236	89/51	m	Sa	103d	coccidiosis + pneumonia
31/12/89	3238	J45	f	Sa	108d	cachexia + pneumonia
31/12/89	3239	89/55	m	Sa	62d	cachexia + coccidiosis

4/1/90	3247	J54	f	c	75d	pneumonia + coccidiosis
13/1/90	3260	J47	f	Sa	115d	pneumonia + coccidiosis
16/1/90	3264	89/36	m	Sa	127d	pneumonia + coccidiosis
21/1/90	3274	J50	f	c	115d	pneumonia
1/6/90	2437	n/n	f	Sa	?	tracheitis + septicaemia
31/8/90	3547	H14	f	Sa	0d	born dead
10/10/90	3663	J5	f	c	37d	myocarditis + heart failure
12/10/90	3667	H68	f	c	19d	pneumonia
12/10/90	3670	89/321	f	i	1y	mastitis + vaginitis
15/10/90	-	90/44	m	Sa	36d	ataxia (front girdle)
2/11/90	3695	L473	f	Sa	3y	ketosis
4/11/90	3696	L450	f	Sa	3y	pneumonia + mastitis
25/11/90	3728	87/503	f	i	3y	hepatic cirrhosis
26/11/90	3729	90/38	m	c	80d	?
5/12/90	3757	90/57	f	3q	76d	chronic arthritis
17/12/90	3786	H79	f	i	78d	pneumonia
18/12/90	3788	J30	f	Sa	15mth	pneumonia
23/12/90	3793	90/67	m	3q	90d	pneumonia
24/12/90	3792	H34	f	Sa	106d	(autolysed)

Table P3: Goat post-mortem Records (continued)

Date	pm No.	Number	Sex	Breed	Age	REASON
7/1/91	3811	90/55	m	Sa	110d	coccidiosis
8/1/91	3816	90/96	m	c	93d	coccidiosis
10/1/91	3820	90/63	m	3q	110d	coccidiosis
19/1/91	3838	L410	f	Sa	4y	peritonitis (rupture of intestine)
24/1/91	3851	90/53	m	i	130d	cachexia
11/2/91	3882	90/81	m	i	133d	coccidiosis + pneumonia
21/2/91	-	H53	f	3q	157d	coccidiosis
22/2/91	3904	H31	f	Sa	168d	coccidiosis
28/8/91	4175	K51	f	c	3y	ketosis
19/9/91	4215	91/37	m	Sa	2d	enteritis
26/9/91	4227	K449	f	Sa	4y	acute mastitis ("blue udder")
26/9/91	4226	G40	f	Sa	5d	pneumonia
26/9/91	4225	91/68	m	3q	3d	inanition
30/9/91	4232	91/76	m	Sa	5d	inanition
6/10/91	4247	J39	f	Sa	2y	acute mastitis
11/10/91	4258	91/84	m	3q	7d	inanition
14/10/91	4261	G47	f	3q	23d	?colibacillosis
14/10/91	4260	G74	f	Sa	2d	inanition
31/10/91	4282	91/57	m	Sa	40d	poor condition
17/11/91	-	91/33	m	3q	2d	coccidiosis
19/11/91	4301	G22	f	3q	67d	coccidiosis
20/11/91	4305	G64	f	Sa	52d	coccidiosis
22/11/91	4312	J27	f	Sa	2y	acute mastitis
25/11/91	4316	91/82	m	3q	53d	pneumonia + coccidiosis
8/12/91	4328	91/89	m	3q	49d	coccidiosis
8/12/91	4329	91/52	m	Sa	78d	coccidiosis + pneumonia
12/12/91	4339	91/43	m	Sa	84d	coccidiosis
12/12/91	4340	91/34	m	3q	89d	coccidiosis
13/12/91	4345	G73	f	Sa	43d	coccidiosis + pneumonia
19/12/91	4354	G62	f	Sa	83d	coccidiosis
19/12/91	4353	91/54	m	Sa	89d	coccidiosis
20/12/91	4357	G9	f	i	115d	coccidiosis
21/12/91	4358	91/80	m	3q	84d	coccidiosis
21/12/91	4356	91/62	m	c	90d	coccidiosis
24/12/91	4361	91/65	m	Sa	92d	coccidiosis
24/12/91	4360	G38	f	3e	94d	coccidiosis
26/12/91	4364	91/7	m	i	123d	conc. overload = enteritis
26/12/91	4364	91/5	f	i	124d	conc. overload = enteritis

7/1/92	4375	G70	f	c	94d	coccidiosis + pneumonia
13/1/92	4395	91/55	m	3e	114d	coccidiosis
13/1/92	4394	91/45	m	Sa	115d	pneumonia
13/1/92	4391	91/69	m	Sa	112d	pneumonia
17/1/92	4403	n/n	m	?Sa	?4mth	coccidiosis
8/1/92	4410	G32	f	Sa	121d	coccidiosis + pneumonia
18/1/92	4408	91/79	m	Sa	111d	pneumonia
18/1/92	4407	G61	f	Sa	113d	pneumonia
18/1/92	4406	G69	f	3q	106d	coccidiosis + pneumonia
23/1/92	4420	G67	f	c	113d	coccidiosis
30/1/92	-	G55	f	3q	129d	pneumonia
31/1/92	4432	91/88	m	3q	105d	coccidiosis + pneumonia
3/2/92	4435	G28	f	Sa	138d	coccidiosis + monezia
10/2/92	4447	H41	f	Sa	18mth	mastitis + septicaemia
21/2/92	4466	G42	f	3q	162d	pneumonia
30/2/92	4481	J81	m	Sa	billy:3y	heart failure?
28/4/92	4538	91/59	m	Sa	8mth	pneumonia + enteritis
25/5/92	4566	Kenny	m	Sa	billy:3y	peritonitis
3/7/92	4599	H52	f	i	2y	pneumonia
7/7/92	4603	n/n	f	3q	3d	? not known
10/7/92	4604	H1	f	c	2y	ketosis
11/7/92	-	J18	f	c	3y	mastitis (Staph)
15/7/92	4610	H80kid	f	c	?4d	inadequate colostrum
17/7/92	4616	H86	f	3q	2y	peritonitis; ketosis
17/7/92	4615	H24	f	Sa	2y	ketosis

Table P3: Goat post-mortem Records (continued)

Date	pm No.	Number	Sex	Breed	Age	REASON
18/7/92	4623	F11	f	7e	3d	born weak
18/7/92	4622	F13	f	c	2d	born weak
18/7/92	4624	n/n	f	?c	?1d	born weak
18/7/92	4625	n/n	m	?c	?1d	born weak
18/7/92	4626	n/n	m	?c	?1d	born weak
20/7/92	4632	n/n	m	?	?3wk	septicaemia
15/8/92	4656	F25	f	3q	17d	hypothermia
15/8/92	4666	G45	f	3q	11mth	pneumonia
17/8/92	4667	n/n	m	?Sa	adult	*Pasteurella* pneumonia
31/8/92	4691	F44	f	3q	23d	pneumonia
1/9/92	4690	87/414	f	i	5y	unknown
29/9/92	4744	n/n	m	?Sa	?3wk	unknown
3/10/92	4757	F21	f	c	64d	renal dysplasia
6/10/92	4766	92/21	m	Sa	81d	pneumonia
7/10/92	4767	92/57	m	Sa	38d	pneumonia(*Corynebacterium*)
8/10/92	4770	92/60	m	3q	2d	emaciated
9/10/92	4774	92/64	m	Sa	1d	pneumonia
10/10/92	4771	92/61	m	Sa	4d	pericarditis + pleuritis
10/10/92	4772	92/90	m	?Sa	?1d	enteritis; emaciated
10/10/92	4773	92/59	m	3q	4d	pneumonia
27/10/92	4809	F15	f	Sa	102d	coccidiosis
27/10/92	4803	F35	f	i	87d	coccidiosis
29/3/93	-	J44	f	Sa	4y	spinal abscess
2/4/93	-	G13	f	i	2y	pregnancy toxaemia
5/4/93	5017	D28	f	c	7d	(autolysed)
17/5/98	5068	D68	f	Sa	15d	coccidiosis
5/6/93	5083	H92	f	c	3y	**heartwater**
5/6/93	-	L466?	f	Sa	6y	*Pasteurella*
27/6/93	5109	D16	f	c	3mth	asphyxiation (stuck in feed bin)
27/6/93	5108	D33	f	c	3mth	asphyxiation (stuck in feed bin)
10/7/93	5131	93/37	m	Sa	91d	coccidiosis
28/7/93	5148	n/n	f	Sa	2d	*E.coli* septicaemia
28/7/93	-	n/n	f	Sa	2d	*E.coli* septicaemia
9/8/93	5163	D85	f	3q	10d	pneumonia
9/8/93	5161	D67	f	3q	100d	enteritis + pneumonia
1/10/93	5253	93/35	m	3q	7mth	pneumonia
20/1/94	5405	L481	f	Sa	7y	carcinoma (squamous cell)
24/3/94	-	G23	f	Sa	3y	plastic in rumen
1/8/94	5601	J13	f	c	5y	dystocia; peritonitis
10/8/94	5610	G3kid	f	c	0d	born dead
11/8/94	5609	F17kid	f	Sa	0d	born dead
12/8/94	5612	F172kid	f	Sa	0d	born dead
15/8/94	5617	P1	f	?	1d	septicaemia
15/8/94	5623	C25	f	Sa	11d	enteropathy
15/8/94	5615	C26	f	Sa	10d	pneumonia
16/8/94	5616	J40	f	Sa	5y	metritis + mastitis
19/8/94	5627	C46	f	Sa	5d	pneumonia
19/8/94	5626	94/29	m	Sa	15d	pneumonia
23/8/94	5634	C28	f	3q	18d	*E.coli*
24/8/94	5635	H15	f	c	4y	nephrosis; renal calculi
30/8/94	5652	n/n	f	?Sa	?	pneumonia
30/8/94	5653	n/n	f	?Sa	?	septicaemia
30/8/94	5649	n/n	f	?Sa	?2wk	septicaemia
9/9/94	5681	94/48	m	Sa	25d	pyogenic bacterial embolism
21/9/94	5684	C54	f	Sa	33d	pneumonia
27/9/94	5686	C38	f	Sa	45d	coccidiosis
25/10/94	-	C39	f	Sa	73d	(autolysed)
22/11/94	5766	C73	f	c	87d	coccidiosis
22/4/94	5767	H3	f	c	3y	*Corynebacterium* abscesses; pneumonia
2/12/94	5795	C92	f	Sa	70d	coccidiosis

APPENDIX D

TABLES OF HEARTWATER EXPERIMENT

[Note: Tables H30 to H43 are in the text]

Table H24: A comparison of Saanen goats treated or not: temperature before reaction (T_BEF).

Table H25: A comparison of Saanen goats treated or not: temperature at day of rise (T_RISE).

Table H26: A comparison of Saanen goats treated or not: day of rise in temperature (D_RISE)

Table H27: A comparison of Saanen goats treated or not: temperature at peak (T_PEAK).

Table H28: A comparison of Saanen goats treated or not: day of peak temperature (D_PEAK)

Table H29: A comparison of Saanen goats treated or not: temperature rise (T_UP).

Table H1: Goats with heartwater: Pre-febrile temperatures: morning and afternoon (means ± SE)

Groups	Goats	Morning °C	Afternoon °C
1991: Saanen: females	8	38.7 ± 0.30	39.3 ± 0.28
1991: Crossbred: males females all	5 3 8	38.8 ± 0.27 38.8 ± 0.25 38.8 ± 0.26	39.5 ± 0.22 39.4 ± 0.18 39.5 ± 0.21
1991: Indigenous: males females all	2 6 8	39.0 ± 0.32 38.8 ± 0.25 38.8 ± 0.29	39.6 ± 0.18 39.5 ± 0.35 39.5 ± 0.29
1992: Crossbred: males females all	6 6 12	39.2 ± 0.26 39.0 ± 0.36 39.1 ± 0.34	39.6 ± 0.25 39.5 ± 0.30 39.6 ± 0.28
1992: Indigenous: males females all	6 6 12	39.1 ± 0.37 39.0 ± 0.36 39.0 ± 0.37	39.8 ± 0.34 39.5 ± 0.30 39.6 ± 0.34
1992: 3/4 Saanen: males females all	5 4 9	39.2 ± 0.31 39.1 ± 0.38 39.2 ± 0.34	39.6 ± 0.36 39.5 ± 0.36 39.6 ± 0.37
1992: Saanen: treated males females all	 4 5 9	 39.1 ± 0.40 38.7 ± 0.38 38.9 ± 0.42	 39.7 ± 0.27 39.4 ± 0.31 39.5 ± 0.33
1992: Saanen: untreated males females both	 1 1 2	 39.3 ± 0.31 39.1±0.50 39.2±0.43	 39.6 ± 0.23 39.5 ± 0.27 39.6 ± 0.25
All goats: males females all	29 39 68	39.1±0.35 38.9±0.38 39.0±0.37	39.6 ± 0.29 39.4 ± 0.30 39.5 ± 0.32
G36 (3/4 Saanen) - uninfected	1	38.8±0.33	39.2 ± 0.37

Table H2: Temperature reactions: all goats not treated.

Variable	n	Means	SD	min.	max.
Mean temp. before (°C)	59	39.03	0.21	38.60	39.50
Temp.: day of rise (°C)		40.59	0.45	40.00	41.90
Day of temp. rise (D)		10.17	0.67	8.00	11.00
Peak temp. (°C)		41.74	0.34	41.10	42.40
Day of peak temp. (D)		11.93	0.94	10.00	14.00
Temp. rise (°C)		2.71	0.28	2.10	3.30
Day of temp. drop (D)	32	15.66	0.97	14.00	17.00
Days: peak to drop (d)		3.56	0.84	2.00	5.00
Days: rise to drop (d)		5.34	1.00	4.00	7.00
Day of death (D)	27	15.11	1.69	12.00	19.00

Table H3: Temperature reactions: Saanens not treated.

Variable	n	Means	SD	min.	max.
Mean temp. before (°C)	10	38.87	0.23	38.70	39.40
Temp.: day of rise (°C)		40.56	0.34	40.00	41.00
Day of temp. rise (D)		10.20	0.42	10.00	11.00
Peak temp. (°C)		41.59	0.41	41.10	42.30
Day of peak temp. (D)		11.60	0.84	11.00	13.00
Temp. rise (°C)		2.72	0.32	2.20	3.20
Day of temp. drop (D)	0	-	-	-	-
Days: peak to drop (d)		-	-	-	-
Days: rise to drop (d)		-	-	-	-
Day of death (D)	10	14.40	1.78	12.00	18.00

Table H4: Temperature reactions: Indigenous goats.

Variable	n	Means	SD	min.	max.
Mean temp. before (°C)	20	39.02	0.19	38.60	39.50
Temp.: day of rise (°C)		40.51	0.43	40.00	41.90
Day of temp. rise (D)		10.35	0.49	8.00	11.00
Peak temp. (°C)		41.66	0.28	41.10	42.40
Day of peak temp. (D)		12.20	0.95	10.00	14.00
Temp. rise (°C)		2.64	0.22	2.10	3.30
Day of temp. drop (D)	19	15.79	0.85	14.00	17.00
Days: peak to drop (d)		3.53	0.77	2.00	5.00
Days: rise to drop (d)		5.42	0.84	4.00	7.00
Day of death (D)	1	17.00	-	17.00	17.00

Table H5: Temperature reactions: Crossbred goats.

Variable	n	mean	SD	min.	max.
Mean temp. before (°C)	20	39.06	0.22	38.70	39.40
Temp.: day of rise (°C)		40.62	0.46	40.00	41.40
Day of temp. rise (D)		10.20	0.70	9.00	11.00
Peak temp. (°C)		41.72	0.25	41.10	42.10
Day of peak temp. (D)		11.80	0.89	10.00	13.00
Temp. rise (°C)		2.66	0.28	2.10	3.20
Day of temp. drop (D)	11	15.27	1.10	14.00	17.00
Days: peak to drop (d)		3.55	1.04	2.00	5.00
Days: rise to drop (d)		5.00	1.18	4.00	7.00
Day of death (D)	9	15.33	1.41	13.00	18.00

Table H6: Temperature reactions: Three-quarter Saanens.

Variable	n	mean	SD	min.	max.
Mean temp. before (°C)	9	39.19	0.11	39.00	39.30
Temp.: day of rise (°C)		40.76	0.62	40.00	41.90
Day of temp. rise (D)		9.67	1.00	8.00	11.00
Peak temp. (°C)		42.18	0.25	41.70	42.40
Day of peak temp. (D)		12.00	1.12	11.00	14.00
Temp. rise (°C)		2.99	0.24	2.60	3.30
Day of temp. drop (D)	2	16.50	0.71	16.00	17.00
Days: peak to drop (d)		4.00	0.00	4.00	4.00
Days: rise to drop (d)		6.50	0.71	6.00	7.00
Day of death (D)	7	15.57	1.81	14.00	19.00

Table H7: Breed comparison for mean temperature before heartwater (T_BEF)
[Bonferroni (Dunn) T tests]

Breed	n	Mean T_BEF (°C)	Bon grouping
Saanen	10	39.87	B
Indigenous	20	39.01	A B
Crossbred	20	39.06	A B
Three-quarter Saanen	9	39.19	A

[Means with the same letter are not significantly different (P<0.05)]

Table H8: Breed comparison for mean temperature at day of rise (T_RISE)
[Bonferroni (Dunn) T tests]

Breed	n	Mean T_RISE (°C)	Bon grouping
Saanen	10	40.56	A
Indigenous	20	40.50	A
Crossbred	20	40.62	A
Three-quarter Saanen	9	40.76	A

[Means with the same letter are not significantly different (P<0.05)]

Table H9: Breed comparison for day of temperature rise above 40°C (D_RISE)
[Bonferroni (Dunn) T tests]

Breed	n	Day D_RISE	Bon grouping
Saanen	10	10.20	A
Indigenous	20	10.35	A
Crossbred	20	10.20	A
Three-quarter Saanen	9	9.67	A

[Means with the same letter are not significantly different (P<0.05)]

Table H10: Breed comparison for peak temperature (T_PEAK)
[Bonferroni (Dunn) T tests]

Breed	n	Peak Temp. (°C)	Bon grouping
Saanen	10	41.59	B
Indigenous	20	41.65	B
Crossbred	20	41.71	B
Three-quarter Saanen	9	42.18	A

[Means with the same letter are not significantly different (P<0.05)]

Table H11: Breed comparison for peak temperature (T_PEAK): All animals that died
[Bonferroni (Dunn) T tests]

Breed	n	Peak Temp. (°C)	Bon grouping
Saanen	10	41.59	A
Indigenous	1	41.50	A
Crossbred	20	41.76	A
Three-quarter Saanen	9	42.20	A

[Means with the same letter are not significantly different (P<0.05)]

Table H12: Breed comparison for day of peak temperature (D_PEAK):
[Bonferroni (Dunn) T tests]

Breed	n	Day of Peak Temp.	Bon grouping
Saanen	10	11.60	A
Indigenous	20	12.20	A
Crossbred	20	11.80	A
Three-quarter Saanen	9	12.00	A

[Means with the same letter are not significantly different (P<0.05)]

Table H13: Breed comparison for degrees rise in temperature (T_UP)
[Bonferroni (Dunn) T tests]

Breed	n	Temp. Rise (°C)	Bon grouping
Saanen	10	2.72	B A
Indigenous	20	2.64	B
Crossbred	20	2.66	B
Three-quarter Saanen	9	2.99	A

[Means with the same letter are not significantly different (P<0.05)]

Table H14: Breed comparison for degrees rise in temperature (T_UP): for the year 1992 only.
[Bonferroni (Dunn) T tests]

Breed	n	Temp. Rise (°C)	Bon grouping
Saanen	2	3.00	A
Indigenous	12	2.73	A
Crossbred	12	2.59	A
Three-quarter Saanen	9	2.99	A

[Means with the same letter are not significantly different (P<0.05)]

Table H15: Breed comparison for day of temperature drop (D_DROP):
[Bonferroni (Dunn) T tests]

Breed	n	Day of Temp.Drop	Bon grouping
Saanen	0	-	
Indigenous	19	15.79	A
Crossbred	11	15.27	A
Three-quarter Saanen	2	16.50	A

[Means with the same letter are not significantly different (P<0.05)]

Table H16: Breed comparison for days from peak to temperature drop (D_PTOD): [Bonferroni (Dunn) T tests]

Breed	n	Days from peak temp. to drop	Bon grouping
Saanen	0	-	
Indigenous	19	3.53	A
Crossbred	11	3.55	A
Three-quarter Saanen	2	4.00	A

[Means with the same letter are not significantly different (P<0.05)]

Table H17: Breed comparison for days from temperature rise to drop (D_RTOD): [Bonferroni (Dunn) T tests]

Breed	n	Days from peak temp. to drop	Bon grouping
Saanen	0	-	
Indigenous	19	5.42	A
Crossbred	11	5.00	A
Three-quarter Saanen	2	6.50	A

[Means with the same letter are not significantly different (P<0.05)]

Table H18: Breed comparison for day of death (D_DEATH): [Bonferroni (Dunn) T tests]

Breed	n	Day of Death	Bon grouping
Saanen	10	14.40	A
Indigenous	1	17.00	A
Crossbred	9	15.33	A
Three-quarter Saanen	7	15.57	A

[Means with the same letter are not significantly different (P<0.05)]

Table H19: A comparison of peak temperature for goats that died and those that survived. All goats. [t-test]

Group	n	Mean (°C)	SD	SE	Min.	Max.
Died	27	41.80	0.410	0.079	41.1	42.4
Survived	32	41.70	0.267	0.047	41.3	42.2

Variances	t	DF	P
Unequal	1.1207	43.3	0.2686
Equal	1.1606	57.0	0.2506

Table H20: A comparison of peak temperature for goats that died and those that survived. Indigenous goats. [t-test]

Group	n	Mean (°C)	SD	SE	Min.	Max.
Died	1	41.50	-	-	41.5	41.5
Survived	19	41.66	2.812	6.453	41.3	42.2

Variances	t	DF	P
Unequal	-	-	-
Equal	-0.5654	18.0	0.5788

Table H21: A comparison of peak temperature for goats that died and those that survived. Crossbred goats. [t-test]

Group	n	Mean (°C)	SD	SE	Min.	Max.
Died	9	41.76	0.296	0.099	41.1	42.1
Survived	11	41.68	0.204	0.062	41.3	42.0

Variances	t	DF	P
Unequal	0.6337	13.8	0.5367
Equal	0.6581	18.0	0.5188

Table H22: A comparison of peak temperature for goats that died and those that survived. Three-quarter Saanen goats. [t-test]

Group	n	Mean (°C)	SD	SE	Min.	Max.
Died	7	42.20	0.283	0.107	41.7	42.4
Survived	2	42.10	0.141	0.100	42.0	42.2

Variances	t	DF	P
Unequal	0.6831	3.8	0.5347
Equal	0.4667	7.0	0.6549

Table H23: Goats with heartwater: year effects (untreated goats): temperature reaction. [Morning temperatures; means ± se]

Year/ breed	Goats		Temperature rise		Peak temperature		Temp. fall
	No.	Died	Day	°C	Day	°C	Day
1991							
Crossbred	8	2	10.4 ± 0.5	40.6 ± 0.5	11.6 ± 1.1	41.6 ± 0.2	15.3 ± 1.4
Indigenous	8	1	10.2 ± 0.4	40.5 ± 0.5	12.2 ± 1.3	41.4 ± 0.2	15.7 ± 1.1
Both breeds	16	3	10.3 ± 0.5	40.5 ± 0.5	11.9 ± 1.2	41.5 ± 0.2	15.5 ± 1.2
1992							
Crossbred	12	7	10.1 ± 0.8	40.6 ± 0.4	11.0 ± 0.8	41.8 ± 0.3	15.2 ± 0.8
Indigenous	12	0	10.4 ± 0.5	40.5 ± 0.4	12.2 ± 0.7	41.8 ± 0.2	15.8 ± 0.7
Both breeds	24	7	10.2 ± 0.7	40.6 ± 0.4	12.0 ± 0.7	41.8 ± 0.2	15.6 ± 0.8

Table H24: A comparison of Saanen goats treated or not: temperature before reaction (T_BEF).
[t-test]

Group	n	Mean (°C)	SD	SE	Min.	Max.
Treated	10	38.87	0.226	0.072	38.7	39.4
Not treated	9	38.93	0.328	0.109	38.5	39.5

Variances	t	DF	P
Unequal	-0.4848	14	0.6353
Equal	-0.4945	17	0.6273

Table H25: A comparison of Saanen goats treated or not: temperature at day of rise (T_RISE).
[t-test]

Group	n	Mean (°C)	SD	SE	Min.	Max.
Treated	10	40.56	0.337	0.107	40.0	41.0
Not treated	9	40.70	0.640	0.213	40.0	41.9

Variances	t	DF	P
Unequal	-0.5867	11.8	0.5684
Equal	-0.6056	17.0	0.5528

Table H26: A comparison of Saanen goats treated or not: day of rise in temperature (D_RISE)
[t-test]

Group	n	Day	SD	SE	Min.	Max.
Treated	10	10.20	0.422	0.133	10.0	11.0
Not treated	9	9.33	1.225	0.408	8.0	11.0

Variances	t	DF	P
Unequal	2.0180	9.7	0.0722
Equal	2.1089	17.0	0.0501

Table H27: A comparison of Saanen goats treated or not: temperature at peak (T_PEAK). [t-test]

Group	n	Mean (°C)	SD	SE	Min.	Max.
Treated	10	41.59	0.412	0.130	41.1	42.3
Not treated	9	41.70	0.255	0.085	41.3	42.1

Variances	t	DF	P
Unequal	-0.7069	15.2	0.4903
Equal	-0.6896	17.0	0.4998

Table H28: A comparison of Saanen goats treated or not: day of peak temperature (D_PEAK) [t-test]

Group	n	Day	SD	SE	Min.	Max.
Treated	10	11.60	0.843	0.267	11.0	13.0
Not treated	9	11.33	0.707	0.236	10.0	12.0

Variances	t	DF	P
Unequal	0.7493	16.9	0.4640
Equal	0.7420	17.0	0.4682

Table H29: A comparison of Saanen goats treated or not: temperature rise (T_UP). [t-test]

Group	n	Mean (°C)	SD	SE	Min.	Max.
Treated	10	2.72	0.319	0.101	2.20	3.20
Not treated	9	2.77	0.342	0.114	2.00	3.10

Variances	t	DF	P
Unequal	-0.3062	16.4	0.7633
Equal	-0.3074	17.0	0.7623

REFERENCES

ABOUL-NAGA,A.M. & HANRAHAN,J.P., 1992. Genetics of reproduction in female goats. In: Pre-Conf. Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers, 2(2):334-341.

ACHARYA,R.M. & SINGH,N.P., 1992. The role of goat in conservation of ecology and livelihood security. In: Pre-Conf. Proc., V Intl.Conf. on Goats, New Delhi, March 1992. Plenary Papers:81-99.

ADAMS,D.S., OLIVER,R.E., AMEGHINO,E., DEMARTINI,J.C., VERWOERD,D.W., HOUWERS,D., WAGHELA,S., GORHAM,J.R., HYLLSETH,B., DAWSON,M., TRIGO,F.J. & MCGUIRE,C., 1984. Global survey of serological evidence of caprine arthritis-encephalitis virus infection. *Vet.Rec.*115:493-495.

ADDEO,F., DI LUCCIA,A., MAURIELLO,R., CHIANESE,L. & FERRARA,L., 1987. The casein of goat's milk. In: Proc. 4th Int. Conf. Goats, EMBRAPA-DDT, Brasilia, 1475.

ADEMOSUN,A.A., BOSMAN,H.G., HAENLEIN,G.F.W. & ADEBOWALE,E.A., 1992.Recent advances in nutrient requirements of goats. In: Pre-Conf.Proc., V Intl.Conf on Goats, New Delhi, March 1992. Invited Papers: 183-194.

ALEXANDER,A.F., DEMARTINI,J.C.,McGUIRE,T.C. & OLANDER,H.J., 1989. Animal health research in the small ruminant collaborative research support program. *J. Anim. Sci.* 67:3103-3110.

ALEXANDRE,G., AUMONT,G., COPPRY,O., MAYNAUD,J.C. & FLEURY,J., 1996. Effects of age regrowth of *Digitaria decumbens* irrigated pasture on milk production and growing rate in Creole goats. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:604-609.

ALLAN,C.J. & HOLST,P.J., 1996. The ecological role of the goat in maintaining pasture and range. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China: 427-435.

ALLAN,C.J., HINCH,G.N. & HOLST,P.J., 1992. A comparison of techniques for the determination of early post natal death of kids. In: Pre-Conf. Proc, V Intl. Conf on Goats, New Dellhi, March 1992, Abstr. Contrib. Papers: 328.

ALLAN.C.J., HOLST,P.J. & HINCH,G.N., 1992. Factors affecting survival of Australian bush goat kid. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992, Abstr. Contrib.Papers: 329.

ALVAREZ,F.J., SAUCEDO,G., ARRIAGA,A. & PRESTON,T.R., 1980. Effect on milk production and calf performance of milking crossbred European/Zebu cattle in the absence or presence of the calf, and of rearing their calves artificially. *Tropical Animal Production* 5:25-37.

AMOAH,E.A. & GELAYE,S., 1990. Superovulation, synchronization and breeding of does. *Small Rumin.Res.*3:63-72.

ANDERSON,N., 1982. Internal parasites of sheep and goats. In: Sheep and Goat Production, Ed.I.E.Coop. Elsevier, Amsterdam: 175-191.

ANGWENYI,G.N. & CARTWRIGHT,T.C., 1987. Effects of crossbreeding East African, Galla and Boer goats on body size, growth rate and kid survivability in Kenya.In: Proc. 4th Int. Conf. Goats, EMBRAPA-DDT, Brasilia: 1315.

ANOUS,M.R. & SHAHIN,K.A., 1993. Genetic and castration influence on cross-sectional

areas and composition of the gigot in goats. *Small Rumin. Res*. 10:165-173.
ANTIC,S., TESIC,M. & PETROVIC,R., 1986. Characteristics of goats and development of goat husbandry in the world, individual continents and individual countries, with particular regard to the current situation and the need and potential for development in Serbia. [*Dairy Sci.Abstr.*49:3288(1987)].
APPLEMAN,R.D., 1984. Housing. In: Extension Goat Handbook. Ed:G.F.W.Haenlein and D.L.Ace, USDA, Washington.p B-1,8.
ARMSTRONG,D.T., MICHALSKA,A., ASHMAN,R.J., BESSOUDO,E., SEAMARK,R.F., VIZE,P. & WELLS,J.R.E., 1987. Gene transfer in goats: methodologies and potential applications.
In: Proc. 4th Int. Conf. Goats, EMBRAPA-DDT, Brasilia: 601-610.
ASHBROOK,P.F., 1982. Year-around breeding for uniform milk production. In: Proc. 3rd Int. Conf. Goat Prod. and Disease, Univ. Arizona,Tucson: 153-154.
AYERS,J.L., 1984a. Diarrheal diseases.In: Extension Goat Handbook. Ed. G.F.W.Haenlein and D.L.Ace, USDA, Washington DC: G-4.

AYERS,J.L., 1984b. Enterotoxemia.In: Extension Goat Handbook. Ed. G.F.W.Haenlein & D.L.Ace,USDA, Washington DC.: G-10.
BAS,P. & MORAND-FEHR,P., 1992. Changes in blood metabolites after weaning in young goats. In: Pre-Conf Proc., V Intl. Conf on Goats, New Delhi, March 1992. Abstr.Contrib.Papers: 148.
BAS,P., MORAND-FEHR,P. & SCHMIDELY,P., 1991. Weaning: a critical period for young kids. In: Goat Nutrition, Ed: P. Morand-Fehr, EAAP Publ. No.46, Pudoc Wageningen: 271-283.
BAJHAU,H.S. & KENNEDY,J.P., 1990. Influence of pre- and postpartum nutrition on growth of goat kids. *Small Rumin. Res.* 3:227-236.
BAKER,G.A. & DE SOUZA NETO,J., 1989. Assessment of the potential of dual-purpose goats in Northeast Brazil. *Small Rumin. Res.* 2:97-105.
BAKKENE,G., 1985. [Effect of crossbreeding on quality of goats' milk]. *Meieriposten* 74:35-39.[*Dairy Sci. Abstr*.49:1969(1987)].
BALLESTER,P., 1986. Production and use of sheep and goat milk in Spain. *Bull. Int. Dairy Fed.* No. 202:212-214. [*Dairy Sci. Abstr.*49:2686(1987)].
BARRY,D.M. & VAN NIEKERK,C.H., 1990. Anaplasmosis in improved Boer goats in South frica artificially infected with *Anaplasma ovis. Small Rumin.Res.*3:191-197.
BATH,D.L., DICKINSON,F.N., TUCKER,H.A. & APPLEMAN,R.D., 1985. Dairy attle:principles, practices, problems, profits. 3rd Edition. Lea and ebiger,Philadelphia.
BEMBRIDGE,T.J., 1987. Aspects of cattle production in Transkei. *S.Afr.J.Anim.Sci.*17:74-78.
BEMBRIDGE,T.J., 1991. The practice of agricultural extension: a training manual. velopment Bank of Southern Africa, Halfway House, South Africa.
BENAVIDES,J., 1992. Agroforestry and goat feeding for small-scale farmers in Central merica. In: Roundtable on goats for small-holders with a focus on women's roles. International Conference on Goats, New Delhi, India, 6 March 1992.
BERNABE,A., GOMEZ,M.A., NAVARRO,J.A., GOMEZ,S., SANCHEZ,J., SIDRACH,J. & MENCHEN,V.1991. Pathological changes of spontaneous dual infection of uberculosis and paratuberculosis in goats. *Small Rumin. Res.*5:377-390.

BHATNAGAR,D.S., CHAWLA,D.S. & SHARMA,R.C., 1982. Effect of crossbreeding on milk production in dairy goats.In: Proc. 3rd Int. Conf.Goat Prod. and Disease, Univ. Arizona, Tucson: 353.

BLISS,E.L., 1984. Herd health program.In: Extension Goat Handbook. Ed.G.F.W.Haenlein nd D.L.Ace, USDA, Washington DC. pG-1.

BOOGAERT,D.H.van A., 1982. Goat husbandry in the Netherlands. In: Proc.3rd Int. Conf. Goat Prod. and Disease. Univ.Arizona, Tucson: 506.

BOOR,K.J., BROWN,D.L. & FITZHUGH,H.A., 1987. The potential for goat milk production. *World Animal Review*, No.62:31-40.

BOYAZOGLU,J. & MORAND-FEHR,P., 1987. Systems of goat production and the environment.In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 95-106.

BOYLAN,W.J., MAKHAMBERA,T.P.E., KAMWANJA,L.A., SWARTZ,H.A. & PATTEN,S.E., 1996. Breeding goats in the tropics to enhance child nutrition and health. In: roc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:51-53.

BRADFORD,G.E.,BURFENING,P.J. & CARTWRIGHT,T.C., 1989. Evaluation of production and reproduction of sheep, goat, and alpaca genotypes in the small ruminant collaborative research program. *J. Anim. Sci*. 67:3058-3067.

BROWNING,R., LEITE-BROWNING,M.L. & SAHLU,T., 1995. Factors affecting standardized milk and fat yields in Alpine goats. *Small Rumin. Res.* 18:173-178.

BRUN-BELLUT,J., LINDBERG,J.E. & HADJIPANAYIOTOU,M., 1991. Protein nutrition and requirements of adult dairy goats. In: Goat Nutrition Ed: P.Morand-Fehr. EAAP Publ. No.46, Pudoc, Wageningen: 82-93.

BUFANO,G., DARIA,C., LAUDADIO,V. & DELL'AQUILA,S., 1996. Permanent stabling breeding system in goats: quanti-qualitative aspects of milk yield in Saanen goats reared in southern Italy. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:933-936.

BUSWELL,J.F., KNIGHT,C.H. & BARBER,D.M.L., 1989. Antibiotic persistence and tolerance in the lactating goat following intramammary therapy. *Vet.Rec.*125:301-303.

CABARET,J., ANJORAND,N. & LECLERC,C., 1989. Parasitic risk factors on pastures of French dairy goat farms. *Small Rumin.Res*.2:69-78.

CALDERON,I., DE PETERS,E.J., SMITH,N.E. & FRANKE,A.A., 1980. Composition of goat's milk: Changes within milking and effects of a high concentrate diet. *J.Dairy Sci.*67:1905-1911.

CARLES,A.B. & SCHWARTZ,H.J., 1992. Factors affecting flock productivity of small East African goats on a Kenyan rangeland. In: Pre-Conf.Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers:10.

CASEY,N.H., 1992. Goat meat in human nutrition. In: Pre-Conf. Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers, 2(2):581-598.

CASEY,N.H. & VAN NIEKERK,W.A., 1988. The Boer goat. I. Origin, adaptability, performance testing, reproduction and milk production. *Small Rumin.Res*. 1:291-302.

CHARTIER,C., PORS,I. & PELLET,M.P., 1992. Internal parasitism of dairy goats raised in a zero-grazing system in France. In: Pre-Conf.Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 456.

CHAWLA,D.S. & BHATNAGAR,D.S., 1982. Reproductive performance of dairy goats.In: Proc.3rd Int. Conf. Goat Prod. and Disease, Univ. Arizona,Tucson: 304.

CHAWLA,D.S. & VERMA,N.K., 1982. Variation in milk yield and its components in dairy goats.In:Proc.3rd Int. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 360.

CHATTOPADHYAY,S.K., PARIHAR,N.S. & SIKDAR,A., 1992. Caprine pulmonary mycosis in India: spontaneous and experimental studies. In: Pre-Conf. Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 457.

CHEMINEAU,P., 1992. Seasonality and photoperiodic influence in the female goat reproduction. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers, 2(2):355-368.

CHEMINEAU,P., BARIL,G., LEBOEUF,B., MAUREL,M.C. & COGNIE,Y., 1996. Recent advances in the control of goat reproduction. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:776-784.

CHEMINEAU,P., DAVEAU,A., MAURICE,F. & DELGADILLO,J.A., 1992. Seasonality of estrus and ovulation is not modified by subjecting female Alpine goats to a tropical photoperiod. *Small Rumin. Res.* 8:299-312.

CHHABRA,R.C. & PANDEY,V.S., 1992. Caprine coccidiosis and its control in Zimbabwe. In: Pre-Conf. Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 459.

COETZER,R., 1996. Personal communication. Informatics, ARC, Pretoria.

CONSTANTINOU,A., 1989. Genetic and environmental relationships of body weight, milk yield and litter size in Damascus goats. *Small Rumin. Res*. 2:163-174.

CONTRERAS,A., PAAPE,M.J., DI CARLO,A.L., MILLER,R.H. & RAINARD,P., 1997. Evaluation of selected antibiotic residue screening tests for milk from individual goats. *J. Dairy Sci.* 80:1113-1118.

COOP,I.E., 1982. Intensive grassland systems.In: Sheep and Goat Production, Ed.I.E.Coop, Elsevier, Amsterdam: 351-375.

COOPER,R.A., KIRK,J.A., KAMWANJA,L. & BANDA,J., 1994. Milk production from the Indigenous Malawi goat. International Livestock Centre for Africa, Small Ruminant Research Network, Third Biennial Conference, 5-9 December 1994.

CORTEEL,J.M., LEBOEUF,B. & BARIL,G., 1988. Artificial breeding of adult goats and kids induced with hormones to ovulate outside the breeding season. *Small Rumin.Res.*1:19-35.

CUMLIVSKI,B. & STOURAL,F., 1993. Aspects of machine milking of goats. Fifth Intl. Symp. Machine Milking of Small Ruminants, 14-20 May 1993, Budapest, Hungary:94.

CUNNINGHAM,J.M.M., 1982. Extensive grazing systems.In: Sheep and Goat Production, Ed.I.E.Coop, Elsevier, Amsterdam: 331-350.

DA COSTA MENDES,V.M., DE BEER,M.C., ELS,H.J., GOOSEN,G.H., THERON,J. & STEELE,A.D., 1994. Rotavirus in Saanen goats. *J. S. Afr. Vet. Ass.* 65(3):132-133.

DAMASSA,A.J. & BROOKS,D.L., 1987. The importance of caprine mycoplasmosis in the United States. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 1351.

DAMASSA,A.J., BROOKS,D.L., HOLMBERG,C.A. & MOE,A.I., 1987. Caprine mycoplasmosis:an outbreak of mastitis and arthritis requiring the destruction of 700 goats. *Vet.Rec.* 120:409-413.

DANIELSSON,M.L., HAMMARBERG,K.E. & WITTANDER,G., 1982. On the bacteriology of goat milk and cheese.In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 358.

DAS,S.M. 1992. Reproduction, growth and milk yield of blended goats in Tanzania. In: Pre-Conf. Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 52.

DAVIDSON,S., PASSMORE,R., BROCK,J.F. & TRUSWELL,A.S., 1984. Human Nutrition and Dietetics, 7th Edition. Churchill Livingstone, Edinburgh.

DEBENETH,A. & COLL, 1992. Male-female differences in seasonal reproductive rhythms in the goat. In: Pre-Conf Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 261.

DE GROOT,B., PRASAD,R.A.N., SONI,R.L., NETT,P. & KROPF,W., 1992. Performance of Sirohi goats under village conditions in Rajasthan, India. In: Pre-Conf.Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 53.

DE LANGE,A.O., 1989. Modern animal breeding techniques for developing areas. In: Proc. Symposium, S.A. Society of Animal Production, Developing Areas Branch, MEDUNSA: 38-47.

DELGADILLO,J.A., LEBOEUF,B. & CHEMINEAU,P., 1992. Abolition of seasonal variations in semen quality and maintenance of sperm fertilizing ability by photoperiodic cycles in goat bucks. *Small Rumin. Res.* 9:47-59.

DELAGADILLO,J.A. & MALPAUX,B., 1996. Reproduction of goats in the tropics and subtropics. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:785-793.

DEMMENT,M.W. & LONGHURST,W.M., 1987. Browsers and grazers: constraints on feeding ecology imposed by gut morphology and body size. In: Proc. 4th Int. Conf. Goats, EMBRAPA-DDT, Brasilia : 989-1004.

DENTINE,M.R. & McDANIEL,B.T., 1982. Potential genetic gain in U.S. dairy goats. In: Proc.3rd Int. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 302.

DERCKSEN,D.P., TER LAAK,E.A. & SCHREUDER,B.E.C., 1996. An eradication programme for caseous lymphadenitis in the southern Netherlands. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:735-737.

DEVENDRA,C., 1987a. The role of goats in food production systems in industrialised and developing countries. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 3-40.

DEVENDRA,C., 1987b. Feed resources and their relevance in feeding systems for goats in developing countries. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 1037-1062.

DEVENDRA,C., 1992a. Goats and rural prosperity. In: Pre-Conf. Proc., V Intl. Conf on Goats, New Delhi, March 1992. Plenary Papers: 6-25.

DEVENDRA,C., 1992b. Recent advances on feed availability and utilization. In: Pre-Conf. Proc. V Intl.Conf. on Goats, New Delhi, March 1992. Invited Papers 2(1):156-167.

DEVENDRA,C., 1996. Goat production in small farm systems in Asia. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:25-50.

DEVENDRA,C. & BURNS,M., 1983. Goat Production in the Tropics. Commonwealth Agricultural Bureaux, Slough, England.

DEVENDRA,C. and COOP, I.E., 1980. Ecology and distribution.In: Sheep and Goat

Production. Ed:I.E.Coop. World Animal Science, C1. Elsevier Scientific Publishing Company, Amsterdam. p1.
DEVESON,S.,FORSYTH,I.A. & ARENDT,J., 1989. Long-day followed by melatonin treatment of goats to advance seasonal breeding. *J.Reprod.Fertil.* 86: Suppl. Abstract Series No.3:12.
DEWHURST,R.J. & KNIGHT,C.H., 1993. An investigation of the changes in sites of milk storage in the bovine udder over two lactation cycles. *Anim.Prod.* 57:379-384.
DEWHURST,R.J. & KNIGHT,C.H., 1994. Relationship between milk storage characteristics and the short-term response of dairy cows to thrice-daily milking. *Anim.Prod.* 58:181-187.
DODD,F.H. & NEAVE,F.K., 1970. Mastitis control. National Institute for Research in Dairying: Biennial Reviews 1970: NIRD Paper No.3559: 21-60.
DONKIN,E.F., 1988. The role of goats in small farm systems in the developing areas of Southern Africa.In: Proc. Symposium, S. Afr. Soc. Anim. Prod., Developing Areas Branch: 38-46.
DONKIN,E.F., 1991. Small-scale milk production. Paper presented at the Annual Symposium, Developing Areas Branch, South African Society of Animal Science, Golden Gate National Park, South Africa, October 1991.
DONKIN,E.F., BOYAZOGLU,P.A. & LUBOUT,P.C., 1990. First lactations of Saanen and Indigenous goats given a complete diet *ad libitum*. S. Afr. Soc. Anim. Prod. Congress, Stellenbosch. (Poster).
DONKIN,E.F., STEWART,C.G., MACGREGOR,R.G., ELS,H.C., RAMSAY,K.A. & BOYAZOGLU,P.A., 1992. Resistance of indigenous and crossbred goats to heartwater (*Cowdria ruminantium*). In: Recent Research in Goat Production. Proc. V Intl. Conf. on Goats, New Delhi, 2-8 March 1992: 1716-1719. Publ. International Goat Association.
DONKIN,E.F., BOYAZOGLU,P.A., ELS,H.C., MACGREGOR,R.G., RAMSAY,K.A. & LUBOUT,P.C., 1996. Productivity of Saanen, South African Indigenous and Crossbred goats fed a complete feed: preliminary results. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:132-135.
DUBEY,J.P., 1987. Toxoplasmosis in goats. In: Proc. 4th Int. Conf. Goats, EMBRAPA-DDT, Brasilia: 513-520.
DUBEY,J.P., 1992. Protozoal and metazoal diseases of goats. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers, 2(1): 541-548.
DUNN,P.G.C., 1985. Goat Veterinary Society survey data 1983-1984: diseases of the periparturient goat. *Goat Vet. Soc. J.* 6:49-50. [*Dairy Sci. Abstr.* 48:4046(1986)].
DU PLESSIS,J.L., 1985. The natural resistance of cattle to artificial infection with *Cowdria ruminantium*: the role played by conglutinin. *Onderstepoort J. vet. Res.* 52: 273-277.
DU PLESSIS,J.L. & BEZUIDENHOUT,J.D., 1979. Investigations on the natural and acquired resistance of cattle to artificial infection with *Cowdria ruminantium*. J. South African Vet. Ass. 50(4): 334-338.
DU PLESSIS,J.L., DE KOCK,L.D., LOOCK,P.J., LÜDEMANN,C.J.F., MALAN, L., VAN WYK,L. & VISSER,D., 1986. Heartwater immunization of improved Boer goats feasible but demanding. *Onderstepoort Newsletter* (1986):17.
DU PLESSIS,J.L., JANSEN,B.C. & PROZESKY,L., 1983. Heartwater in Angora goats.

1.Immunity subsequent to artificial infection and treatment. *Onderstepoort J. Vet. Res.* 50:137-143.
DU PLESSIS,J.L. & MALAN,L., 1987. The non-specific resistance of cattle to heartwater. *Onderstepoort J. Vet. Res.* 54:333-336.
DU PLESSIS,J.L., MALAN,L. & KOWALSKI,Z.E., 1987. The pathogenesis of heartwater. *Onderstepoort J. Vet. Res.* 54:313-318.
DURAN,S.P., MANZANO,J.V., VALERA,R.C. & MACHOTA,S.V., 1990. In-vitro antimicrobial susceptibility of *Bacteroides* and *Fusobacterium* isolated from footrot in goats. *Br. Vet. J.* 146: 437-442.
EAST,N.E., BIRNIE,E.F. & FARVER,T.B., 1987. Risk factors associated with mastitis in dairy goats. *American J. Vet. Res.* 48:776-779.
EAST,N.E., ROWE,J.E., DAHLBERG,J.E., THEILEN,G.H. & PEDERSEN,N.C., 1993. Modes of transmission of caprine arthritis-encephalitis virus infection. *Small Rumin. Res.* 10:251-262.
EL-HASSAN,A.M. & RAMADAN,R.O., 1982. Malignant melanoma in the goat. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 373.
FAO, 1986. Food and Agriculture Organization.Production. External trade. FAO Monthly Bulletin of Statistics 9:34-69. [*Dairy Sci. Abstr.* 49:3592(1987)].
FAO, 1994. Ticks and tickborne diseases of sheep and goats: First expert consultation. (Report). Rome:14pp.
FERNANDEZ,J.M., SAHLU,T., LU,C.D. & JACQUEMET,N., 1992. Metabolic aspects of the *Leucaena* toxin mimosine in goats. In: Pre-Conf. Proc. V Intl.Conf. on Goats, New Delhi, March 1992. Abstr. Contrib.Papers: 463.
FOOTE,W.C., CALL,J.W. & BUNCH,T.D., 1987. The potentials and limitations of embryo transfer in goats. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 611-621.
FOWLER,P.A., KNIGHT,C.H. & FOSTER,M.A., 1991. Omitting the dry period between lactations does not reduce subsequent milk production in goats. *J. Dairy Res.* 58:13-19.
FOX,L.K., HANCOCK,D.D. & HORNER,S.D., 1992. Selective intramammary antibiotic therapy during the nonlactating period in goats. *Small Rumin. Res.* 9: 313-318.
GALAL,E.S.E., 1987. Biological aspects of increasing production.In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 56-74.
GALINA,M.A., MORALES,R., LOPEZ,B. & CARMONA,M.A., 1996. Sources of variation of somatic cell count during lactation in Mexican dairy goats. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:325-328.
GALL,C., 1975. Milk production from sheep and goats. *World Anim. Rev.* 13:1-8.

GALL,C., 1981. Milk production.In: Goat Production,Ed.C.Gall. Academic Press, London: 309-344.
GARCIA,O., BRAVO,J., KENNEDY,B. & GARCIA,E., 1982. Crossbreeding of imported and native goats in a dry tropical environment II. Production and reproduction. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, EMBRAPA-DDT, Brasilia: 509.
GARCIA,O., GARCIA,E., KENNEDY,B. & BRAVO,J., 1982. Crossbreeding of imported and native goats in a dry tropical environment I. Survival and growth

of kids. In: Proc. 3rd Intl. Conf. Goat Prod and Disease, EMBRAPA-DDT, Brasilia: 510.
GEISSLER,B., 1987. Jahresbericht 1985-1986. Landesverband Bayerischer Ziegenzuchter e.V.: 17pp.
GEZON,H.M., BITHER,H.D., HANSON,L.A. & THOMPSON,J.K., 1991. Epizootic of external and internal abscesses in a large goat herd over a 16-year period. *J. Amer. Vet. Med. Ass.* 198: 257-263.
GIGER-REVERDIN,S. & GIHAD,E.A., 1991. Water metabolism and intake in goats. In: Goat Nutrition. Ed: P.Morand-Fehr. EAAP Publ. No.46, Pudoc, Wageningen: 37-45.
GIGER-REVERDIN,S. & SAUVANT,D., 1991. Evaluation and utilization of concentrates in goats. In: Goat Nutrition. Ed: P.Morand-Fehr. EAAP PUBL. No.46, Pudoc, Wageningen: 172-183.
GILL,J.P.S. & JOSHI,D.V., 1992. Microbiological assay of goat meat with special reference to pathogenic organisms. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 536.
GILL,H.S., POMROY,W.E., CHARLESTON,W.A.G. & MORIARTY,K.M., 1991. Caprine haemonchosis: lymphocyte responses to parasite antigen and mitogens. *Small Rumin. Res.* 4: 101-108.
GIPSON,T.A. & GROSSMAN,M., 1989. Diphasic analysis of lactation curves in dairy goats. *J.Dairy Sci.* 72: 1035-1044.
GIRDHAR,N., LALL,D. & PATHAK,N.N., 1991. Effect of feeding *Leucaena leucocephala* as the sole ration on nutrient utilization and body weight in goats. *J. Agric. Sci. Camb.* 116:303-307.
GOGOI,D., LAHON,D.K., PATHAK,S.C. & LEKHARU,J.C., 1992. Coenurosis in goat. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 466.
GONZALEZ,R.J. & TORTORA,P.J., 1992. Prevalence and distribution of caseous lymphadenitis lesions in goats under two different production systems. In: Pre-Conf. Proc., V Intl. Conf on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 467.
GONZALEZ-STAGNARO,C. & MADRID-BURY,N., 1982. Sexual season and estrous cycle of native goats in a tropical zone of Venezuela. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, EMBRAPA-DDT, Brasilia:311.
GORNEY,K.G., 1982. Goat milk - vital in the management of allergic disease. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, EMBRAPA-DDT, Brasilia: 361.
GREENWOOD,P.L., 1992. Development of advisory programmes to eradicate CAEV. In: Pre-Conf. Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 470.
GREENWOOD,P.L., 1993. Rearing systems for dairy goats. *Small Rumin. Res.* 10: 189-199.
GREYLING,J.P.C., 1988. Report on Study Tour to France: Reproductive Physiology. Animal and Dairy Science Research Institute, Irene, South Africa. 36pp.
GRIFFIN,L. & ALLONBY,E.W., 1979. Trypanotolerance in breeds of sheep and goats with an experimental infection of *Trypanosoma congolense*. *Vet. Parasitol.* 5:97-105.
GRIFFIN,C.L., ORCUTT,M.W., RILEY,R.R., SMITH,G.C., SAVELL.J.W. & SHELTON,M., 1992. Evaluation of palatability of lamb, mutton, and chevon by sensory panels of

various cultural backgrounds. *Small Rumin. Res.* 8:67-74.
GROENEWALD, P.C.N., FERREIRA, A.V., VAN DER MERWE,H.J. & SLIPPERS,S.C., 1995. A mathematical model for describing and predicting the lactation curve of Merino ewes. *Anim. Science* 61:95-101.
GUSS,S.B., 1983. A health program for dairy goats. In: Sheep and Goat Handbook, Vol.3. Ed.F.H.Baker. International Stockman's School Handbook, Westview Press, Boulder, Colorado: 483-497.
GUSS,S.B., 1984. Mastitis. In: Extension Goat Handbook Ed.G.F.W.Haenlein and D.L.Ace, USDA, Washington DC.: G-7.
HADALGO,M.A.G., 1987. Goat enzotic pneumonia. A review. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 449-460.
HADJIPANAYIOTOU,M., BRUN-BELLUT,J. & LINDBERG,J.A., 1991. Protein nutrition and requirements of growing goat. In: Goat Nutrition. Ed: P.Morand-Fehr. EAAP Publ. No.46, Pudoc, Wageningen: 94-103.
HADJIPANAYIOTOU,M., ECONOMIDES,S., MORAND-FEHR,P., LANDAU,S. & HAVREVOLL,O., 1991. Postweaning feeding of young goats. In: Goat Nutrition. Ed: P. Morand-Fehr. EAAP Publ. No.46, Pudoc, Wageningen: 284-291.
HADJIPANAYIOTOU,M. & MORAND-FEHR,P., 1991. Intensive feeding of dairy goats. In: Goat Nutrition. Ed.P.Morand-Fehr. EAAP Publ. No.46, Pudoc, Wageningen: 197-208.
HAENLEIN,G.F.W., 1980. Mineral nutrition of goats. *J. Dairy Sci.* 63:1729-1748.
HAENLEIN,G.F.W., 1986. Dimensions of the goat milk industry in the USA. Bull.Intl. Dairy Fed. No.202:215-217.[*Dairy Sci.Abstr.* 49:2648].
HAENLEIN,G.F.W., 1992. Recent advances in goat requirements of macroelements. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers: 195-201.
HAMMOND,A.C., 1995. Leucaena toxicosis and its control in ruminants. *J. Anim. Sci.* 73:1487-1492.
HARBOLA,P.C. & RATAN,B., 1992. Enterotoxaemia in goats due to *Clostridium perfringens* and its control. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992.
Abstr. Contrib. Papers: 472.
HARDESTY,L.H., 1988. Livestock management in a mixed farming system. In: Proc. 1988 Intl. Rangeland Development Symposium, Corpus Christi, Texas. Editors:C.W.Gay, G.Perrier & J.Tiedeman, Utah State Univ., Logan, Utah:147-155.
HARRINGTON,G.N., 1982. Grazing behaviour of the goat. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, EMBRAPA-DDT, Brasilia: 398-403.
HARRISON,J., 1988. Presentation d'un projet caprin: le Zimbabwe. Bulletin de Liaison de l'UCARDEC, Paris: 13-19.
HASSO,S.A., AL-AUBAIDI,J.M. & AL-DARRAJI,A.M., 1993. Contagious agalactia in goats: its severity as related to the route of infection and pregnancy. *Small Rumin. Res.* 10: 263-275.
HATZIMINAOGLU,J., BOYAZOGLU,J. & MATSOUKAS,J., 1982. A note on goat production in Greece. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 506.

HAVREVOLL,O., HADJIPANAYIOTOU,M., SANZ SAMPELAYO,M.R., NITSAN,Z. & SCHMIDELY,P., 1991. Milk feeding systems of young goats. In: Goat Nutrition. Ed: P.Morand-Fehr. EAAP Publ. No.46, Pudoc, Wageningen: 259-270.

HERNANDEZ-NAUS,A., ALJARO,M. & RUIZ,G., 1987. First official milk recording lactations of selected crossbred goats. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 1324.

HILL,W.G. & MEYER,K., 1988. Developments in methods for breeding value and parameter estimation in livestock. In: Animal Breeding Opportunities, BSAP Occasional Paper No.12: 81-98.

HOFMEYER,H.S., 1969. Die melkbok in Suid-Afrika. Dept Landbou-Tegniese Dienste, South Africa. Pamflet Nr.387.(26pp).

HOGG,B.W., MERCER,G.J.K., MORTIMER,B.J., KIRTON,A.H. & DUGANZICH,D.M., 1992. Carcass and meat quality attributes of commercial goats in New Zealand. *Small Rumin. Res.* 8:243-256.

HOLTZ,W. & SOHNREY,B., 1992. Oestrus induction during the anoestrus season in goats. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 342.

HORST,P., 1997. Animal breeding as a factor of influence on the conservation of natural resources and utilisation of genetic resources. *Animal Research and Development* 46:63-74.

HORTON,C.T. & DAWSON,J.E., 1987. Livestock diversification in New Zealand involving goats for meat and dairy production. *Proc. New Zealand Soc. Anim. Prod.* 47:125-126. [*Dairy Sci. Abstr*. 51:4061].

ILEMOBADE,A.A., 1982. Blood parasites of African goats. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 68-71.

ILLIUS,A.W. & GORDON,I.J., 1991. Prediction of intake and digestion in ruminants by a model of rumen kinetics integrating animal size and plant characteristics. *J.Agric. Sci. Camb.*116:145-157.

ISHWAR,A.K. & MEMON,M.A., 1996. Embryo transfer in sheep and goats: a review. *Small Rumin. Res.* 19:35-43.

JAWARA,D.K., 1990. Animal disease as a factor limiting economic development in Africa. *Cornell Vet*. 80:17-25.

JENNESS,R., 1980. Composition and characteristics of goat milk: Review 1968-1979. *J. Dairy Sci*. 63:1605-1630.

JIABI,P. & SINN,R., 1992. Training programs with a focus on women. In: Roundtable on goats for small-holders with a focus on women's roles. V Intl. Conf. on Goats, New Delhi, India, 4 March 1992.

JOHNSON,W.L & DJAJANEGARA,A., 1989. A pragmatic approach to improving small ruminant diets in the Indonesian tropics. *J. Anim. Sci.* 67:3068-3079.

JONES,G.E., 1989. Contagious caprine pleuropneumonia(CCPP). Tech. Series No.9, Office International des Epizootics, Paris: 1-63.

JONES,R.J., 1981. Does ruminal metabolism of mimosine explain the absence of *Leucaena* toxicity in Hawaii? *Aust.Vet.J.*57:55-56.

KALOGRIDOU-VASSILIADOU,D., 1991. Mastitis-related pathogens in goat milk. *Small Rumin. Res.* 4:203-212.

KALOGRIDOU-VASSILIADOU,D., MANOLKIDIS,K. & HATZIMINAOGLOU,J., 1991. Changes in mastitis pathogens in goat milk throughout lactation. *Small Rumin. Res.* 4:197-201.

KATSAOUNES,N., 1986. [Milk production in Greece. The present situation and ways to improve it.] *Deltion tes Ellenikes Kteniatrikes Etaireias* 37:197-205. [*Dairy Sci. Abstr.* 49:4801(1987)].

KAWAS,J.R., FOOTE,W.C. & SIMPLICIO,A., 1992. Nutritional aspects of female reproduction. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers 2(2): 342-354.

KAWAS,J.R., LOPES,J., DANELON,D.L. & LU,C.D., 1991. Influence of forage-to-concentrate ratios on intake, digestibility, chewing and milk production of dairy goats. *Small Rumin. Res.* 4:11-18.

KESSLER,J., 1991a. Mineral nutrition of goats. In: Goat Nutrition. Ed:P.Morand-Fehr. EAAP Publ. No46, Pudoc, Wageningen: 104-119.

KESSLER,J., 1991b. Vitamin Nutrition of goats. In: Goat Nutrition. Ed: P.Morand-Fehr. EAAP Publ. No.46, Pudoc, Wageningen: 120-123.

KHERA,S.S. & HARBOLA,P.C., 1982. Incidence of perinatal and youngstock mortality at goat farms in India. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 499.

KIHIA,L., 1992. The potential of indigenous fodder crops for livestock in the arid and semi-arid lands of Kenya. First Symposium Developing Areas Branch, Grassland Society of Southern Africa, 16-18 Septemeber 1992, Cathedral Peak Hotel, South Africa.

KINGWILL,R.G., DODD,F.H. & NEAVE,F.K., 1979. Machine milking and mastitis. In:Machine Milking; Ed. C.C.Thiel and F.H.Dodd. Technical Bull. No.1, NIRD, Reading, England: 231-285.

KITIVO,D., BARTILOL,P. & ALLONBY,E.W., 1982. Milk goats and women's groups in Kenya. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 354.

KNIGHT,C.H., BROSNAN,T., WILDE,C.J. & PEAKER,M., 1989. Evidence for a relationship between gross mammary anatomy and the increase in milk yield obtained during thrice-daily milking in goats. *J. Reprod. Fertil.* 86: Suppl. Abstract Series No.3:32.

KNOWLES,D.P., CHEEVERS,W.P. & GORHAM,J.R., 1987. Caprine arthritis-encephalitis virus epidemiology, transmission, and prevention. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia:1352.

KOLAR,J., 1987. Goat brucellosis and human health. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 505-512.

KUMAR,M. & ISSANI,G.B., 1992. Utilization of edible and non-edible by-products from slaughter of goats. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers, 2(2):487-493.

LACHMAN,P.J., 1967. Conglutinins and immunoconglutinins.In: Advances in Immunology, 6:480-527.

LAKER,J.P., 1996. Production systems for goat fibre in Europe, Africa and the Americas. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:16-24.

LAOR,M., 1982. The dairy goat industry of Israel (semi-arid conditions).In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 505.

LEBBIE,S.H.B., MUKASA-MUGWERA,E. & WILSON,R.T., 1996. Disease and reproductive wastage as constraints to small ruminant production in the tropics. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:727-734.

LEBOEUF,B., 1992. Extensive applications of artificial insemination in goats. In: Pre-Conf. Proc., V Intl. Conf. On Goats, New Delhi, March 1992. Invited Papers, 2(2):298-308.

LEE,H.J. & McINTOSH,G.H., 1982. Nutritional diseases.In: Sheep and Goat Production Ed.I.E.Coop. Elsevier, Amsterdam: 135-150.

LEFEVRE,P.C., 1987a. Disease as an element of adaptation. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 131-142.

LEFEVRE,P.C., 1987b. *In utero* infections causing abortions and weak kids.In:Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 355-371.

LE JAOUEN,J.C., 1981. Milking and the technology of milk and milk products. In: Goat Production. Ed. C.Gall. Academic Press, London: 345-377.

LE JAOUEN,J.C., 1982. La fabrication du fromage de chevre fermier. Institut Technique de l'Elevage Ovin et Caprin, ITOVIC, Paris.

LE JAOUEN,J.C., 1986. Composition du lait - de nombreux facteurs. La Chevre, No.153:10-13.

LERONDELLE,C., RICHARD,Y. & ISSARTIAL,J., 1992. Factors affecting somatic cell counts in goat milk. *Small Rumin. Res.* 8:129-139.

LEWIS,G.A.A., 1975. Goat's milk: legal, disease risk and micro-biological considerations. *J.Royal Soc. Health*, 105:156-159.

LOEWENSTEIN,M., 1982. Dairy goat milk and factors affecting it. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 226-236.

LONKAR,P.S. & PRASAD,M.C., 1992. Pathology of amprolium-induced cerebrocortical necrosis in goats. *Small Rumin. Res.* 13:85-92.

LOPES PEREIRA,C., BAULE,C., COSTA,R. & LANGA,A., 1989. Occurrence of caprine arthritis-encephalitis in Mozambique. *Trop. Anim. Hlth. Prod.* 21:237-238.

LOW,A., 1986. Agricultural Development in Southern Africa: Farm household economics and the food crisis. James Currey, London.

LU,C.D., 1988. Grazing behaviour and diet selection of goats. *Small Rumin. Res.* 1:205-216.

LU,C.D., 1989. Effects of heat stress on goat production. *Small Rumin. Res.* 2:151-162.

LU,C.D., POTCHOIBA,M.J. & LOETZ,E.R., 1991. Influence of vacuum level, pulsation ratio and rate on milking performance and udder health in dairy goats. *Small Rumin. Res.* 5:1-8.

LYONS,D.M., 1989. Individual differences in temperament of dairy goats and the inhibition of milk ejection. *Appl. Anim. Behav. Sci.* 22:269-282.

MACKENZIE,D., 1980. Goat Husbandry (4thEdition). Faber and Faber, London.

MAISI,P. & RIIPINEN,I., 1991. Pathogenicity of different species of Staphylococci in caprine udder. *Br. Vet. J.* 147:126-132.

MAJUMDAR,A.C., 1992. Basic mechanisms involved in the elaboration of the male goat gamete. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers 2(2): 271-278.
MALETNLEMA,T.N., 1987. Nutritional aspects of milk products in developing countries. In: Milk - The Vital Force. Ed. Organizing Committee of the XXII International Dairy Congress. Proceedings: 269-277. D.Reidel Publ. Co.
MALLICK,B.B., DAS,S.K., GOSWAMI,T.K. & KISHORE,S., 1992. Development of a live modified cell culture goat-pox vaccine: field studies. In: Pre-Conf. Proc, V Intl. Conf on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 483.
MALLICK,B.B., SHANKAR,H. & BANSAL,R.P., 1992. Viral diseases of goats with special reference to India. In: Pre-Conf. Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers 2(2):549-557.
MANDEBVU,F.G., 1991. C.S.C. goat marketing policy and constraints. In: Goat Development in Zimbabwe: Prospects and Constraints. Ed: L.R. Ndlovu, Matopos Research Station, November 1991: 152-154.
MANDEBVU,P. & PRASAD,V.L., 1991. Fattening systems for goats. In: Goat Development in Zimbabwe: Prospects and Constraints. Ed: L.R.Ndlovu, Matopos Research Station, November, 191: 28-38.
MANSER,P.A., 1986. Prevalence, causes and laboratory diagnosis of subclinical mastitis in the goat. *Vet. Rec*. 118:552-554.
MAREE,H.P., 1978. Goat milk and its use as a hypo-allergenic infant food. *Dairy goat J.*, May 1978: 62-72.
MARGETIN,M., 1992. Polledness and reproductive parameters of goats in CSFR. In: Pre-Conf. Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 353.
MARTINEZ,A., GETZ,W., GEERS,E., ARNOUX,S. & ZIEHE,G., 1992. Productivity of Haitian and exotic crossbred does. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers:63.
MASON,I.L., 1981. Breeds. In: Goat Production. Ed. C.Gall. Academic Press, London: 57-110.
MASSON,C., RUBINO,R. & FEDELE,V., 1991. Forage utilization in goats. In: Goat Nutrition. Ed: P.Morand-Fehr. EAAP Publ. No.46, Pudoc, Wageningen: 145-159.
MATHERON,G., BARRE,N., CAMUS,E. & GOGUE,J., 1987. Genetic resistance of Guadeloupe native goats to heartwater. *Onderstepoort J. vet. Res*. 54:337-340.
MATTHEWMAN,R.W., 1985. Milk production from goats.In: Milk production in developing countries. Proc. Conf. Edinburgh, 2nd to 6th April, 1984. Centre for Tropical Veterinary Medicine,Edinburgh: 403-423.
MAVROGENIS,A.P. & NARJISSE,H., 1992. Efficiency of intensive systems of goat milk and meat production. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers 2(1): 31-35.
MAVROGENIS,A.P. & PAPACHRISTOFOROU,C., 1988. Estimation of the energy value of milk and prediction of fat-corrected milk yield in sheep and goats. *Small Rumin. Res.* 1:229-236.
MCKELVEY,W.A.C. & BHATTACHARYYA,N.K., 1992. Embryo biotechnology in goats. In:Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Plenary Papers: 51-70.
McDONALD,I., ROBINSON,J.J. & FRASER,C., 1981. Studies on reproduction in prolific

ewes 7. Variability in the growth of individual foetuses in relation to intra-uterine factors. *J. Agric. Sci. Camb.* 96:187.
MELLADO,M., FOOTE,R.H. & BORREGO,E., 1991. Lactational performance, prolificacy and relationship to parity and body weight in crossbred native goats in northern Mexico. *Small Rumin.Res*. 6:167-174.
MELLADO,M., VERA,A. & LOERA,H., 1994. Reproductive performance of crossbred goats in good or poor body condition exposed to bucks before breeding. *Small Rumin. Res.* 14:45-48.
MELLOR,D.J. & MURRAY,L., 1985. Effects of maternal nutrition on udder development during late pregnancy and on colostrum production in Scottish Blackface ewes with twin lambs. *Res. Vet Sci.*39:230-234.
MEMON,M.A. & EBERT,K.M., 1992. Gene manipulations in goats through biotechnology. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Plenary Papers: 37-50.
MEURET,M., BOZA,J., NARJISSE,H. & NASTIS,A., 1991. Evaluation and utilization of rangeland feeds by goats. In: Goat Nutrition. Ed: P.Morand-Fehr. EAAP Publ.No.46, Pudoc, Wageningen: 160-171.
MGASA,M.N. & ARNBJERG,J., 1993. Occurrence of lameness and digital lesions in Tanzanian goats. *Small Rumin. Res.* 10: 55-62.
MILLER,K. & MWANGI,N., 1996. Promotion of dairy goat farming for small holders - a Kenyan model. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:62-65.
MISRA,R.K. & ACHARYA,R.M., 1987. Factors affecting survival up to 180 days of age in Sirohi and Beetal x Sirohi kids. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 1462.
MITTAL,J.P., 1992. Scope for introduction of crossbred goats under arid environment. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 282.
MOCQUOT,J.C., 1985. La reduction du nombre de traites: mythe ou realite? In: Traite mechanique des chevres. Ed. P.LeMens. Les Dossiers Techniques ITOVIC-SPEOC. Institut Technique de l'Elevage Ovin et Caprin, Paris.
MONTALDO,H., ALMANZA,A. & JUAREZ,A., 1997. Genetic group, age and season effects on lactation curve shape in goats. *Small Rumin. Res.* 24:195-202.
MONTALDO,H. & MARTINEZ-LOZANO,F.J., 1993. Phenotypic relationships between udder and milking characteristics, milk production and California mastitis test in goats. *Small Rumin. Res.* 12:329-337.
MOORE,N.W., 1987. Techniques and advances in the recovery, storage and transfer of embryos in the goat. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 587-599.
MOORE,S.J., 1996. Milking systems. In: Annual report of the National Dairy Cattle Performance Testing Scheme, Animal Improvement Institute, Irene, South Africa: 38 – 42.

MORAND-FEHR,P., 1985. Influences des conditions et des techniques d'elevage sur l'etat sanitaire des chevres. *La Chevre*, No.149:9-12.
MORAND-FEHR,P., 1987. Management programs for the prevention of kid losses. In: Proc. 4th Int. Conf. Goats, EMBRAPA-DDT, Brasilia: 405-423.
MORAND-FEHR,P., CHILLIARD,Y. & SAUVANT,D., 1982. Goat milk and its components: secretory mechanisms and influence of nutritional factors. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 113-121.
MORAND-FEHR,P., FALAGAN,A., RUBINO,R., MOWLEM,A. & SKJEVDAL,T., 1992. Goat meat production and processing in Europe. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992, Invited Papers: 473-486.
MORAND-FEHR,P., HAVREVOLL,O., BAS,P., COLOMER-ROCHER,A., FALAGAN,A., SANZ SAMPELAYO,M.R., SAUVANT,D. & TREACHER,T.T., 1991. Influence of feeding and rearing methods on the quality of young goat carcasses. In: Goat Nutrition Ed: P.Morand-Fehr, EAAP Publ. No.46, Pudoc, Wageningen: 292-303.
MORAND-FEHR,P., HERVIEU,J., BAS,P. & SAUVANT,D., 1982. Feeding of young goats.In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 90-104.
MORAND-FEHR,P., HERVIEU,J. & SAUVANT,D., 1996. Effect of mixed or separated feeds supplies and rate of ingestion on the performances of dairy goats. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:566-568.
MORAND-FEHR,P. & SAUVANT,D., 1980. Composition and yield of goat milk as affected by nutritional manipulation. *J.Dairy Sci*. 63:1671-1680.
MORANT,S.V. & GNANASKATHY,A., 1989. A new approach to the mathematical formulation of lactation curves. *Anim. Prod.* 49:151-162.
MORLEY,D. & LOVEL,H., 1986. My Name Is Today. Macmillan Publishers Ltd, London.
MOURAD,M., 1992. Effects of month of kidding, parity and litter size on milk yield of Alpine goats in Egypt. *Small Rumin. Res*. 8:41-46.
MOWLEM,A., 1988. Goat Farming. Farming Press Books, Ipswich, England.
MOWLEM,A., 1992. Role of artificial insemination for improving goat production in difficult environments such as the tropics. In: Pre-Conf. Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 283.
MREMA,M.N., 1996. The economics of indigenous goat production among small holder farmers in Botswana. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:245-248.
MREMA,M. & RANNOBE,S., 1996. Effects of goat and cattle production on the environment: the case of communal areas of Botswana. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:413-415.
MTENGA,L.A., 1992. Experiences in introducing dairy goats to small-scale farmers in Mgeta Highlands, Tanzania. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 26.
MTENGA,L.A. & SHOO,R.A.,1990. Growth rate, feed intake and feed utilization of small East African goats supplemented with *Leucaena leucocephala*. *Small Rumin. Res.* 3:9-18.

MUKHERJEE,T.K., 1992. Improvement of goats in the tropics through genetic and biotechnological methods. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Plenary Papers: 26-36.
MUKHERJEE,T.K., SAMUDRAM,A.R. & SIVARAJ,S., 1985. Milk composition of local and F1
(local x Improved German Fawn male goats. *Malaysian Applied Biology* 14:100-103. [*Dairy Sci. Abstr.* 49:1256(1987)].
MUNOZ,M., LANZA,I., ALVAREZ,M. & CARMENES,P., 1994. Rotavirus excretion by kids in a naturally infected goat herd. *Small Rumin. Res.* 14:83-89.
MURRAY,M.D., 1982. External parasites of sheep and goats. In: Sheep and Goat Production Ed.I.E.Coop. Elsevier, Amsterdam: 193-203.
MUWALLA,M.M., ABO-SHEHADA,M.N. & TAWFIQ,F., 1994. Effects of monensin on daily gain and natural coccidial infection in Awassi lambs. *Small Rumin. Res.* 13;205-209.
NAGY,B., PALFI,V., NAGY,G., BAJTOS,I. & MERENYI,L., 1987. Infectious gastrointestinal disease of young goats. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 373-388.
NDLOVU,L.R. & SIMELA,L., 1996. Effect of season of birth and sex of kid on the production of live weaned single born kids in smallholder East African goat flocks in north East Zimbabwe. *Small Rumin. Res.* 22:1-6.
NELSON,D.R., 1984. Metabolic and nutritional diseases. In: Extension Goat Handbook.Ed.G.F.W.Haenlein and D.L.Ace. USDA, Washington DC.:C-5.
NETO,J.deS. & BAKER,G., 1987. Dairy goat production in northeast Brazil: Production characteristics and research needs. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 1534.
NDLOVU,L.R. & SIBANDA,L.M., 1991. Productivity of indigenous goats in communal areas of Nyanga North and Gwanda South: Performance of kids from birth to weaning and implications for management and extension. In: Goat development in Zimabawe: Prospects and Constraints. Proc. Workshop, Matopos Research Station, November 1991. Ed:L.Ndlovu: 97-105.
NOLAN,M.F., LIPNER,M.E. & McCORKLE,C.M., 1989. Sociology in the SR-CRSP: Research highlights and the dilemmas of participation. *J. Anim. Sci.* 67:3111-3117.
NICHOLAS,F.W., 1987. Veterinary Genetics. Clarendon Press, Oxford.
NRC, 1981. Nutrient Requirements of Goats. National Research Council. National Academy Press, Washington DC.
NYGAARD,J., 1986. [Dairying in Norway during 1985]. *Nordisk Mejeriindustri* 13:6-8. [*Dairy Sci. Abstr.*49:6380(1987)].
O'BRIEN,J.P. & SHERMAN,D.M., 1993a. Serum immunoglobulin concentrations of newborn kids and subsequent kid survival through weaning. *Small Rumin. Res.* 11:71-77.
O'BRIEN,J.P. & SHERMAN,D.M., 1993b. Field methods for estimating serum immunoglobulin concentrations in newborn kids. *Small Rumin. Res.* 11:79-84.
OBWOLO,M.J., 1991. Disease conditions of goats in communal land areas. In: Goat Development in Zimbabwe: Prospects and Constraints. Matopos Research Station, November 1991. Ed: L.R. Ndlovu.: 56-75.
O'CONNOR,D.L. 1994. Folate in goat milk products with reference to other vitamins and minerals:a review. *Small Rumin. Res.* 14:143-149.

OJO,M.O., 1987. Pathology of young goats respiratory diseases. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 389-403.

OJO,S.A., 1996. Studies on perinatal kid mortality in Red Sokoto goats. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:820-822.

OLANDER,H.J. & BROWN,C.C., 1987. Caseous lymphadenitis and tropical diseases of adult goats. In: Proc. 4th Int. Conf. Goats, EMBRAPA-DDT, Brasilia: 435-448.

OPPONG,E.N.W. & YEBUAH,N.M.N., 1981. Some production traits of the West African Dwarf goat. *Trop. Anim. Hlth. Prod.* 13:208-212.

ORSKOV,E.R., 1982. Very intensive systems. In: Sheep and Goat Production.Ed.I.E.Coop. Elsevier, Amsterdam: 401-416.

OUZUNOV,G. & ZOUNEV,P., 1993. Results from machine milking of Bulgarian dairy white goat breed. Fifth Intl. Symp. Machine Milking of Small Ruminants, 14-20 May 1993, Budapest, Hungary:246.

OWEN,E. & de PAIVA,P., 1982. Artificial rearing of goat kids. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 491.

OZCAN,L. & GURSOY,O., 1982. Possibilities of using Saanen and B1 genotypes in breeding Turkish local Kilis and Kil goats. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease,
Univ. Arizona, Tucson: 507.

PANANDAN,J.M., MUKHERJEE,T.K. & HORST,P., 1992. Reproduction, birth weight, kid mortality and growth of crosses between Malaysian and German Fawn goats. In : Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 71.

PARK,Y.W., 1994. Hypo-allergenic and therapeutic significance of goat milk. *Small Rumin. Res.* 14:151-159.

PARK,Y.W. & CHUKWU,H.I., 1988. Macro-mineral concentrations in milk of two goat breeds at different stages of lactation. *Small Rumin. Res.*1:157-166.

PARK,Y.W. & HUMPHREY,R.D., 1986. Bacterial cell counts in goat milk and their correlations with somatic cell counts, percent fat and protein. *J. Dairy Sci.* 69:32-37.

PARK,Y.W., MAHONEY,A.W. & HENDRICKS,D.G., 1986. Bioavailability of iron in goat milk compared with cow milk fed to anaemic rats. *J. Dairy Sci.* 69:2608-2615.

PARKASH,S. & JENNESS,R., 1968. The composition and characteristics of goats' milk: a review. *Dairy Sci. Abstr.* 30:67-87.

PENDLETON,R.J., YOUNGS,C.R., RORIE,R.W., POOL,S.H., MEMON,M.A. & GODKE,R.A., 1992. Comparison of fluorogestone acetate sponges with norgestomet implants for induction of estrus and ovulation in anestrous dairy goats. *Small. Rumin. Res*. 8:269-273.

PERAZA,C.C., 1986. Preliminary notes on the marketing of goat's milk and goat's milk products in Mexico. *Bull. Int. Dairy Fed.* No.202:197-200. [*Dairy Sci. Abstr.* 49:2647(1987)].

PERRIN,G.G. & POLAK,B., 1992. Caprine arthritis encephalitis: a review. In: Pre-Conf. Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers 2(2):568-574.

PODLESKI,W.K., 1992. Milk protein sensitivity and lactose intolerance with special reference to goat milk. In: Pre-Conf. Proc. V Intl. Conf. on Goats , New Delhi, March 1992. Invited Papers 2(2):610-613.

POMROY,W.E., 1996. Anthelmintic resistance in goats. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:717-726.

POOLE,D.A., 1986. Food intake, milk production and body-weight change of milking cows given complete diets to appetite. *Anim. Prod*. 42:305.

POOLE,J.D.H., 1962. Flock immunisation of sheep and goats against heartwater. PartII: Preliminary experiments on flock immunisation of goats. *J. S. Afr. Vet. Med. Ass.* 33(3):357-362.

PORTOLANO,B., SPATAFORA,F., BONO,G., MARGIOTTA,S., TODARO,M., ORTOLEVA,V. & LETO,G., 1996. Application of the Wood model to lactation curves of Comisana sheep. *Small Rumin. Res.* 24:7-13.

POULIN,N., GULER,A., PIGNON,P. & COGNIE,Y., 1996. *In vitro* production of goat embryos: heparin in IVF medium affects developmental ability. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:838-840.

PRAKASH,B. & KHAN,B.U., 1987. Incidence of multiple births in Barbari goats. In:Proc. 4th Int. Conf. Goats, EMBRAPA-DDT, Brasilia: 1514.

PRASAD,V.S.S. & KIRTON,A.H., 1992. Evaluation and classification of live goats, their carcasses and cuts. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers: 440-450.

PROVOLO,G., MOLLER,F. & SANGIORGI,F., 1993. The reliability of goat and sheep lactation estimate with reference to the total milk recording practice. Fifth Intl. Symp. Machine Milking of Small Ruminants, 14-20 May 1993, Budapest, Hungary:255.

PROZESKY,L., 1987. The pathology of heartwater. III. A review. *Onderstepoort J. Vet. Res.* 54:281-286.

PROVOST,A. & BEZUIDENHOUT,J.D., 1987. The historical background and global importance of heartwater. *Onderstepoort J. Vet. Res.* 54:165-169.

PU,J., LIU,X. & PELANT,R., 1987. Crossbreeding for milk production in Sichuan Province,China. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 1445.

QUILES,A., GONZALO,C. BARCINA,Y., FUENTES,F. & HEVIA,M., 1994. Protein quality of Spanish Murciano-Granadina goat milk during lactation. *Small Rumin. Res.* 14:67-72.

RAATS,J.G., 1988. The role of sheep in small farm systems. In: Proc. Symp. Developing Areas Branch, S. Afr. Soc. Amin. Prod., Univ. Fort hare, 30 November-2 December 1988:47-59.

RAE,A.L., 1980. Breeding. In: Sheep and Goat Production Ed. I.E. Coop, Elsevier, Amsterdam:15-55.

RAJAN,A., SREEKUMARAN,T. & SULOCHANA,S., 1982. Incidence and pathology of endemic ethmoid carcinoma in goats. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona,
Tucson: 373.

RAMSAY,K.A. & SMIT,C.H., 1987. The potential of the indigenous veld goat as an alternative to the improved Boer goat in South Africa. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 1369.

RANDY,H.A., SNIFFEN,C.J. & HEINTZ,J.F., 1988. Effect of age and stage of lactation on dry matter intake and milk production in Alpine does. *Small Rumin. Res.* 1:145-149.

RAO,K.S. & RAO,G.G., 1992. Production, processing and export of goat skins. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers, 2(2):526-533.

RAYNER,I.H., 1985. Milk production from the goat. In: Goat Production and research in the tropics. Proceedings of a workshop held at the University of Queensland, Brisbane, Australia, 6-8 February, 1984. [*Dairy Sci. Abstr*. 48:1727(1986)].

REDDY,M.R. & RAGHAVAN,G.V., 1992. Recent advances on feed processing and complete feeds for goats. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers 2(1):168-177.

REGE,J.E.O., ABOAGYE,G.S., AKAH,S. & AHUNU,B.K., 1994. Crossbreeding Jersey with Ghana Shorthorn and Sokoto Gudali cattle in a tropical environment: additive and heterotic effects for milk production, production and calf growth traits. *Anim.Prod.* 59:21-29.

RESTALL,B.J., 1992. The male effect in goats. In: Pre-Conf. Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers, 2(2):322-331.

RICHARD,S. & CABARET,J., 1992. Individual variations in efficacy of fenbendazole against the small lungworm *Muellerius capillaris* in dairy goats. *Small Rumin. Res*. 8:151-159.

RISCHKOWSKI,B. & STEINBACH,J., 1997. Goat's milk for smallholders in Malawi - a way of improving the nutrition of the rural population? *Animal Research and Development* 46:55-62.

RICORDEAU,G., 1981. Genetics: breeding plans. In: Goat Production. Ed. C.Gall. Academic Press, London:111-169.

RICORDEAU,G., WIGGANS,G.R., SERRADILLA,J.M., KHAN,B.U., SANCHEZ,G.F., MAVROGENIS,A.P., MISRA,R.K. & MANFREDI,E.J., 1992. Breeding plans for milk and meat production. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers: 85-99.

RIVIERE,J., 1991. Development of goat production in communal areas. In: Goat Development in Zimbabwe: Prospects and Constraints. Workshop, Matopos Research Station, November 1991. Ed: L.Ndlovu: 136-144.

ROCA,J., MARTINEZ,E., VAZQUEZ,J.M., RUIZ,S. & COY,P., 1991. Influence of season on testicle size and libido in male goats from the Mediterranean area. *Anim.Prod.* 52:317-321.

RONNINGEN,K., 1966. A study of genetic parameters for milk characteristics in goats. Report No.232 :1-18. Institute of Animal Genetics and Breeding, Agric.College of Norway.

ROTA,A.M., GONZALO,C. RODRIGUEZ,P.L., ROJAS, A.I., MARTIN,L. & TOVAR,J.J., 1993. Somatic cell types in goats milk in relation to total cell count, stage and number of lactation. *Small Rumin. Res.* 12:211-219.

ROY,R., SINGH,S.K. & KHAN,B.U., 1992. Milk yield of Jamunapari does. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 77.

RSA, 1996. Annual Report, National Dairy Cattle Performance Testing Scheme, South Africa. Animal Improvement Institute, Agric. Research Council. Vol.16:18.

RUSSO,S.L. & SPENCER,W.P., 1988. Goal conflicts: cattle production in the Gambia. In: Proc. 1988 Intl. Rangeland Development Symposium, Corpus Christi, Texas. Editors:C.W.Gay, G.Perrier & J.Tiedeman, Utah State Univ., Logan, Utah:65-80.
RUVUNA,F., CARTWRIGHT,T.C., OKEYO,M.A. & BLACKBURN,H.D., 1987. Milk yield and growth rates of kids under different milking methods of tropical goat breeds. In: Proc.4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 1542.
RUVUNA,F., CARTWRIGHT,T.C., TAYLOR,J.F., AHUYA,C. & CHEMA,S., 1991. Factors affecting body weight of East African and Galla goats. *Small Rumin. Res*. 4:339-347.
RUVUNA,F., KOGI,J.K., TAYLOR,J.F. & MKUU,S.M., 1995. Lactation curves among crosses of Galla and East African with Toggenburg and Anglo Nubian goats. *Small Rumin. Res.* 16:1-6.
RUVUNA,F., TAYLOR,J.F., DAVIS,S.K., MWANDOTTO,B.A.J., RURANGIRWA,F.R. & McGUIRE,T.C., 1992. Production parameters and resistance to gastrointestinal helminths of the Kenya dual-purpose goat. In: Pre-Conf. Proc, V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers:78.
RUVUNA,F., TAYLOR,J.F., OKEYO,M., WANYOIKE,M. & AHUYA,C., 1992. Effects of breed and castration on slaughter weight and carcass composition of goats. *Small Rumin. Res*. 7:175-183.
SAHNI,K.L. & CHAWLA,D.S., 1982. Crossbreeding of dairy goats for milk production. In: Proc. 3rd Intl. Conf. Goat Prod and Disease, Univ. Arizona, Tucson: 575-583.
SAINI,A.L. & KHAN,B.U., 1986. Production and processing of goat milk in India. *Livestock Adviser* 11:30-33. [*Dairy Sci. Abstr*. 49:5900(1987)].
SAITHANOO,S. & HUQ,M.A., 1992. Goat meat production and processing in Asia. In: Pre-Conf. Proc. V Intl. Conf. on Goats, Invited Papers 2(2):451-457.
SAITHANOO,S. & NAIDU,A.S., 1996. Goat meat production, skins and processing in Asia. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:300-309.
SAKUL,H. & BOYLAN,W.J., 1992. Lactation curves for several US sheep breeds. *Anim. Prod.* 54:229-233.
SANCHEZ,H., MORALES,A.F., EPEDA,O. & TORTORA,J., 1992. Presence of *E. gilruthi* in a mixed coccidial infection. In: Pre-Conf. Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers:500.
SANDS,M. & McDOWELL,R.E., 1978. The potential of the goat for milk production in the tropics. *Cornell International Agricultural Mimeograph* No.60:1-53.
SANZ SAMPELAYO,M.R., BAS,P. & SCHMIDELY,P., 1991. Energy nutrition in growing goats. In: Goat Nutrition. Ed: P.Morand-Fehr. EAAP Publ. No.46, Pudoc, Wageningen: 73-81.
SARABOL,S., 1985. Goat research and development in Thailand. In: Goat production and research in the tropics. Proceedings of a workshop held at the University of Queensland, Brisbane, Australia, 6-8 February, 1984:22-23. [*Dairy Sci. Abstr*. 48:1726(1986)].
SAS INSTITUTE, 1989. SAS/STAT User's Guide Version 6, Fourth Edition, Volume 2. The GLM Procedure: 891-996.
SAUVANT,D., 1992. Modelling the goat nutrition. In: Goat Nutrition. Ed: P.Morand-Fehr.

EAAP Publ. No.46, Pudoc, Wageningen: 224-230.
SAUVANT,D., CHILLIARD,Y. & MORAND-FEHR,P., 1991. Etiological aspects of nutritional and metabolic disorders of goats. In: Goat Nutrition. Ed: P.Morand-Fehr. EAAP Publ. No.46, Pudoc, Wageningen: 124-142.
SAUVANT,D. & MORAND-FEHR,P., 1991. Energy requirements and allowances of adult goats. In: Goat Nutrition. Ed: P.Morand-Fehr. EAAP Publ. No.46, Pudoc, Wageningen: 61-72.
SAUVANT,D., MORAND-FEHR,P. & GIGER-REVERDIN,S., 1991. Dry matter intake of adult goats. In: Goat Nutrition. Ed: P.Morand-Fehr. EAAP Publ. No.46, Pudoc, Wageningen: 25-36.
SAVAIANO,D.A.and LEVITT,M.D.(1987). Milk intolerance and microbe-containing dairy foods. *J. Dairy Sci*. 70:397-406.
SCHILLHORN VAN VEEN,T.W., 1982. Role of parasitism in goat management. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 85-89.
SCHMIDELY,P. & HADJIPANAYIOTOU,M., 1991. Growth promoters for fattening kids. In: Goat Nutrition. Ed: P.Morand-Fehr. EAAP Publ. No.46, Pudoc, Wageningen: 184-193.
SCHMIDT,G.H. & VAN VLECK,L.D., 1974. Principles of Dairy Science. W.H.Freeman and Company, San Francisco.
SCHUMACHER,A., RENNER,E. & STEINBACH,J., 1982. Milk composition of Alpine and Boer does and the crosses (F1) between these breeds during early stages of lactation. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 359.
SCHWARTZ.H.J. & CARLES,A.B., 1987. Effects of seasonal forage supply on semi-arid pastures on herd productivity in small East African goats. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 1456.
SCRIMSHAW,N.S., 1990. Individual, social and political consequences of malnutrition. *S. Afr. J. Food Sci. Nutr*. 2:Suppl: 14.
SEMENYE,P.P., ONIM,J.F.M., CONELLY,W.T. & FITZHUGH,H.A., 1989. On-farm evaluation of dual-purpose goat production systems in Kenya. *J. Anim. Sci.* 67:3096-3102.
SHANKAR,H., SINGH,S.V., SINGH,N. & VIHAN,V.S., 1992. Occurrence of foot-and-mouth disease in small ruminants. In: Pre-Conf. Proc., V Intl. Conf. on Goats, New Delhi, March 1992.
Abstr. Contrib. Papers:504.
SHARMA,D.K., SINGH,N., SINGH,S.V., VIHAN,V.S. & TIWARI,H.A., 1992. Mortality in goats due to parasitic infestation. In: Pre-Conf. Proc., V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 505.
SHEEHY,D.P., 1988. Desertification on the Yihenoer Pilot Demonstration Area in Balin Right Banner, Inner Mongolia. In: Proc. 1988 Intl. Rangeland Development Symposium, Corpus Christi, Texas. Editors:C.W.Gay, G.Perrier & J.Tiedeman, Utah State Univ., Logan, Utah:65-80.
SHELTON,M., 1978. Reproduction and breeding of goats. *J.Dairy Sci.* 61:994-1010.
SHELTON,M., 1986. Breed use and crossbreeding in goat production. In: 3rd World Congress on Genetics Applied to Livestock Production, Lincoln, Nebraska, USA, July 16-22. IX. Breeding programs for dairy and beef cattle, water buffalo, sheep and goats: 523-532.

SHENKORU,T., SAHLU,T., DAVIS,J.J. & PUCHALA,R., 1996. Leucaena in a ration for high producing Alpine goats. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:626-629.

SHERMAN,D.M., 1987. Causes of kid morbidity and mortality: An overview. In: Proc.4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 335-354.

SHERMAN,D.M., 1992. A compendium of bacterial diseases of goats. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers 2(2):558-567.

SHONGJIA,L., XIANGMO,L., GANGYI,X. & SHENOU,C., 1992. Relationship between physical traits, litter size and milk yield in Saanen, Guanzhong and crossbred goats. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 83.

SHKOLNIK,A., 1992. Digestive efficiency: significance of body size and of adaptations to a stressful environment. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers, 2(1):253-260.

SHRESTHA,N.P., ARYAL,I.K. & TAMANG,B.B., 1992. Performance of Chyangra mountain goat of Nepal. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992.
Abstr. Contrib. Papers: 82.

SIGWALD,J.P. & LEQUENNE,D., 1985. Resultats de controle laitier en elevage caprin, campagne (1985). ITOVIC, Institut Technique de l'Elevage Ovin et Caprin, Paris.

SIMON,M., DELAHAYE,J., LE JAOUEN, J.-C., DE SIMIANE,M., TOUSSAINT,G. & GRENOUILLOUX,P., 1986. Elevage des jeunes caprins. Institute Technique de l'Elevage Ovin et Caprin, Paris. 128pp.

SINAPIS,E., LABUSSIERE,J. & HATZIMINAOGLOU,J., 1993. L'aptitude a la tratie mecanique des chevres de la race locale Greque. Fifth Intl. Symp. Machine Milking of Small Ruminants, 14-20 May 1993, Budapest, Hungary:457.

SINGH,R.V., 1992. Role of goat in desertification. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Plenary Papers: 100-109.

SINGH,R.N. & ACHARYA,R.M., 1982. Improvement through selection for milk in a closed flock of Beetal goats. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson:305.

SINGH,M. & SINGH,K., 1992. Adaptability to hot climates for growth and reproductive performance. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers 2(1):244-252.

SINGH,D.K., SINGH,C.S.P. & MISHRA,H.R., 1991. Genetic and non-genetic factors affecting post-weaning survivability in goats. *Anim. Prod.* 53: 199-202.

SINGH,S.V., SINGH,M.P., SINGH,N., VIHAN,V.S. & LALWANI,D.D., 1992. Incidence of abortion and seroprevalence of caprine brucellosis. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 516.

SINGH,N., VIHAN,V.S., SINGH,S.V. & GUPTA,V.K., 1992. Prevalence of Johne's disease in organized goat flocks. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992.
Abstr. Contrib. Papers: 513.

SINGH,N., VIHAN,V.S., SINGH,S.V. & TIWARI,H.A., 1992. Prevalence and pathology of *Escherichia coli* infection in neonatal kids. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 512.

SINN,R. & WAHYUNI,S., 1996. Women, gender issues and goat development. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:240-244.

SLATER,A.J., 1987. Veterinary aspects of goat nutrition. In: Developments in Goat Production 1986/87. Ed B.A.Stark, Goat Producers Assoc (GB)Ltd: 55-63.

SMITH,G.C., 1992. Goat meat production and processing in the United States of America. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 409.

SMITH,M.C., 1984. Coccidiosis. In: Extension Goat Handbook.Ed.G.F.W.Haenlein and D.L.Ace, USDA, Washington DC:G-6.

SMITH,M.C., 1992. Subfertility and infertility problems in breeding bucks. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers 2(2):309-321.

SMITH,O.B., 1992. Feed resources for goats: recent advances on availability and utilization in Africa. In: Pre-Conf. Proc. V Intl. Conf on Goats, New Delhi, March 1992. Invited Papers 2(1):121-133.

SOPEXA, 1986. Goat Farming in France. In: Bulletin de l'Elevage francais: 2-43.

STANTON,T., 1982. Introduction and acceptance of goats and their socio-economic importance in the Caribbean and Central America. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease,Univ. Arizona, Tucson:182-185.

STARK,B.A., 1987. Principles of goat nutrition. In: Developments in Goat Production 1986/87. Ed.B.A.Stark. Goat Producers Assoc.(GB)Ltd: 21-31.

STEINE,T.A., 1982. Principles of selection for milk production in dairy goats. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 19-22.

STEINBACH,J., 1987. Evaluation of indigenous and exotic breeds and their crosses for production in unfavourable environments. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 625-641.

STEMMER,A., HORST,P., MUKHERJEE,T.K. & VALLE-ZARATE,A., 1996. Crossbreeding the local goat in Malaysia with Improved German Fawn: influence on milk performance. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:148-151.

STEWART,C.G., 1987. Specific immunity in farm animals to heartwater. *Onderstepoort J. vet. Res*. 54:341-342.

STOTZ,D., 1982. Dairy goats or cattle (a smallholder farm management analysis). In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 355.

SYRSTAD,O., 1990. Dairy cattle crossbreeding in the tropics: the importance of genotype x environment interaction. *Livestock. Prod. Sci.* 24:109-118.

TAPSON,D.R., 1990. A socio-economic analysis of small-holder cattle producers in KwaZulu. PhD Thesis, Vista University, South Africa.

TEH,T.H. & ESCOBAR,E.N., 1987. Effect of body condition and age of pregnant doelings on litter size and birthweight of goat kids and its influence on milk production. In: Proc. 4th Intl. Conf. Goats, EMBRAPA-DDT, Brasilia: 1451.

TISSERAND,J.L., HADJIPANAYIOTOU,M. & GIHAD,E.A., 1991. Digestion in goats. In: Goat Nutrition. Ed: P.Morand-Fehr. EAAP Publ. No.46, Pudoc, Wageningen: 46-60.

UPADHYAYA,T.N. & RAO,A.T., 1993. Diagnosis and threshold values of subclinical mastitis in goats. *Small Rumin. Res.* 12:201-210.

VAN AKEN,D., DE BONT,J. & VERCRUYSSE,J., 1989. Benzimidazole resistance in a field population of *Haemonchus contortus* from goats in Sri Lanka. *Small Rumin. Res.* 2:281-287.

VAN DER WESTHUYSEN,J.M., WENTZEL,D. & GROBLER,M.C., 1988. Angora Goats and Mohair in South Africa. (3rd Edition). The Mohair Board, Port Elizabeth, South Africa.

VAN WINKELHOFF,A.J. & UILENBERG,G., 1981. Heartwater: Cross-immunity studies with strains of *Cowdria ruminantium* isolated in West and South Africa. *Trop. Anim. Hlth. Prod*. 13:160-164.

VAN ZYL,J.P., NAUDE,R.T. & SMITH,A., 1988. 4%-Fat corrected milk - is this a meaningful criterion for the comparison of milk production on an iso-energetic basis? Annual Report Vol.8:67-84. National Dairy Cattle Performance and Progeny Testing Scheme, Dept. Agric. and Water Supply, South Africa.

VIHAN,V.S., 1988. Immunoglobulin levels and their effects on neonatal survival in sheep and goats. *Small Rumin. Res*. 1:135-144.

VIHAN,V.S., 1992a. Use of *Escherichia coli* vaccine in goats for passive protection against neonatal colibacillosis. In: Pre-Conf. Proc. V Intl. Conf on Goats, New Delhi, March 1992. Abstr. Contrib. Papers:530.

VIHAN,V.S., 1992b. Epidemiological investigation on neonatal kid mortality due to enteropathogenic colibacillosis. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992.
Abstr. Contrib. Papers:531.

VIHAN,V.S., 1993. Use of *Escherichia coli* vaccine for passive protection against neonatal colibacillosis in goats. *Small Rumin. Res.* 11:179-185.

WAHID,S.A., SARAWAK,M.N., YUNUS,J.M. & ZAHARI,M.W., 1992. Status of minerals in bones and soft tissues of four breed groups of goats. In: Pre-Conf. Proc. V Intl. Conf on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 217.

WAHOME,R.G., CARLES,A.B. & SCHWARTZ,H.J., 1994. An analysis of the variation of the lactation curve of Small East African goats. *Small Rumin. Res.* 15:1-7.

WALKDEN-BROWN,S.W. & RESTALL,B.J., 1996. Environmental and social factors affecting reproduction. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:762-775.

WALKER,J.B. & OLWAGE,A., 1987. The tick vectors of *Cowdria ruminantium* (Ixodoidea, Ixodidae, genus *Amblyomma*) and their distribution. *Onderstepoort J. Vet. Res.* 54:353-379.

WENTZEL,D., 1982. Non-infectious abortion in Angora goats. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 155-161.

WESONGA,H.O., LITAMOI,J.K., KAGUMBA,M. & WAKHUSAMA,E., 1993. Relationship between clinical signs and early lesions of contagious caprine pleuropneumonia caused by *Mycoplasma* strain F38. *Small Rumin. Res.*10:45-54.

WIGGANS,G., 1984. Adjustment factors for milk records. In: Extension Goat Handbook.Ed.G.F.W.Haenlein and D.L.Ace, USDA, Washington DC: D-5.

WIGGANS,G.R. & DICKINSON,F.N., 1984. USDA-DHIA buck evaluations for milk and fat.In: Extension Goat Handbook.Ed.G.F.W.Haenlein and D.L.Ace, USDA, Washington DC: D-11.
WILDE,C.J. & PEAKER,M., 1990. Autocrine control in milk secretion. *J.Agric.Sci.Camb.*114:235-238.
WILLIAMS,C.S.F., 1981. Diseases. In: Goat Production.Ed.C.Gall. Academic Press, London: 433-488.
WILLIAMS,J.C., 1993a. An empirical model for the lactation curve of white British dairy goats. *Anim. Prod.* 57:91-97.
WILLIAMS,J.C., 1993b. Influence of farm, parity, season and litter size on the lactation curve parameters of white British dairy goats. *Anim. Prod.* 57:99-104.
WILSON,D.J., STEWART,K.N. & SEARS,P.M., 1995. Effects of lactation, production, parity and season on somatic cell counts in infected and uninfected dairy goats. *Small Rumin. Res.* 16:165-169.
WILSON,R.T., 1988. Small ruminant production systems in tropical Africa. *Small Rumin. Res.* 1:305-325.
WILSON,R.T., 1992. Goat meat production and research in Africa and Latin America. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers 2(2): 458-472.
WILSON,R.T., MURAYI,T.H. & ROCHA,A., 1989. Indigenous African small ruminant strains with potentially high reproductive performance. *Small Rumin. Res.* 2:107-117.
WILSON,R.T., SHARMA,K. & GALAL,E.S.E., 1992. Small-holder goat production systems in Africa and Asia. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Invited Papers: 36-53.
WOLDEGHEBRIEL,A., CORLEY,R.N. & MURPHY,M.R., 1992. A microcomputer model simulating biological control of kudzu-infested timberland by angora goats. In: Pre-Conf. Proc. V Intl. Conf. on Goats, New Delhi, March 1992. Abstr. Contrib. Papers: 137.
WOOD,P.D.P., 1989. Factors affecting the shape of the lactation curve in cattle. *Anim. Prod.* 11: 307-316.
YADAV,S.C. & SENGAR,O.P.S., 1982. Breed variations in the gastro-intestinal parasitism of Indian goats. In: Proc. 3rd Intl. Conf. Goat Prod. and Disease, Univ. Arizona, Tucson: 342.
YOUZHANG,Z., 1996. Goat industry and its significance in Chinese economy. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:1-8.
ZENG,S.S., 1996. Comprative study of goat milk standards and cow milk standards for analyses of goat milk. In: Proc. VI Intl. Conf. on Goats, 6-11 May 1996, Beijing, China:916-919.
ZENG,S.S. & ESCOBAR,E.N., 1996. Effect of breed and milking method on somatic cell count, standard plate count and composition of goat milk. *Small Rumin. Res.* 19:169-175.
ZYGOYIANNIS,D., KUFIDIS,D., KATSAOUNIS,N. & PHILLIPS,P., 1992. Fatty acid composition of carcass fat of indigenous (*Capra prisca*) suckled Greek kids and milk of their does. *Small Rumin. Res*. 8:83-95.