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	2.98 ± 0.43	2.47 ± 0.30	1.38 ± 0.17
pm	1.07 ± 0.30	0.99 ± 0.25	0.61 ± 0.14
daily	4.16 ± 0.60	3.47 ± 0.33	1.99 ± 0.24
Ratio	0.26	0.29	0.30
Goat No. L234			
am	3.36 ± 0.28	2.76 ± 0.29	2.20 ± 0.26
pm	1.13 ± 0.31	1.05 ± 0.13	0.96 ± 0.14
daily	4.50 ± 0.45	3.81 ± 0.31	3.16 ± 0.26
Ratio	0.25	0.28	0.30
Goat No. L481			
am	2.27 ± 0.28	1.91 ± 0.21	1.57 ± 0.21
pm	0.79 ± 0.25	0.81 ± 0.16	0.67 ± 0.10
daily	3.06 ± 0.33	2.72 ± 0.25	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	1.62 ± 0.23	1.54 ± 0.23	1.51 ± 0.18
pm	0.66 ± 0.12	0.67 ± 0.14	0.64 ± 0.18
daily	2.28 ± 0.25	2.22 ± 0.26	2.16 ± 0.25
Ratio	0.29	0.30	0.30
Goat No. K23(Sa)			
am	1.21 ± 0.22	1.12 ± 0.18	0.97 ± 0.20
pm	0.49 ± 0.15	0.47 ± 0.10	0.37 ± 0.11
daily	1.69 ± 0.27	1.59 ± 0.19	1.34 ± 0.24
Ratio	0.29	0.29	0.28
Goat No. K18(c)			
am	1.01 ± 0.19	1.06 ± 0.11	0.99 ± 0.17
pm	0.41 ± 0.07	0.46 ± 0.12	0.37 ± 0.06
daily	1.42 ± 0.20	1.52 ± 0.16	1.36 ± 0.17
Ratio	0.29	0.30	0.27
Goat No. K28(c)			
am	1.00 ± 0.19	1.02 ± 0.23	0.97 ± 0.21
pm	0.41 ± 0.12	0.49 ± 0.12	0.38 ± 0.12
daily	1.40 ± 0.28	1.50 ± 0.27	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

	Milk Date Fat Prot. Lac.
GOAT No. L19 Sa (ZKFU 875)	
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)

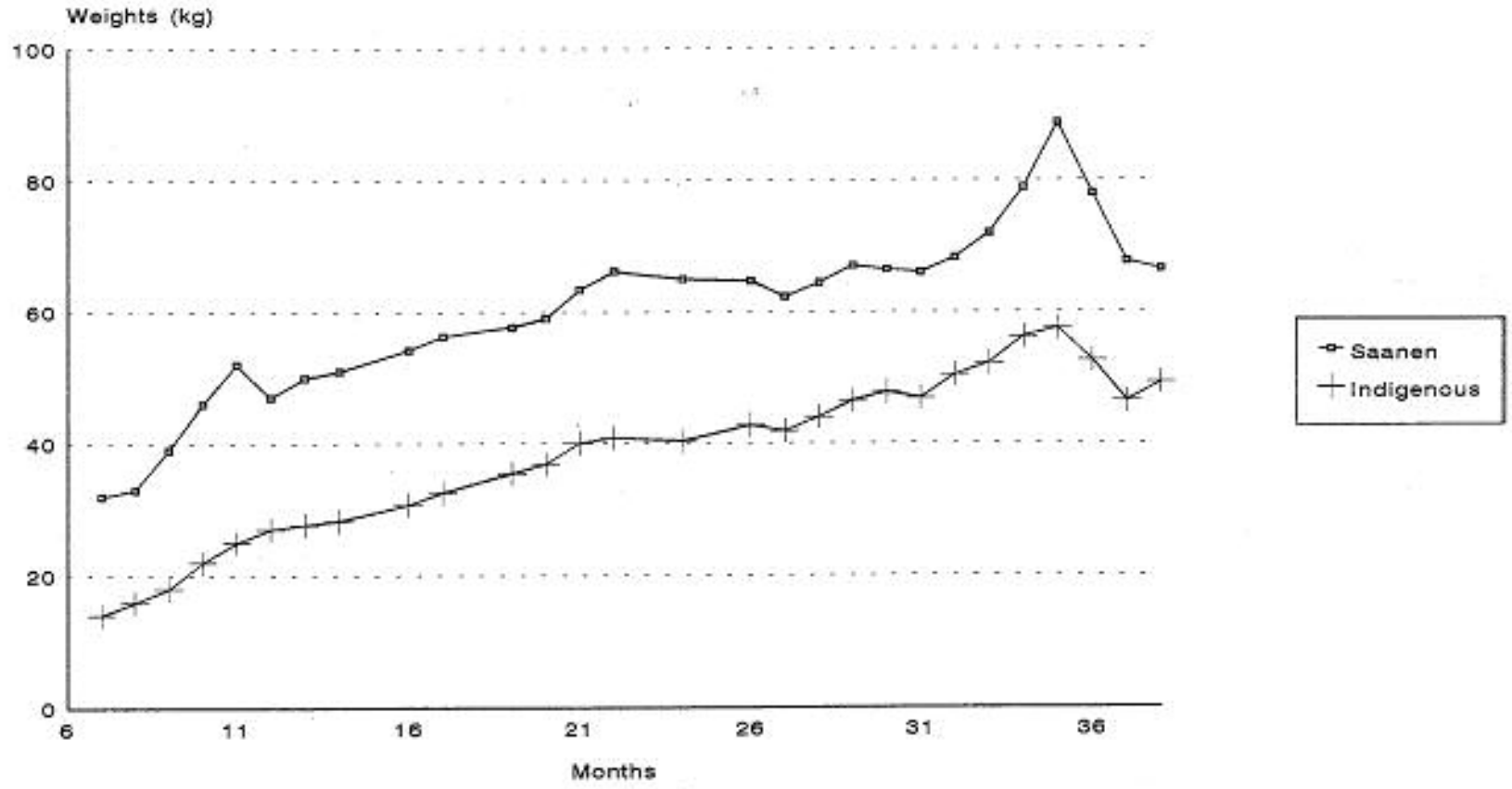

Figure M2: Goat weights: Saanen and Crossbred females:1988 to 1990
Mean monthly weights (kg)