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PROCEEDINGS OF THE SIXTH KENYA VETERINARY ASSOCIATION/SMALL RUMINANT CRSP WORKSHOP

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KENYA
1987

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P.O. BOX 29019
KABETE
KENYA

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HON. PAUL JOSEPH NGEI, EGH, MP

MINISTER FOR LIVESTOCK DEVELOPMENT

Ladies and Gentlemen:

I am very pleased to be invited to open the sixth workshop of the Small Ruminant Collaborative Research Support Programme. I recall opening the second Small Ruminant - CRSP workshop in 1982, but today, I am even more pleased to be able to address the first joint meeting between the Kenya Veterinary Association (the KVA) and the Small Ruminant CRSP. It is perhaps surprising that this has not taken place before since so many common interests are shared by the two groups. However, I understand that previous CRSP workshops have always been open to all and indeed several Veterinarians are participating scientists in the CRSP Programme.

Clearly, the whole sphere of small ruminant production is of immense importance to livestock development in Kenya. In the past, it has been usual to place more emphasis on cattle production than on sheep and goat production. In many areas of Kenya, this is inappropriate since small stock are more numerous and more suited to varying climatic conditions. There are some 14 million small stock in Kenya producing approximately one third of the total meat consumed. Sheep and goats are a major source of food for pastoralists.

For example, when compared to the cow, dual purpose goats which have been developed for both meat and milk, have lower maintenance requirements. These together with their good performance in Western Kenya, has meant that farmers are now accepting goats as able repiacers of the cow. Because of feed and land scarcity, there is a trend in Western Kenya where farmers are increasingly turning to small ruminants, and the number of cattle is being reduced. Human population needs are increasing so rapidly that a mixed farming system where crops and livestock are raised together becomes a very attractive undertaking for the small scale farmers especially because it generates not only meat, milk and cash, but also adequate quantities of manure for good crop and pasture production. There are 750 veterinarians in our country, one third of whom are members of the Kenya Veterinary Association.

As you all no doubt know, the Kenya Veterinary Association is a voluntary professional association committed to the improvement of all aspects of animal health, production and welfare. I am glad to note that it is also committed to the scientific advancement of the veterinary profession itself. Its activities have been increasing over recent years through meetings, publications and the development recently of regional branches to encourage veterinarians to come together and to share information and to develop strategies for disease control.

I gather that a tradition has developed where one of the KVA scientific meetings each year concentrates on a single species of domestic livestock. Last year, I understand there was a meeting on donkey diseases and management and before that a meeting on camels attracted record numbers of participants.

It is appropriate, therefore, that when sheep and goats are to be the subject of such a meeting, it should be held in collaboration with the group that specialises in so many aspects of small ruminant research.

The Small Ruminant CRSP was started in 1980 with funds from the Ministry of Livestock Development and United States Agency for International Development (USAID), and a number of participating United States Institutions.

The two major objectives of the Kenya Small Ruminant CRSP are:-

1. To develop and carry out research on dual purpose goat production systems which will contribute to increased production of food protein through meat and milk as well as manure, and to improved cash flow through marketable goats and goat products in small scale intensive systems; and

2. To provide training which will increase the longterm capability for research and development on sheep and goats in Kenya, and other countries with similar farming conditions.

A farming system approach is applied by the multi-disciplinary team of scientists in pursuit of Small Ruminant CRSP objectives. The disciplines involved are Animal Breeding, Systems Analysis, Animal Health, Animal Nutrition and Management, Feed Resources, Agricultural Economics and Rural Sociology.

In attempting to fulfill the first major objective, the various research disciplines of the Small Ruminant CRSP have made commendable progress in the last seven years, and I will only mention a few of them. The genetic foundation for a possible new breed of the dual purpose goat has been produced from a series of crosses among local and exotic breeds. With simple management at farmers' level, the milk yield of these dual purpose goats ranges between 0.5 to 1.2 litres per day. At the age of one year, dual purpose goat yearlings weigh between 18 and 26 kg. This range of body weight is the same for mature local East African goats. With a higher level of nutrition and management, these production levels will no doubt be increased. To improve nutrition for the dual purpose goats and livestock in general on the farm, simple feed conservation techniques such as hay and silage production have been developed and a wide range of suitable cultivars of high quality forages have been developed and farmers are already growing them. Utilization of improved dual purpose crops for human food and animal feed for example, sweet potatoes is also encouraged. Also, increased feeding of crop residues and industrial by-products e.g. molasses and brewer's wastes is recommended.

The Small Ruminant - CRSP has also developed a vaccine against the most important killer pneumonia of goats (i.e. CCPP) together with a simple and reliable diagnostic test for it. A vaccine for Heartwater, the deadly and widespread disease of goats, sheep and cattle is also being developed. Experience of small ruminant diseases has shown that preventive measures such as timely vaccinations, health management and good nutrition are the best options for all stock procedures and especially the small stock holder.

I would like to see a concerted effort by veterinarians, extension workers and research workers in emphasizing this need for preventative measures in animal production. All of the various technologies developed by the Small Ruminant - CRSP are constantly being tested by simulation and on the farms for their economic viability and social acceptability by the farmers.

Small Ruminant - CRSP scientists have adopted the farming systems research approach in which the researcher and the farmer are partners. Through this partnership, Small Ruminant - CRSP have been placing goats on farms since 1982, and testing out the various dual purpose goat research packages. There has been a significant placement of goats on farms. In 1986 alone, a total of 144 female goats were distributed to 72 farmers in Western Kenya and over 60 improved bucks in the whole country. This buck distribution scheme is aimed at rapidly improving our local goat flocks in the whole country. In the current phase, the placement of goats will be accelerated and a total of 350 goats will be distributed to farmers. These goats will be tested together with all the other component technological packages that have been developed by the Programme since 1980.

The second objective on training and building of research capability has also had excellent results. I am pleased to note that, to date, 3 Kenya research officers are being trained at PhD level in the USA and 17 others have trained at the MSc. level both in USA and UK. Besides, many research officers have been sponsored to national, regional and international training workshops and conferences.

I am also pleased to note that funding of Small Ruminant - CRSP has been extended up to 1990.

In conclusion, Mr. Chairman, I would like to take this opportunity to thank all the participants and donors for their generous support to this programme and to wish all of you every success in you deliberations during this workshop.

It is with great pleasure, that I now declare this joint Kenya Veterinary Association/Small Ruminant Collaborative Research Support Programme scientific workshop officially open.

BREEDING AND SYSTEMS ANALYSIS

APPRAISAL OF A MATING STRATEGY AND SELECTION CRITERIA FOR EVOLVING A DUAL PURPOSE GOAT BREED FOR KENYA

F. Ruvuna[1], T.C. Cartwright[1], M. Okeyo[2] and S. Tallam[2]

INTRODUCTION

Increased dual purpose goat production in Kenya requires establishment of a breed which will live and thrive in the environment, and produces meat and milk efficiently. That is, a breed is required with the capability to live, grow, reproduce, and produce milk and meat given an improved but practical environment that is within the constraints of the farmers. The intensity of the problem varies with the degree of severity of the environmental conditions. The purpose of this paper is to illucidate the conceptual breeding strategies that are followed in developing a dual purpose goat for Kenya, to update on the present research results and to outline a possible selection criteria. The basic strategies are not only applicable to dual purpose goats, but are possible novel techniques that could be employed and adapted to other livestock species and may be useful in other tropical climates for improving meat and/or milk production. An assessment and restatement of considerations thought to be most important will be used as basis for appropriate mating strategies and selection criteria employed.

Mating Strategy

A first step for any genetic improvement is characterisation of animal populations for the multiple traits that cummulatively determine lifetime productivity and efficiency. The average milk yield and associated variability indicated that selection within the indigenous breeds of Kenya, Galla and East African, was not sufficient to accomplish desired production levels within a feasible time by selection within these breeds (Ruvuna et al. 1983; 1985; 1986). If a goal of 200g milk per day for each family member was to be met, goats with higher levels of milk yield were required. The Toggenburg and Anglo Nubian had been introduced to Kenya but required a level of care and nutrient to survive and produce that was not feasible on the small farms. Therefore, neither selecting within indigenous breeds nor importing "improved" exotic breeds was feasible and a different approach was taken. The two indigenous populations were screened from flocks that emphasized milk offtake. Individual does were visually selected from those flocks for large, sound udders and teats. These selected, plus other unselected East African (EA) and Galla (G) does were mated, either naturally or by AI, to imported or locally available Toggenburg (T) and Anglo Nubian (N) bucks to produce four F1s: TxEA, TxG, NxEA and NxG. Data from these F1s indicated that they grew, produced milk, reproduced and survived at satisfactory levels (Ruvuna et al. 1986, 1988).

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General conclusion from the results revealed that a new synthetic or composite breed established from multibreed combinations was the most logical and practical approach for obtaining a DPG for Kenya. Therefore, a decision was made to proceed with developing a synthetic dual purpose breed. Four breeds, composed of the 2 indigenous breeds, East African (EA) and Galla (G), and the 2 imported dairy breeds Toggenburg (T) and Anglo Nubian (N) are being used in the formation of the new breed (1/4EA x 1/4G x 1/4T x 1/4N). Detailed mating design has been reported (Cartwright, 1984). The combination of 4 breeds assures that during stabilization of the breed, less heterosis will be lost due to recombination. The 50% exotic inheritance will be superior to the productive (meat and milk) potential of indigenous adapted breeds. The possibilities of the crossing of the two types are widely recognised in Kenya but have lacked well defined, highly integrated framework of crossbreeding strategies that are prerequisites for a successful breeding program. The adherence to one breed and its crosses is distinctly to be preferred to mixed crossings with several breeds which prevents concerted selection for improvement. In the past where crossbreeding has been employed as the process for livestock improvement in the tropics, quick benefits have been realised, but this is a short-term strategy and requires increased supervision and management input to make such a strategy of continuing benefit. The need and importance of creating new breeds as the future hope for livestock improvement in tropical countries is shared by others (Lindstrom, 1976; Bradford et al., 1987). Such synthetics have proved especially valuable as a means of incorporating improved productivity with adaptability. The four-breed composite synthetic possesses essentially all of the desirable traits of the F1, but also creates a population which is very responsive to selection to hold or increase production traits (milk and growth) while selecting for enhanced adaptability such as resistance to internal parasites.

Another major research area being addressed is development and characterisation of different goat strains to optimally match different geographical areas and different management and feeding strategies that exist in Kenya. Our studies (Cartwright, et al. 1985) have shown that a goat of genetic potential for a mature size of 40 kg. and a peak milk production of 4 kg. results in the near maximal level of productivity which the smallholder environment would hold. Though a bigger size genotype of 50 kg and peak milk of 5 kg. would produce more, this type of goat would not withstand the environmental variations and periods of low feed availability. This demonstrates the importance of synchronisation of genotype and production resources on the farm for efficient animal production. A 1/2 dairy exotic x 1/2 indigenous provides an optimal combination for productivity and hardiness for the smallholder production system with medium level of care (management and nutrition). Intensive goat dairying requires a higher level of milk per doe and the solution is a larger fraction of exotic dairy breeding (3/4 dairy x 1/4 indigenous) combined with selection and high level management and feeding. A semi-arid environment with low level of management and nutrition requires higher level of hardiness which is mediated by increased level of indigenous breeding (3/4 indigenous x 1/4 dairy). A breeding plan being pursued to cater for the three major types of goat feeding/production systems

in Kenya (intensive dairy, smallholder environment, and large flocks of semi-arid environments) is shown in Table 1. The mating plan for evolving a dairy breed and a breed for semi-arid area using the new synthetic dual purpose breed as a base is outlined in Figure 1.

Selection Criteria

Selection strategy for the new breed is an essential part of the breeding strategy. The intentions are to use the synthetic breed (1/4 EA x 1/4 G x 1/4 T x 1/4 N) as base genotype and initially use a simple index for ranking or selecting for dual purpose potential. The traits to be included in the index are:

1. Dairy milk production per year (Xm)
2. Total offspring yearling weight (Xy)
3. Mature size (WMA) estimated as weight at maturity (Xw)

A feasible and appropriate approach in the absence of estimates of genetic parameters is to initially use a weight-free performance index based on selection index criteria that optimally combines the different economically important phenotypic expressions of a genotype in a particular environment such that the excellence with respect to one of the traits can to a certain extent compensate for, but not entirely overrule weakness with respect to other traits. This implies that the function of the measures on the various traits to maximise is:

$$I = w_1x_1 + w_2x_2 + \dots w_px_p = \quad w_ix_i$$

Where

I = index

w_i's = economic weights

x_i = are economic traits

Assuming that all the traits have equal importance, then the function to maximise is:

$I = x_1 + x_2 + \dots x_p$ so that $w_i = 1$, i.e. all traits have equal economic weighting or of equal importance, and should also satisfy the following conditions:

a) It must take on its smallest value if one of $x_i = 0$ whatever the values of other x_i.

b) Must take on its smallest value when all x_i are smallest.

c) Must take on its greatest values when all x_i are greatest.

d) Order of ranking is invariant under magnification of any of the scales used to measure the x_i.

The simplest mathematical function that satisfies the four conditions:

$$(x_1 - k_1)\ (x_2 - k_2)\ (x_p - k_p)$$

Or

$$\prod_{i=1}^{p} (x_i - k_i)$$

Where k_i = minimum value of trait x_i.

In this way an individual that scores lowest in any one trait automatically has an index of zero. However, if the index is to rank individuals, this procedure is inadequate, for it necessitates that at least p individuals (those with lowest score of zero for any one trait) tie for lowest rank. This may be avoided by letting $k_i = (n \min x_i - \max x_i)/(n-1)$, where n is the number of individuals. The value of Ki may be on the large side, but since it is small enough to prevent zero values of $(x_i - k_i)$ from occurring, it is reasonable enough to use.

Another concept to use is "PRODUCTIVITY GAP" or comparison "TO THE IDEAL" whereby deviations of each individual's value from the "ideal" is used for ranking the individuals. In this case selection will be for the smallest absolute deviation values from the ideal. For the traits that favour smallest values, minus values or reciprocals may be used.

Initially the proposed index will be used for ranking young bucks and for selecting or culling of does (dams).

Selection of young bucks will be based on individual yearling weight combined with dam's milk yield and then will shift from individual records to progeny test records of the daughters for milk production, total yearling weight of offspring(s) per doe kidding and individual mature weight. Doe selection will be based on own lactation production, total offspring yearling weight per kidding and individual mature weight.

DOE INDEX (DI) = (Xm - Km) (Xy - Ky) (Xw - Kw)

BUCK INDEX (BI) = (Xy - Ky) (Xm - Km)

Appendix A gives examples of the rankings and selection criteria of bucks and does.

Large Scale Field Multiplication, Progeny Testing and Data Recording

There is need to establish elite flocks of synthetics and continue selection under field production conditions. In order to effectively utilize data for continued improvement through selection, a record keeping program, possibly involving selected farmers, will be developed. Artificial insemination and embryo transfer will be employed as feasible and as needed to test and promulgate elite bucks for use by farmers, assist farmers with recordkeeping and recover bucks identified with proven, outstanding performance. This phase of the program is only at the conceptual level and definite mechanism or details will be worked out in future.

RESEARCH RESULTS

Apart from the major thrust of developing a new dual purpose goat breed, useful information is being collected on the breed flock. The data is being analysed and is providing useful information on growth, milk production, reproduction and management and nutrition information that will be useful in the efficient utilization and general improvement of goat production in Kenya. Past reported results have included characterisation of breeds and crosses for growth and milk production (Ruvuna et al. 1987, 1985, 1983), reproduction (Ruvuna et al. 1987; Okeyo et al. 1985, 1985), mortality/adaptability (Ruvuna et al. 1987; Okeyo et al. 1986, 1985), genetic parameters (Ahuya, 1987) and management (Ruvuna et al. 1987, 1985). Recently completed studies are summarised in Tables 2 and 3. The weights of kids of different breed groups at birth, 4 mo. and 9 mo. of age expressed as percent of mean weights of East African (base breed means) are in Table 2. In absence of interactions of breed group by stage of growth, the columns of relative change from birth to 4 mo. of age and from 4 mo. to 9 mo. of age have expected values of zero. Thus, the results suggest interaction of breed group with stage of growth. The causes of this interaction may be due to the indigenous dams that did not have enough milk to meet the genetic growth potential of the crossbred kids and/or is due to the relatively early growth of EA compared to the other breed groups which would be an indicator of adaptability of the EA breed. Since the relative change from birth to 4 mo. is negative, the positive relative change from 4 mo. to 9 mo. may indicate compensatory gain.

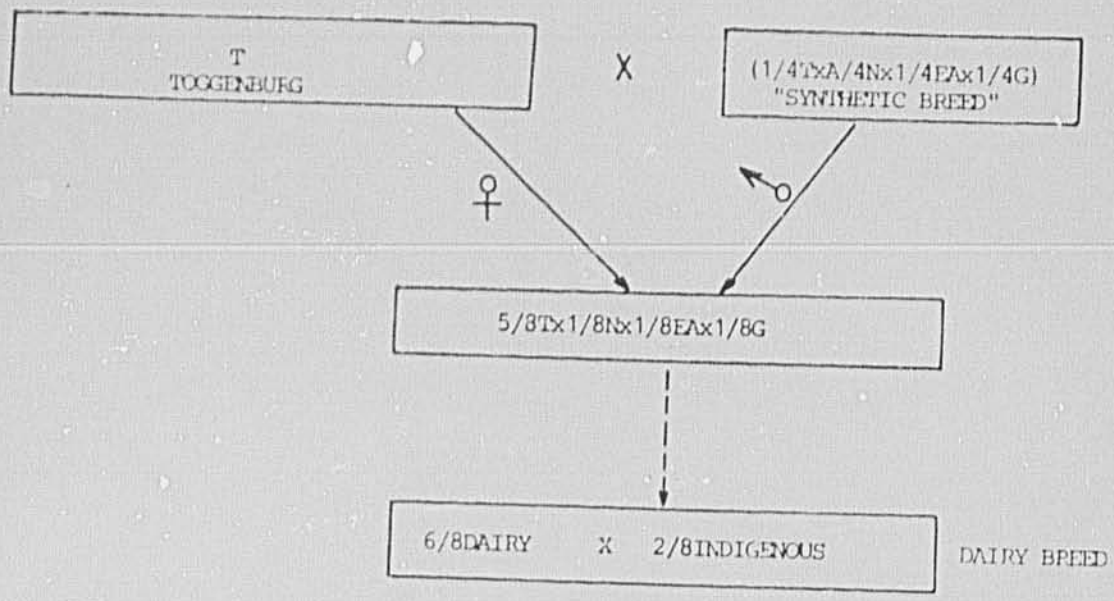
Table 3 shows the effect of pregnancy and lactation on body weights of EA and G. The results show increase in body weight up to 18% during pregnancy and loss in body weight up to 12% during lactation. Three possible biological implications of this finding are:

1. Estimates of body weights without adjustments of pregnancy and/or lactation or controlled time of weighing are biased.

2. There is need to supplement lactating does to prevent loss of condition during lactation (and adverse reproduction and other effects).

3. There is need to either develop correction factors to adjust body weights for pregnancy and lactation or develop uniform weighing procedures.

i. Mating plan for a dairy breed



T = TOGGENBURG; N = ANGLO-NUBIAN; EA = EAST AFRICAN; G = GALLA

ii. Mating plan for a breed for semi-arid areas

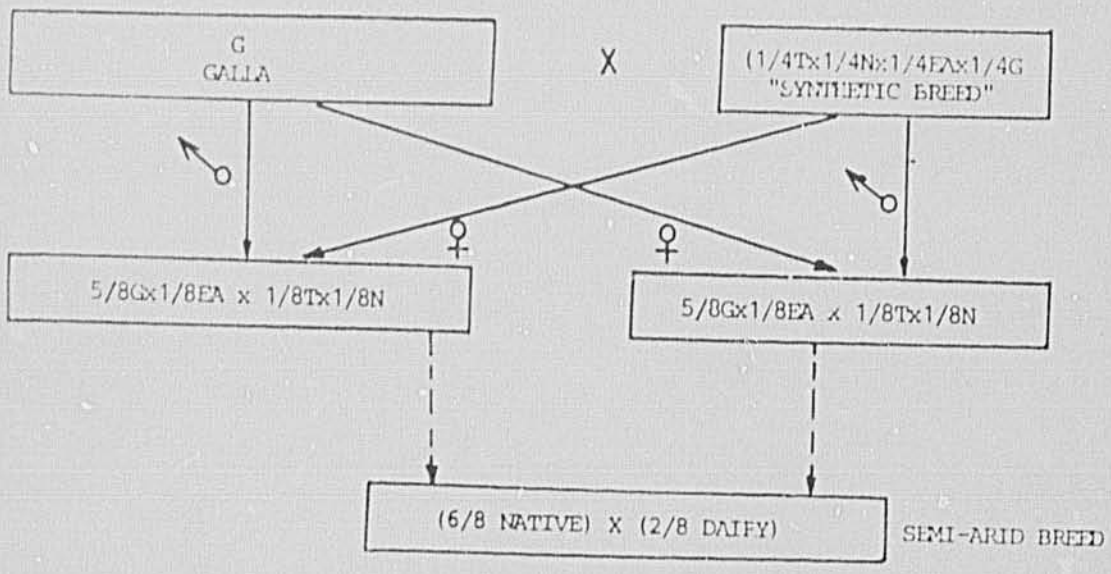


Figure 1: Mating plans for evolving a dairy breed and a breed for semi-arid area

Table 1: Recommended genotypes to optimally match three major goat production systems in Kenya

Physical Environment	Type of Breed	Level of Temperate Dairy Inheritance	Level of Indigenous Inheritance	Genotype	Projected Optimal Production
Smallholder Environment	Dual-purpose goat combining both hardiness and production in equal proportions	50%	50%	(1/4EA,1/4G 1/4T, 1/4N)	Milk = 4kg Mature Weight=40kg
Intensive Commercial Goat Dairy	High Milk Production combined with good management and feeding	75%	25%	(1/8EA,1/8G, 5/8T,1/8N)	Milk=4kg Mature Weight=50kg
Semi-arid Environment	Increased hardiness/adaptability combined with meat and milk	25%	75%	(1/8EA,5/8G, 1/8T,1/8N)	Milk=2kg Mature Weight=35kg

Table 2: Breed group least squares means of weights expressed as percentage of East African, with the change in percent relative to East African from birth to 4 mo. and 9 mo. of age

	%				
Breed Group	Birth Weight (BW)	4 mo. Weight (W4)	Relative Change (W4-BW)	9 mo Weight (W9)	Relative Change (W9-W4)
G	130.0	103.4	-26.6	110.1	+6.7
T×EA	110.0	110.2	+0.2	119.3	+9.1
N×EA	110.0	108.0	-2.0	109.2	+1.2
T×G	130.0	115.9	-14.1	116.8	+0.9
N×G	140.0	118.2	-21.8	126.9	+8.7
EA[a]	(2.0)	(8.8)		(11.9)	
No. of Records	810	392		142	

[a] Base least square means (kg) of East African

Table 3: Effect of pregnancy and lactation on body weights expressed as percentage of 5 mo pre and postpartum, least squares means, kg

	AGE OF DOE			
Classification	2YR	3YR	4YR	5+YR
Base Means:				
5mo pre and postpartum	24.9	29.0	30.5	30.7
4mo pre	.4%	3.4%	3.0%	3.0%
3mo pre	3.6%	5.5%	8.2%	10.7%
1mo pre	8.8%	13.1%	14.8%	17.9%
Mo of par	12.0%	9.7%	11.5%	10.1%
1mo post	0.4%	-4.1%	-1.6%	0%
2mo post	-1.2%	-7.9%	-3.3%	1.0%
3mo post	-1.6%	-5.2%	-5.9%	-0.7%
4mo post	a	-12.1%	-8.2%	-7.2%

[a] No records in the class

Appendix A

KID NO.	KID BWT	KID YWT	DAM NO	DAM TMLK	DAM DIM	DAM WT
6083	3.0	22.0	3213	94.56	120	38.0
6084	2.0	21.0	4470	84.12	120	26.0
6085	3.5	21.0	3215	87.20	120	36.0
6088	2.5	22.0	3195	102.60	120	35.0
6089	2.5	20.0	3188	78.40	120	35.0
6090	3.0	21.0	0219	84.80	120	30.0
6091	3.0	24.0	4508	115.00	120	34.0
6093	3.5	22.0	4319	118.40	120	32.0
6094	3.5	22.0	4364	108.40	120	32.0
6095	3.0	23.0	3456	120.00	120	35.0
6098	3.5	29.0	2457	105.20	120	36.0

DAM INDEX (DI) = (Xm - Km) (Xy - Ky) (Xw -Kw)
BUCK INDEX (BI) = (Xy - Ky) (Xm - Km)

Ki = (n min Xi - max Xi)/(n-1)
Km = (11*78.40 - 120)/(10) = 74.24
Ky = (11*20.0 - 29.0)/(10) = 19.10
Kw = (11*25.0 - 38.0)/(10) = 23.70

			DAM INDEX		BUCK INDEX	
Xm-Km	Xy-Ky	Xw-Kw	DI	Rank	BI	Rank
23.32	2.9	14.3	967.1	6	33.8	7
9.88	1.9	2.3	43.2	10	9.4	10
12.96	1.9	12.3	302.9	8	12.3	9
26.36	2.9	11.3	863.8	5	38.2	6
4.16	0.9	1.3	4.9	11	3.7	11
10.56	1.9	6.3	126.4	9	20.1	8
40.76	4.9	10.3	2057.2	2	199.7	2
41.16	2.9	8.3	1062.9	4	128.1	4
34.16	2.9	8.3	822.2	7	99.1	5
45.76	3.9	11.3	2016.6	3	178.5	3
30.96	9.9	12.3	3770.0	1	306.5	1

YWT = Yearling weight
TMLK = Milk yield (kg)
DIM = Days in milk

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ADDITIVE AND HETEROTIC EFFECTS FROM CROSSBREEDING GOATS IN KENYA

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ABSTRACT

Birth weights (BWT) and Weaning weight (WWT) were analysed for 1436 kids of East African (EA), Galla(G), Toggenburg (T), Anglo-Nubian (N) and their crosses. Direct additive and Heterotic effects for the straightbreds and their crosses were estimated using a regression model. The additive effects of EA, T and N for BWT and WWT were significant ($P < .01$). The environmental factors that were significant sources of variation included year, season dam age, sex, kid breed and birth type.

INTRODUCTION

The goat has a wider geographical distribution than any other herd animal (Harris 1960) and has traditionally been a meat animal. In developing countries, goats are found mainly in marginal areas, where cattle population is low due to tsetsefly, (Hornby & Van Rensburg, 1948) or on poor rangelands (Gaili 1978). Goats have diversified through natural and human selection into many functionally different breeding gene pools. These include the mountain breeds that are used for meat and pashmina (hair), the desert breeds which are good travellers and low consumers, the milk or Alphine types, the African and dwarf breeds (McFarlane 1982). Goats are found almost everywhere in Kenya, but none of the indigenous breeds available has been selected for milk and meat production partly because, research in goats has been minimal in the past. The greatest contribution of the goat would be the impact on rural health and nutrition particularly for farm families who live under poor conditions.

Ruvuna et al (1983) indicated the need for a suitable dual purpose goat for subsistence farming communities in higher rainfall areas of Western Kenya as one way to improve the nutritional status of these communities. Small Ruminant Collaborative Research Support Program (SR-CRSP) has as one of its objectives to develop a breed of goat that could produce milk and meat, utilize crop residues for feed and be hardy enough to withstand the diseases, parasites and other rigors of the tropics.

For this dual purpose goat breed to contribute towards both rural and national economy, it is important that the production parameters of the breed are fully studied and defined to determine the appropriate genetic improvement criteria. Consideration of cross breeding as a form of genetic manipulation requires estimates of the proportions of the genetic variance that is attributable to additive and non additive gene action. The objectives of this study were:-

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(1) To estimate individual effects of EA,G,T and N breeds.

(2) To estimate heterotic effects due to interaction between two breeds.

MATERIALS AND METHODS

The data used in this study were collected from SR-CRSP Breeding Project at Olmagogo field station of the National Animal Husbandry Research Station (N.A.H.R.S), Naivasha, Kenya. The flock was established from 1979 to 1981. The foundation stock were purchased from various parts of the country where they had been traditionally kept for many years. Obtaining animals from different parts of the country was assumed to give a good representative sample and a large base of genetic material. The indigenous breeds, EA and G were mainly between 1 and 3 years old. Their age was estimated by detention since the local farmers do not generally keep records. Olmagogo farm is 1000 m above sea level, receives an annual rainfall of 750 mm and is an ecotone between zone 3 and zone 4. The flock is subdivided into small groups for management purposes. The general management and feeding of the whole flock is uniform. Mature and weaned goats graze throughout the year from 0900 to 1700 hrs daily. Kids remain inside the pens and are offered lucerne hay to introduce them to solid diet and help in early rumen development. Drinking water is provided. Crossbreeding EA and G with T and N started in 1982. Semen of T and N imported from the U.S. was used on EA and G to produce T x EA, T x G, N x EA and N x G F1 crosses. The crosses were intermated to produce four-breed crosses composed of 1/4 of each of the four breeds (1/4N 1/4T 1/4EA 1/4G). Detailed mating design has been reported by Cartwright (1984) and Ahuya (1987).

The statistical analyses of the data were performed using the General Linear Models (GLM) procedure of the Statistical Analysis System (SAS, 1982). The genetic effects were estimated as linear coefficients from regression models with the basic assumption of a linear relationship between the level of heterozygozity and dominance for the coefficients fitted for direct additive and heterotic effects.

Model 1 was used to make breed comparisons among the eleven breed groups that were represented in the study. The independent variables in this model included environmental factors known to affect the traits studied.

Model I

$$Y_{ijklmno} = U + BY_i + S_j + KBR_k + DAGE_l + Sex_m + BTY_n + e_{ijklmno}$$

where $Y_{ijklmno}$ = observation on the Oth kid of nth birthtype, mth sex and lth dam age, of kth breed, born in jth season of ith year.

U = constant to all observations

BY_i = Birth year

S_j = effect due to jth season of kidding

KBR_k = effect due to kth breed of kid (k = I, 2)

$DAGE_l$ = effect due to lth age of dam (L = 1,2,3,4)

Sex_m = effect due to mth sex of kid (m = 1,2)

BTY_n = effect due to nth birth type (n = 1,2)

$e_{ijklmno}$ = random residual error associated with $Y_{ijklmno}$, NID $(0,\sigma_e^2)$

All effects were assumed fixed except for random error. Months of kidding were grouped into two seasons: wet season = April, May, June, September, October and dry season = December, January, February, March, August.

Dam ages were grouped into four classes of > 2 years, 3years, 4 and >5 years.

Model II was used to estimate the contribution of breed additive and heterotic effects to differences in the traits. The model was obtained by defining the breed group effects (KBR_k) in model I in terms of dummy variables for breed additive and heterozygotic effects. The coefficients used for these independent variables were expressed as fractions based on expected proportions of genes contributed by each breed for additive and heterotic effects as shown in table 1.

Table 1: Coefficients for the Fractions of breed Additive, Genetic effects and Heterozygotic Loci for various breed groups

	Additive				Heterozygozity					
BREED	1	2	3	4	21	31	32	41	42	43
1	1	0	0	0	0	0	0	0	0	0
2	0	2	0	0	0	0	0	0	0	0
21	.5	.5	0	0	1	0	0	0	0	0
31	.5	0	.5	0	0	1	0	0	0	0
32	0	.5	.5	0	0	0	1	0	0	0
41	.5	0	0	.5	0	0	0	1	0	0
42	0	.5	0	.5	0	0	0	0	1	0
3142	.25	.25	.25	.25	.25	0	.25	.25	0	.25
3241	.25	.25	.25	.25	.25	.25	0	0	.25	.25
4132	.25	.25	.25	.25	.25	.25	0	0	.25	.25
4231	.25	.25	.25	.25	.25	0	.25	.25	0	.25

1 = East African (EA)
2 = Galla (G)
3 = Toggenburg (T)
4 = Nubian (N)
21 = G × EA
31 = T × EA
32 = T × G

41 = N × EA
42 = N × G
3142 = (T × EA) × (N × G)
3241 = (T × G) × (N × EA)
4132 = (N × EA) × (T × G)
4231 = (N × G) × (T × EA)

* For F_{1s}, the first letter represents the sire breed
For 4-ways, the first two letters represent the sire breed
These fractions were considered as continuous variables.

MODEL II

$$Y_{ijklmno} = U + BY_i + S_{ij} + KBR_k + DAGE_l + SEX_m + BTY_n + b_1A_1 + b_2A_2 + b_2A_3 + b_4A_4 + b_5H_{21} + b_6H_{31} + b_7H_{32} + b_8H_{41} + b_9H_{42} + b_{10}H_{43} + e_{ijklmno}$$

where U, BY_i, S_{ij}, KBR_k, $DAGE_l$, SEX_m, BTY_n and e_{ijklmn} are as described for model I

b_1, b_2, b_3, b_4 = breed additive effects for breeds 1,2,3,4.

A_1, A_2, A_3, A_4 = percentage of genes contributed by breeds 1,2,3,4.

$b_5, b_6, b_7, b_8, b_9, b_{10}$ = heterosis effect due to interaction of two alleles at the same locus with alleles being from breeds 1&2, 3&1, 3&2, 4&1, 4&2 4&3

RESULTS AND DISCUSSION

Breed Group Differences

Model I was used to make comparisons among breed groups. The analysis of variance for BWT and WWT are presented in Table 2. All effects included in the model were significant sources of variation. Differences between sexes were significant ($P < .01$) for BWT and WWT. Such differences between sexes have also been reported by Ahmed and Tantawawy (1960). Effects of age of dam on BWT and WWT were significant. As the age of dam increased from 2 to over 5 years BWT and WWT also increased. Iloeje et al (1980) reported that milk yield increased linearly with age until about the third to fifth lactation when it tends to decrease. This trend could directly influence the WWT. Breed group differences were highly significant for both BWT and WWt. Table 3 shows the least squares means for the breed groups. These values show differences among the eleven breed groups with (N X G) being heaviest at birth and weaning. Of the two indigenous breeds, G and EA, G was higher for both characters. Among the Fls, N X G ranked highest. The G seems to provide a better maternal environment than EA because in all crosses of N and T with EA and G, the progenies ranked higher when the G was used as a dam. It should be noted that the Galla is considered a desert goat and thrives best in Northern Kenya. For BWT and WWT all the four crosses were lower than the straightbred G but were higher than the EA.

Table 2: Analysis of Variance for Birthweight (BWT) and Weaning Weight (WWT) by Model 1

Source	(BWT)		(WWT)
	df	F	F
Season (Birth year)	9	33.88*	61.42*
Dam age	3	8.34*	21.33*
Sex	1	59.84*	58.89*
Kid breed	10	48.26*	14.63*
Birth type	1	335.69*	133.37*
Error	1425		1014

* P < .01

Table 3: Least Squares Means and Standard Errors for Birth Weight (BWT) and Weaning Weight (WWT) by Model 1 for Breed groups

BREED GROUP	BWT	WWT
EA	2.00 ± .04	8.63 ± .19
G	2.62 ± .06	9.34 ± .31
GXEA	2.19 ± .06	8.73 ± .31
TXEA	2.29 ± .04	9.68 ± .18
TXG	2.72 ± .04	10.24 ± .19
NXEA	2.40 ± .05	10.06 ± .23
NXG	2.96 ± .05	10.97 ± .21
(TXEA)X(NXG)	2.42 ± .13	9.02 ± .50
(TXG)X(NXEA)	2.24 ± .13	9.08 ± .60
(NXEA)X(TXG)	2.39 ± .15	8.88 ± .66
(NXG)X(TXEA)	2.24 ± .12	7.96 ± .50

Genetic Effects

Model II was used to estimate the contributions of breed additive and heterotic effects for BWT and WWT. Regression coefficients for additive effects of EA, T and N expressed as deviations from G, and regression coefficients for heterozygosity are in Table 4. The BWT additive effects for EA were lower than for G but T and N additive effects were higher than for G. All WWT additive effects for EA, T and N were higher than for G.

Table 4: Estimates for Breed Additive and Heterosis for BWT and WWT using Model II

	BWT		WWT	
Genetic component	b	SE	b	SE
Additive				
EA	-.68	.19	.01	1.08
T	.86	.60	2.22	3.18
N	.54	.78	3.12	4.21
Heterozygosis				
T x EA	-.46	.22	.13	1.50
T x G	-.43	.23	.28	1.37
N x EA	-.16	.40	1.01	2.4
N x G	-.08	.53	.05	2.3
G x EA	.12	.13	.21	.50

SUMMARY AND CONCLUSIONS

Birth and Weaning weights of kids born between 1982 and 1987 at Olmagogo were studied. The kids comprised of 11 breed groups involving EA, G, T, N and their crosses.

Differences in birth weight (BWT) and weanings weight (WWT) among groups were significant ($P < .01$). The EA had the lowest birth weight of 2.0 kg followed by (G x EA) 2.19 kg. The weaning weight for EA was also lowest, 8.63 kg followed by (G x EA) 8.73 kg. Enviromental factors that significantly affected BWT and WWT included year, season within birth type. Genetic analysis revealed differences among breeds for additive and heterotic effects for BWT and WWT. The G appeared to provide better maternal environment than EA. The G was 0.63 kg and 0.71 kg heavier than the EA for BWT and WWT respectively. The G also ranked higher than any of the four way crosses. It should be noted that the T and N are established dairy breeds while the Galla has not been selected for either meat or milk. Depending on selection emphasis the G, indigenous breed, has potential for genetic improvement for either meat or milk production under Kenyan conditions.

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MANAGEMENT OPTIONS FOR INCREASED ANIMAL PRODUCTIVITY: SIMULATED MEAT AND MILK OFFTAKE POTENTIALS

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A major characteristic of subsistence farming in most developing countries is the combination of livestock with mixed cropping systems (Harwood, 1979). This is true of most smallholder farms in Western Kenya whose traditional agricultural methods have evolved in response to certain resource limitations. The goal of the small farmer is to meet multiple needs that often include family nutrition and cash income. He thus needs to adapt methods that use his resources efficiently.

The genetic makeup of both crops and livestock determines their potential production levels given certain environmental conditions. Forage availability must be synchronised with livestock genetics and individual animal physiological status, such that, animal nutritional needs are met and production potentials realised. Several methods of improving feed resources in Western Kenya have been investigated (Onim et al., 1984). These methods include alley cropping or intercropping forage with food crops and hedge row cut-and-carry forages. The seasonal fluctuation in feed resources, prevalent in these farms, can be overcome by forage preservation methods such as hay baling (Onim et al., 1985) to insure that quantity and quality feed is available throughout the year to maintain continuous animal productivity.

For any given genotypes, management plays an important role in determining the level of production realised. Such management aspects include flock structure, culling levels, kid rearing methods, kidding intervals, feed supplementation and breeding schedules. It is the responsibility of the farmer to manipulate these management alternatives either in combinations or individually, to obtain optimum productivity in terms of meat and milk offtake. The objectives of this study were to devise weaning and supplementation strategies for DPG for increased animal productivity and quantify the meat and milk offtake potentials on small holder farms in Western Kenya, considering, that the DPG technology was an addition to other farming practices for the smallholder farmer. It was assumed that a 1 - ha farm in Hamisi had 1 cow and 2 sheep (with their "followers" and lambs) (Hart et al., 1984). The feed remaining after the demand for these animals was assumed available for dual purpose goat production (Hart et al., 1984).

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Experimental Design and Assumptions

Data and experience from other SR-CRSP projects (Hart et al., 1984; Onim et al., 1985; Onim et al., 1986; Mathuva et al., 1985 and Sidahmed et al., 1984) were used to determine forage resource levels and quality feasible on the small farms. The forage available during the year described by Hart et al. (1984) consisted of dried corn stover, fence row growth, fallow growth, and bean and cassava leaves. These constituted the base diet. Previous simulations using these forage inputs showed that DPG flocks could not be viable due to low quality of the forage (Cartwright et al., 1984; 1985; 1986). By incorporating Sudan grass and pigeon pea in the cropping system a better quality forage resource was obtained. Flocks on this diet were viable but low digestibilities in some months lowered animal productivity. This study assumed that instead of Sudan grass, sesbania stored as hay and utilised as supplement feed be used.

Simulations using goat production model (Blackburn et al., 1984) were designed to determine effects of early weaning and feed supplementation on individual animal productivity. Two diets were considered. One diet (NS) did not include supplementation while the second (S) included supplementation of lactating does at the rate of 1 kg per day for 60 days post partum and .5 kg/day till drying period. Kids were also given supplement for 60 days post weaning. Kid supplementation was introduced gradually upto a maximum of .5 kg/day. Weaning was done at the age of 60 days. Milking of does was terminated when the daily yield dropped to less than .25 kg. The supplement was considered to have a digestibility of 74% and protein level of 21%. These values are equivalent to those for Sesbania hay (Onim et al., 1985; Sidahmed et al 1984). Kids may also be supplemented with sweet potato vines which have 72% digestibility and 20% CP (Semenye et al., 1986). Weaned kids were kept upto 1 yr of age when they were either sold or used as replacements. Does were culled at 7 yrs of age or if they failed to breed at 2 yrs of age. Two goat genotypes were considered. The target genotype being developed by the SR-CRSP breeding project utilising the indigenous Galla and East African types, selected for milk production and crossed with Toggenburg and Anglo Nubian breeds (Ruvuna et al., 1986; Cartwright et al., 1984).

This DPG is assumed to have a genetic potential of 40 kg mature doe body weight and a peak daily potential milk production of 4.0 kg at maturity. An intermediate genotype of similar mature weight but lower milk potential (3.0 kg/day) was also considered. Flock sizes sustainable within the forage resource domains were determined and their productivity quantified. The simulations were done for a period of 10 yrs.

RESULTS AND DISCUSSION

The simulated results are shown in Figure 1. For the non-supplement regimen (NS), early weaning at 60 days was not viable. Kids failed to grow due to low quality of the feed. Providing .65 kg/day of milk and weaning at 105 days of age facilitated kid growth comparable to that demonstrated under the supplementation regimen (S) with early weaning at 60 days and milk consumption of .5 kg/day. Supplementation and early weaning increased dairy milk production by 78.4 kg per lactation and yearling weight by 4.5 kg. Does were able to milk longer with the supplement than without it (195 days versus 165 days).

Results of flock productivity are summarized in Tables 1 and 2. These results are averaged over 10 years. There was no difference in average weaning and yearling weights between the two genotypes on a per doe or kid basis (Table 1). This is to be expected because they are of the same mature size and received similar nutrition. The 40/4.0 genotype as expected, produced more milk per lactation.

The 40/3.0 genotype maintained a good body condition with the lowest being .79 during beginning of lactation. Due to a higher milk potential the 40/4.0 genotype had to mobilize body stores to meet the requirements of lactation and thus had a lower body condition of .73 at the beginning of lactation. Overall flock body condition was also lower (.82 vs. .90) for the flock with higher milk potential.

Flock offtake and feed requirements are summarised in Table 2. On the same forage resource, more does (7.6) could be sustained and more milk and meat offtake realised where the 40/3.0 genotype was raised. This is the result of the lower lactation requirement per doe, such that a greater number of animals could be kept on the same feed resource. More does also resulted in a greater number of yearlings (7.7 vs. 6.3) and average annual sale weight of 238.3 kg. Considering the meat and milk offtakes, the 40/3.0 genotype would perform better than the 40/4.0. Although total feed demand by the 40/3.0 flock was higher it never exceeded the available resource at any time of the year.

In addition to meeting family nutritional needs, these production levels are a source of cash inflow. Assuming that average milk requirements for family use is 172 litres per annum (Mukhebi et al., 1986; Conelly and Nolan, 1986) surplus milk of approximately 1666 kg could be sold at KSh. 5.50/litre (Oyugi et al., 1986) realizing KSh. 9163.00 per annum. Surplus yearlings and culls (198 kg) would be sold at KSh. 8.26/kg live weight (Mukhebi et al., 1986) realizing an additional KSh. 1635.00. These would realize total cash inflow of KSh. 10,804.00 per annum. These cash approximations do not take into account the costs of labour, health, housing and risk considerations. It has been suggested in previous discussions (P.P Semenye and J.F.M. Onim, personal communication) that keeping a flock size of 6 does would not be feasible in the farming systems of Western Kenya. This is a significant point to consider realizing the labor and housing constraints. The productivity simulated in this study demonstrate sustainable levels as far as biological resources are concerned.

These potentials may be lowered due to labor, animal housing and any other non-biological constraints. The feasible size of the flock may be lower due to these constraints. One aspect that should always be considered about small holder farms is that the DPG technology is additional to other livestock and crop practices. Farmers often prefer to incorporate the technology to already existing practices rather than adopt it to replace existing enterprises.

SUMMARY AND CONCLUSIONS

A simulation study was done to quantify dual purpose goat production potentials under early weaning and feed supplementation regimens. These regimens were management options to increase productivity of the small holder farms in Western Kenya. Data and experience from other SR-CRSP projects were used to determine forage resource levels and quality feasible on the small holder farms.

Two goat genotypes were considered: a target genotype of 40 kg mature liveweight and 4 kg/d milk yield at peak day of lactation and an intermediate genotype of similar mature live weight but a lower milk potential of 3 kg/d.

Simulation results indicated increases of 78.4 kg in dairy doe milk per lactation and 4.5 kg in kid yearling weight under supplementation and early weaning. Does also were able to sustain longer lactations.

Flock productivity of the 40/3.0 genotype was higher than that of the 40/4.0. The 40/3.0 genotype produced an annual average of 238.3 kg sale weight and 1901 kg of dairy milk while the 40/4.0 genotype produced 198.7 kg sale weight and 1838 kg of dairy milk. In addition to meeting family milk needs, surplus milk sold could realize cash inflow. Together with sale weights total cash inflow could approximate KSh. 10,804.00 per annum. These approximations do not take into account labor, health and animal housing costs, and risk considerations.

The simulations demonstrated the biological feasibility of increasing animal production offtake by early weaning and supplementation. The feasible flock size may be limited by the non-biological constraints and subsequent production offtake lowered. Nevertheless early weaning with supplementation on an individual animal basis has great potential of increasing meat and milk offtake levels.

Table 1: Simulated Average Productivity per Doe or Kid

Item[b]	Genetic Potential[a]	
	40/3.0	40/4.0
Total milk per lactation, Kg	216.2	230.8
Lactating doe body condition	.90	.82
Weaning weight, Kg	8.6	8.8
Yearling weight, Kg	22.2	21.9

Table 2: Simulated Annual Flock Offtake and Feed Requirements

DM Consumption and Productivity[b]	Genetic Potential[a]	
	40/3.0	40/4.0
Dairy milk yield, Kg	1901	1838
Live weight sale, Kg	238.3	198.7
Flock size (No. of does)	7.6	6.7
Supplement consumed, Kg	1430.0	1246.5
Total Dm consumed, Kg	6416.7	5722.5

[a]Values represent mature body size of doe and its peak day milk production under ideal health and nutrition environment.

[b]The values are annual means of a 10 year simulation period.

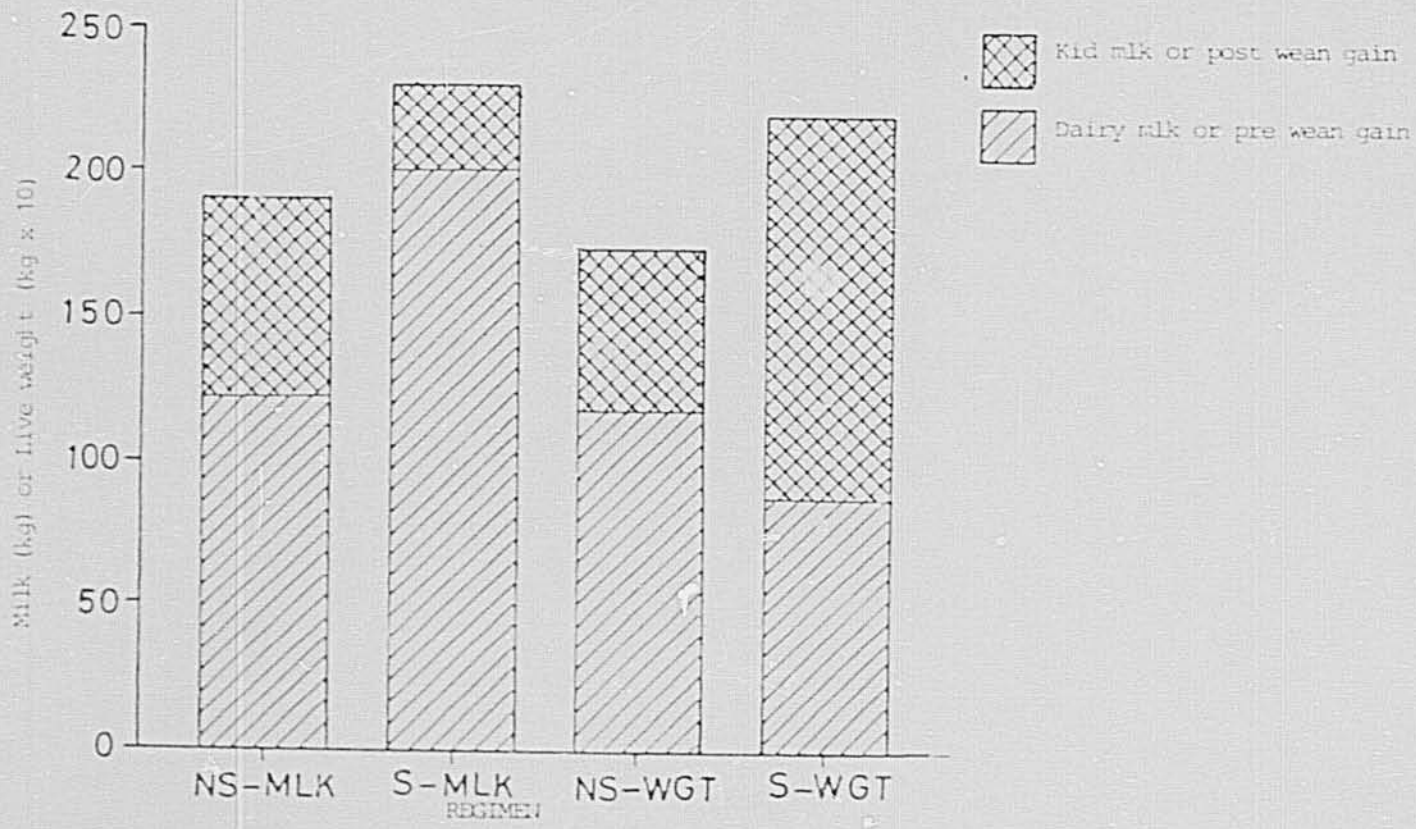

Figure 1. Production Potentials by Regimen
NS - Non supplement, S - Supplement

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THE POTENTIAL PRODUCTIVITY OF INTENSIVE SMALLHOLDER GOAT DAIRIES IN WESTERN KENYA

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The SR CRSP has focused on dual purpose goats (DPG) as a supplementary farm enterprise to supply milk for family use and sales of surplus kids. The current price structure for milk and kids in Kenya suggests that a goat dairy would be economically competitive with crop production. Utilizing data and experience from other SR CRSP projects, productivity of a goat dairy of 50 doses was simulated utilizing management and other conditions feasible for a small farm in order to obtain detailed, quantitative production input/output data. These data would then be available for economic analysis and sociological evaluation. Since intensification of livestock production tends to increase risk as well as potentials, the same as it does with crop production, risk analysis should be included in the economic analysis and sociological evaluation. Also, since goat milk is not an established commodity in local markets, the market element must also be of concern.

The data reported here are not only intended to illustrate systems analysis and use of simulation to substitute for long and expensive research, but to suggest a possible opportunity for farmers with limited land holdings to enhance their economic potential as well as producing a product of value for the people of the local area. Not only the value of the potential dairy product should be considered, but the potential for producing breeding stock which are in high demand is important.

DATA AND METHODS

The decision was made to simulate flocks that would be managed to maintain a maximum of 50 does and to estimate the amount of land and supplemental feed required for each flock, depending on the location. At times the total number does fell below 50 because bred doe-kid replacements were not counted until they first kidded.

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Forage production parameters interpolated from the report by Mathuva *et al.* (1985) were assumed to be conservative estimates for farm production devoted primarily to producing forage for the dairy goats. The digestibility of the forage for each 15-day period ranged from 58% to 65% and the crude protein from 11% to 14% (figure 1). In order to maintain these levels minimal amounts of forage would be harvested and stored as hay (see comments on land area below). Prior simulations had indicated the value of supplementing relatively high producing dairy goat flocks. Preliminary simulations for this study showed that, assuming that forage would be produced in quantities needed, supplementation with dairy meal of 75% digestibility and 15% crude protein would be near optimal if lactating does were provided 1kg for the first 15-day period of lactation, .5kg/day for the second 15-day period and .25kg/day for the third 15-day period.

It was assumed that dairy goats with the genetic potential to grow and produce milk at the level of the new dual purpose goat (DPG) breed being developed by the breeding project (Ruvuna *et al.*, 1986) would be available. These DPG are characterized for simulation by the unstressed mature size and lactation of does as 40 kg body weight and 4.0 kg of peak day milk. The genetic potential for the DPG is designated or coded as 40/4.0. It should be noted that these are potentials toward which genetic mediation directs the doe but actual production is almost always lower due to various limitation of the production environment. The average ovulation rate potential was 1.2 ova per ovulation. These DPG are reasonably well adapted to western Kenya production conditions. In order to demonstrate the potential for goats bred for higher dairy potential, three other breed types of 44/4.5, 48/5.0 and 52/5.5 were also included in the simulation.

Management practices were set to be similar to those expected under practical conditions. These included the following:

Milking does for 195 days or until milk production dropped to below .25 kg/day.

Kids received .5 kg milk per day until 105 days (seven 2-week periods) of age.

Does were culled at 7 years of age if they lived that long.

Doe kids were bred when they reached both 14 kg body weight and 18 periods age (270 days) as minima; after breeding they were available as needed for replacement.

Excess doe and male kids were sold at one year of age (24 periods).

Treatment with anthelmintics was conducted according to season and was considered to be moderately effective.

RESULTS

Breedtypes

The composition of flocks of each of the genetic potentials examined is presented in table 1. Since does dying or culled are replaced by bred doe kids that are available, the sizes of the flocks over a 10-year period averaged about 49 does. The average annual productivity of these flocks in terms of output of dairy milk and liveweight sales and input of forage dry matter (DM) and dairy meal supplement are given table 2. Key per animal productivity values are given in table 3 for the four breedtypes. Productivity of the breedtypes in output/input terms is given in table 4.

It is evident that the breedtypes with high milk production potential produced more dairy milk offtake as a flock and as individuals; however they did consume more forage DM and dairy meal, as expected. The liveweight offtake was similar for all breedtypes reflecting a higher mortality rate among the breedtypes with higher potential and insufficient forage quality for the larger size breedtypes to gain and weigh more than the 40/4.0 DPG by one year of age as seen in table 3. Note that average body condition was lower for the breedtypes with higher potential; these average levels are considered satisfactory, but at more stressing periods the higher potential does tended to drop to a critical 70 to 75% level.

In conclusion, it appears that the DPG (40/4.0) in comparison to the highest genetic potential breedtype (52/5.5) produced almost 80% as much dairy milk, 10% less efficiently with respect to forage and almost 14% more efficiently with respect to dairy meal supplement. The DPG produced slightly more liveweight sales on less DM and supplement. It appears that since the DPG has lower mortality, maintains higher levels of body conditions and is generally considered to be more robust, that at present forage quality and levels of management that the DPG is probably the most satisfactory breedtype for smallholder dairies at the current time. With improved nutrient resources and management the higher potential breedtypes should be considered.

Potential for DPG Dairy

In order to approximate some baseline output/input data in economic terms, the productivity data from the DPG were taken as realistic potentials. Since forage production varies greatly from area to area in western Kenya, a range of forage production based on reports of Mathuva *et al.* (1985) was arbitrarily set. These values of production per flock converted to farm size required to maintain the 50 doe DPG flock ranged from less the 2 ha to over 7 ha. One additional hectare was added to allow for pens, barns, pathways, etc. The total farm size required ranged from 2.78 ha to 8.11 ha (table 5).

Prices paid (farmgate) for milk and average goats were taken from Mukhebi and Onim (1985) and Oyugi *et al.* (1986). These prices were again used to set an arbitrary range within which milk and goat

liveweight prices could be expected to range (table 5). Taking these ranges of forage production and prices, a range of gross income was projected for a 50 doe flock of DPG managed as a goat dairy (table 5).

These gross income projections were summarized for low, intermediate and high prices for both milk and animal sales (table 6). Cost of forage production and dairy supplement was estimated using the report of Mukhebi and Onim (1985) for forage and historical prices for supplement and drenching (table 6). Differences between gross income and the major costs of forage, supplement and drenching were calculated and are given in table 6. These differences do not represent net income since labor, facilities, equipment and some other costs were not included. These differences are presented to indicate that the potential suggests that a full economic analysis would be appropriate.

SUMMARY AND CONCLUSIONS

Utilizing data collected on the Forage, Economics and Breeding Projects of the SR CRSP, the productivity of dairy goats was simulated for flocks suitable for smallholder farmers in western Kenya. The new dual purpose breed (DPG) being developed by the Breeding Project was simulated to be almost as productive, and more robust, than dairy goat breedtypes of higher potential. Simulated DPG flocks of 50 does produced 15,111 kg of dairy milk and 1.323 kg of sale animals per year. Depending on location and fertilizer practice, farm size required ranged from about 3 to 8 ha. Various price/cost scenarios were used to project gross income and income over costs of forage production, dairy meal supplement and anthelmintics. The approximated returns do not include all expenses or risk considerations, but are of sufficient magnitude; 1,000 to 10,000 Ksh/ha; to encourage further economic analysis and developmental research to explore the feasibility of goat dairies as an alternative to traditional crop production for some farmers.

A major concern in the assumptions was that of a market for goat milk which is not established. The current situation would have to be resolved before the feasibility should be explored. Another assumption was that the excess kids and cull does were sold at slaughter prices. Improved DPG kids are expected to sell at much higher prices.

Finally, these results illustrate that simulation and systems analysis is an expeditious and inexpensive way to conduct a "production experiment" to examine a practice that appears to have merit.

Table 1. Simulated numbers of goats in flock of fifty does utilising one of four breeds[a]

Breed potential		Average annual number				
Size, kg	Milk, kg/d	Does[c]	Total	Births	Weaned	Sold[b]
40	4.0	48.8	103.7	81.2	55.2	45.4
44	4.5	49.1	101.7	81.2	52.8	42.7
48	5.0	48.4	99.9	78.6	51.0	40.8
52	5.5	49.2	102.1	77.8	53.5	43.1

[a] These means are for 10 years after 15 years of simulation to reach stabilization. The breeds are represented by the weight of a mature doe in good condition and peak day lactation of a mature with all nutritional requirements met.

[b] Number sold includes all male kids and excess female kids.

[c] Flock managed so that the maximum number was 50 does; any doe leaving the herd was replaced by a bred doe kid.

Table 2. Simulated annual offtake and consumption of flocks of fifty does of four breeds[a]

Breed potential[a] Size, kg	Milk, kg/d	Dairy milk, kg	Liveweight sale, kg	Feed consumption, kg Total DM	Supplement
40	4.0	15,111	1,323	35,565	1,347
44	4.5	16,339	1,221	36,815	1,557
48	5.0	17,256	1,255	38,063	1,737
52	5.5	18,929	1,287	40,347	1,959

[a]The size represents the weight of a mature doe in good condition. The milk represents the peak day lactation of a mature doe with all nutritional requirements met.

Table 3. Simulated average productivity per doe or kid in flocks of four breeds[a]

Breed potential[a] Size, kg	Milk, kg/d	Weaning weight, kg	Yearling weight, kg[b]	Feed consumption, kg lactation[b]	condition %[c]
40	4.0	12.7	20.9	267 (267)	87
44	4.5	12.8	20.7	286 (300)	86
48	5.0	12.9	19.7	305 (333)	85
52	5.5	13.0	20.1	324 (367)	85

a The size represents the weight of a mature doe in good condition. The milk represents the peak day lactation of a mature doe with all nutritional requirements met.

b Mature does only; numbers in parenthesis indicate the potential for the breed when nutrition is not limiting.

c The average doe weight as a percentage of expected weight in unstressed condition.

Table 4. Simulated offtake from a flock of fifty does

Breed potential		Feed consumed/dairy milk		Feed consumed/sale liveweight	
Size,kg	milk,kg/d	Dry matter,kg	Supplement,kg	Dry matter,kg	Supplement kg
40	4.0	2.35	.089	26.9	1.02
44	4.5	2.25	.095	30.2	1.28
48	5.0	2.21	.101	30.3	1.38
52	5.5	2.13	.103	31.4	1.52

Table 5. Estimates of gross income per hectare from milk and animal sales from a flock of fifty simulated DPG does[a]; KSh

Production per ha mt DM	Number of ha[b]	Milk sale, @ KSh/kg[c]			Animal sales, @ KSh/kg[c]		
		2.60	3.60	4.60	5.50	6.50	7.50
5	8.11	4,844	6,708	8,571	897	1,060	1,223
7.5	5.74	6,833	9,461	12,089	1,265	1,496	1,726
10	4.56	8,616	11,930	15,244	1,596	1,886	2,176
15	3.37	11,658	16,142	20,626	2,159	2,552	2,944
20	2.78	14,133	19,568	25,004	2,617	3,093	3,569

a DPG does of the 40/4.0 breed potential.

b One hectare was added to the forage production area to allow an area for keeping the flock.

c Prices (kshs/kg) vary with age and condition of animal, season etc.; these ranges were chosen arbitrarily as average from reports by Mukhebi and Onim (1985) and Oyugi *et al.* (1986).

Table 6. Approximations of gross income and major expenses and their differences for a flock of fifty simulated DPG does[a]

Income or expense item	Income or expense, Ksh/ha	Total or diff., Ksh per flock	per ha
Milk sales			
Low price (2.60/kg)	39,288		
Intermediate price (3.60/kg)	54,399		
High price (4.66/kg)	69,511		
Animal sales			
Low price (5.50/kg)	7,277		
Intermediate price (6.50/kg)	8,600		
High price (7.50/kg)	9,923		
Total of sales			
Low price		46,565	12,384
Intermediate price		62,999	16,754
High price		79,429	21,125
Cost of forage production[d]			
2.76 ha without fertilizer	36,000		
Supplement cost (1,347/kg)[d]	2,598		
Drenching cost (103 head)[e]	4,285		
Total of costs		42,883	11,405
Difference, sales less costs			
Low price		3,682	978[e]
Intermediate price		20,116	5,349[e]
High price		36,546	9,720[e]

a The DPG, dual purpose goat, is being bred to reach 40 kg mature doe weight and 4.0 kg milk/day at peak.

b Difference per hectare; 1 ha was allowed for keeping flock and 2.76 ha for forage; total of 3.76 ha.

c Cost of producing 35,569 kg DM of forage based on approximation using data from Mukhebi and Onim (1985). With use of fertilizer this cost was approximated as Kshs 34,000 for 1.78 ha.

d Based on prices paid by Breeding Project in 1986, Ksh 1.9286/kg/

e Costs based on Mukhebi *et al.* (1985).

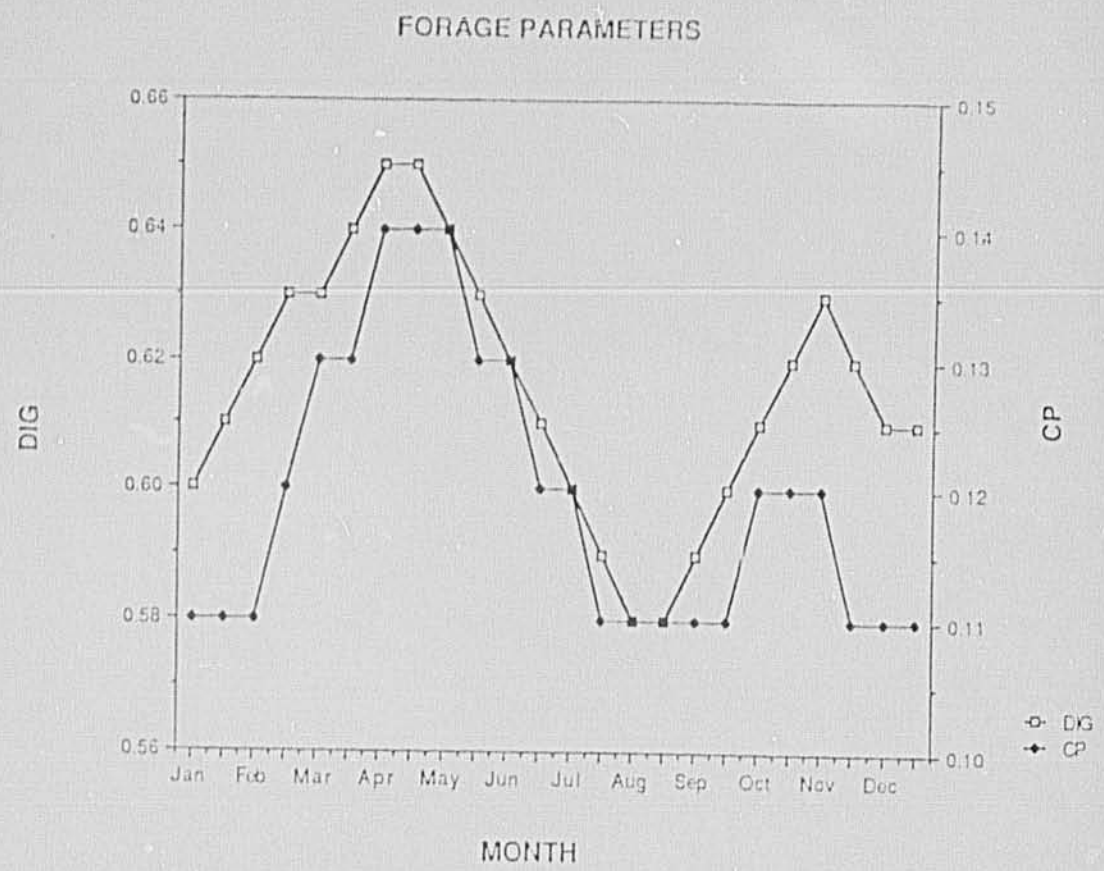

Figure 1. Digestibility and crude protein forage parameters used for simulation.

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ANIMAL HEALTH

PRELIMINARY REPORT ON CLONING OF PUTATIVE *COWDRIA RUMINANTIUM* DNA

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Heartwater or cowdriosis is a tick-borne disease of domestic and wild ruminants caused by rickettsia, *Cowdria ruminantium* (1). This disease, like other tick-borne diseases, is a major constraint to livestock production in many of the tropical and subtropical areas of the world. The disease is endemic in sub-Saharan Africa in an area estimated to be 5 million square miles (2). The disease has the potential to spread from its present areas of occurence as the tick vector (Amblyomma) is widely distributed in the world. More recently it has been recognised in the Caribbean Islands (3, 4).

There are no effective control measures of heartwater. Vector containment with acaricides is expensive and difficult. In some countries, vaccination by infection and treatment is carried out. This procedure is associated with several problems:

i) the virulence of the vaccine varies with each batch, and

ii) there is a possibility of transmitting intercurrent diseases.

Lack of an effective and safe vaccine for heartwater stems from inability to grow the organism *in vitro* to obtain sufficient quantities of *C. ruminantium*. To circumvent this problem, an attempt to produce recombinant *C. ruminantium* surface proteins which would be used to induce a protective immune response against heartwater was carried out.

C. ruminantium was partially purified from infected nymphs of *Amblyomma variegatum*. The nymphs were infected by attaching clean larvae of *A. variegatum* onto goats inoculated with a heartwater blood stabilate. The larvae were allowed to engorge, drop and moult into nymphs. The flat nymphs were then attached to a heartwater susceptible goat for engorgement during which period the cowdria amplifies within the epithelial cells of the tick guts. Guts from infected nymphs were dissected out and homogenized. A differential centrifugation was performed on the homogenate. Control uninfected nymphs were similarly treated. The fractions were tested for their infectivity by inoculating each fraction into five goats. Results in Table 1 indicate the enrichment of *C. ruminantium* in the 10K pellet. DNA was extracted from this fraction by a modified procedure of Marmur (5). An aliqout of the DNA from 10K pellet of uninfected and infected nymph guts was electrophoresced on 0.6 pre cent agarose gel. A unique band of DNA migrating at approximately 23kb was observed in the DNA from the infected nymphs. This band of DNA was eluted from the gel and restricted with the restriction enzyme Sau 3A to generate random

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fragments. These fragments were ligated into the Bam Hi cleaved and dephosphorylated plasmid pBR322 and the ligation mixture used to transform *E. coli* strain HB 101 by the high efficiency procedure of Hanahan (6). The transformants were selected on their resistance to ampicillin and sensitivity to tetracycline. Plasmid DNA was prepared from the transformants. Seven of the recombinant plasmids were selected and their DNA labeled with biotin-DATP by nick translation and used as probes for a differential hybridization with DNA from uninfected and infected tick DNA. One of the recombinant plasmids DNA hybridized only to infected tick DNA on a dot blot hybridization.

Currently, a bigger library from the DNA of the unique band has been prepared for screening for expression of *C. ruminantium* proteins in *E. coli*. Screening will be done with a post-convalescent serum from a heartwater infected goat.

Completion of the objective of this study would be a major step in the development of an effective and a safe subunit vaccine for heartwater. Subsidiary to this, it could lead to the development of a reliable diagnostic test using either one of the inserts in the recombinant plasmids as a DNA probe or the expressed protein in an immunoassay.

Table 1: Enrichment of *Cowdria ruminantium* in the 10K pellet of the infected nymph homogenate measured by infectivity in goats.

Inoculum	No. dead/ No. inoculated
Sonicated nymph gut homogenate	2/5
2K pellet	2/5
10K pellet	4/5
30K pellet	1*/5
30K supernatant	0/5

*The goat died without pyrexia on 27th day post inoculation.

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CONTROL OF ENDOPARASITES IN SMALL RUMINANTS - AN OVERVIEW

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SUMMARY

Helminths cause high economic losses in sheep and goats in Africa. They cause various types of damage to the animal, categorised as mechanical, digestive, depletive, allergenic and anaemic. These damages cause two types of economic losses, that is, direct and indirect losses. Direct loss is due to acute illness leading to death and affects the most susceptible individuals in the herd. Indirect loss is due to subclinical helminthiasis that is a herd problem which farmers do not easily recognise.

INTRODUCTION

Parasites constitute a major variable in livestock production systems, particularly in sheep and goats, worm infestations are the single greatest constraint to sheep and goat production in the tropics (Allonby & Urquhart, 1975). In Kenya, there is an annual loss of 26 million dollars in the agricultural sector attributable to helminthiasis in sheep (Preston & Allonby, 1979). In a country-wide survey of causes of mortality in small ruminants in Kenya endoparasites ranked highest in both range and particularly, high rainfall regions (Kariuki, 1980). This is indication of the importance of helminthiasis in a wide range of agro-climatic zones. Studies on epidemiology and economics of helminth infections in small ruminants have also been reported in Ethiopia (Tseggai, 1981), Zimbabwe (Grant, 1981), South Africa (McCulloch *et al.*, 1984; Swan *et al.*, 1984), Zaire (Pandy & Verhulst, 1976), Nigeria (Malaki, 1976), Senegal (Vercruysse, 1985) and Morocco (Ouhelli *et al.*, 1981) indicating the economic significance of helminthiasis in the small ruminants in those countries.

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EFFECTS OF PARASITISMS

Damage to Host

The nature and extent of damage on the host varies for different parasites. Damage can be classified as:-

a) Mechanical — Feeding parasites examplified by *Haemonchus contortus* destroy tissue and cause wounds. As a result bleeding occurs from small blood vessels in the lining of the abomasum. Mechanical damage may also be brought about by obstruction in the small airways of lungs infected with *Dictyocaulus filaria*. The obstruction impairs the function of the lungs resulting into pneumonia and collapse of the lungs.

Echinococcus granulosus cysts are yet another example of mechanical damage caused by pressure, for example, on the liver or lungs.

b) Digestive — *Ostertagia*, a parasite of the more temperate Northern and Southern parts of Africa, destroys host cells and tissues by enzymatic digestion.

c) Depletive — Tapeworms, e.g., *Moniezia expansa*, absorb food already digested by the host thus depriving the host of its nutrients.

d) Allergenic — *Dictyocaulus* and *Bunostomum* larvae penetrating the skin of sheep and goats cause allergy resulting in intense itching, especially of the feet.

e) Anaemic — Parasites like *Haemonchus*, *Bunostomum* *Chabertia* and *Fasciola*, ingest large amounts of blood from the host leaving bleeding sites. The result is iron-deficiency anaemia.

Economic Losses:-

Losses due to parasitism are a result of the damages to the host enumerated above and can be categorised as direct and indirect (Beller, 1977). The direct losses are due to acute illness and death, premature slaughter and rejection of parts at meat inspection. Acute parasitisms are easily recognised by the farmer and treated. Direct losses could therefore be avoided by early treatment.

Indirect losses are caused by subclinical levels of parasitisms which cause no obvious clinical symptoms. This type of parasitism is regarded as the most important cause of economic loss as it is a herd problem unlike the acute syndrome which tends to affect low plane of nutrition and the lactating does and ewes. It is also the type many

farmers do not easily recognise. Subclinical parasitisms cause diminution of potential productivity of sheep and reduce feed intake (Spedding, 1954). These effects cause measurable losses of productivity such as decreased growth rates, milk yields, poor mutton quality and poor reproductive performance or infertility.

CONTROL MEASURES

Factors:

The ultimate criterion of success in the control of parasitisms is the net profit that accrues and not the number of parasites killed (Whitlock, 1955).

Before instituting any control measures it is imperative to predict the factors which favour the occurrence of helminthiasis. These factors can be put under several categories.

a) The biology of the parasite. Control of parasites is basically aimed at breaking the life cycle either by killing the parasitic stages inside the host thus preventing the discharge of eggs into the environment which result into the free-living stages, or by preventing the host from taking in the infective larvae.

b) The host characteristics. Age, sex and breed are recognised as important factors in determining the extent of helminthiasis in livestock. The young, the lactating does and ewes and the old (broken-mouthed) are the most susceptible groups. Adult animals resistance to helminthiasis has been documented in sheep)Preston and Allonby, 1978; 1979), while in goats there are similar indications although much less research has been done (Njanja, 1985; and Shavulimo, 1985).

c) The environment. Warmth and moisture are usually necessary for the development of infective round worm larvae. Moisture on pasture also allows the proliferation of the intermediate hosts for Fasciola. Most of Eastern and Southern Africa falls within the tropics. There is, however, tremendous variability in climate, ranging from the high rainfall, humid zones to the low, unreliable rainfall arid/semi-arid zones. Animals in the humid zones are exposed to a multitude of parasites and their vectors, referred to as "Walking helminthic ZOO" by Schillhorn Van Veen (1982). Despite this the sheep and goats thrive well due to their natural resistance, their high fecundity and rapid maturation. Animals in the arid/semi-arid zones are usually kept under low stocking densities, but often in large nomadic or semi-nomadic flocks. This environment is not very favourable for development and survival of helminths. Some parasites like *Haemonchus*, however, have adapted well by their ability to rapidly increase their population when circumstances become temporarily favourable.

1. Control by use of Anthelmintics:

There has been tremendous progress in recent decades in developing chemicals for destroying parasites. An increasing number of livestock production systems, especially where significant losses due to parasites occur are dependent on regular use of anthelmintics with undoubted benefits in increasing productivity.

Chemotherapy is aimed at eliminating the parasitic stages of helminths in the host thus preventing the discharge of eggs and larvae into the environment. As stated earlier, the frequency being the biology of the (dominant) parasite, the environment, stocking rates, grazing history of the particular area and the benefits accruing from the proposed treatment schedule.

The view has been expressed that a biological equilibrium becomes established between the host and the parasites so that a mild or medium infection no longer causes production loss. Premunition is probably the most important functional type of host resistance and results from exposure to active infection in grazing stock. Thus periodic anthelmintic medication may interfere with the process of premunition (Georgi, 1974). Todd (1974) demonstrated significantly higher milk yields in dairy cows which had been treated as opposed to those that were not, even though in both groups the parasite egg counts were as low as 36 or even 10 strongyle eggs per gram of faeces. Stanev *et al.* (1974) demonstrated higher weight gains in treated lambs compared to those that were not, even though the infection was mild in both cases. In both examples higher production was achieved due to regular anthelmintic treatment. Chemotherapy has inherent dangers of development of resistance against them by parasites. There is therefore a need to find a treatment schedule that will allow animals to develop premunition and at the same time prevent excessive build up of helminths in the pasture.

2. Control through management:

No anthelmintic can overcome excessive exposure to helminth infection (Georgi, (1974). High strongyle worm burdens could not be overcome by periodic anthelmintic medication (Ross, 1967). The reason was a high stocking rate resulting in high rate of recontamination of the pasture. In pastoral areas where most of the small ruminants are found stocking densities have been a concern in connection with causing soil erosion, but equally important danger with high stocking rate, even in marginal potential to semi-arid and arid areas, when conditions become temporarily favourable, parasites with high fecundity like *Haemonchus* (Schillhorn Van Veen, 1982) can cause high economic losses in sheep and goats.

Rotational grazing has for along time been accepted as an important management practice in the control of helminth infections. In theory, rotational grazing seeks to prevent or limit intake of infective larvae by permitting animals to graze on a particular areas of pasture not longer than three days, the time it takes for worm eggs passed in faeces to develop into infective larvae; and then not allowing the animals to return to the same pasture until all the infective larvae have died. According to Georgi (1974) rotational grazing, if rigidly followed, has the same danger as overzealous application of anthelmintics in that animals have no chance to develop premunition and if they encountered a highly contaminated paddock the results would be disastrous.

Lambs and kids are more susceptible to worm infections than adults and should be separated from their dams as early as possible and grazed on clean paddock - ahead of the adult flock in a rotational grazing practice.

In intensive management, as on smallholder farms, where animals are tethered or stabled, contamination of feed with faeces is a real danger and can be avoided by use of raised troughs and hay racks. Feed should not be left on the troughs for a long time as it will be contaminated by larvae which migrate from the floor.

Well nourished animals are much less susceptible to Helminths (Preston and Allonby 1978). Although some worms establish, their effects are lessened and spontaneous cure (self-cure) occurs. If however, pastures are highly contaminated the worm burden may be too high even for the well fed and other control measures such as chemotherapy - should be applied.

3.2 Control by breeding for resistant stock

Breeding for disease resistant stock is probably one of the longest worm control practices in use (Whitlock, 1966, Georgi, 1974). There are places in Africa (and else where in the world) where livestock thrive under many systems of husbandry without interference from science and technology; these animals have worms, as a population, and handle them effectively, although individuals may succumb occasionally.

Host resistance to diseases has continued to be of paramount importance although, until very recently, conscious selection of resistant stock has not been part of breeding programmes.

Preston and Allonby (1978) demonstrated that the Red Masai breed of sheep was superior to the Corriedale, Hampshire down and Merino breeds in its resistance to heavy infection with *Haemonchus contortus*. Studies on breeding *Haemonchus contortus* resistant sheep have been done in Australia (Albers *et al.*, 1984). Gray *et al.* (1984) also working in Australia demonstrated that the resistance of Merino weaners to *H. contortus*, defined as the level of egg output, had a heritability of 30%. The results from these studies indicate that

selection for resistance is feasible. There is, however, a need for further research into genetic resistance in local African breeds of sheep, the Red Masai is perhaps the only breed studied so far and has very promising use in breeding programmes. Much less work has been done to demonstrate genetic resistance in goats. From the studies by Shavulimo (1985) and Njanja (1985) in which three breeds of goats, the East African, the Galla and the Toggenburg were compared for resistance against *H. contortus*, it would appear that the local goat breeds do not have high genetic resistance like the sheep. According to Preston and Allonby (1978), and Schillhorn Van Veen (1982) goats in their natural environment are browsers and as a result they have had relatively less parasite challenge compared with sheep. The goats have, therefore, not built up high genetic resistance. Carles *et al.* (1984) working in semi-arid northern Kenya showed that sheep has an average of 20% higher strongyle worm egg counts than goats, an indication of variation in the rates of intake of infective larvae rather than resistance. There is, however, a need for further research into the genetic resistance of the various local goat breeds to be able to come to firm conclusions.

4. Control by immunisation

Certain nematodes stimulate substantial immunity that persists after infection, a rather uncommon property (Georgi, 1974). The larvae are attenuated by ionizing radiation. The irradiated larvae migrate and may moult but do not reach maturity.

So far Lungworm vaccine in cattle against *Dictyocaulus viviparous* is commercially available - mostly in Britain and United States of America.

Research using nuclear techniques is currently underway to identify factors that would facilitate the development of a vaccine against important sheep and goat nematodes such as *H. contortus*, *trychostrongylus* spp (Dargie, 1984; Mitchell, 1984). Willets (1984) discussed the use of recombination DNA technology to develop vaccines against helminths infections in animals.

Although vaccination would not prevent infection completely, it would certainly reduce the probability of an animal being overwhelmed by worm infection when turned to pasture. It would minimize the use of anthelmintics.

CONCLUSION

Strategies for further research

While sheep and goats are often considered to share a common susceptibility to parasitic infections, it has been observed that there exists significant variation in their resistance (Smith *et al.*, unpublished; Preston and Allonby, 1978; Shavulimo, 1985). Dunn (1978)

noted that the available information on small ruminant disease incidence, prevalence and seasonality mostly referred to sheep and could not be entirely applicable to goats. There is therefore a need for further research into the incidence, prevalence, separately for sheep and goats. On the basis of the findings by Carles *et al.* (1984) strategies for control of helminths may need to be considered separately for sheep and goats in the same herd based on the knowledge of the levels of infection and the economic returns.

Although some research has been accomplished demonstrating genetic resistance in some sheep breeds against *Haemonchus* infection (Preston and Allonby, 1978; Albers *et al.*, 1984; Gray *et al.*, 1984), there is a need to investigate this factor in all the other sheep breeds in Africa. Much less work has been done to demonstrate genetic resistance in goat breeds. Once resistant breeds and the genetic markers for resistance have been identified, breeding for resistance to helminthiasis will form an important aspect of small ruminant development programmes.

The current studies into the use of irradiated larvae for immunisation of sheep against some common nematodes need to be strengthened with emphasis on nematodes of economic importance such as *Haemonchus*. The use of resistant breeds and immunisation would definitely offer farmers a good alternative reducing the current over-reliance on anthelmintics for the control of helminthiasis.

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DETECTION OF *ANAPLASMA OVIS* USING A DNA PROBE

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INTRODUCTION

Anaplasma ovis is defined as a distinct species from *A. marginale* and *A. centrale* based on the distribution of the inclusion bodies in infected erythrocytes and host specificity (3,4). *A. ovis* inclusion bodies are found 60-65% marginal and 35-40% submarginal or central (3,4,5). In comparison, those of *A. marginale* are found 90% marginal and 10% submarginal or central while those of *A. centrale* are largely central (1,5). With regard to host specificity, inoculation of intact goats or sheep with *A. ovis* results in clinical disease (3,4,13) while in cattle, *A. ovis* produces inapparent infections (1). *A. marginale* causes a severe disease in cattle (14), but inoculation of goats or sheep causes parasitemia without clinical disease (1,12). *A. centrale* infects cattle causing a mild or sometimes a severe clinical disease, and also causes a parasitemia in sheep and goats (1).

A. ovis infections of goats are characterised by an incubation period of 8-40 days. Manifestations of severe or mild disease in infected goats may depend on the presence or absence of premunition. In severe infections, debility, depression and progressive anemia develop followed by death. Goats recovered from *A. ovis* disease remain persistently infected and are inapparent carriers (3,4).

Diagnosis of anaplasmosis is based on detection of *Anaplasma* inclusion bodies in blood smears, subinoculation of blood into splenectomized animals and detection of antibodies *Anaplasma* antigens in serological tests. These diagnostic procedures lack sensitivity and specificity. Therefore, there is a need to develop improved diagnostic methods for routine use in surveillance and epidemiological studies. DNA hybridization methods are very specific and sensitive diagnostic procedures for identification of infectious agents and are used to detect malaria and babesia organisms in blood (17,18). Nucleic acid hybridization can be especially useful in detecting pathogens in diseases where carrier animals are reservoirs of infection.

In this report, I have identified the *Anaplasma* parasite infecting goats as *A. ovis* and developed a DNA probe to detect *A. ovis* in infected blood from goats.

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MATERIALS AND METHODS

Growth of A. ovis and isolation of inclusion bodies:

An *A. ovis* Idaho isolate[a] was inoculated into a splenectomised goat, parasitemia monitored daily, and blood taken when the parasitemia reached 21%. Parasitemic blood was washed 3 times with phosphate buffered saline (0.13M NaCl, 0.0015M KH_2PO_4, 0.0015M Na_2HPO_4, 0.0027M KCl) (PBS) and the buffy coat removed at each wash. The washed blood (PCV 50%) was frozen at -20°C in order to lyse the erythrocytes. A 100 ml volume of the erythrocyte suspension was thawed and centrifuged at 19,000 x g for 20 min at 4 C to pellet *A. ovis* initial bodies and erythrocyte membranes. Hemoglobin was removed by washing the pellet three times in PBS at 19,000 x g for 20 min. *A. ovis* DNA was isolated according to a described procedure (20). Further removal of proteins was achieved by phenol, phenol-chloroform and chloroform extractions followed by ethanol precipitation (21).

Construction and screening of the recombinant A. ovis genomic DNA library:

Anaplasma ovis DNA (1 ug) was partially restricted with Sau 3A and ligated to 200 ug of Bam hI, cleaved and dephosphrylated pBR322 using 10 units of T4 DNA ligase (21). *Escherichia coli* strain HB 101 cells grown to $O.D_{550}$=0.413 were transformed by a high efficiency transformation procedure (22). Colonies resistant to ampicillin were selected on yeast-tryptone media (0.8% bacto-tryptone, 0.8% bacto-yeast extract, 0.5% NaCl and 1.5% bacto-agar) containing ampicillin (100 ug ml). The *A. ovis* genomic library was screened by colony hybridization (23) using a biotin labeled genomic *A. ovis* DNA probe prepared by nick translation with biotin-7-dATP (24). After hybridization, the nitrocellulose filters were processed for color development as recommended in the BlueGene kit (BRL, Inc. MD), which included incubating the nitrocellulose paper with streptavidin-alkaline phosphatase conjugate for 10 minutes followed by incubation with freshly prepared dye solution of nitroblue tetrazolium and 5-bromo-4-chloro-3-indolylphosphate in a sealed bag. Color development was allowed to proceed in the dark for 30 minutes at room temperature. Bacteria colonies with the strongest color reaction were selected.

Preparation of recombinant DNA probes:

Selected individual colonies were amplified overnight at 37°C in YT media (0.8% bacto-tryptone, 0.8% bacto-yeast extract and 0.5% NaCl) containing 100 ug/ml ampicillin. Plasmid DNA was extracted by alkaline lysis (25) and electrophoresced in 0.6% agarose to select clones with *A. ovis* DNA inserts. The DNA of the selected clones was isolated and treated with restriction endonuclease enzymes AvaI, BamHI and EcoRI and electrophoresced in a 0.6% agarose gel to determine the size of the DNA inserts. The clones with the largest *A. ovis* DNA inserts were selected for labeling with biotin-7-dATP by nick translation (24).

The cloned *A. ovis* DNA labeled with biotin-7-dATP and used as a probe. This probe was used in hybridization reactions with genomic *A. ovis* and *A. marginale* DNA. Ten-fold serial dilutions (100 ng to 1 pg) of *A. ovis*, *A. marginale* and goat leukocyte DNA were prepared in TE buffer (10 mM Tris.HCl, lmM EDTA pH 8). The microlitres of each DNA sample dilution was spotted on nitrocellulose paper and baked for 2 hrs at 80 C. Hybridization conditions were as described (19).

To determine whether multiple copies of the cloned *A. ovis* fragment were present in the *Anaplasma* species genome, *A. ovis*, and *A. marginale* genomic DNA were restricted with SstI and electrophoresced on 0.8% agarose. Goat leukocyte DNA was used as control. The DNA fragments were transferred to nitrocellulose paper (27) and probed with the cloned *A. ovis* DNA probe.

Characterisation of Anaplasma organisms from goats in Kenya:

Thin blood smears from 4 *Anaplasma* isolates from goats and 4 isolates of *A. marginale* from cattle were Giemsa stained. The location of the intraerythrocytic inclusion bodies for each isolate was determined as either marginal, submarginal or central. To further characterise the *Anaplasma* organisms infecting goats, DNA was extracted from the *Anaplasma* isolates from goats and *A. marginale* isolates from cattle. Ten-fold serial dilutions of the DNA (100 ng to 1 pg), were spotted on nitrocellulose paper and hybridized to the cloned *A. ovis* DNA probe and an *A. marginale* DNA probe previously described (30).

RESULTS

Evaluation of cloned A. ovis DNA:

Ninety-four transformed *E. coli* colonies hybridized with varying intensities to a biotin labeled *A. ovis* genomic DNA probe. One of these, pAO12A had the strongest reaction and was isolated for further study. The pAO12A transformed bacteria were isolated, amplified and the plasmid DNA purified. Analysis of pAO12A DNA revealed the *A. ovis* DNA insert was 10 Kb and a restriction endonuclease map is shown in figure 1.

Isolated and biotin labeled pAO12A DNA hybridized to a minimum of 1 ng of the 10 Kb DNA, 10 ng of *A. ovis* genomic DNA and 100 ng of *A. marginale* genomic DNA on dot blots (Fig 2). The probe did not hybridize to 1 ug of goat leukocyte DNA (Fig 2). To determine whether multiple copies of cloned *A. ovis* DNA fragment were present in the *Anaplasma* genome, the labeled probe was hybridized to *A. ovis* and *A. marginale* genomic DNA restricted with SstI. The probe hybridized at different intensities to at least 9 bands in the *A. ovis* and to only 5 bands in the *A. marginale* DNA (Fig 3).

Characterization of Anaplasma organisms from goats in Kenya:

Anaplasma parasites in goats were characterized by location in erythrocytes, host specificity and reactivity with DNA probes. Intraerythrocytic *Anaplasma* inclusion bodies from 4 *Anaplasma* isolates from goats and 4 of *A. marginale* from cattle were classified into 3 intraerythrocytic locations (Table 1) and the mean for each location for isolates from each species compared. A significant difference ($p < .025$) was observed between the intraerythrocytic location of the *Anaplasma* organisms from goats and *A. marginale* from cattle (Table 1).

DISCUSSION

I have developed and evaluated a DNA probe for use in detecting *A. ovis* in goats. The probe, a 10 Kb insert of *A. ovis* genomic DNA in pBR322 (pAO12A) was selected because of a strong signal obtained during colony hybridization using biotin labeled *A. ovis* genomic DNA. The strong hybridization signal suggested that multiple copies of the cloned fragment existed in the genomic DNA. Southern blotting analysis of *A. ovis* genomic DNA cut with the SstI which does not restrict the cloned pAO12A DNA, revealed at least 9 bands when probed with pAO12A DNA. Also, the probe reacted with 5 bands on the *A. marginale* genomic DNA. The cloned *A. ovis* DNA probe labeled with biotin hybridized to approximately 1 ng of the 10 Kb DNA insert, 10 ng of *A. ovis* genomic DNA and 100 ng of *A. marginale* genomic DNA on dot blots.

The *Anaplasma* organisms infecting goats in Kenya were identified as *A. ovis* based on the location of the inclusion bodies in infected erythrocytes, host specificity and DNA hybridization reactions. The intraerythrocytic location of inclusion bodies of 4 isolates of *A. ovis* from Kenya was significantly different ($p < 0.025$) from those of *A. marginale*. Similar differences have been reported previously (3,4,5).

In conclusion, the *Anaplasma* infecting goats in Kenya was identified as *A. ovis* by location of inclusion bodies in infected erythrocytes, host specificity to cloned *A. ovis* and *A. marginale* DNA probes. The DNA probe detected *A. ovis* parasitemias below levels detectable on blood smears and the prevalence of *A. ovis* in Kenya was observed to be high. The DNA probe provides a diagnostic procedure to evaluate the economic constraints caused by *A. ovis* infections in goats and sheep in countries where the organism occurs.

Table 1: Intraerythrocytic location of *Anaplasma* organisms isolated from goats and *A. marginale* isolates from cattle.

Source of Anaplasma	Number of isolates	Location of organisms (mean %)		
		Marginal	Submarginal	Central
Goats in Kenya	4	73+/-3[a]	21+/-2[a]	7+/-1[a]
A. marginale from cattle	4	83+/-5	14+/-3	3+/-2

a = significantly different ($p<0.025$) from *A. marginale*.

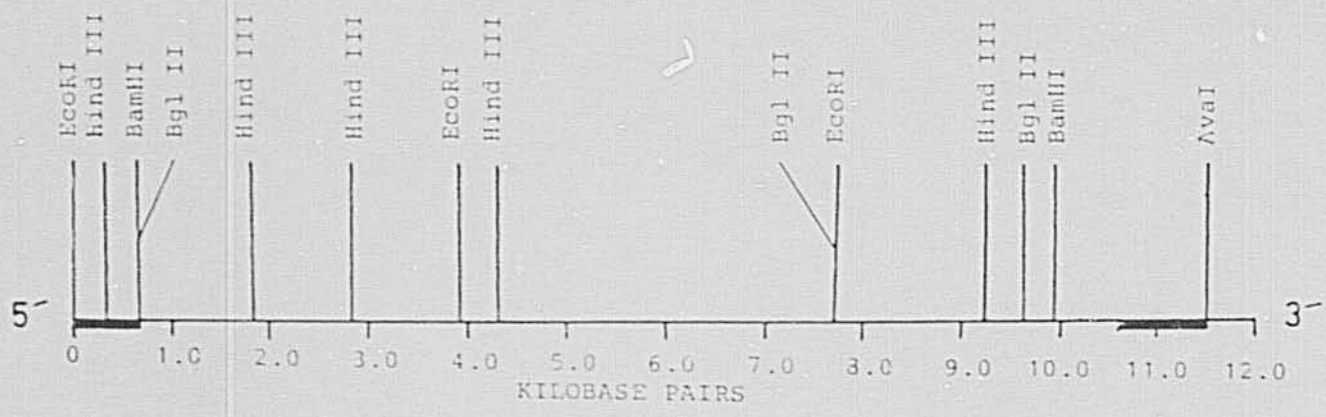

Figure 1: Endonuclease Restriction Enzyme Map of pAO12A

Restriction endonuclease map of the 10kb cloned A. ovis DNA inserted at the BamHI site of pBR322. The pBR322 EcoRI site is 5' and pBR322 AvaI site is 3' to the BamHI cloning site. Distances are in kilobase pairs.

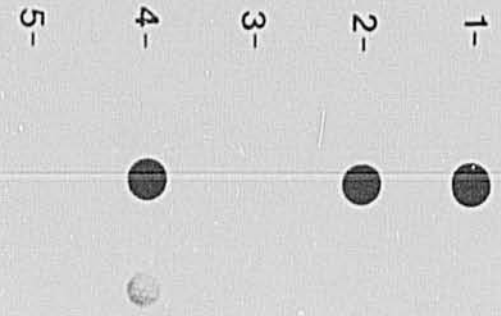

Figure 2; Detection of Anaplasma genomic DNA with biotin labelled pA012A DNA probe. DNA concentrations were 100 ng, 10 ng, 1 ng, 100 pg, 10 pg, and 1 pg. Row 1, A. ovis DNA (Idaho), row 2, A. ovis DNA (Kenya), row 3, A. marginale (Kenya), row 4, A. ovis 10 kb DNA insert, row 5, 1 ug of goat leukocyte DNA on each spot.

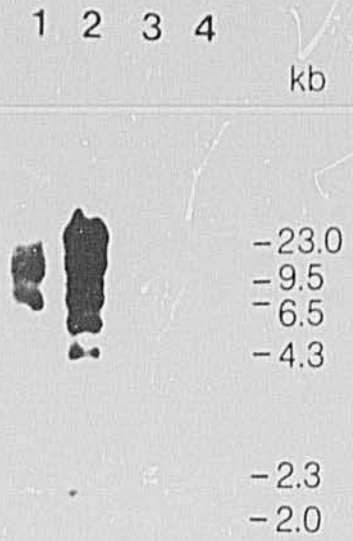

Figure 3: Southern blotting of Anaplasma genomic DNA with cloned A. ovis DNA. Lane 1 and 2, SstI restricted A. marginale and A. ovis DNA, lane 3, SstI restricted goat leukocyte DNA, lane 4, Hind III restricted lambda standards.

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PRIMARY PRODUCTION

AND

UTILIZATION

INTERACTION OF DUAL-PURPOSE GOATS WITH SUBSISTENCE CROPS AND WEEDS

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The Small Ruminant Collaborative Research Support Program (SR-CRSP) has been conducting farming systems research directed toward introducing dual-purpose goats to enhance household nutrition and cash income in western Kenya.

This paper presents results on how sweet potato (*Ipomea batatus*), a dual-purpose crop; maize stover (*Zea mays*), a crop residue; and couch grass (*Digitaria scalarum*), a weed, are used to enhance goat production for both milk and meat, on small-scale farms in western Kenya. Leaves and vines of sweet potato (SPV) are used for creep feeding and as a proteinaceous supplement for lactating does. SPV qualified in these roles because of its digestibility of 68% and its crude protein content of 20%, and because it ranked number one in palatability among six proteinaceous fodders.

Maize stover, a crop residue of the staple crop in western Kenya, is available in quantities of one or more tons per farm annually. Results are presented to demonstrate how its intake and use can be enhanced through treatment with molasses and common table salt, and by feeding it in combination with proteinaceous forages.

Couch grass, which is a notorious weed, is used as a livestock feed. It ranked first in palatability among common grass forages of western Kenya. Due to its palatability and high nutritive value, it is recommended for feeding goats and other livestock, after it is weeded from food crops.

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INTRODUCTION

The objective of the Small Ruminant Collaborative Research Support Program (SR-CRSP) in Kenya is to develop and evaluate dual-purpose goat (DPG) production systems in small scale farms in Western Kenya. Research on the DPG, which follows the farming systems research (FSR) is focused, on increasing production of food protein through milk and meat, and cash generation through sales of goats and their products.

In the first phase of FRS constraints were identified. Of the constraints identified, land size was found to be the most limiting(Sands et al 1983; Mukhebi et al 1986).Consequently land reserved for pastures over the years have been taken for growing food crops due to population pressure. Therefore, for success of any livestock in these small farms, their nutritional needs must rely heavily on dual-purpose crops, crop residues, weeds and multi-purpose legume trees. As a result DPG nutritional studies in western Kenya are based on these feedstuffs.

MATERIALS AND METHODS

Sweet potato leaves and vines (SPV) *Ipomea batatus*

Kids born within the same weak were randomly allocated into two treatments. In Treatment 1 kids had full access to the milk of their dams, while in Treatment 2 they had full access only in the first two weeks. From the third week access was gradually reduced, reaching zero by the end of the fourth week. In other words at the age of four weeks they were weaned. They were weaned to fresh sweet potato vines, which was initially introduced to them *ad lib* from the age of two weeks. All the kids were weighed weekly and those on SPV their intakes were measured daily and from the dams milk measurements were also taken daily.

Maize stover (*Zea mays*, Hybrid 612)

Six castrates were used in a 6 x 6 latin square design to study the effect of maize stover on goat performance. The treatments included feeding of stover alone, stover plus sprinkled salt, stover plus molasses, stover plus sweet potato vines, stover plus *Tylossema spp* and stover plus *Sesbania sesban*. The adaptation and the experimental period for feeding were ten days for each. In all the treatments the stover from Hybrid 612 was chopped into lengths of approximately two inches. Fresh stover plus the supplements were offered twice daily at 8 am and 4 p.m. Stover was offered in excess of intake by 20%.

Couch grass (*Digitaria scalarum*)

Six crossbred pregnant does, with an average liveweight of 36 kg were used. Six grass species were offered in a cafeteria style for five adaptation, and five experimental days. The grass species were in the same vegetative stage and only the aerial parts were offered. There were two feeding sessions per day lasting an hour each at 9:00 to 10.00 am and 4:00 to 5:00 p.m. In the cafeteria each species was presented randomly in two hanged bundles of one kg each. After each feeding session the orts were weighed and then discarded. Preference was determined by the level of intake. Chemical analysis included dry matter, crude protein and *in vitro* digestibility.

RESULTS AND DISCUSSIONS

There was no difference in growth performance between the kids that were weaned on SPV and those with total access to their dams' milk as shown in Table 1. A major and significant difference between the treatments was in milk offtake for human use. From the does whose kids were weaned to SPV, each doe was milked 87 kg in 120 days. So by utilization of the SPV, which farmers grow as a crop, the accrued side benefit was 87 kg of milk or in monetary terms Ksh. 522/= (1 US dollar = 16 Kshs.).Furthermore, early weaning has the added advantage of enhancing rumen development (Semenye et al 1986).SPV is an ideal milk substitute because nearly all the farmers in western Kenya grow sweet potatoes and because of its chemical composition. Sweet potatoes are grown in small plots with estimated size range of 16 to over 100 sq. metres. From the smaller plots sufficient SPV can be harvested to meet the requirements of a kid, of 30 g. DM/kg body weight/day. The chemical composition of milk and SPV are comparable in that, the moisture content and digestibility of milk are 85 and 86%, while for SPV are 80 and 72% respectively.

The chemical composition of the maize stover treatments are presented in Table 2. Maize stover which was the basal diet of the six treatments had the highest and the lowest dry matter content and nutritive values respectively.

Dry matter intake of chopped maize stover is shown in Table 3. Treatments of maize stover with SPV, *Sesbania sesban, Tylossema spp.* and salt did not enhance intake beyond maize stover alone treatment. It is likely these protein rich forages were not offered in sufficient amounts to enhance rumen utilization of the maize stover. The supplements of *Sesbania sesban, Tylossema spp.* and SPV comprised 9, 9 and 5% of the basal diet dry matter respectively. These levels were taken because they were equivalent to one kg of as-fed; and is the level of supplementation of many farmers. The maize stover plus molasses treatment had the lowest intake. The effect of molasses here that comprised 4 % of the basal diet dry matter was negative. Negative impact of molasses was probably due to proliferation in the rumen of the fast-growing sugar digesting micro-organisms. This implies that the supply of nitrogen to goats feeding low quality roughages such as maize stover is more beneficial than energy supply (molasses for

instance). A combination of energy and nitrogen supplement to a crop residue basal diet has been reported as more effective than any of the components singly (Nuwanyakpa and Butterworth 1987). The performance of the goats in liveweight changes is shown in Figure 1. The differences in liveweight changes depicted in the figure, should serve only as an indicator of the trend because, the differences are not statistically significant at $P < 0.05$. It follows, therefore, that maize stover as a sole ration without any treatment is sufficient for maintenance requirements for goats averaging 37 kg. Nonetheless daily treatment of maize stover with common salt should be discouraged because of its failure to maintain body weights. This is a common practice with some of the farmers. However, farmers do treat only occasionally and not routinely as in the experiment.

For all the treatments intake as a percentage of the body weight ranged from 3.7 to 4.3%. This figure might not be achieved for on-farm situations because goats usually don't have access to feed stuffs for 24 hours. Consequently,goats on-farm might not be able to maintain their body conditions and hence, body weights on maize stover alone.

In a palatability study in which six graminoid species were ranked, couch grass (Digitaria scalarum) ranked first. The results of the rankings are presented in Table 4. For couch grass having ranked first is a blessing in disguise because it is reputed as the most troublesome of all East African weeds (Ivens 1967). As couch grass has high palatability and nutritive value, it is an ideal candidate for feeding livestock after it has been weeded. Soil attached to the root system should be shaken off and then the aerial parts taken for livestock feeding.

Table 1: Performance of kids and milk offtake

Age-days	0	30	60	90	120	Milk offtake
Total Suckle kg	2.9	2.9	4.6	5.6	7.3	NIL
Weaned on SPV kg	2.4	6.3	6.6	8.4	7.9	87

Table 2: Chemical composition (%) of feed components

Feed	Dry matter	Crude protein	Dry matter digestibility
Maize stover	89	4	36
Tylossema spp	43	14	64
Sesbania sesban	43	26	68
SPV	25	20	68

Table 3: Dry matter intake of chopped maize stover (kg)

Treatment	Stover alone	Stover + Salt	Stover + molasses	Stover + SPV	Stover + Tylossema	Stover + Sesbania
n	54	54	54	54	54	54
Minimum	0.83	0.25	0.45	0.95	0.45	0.63
Maximum	2.14	2.11	1.91	2.66	2.14	2.70
Mean	1.55 a)	1.49 ab)	1.37 b)	1.60 a)	1.48 ab)	1.60 a)

ab) Means followed by different letters in the same row differ significantly ($P \leq 0.05$)

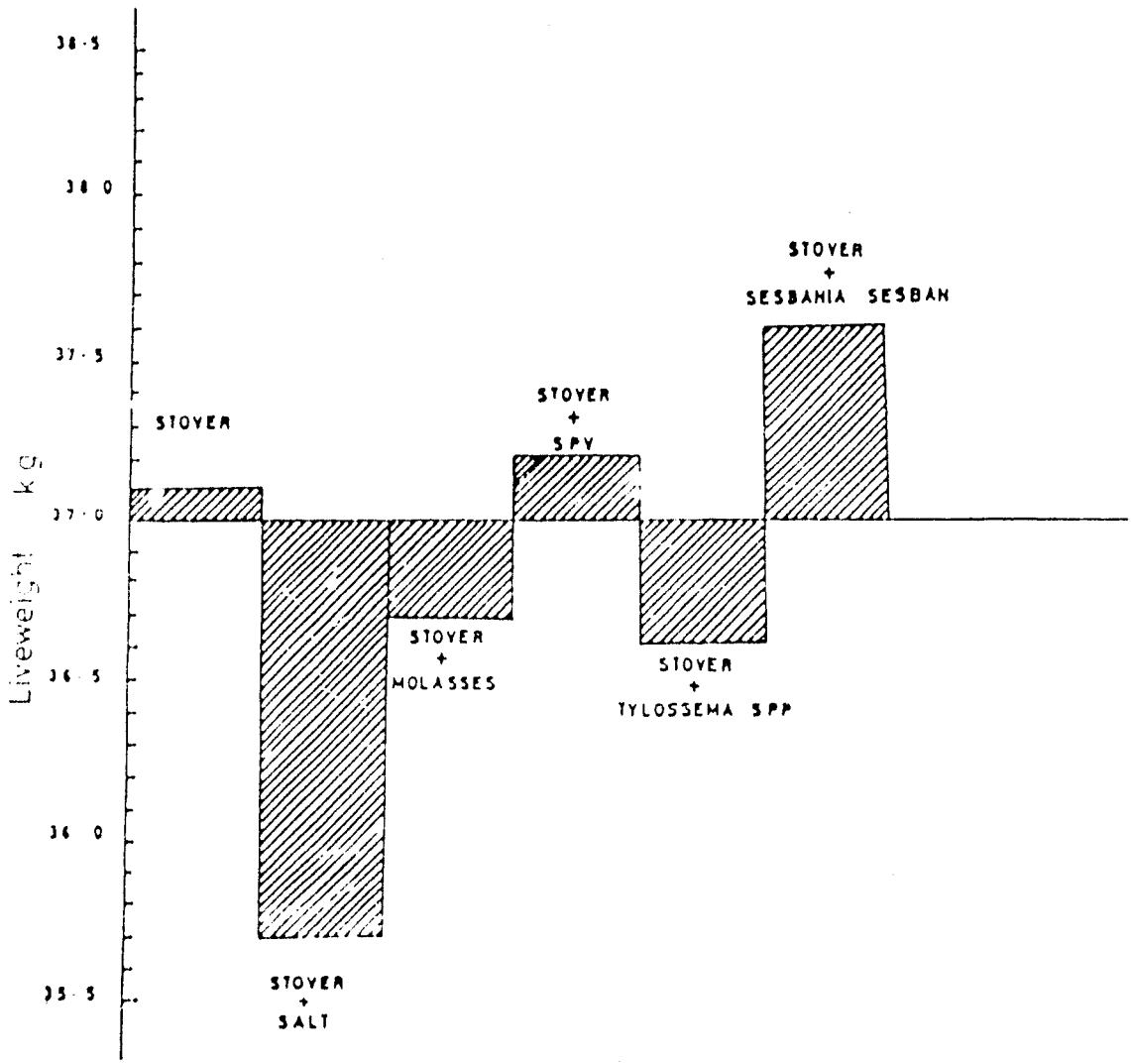
Table 4: Preference ranking of grass species

Species	Rank	Intake g.	CP%	DMD
Cough grass	1	1223 a)	17	65
Napier (13)	2	1080 a)	9	63
Giant panicum	3	890 b)	9	54
Brachiaria spp	4	741 b)	11	51
Rhodes grass	5	703 b)	8	50
Bana grass	6	672 b)	13	57

ab) Means not having the same superscript in common differ at $P \leq 0.05$

DMD = in vitro dry matter digestibility

Figure 1 Mean Liveweight trend by treatment



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SESBANIA GERMPLASM COLLECTION IN TANZANIA AND PARTS OF WESTERN KENYA

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ABSTRACT

The recognised potential of *Sesbania* for Agricultural and medicinal purposes has currently generated alot of interest in the species. Of particular interest to animal scientists are its potentials both as a protein supplement for livestock and for integration into smallholder Agricultural Systems in developing countries.

To increase the range of genetic diversity available for both conservation and effective utilisation of the species requires a deliberate effort to explore and collect the available germplasms. This paper reports part of such a collection undertaken in Tanzania between 24th July and August, 1987, and on a separate mission, in parts of Western Kenya.

A total of 96 accessions comprising 14 species were collected in Tanzania during the period reported. Of these, 38.54% were *S. sesban var. nubica.*, and 34.36% were *S. macrantha.* From Western Kenya in part of Siaya, Kisumu and Kakamega districts, a total of 33 accessions of three species were collected, of which 84.85% were *S. sesban* var. *nubica.*

Most of the accessions from Tanzania were collected at an altitudinal range of 1001 to 1500 m. above sea level (a.s.l), which is also the altitudinal range within the area covered in Western Kenya. This indicates a good potential for introducing the accessions from Tanzania into Western Kenya and vise versa.

S. sesban var. *nubica* in most cases had pods containing seeds with high levels of pest damage. *S. macrantha* on the other hand had relatively less pest damage. This species had very long pods which in some cases measured upto 38 cm long.

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INTRODUCTION

The genus Sesbania belongs to the family leguminosea, and, subfamily papilionoideae. It consists of about 50 species of fast - growing trees, perennial shrubs and herbaceous annuals which grow all the year round in the tropics and subtropics, and summer annuals in temperate zones (Evans, D.O. 1986). Of the 50 species 33 are found in Africa, a diversity unknown elsewhere (Gillet, 1963), 10 in Australia (Burbidge, 1965), and seven in Hawaii (Char, Unpublished). Out of the 33 species found in Africa, 20 occur in Eastern Africa, out of which Tanzania is the major centre of distribution and diversity with 15 species, followed by Kenya with 11, Ethiopia with 10 Ganda with seven and Somalia with five.

The species are divided into at least four subgenera and of these only two *Sesbania* and *Agati* contain species of potential agricultural value. Most of the species belong to the subgenus *Sesbania* and they are distributed worldwide and some of them have been extensively used both as green manures in other countries. The subgenus *Agati*, which is mainly found in Asia, contains the tree species *S. grandiflora* and *S. formosa*. In countries such as Indonesia, *S. grandiflora* is grown for fodder, pulpwood, and improvement of soil fertility.

According to Dale. O.E. and P.P Rotar (1987) the majority of Sesbania species are annuals and the known perennials include *S. grandiflora*, *S. formosa*, *S. sesban* and the seven Hawaiian species. The potential of Sesbanias as a fodder crop lies in their exceptionally vigorous association with nitrogen fixing Rhizobium bacteria, characterised by rapid development of large numerous clusters of root and even stem nodules as in *S. rostrata*, which results in high crude protein in the forage. This coupled with their ability to tolerate a wide range of soils which would otherwise be unutilised to most other legumes, Sesbanias can be sources of nitrogen fixation and biomass production on diverse lands.

A number of Agricultural and medicinal uses of the species have been reported from a number of countries. These include uses such as fuelwood and shade tree in coffee plantations. In Indonesia and Australia, some species such as *S. grandiflora* are being tried in the pulpwood industries (Hu Ta-wei, 1986). In the arid and semi-arid regions of India where approximately seven million hectares of otherwise cultivable land is affected by salinity and alkalinity, the use of tree type sesbania species such as *S. sesban* and *S. glabra* are being emphasised. These can tolerate salinity and alkalinity stresses respectively (Ghai PE *et al* 1985). *S. bispinosa* is also being used in India as a green manure to reclaim land affected by high salinity and alkalinity. A number of medicinal uses have also been reported. In western Kenya for instance, *S. sesban* var. *nubica* is being used by some communities in the treatment of Kwashiokor in children.

Of particular interest to animal scientists is the potential of the species as a protein supplement for livestock and the fact that it can be integrated into the smallholder Agricultural systems in Africa.

The considerable degree of genetic diversity among and within species of the genus as well as the known utility of some species indicate a favourable potential for Agricultural purposes and thus the need to further develop it. It is in this light that a decision was made to assemble the available genetic variability both for intensive evaluation for forage production, fuelwood, improvement of soil fertility and for conservation. The decision to collect the Sesbania germplasm in Tanzania was therefore part of an overall plan to collect in the sub-saharan Africa and particularly in the Pasture Network for Eastern and Southern Africa (PANESA) region (Onim, *et al.*, 1987).

This paper reports only the results of part of the collection mission in Tanzania (24th July - 24th August, 1987) in which the Small Ruminant Collaborative Research Support Programme (SR-CRSP), Kenya, participated. Included in the report are also the results of a brief collection (15th -16th Sept. 1987) undertaken by the Feed Resources (FR) project of SR-CRSP in parts of Western Kenya.

MATERIALS AND METHODS

The collection team in Tanzania consisted of participants from Ethiopia - International Livestock Centre for Africa (ILCA), Tanzania (Tanzania Livestock Research Organisation (TALIRO), Forest Department, Uganda and Kenya-SR-CRSP in the Ministry of Livestock Development. The mission which was led by ILCA and hosted within TALIRO was funded by the International Development Research Centre (IDRC) with support from the International Board of Plant Genetic Resources (IBPGR).

The collection started on 6th July 1987 in Dar es salaam, moving along the coast southward through Utete/Kilwa Masoko, Liwali, Tunduru, Songea, Njombe and back to Dar es salaam (Appendix 1). The second phase which is the subject of this report started in Dar es salaam on 28th July 1987 with a brief round trip within Kisarawe District, Coastal Region, upto Maneromago and back to Dar es salaam through Mlandizi. Another route was upto Bagamoyo, and then joining the main Dar es salaam Morogoro road at Mlandizi. The subsequent route went upto Iringa, Mbeya, Laela-Lake Rukwa, Simbawanga-Lake Rukwa, Mpanda, Kigoma, Kasulu, Kibondo, Biharamulo, Buloba, Karagwe, Biharamulo, Geita, Busisi, Mwanza - Saa nane Island in L. Victoria, Shinyanga, Singida, Arusha, Ngorongoro Crater, Waso, Loliando, Lake Natron and ending in Arusha on 24th. August, 1987 (Appendix 1). The collection that was undertaken in Western Kenya was brief and covered mainly parts of three districts of Siaya, Kisumu and Kakamega (Appendix II).

The methodology used in both missions was broadly based on the principles described by Lazier (1984). However, since *Sesbania* species occur in specific habitats, it was not necessary to stop at regular intervals along the collection route. The stops depended entirely on the availability of the species and these could be sited clearly from the vehicle. Where the species occurred over a wide area along a route, the collection stops were more or less based on locations of interest or variation.

The details of an accession and its site of collection were recorded in the standard ILCA Accession/collection sheets (Lazier, 1984). Altitudes were read off an altimeter at every collection site. During the Tanzania collection, an accession for an individual species was made up of bulked seeds from individual plants of the same species at the site. A different species at the same site would then form a separate accession. For the Western Kenya collection, each accession for a given species was from a single tree. This latter method has an advantage of rapid genetic studies in the progenies during screening.

Identification of the different species was based on the key as provided in the Flora of Tropical East Africa (F.T.E.A). Visits were also made to the East African Herbarium, Nairobi, Kenya, the teaching Herbarium at the University of Nairobi at Chiromo Campus, and the University of Dar es salaam Herbarium. In cases where field identification was not satisfactory, herbarial specimens were taken for further authentification.

Where possible, brief informal discussions were held with the local farmers to elicit their views on the importance of the species to them.

RESULTS AND DISCUSSION

A total of 96 accessions of 14 species were collected in Tanzania as summarised in Table 1. Of these 38.54% were *S. sesban* var. *nubica* and 34.36% *S. macrantha*. The remaining 27.08% was shared between the other species with *S. quadratea* taking the largest share of 7.2%.

The results from Tanzania show that *S. sesban* var. *nubica* is well represented across a wide range of altitude both below and above 1000 m. Even along a route where a lot of *S. macrantha* occurred such as from sumbawanga to goma, those sites that were below 1000 m. above sea level such as the banks of River Malagarasi and the shores of Lake Tanganyika had only *S. sesban* var. *nubica*. This indicates a strong altitudinal influence on the distribution of the species. The majority of the accessions (52 out of 96) were collected at an altitudinal range between 1001 m. and 1500 m. a.s.l. Only *S. keniensis* occurred at altitudes above 2000 m. a.s.l. (Table 2).

In Western Kenya only 33 accessions of three species were collected and most of these (84.85%) were *S. sesban* var. *nubica* (Table 3).

The area covered in Western Kenya was at an altitude between 1140 m.a.s.l. at Usenge, Yimbo, and 1463 m. a.s.l. at Maseno, Equator point. It would be difficult here to make any conclusive generalization in terms of altitudinal distribution of the species since not all possible range of altitude was covered as in Tanzania. However, it should be noted that it is within the same range of altitude (Table 4) that most accessions were collected in Tanzania and this indicate a good potential for introducing the accessions from Tanzania into Western Kenya and vise versa.

The altitudinal distribution of species as reported here agree with that reported in the F.T.E.A. with the exception of *S. somalensis*. (Table 5)In the F.T.E.A. the species is reported to occur at altitudes between 300 m. and 1050 m. a.s.l. The species that was recorded as *S. somalensis* during the collection was at a site 1160 m. a.s.l. Again, there are no records in the F.T.E.A. of the species having been collected in Tanzania. Until further identification is done during the evaluation sage, it is very unlikely that this acession was *S. somalensis*.

Tables 6 and 7 summarise some of the local names and uses, respectively, of the accessions collected in Tanzania. Inspite of the excellent seeding capability of *S. sesban* var, *nubica* its pods and seeds showed a lot of pest damage. *S. macrantha*, on the other hand, had very clean and pest free pods and seeds. The pods were long and sometimes measuring upto 38 cm.

There was alot of variation occurring in the colour of the floral standard of *S. sesban* var *nubica*. Some accessions had mottled standards whereas some had uniformly yellow standards. This was true both in Tanzania and in Western Kenya. In the F.T.E.A., it is stated that the standard in the floral area for *S. sesban* is almost always streaked and spotted with violet, elsewhere sometimes uniformly yellow or suffused with purple (var. *bicolor*). It would have been useful to collect these variations as separate accessions in Tanzania since it is easier to isolate variations from single plant collections during screening than from bulked seeds.

Future Plans

It should be noted here that SR-CRSP has been continually involved with sesbania within its Feed Resources (FR) Research Project. However, much of the work has been on *S. sesban* var, *nibuca*. Our involvement with the germplasm collection in Tanzania is therefore a significant contribution to the FR Project sesbania work in that it has made available to us several germplasm that have hitherto not been considered in our research activities.

Broadly, FR Project of the SR-CRSP at Maseno in Western Kenya intends to carry out first a preliminary evaluation of the germplasms collected for their potential as sources of cut-and -carry forage for livestock in general and dual-purpose goats (DPGs) in particular. They would also be assessed in terms of their response to repeated cutting fuelwood and soil fertility improvement potentials.

Lastly, but not least, we hope that with the experience gained in Tanzania, IDRC will extend their generosity to us more to enable us to participate in future sesbania germplasm collections and provide funds for effective evaluation of germplasms at several locations in Africa.

Table 1: Sesbania species collected in Tanzania and the approximate number of accessions per species

Species	Number of accessions	% of total
S. sesban var. *nubica.*	37	38.54
S. macrantha	33	34.36
S. hirtistyla var. *hirtistyla*	1	1.04
S. greenwayi	1	1.04
S. quadrate	7	7.29
S. sericea	4	7.29
S. bispinosa	1	4.17
S. speciosa	1	1.04
S. rostrata	3	3.13
S. microphylla	3	3.13
S. hirtisyla var. *muricata*	1	1.04
S. somalensis	1	1.04
S. keniensis	2	2.08
S. goetzei	1	1.04
TOTAL	96	99.98

Table 2: Approximate altitudinal distribution of the sesbania accessions collected in Tanzania

Species	Number of accessions per altitudinal range (m) a.s.l.					
	0-200	201-500	501-1000	1001-1500	1501-2000	>2001
S. sesban var. *nubica*	-	-	13	17	7	-
S. macrantha	-	-	-	25	7	-
S. hirtistyla var. *hirt.*	-	-	1	-	-	-
S. greenwayi	-	-	1	-	-	-
S. quadrata	-	-	4	3	-	-
S.sericea	1	-	3	-	-	-
S. bispinosa	1	-	-	-	-	-
S. speciosa	1	-	-	-	-	-
S. rostrata	-	-	2	1	-	-
S. microphylla	-	-	-	3	-	-
S. hirtistyla var. *mur.*	-	-	-	1	-	-
S. somalensis	-	-	-	1	-	-
S. keniensis	-	-	-	1	-	1
S. goerzei	-	-	1	-	-	-
TOTAL	3	0	25	52	14	1

Table 3: Sesbania Species collected in Siaya and parts of Kisumu and Kakamega Districts and the number of accessions per species

Species	Number of accessions	% of Total
S. sesban var. *nubica*	28	84.85
S. macrantha	2	6.06
S. quadrata	3	9.09
TOTAL	33	100

Table 4: Altitudinal distribution of the Sesbania accessions collected in Siaya and parts of Kisumu and Kakamega Districts

Species	Number of accessions per altitudinal range (metres above sea level)					
	0-200	201-500	501-1000	1001-1500	1501-2000	>2001
S. sesban var. *nubica*	-	-	-	28	-	-
S. macrantha	-	-	-	2	-	-
S. quadrata	-	-	-	3	-	-
TOTAL	0	0	0	33	0	0

Table 5: The altitudinal distribution of Sesbania species as reported in the Flora of Tropical East Africa (F.T.E.A.)

Species	Altitudinal range (m) a.s.l.
S. sesban var. *nubica.*	100-2200 (but not common below 1000m)
S. macrantha	1100-2000
S. hirtistyla var. *hirtistyla*	200-600
S. greenwayi	0-600
S. quadrate	200-1600
S. sericea	0-850
S. bispinosa	0-300
S. speciosa	Normally below 100
S. rostrata	500-1600
S. microphylla	1000-1200
S. hirtisyla var. *muricata*	200-600
S. somalensis	300-1050
S. keniensis	1200-2400
S. goetzei	900-1900

Table 6: Some local names of sesbania accessions collected in Tanzania

Acc. No.	Species	Local Name	Language
	S. quadrata	Maseselesanga	Gogo
T 042	*S. speciosa*	Mipombo?/Mkengepoli	Kizarawe
T 057	*S. sesban* var. *nubica*	Ameseke su	Kiwanda
T 063	*S. macrantha*	Namsinkwa	Kifipa
T 067	*S. macrantha*	Mbalazi	Pimbwi
T 083	*S. macrantha*	Kasiha	Kisugi
T 119	*S. quadrata*	Kiruwi	Msandawi
T 120	*S. kenyensis*	Oloiyangalani	Masai
	S. sesban var. *nubica*	Minyegenyege	Kiha

Table 7: Some local uses of Sesbania accessions collected in Tanzania

Acc. No.	Species	Where collected	Local uses
T 045	*S. sesban* var. *nubica*	Igando area, District	: Leaves pounded together with other herbs for the treatment of syphilis.
T 053	*S. macrantha*	Ukwili, Mbozi District	: Leaves can be used for washing clothes as soap.
T 063	*S. macrantha*	Ntendo area, 8km from Sumbawanga	: Leaves concocted for the treatment of stomach ache and malnourished kids.
T 067	*S. macrantha*	Near Mpanda	: Seeds roasted to remove outer covering then cooked and eaten like beans.
T 083	*S. macrantha*	Kisabya area 6km from Biharamulo	: Roots boiled for treating malnourished kids.

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PRODUCTIVITY OF GRASS-SESBANIA INTERCROP AS COMPARED TO GRASS-NITROGEN INTERACTION

M. Mathuva[2], J.F.M. Onim[1], K. Otieno[2] and H.A. Fitzhugh[1]

INTRODUCTION:

Small scale farming in the humid tropics will benefit from maximising energy production from biomass (Preston and Leng, 1985). This can be done by growing plants which will utilize solar radiation efficiently to yield large amounts of biomass that can be partitioned into feed and fuel. Bana grass (*Pennisetum purpureum*) and Sudan grass(*Sorghum sudanense*) are high yielding when moisture, nitrogen and other minerals are not limited (Mathuva, *et al.*, 1985). Nitrogen is the most limiting nutrient in feed production. Nitrogen fertilizers are expensive and attempts have been made to intercrop grasses with legumes to substitute nitrogen fertilizer. However, trailing legumes rarely provide sufficient nitrogen for optimum grass growth (Date, 1973). This is mainly due to the decline of the legume component in the sward. Tree legumes could be an alternative. These could provide feed, fuel and nitrogen fixation into the soil. In addition, tree legumes are easier to manage. Sesbania(*Sesbania sesban*) is a tree legume of high potential in feed productivity, quality and nitrogen fixation (Onim, *et al.*, 1984). Supplementing straw based diets with sesbania hay was found to improve live weight gains in sheep (ILCA, 1985/86).

MATERIALS AND METHODS:

Bana grass, Sudan grass and sesbania were used. Three treatments were adopted. These were, pure grass, grass intercropped with Sesbania and grass fertilized with 250 kg ha^{-1} of nitrogen, and 250 kg ha^{-1} of P_2O_5 from compound fertilizer. NPK = 20:20:0. The trial was planted in a complete randomized block design replicated four times. Planting was done at the onset of the rains. Stakes of bana with three nodes were planted at a spacing of 1 x 0.5m. Sudan grass seeds were drilled in rows 1 m apart. Seedlings of sesbania were established one month before grasses were planted. The planting was such that two rows of sesbania each 30cm from grass row and 40cm apart ran along two grass rows. Sesbania seedlings were spaced 50cm within the row. Fertilizer was applied in two equal splits in the long and short rains. Plots were kept free of weeds. At a height of 1m bana was cut 5cm from the ground while sesbania was cut after attaining the height of 1.5m at 60cm from the ground. Sudan grass was cut at flowering stage. Dry matter(DM) yield, crude protein (CP%) and sesbania mortality rate were determined. Comparison of means was based on Duncan's multiple range test.

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RESULTS AND DISCUSSION:

Figure 1 indicates individual plant DM yield. Bana grass in fertilized treatment gave significantly higher DM yield than in other treatments ($P<0.05$). DM yield of bana in bana-sesbania intercrop was slightly higher than that of pure unfertilized one. However, this was not significant at $P<0.05$. Nitrogen application to Sudan grass was superior to the sesbania intercrop. There was a significant ($P<0.05$) suppression of sesbania by bana as compared to pure sesbania and sudan-sesbania intercrop. Total DM yield (Figure 2), shows the effect of intercropping on production per hectare. Fertilized bana yielded significantly higher DM than any other treatment($P<0.05$). Total DM production from bana-sesbania intercrop was higher than that from pure unfertilized bana. This difference was not significant at $P<0.05$. There were no significant differences in yields between fertilized and intercropped Sudan grass. This was mainly due to the high DM yields of sesbania component in the sward.

From the management adopted in this trial, it is clear that tree legume intercrop is not a substitute of nitrogen-phosphate fertilization of high potential fodder grasses. In lower potential grasses introduction of tree legumes could replace nitrogen-phosphate fertilization all together; something which trailing legumes have been unable to do. Intercropping bana with sesbania showed a tendency to improve total DM yield above that of pure unfertilized bana. This opportunity could be explored further by changing planting and management methods i.e. one row of sesbania could be planted exactly between two rows of bana to reduce competition. Legume trees could be allowed to grow taller then pruned systematically or cut at higher levels. Recent work has proved that phosphate is lacking in soils planted and mulched with tree legume foliage (Onim, *et al.*, 1987). Thus application of phosphate fertilizers could enhance DM production from grass-tree legume intercrop.

Figure 3 demonstrates pattern of DM production from bana cropping. It is clear that there was efficient utilization of fertilizer giving high yields in the second sampling, followed by a declining production trend. This proves the importance of fertilizers in DM production. Unfertilized bana and bana-sesbania intercrop showed similar and steadily rising DM yield probably due to the utilization of existing soil nutrients - after which pure bana declined as a result of exhausting soil nutrients. Bana-sesbania intercrop continued to yield persistently higher total DM than pure and unfertilized bana due to similar performance of both sward components (Figure 4). Rising DM yield in the fifth sampling was mainly due to the onset of the short rains during which regrowth of fertilized bana was poor probably as a result of tiller suppression by initial high DM yields in the long rains.

Figure 5 shows the performance of Sudan grass cropping. Fertilizer application resulted in initial high DM yield followed by a decline. Sudan grass was harvested at flowering stage when high sward density had been achieved. This has the effect of reducing tiller regrowth (Jewiss, 1972). Sudan grass in sesbania showed a similar

trend but the sesbania component gave progressively higher DM yields than Sudan grass (Figure 6).

Figure 7 indicates sesbania mortality rate. At the end of the experiment several sesbania plants had dried up. Sesbania intercropped with bana showed the highest mortality rate. Field observations indicate that sesbania death occurred gradually after cutting due to attack by adults and nymphs of the black beetle. Weaker plants in bana showed little tolerance. There was also attack by moles which tended to prefer bana-sesbania plots. However, sesbania mortality rate between treatments was not significantly different.

In the third sampling, forages were analyzed for CP% (Table 1). It was found that cropping had no significant effect on CP% content of bana, Sudan and sesbania.

CONCLUSION:

Unlike tropical trailing legumes which show a progressive decline of their proportion in sward, sesbania showed a curve of persistent DM production. This was mainly due to the growth pattern which allows sesbania to be harvested separately. Unlike Sudan grass, bana was more persistent in production. Fertilizer application gave the highest DM yield in bana. Intercropping with sesbania tended to increase total DM yield above that of pure unfertilized grass. There is need to try and apply phosphate fertilizer to sesbania-grass intercrop. Also, sesbania crops should be planted in such a way as to reduce competition with associated grass. This will result in healthier plants that will resist pest attacks.

Table 1 % C.P. - 3rd Sampling

Sesbania + Bana	25.5
Sesbania	23.1
Sesbania + Sudan	19.9
Bana + Sesbania	11.3
Bana	10.7
Bana + N	10.7
Sudan + N	9.6
Sudan	8.1
Sudan + Sesbania	6.3

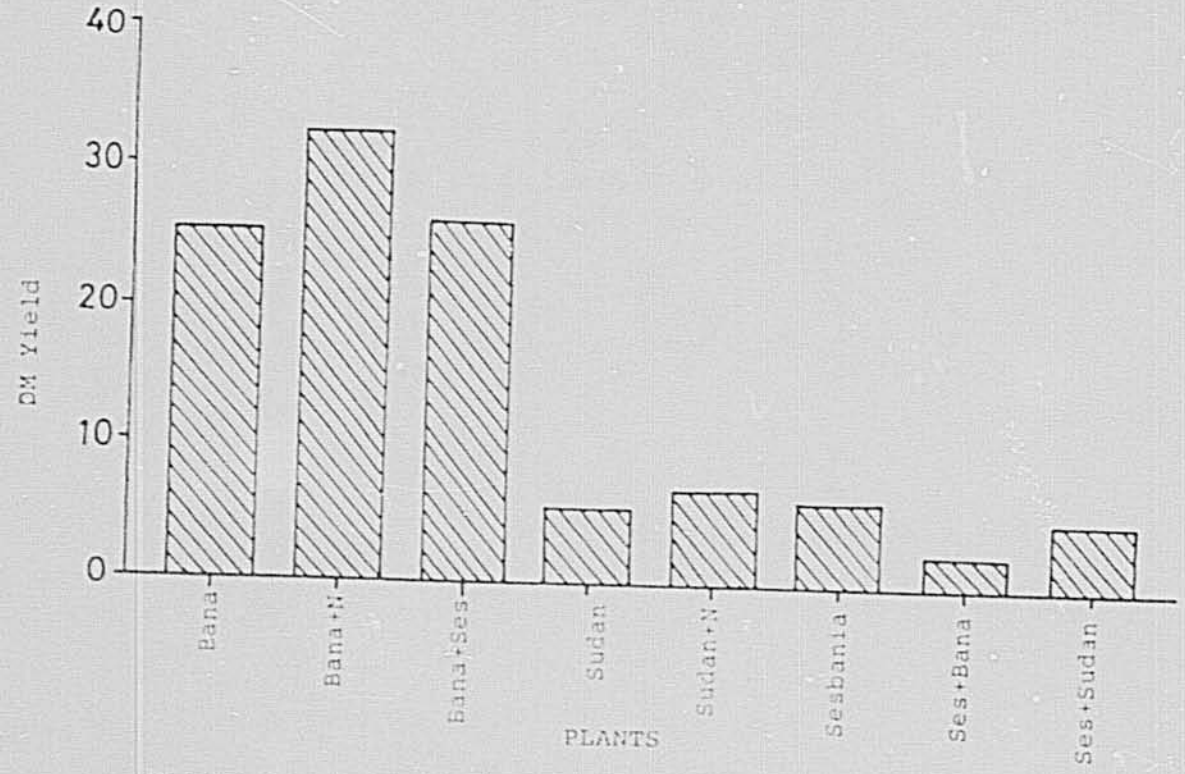


Figure 1: Individual Crops and Crop Production

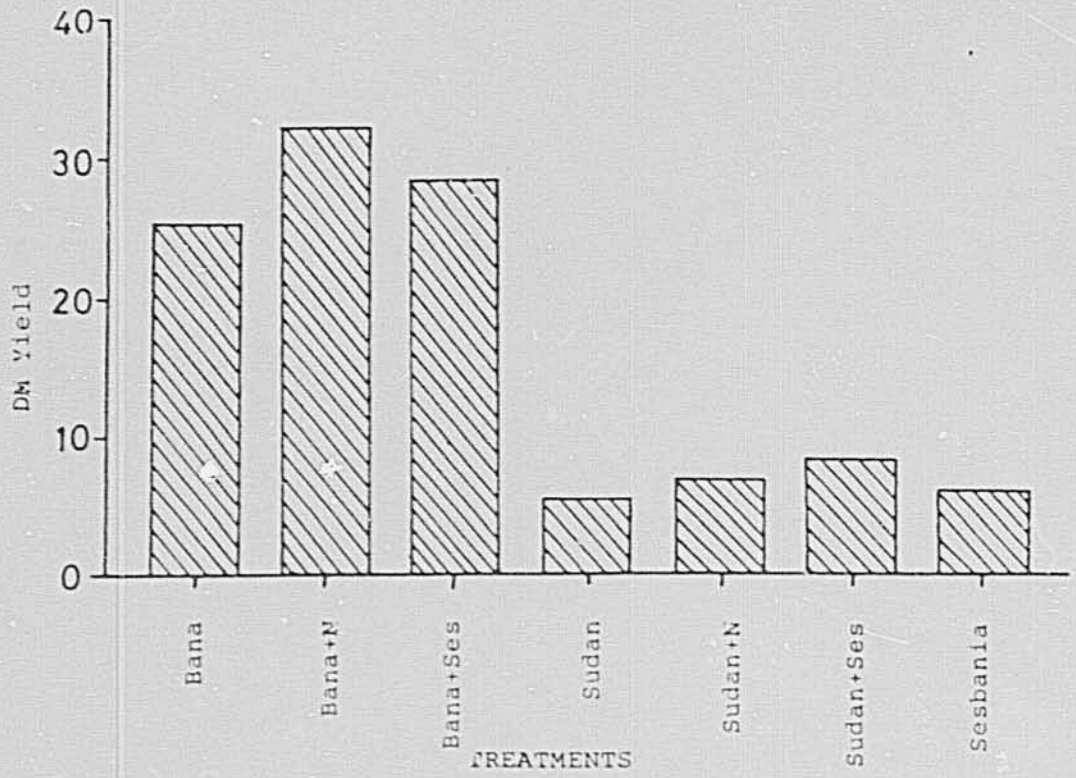


Figure 2: Total DM Yield (Ton/Hay)

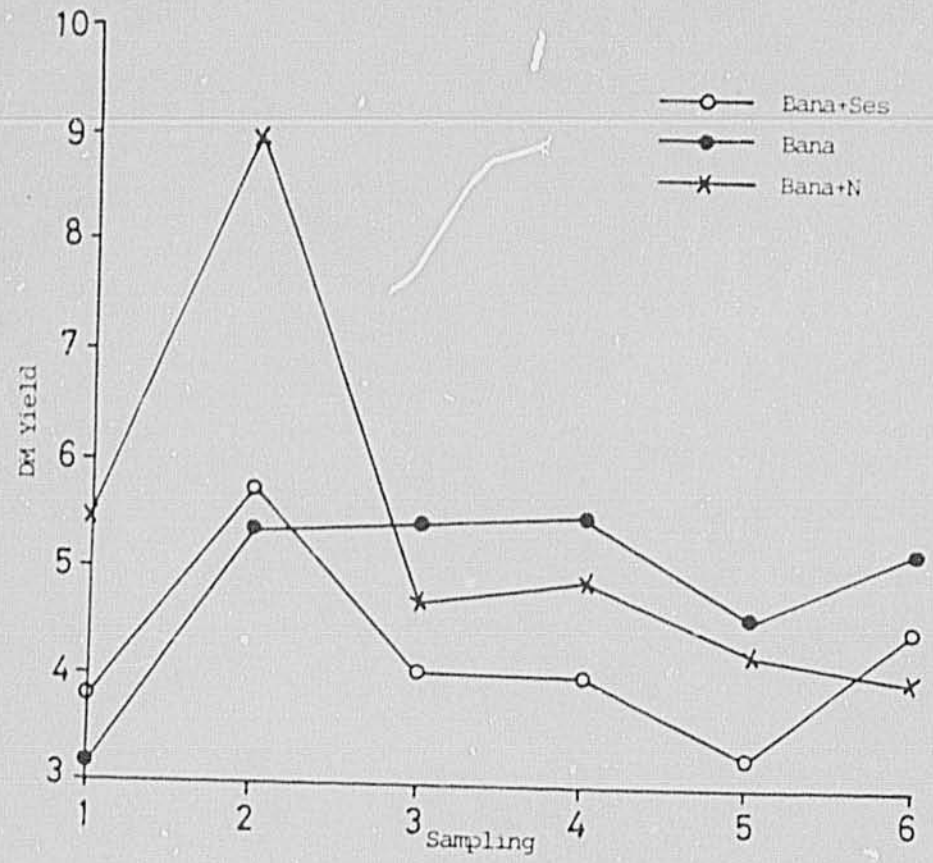


Figure 3: Bana Cropping DM Yield (Ton/Ha)

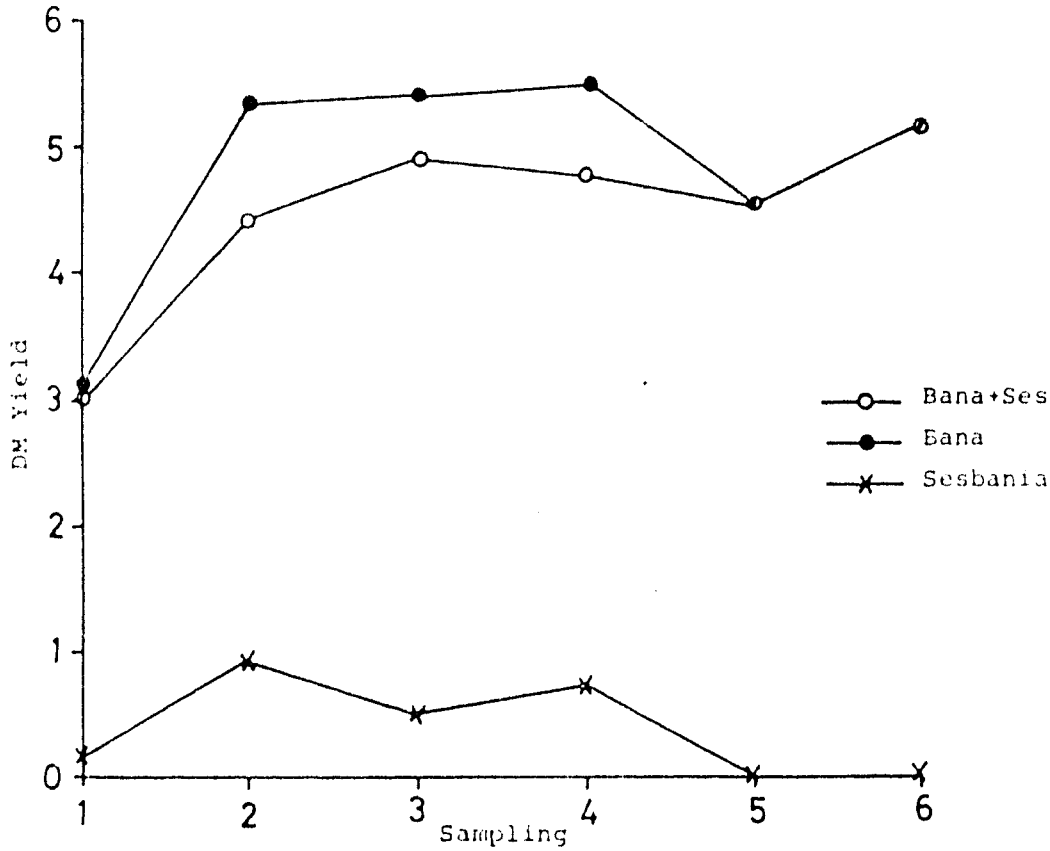
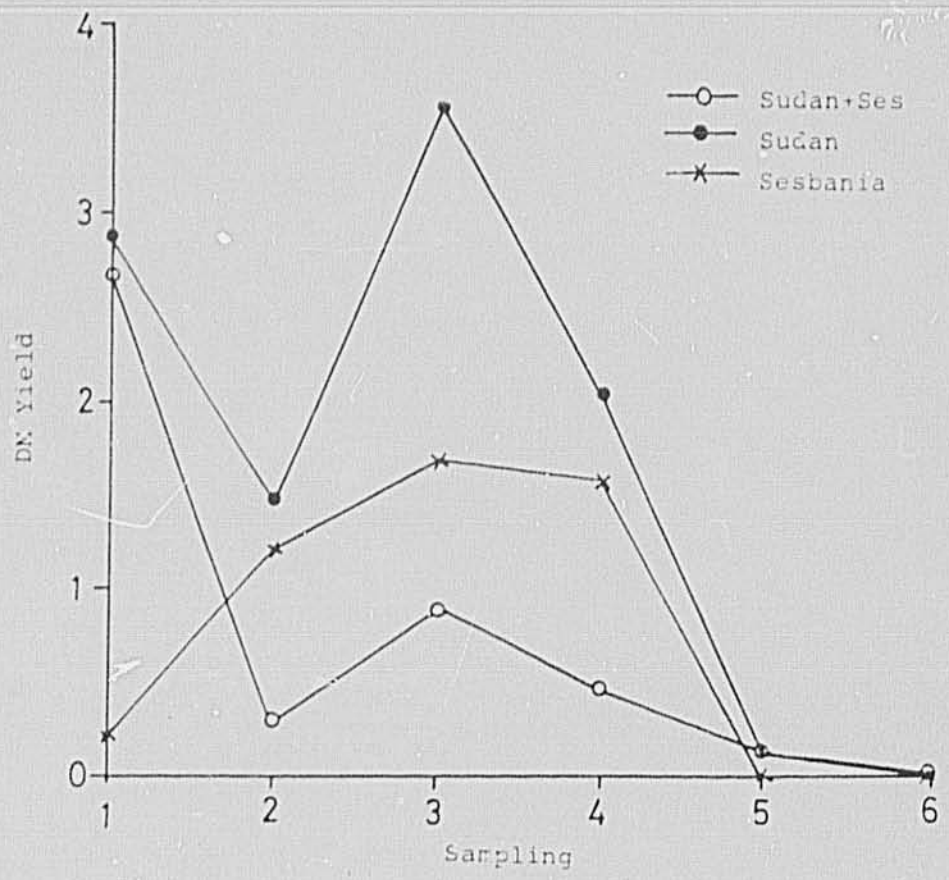


Figure 4: Bana - Sesbania Intercrop (Ton/Ha)

Figure 6: Sudan Sesbania Intercrop (Ton/ha)



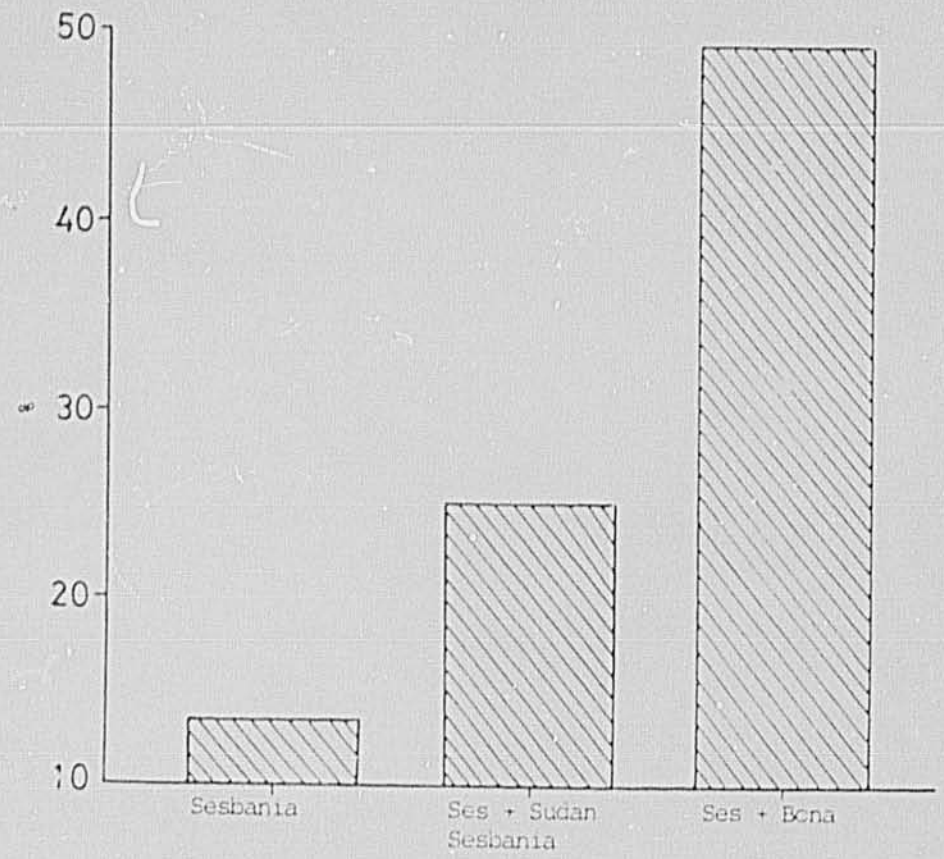


Figure 7: Sesbania Mortality Rate %

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TOXICITY OF LEUCAENA LEUCOCEPHA AND SESBANIA SESBAN SUN DRIED LEAF HAY

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INTRODUCTION

Kenya and many other Third World countries are looking for a cheap source of protein for feeding livestock. The search is on because of lack of money to purchase protein rich concentrates such as bone meal. High-protein forages are therefore seen as a suitable alternative. Such tropical legume trees like Leucaena (*Leucaena leucocephala*) and sesbania (*Sesbania sesban*) with crude protein (CP) contents of approximately 26% are very promising although they contain toxic substances that need further research. In case of leucaena, the toxic substance is mimosine, an amino acid. It has been shown that 3-hydroxy-4-1(H)-pyridone (DHP), a breakdown product of mimosine in the rumen, is the root cause of the toxicity (Hegarty *et al* 1976). Incase of sesbania, toxicity has been reported in non-ruminants by Rotar and Evans (1984). Onim et al. (unpublished data) have found sesbania leaves to be lethal when fed to growing broiler chicks. In ruminants, according to the literature reviewed by Rotar and Evans (1984), toxicity has resulted from feeding sesbania pods, while other parts of the plant have been reported as relatively free of toxicity. With this background, two trials were initiated. The first was a comparative study between leucaena and sesbania hays and the second one monitored the effect of feeding fresh leucaena as the sole diet of bucklings, to ascertain the presence or absence of mimosine degrading microbes.

MATERIALS AND METHODS

Comparative trial

Six crossbred (Toggenburg x Small East African bucklings with average weight of 16.4 kg were used. At the beginning of the trial, each buckling was administered with an antihelmintic (Nilzan) and an antibiotic (Injectable Oxytetracycline). The preparatory period took 10 days and the experimental period was for 40 days. Fresh hay of each species was placed in the crates daily at 8 am and 4 pm. Water and a mineral lick were supplied *ad libitum*. Liveweights of the bucklings were taken twice weekly. Total faecal and urine output were collected every 24 hours.

In the laboratory, dry matter (DM) and (N) nitrogen content of the different hays, faeces and urine were determined. Six bucklings in a change-over design, were allocated randomly to two treatments. The treatments were sun-dried leucaena hay and sesbania leaves hay.

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Trial with Fresh Leucaena

Eight bucklings with a mean birth weight of 3.5 kg were selected from a crop of 30 kids. Four bucklings were offered fresh leucaena from the age of two weeks onwards. They were weaned at the weight of 10 kg. Following weaning, they had no access to any other feedstuff except fresh leucaena, mineral lick and clean water. The other four bucklings (controls) were weaned on pastures and had access to water and mineral licks. All the eight bucklings were crossbreeds of Toggenburg with Small East African. Their liveweights were taken weekly and were examined daily for signs of clinical toxicity such as excessive salivation, alopecia, loss of appetite, incoordination of gait and enlargement of the thyroid gland. Mimosine was tested in the urine from a base solution of ferric chloride and concentrated hydrochloric acid (Jones and Megarrity 1983).

The hypothesis was: goats that have been exposed to no other forage except leucaena would naturally develop mimosine degrading microbes.

RESULTS

The DM, CP content and *in vivo* dry matter digestibility of the hays and the fresh leucaena are in Table 1. There was no difference between the dry matter digestibility of leucaena and sesbania hay, while the digestibility of the fresh leucaena was higher by 7 %.

The intake of leucaena was higher than that of sesbania (Table 2). Intake as a percentage of body weight was particularly low for sesbania (1.4%).

Growth curves of the six bucklings are in Table 3 and Figure 1. Neither sesbania nor leucaena was able to sustain growth. However, there was a lag period before Leucaena toxicity inhibited growth. This is shown by the comparable drop in weight of approximately 2kg occurring a week after sesbania's.

When Leucaena was fed to the buckling that survived in the Sesbania treatment, was fed leucaena it stopped diarrhoering and started gaining weight immediately. On the other hand, the buckling that was switched from leucaena to sesbania maintained its body weight, while the one that remained on leucaena continued to lose weight.

The first signs of clinical toxicity were observed on the bucklings feeding on sesbania hay. By Day-16, one of the sesbania bucklings was lethargic, diarrhoering and had no appetite. These symptoms persisted with presence of blood stains in the diarrhoea. On Day-19 it died. Post-mortem findings revealed ulcerated oesophagus and discoloured lungs. The remaining two bucklings on sesbania intermittently, lost appetite, looked lethargic and had diarrhoea with blood stains. Day-28 one buckling died while the other was switched to leucaena hay. Post-mortem results were similar to the first except for discolouration of the lungs. The goat that was switched to leucaena

stopped diarrhoering immediately. The goat that switched to sesbania from leucaena started showing clinical signs of diarrhoea from day-38 to Day-40. By Day-40 when it was put-off sesbania the outcome of impending death was obvious.

The leucaena bucklings grew faster than their contemporaries on pastures to the age of seven months (Table 4 and Figure 2). After this the pasture ones grew faster up to the age of 17 months. The buckling that survived in the leucaena treatment weighed only 11 kg at the age of 17 months which was half of the liveweight of bucklings on pasture (control).

Of the four bucklings on leucaena by the age of 17 months all had died, while the pasture ones had no mortality. The deaths occurred on the 10th, 11th, 12th, and 17th months of age. The last buckling to die had preference for the succulent bark of leucaena over its leaves. This behaviour was probably prompted by differences of mimosine concentration between the leaves and the bark.

The bucklings were weaned at the age of five months, when they weighed approximately 10 kg each. Two months after weaning they exhibited no clinical symptoms. In their eighth month they started looking dull and bloated. They appeared to be suffering from cold while the control goats were active and playful. Their overall posture was arched, while their tails uncharacteristically pointed downwards. From one of the leucaena goats falling of hair around one of the ears was noticed. Affected patches were four to five mm in diameter. The one surviving to the age of 17 months, a month before its death, hair had started falling. The falling hair was not excessive in that you noticed it when you looked for it or when holding the goat's body, hair was left on your hands. This was not the case with the hair of the control bucklings.

Post-mortem findings of the three bucklings that died revealed lesions in the oesophagus and reticulo-rumen, and congestion of the lungs, but there was no noticeable enlargement of the thyroid glands. Out of 52 urine samples collected over a period of 52 days, for the assessment of the presence or absence of mimosine or DHP, 36 or 69% of the tests were positive. Of the positive tests 11 and 25 gave blue and purple colouration respectively. The 16 negative tests gave yellowish colouration. A pattern emerged out of the tests, of approximately eight and two consecutive days of positive and negative results respectively.

DISCUSSION

The DMD of 58% for both leucaena and sesbania hay was much higher than of leucaena reported by Sriskandarajah and Komolong (1986) of 42%. However, with regards to intake of leucaena the later reported a dry matter intake of 894 g/d or 3.9% of the body weight as opposed to this study's of 349g/d or 2.2% of the body weight. Jones and Lowry (1984) reported an even lower intake of 290 g/d, with Australian goats, which did not possess the mimosine degrading microbes. The goats of Sriskandarajah and Komolong (1986) had a high intake despite a low DMD presumably because the urine of their experimental goats had no DHP. Therefore the low intakes of Kenyan and Australian goats was most probable due to mimosine toxicity.

The intake of sesbania was much lower than for leucaena hay. It could therefore be postulated that toxicity of sesbania is expressed at a lower threshold of DM intake than that of leucaena. Disappearance of the clinical toxicity signs after feeding change from sesbania to leucaena, exonerates bacteria from being the causative organism. Whereas in leucaena, mimosine is the cause of toxicity in ruminants, in sesbania no conclusive evidence has been reported on the toxin. Saponin is however, suspected because of its biological activity on cellular and membranal components (Chubb, 1983).

The hypothesis that goats having had leucaena forage only and no other since birth, will develop mimosine and DHP degrading microbes must be discounted. The presence of mimosine in the urine of such fed goats is a clear indication of lack of the degrading microbes. Goats in Kenya like those in Australia therefore have no microbes for degrading mimosine. Unless degrading microbes are introduced to Kenyan goats, leucaena should not be fed as a sole diet. According to the review of Jones (1979) diets containing less than 30% of leucaena are not expected to cause toxicity. Leucaena is grown by farmers in Kenya as a protein supplement, therefore feeding it beyond 30% under normal circumstances is unlikely. However, due to its high palatability and the temptations of feeding it as a sole diet in periods of plenty, farmers should be cautioned about its side effect, when fed at more that 30% of the diet. The same is true for sesbania although its safe limit has not been established. Nonetheless, sesbania has shown good promise as a feed supplement to straw based diets (ILCA 1986).

It should be remembered that scores of plants contain material toxic to livestock if eaten in sufficient quantity. This is not very apparent with free ranging livestock because instinct regulates intake of injurous species. This explains why the longest surviving buckling had preference for the bark, which is low in mimosine concentration compared with the young leaves. On the other hand if selection is limited as in a drought or in a cut and carry system, an animal has no choice but to continue until it is poisoned. According to Ace and Hutchinson (1984) the severity of poisoning is related to the quantity of material eaten, the species of animal eating the

plant, portion of the plant and condition of the plant eaten, level of ground moisture, general health of the animal prior to ingesting the substance and the age and size of the animal. Therefore some livestock can eat some of the toxic plants and under several of the mentioned conditions, fail to show symptoms of injury or poisoning. At other times death may occur.

Results of this study show that both leucaena and Sesbania should not be fed as sole diets to goats. Due to their crucial role of protein supplementation in livestock diets, more research should be done particularly, with Sesbania to ascertain appropriate feeding levels. Plant breeders should come-up with varieties of leucaena and sesbania with none or considerable reduced toxin concentrations. Introduction of DHP degrading microbes should also be encouraged. Positive results have been reported of inoculated goats and sheep with microbes imported from Australia by the International Livestock centre for Africa (ILCA 1986).

Table 1: Chemical composition and dry matter digestibility

Product	DM %	CP %	DMD %
Sesbania hay	95	26	58
Leucaena hay	94	21	58
Leucaena fresh	31	21	65

Table 2 Intake of sesbania and leucaena hays.

Species	Dry matter Intake (g)	Dry matter intake % body weight	g per $kgW^{0.75}$
Leucaena	349	2.2	44
Sesbania	217	1.4	30
Difference d	132**	0.8**	14**

** $P < 0.01$

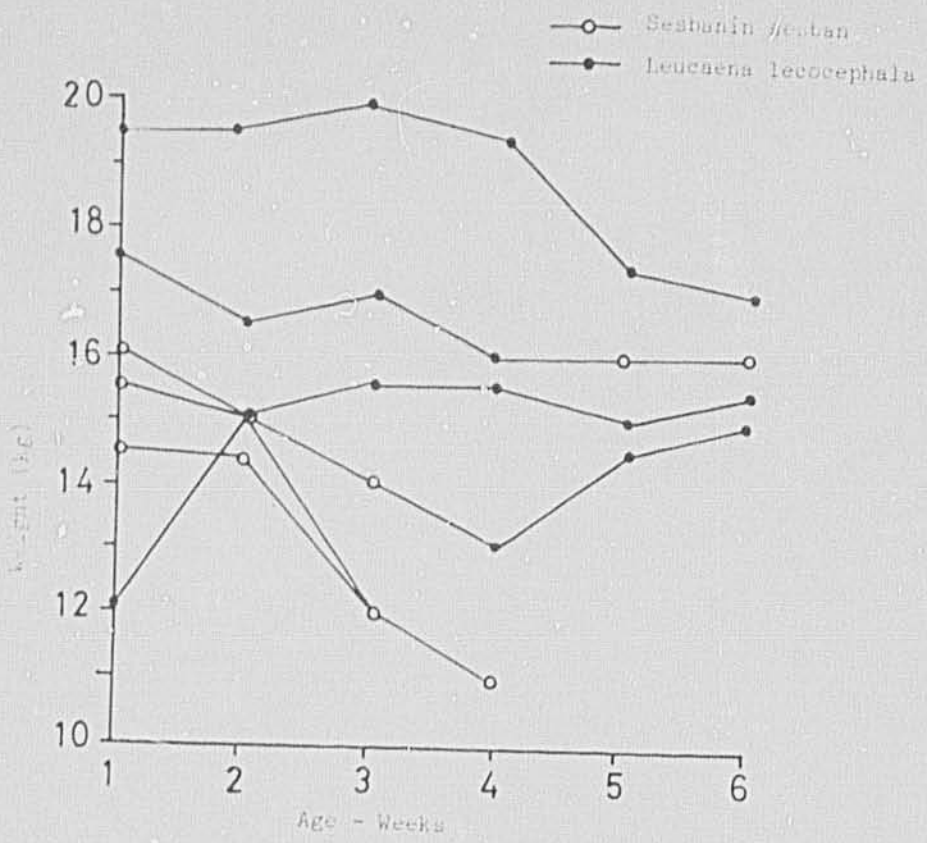
Table 3 Liveweight means and differences by fodder species (kg).

Week	n	0	1	2	3	4
Sesbania bucklings	3	15.0±0.5	15.2±0.8	14.8±0.3	12.7±1.2	12.2±1.6
Change from previous weight +		-	+0.2	-0.4	-2.1	-0.5
Leucaena bucklings	3	16.7±2.5	16.7±2.5	17.0±2.3	17.5±2.3	15.5±2.2
Change from previous weight +		-	NIL	+0.3	+0.5	-2.0

Table 4 Liveweight means and differences by feed source (Kg)

Age months	0	1	2	3	4	5	6	7	8	9	10	17
n	4	4	4	4	4	4	4	4	4	4	3	1
Leucaena bucklings	2.8	4.3	5.9	7.1	8.4	9.5	13.5	15.0	12.4	11.7	11.3	11.0
n	4	4	4	4	4	4	4	4	4	4	4	4
Pastures Bucklings	2.2	3.2	4.7	5.6	6.7	8.3	11.5	13.2	14.8	17.2	16.9	22.0
Difference	0.6	1.1	1.2	1.5	1.7	1.2	2.0	1.8	2.4	5.5	5.6	11.0

Figure 1: Growth of bucklings by fodder species



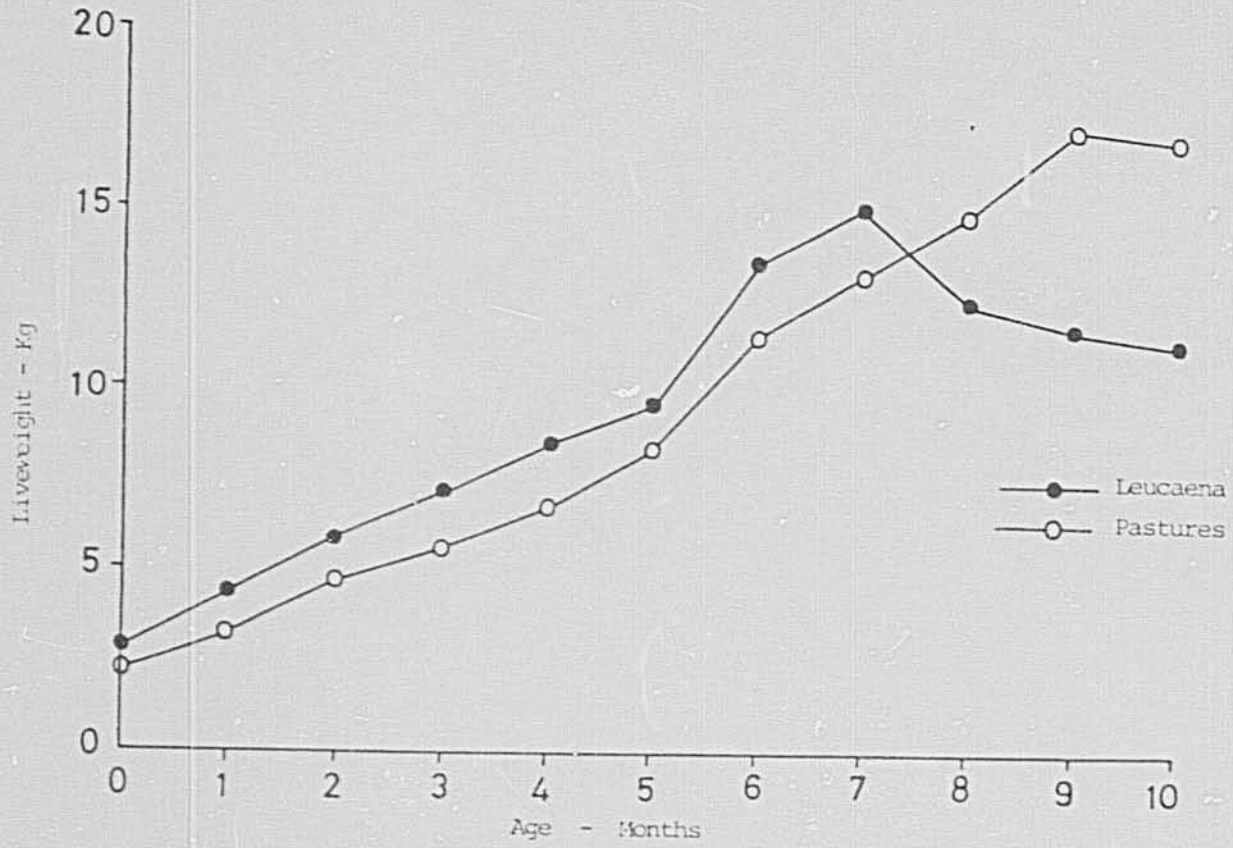


Figure 2: Growth curves of bucklings by forage type

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DRY MATTER, NITROGEN AND GREEN MANURE YIELDS OF LEUCAENA, SESBANIA AND PIGEON PEA IN A CUTTING FREQUENCY STUDY

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INTRODUCTION.

The small scale farmers in western Kenya who keep livestock and also grow food crops experience severe shortage of good quality feeds during dry season (Brown *et al.*, 1984) They grow two crops per year with no or minimum fertilizer inputs, and this has resulted in very poor soils (Onim *et al.*, 1986) An experiment was therefore set up with the following objectives: (1) determine dry matter (DM), nitrogen (N), and crude protein (CP) yields in pigeon pea (*Cajanus cajan*), sesbania (*Sesbania sesban* var *nubica*) and leucaena (*Leucaena leucocephala*) in a fixed cutting frequency study; (2) estimate distribution of DM, N and CP production from these forages throughout the year; (3) analyse the soils every two months and monitor changes in soil fertility due to incorporation of green manures of these crops and compare these to incorporation of maize(*Zea mays*) stover and fallow; and (4) test soil fertility changes after 12 months with an intercropped maize with food beans (*Phaseolus vulgaris*).

MATERIALS AND METHODS

Experiment 1: Testing the effects of green manures on soil fertility.

Five plots measuring 4.5 m by 10.0 m were assigned to fallow, maize, pigeon pea, sesbania and leucaena in each block. Randomized block design with four replications was used. Maize and pigeon pea were planted on 7th November, 1985 at the beginning of short rains while one month old seedlings of sesbania and leucaena were transplanted into their respective plots. No fertilizers were used and all crops were planted at a spacing of 90 cm between rows and 30 cm within row. This resulted in a plant population of 37,000/ha.

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2 National Sugar Research Station, Kibos, Kisumu
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3 Ministry of Livestock Development, Kenya.

Soil samples were taken from each plot before the experiment was established, and every two months thereafter. The soil samples were taken at a depth of 30 cm from three randomly chosen places in each plot. These were thoroughly mixed and composited to constitute the sample for that particular plot. The soils were analysed for pH, N, phosphorus (P), potassium (K), calcium (Ca), organic carbon (C), sodium (Na), magnesium (Mg) and manganese (Mn).

After two months from planting/transplanting, pigeon pea, sesbania and leucaena were cut at a height of 60 cm from the ground. The harvested biomass was weighed before small samples were taken for DM yield estimates and analyses for N. The remaining plant material was chopped up and incorporated into the soil between the rows within the same plot. The soils in each plot were sampled before plant materials were incorporated. Pigeon pea, sesbania and leucaena were cut every two months for 12 months, altogether resulting in six cuttings. Soil samples were taken from each plot before incorporation of green manure after every cutting.

Maize crop was harvested at the end of the first season on 18th February, 1986, while the second season maize crop was harvested on 28th August 1986. In both cases, only the cobs were taken for grain yield estimates while the stover was chopped and incorporated into the soil. The sixth and final soil samples were taken on 22nd January, 1987. Stumps of pigeon pea, sesbania and leucaena were counted for survival. The stumps were then removed and all plots cultivated.

Experiment 2: Testing the effects of green manures on soil fertility changes with maize and beans.

After six cuttings and green manure incorporations, a fertility test crop of maize intercropped with beans was planted at the onset of long rains on 13th March , 1987. Maseno Double Cobber (DC) maize cultivar and bean variety GLP 2 were planted in this experiment. The maize was planted at a spacing of 90 cm between rows and 30 cm between plants within row. Two rows of beans were planted between maize rows at a spacing of 30 cm from each other and also 30 cm from maize rows while spacing between plants within row was 15 cm.

Because P was shown to be highly deficient in all plots in the sixth soil sampling, double superphosphate fertilizer was applied to maize at planting time at the rate of one teaspoonful per hill.

The crop was weeded twice before harvesting. Beans were harvested by uprooting whole plants when pods were dry. These were sun dried for two days then threshed. The bean grains were sun dried to a constant weight before weighing was done. Moisture contents were estimated at weighing by using a moisture meter (Model Dickey Jones, DJGMT SN 0528-35223). The grain weights were then corrected to 13 % moisture content (m.c.). The remaining bean haulms were sun dried to a constant weight at 12% m.c. and then weighed for each plot.

When the maize crop matured on 13th August, 1987, the cobs were removed from the husks, dried and shelled. The grain was sun dried to a constant weight before weighing and adjusting to 13 % m.c.

RESULTS AND DISCUSSIONS

Experiment 1

a) DM, CP and N distribution around the year

Mean survival rates of 62.9 %, 82.0 % and 28.6 % were observed for sesbania, leucaena and pigeon pea respectively.

The total accumulated DM and N from each crop that was incorporated into the soil is presented in Table 1. Results presented in Table 1 show that there were no significant differences among DM yields ($p < 0.05$) despite the fact that there were very large differences in DM yields between some crops. This may be explained by the fact that there were very large fluctuations in DM yields between different cuttings within the same crop due to rainfall changes during the 12 months period. Leucaena provides a good example where cuttings one and two gave DM yields of 116 and 493 kg/ha respectively, while cuttings five and six resulted in 3667 and 5743 kg/ha respectively (Figure 1). However, leucaena and sesbania yielded the highest DM of 16659 and 13603 kg/ha respectively, while maize and pigeon pea had much lower DM yields of 7793 and 4806 kg/ha respectively.

The distribution of DM throughout the year from the various crops is presented in Figure 1. These results show that maize and pigeon pea have poor distributions of DM around the year, whereas leucaena and sesbania have good distributions. This means that leucaena and sesbania are suitable for feed banks for cut - and - curry in small as well as large scale livestock managements. This pattern of DM distribution is the same for CP and N but at lower magnitudes as shown in Table 1.

b) Effects of green manures on soil fertility.

The amounts of DM shown in Table 1 that was incorporated into the soil added 120, 643, 448 and 161 kg/ha of N from maize, leucaena, sesbania and pigeon pea respectively (Table 1) Several other plant nutrients were also added to the soil from the incorporated plant biomass, although these were not estimated in this experiment. Soil fertility changes due to incorporation of the various green manures as compared to fallow are shown in Table 2.

Results shown in Table 2 indicate that there were large shifts in nutrient availability due to both incorporation of green manures and time. Soil acidity (pH) improved in all plots, but most remarkably in fallow (by 27.0 %). Soil acidity did not change in other plots as much as in fallow probably because of release of organic acids from the decomposing green manures. The three soil samples that were analysed for N showed losses of N for maize (20.3 %), sesbania (4.4 %) and fallow (32.5 %) over the 12 months. N losses shown for sesbania and maize may indicate that these plant materials mobilized a lot of N from the soil before they could be decomposed. However, leucaena and pigeon pea required much less N from the soil to break down their plant materials, resulting in net N released to the soil of 28.6 % and

38.7 % respectively. In all treatments, large quantities of P disappeared in the soil, perhaps fixed since these soils are strongly acidic (mean pH before experiment started = 4.4). The mean P level when the experiment started was 36.6 ppm and this dropped to a mean value of 4.9 ppm by the time the experiment ended. In Table 2, this showed a mean P loss of 86.7 %. There were large increases of both K and Na in all treatments including fallow. The reasons for these changes are not obvious, however, they may be caused by replacement of K and Na on soil and organic matter particles by H ions which moved from the soils as shown by corresponding exchangeable acidity Hp (Hp dropped by 84.3 % on the average). Mn disappeared in the soils while Mg increased in all cases. It is known that Mn and Mg always have negative associations in the soil,and this is directly associated with pH; where Mn increases in lower pH while Mg decreases (Buckman and Brady,1969). Calcium increased in all cases (Tables 2), showing highest increases under legume green manures (e.g. 677.8 % under pigeon pea) and 393.3 % and 140,0 % under maize and fallow respectively. It is Known that the three legumes have deep rooting systems that mined Ca from deeper soil levels and brought it nearer the surface. However, it is apparent that this did not influence pH directly since where Ca increased most under pigeon pea, the same plot did not have the largest reduction in pH. Complex cation exchange must have been in play as a result of changing pH (Buckman and Brady, 1969). Organic carbon increased in all plots including the fallow one. The three legumes showed the highest C increases to the soil with leucaena adding the most (37.0 %). This is expected since legumes have a much better C:N ratios as compared to cereals e.g. maize (C = 12.2 %). Since high organic carbon in the soil is directly associated with larger humus quantities and increased soil fertility, it is believed that these three legumes increased soil fertility by 37.0 %, 27.3 % and 22.9 % over the 12 month period for leucaena, sesbania and pigeon pea respectively, as compared to maize 12.2 % and fallow 14.4 % over the same period (Table 2).

c) N added to the soil from the biomass of the three legumes and maize.

As shown in Table 1, leucaena and sesbania significantly ($P < 0.05$) added to the soil more N (643 and 448 kg/ha respectively) as compared to maize (120 kg/ha) and pigeon pea (161 kg/ha). Converting these N figures into a commercial N containing fertilizer like calcium ammonium nitrate (CAN) which contains 46 % N, the various crop biomass added to the soil contributed equivalents of 261, 1397, 974 and 350 kg/ha of CAN from maize, leucaena, sesbania, and pigeon pea respectively. In cash terms, this is a very impressive saving for small scale farmers, who have little or no purchasing power for such vital inputs like chemical fertilizers. It must be noted, however, that N fixed in the nodules that was not mobilized to the plant aerial biomass was not accounted for in these N estimates.

Experiment 2: Effects of green manure on soil fertility changes as tested with maize and beans

The bean crop was suppressed by maize and did not give high grain yields. Table 3 shows that there was no significant difference ($P < 0.05$) for bean grain yields between different treatments. These grain yields are within the range reported elsewhere for intercropped beans with maize e.g. (Ssali and Keya, 1982). There were, however, significant differences ($P < 0.05$) for haulms between some treatments. Sesbania, Leucaena and fallow treatments produced significantly ($P < 0.05$) more haulms than pigeon pea and maize.

The maize crop recoverable biomass was partitioned into three products - stover, dry shelled cobs and dry maize grain. At the time of harvesting the cobs, there were very highly significant differences ($P < 0.001$) in wet stover yields between treatments. Results shown in (Table 3) showed that there was no significant difference of wet stover yields between pigeon pea and leucaena. Similarly, leucaena and sesbania had no significant difference. However, sesbania had a significantly ($P < 0.05$) higher wet stover yield than pigeon pea. Wet stover yields from maize and fallow treatments were very highly significantly ($P < 0.001$) lower than those from the three legumes. It is interesting to note, however, that there were no significant differences ($P < 0.05$) among DM stover yields in all treatments. This therefore means that the green manures from the three legumes increased soil fertility which in turn increased lush growth, hence more moisture in wet stover than in the maize and fallow treatments.

Maize stover constitutes a very important feed resource on small scale livestock farms(Onim *et al.*, 1986; Semenye *et al.*, 1987) Therefore the observed increased DM stover yields of more than two tonnes from the legume treatments over fallow and maize are a significant contribution to livestock nutrition.

Dry shelled cob yields showed significant differences ($P < 0.05$) between different treatments (Table 3). Leucaena treatment had significantly ($P < 0.05$) higher cob yield than all the other treatments which showed no significant differences between themselves. Although dry cobs could be put to other uses in other situations, their most popular use in small scale farms is as fuelwood. Energy for cooking is critically short in these farms and this contribution of approximately two tonnes of dry cobs from leucaena treatment, and approximately 1.3 tonnes from pigeon pea , sesbania and maize treatments would alleviate the energy shortage for some time on the farms.

Dry maize grain is the most important output from maize crop to the small scale farmer. It is therefore interesting to note that there were very highly significant differences ($P < 0.001$) between treatments for this parameter (Table 3). The three legumes significantly ($P < 0.05$) produced more dry maize yields than maize treatment. The highest dry grain yield of 6667 Kg/ha was observed under sesbania treatment, while that of maize was 5156 Kg/ha, resulting in a range of 1511 Kg/ha. Maize treatment also significantly outyielded fallow ($P < 0.05$). However, the three legumes

very highly significantly outyielded fallow ($P < 0.001$) by a range of 2756 Kg/ha, for example between sesbania treatment and fallow (Table 3). Using dry maize grain yield under fallow as 100 %, the gains in grain yield under pigeon pea, sesbania, leucaena and maize biomass incorporations are 63.1, 75.5, 68.2 and 31.8 % higher. These results show that incorporation of green manures from the three legumes over a period of 12 months significantly improved soil fertility. However, leaving the land fallow under grass for 12 months did not improve the soil fertility much. Economic significance of green manures shown in this study is critically important to the small scale farmer as a cost effective technology. These results are similar to those obtained elsewhere when green manures of, for example sesbania, was used on maize crop (Singh and Sinha, 1962).

Recoverable total biomass from the test crops in the various treatments are shown in the last column of Table 3. These results show that both sesbania and leucaena green manures were significantly ($P < 0.05$) superior to pigeon pea. Sesbania and leucaena treatments produced over 8 tonnes DM of biomass above that from fallow.

CONCLUSION

This study shows that sesbania, leucaena and pigeon pea produced large quantities of DM, CP and N that can be effectively utilized by the small scale farmers to feed their livestock or incorporate into the soil as green manures. The distribution of DM, CP and N around the year was much better for sesbania and leucaena but poor for pigeon pea and maize. There were large shifts in plant nutrients in the soil, showing large increases in Na, K and Ca, moderate increases in pH, N, C and Mg, large losses in P and moderate losses of N and Mn in various green manure treatments. Although 12 months is a short time to determine long term soil changes, these results are important because they reflect a workable rotation management period that is typical to what small scale farmers who are short of farming land practice. The analysed soil fertility changes were verified by the test crops of maize and beans. Incorporation of green manures from pigeon pea, sesbania and leucaena significantly. ($P < 0.001$) increased dry maize grain yield in the test crops upto 2756 Kg/ha above fallow and total recoverable biomass higher yield of upto 8343 Kg/ha. Incorporation of green manures from pigeon pea, sesbania and leucaena for only 12 months has been shown to be effective in this study.

Table 1. Cumulative DM, N and CP yields of maize, pigeon pea, sesbania and leucaena incorporated into the soil after 12 months (Kg/ha).

Crop	DM	CP	N
Maize	7793 a	751 a	120 a
Leucaena	16659 a	4015 b	643 b
Sesbania	13603 a	2803 b	448 b
Pigeon pea	4806 a	1007 a	161 a

Figures followed by the same letter are not significantly different at $P < 0.05$ level

Table 2: Mean changes (%) of some available plant nutrients in the soil between the first and sixth samplings.

Green Manure Treatment	pH	N %	P (ppm)	K (m.e %)	C %	Na (m.e %)	Mn (m.e %)	Mg (m.e %)	Ca (m.e %)
				Plant Nutrients					
Maize	+18.2	-20.3*	83.4	+780.0	+12.2	+216.7	-44.1	+6.4	+393.3
Leucaena	+23.6	+28.6*	-92.5	+53.3	+37.0	+200.0	-44.9	+55.7	+453.6
Sesbania	+14.1	4.4*	84.2	+360.0	+27.3	+160.0	-51.8	+33.7	+407.5
Pigeon pea	+9.7	+38.7*	80.5	+457.1	+22.9	+260.0	-47.1	+36.7	+677.8
Fallow	+27.0	-32.5*	92.7	+233.0	+14.4	+66.7	58.0	+44.1	+140.0

* Only between the first and third samplings since equipment broke down.

Table 3: Mean recoverable biomass DM of test crops (kg/ha)

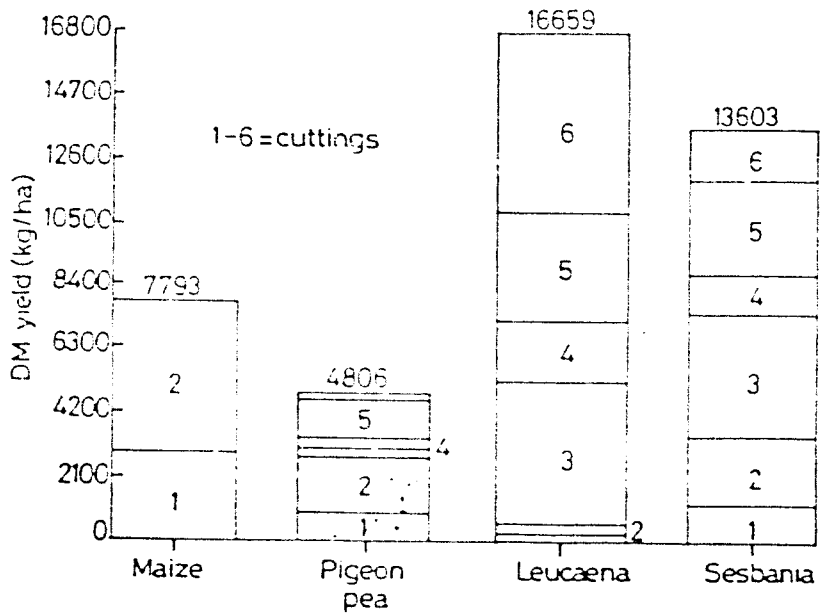
Treatments	Maize				Beans		
	Stover		Cobs	Grain	Haulms	Grain	Total
	Wet x	Dry					
Pigeon pea	15244a	8289a	1222a	6378a	244a	389a	16522a
Sesbania	19000ab	8498a	2124ab	6667a	784 b	433a	18506 b
Leucaena	17400 bc	9265a	1958 b	6578a	580 b	478a	18859 b
Maize	10733 d	6776a	1180a	5156 b	293a	596a	14001 c
Fallow	9200 d	4767a	833a	3911 c	698 b	307a	10516 d
Significance levels	***	NS	*	***	*	NS	***

x This column is not added into the total biomass in the last column.

Figures followed by the same letters in a column are not significantly different at $P < 0.05$.

* Significant at $P < 0.05$, and *** $P < 0.001$.

Fig 1. Cummulative DM yields of maize, pigeon pea, leucaena and sesbania after six cuttings



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SOCIO ECONOMICS

PRELIMINARY OPTIMAL FARM PLANS FOR ADOPTION OF DUAL-PURPOSE GOATS IN HAMISI DIVISION, KAKAMEGA DISTRICT, WESTERN KENYA

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INTRODUCTION

The Small Ruminant Collaborative Research Support Program (SR-CRSP) has been conducting farming systems research in Western Kenya since 1980, developing technologies for the introduction of Dual-purpose Goat (DPG) technologies into small-scale farms to provide meat and milk for enhancement of household nutrition and cash flow. Considerable amount of biological and socioeconomic data have been generated and partially analyzed by each of the SR-CRSP projects on the potential of introducing DPG into small-scale farming systems. This study provides a framework for testing and evaluating DPG technologies during the on-farm farmer managed trial phase scheduled to start in the second half of 1988. This preliminary study covers Hamisi in Kakamega District which is one of the SR-CRSP cluster areas. It will be expanded to cover the remaining cluster areas of Kaimosi and Masumbi in Kakamega and Siaya Districts, respectively. The study is preliminary in the sense that only basic activities were considered. A more detailed study is underway that will provide detailed representative farm models for farms in Kakamega and Siaya District cluster areas.

METHODOLOGY

The farming systems approach to research explicitly recognizes the need for designing technologies which link into various farm enterprises within the same farming household. Such interactions are often difficult to include in simple economic analysis methods such as gross margin analysis or partial budgeting. Linear Programming (LP), however, offers a method for the evaluation of technologies at an early step in the development (of new technologies) process. LP takes into account some essential farmer circumstances (prices, resources) without incurring the expense of on-farm testing. Shadow prices are a meaningful definition of constraints and also the opportunity cost of resources used under alternative management plans can be used.

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Furthermore, LP allows a rapid and cheap evaluation under a range of alternative assumptions about resources available, and prices (Knipscheer *et al.*, 1983).

SR-CRSP component projects -- feed resources (FR), nutrition and management (NM), sociology (SOC), health (HL), and economics (EC) have collected farm level data over the past 7 years. These data have been used in developing enterprise budgets for the major crop and livestock enterprises reported in tables 7-12, which include DPG enterprise budgets for the Hamisi cluster. Most of the input/output data were derived from surveys conducted by the EC project since 1983 and from the NM and FR on-farm trials. The Ministries of Agriculture and Livestock Development, farm management figures (Ministry of Agriculture and Livestock Development, 1986) have been used to supplement these data where necessary.

Farms in Hamisi cluster were categorized into three farm size groups; small, medium, and large to enable analysis of the impact of farm size on optimal farm production plans generated by this study. Farms of less than 1 ha are grouped as small, 1 to 2 ha as medium, and above 2 ha as large. A list of 95 randomly selected farms in Hamisi was obtained from SOC Rapid Appraisal Survey Records conducted in 1986. For each farm size group, a representative farm was derived by averaging the land, labour, and capital resource base (table 1). This was done to enable development of a whole farm model for each farm size group for economic analysis of the DPG intervention at the farm level.

The means for all farms less than 1 ha, between 1 and 2 ha, and above 2 ha were calculated (table 1). The labour supply for three representative farm groups was also derived from SOC Rapid Appraisal Survey Records.

The basic crop activities were determined by selecting crops grown by at least 50% of the farmers except tea and coffee which are the main cash-crops, and sorghum which is the only cereal crop grown during the short-rains season. Three levels of management scenarios were modeled for the DPG enterprise in each representative farm as low, average, and high. The low, average, and high management levels are defined with respect to milk and meat (live weight) production levels derived from on-farm trial data generated by the NM project. The production levels are the means of observed data from all the three SR-CRSP research clusters (table 1). Other crop, livestock, and off-farm activities are omitted in this preliminary study but are included in the detailed study of farm models underway. Subsistence constraints are included in the model to ensure that the basic food requirements mainly maize and beans, for farm families are produced in the farms in line with the farmers' practice in Hamisi. The quantity of subsistence maize and beans required by each household in a representative farm group was determined by multiplying the number of adult-equivalents in each farm group household by the quantity required of the respective foodstuff on an annual basis as stipulated in Bohdal's nutritional survey conducted in Kenya (Bohdal *et al.*, 1968). It is therefore assumed that any other food requirement is purchased from cash income generated by the farm business. Most of

the livestock feeds for small-scale farming in Western Kenya comes from 1) communally grazed land, 2) fallow land on the farm, 3) crop thinnings, toppings, leaf strippings, stover and residues, and 4) cut-and-carry fodder from planted forages (Onim *et al.*, 1985), hence minimum land allocation in the farm model. The activities in the models were defined as:

Activity	Unit of Activity
Maize and beans intercrop, long rains	1 ha
Zebu	1 cow-calf
Coffee and bananas intercrop	1 ha
Tea	1 ha
Sorghum, short rains	1 ha
Maize consumption	1 kg
Beans consumption	1 kg
DPG (low management level)	1 doe-kid
DPG (average management level)	1 doe-kid
DPG (high management level)	1 doe-kid

The constraints were defined as:

Constraints	Unit of Constraint
Land, long rains	ha
land, short rains	ha
January to December labour	man-days
Operating capital	kshs
Producing maize	kg
Producing beans	kg
Subsistence maize	kg
Subsistence beans	kg

A standard linear programming (LP) model was constructed for each representative farm, both with and without the DPG enterprise assuming a profit maximization objective. A linear programming software package was used to determine the optimal combination of enterprises for each representative farm. Mean prices from the EC marketing study (Oyugi *et al.*, 1986) for milk and live weight were used in the initial LP runs. Sensitivity analysis was carried out to test the stability of the farm plans under varying DPG live weight and milk prices for each representative farm. Several LP runs were run as follows:

Milk price was increased to the highest observed level (kshs 7.68 per kg) from the EC project marketing study (Oyugi *et al.*, 1986) while holding everything else constant.

Live weight price was increased to the highest observed level (kshs 11.57 per kg) from the EC marketing study while holding everything else constant.

Both milk and live weight prices were increased to the highest observed levels while holding everything else constant.

The above three scenarios were modeled into the small, medium, and large representative farms.

RESULTS AND DISCUSSIONS

Optimal Farm Plans without the DPG Enterprise

Optimal farm plans without the DPG enterprise are reported in table 2. For all farm size groups, the maize and beans intercrop is selected for the long-rains season while the model selects sorghum for the short-rains season, taking up all the land in each season. When the farm models were run without the subsistence food constraints the coffee and bananas intercrop was the only crop association included in the optimal farm plans due to its relatively high gross margin per hectare (see enterprise budgets in table 9). However, inclusion of subsistence household requirements in terms of maize and beans excluded the cash crops from the farm plans. Field observations indicated that in Hamisi cluster only 16% grow coffee and 45.83% grow tea. The total gross margins generated without the DPG enterprise were kshs 6,509 for the small farm, kshs 16,853 for the medium farm, and kshs 27,894 for the large farms.

Optimal Farm Plans with DPG Intervention

The optimal farm plans with DPG intervention are reported in table 3. For small farms the DPG enterprise is only included at high management level, i.e., with milk off-take of 144 kg per annum. The number of doe units in the optimal farm plan is eight. The total farm gross margin for the small farm size group is increased from kshs 6,509 (without the DPG enterprise) to kshs 8,083 (with the DPG enterprise), an increase of 24%. For the medium and large farms, the DPG enterprise does not enter into the optimal farm-plan at the mean milk and live weight price scenarios. The objective function sensitivity analysis for these two farm size groups indicates that for the DPG enterprise to be included into the optimal farm plan, its gross margin per doe unit per annum should be at least kshs 1,162.24 for the medium size farms and kshs 1,743.36 for the large size farms (compared with kshs 782 for the high DPG management level budget, table 12).

Sensitivity Analysis with Varying Prices

Results of sensitivity analysis with varying milk and live weight price combinations are reported in tables 4-6. Using the highest observed milk price of kshs 6.78 per kg while everything else is held constant yields the following results:

Small farms: 0.17 ha long-rains maize and beans intercrops, 0.17 ha short-rains sorghum and 7.8 DPG doe units yielding a total gross margin of kshs 10,486.

Medium farms: 1.45 ha long-rains maize and beans intercrop, 1.45 ha short-rains sorghum yielding a total gross margin of kshs 16,852.50.

Large farms: 2.4 ha long-rains maize and beans intercrop, 2.4 ha short-rains sorghum yielding a total gross margin of kshs 27,893.79.

Using the highest observed live weight price of kshs 11.57 per kg "ceteris paribus" yields the following results:

Small farms: 0.17 ha long-rains maize and beans intercrop, 0.17 ha short-rains sorghum and 7.8 DPG doe units yielding a total gross margin of kshs 9,103.49.

Medium farms: 1.45 ha long-rains maize and beans intercrop, 1.45 ha short-rains sorghum yielding a total gross margin of kshs 16,852.50.

Large farms: 2.4 ha long-rains maize and beans intercrop, 2.4 ha short-rains sorghum yielding a total gross margin of kshs 27,893.79.

Using the highest observed prices for both milk and live weight yields the following results:

Small farms: 0.17 ha long-rains maize and' beans intercrop, 0.17 ha short-rains sorghum and 7.8 DPG doe units yielding a total gross margin of kshs 11,506.13.

Medium farms: 0.43 ha long-rains maize and beans intercrop, 0.43 ha short-rains sorghum and 10.17 DPG doe units yielding a total gross margins of kshs 17,430.66.

Large farms: 2.4 ha long-rains maize and beans intercrop, 2.4 ha short-rains sorghum yielding a total gross margin of kshs 27,893.79.

Labour

One of the critical decisions underlying any economic analysis of crop-livestock systems is the treatment of labour. Depending on the season of the year, and the schedule of the household members, DPG in Western Kenya are left tethered to graze in or near the compound (about 2/3 of the households, Conelly *et al.*, 1987). The DPG are generally brought back to the compound at the end of the day when it may be milked for a second time (first time in the morning). These activities take only about 15 minutes/day or about 7 1/2 hrs/animal/month.

However low the labour requirement for DPG in time units, there are at least two characteristics which differentiate labour spent on livestock from labour spent on crop activities. First, one hour spent on crop activities (e.g., land cultivation) cost much more energy than one hour of livestock herding. Although equal in time, the livestock activities are much less demanding physically and lend themselves well to be done at the end of a tiring day. Second, the quality of management (e.g., in detecting if your animal is sick and what measures to take) may have a larger impact on livestock production and crop productivity. The LP model used does not differentiate between these types of labour.

SUMMARY AND CONCLUSIONS

It is seen from the above preliminary results that the DPG enterprise would be an economically viable enterprise under the following conditions:

Small farms (<1 ha) under high management level achieving 144 kg of milk off-take and 22.84 kg of live weight per doe unit per annum, at mean market prices of kshs 5.55 per kg milk and kshs 6.31 per kg live weight production scenario. This scenario would bring 8 doe units into the farm plan and increase total farm gross margin from kshs 6,509 without DPG to kshs 8,083 with the DPG enterprise. This will increase farm gross margin by 24% per annum. Although the production levels under these scenarios are termed high it is envisaged that most DPG technology adopters would be able to achieve these easily when fully adoptive DPG packages are developed and passed on via extension. The milk off-take levels are those which have been achieved by many of the does (30%) in the study area. Some have attained milk off-take above 144 kg per annum. The highest milk off-take per doe per day observed in Hamisi is 3 kg per day.

Small farms (<1 ha) under high management level achieving 144 kg milk off-take and 22.84 kg of live weight per doe unit per annum and at a high market price of milk (kshs 7.68) per kg and mean market price of live weight (kshs 6.31) per kg scenario. This would include 8 doe units into the farm plan and increase the total gross margin from kshs 6,509 without the DPG to kshs 10,469 with the DPG enterprise. This would result in a gross margin increase of 60.84% per annum.

Small farms (<1 ha) under high management level achieving 144 kg of milk off-take and 22.84 kg of live weight per doe unit per annum and at a high market price of live weight (kshs 11.57) per kg and mean milk price (kshs 5.55) per kg scenario. This scenario would bring 8 doe units into the farm plan and increase the total gross margin from kshs 6,509 without the DPG to kshs 9,092 with the DPG enterprise. This is an increase of 39.68% per annum.

Medium farms (1-2 ha) under high management level achieving 144 kg of milk off-take and 22.84 kg of live weight per doe unit per annum and at both high market price of milk and live weight (kshs 7.68 and kshs 11.57, respectively) per kg. This scenario would bring 10 doe units into the farm plan and increase the total gross margin from kshs 6,509 without DPG to kshs 17,433 with DPG enterprise. This is an increase of 167.83%.

This analysis is preliminary as indicated above. Only the major farm enterprises were included in the model and in an aggregated way, and for only one of the clusters, Hamisi in Kakamega District. More comprehensive models including several cropping and livestock activities, marketing activities, and other disposal activities, crop production and off-farm activities, etc., are being developed and will be applied for the economic analysis of the DPG enterprise interventions in each cluster. The economic analysis will be extended to include cost-benefit analysis of the DPG intervention over a number of years for the cluster areas. Nevertheless, the results presented in this paper help to highlight a number of scenarios where the DPG enterprise would be economically viable under existing farming systems. It also indicates how many doe units would be kept with different resource levels among farms under the various scenarios. The orders of magnitude in these models are merely indicative at this preliminary stage and may be useful for planning the large scale DPG distribution for the next phase of SR-CRSP on-farm trials.

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Appendix table 1. Representative farm resource distribution, Hamisi cluster, Kakamega District, Western Kenya, 1986.

Resource	Land[a] (ha)		Labour[b] (md)		Operating Capital[c] (Kshs)	
Representative farm group[d]						
Small	0.54[e]	(0.21)[h]	643.44[f]	(374.64)	3745.40[g]	(1143.22)
Medium	1.45	(0.31)	1666.08	(970.05)	5891.15	(3058.45)
Large	2.40	(0.35)	2757.60	(1505.06)	10657.56	(9730.34)

a,b sociology Project Rapid Appraisal Survey, 1986.
c Derived from Mukhebi *et al.* (1986), cash Flow patterns of Small Scale Farm Households in Western Kenya.
d Small, medium, and large farms constitute 62.11%: 34.74%, and 3.16%, respectively of the farm sample.
e,f,g Refers to mean annual household cash in-flow.
h figures in parentheses are standard deviations.

Appendix table 2. Optimal farm plans without the DPG enterprise, Hamisi cluster, Kakamega District, Western Kenya, 1987.

	Enterprise	Unit of activity	Activity level in plan	Gross margin kshs
Farm size group				
Small (<1 ha)	Maize/beans, long rains	ha	0.56	5538.12
	Sorghum, short rains	ha	0.56	970.43
	Total gross margin (kshs)			6508.55
Medium (1-2 ha)	Maize/beans, long rains	ha	1.45	14339.78
	Sorghum, short rains	ha	1.45	2512.72
	Total gross margin (kshs)			16852.50
Large (>2 ha)	Maize/beans, long rains	ha	2.40	23734.80
	Sorghum, short rains	ha	2.40	4158.98
	Total gross margin (kshs)			27893.78

Source: Computer output.

Appendix table 3. Optimal farm plan with DPG enterprise, Hamisi cluster, Kakamega District, Western Kenya, 1987.

	Enterprise	Unit of activity	Activity level in plan	Gross margin kshs
Farm size group				
Small (<1 ha)	Maize/beans long rains	ha	0.17	1681.22
	Sorghum, short rains	ha	0.17	294.59
	DPG (high management level[a]	doe	7.83	6124.31
	Total gross margin (kshs)			8100.12[b]
Medium (1-2 ha)	Maize/beans, long rains	ha	1.45	14339.78
	Sorghum, short rains	ha	1.45	2512.72
	Total gross margin (kshs)			16852.50
Large (>2 ha)	Maize/beans, long rains	ha	2.40	23734.80
	Sorghum, short rains	ha	2.40	4158.98
	Total gross margin (kshs)			27893.78

Source: Computer output.

[a] High (observed) milk off-take per doe per year, low doe/kid mortality and low variable costs.

[b] Increase in gross margin of 24.46% above plan without DPG.

Appendix table 4. Sensitivity analysis of optimal farm plans with highest observed milk price per kg (kshs 7.68), Hamisi cluster, Kakamega District, Western Kenya, 1987.

Representative farm group	Enterprise	Unit of activity	Activity level in plan	Gross margin kshs
Small (<1 ha)	Maize/beans, long rains	ha	0.17	1681.22
	Sorghum, short rains	ha	0.17	294.59
	DPG (high management level[a]	doe	7.8	8493.26
	Total gross margin (kshs)			10469.07
Medium (1-2 ha)	Maize/beans, long rains	ha	1.45	1433.78
	Sorghum, short rains	ha	1.45	2512.72
	Total gross margin (kshs)			16852.50
Large (>2 ha)	Maize/beans, long rains	ha	2.40	23734.80
	Sorghum, short rains	ha	2.40	4158.98
	Total gross margin (kshs)			27893.78

Source: Computer output.

[a] High (observed) milk off-take per doe per year, low doe/kid mortality and low variable costs.

Appendix table 5. Sensitivity analysis of optimal farm plans with highest observed live weight price per kg (kshs 11.57), Hamisi cluster, Kakamega District, Western Kenya, 1987.

	Enterprise	Unit of activity	Activity level in plan	Gross margin kshs
Representative farm group				
Small (<1 ha)	Maize/beans, long rains	ha	0.17	1681.22
	Sorghum, short rains	ha	0.17	294.59
	DPG (high management level[a]	doe	7.8	7116.64
	Total gross margin	(kshs)		9092.45
Medium (1-2 ha)	Maize/beans, long rains	ha	1.45	14339.78
	Sorghum, short rains	ha	1.45	2512.72
	Total gross margin	(kshs)		16852.50
Large (>2 ha)	Maize/beans, long rains	ha	2.40	23734.80
	Sorghum, short rains	ha	2.40	4158.98
	Total gross margin	(kshs)		27893.78

Source: Computer output.

[a] High (observed) milk off-take per doe per year, low doe/kid mortality and low variable costs.

Appendix table 6. Sensitivity analysis of optimal farm plans with highest observed milk price per kg (kshs 7.68), Hamisi cluster, Kakamega District, Western Kenya, 1987.

	Enterprise	Unit of activity	Activity level in plan	Gross margin kshs
Representative farm group				
Small (<1 ha)	Maize/beans, long rains	ha	0.17	1681.22
	Sorghum, short rains	ha	0.17	294.59
	DPG (high management level[a]	doe	7.8	9509.06
	Total gross margin (kshs)			**11484.87**
Medium (1-2 ha)	Maize/beans, long rains	ha	0.43	4252.49
	Sorghum, short rains	ha	0.43	745.15
	DPG (high management level[a]	doe	10.2	12434.92
	Total gross margin (kshs)			**17432.56**
Large (>2 ha)	Maize/beans, long rains	ha	2.40	23734.80
	Sorghum, short rains	ha	2.40	4158.98
	Total gross margin (kshs)			**27893.78**

Source: Computer output.

[a] High (observed) milk off-take per doe per year, low doe/kid mortality and low variable costs.

Appendix table 7. Maize and beans crop budget per hectare, Hamisi cluster, Kakamega Division, Western Kenya, long rains, 1986.

Output:	
Maize 2500[a] kg @ kshs 3.24[b] per kg	8,100
Beans 600[a] kg @ kshs 5.78[b] per kg	3,468
Total output	11,568
Variable costs (VC)[c]	
Land preparation, hired labour, 30 man-days (md) @ kshs 16 per md	480.00
Maize seed, 25 kg @ kshs 3.24 per kg	81.00
Bean seed, 13.3 kg @ kshs 5.78 per kg	76.87
Fertilizer and manure	260.70
Weeding, hired labour, 25 md @ kshs 16	400.00
Harvesting, hired labour, 15 md @ kshs 16	240.00
Baskets, 4 kshs 15	60.00
Other @ 5% per annum (p.a.)	79.93
Total variable costs	1,678.50
Gross margin (GM) per hectare	9,889.50
GM per md, kshs 9,889.50/140 md	70.64
GM per Ksh VC 9,889.50/kshs 1,678.50	5.89

Labour input in man days (md) per ha per month:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Labour (md)	19	19	20	20	20	10	10	22	0	0	0	0	140

Notes:

a Maize and beans yield levels obtained from SR-CRSP, Feed Resources

b Prices from SR-CRSP, Economics project cash-flow Study on Small Scale Farm Households in Western Kenya, 1986.

c Input levels from SR-CRSP, Economics Project, Rapid Appraisal Survey, 1984.

Appendix table 8. Annual Zebu cow-calf budget, Hamisi cluster, Kakamega District, Western Kenya, 1986.

Output:	
Milk offtake, 361 kg[a] @ kshs 5.55[b] per kg	2,003.55
Calf, 0.32 Tropical Livestock Unit (TLU)	408.96[c]
Cow cull value @ 10% culling rate per year	127.80[d]
Total value of output	2,540.31
Variable costs (VC):[e]	
Dipping, once a week @ kshs 1.00 per head	104.00
Salt[f] 1 kg per month @ Kshs 1.50 per kg	18.00
Treatments	80.00
Vaccinations	10.00
Breeding	10.00
Ropes 1.8 pieces per month @ kshs 3.00	64.80
other @ 5% of VC	14.34
Total variable costs	301.14
Gross margin (GM) per cow-calf unit	2,239.17
GM per hectare, kshs 2,239.17/1.0 ha	2,239.17
GM per man-day, kshs 2,239.17/57	39.28
GM per kshs VC kshs 2,239.17/301.14	7.44

Annual labour input in man-days (md) per cow-calf unit per month:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Labour (md)	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	57

Notes:

a From SR-CRSP, Baseline Survey, 1981.

b Annual mean price per kg of fresh unprocessed cow milk in Western Kenya from SR-CRSP Economics Project Milk Marketing Survey, 1986.

c One year Zebu calf weighs approximately 80 kg which is equivalent to (250 kg/80 kg) = 0.32 TLU. From SR-CRSP Economics Project Livestock Marketing Survey in Western Kenya 1986, average price of a Zebu cow is kshs 1,278. Therefore, 0.32 head is equivalent to (kshs 1,278/0.32 head) = kshs 408.96.

d 10% x kshs 1,278 = kShs 127.80.

e Computed from SR-CRSP Economics Project Rapid Appraisal Survey, 1984.

f It is a common practice for farmers to provide table salt to Zebu animals.

Appendix table 9. Annual coffee and bananas crop budget per hectare, Hamisi cluster, Kakamega District, Western Kenya, 1986.

Output:[a]	
Coffee, 2,989 kg @ kshs 3.00 per kg cherry	8,967.00
Bananas 515 bunches @ kshs 12	6,180.00
Total output	15,147.00
Variable costs (VC):[a]	
Weeding, twice/year, hired labour, 30 md @ kshs 16	480.00
Fertilizer, CAN, 250 kg @ KShs 206.15[b] per 50 kg bag	1,030.75
Spraying	870.00
Picking, hired labour, 40 md @ kshs 16	640.00
Baskets, 6 @ kshs 15	90.00
Transporting cherry @ kshs 0.10 per kg	298.90
Other 5% of VC	170.48
Total variable costs	3,580.13
Gross margin (GM) per hectare	11,566.86
GM per man-day, kshs/136 md	85.05
GM per kshs VC, ksh/3,580.13 kshs	3.23

Labour input in man-days (md) per ha (fourth year) per month:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Labour (md)	1.0	2.0	8.0	20.0	20.0	5.0	5.0	19.0	15.0	25.0	15.0	1.0	136

Notes:

[a] From SR-CRSP, Economics project Rapid Appraisal Survey, 1984.
[b] Based on Kisumu/Kakamega Kenya Grain Growers Cooperative Union (KGGCU) prices, 1986.

Appendix table 10. Annual (4th year of crop establishment) tea crop budget per hectare, Hamisi cluster, Kakamega District, Western Kenya, 1986.

Output:	
Yield, 2,780 kg[a] @ kshs 5.90[b] per kg	16,402.00
Variable costs (VC)[a]	
Fertilizer, NPK, 3 bags (50 kg each) @ kshs 273.40[c]	820.20
Weeding, hired labour, 30 md @ kshs 16	480.00
plucking @ kshs 1.90[c] per kg	5,282.00
plucking table	350.00
Other 5% of VC	346.60
Total variable costs	7,278.80
Gross margin (GM) per hectare	3,123.20
GM per md, kshs 9,123.20/168 md	54.30
GM per VC, kshs 9,123.20/kshs 7,278.60	1.25

Labour input in man-days (md) per ha per month:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Labour (md)	3.0	5.0	8.0	25.0	25.0	20.0	19.0	10.0	20.0	20.0	10.0	3.0	168

Notes:

a From SR-CRSP Economics project, Rapid Appraisal Survey, 1984.

b Price paid by Kenya Tea Development Authority (KTDA) in Western Kenya and is composed of Kshs 1.90 paid per kg delivered per month and an average of kshs 4.00 per kg, bonus paid at the end of the year.

c Payment to tea pluckers set by KTDA.

Appendix table 11. Sorghum crop budget per hectare, Hamisi cluster, Kakamega District, Western Kenya, short-rains season, 1986.

Output:	
Yield, 678 K[a] @ kshs 3.35[b]	2,271.30
Variable costs (VC):[a]	
Land preparation, hired labour, 14 md @ kshs 16	224.00
Seed, 5 kg @ kshs 3.35	16.75
Weeding, hired labour, 17 md @ kshs 16	272.00
other 5% of VC	25.64
Total variable costs	538.39
Gross margin (GM) per hectare	1,732.91
GM per md, kshs 1,732.91/57 md	30.40
GM per kshs VC, kshs 1,732.91/538.39 kshs	3.22

Labour input in man-days (md) per ha per month:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Labour (md)	6.0	0	0	0	0	0	10.0	6.0	13.0	10.0	6.0	6.0	57

Notes:

a From SR-CRSP Economics project Rapid Appraisal Survey, 1984.

b From SR-CRSP Economics project, Cash Flow Study on Small Scale Farm Households in Western Kenya, 1986.

Appendix table 12. Annual dual-purpose goat, doe-kid budget for Hamisi cluster, Kakamega District, Western Kenya, 1986.

Item	Unit	Management/yield levels Low	Average	High
Output:				
Milk yield[a] per doe per year (off-take)	kg	18	60	144
Milk value @ kshs 5.55[b] per kg	kshs	99.90	333.00	799.20
Weaner live weight[a] per doe per year	kg	8	10	16
Value of weaners[i]	kshs	33.31	60.58	113.08
Cull live weight per doe per year	kg	3.92[d]	5.28	6.84
Value of culls @ kshs 6.31[c] per kg live weight	kshs	24.74	33.32	43.16
Total value of output	kshs	157.95	426.50	955.44
Variable costs:[e]				
Drenching	kshs	39	26	19
Vaccinations	kshs	1	1.50	2
Antibiotics	kshs	15	10	5
Minerals	kshs	0.50	17.65	31.00
Doe replacement	kshs	17.67[f]	37.86	71.93
Hopes	kshs	18	24	36
other @ 5% of VC	kshs	7.33	6.00	8.35
Total variable costs (TVC)	kshs	98.50	123.01	173.28
Gross margin per doe-kid unit	kshs	59.45	303.49	782.16
Gross margin per man-day	kshs	0.65	4.34	15.96
Gross margin per kshs 1.00 of variable cost	kshs	0.60	2.47	4.51
Gross margin per ha (5 doe-kid units)[g]	kshs	297.25	1,517.45	3,910.80

Annual labour input in man-days (md) per doe-kid[h] unit per month at different levels of management:

	Low	Average	High
Man-days per month 7.58	5.83		4.08
Total md per year	91	70	49

Notes:

a From SR-CRSP, Nutrition and Management Project data bank.

b Annual mean price per kg of fresh unprocessed cow milk in Western Kenya from SR-CRSP Economics Project Marketing Study, 1986.

c Annual mean price per kg live weight in Western Kenya Livestock Markets from SR-CRSP Economics Project Marketing Study, 1986.

d Cull rate at 20% of doe live weight of 28 kg less doe mortality of 30%.

e Computed from SR-CRSP, Nutrition and Management Records.

f 10% for low management level, i.e., 10% x doe live weight of 28 kg x kshs 6.31 = kshs 17.67.

g Land carrying capacity 1 ha per 1 tropical livestock unit (TLU), 1 doe-kid unit equals 0.2 TLU. 1 ha/0.2 TLU = 5 doe-kid units.

h From SR-CRSP, Economic project Survey on Implications of Family Labour Use for Adoption of Dual Purpose Goat Enterprises on Small Farms in Western Kenya, 1984, by F. B. Nyaribo.

i The weaner live weight less weaner mortality plus twinning multiplied by price per kg live weight.

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HOUSEHOLD LABOR ALLOCATION IN AN INTENSIVE CROP/LIVESTOCK FARMING SYSTEM IN WESTERN KENYA

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ABSTRACT

The Small Ruminant Collaborative Research Support Program (SR-CRSP) is carrying out an on-farm evaluation of the potential for introducing dual-purpose meat and dairy goats (DPGs) into smallholder farming systems in Western Kenya. As part of this evaluation, research has been conducted to determine the labor investment required by livestock enterprises and whether labor constraints pose a potential obstacle to the adoption of DPGs by farmers. Based on a year-long time allocation study in an intensive crop/livestock farming system in Western Kenya, this paper looks at the overall work requirements of managing livestock, including the labor invested in producing food/feed crops. Attention is given to the seasonality of livestock labor and the role of women in livestock management. The implications of this information for the adoption of the DPG enterprise by small-scale farmers are discussed.

INTRODUCTION

The Small Ruminant Collaborative Research Support Program (SR-CRSP) is a multi-disciplinary research project investigating the feasibility of introducing dual-purpose meat and dairy goats into smallholder farming systems in Western Kenya. Small ruminants have always been part of the indigenous farming system, but cattle keeping has traditionally been the most important livestock enterprise and milk cows have long provided an essential source of protein in the diet. In recent decades, however, both the size and productivity of cattle herds in Western Kenya have declined because of a rapid increase in the human population and the resulting decline in farm size and the availability of grazing land. As a consequence, farmers report that milk consumption has dropped while at the same time they find themselves more dependent on purchases of expensive commercial milk products (Conelly et.al. 1986a). It is hoped that the introduction of dual-purpose dairy goats (DPGs) will provide a low cost alternative to milk cows that can be sustained by the limited resources of small-scale farmers.

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During 1986-87 an on-farm trial was carried out by the SR-CRSP to evaluate the biological performance of the DPGs and to develop a package of recommendations for their feeding and management. The trial was also designed to assess the impact of the DPGs on the economic and nutritional welfare of the farmers. As part of this evaluation, research was carried out by the Sociology and Economics projects to determine the labor investment required by livestock raising in general and the DPG enterprise in particular and to determine if these time costs posed a potential constraint to the adoption of DPGs by farmers[1].

The study had the following objectives:

1. To measure the labor expended on day to day livestock care and to study the way livestock management is integrated into other farm and off-farm activities.

2. To evaluate the significance of cut and carry feed crop production in the livestock management system.

3. To determine the importance of the contribution of women to the management of livestock.
4. To assess the implications of the time allocation and labor use data for the adoption of the DPG enterprise.

Research Site

The SR-CRSP on-farm evaluation of DPGs is being carried out with the cooperation of 75 farmers in three research clusters in Western Kenya. This paper focuses on the community of Hamisi located at an elevation of 5500 ft. (1675 m) in Kakamega District of Western Province (Figure 1). The Hamisi area has one of the highest population densities found in rural Africa with an estimated 700 persons per sq. km. in 1979 (Central Bureau of Statistics 1981). This area of Western Kenya is considered a high potential farming zone because of the heavy and reliable rainfall it receives. The mean annual precipitation in Hamisi is over 1700 mm falling in two rainy seasons - the long rains from March to early June and the short rains from September through November (Figure 2). However, the soils of the area, except for valley bottoms, are of generally low fertility (Jaetzold and Schmidt 1982) and erosion poses a serious problem in the hilly terrain.

The complex and intensive farming system in Hamisi involves a mix of subsistence crops, dominated by double-cropped maize and bean cultivation, with small-scale livestock raising and the production of cash crops including tea, coffee, Eucalyptus trees, and French beans (Table 1). Average farm size in Hamisi is only 1.3 ha., with 43% of the households having a landholding of less than 1.0 ha (Table 2). On average, during the 1986 long rains cropping season 0.35 ha. of land was planted to cash crops, 0.63 ha. was devoted to food crop production, and 0.32 ha. was fallow land including the compound (Table 3). The average number of all livestock in Hamisi was 3.1 animals

(range 0-11) - 2.5 cattle (range 0-9) and 0.6 local goats and sheep (range 0-3).[2]

METHODS

Twenty-four randomly selected households participated in the DPG evaluation trial in Hamisi. Of these, 14 families were included in the study of time allocation and labor use carried out by the Sociology and Economics projects. Another 11 households that were not keeping DPGs were also included in the survey as a control. Information on household time allocation and livestock management activities was obtained from three sources:

- Informal and formal interviews with farmers concerning the daily and seasonal scheduling of livestock labor as well as the division of labor by sex and age within the household.

- A year-long random time allocation survey[3] using a spot-check method of observing the daylight activity patterns of all persons over age six in 25 households. At the same time, random observations were also made of the household's livestock and the livestock management techniques employed by farmers. Over the year, 9496 spot-check observations of individual activities and 10,629 observations of livestock were made.

- All day "follows" in which a detailed record was kept of the activities of members of a single household from 6:00 a.m. until 7:00 p.m. This technique provided supplemental information on time allocation and detailed data on the scheduling and types of livestock labor used in each household. Twenty all day follows were carried out between January and June 1987 using a sub-sample of five representative households in Hamisi.

RESULTS

Labor requirements of livestock management

All livestock in Hamisi are kept in a special room inside the house at night to protect them from inclement weather and the chance of theft. They are removed from the house and tethered in the compound between 6:00 and 8:00 in the morning. This task is usually done by the husband or older son, but in their absence it is often done by the female household head. If any of the cows or DPGs are lactating the first milking of the day takes place at this time. Around 8:00 in the morning the wife or one of her daughters sweeps out the room in the house where the animals have spent the night and carry the accumulated dung to the compost pile for later use as fertilizer or place it directly in a field close to the house, usually the coffee or banana orchard.

Depending on the season of year and the schedule of household members, the animals may be left tethered to graze in the compound (71% of random observations) or, alternatively, they may be taken to

nearby fallow fields (19% of observations) where they can graze and browse on a variety of vegetation. Cut and carry feed crops are provided throughout the year as an essential supplement to grazing. At times, especially during the dry months of December - February when feed crops and grazing are less abundant, cattle may be herded by men or boys along the paths, at the roadside, or into scattered patches of scrub bush. Goats and sheep are now and then herded to the road where they are tethered for part of the day to browse on roadside vegetation.

The animals are usually watered in the compound, though during the rainy season when the vegetation they eat is moist they may be given water only every other day. A few farmers herd their cattle to the river to drink, but there is a general feeling that river water is unhealthy for livestock, particularly small ruminants. In most households, water is instead collected from springs and carried to the compound for the animals to drink. Providing water to the animals is primarily the responsibility of adult women and girls, though small boys may assist at times.

The animals are generally brought back to the compound by 5:00 or 6:00 in the evening and put in the house by about 7:00 when darkness falls. During the rainy season, livestock, particularly local goats and DPGs, may be returned to the house earlier in the afternoon to protect them from rain showers. If a cow or DPG doe is producing adequate milk it will be milked a second time in the evening before being put in the house.

Virtually all livestock labor, including herding, is done by household members. Farmers report that in the past there was some cooperative herding of the animals among neighbors and relatives, but this is no longer practiced. One reason for this change, and the general decline in the importance of herding, was land demarcation and the process of establishing individual land title that was completed in Hamisi by the mid 1970's. While formerly it was possible for farmers to graze their stock on any fallow land, today individual land ownership restricts access to the dwindling supply of grazing land in the community and the land of some of the wealthier farmers is now fenced against the intrusion of livestock.

Overall, based on 9496 random observations over the year (including households with no livestock), the direct labor costs of maintaining livestock in Hamisi required only 2% of all daylight time, or about 15 minutes per person per day. This compares to an average of 1.5 hours/day (11.6%) devoted to crop production, 40 minutes/day (5.4%) to off-farm labor, 2.5 hours (20.8%) to household tasks, 30 minutes/day (4.0%) to social and religious activities, 4.2 hours/day (34%) inactive, 2.5 hours/day (20.1%) school attendance, and 2.1% unknown (Figure 3).

A breakdown of the livestock labor observed during the random time allocation survey shows that cutting and carrying feeds for the animals was the dominant activity accounting for 40% of all the observations. Tethering and herding were observed in 10% and 24% of the cases respectively. Collecting spring water and giving it to the

animals in the compound accounted for another 16% of the observations while milking, cleaning the room where the animals stay at night, and other general livestock care tasks were observed in another 10% of the cases (Figure 4).

The all-day follow data indicate that, for all livestock, an average of 20 minutes of labor was expended per animal each day. For DPGs, the sample farmers spent an average of 18 minutes per day caring for each animal.

Indirect costs of livestock management - food/feed crop production

In addition to the direct day to day labor of managing livestock, the production of crops for feeding the animals is a basic component of the Hamisi farming system that also needs to be considered in analyzing the overall labor requirements of livestock management. Constrained by an acute scarcity of land, Hamisi farmers have developed a complex cropping pattern that emphasizes the production of dual-purpose crops that provide food for both human and animal consumption.

Detailed land use maps of the farms of four households in the community identified an average of 26 crop species grown during the long rains 1987 season on farms averaging 0.88 ha in size. Of all the species identified, an average of 10 (38%) were crops that are also used as animal feeds. A few, such as Napier, which is often grown in strips along erosion ditches, and Sesbania and Leucaena which have been introduced by the SR-CRSP and planted as fence rows and along the borders of fields, are grown specifically as animal feeds. But the majority are cultivated as dual-purpose food/feed crops. In general, farmers are reluctant to grow single-purpose animal feed crops that will compete for the very limited amount of land available to grow food for human consumption (Onim et.al. 1985). In response to this constraint, the SR-CRSP Feed Resources project is emphasizing the development and introduction of improved food/feed crop cultivars, including maize and sweet potato, for the nutrition management of the DPGs.

The random livestock observation survey provided data on the significance of cut and carry feed crops for the management of livestock in Hamisi. Of all the observations over the year (n = 10,629), a cut and carry feed was provided by the farmer for cattle and DPGs in 39% of the cases, 36% for local goats, and 14% for sheep (Figure 5). The use of cut and carry feeds is seasonal, peaking at the time just before and during the long and short rain maize harvests when the provision of feeds for DPGs and cattle peak at over 50% of all livestock observations (Figure 6).

Maize, accounting for 53% of all feeds observed, was clearly the most important feed given to the livestock, followed by Napier grass (16%) and Couch grass (*Digitaria scalarum*) (12%), a common weed of cultivated fields. Maize leaves as well as the stalks of excess or poorly developing maize plants are thinned as livestock feed while the

crop is maturing in the field. Stover is collected and stored during the maize harvest and is then fed to the livestock over the following weeks. Other important feeds utilized by Hamisi farmers include wild plants or weeds such as thistle (mostly for local goats), *Lantana camara*, and blackjack (*Bidens spp.*) as well as cultivated crops including banana leaves and stems, sorghum leaves, bean leaves, sugar cane tops, and sweet potato (Figure 7). The importance of these secondary feed resources increases during the months that the availability of maize is low. Overall, cultivated crops account for over 80% of the feeds utilized by Hamisi farmers.

For Hamisi residents as a whole, 6.0% of their daylight time over the year was devoted to the production of maize and other produce used as dual-purpose food/feed crops. If one-third of this labor is calculated as work for the maintenance of farm animals[4], then the total labor requirement for the management of livestock during 1986-87 was approximately 4% of all daylight time or an average of 30 minutes/day/person (225 minutes/day/household).

The labor demands of maintaining livestock are not constant over the year. The direct day to day tasks of managing livestock show a moderate seasonal variation with March and April being the least active months (rainy months when both herding and cut and carry feeding are low) while the busiest periods are May through August and October through December (when the provision of cut and carry feeds is common). The seasonal variation in labor for the production of food/feed crops is more pronounced. Crop labor shows a strong peak at harvest (June-August, December-January) and planting (July-August, February-March) time during both the long and short rains (Figure 8).

The role of women in livestock management

Preliminary survey data and casual observations reported in previous SR-CRSP studies (Nyaribo et. al. 1984, Mukhebi et. al. 1984, Conelly et. al. 1986b) have indicated that women play an important role in the management of livestock in Western Kenya. A breakdown of the random time allocation observations of livestock labor shows that this is particularly true in Hamisi cluster. Of a total of 179 random observations of direct livestock labor made over the year, 40% were of females. Women and young girls do virtually all the labor involved in providing water for the animals and women make a major contribution to the collecting of feed crops and the tethering of the animals (Figure 9).

In addition to their important role in the day to day tasks of livestock care, women also contribute a disproportionate share of the labor involved in food/feed crop production. Over the year women spent an average of 14.5% of their time (1.8 hours/day) engaged in food/feed crop production, as opposed to 4.2% (30 minutes/day) for men, 3.6% (27 minutes/day) for male children, and 3.4% (25 minutes/day) for female children.

Combining direct livestock labor with a one-third share of food/feed crop labor, adult women in the sample households spent

approximately 7% (52 minutes/day) of their daylight time over the year on work related to the management of livestock as opposed to only 4% (30 minutes) for adult men, 3.7% (28 minutes) for male children, and 2.0% (15 minutes) for girls (Figure 10).

Interviews with farmers in Hamisi indicate that they are aware of the increased share of livestock labor that is now shouldered by women. They attribute this change to two factors: first, they report that while animal care was traditionally an important male activity, in recent decades men have increasingly redirected their labor toward off-farm wage earning opportunities. At the same time, children, especially boys, who in the past made a major contribution to livestock care, now spend five days a week attending school and can assist in the management of the livestock only in the late afternoons and on weekends and holidays.

Another important factor has been the intensification of the livestock management system in Hamisi that has occurred in recent decades with the transition from herding and grazing (tasks done primarily by males) to a system that relies primarily on cut and carry feeding and watering of the animals in the compound, both tasks that entail a heavy input of female labor[5].

SUMMARY AND DISCUSSION

- Over the year, for all households approximately 30 minutes/day/person were spent on all livestock related labor, 15 minutes for direct day to day animal care and 15 minutes for the production of food/feed crops.

- For households with DPGs, the labor spent on direct care was slightly less than 20 minutes per DPG each day

- Livestock management and food/feed crop production labor peak in June-August, January, and March, corresponding to the period of crop harvest and planting and the months when there is heavy utilization of cut and carry feeds. Labor bottlenecks, particularly for women may occur in these months, especially in July when farmers are rushing to plant the short rains crop while still harvesting the long rains maize.

- At the current level of adoption (two DPG does and their offspring) there is, overall, adequate labor availability in Hamisi households to manage the DPG enterprise (Figure 3). In most households there is sufficient discretionary time available (time that is currently inactive) that it would be possible to increase the number of DPGs that are being raised and to intensify management practices to improve production.

- The burden of managing livestock and producing food/feed crops to support them, however, falls heavily on women (and to a lesser extent female children). Females contribute significantly to the direct day to day care of livestock (40% of total) and perform most of the labor for the production of food/feed crops (70%).[6] At the same

time, women have less inactive or discretionary time to devote to increased labor demands of a new livestock enterprise. While adult men were idle (doing nothing, resting, talking or visiting) approximately 38% of the time, women were idle, on average, only 27% of the day. Taking into consideration time spent on social and religious activities, for Hamisi women this translates to an average work day of 7.5 hours (seven days a week) spent on economic activities and work for maintaining the household.

The choice of whether to allocate their remaining discretionary time to the DPGs will depend in part on whether women farmers view the goats as a profitable enterprise that compares favorably with other economic opportunities available to them.

Notes

[1] This study builds on preliminary SR-CRSP research on labor availability and the time costs of livestock keeping in Western Kenya. See: Sands 1983, Nyaribo et. al. 1984, Conelly et. al. 1986b.

[2] Data on the farming system and livestock holdings in Hamisi are based on a survey of 24 randomly selected households that had agreed to participate in the SR-CRSP on-farm trial. The estimates of farm size and the allocation of land to cash crop, food crop, and fallow land are based on sketch maps drawn with the assistance of the owner or one of the household members. The size estimates exclude borrowed or rented land.

[3] The random time allocation method of measuring household labor expenditure is based on numerous spot-check observations of individual activities over the year that minimizes the errors likely to occur in time use studies that rely on informant recall (see Johnson 1975, Grandin 1982). In this method, 25 households in Hamisi were regularly visited by a trained resident field assistant at randomly chosen hours of the day when the activities of all household members over the age of six were recorded at the moment they were first observed. If an individual was away from the compound or nearby fields, another household member was asked to report on his/her whereabouts and activity. Whenever possible these reports were checked by the field assistant and cases where information was unknown or uncertain were recorded as "whereabouts unknown" (2.1% of total).

The sample was divided into five neighborhood clusters each containing five households located close enough to be visited in a reasonably short amount of time. Each month 40 cluster visits were made, resulting in 200 household visits and approximately 800 individual observations. It is assumed from this large number of observations that the relative frequency with which a particular activity was observed closely approximates the actual amount of time spent on the activity.

The random observations of livestock were made during the cluster visits for the survey of household labor allocation. During each household visit the location, activity (feeding, inactive, etc.), and method of control (tethered, herded, loose, etc.) for all livestock in the household were noted. The provision of cut and carry feeds by the farmers and the type of feed resource being utilized were also recorded.

[4] The allocation of one-third of the food/feed crop labor as work for the maintenance of livestock is arbitrary but is based on the critical importance of these crops as livestock feed in Hamisi and the fact that the potential forage yield (in kg. per hectare) of a crop such as maize far outweighs its yield of grain for human consumption (Onim et. al. 1985).

[5] In contrast to Hamisi, time allocation data from a less intensive livestock management system in nearby Siaya District where, because of lower population densities, herding and grazing management still dominate, indicates that males are responsible for the large majority (90%) of livestock labor (Conelly et. al. 1986b).

[6] Based on these observations, it is clear that the management package being developed by the SR-CRSP, which encourages the production of dual-purpose food/feed crops such as improved maize and sweet potato cultivars, will rely heavily on female labor. Nonetheless, the recommendation to grow improved food/feed crops is based on several years of on-farm research experience and is appropriate in the very intensive farming system of Hamisi where farmers would be reluctant to grow fodder crops that would compete for very limited land available for food crop production (see pages 4-5).

ACKNOWLEDGMENTS

The research discussed in this paper was conducted under the Small Ruminant Collaborative Research Program (SR-CRSP) in collaboration with the Ministry of Agriculture and Livestock Development, Kenya. Principal funding was provided by the U.S. Agency for International Development, Winrock International, and the University of Missouri, Columbia. A generous grant to Winrock International from the Rockefeller Foundation provided valuable support for the Sociology component of the research.

TABLE 1.
CHARACTERISTICS OF HAMISI CLUSTER
KAKAMEGA DISTRICT, WESTERN PROVINCE, KENYA

POPULATION	700+ PERSONS/SQ.KM. / MEAN HOUSEHOLD SIZE = 7.5
RAINFALL	1735 MM/YEAR, BI-MODAL WITH TWO CROPPING SEASONS
SOILS	GENERALLY LOW FERTILITY, INTENSIVELY CULTIVATED, EROSION ON HILLSIDES
FARMING SYSTEM	FOOD CROP PRODUCTION DOMINATED BY MAIZE AND BEANS AS WELL AS SWEET POTATOES, BANANA, VEGETABLES,
FRUIT TREES	
	CASH CROPS INCLUDE COFFEE, TEA, EUCALYPTUS TREES, FRENCH BEANS, BANANA, THATCHING GRASS
	LIVESTOCK MOSTLY CATTLE FOR MILK PRODUCTION, SOME GOATS AND SHEEP

TABLE 2.
FARM SIZE IN HAMISI CLUSTER
KAKAMEGA DISTRICT, WESTERN PROVINCE, KENYA

FARM SIZE (HECTARES)	NUMBER	PERCENT
LESS THAN 0.5	3	13
0.5 - 1.0	7	30
1.0 - 1.5	7	30
1.5 - 2.0	2	9
MORE THAN 2.0	4	18
	23	100

AVERAGE FARM SIZE = 1.3 HA

TABLE 3
LAND USE PATTERN IN HAMISI CLUSTER - LONG RAINS 1986
(N = 23)

LAND USE	AVERAGE HECTARES	PERCENT TOTAL AREA
FOOD CROP	0.63	48
CASH CROP	0.35	27
FALLOW/COMPOUND	0.32	25
	1.30	100

FIGURE 1

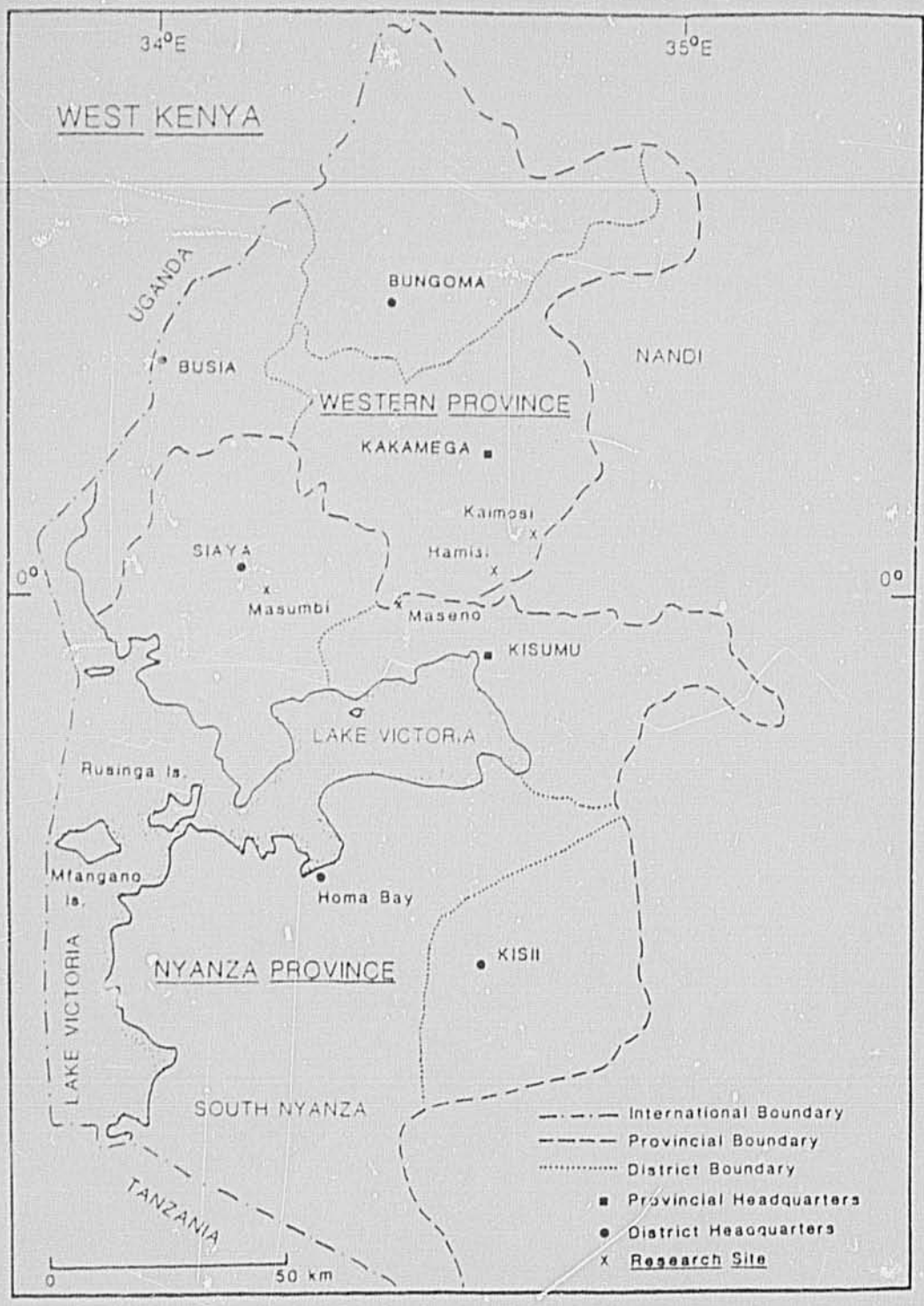

34°E
35°E
WEST KENYA
UGANDA
BUNGOMA
BUSIA
NANDI
WESTERN PROVINCE
KAKAMEGA
Kaimosi
SIAYA
Hamisi
0°
0°
Masumbi
Maseno
KISUMU
LAKE VICTORIA
Rusinga Is.
Mfangano Is.
Homa Bay
KISII
NYANZA PROVINCE
LAKE VICTORIA
SOUTH NYANZA
TANZANIA
International Boundary
Provincial Boundary
District Boundary
Provincial Headquarters
District Headquarters
Research Site
0
50 km

FIGURE 2

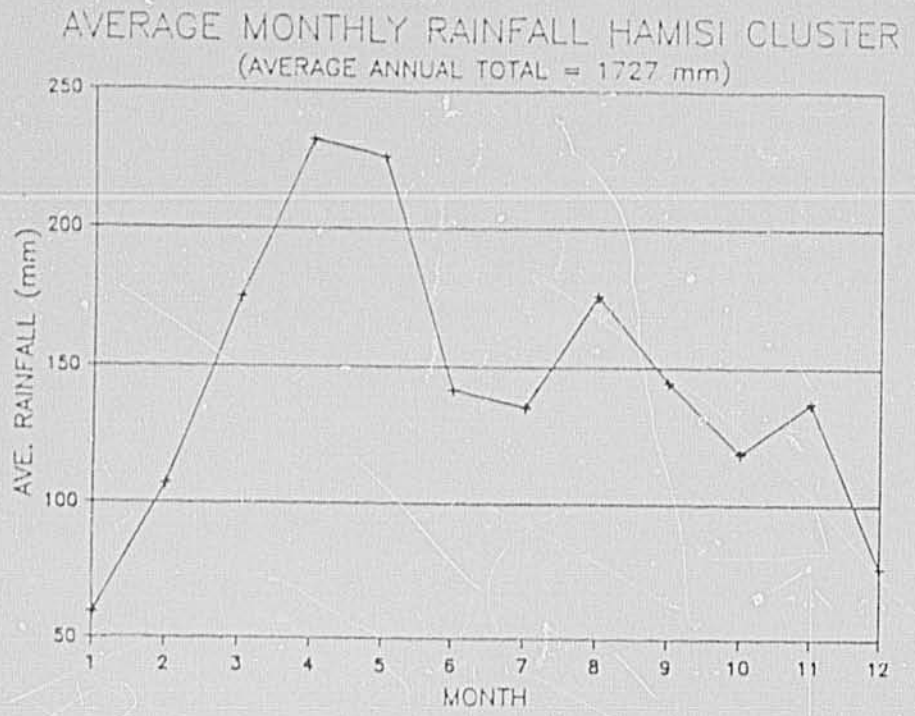


FIGURE 3

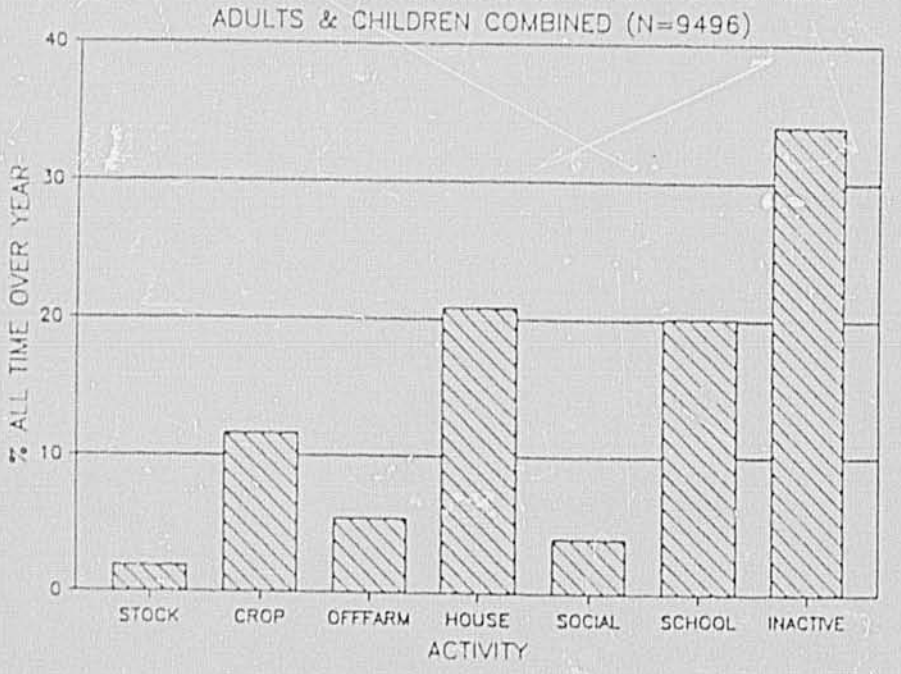


FIGURE 4

LIVESTOCK LABOR BY TASK – HAMISI

(N = 179)

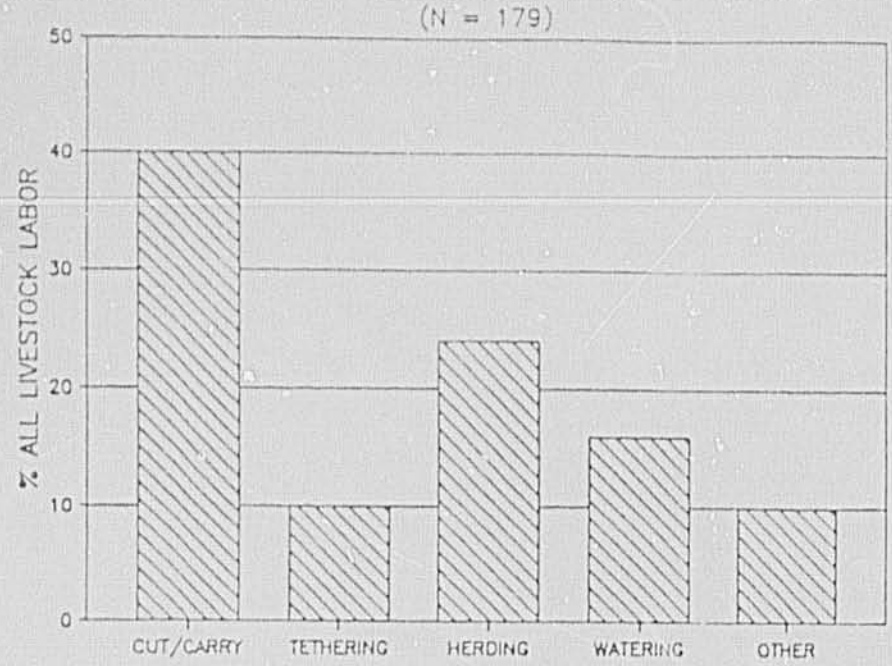


FIGURE 5

PROVISION OF CUT AND CARRY FEEDS – HAMISI

N = 10,629

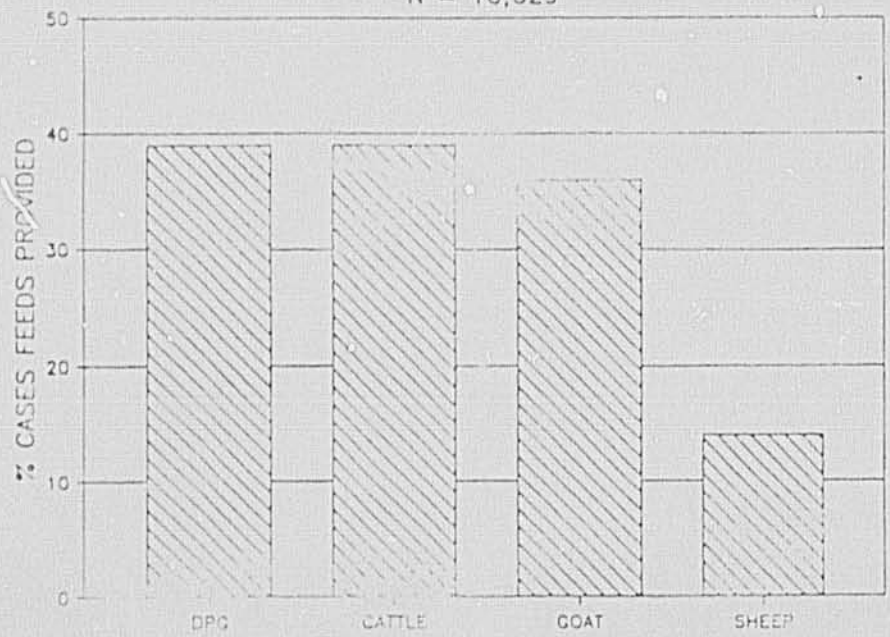


FIGURE 6

CUT & CARRY FEEDS BY MONTH – DPGs/CATTLE

(N = 8,505)

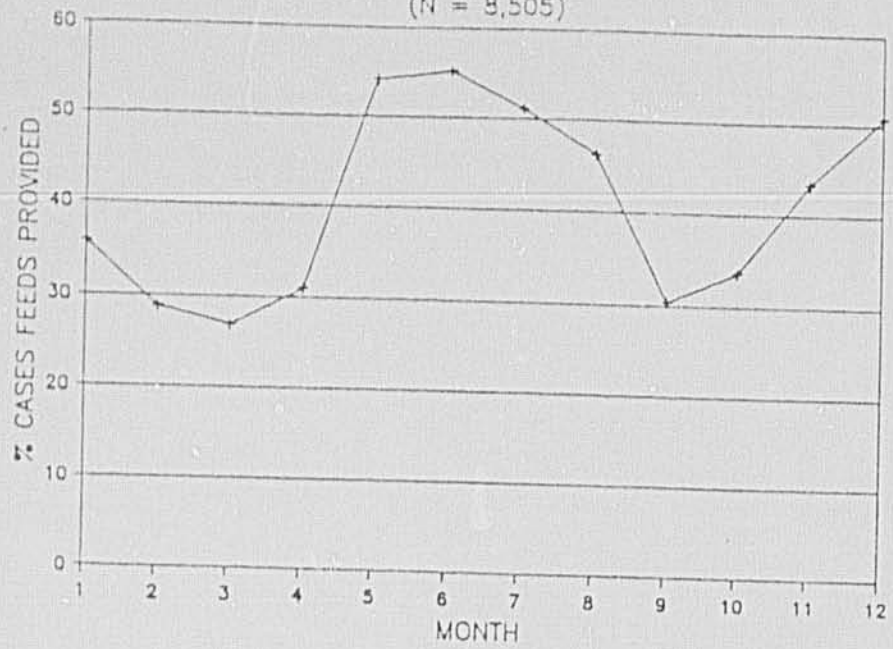


FIGURE 7

MAJOR FEED CROPS UTILIZED IN HAMISI

(N = 10,629)

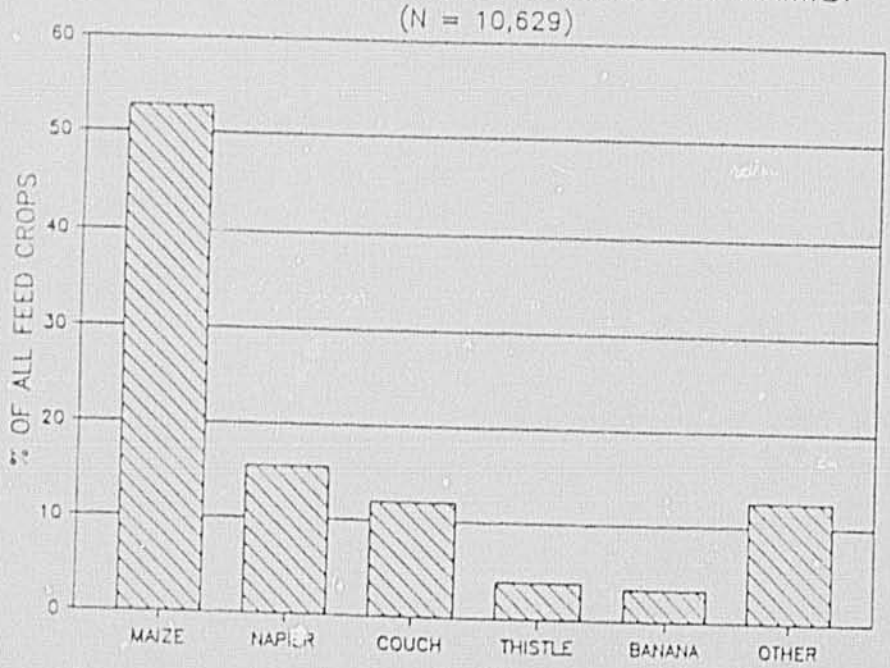


FIGURE 8

MONTHLY VARIATION IN LIVESTOCK LABOR

ADULTS AND CHILDREN COMBINED (N=9496)

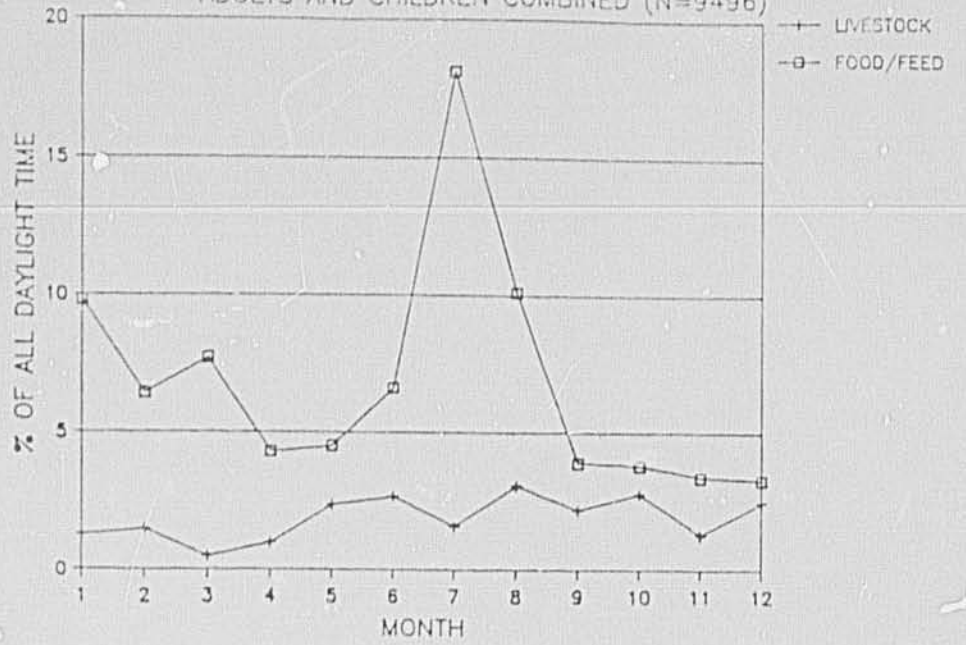
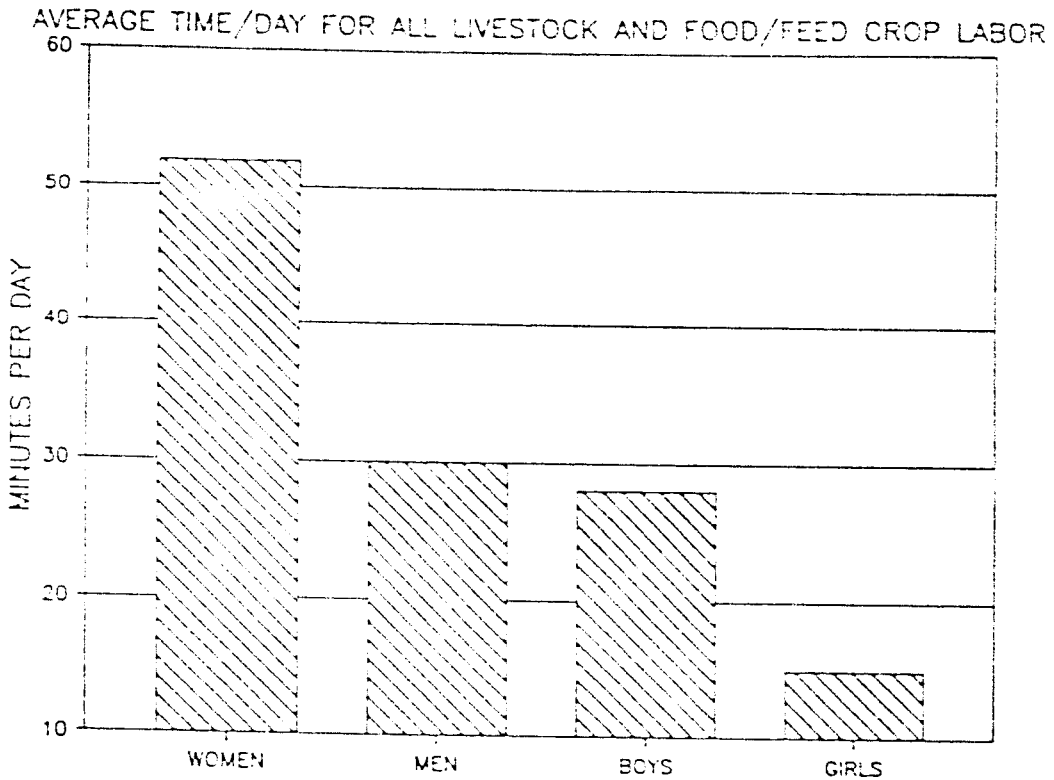


FIGURE 9

LIVESTOCK LABOR BY TASK – HAMISI


AVERAGE TIME/DAY FOR ALL LIVESTOCK AND FOOD/FEED CROP LABOR
MINUTES PER DAY
60
50
40
30
20
10
WOMEN
MEN
BOYS
GIRLS

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CONTRIBUTING PAPERS

PRODUCTION PARAMETERS OF TSWANA GOATS

R.C. Gray[1]

ABSTRACT

The indigenous Tswana breed of goats was evaluated for productivity under farm conditions with 20 ATIP farmers in Tutume District, Francistown Agricultural Region. The data indicates that the genetic potential exists for improvement of both milk and meat production. A kidding rate of 137 percent was observed with a death loss of 11.4 percent to weaning age. Mean weights of kids adjusted to 150 and 300 days of age were 16.2, 22.6, 17.8, 24.4, 14.9, 21.5, 15.4 and 24.5 kg for single born females, single born males, twin born females and twin born males, respectively. Mean total milk production for all farmers was 1.8 litres/day with a mean daily production per goat of 284 ml in 1986. One farmer took a total of 1,388 litres of milk from his herd during 1986 in 174 recorded milkings, averaging 5 litres per day. At the end of the rainy season in May 1987 mature females weighed 40.0 + 4.9 kg and mature males weighed 43.9 + 6.6 kg. Weight losses during the dry season were approximately 10 percent. At the end of the rainy season in May 1987 the herds were composed of 65.7 percent females, 21.7 percent males and 12.6 percent castrates. Only two farmers sold milk in the form of "madila" during peak milk production. Sales and Slaughter of goats were few in number.

INTRODUCTION

Goats are an important subsector of the smallholder farmers in Botswana. They provide a source of cash income, meat for home consumption, milk and skins, and they are often exchanged for goods and services. The total goat population in Botswana in 1986 was 1.2 million, an increase of 87 percent during five years of drought. Over 97 percent were owned by the traditional sector. An estimated 49,600 out of a total of 80,400 traditional farmers, or 61 percent owned goats. (1984 Botswana Agricultural Statistics).

The productivity of the Tswana goat had previously been evaluated by the Animal Production Research Unit (APRU) under government ranch conditions. However, their evaluation did not include milk production.

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Since basic information had not previously been collected under smallholder farmer conditions, a study was undertaken in January 1986 by the Agricultural Technology Improvement Project (ATIP) which does farming systems work in the Tutume District.

MATERIALS AND METHODS

Twenty smallholder farmers in three villages in Tutume Agricultural District participated in this study. All goats in each farmer's herd were ear tagged and weighed and classified into age groups 0 to 4 by the number of pairs of permanent incisor and canine teeth present. All goats were again weighted at the end of the rainy season in May and at the end of the dry season in October. Kids were tagged and weighed at birth and bimonthly weights were taken thereafter. Death losses, sales and other changes were recorded during weekly visits to farms by enumerators. Each farmer was provided with a one litre measuring cup which was graduated into 100 ml units. In order to establish base line information, the farmers were instructed to follow their normal milking procedure and to record the daily amount of milk provided by each goat, measured to the nearest 100 ml on the form provided. The form had space for a weekly record, with each day subdivided into two columns for recording morning and evening milk.

The farmers studied used the traditional management system. Under the traditional system, goats were allowed to graze freely during the day in the village and/or lands area and were kraaled during the night. There were usually herded during the cropping season. Kids were allowed to have all of the milk during the first two weeks after birth and then milk was taken for family use, usually in the morning. After milking began, the kids were penned separately from the dams and were allowed to nurse after milking, and again in the evening. Most farmers fed supplemental mineral-mix.

RESULTS AND DISCUSSION

Reproductive Performance

A total of 298 females fell in age categories 1,2,3, and 4 in May of 1986 and were considered to have reached reproductive maturity. Of these, 289 or 95 percent gave birth to 396 kids during 1986 for a kidding rate of 137 percent. Kidding percent by farm varied from 100 to 217 percent. Variation between villages ranged from 134 to 142 percent. APRU studied the Tswana goat at Sunnyside Ranch from 1976-83 and reported a 121 kidding percentage with 82 percent of the nannies kidding (Livestock and Range Research in Botswana, 1983-84 Report).

Kidding appears to be seasonal, with peak kidding season in June-July, however this was altered in 1987 when peak kidding occurred in February-March. This was probably caused by abnormal rains which occurred in April 1986 which caused heavy regrowth of sorghum and millet and resulted in abnormal grazing in July-August. Sufficient data will not be available until the 1987 data is obtained to give estimates on kidding interval. However, some nannies kid twice a year at six month intervals in two well managed herds.

Death losses averaged 11.4 percent of the kids born during 1986. Death losses in the village of Matobo averaged 20 percent which was significantly higher than in the other two villages. From the observed symptoms, several of these deaths were believed caused by enterotaxaemia and heartwater disease, although this was not confirmed by post-mortem examination.

Herd Structure.

The herds were composed of 72.4, 66.0 and 65.7 percent females, 17.6, 25.7 and 21.7 percent males and 10.0, 8.3 and 12.6 percent castrates in May 1986, October 1987 and May 1987, respectively. An analysis of the herd structure was made to estimate the reproductive rate. The 23 herds were composed of 298, 331 and 291 females of reproductive age (age categories 1, 2, 3 and 4), 174 379 and 387 kids (age category 0) for a 58.4, 114.5 and 133 percent reproductive rate in May 1986, October 1986 and May 1987, respectively.

Growth Rate of Kids.

Birth weights, weights and average daily gain (ADG) of kids were taken in December 1986 and May 1987. Birth dates were obtained on 321 kids and they were reweighed approximately at bimonthly intervals. Birth weights were taken within a few days of birth. If the weight was not obtained prior to one week of age, the kid was dropped from the analysis. The mean birth weights of single born females, single born males, twin born females and twin born males were 3.6+0.9, 4.3+1.5, 3.7+1.0 and 4.3+1.0 kg, respectively. Males outweighed females at birth and twins weighed approximate the same as single born kids. Mean weights in December 1986 and May 1987 were adjusted to a constant 150 and 300 days of age, respectively, with the following formula:

Wt. at 150 (300) days = (ADG X 150 (300) + birth wt.

The weights adjusted to 150 and 300 days of age were 16.2 and 22.6; 18.3 and 24.4; 14.9 and 21.5; and 16.9 and 24.5 kg for single born females, single born males, twin born females and twin born males, respectively. Average daily gain was 83.7+23.3 and 63.3+12.6; 93.0+26.3 and 67.1+14.0; 74.4+20.4 and 59.2+11.9; and 84.2+22.0 and 67.4+13.1 g/day for single born females, single born males, twin born females and twin born males, respectively.

Milk Production.

The number of goats milked by a single farmer ranged from one to 20 with a mean of 6.3 goats in 1986. Mean total daily production for all farmers in 1986 was 1.8 litres/day with a mean daily production per goat of 284 ml. The highest average daily production by a single goat was 960 ml during November 1986. Mean monthly production per farmer was 43.7 litres with a peak of 93 litres in December 1986. The highest total production by a single farmer in one month was in November 1986 when 10 goats produced 231 litres for an average of 802 ml/goat/day. This farmer took a total of 1388 litres of milk from his herd during 1986 in 274 recorded milking days, averaging five litres per day. Milk taken was in addition to the amount which was consumed by the kids. Kids are normally kept penned away from the herd and allowed to nurse twice daily, after the morning milking and again in the evening. If it is assumed that the milk taken from the goat is one-half of the daily production, the highest producing goats were yielding about two litres/day.

Information on length of lactation and production per lactation will be available at the end of 1987. However many goats have milked in excess of 180 days.

Farmers quit taking milk from their goats in April-May 1987 because of the catastrophic drought conditions. No rain fell on most farms after 1 January 1987 and no one supplementally fed their goats.

Goat Weights.

A total of 587 goats were tagged in the original weighing of the 20 herds. Initial herd size ranged from nine to 83 goats with a mean herd size of 29.4 goats. Goat numbers increased to 797 in October 1986 and slightly declined to 744 in May 1987.

Weights of 139, 184 and 173 mature female goats in May 1986, October 1986 and May 1987 were 38.3+5.0, 35.0+4.9 and 40.0+4.9 kg, respectively. Mature males numbered 3,6 and 8 and weighed 44.0+10.4, 39.7+8.2 and 43.6+9.9 kg, respectively. Weight losses during the dry season averaged about 10 percent in all age categories. However, most nannies were heavy in pregnancy when the end of the rainy season weights were taken, and actual body weight loss was not that severe.

The largest female weighed 55 kg, the largest male weighed 48 kg, and the largest castrated male weighed 52 kg, all age category 4, at the end of the rainy season in May 1986.

Marketing of Milk and Offtake.

Only two farmers reported selling goat milk and this was sold as "madila" in Francistown, at an average price of one Pula per litre. Farmers reported sales of 25 goats and slaughter of 12 goats for home consumption during 1986. Deaths of mature goats were reported as 19 and 9 goats were reported lost or stolen. Goat sales have increased in 1987, partially due to introduction of a marketing scheme.

SUMMARY AND CONCLUSIONS

An evaluation of the indigenous Tswana goat breed indicated that the genetic potential exists for improvement of both milk and meat production. Although no information exists on the heritability of traits in Tswana goats, the heterozygous nature of the population indicates that a high response to selection would be expected for traits such as growth rate, carcass desirability and milk production. Improved management should also decrease the high death rates of kids and improve overall productivity.

Although a number of problems were identified and possible interventions have been identified, the present management system requires few inputs other than labour and it is extremely difficult to find interventions that will improve the overall economic profitability of the goat enterprise. Only those interventions that have a low pula input are likely to be feasible, since farmers are reluctant to invest anything other than labour into the goat enterprise. The most promising areas are breeding programmes, kid management and herd health.

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GOAT AND SHEEP POPULATION CHANGES ON MASAI GROUP RANCH IN SOUTH-WESTERN KENYA, 1978-1986

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SUMMARY

Single round surveys of the same goat and sheep flocks at Elangata Wuas Group Ranch were undertaken in August 1978 and in August 1986. The proportion of goats in the flocks increased significantly from one phase to the next. Differences were noted in the proportions of sexes in the flocks, there being more castrates of both species in 1986 than in 1978. The average age of the flocks increased from 1978 to 1986, there being 30 per cent more adult female goats in the latter compared to the former year, the change in sheep in the same sex and age class being about 50 per cent. Both goats and sheep were bigger and heavier in 1986 than 1978, this being largely due to the change in age structure. Owners attitudes to small ruminant production and their assessment of the suitability of different years for small ruminant production are described.

INTRODUCTION

An earlier paper relating to group ranches (Wilson, 1978) noted that "the Masai group ranch project represents a traditional system undergoing development due to both internal and traditional influences and also to external interventions". As such it was considered an appropriate environment for studying several components -- animal sciences, socio-economics and ecology -- of livestock production systems.

An initial study was undertaken in August 1978 in response to these considerations. Fieldwork carried out at that time was considered to be of additional interest as it followed a prolonged dry period culminating in a severe drought in 1975/1976. Studies over a long period initiated in 1978 would then have provided "an opportunity to monitor the post-drought changes of the livestock ensemble, its effects on the grazing resource, and the social and economic consequences resulting from such changes" (Wilson, 1978).

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Only the animal production part of the protocol (and of that mainly the section relating to small ruminants) was pursued in any detail. Following further changes in priorities, fieldwork was terminated in early 1981. Contact was, however, maintained at an informal level with some owners. Drought succeeded drought and, by 1985/1986, herders were complaining of severe grazing shortage and drastic reductions in livestock numbers consequent on very poor rains in 1984/1985. At this stage it was considered that a rapid survey which would compare a "now" situation in August 1986 with a "then" one in August 1978 might provide useful information on changes in population structure and in livestock morphology over time. It was also hoped that some information from owners could be obtained on the reasons for any observed changes and on their attitudes to small ruminants.

MATERIALS AND METHODS

Elangata Wuas Ranch

The Elangata Wuas Group Ranch is situated between kajiado and Magadi in the Ledokalani section of kajiado District. The central point of the ranch is located at 1°50's, 36°35'E at an altitude of about 1500 m. By group ranch standards it is rather large, with about 60,000 ha. of land available for common use. In 1977 there were 415 registered members and the total human population of the ranch was estimated at 3320. According to a "census" carried out at the same time, the livestock population was given as 22,630 cattle and 5140 head of sheep and goats combined although it is probable that the small ruminant population was about 13,000 animals.

The ranch decreases in elevation from 1750 m in the east to 1150m in the west. The eastern area of the ranch is hilly, occasionally steeply sloping, and densely wooded. The western part is a succession of sandstone ridges alternating with grassy valleys on black-cotton soils. Average annual rainfall is in the region of 400 mm to 500 mm falling in two periods, principally in November to December and in March to May (Table 1). The carrying capacity is probably of the order of 80 kg/ha or one livestock unit (LSU) of 300 kg per 3.75 ha.

SURVEY METHODOLOGY

Livestock

Single round surveys were undertaken in august 1978 and again in August 1986 using the same field workers and the same flocks. the aims of both surveys were to establish the population structure by sex and age, the physical type and the average weights of specific sexes and ages of the goats and sheep present on the ranch.

Population structure was determined on the basics of dentition. Four principal classes of animals with permanent incisors were identified, these being those with 1, 2, 3 and 4 pairs respectively.

Table 1: Monthly and annual mean rainfall for 1974 to 1986 and long term annual means for two Kajiado district meteorological stations

	Station	
	Magadi	Sinya
Coordinates	1 53'S 36 17'E	1 40'S 36 50'E
Altitude (m)	733	2078
Rainfall (mm)		
January	39.4	30.2
February	42.0	43.0
March	60.4	59.6
April	127.8	153.9
May	61.4	75.2
June	3.3	9.9
July	6.7	9.3
August	1.7	5.4
September	7.7	11.5
October	14.6	24.7
November	48.4	95.5
December	42.8	62.9
Annual mean 1974-1986	452.7	581.1
Annual mean long term[1)]	420.4	618.5

Notes: 1) 1925-1972 for Magadi; 1963-1972 for Sinya

A subsidiary class of "4 pairs worn" was also used in an effort to establish the percentage of animals thought to be nearing the end of their productive life. Animals with decidous dentition (milk teeth) were assigned to six groups in the 1978 survey on the basis of teeth growth and attrition but were classed in one group only in the 1986 survey. Approximate ages for both species were estimated for the initial analysis of the 1978 survey from the figures provided by Starke and Fretorious (1955) for Blackhead Persian sheep. Following the second round, ages for both surveys have been estimated for each species separately using the data of Wilson and Durkin (1984).

Physical data collected included: measurements of height at shoulder, girth circumference, length of ears (all in centimetres); presence or absence of horns and toggles (wattles) by sex; and liveweight (in kilogrammes) after being penned for the night. Coat colour was noted and degree of hairiness. Tail type was noted in sheep.

Growth curves were calculated for sex and age using the same age classes as for population structure. the average weight of each class was plotted at the mid-point of the age group.

Socio-economics

During the August 1986 survey a questionnaire was used to obtain data from and attitudes of owners on various aspects of small ruminant husbandry.

The questions asked included an estimate of the number of small ruminants, whether the species mix was achieved by directed efforts or occurred naturally, and what were the main reasons for keeping small ruminants. In addition owners were asked to estimate changes in total numbers of small ruminants and cattle in 1986 compared to 1978 and to try to indicate the principal causes of these changes.

The use of "exotic" blood was then explored as were attitudes towards multiple births. The principal problems associated with herding small ruminants and the relative merits of these in comparison to cattle were then established as was the use of purchased inputs. Farmers were finally asked to rank the years 1978 to 1986 on a 5-point scale from very bad to very good.

RESULTS

Total Numbers and Species Mix

The original survey of 1978 included nine flocks comprising 1101 goats and 547 sheep, a total of 1648 animals. All nine flocks kept sheep whilst only seven kept goats. In 1986 the flocks had been fragmented so that there was a total of 15 flocks with only four of the original nine not having split into subgroups. These 15 flocks now comprised 1535 animals of which 1099 were goats and 436 were sheep. Twelve of the 1986 flocks had goats and 11 had sheep. Goats were 66.9 per cent of total animals in 1978 but were 71.6 per cent in 1986.

It appeared that there had been a slight reduction in total numbers over the 8-year period. There was a significant increase ($X = 9.05$, d.f.= 1, $P < 0.01$) in the numbers of goats compared to sheep. Only two (13 per cent) of the 15 respondents in the questionnaire survey stated that they made serious attempts to manipulate species mix, the remaining 13 (87 per cent) considering that the differing proportions occurred naturally. There was, however, an apparent perhaps unconscious preference for goats over sheep in the latter year, this being supported by the greater number of flocks with goats than with sheep and with four flocks herding only goats compared with no flocks herding only goats in 1978. In 1978 two of nine flocks herded only sheep.

Disease was cited twice as often (six times) as drought as the principal reason for reduction in flock numbers, although, it should be remembered that the real reason for reduction in the majority of cases of lowered flock numbers was splitting into sub-units. Where animal numbers increased, it was considered that management was responsible in two cases and the natural reproductive process was cited on three occasions. Purchases of stock were also cited as reasons for increases in number. In response to the same questions in relation to cattle most increases were attributed to purchases, including the provision of a loan though the Agricultural Finance Corporation. Families that owned greatest numbers of cattle owned, in general, greater numbers of small ruminants (Table 2).

Table 2: Relationships between sizes of cattle and small ruminant holdings in 1986 (%of owners)

	Cattle numbers owned	
Small Ruminant numbers owned	< 25 head	> 25 head
< 15	33	11
16-35	11	6
36-75	5	19
> 75	1	14

Population Structure

Sex

The distribution of sexes within the total numbers of each species for 1978 and 1986 is shown in Table 3. There were significant differences between the phases for both goats

Table 3: Composition (%) by sex of goat and sheep flocks in 1978 and 1986

			Sex		
Species	Year	Number of animals	Male	Castrate	Female
Goats	1978	1101	23.5	10.1	66.5
	1986	1099	17.5	18.7	63.9
Sheep	1978	547	16.1	15.4	68.6
	1986	436	10.6	20.2	69.3

(X^2 = 38.6, d.f. = 2, $p < 0.01$) and sheep (X^2 = 8.7, d.f. = 2, $p < 0.05$.

The differences in goats were due to a relatively greater proportion of castrates in the flocks in 1986, there being a similar, though less marked, change in sheep.

Age

There were significant changes between phases in the age structure of goats (X^2 = 15.2, d.f. = 5, $p < 0.01$) and of sheep (X^2 = 17.8, d.f. = 5, $p < 0.01$) (Table 4).

In both goats and sheep there were more animals in the class of age with four pairs of permanent incisors in 1986 compared with 1978. The difference was much more marked in sheep with an increase of 50 per cent in this age class in 1986 over the earlier survey: in goats the relative change was of the order of 30 per cent. The increase in older sheep had been mainly, recruited from the immature age class under 15 months, possibly indicating a reduction in breeding performance in this species over the period 1984 and 1985.

Table 4: Composition (%) by age of goat and sheep flocks in 1978 and 1986

			Age					
				Permanent incisors (pairs)				
Species	Year	Number of animals	Temporary Incisors	1	2	3	4	aged
Goats	1978	1101	46.2	10.3	6.8	11.4	22.7	2.5
	1986	1099	45.3	10.8	5.5	8.0	28.2	2.2
Sheep	1978	547	45.7	12.4	7.3	7.9	22.9	3.8
	1986	436	36.9	10.8	6.7	7.3	34.9	3.4

By way of contrast, immature goats were found in approximately the same proportions at both phases of the study, the greater contribution of mature goats to total flock numbers being achieved by recruitment of small numbers from each of the other age classes. It can thus be assumed that goats had maintained a similar level of reproductive performance in the period preceeding August 1986 to that prior to August 1978.

Physical Characteristics

In the earlier paper (Wilson, 1978) it was stated that neither sheep nor goats could be considered phenotypically comparable to the Mushi sheep and Small East African goats described by Mason and Maule (1960). It was considered in 1978 that there had been considerable infusions of Blackhead Persian and Dorper blood into the sheep and of

Boran (Galla), Boer and some hornless European breed blood into the goats. The trend towards "exotic" blood appears to have continued over time in both goats and sheep but the use of European types in goats has almost entirely disappeared.

Out of 15 respondents, 12 had introduced exotic goats between 1978 and 1986, all of these being Galla type. Seven owners bought only males while five bought males and females. Only two owners bought from the national goat and sheep improvement programme at Naivasha, one of these also obtaining goats from the national range research station at Kiboko. Five other, mainly local, sources of goats were cited.

Only six owners introduced exotic sheep blood, four of these using Blackhead Persian and two using Dorpers: only one of these purchased at Naivasha. Five owners introduced only males and one introduced both males and females.

The main parameters of growth for both goats and sheep are illustrated in Figure 1.

Goats

A classification of goats into general types in the 1986 survey that 717 (65.2 per cent) were Small East African and Galla and 98 (8.9 per cent) were Galla.

Horns were absent in 35.0 per cent of goats in 1978 but by 1986 the proportion of animals without horns was only 17.1 per cent, this difference being significant (X^2 = 76.0, d.f. = 1, P < 0.001). The high frequency of animals without horns in the first survey was considered to be due in the main to exogenous blood. In contrast to 1978, when european breeds were quoted by the Masai as contributing to the gene pool, no mention of this was made in 1986 and it is probable that the greater influence of indigenous african breeds is responsible for a greater proportion of goats carrying horns. There was significant (X^2 = 5.7, d.f. = 1, p , 0.05) increase in the proportion of goats having toggles or wattles in 1986 (7.1 per cent) compared with 1978 (4.8 per cent), which is also probably due to the higher levels of African blood.

The shoulder height of full-mouthed females (four pairs permanent incisors) increased from 64 ± 3.2 cm (n = 239) in 1978 to 68 ± 5.4cm (n = 310) in 1986, the increase probably being due to a greater proportion of Galla blood in the flocks. Least-squares analysis indicated an overall increase in height of the flock)all ages and sexes combined) of about 1.8 cm from 62.8 to 64.6 cm from 1978 to 1986 ($F_{1,2103}$ = 12.9, p<0.001) but this was due to the changes in age structure in the flocks, the phase x age interaction not being significant $F_{5,2103}$ = 0.5, p > 0.05).

The girth of full-mouthed females increased from 72 ± 7.4 cm in 1986. Least-squares analysis again showed highly significant ($F_{1,2103}$ =27.0, p < 0.01) phase differences for all ages, all sexes and all

flocks combined between 1978 (67.1 cm) and 1986 (70.2). this difference, as for height, was principally due to the change in age structure, the phase x age interaction again nor being significant ($F_{5,2103}$ = 1.1, p > 0.05).

Mature females weighed 31.8 + 5.23 kg (n = 251) in 1978 against 38.3 + 8.5 kg (n = 175) in 1986. The mean population weight (MPW =average weight per head of all animals in the flock irrespective of age and sex) increased from 21.2 kg to 23.2 kg over the eight-year period. Least-squares analysis showed this increase to be significant ($F_{1,1853}$ = 21.7, p< 0.001).

Sheep

In 1986 the flocks comprised 347 (79.6 per cent) animals of red Masai type, 36 (8.3 per cent) exhibiting the major characteristics of the Blackhead Persian x Red Masai, 15 (3.4 per cent) were Dorper x Red Masai, 12 (2.7 per cent) were Blackhead Persian x Dorper and 2 (0.2 per cent) were Dorper.

There were no significant differences (X^2 = 2.1, d.f. = 1, P < 0.05) between the first (12.4 per cent) and second (15.8 per cent) phases in the proportions of sheep with horns. Horns were found mainly in males in both surveys. The significant increase (X^2 = 44.8, d.f. = 1, P < 0.001) in the proportion of sheep carrying wattles in 1986 (32.3 per cent) compared to 1978 (15.5 per cent) has no apparent explanation.

Shoulder heights of full-mouth females were 66+3.4 cm (n = 131) in 1978 and were 66+3.9 cm (n = 152) in 1986. Least squares analysis showed that the average shoulder height of the whole flock did not differ ($F_{1,966}$ = 0.02, P > 0.05) between phase one and phase two.

The girth of adult females in 1978 was 77+4.4 cm and was 815.9 cm in 1986. The average girth measurement of the whole flock did not differ ($F_{1,966}$ = 1.47, P > 0.05) between phases.

Adult ewes weighed 32.5+4.55 kg (n = 131) in 1978 against 36.9+7.48 kg (n = 97) in 1986. There was a slight increase in MPW ($F_{1,861}$ = 4.70, P < 0.05) from 30.1 kg in 1978 to 31.9 kg in 1986.

Management

Almost half, seven out of 15 owners, considered that there were advantages in goats having twins and the same numbers (and six of the same respondents) considered that there were advantages to ewes giving twin lambs. All positive responses for goats considered that twins were advantageous in enabling flock size to be increased rapidly. Of the positive responses to twinning in goats, four also saw disadvantages in hat the dam was overstressed and two considered that dams had too little milk to rear twins while two proponents of twins did not perceive any disadvantages. The opponents of twinning cited lack of milk (seven), stress on dam (three) and no milk left for human

consumption (one). The response pattern for owners in relation to sheep was very similar but one owner stressed that twin lamb survival in the dry season was very low.

Only one owner sold small ruminants regularly, seven sold occasionally, one sold rarely and two provided no reply.

The major problems associated with small ruminant production were: disease (14 responses); lack of management skills (8); inadequate reproductive performance (4); and poor marketing channels (2). The major inputs considered to be needed were rated as in Table 5.

Table 5: Inputs required for small ruminants

Rank (n=14)	Proprietory drugs	Tick control	Mineral supplement	Traditional medicines
1	7	6	1	0
2	6	6	2	0
3	1	2	11	0
4	0	0	0	14
$\bar{x}$	1.6	1.7	2.7	4.0

Most owners considered that climate in the Elangata Wuas area was the proximate factor influencing the productivity and dynamics of small ruminant flocks. Between 1978 and 1986 years were rated from very good to very bad. Figure 2 shows the impressions that owners had of these years in relation to recorded rainfall.

Economic Importance

Most households reared small ruminants to supply the household requirement for meat (Figure 3). Most goat offtake was related to current needs for animal protein. In contrast, although the use of sheep for home consumption was very similar overall to that of goats, fat sheep were slaughtered in about equal proportions to all other sheep specifically following childbirth. Hospitality was the second most important use of goats, while gifts of live animals was an important reason for the keeping of sheep. Ritual sacrifices were fairly common in sheep, goats not being used at all for this purpose and the use of sheep to purchase wives was also more common that the use of goats. Goats were kept in a minority of cases to provide milk for the household but the inability of sheep to produce more milk that that required to ensure lamb survival is clearly demonstrated. Cash income or the use of small ruminants to reconstitute cattle herds appear to have low importance.

CONCLUSIONS

Goats and sheep appear to be able to withstand the effects of poor rainfall or to recover very rapidly from such effects. Numbers of animals in this study, at about 18 months after a year of very poor rainfall, were similar on two occasions in 1978 and in 1986. The goat population increased relative to sheep over the period and most owners attributed this to natural, rather that to human, influences. The average age of animals in the flocks, as indicated by population structure, increased between the two phases of the survey: this was possibly due to reduced reproductive performance or higher mortality of young stock. Goat population structure was more similar in 1986 compared to 1978 that was sheep age structure and, in particular, there were fewer young sheep (< 15 months) in the 1986 survey than in the 1978 one.

Average shoulder height and girth circumference of both species increased over the period but this was due mainly to changes in age structure. Mean weights of mature females also increased although real changes were small: it is possible that continued use of "exotic" breeds was responsible for these weight changes but it was subjectively noted in 1986 that animals were in exceptionally good condition and this may have been due, at least in the case of sheep, to reduced stress from a lowered reproductive performance; or it may have been due to within-season differences in actual rainfall and thus the pattern of vegetative growth between the two phases.

More small ruminants were owned by families which also had most cattle. It would not, therefore, appear that small ruminants are kept by this particular group of Masai in order to reconstitute cattle numbers. This hypothesis is confirmed by the replies provided to the questionnaire. Small ruminants are principally kept to supply demands by the household for meat, while cattle are kept to supply milk and to provide income.

The Masai are good judges of the value of individual years for animal productivity, at least if rainfall patterns can be considered to reflect consequent primary productivity in this environment.

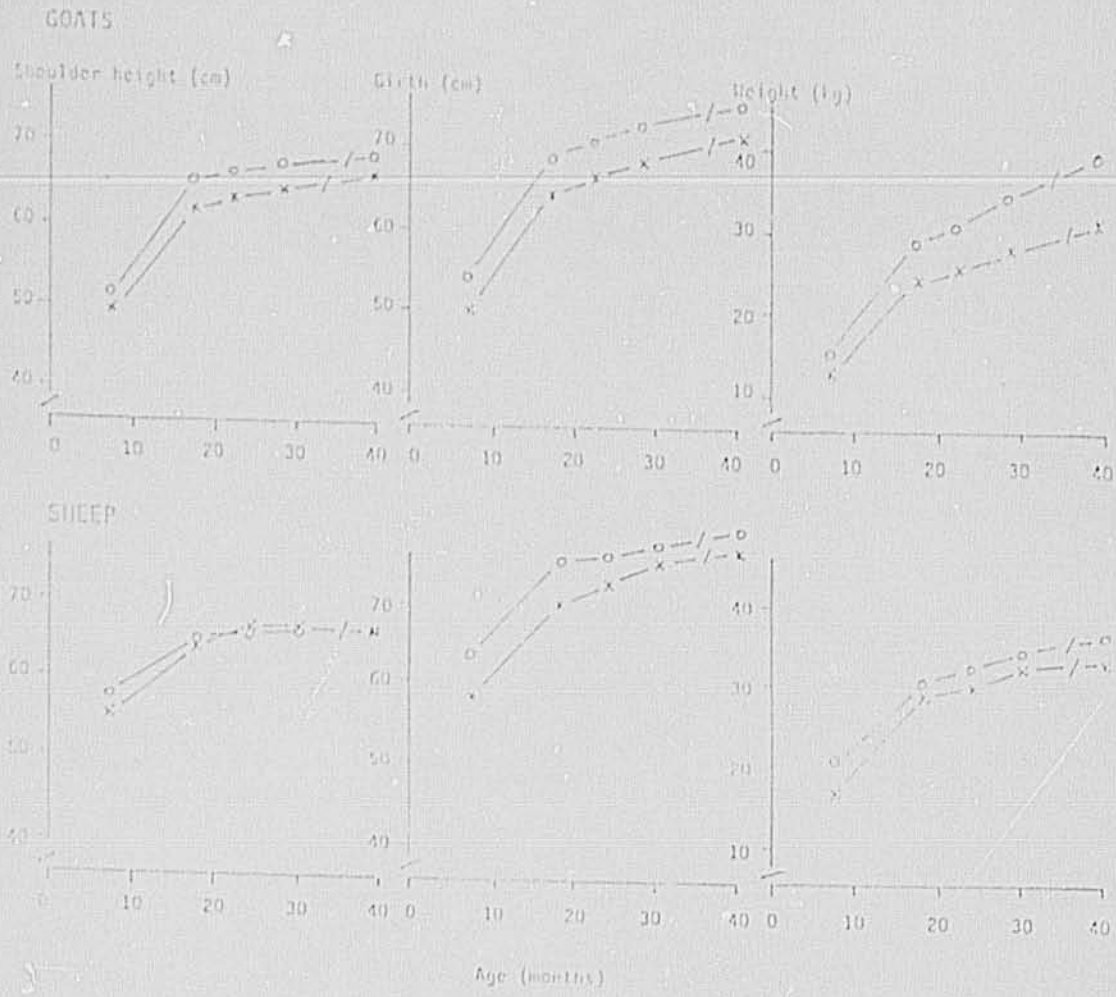

Figure 11. Major characters of growth for Kiangata Wuma goats and sheep in 1978 (x - - -x) and 1986 (o - - - o)

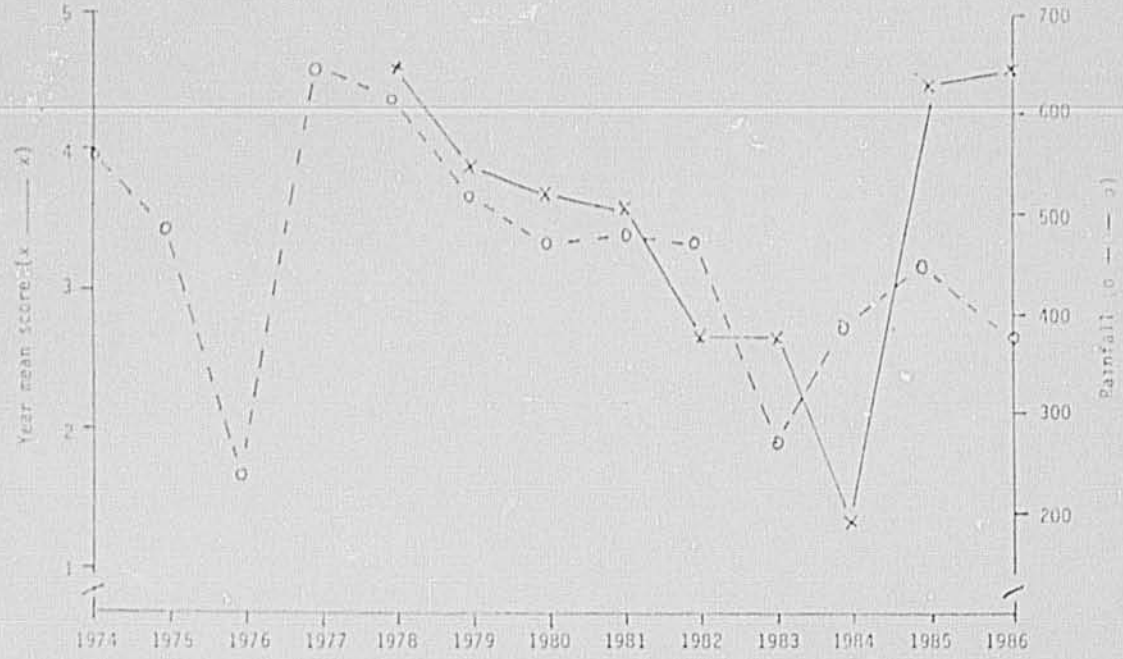

Figure 2: Owner assessment of year values for small ruminant production and a comparison with annual rainfall at Magadi

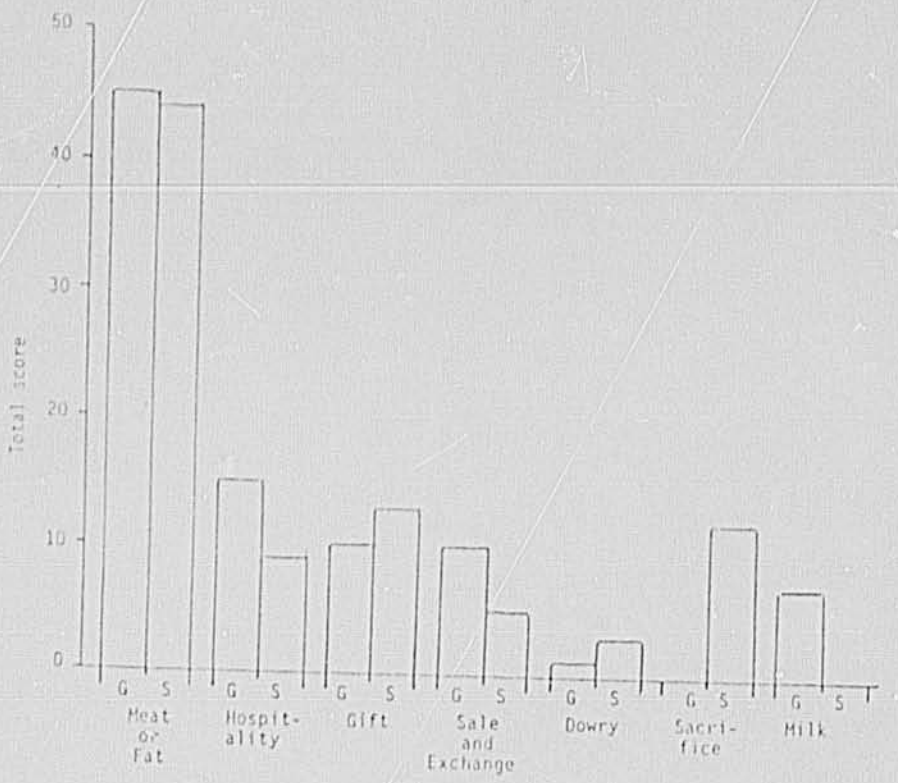

Figure 3: Relative socio-economic importance of goats and sheep at Elangata Wuas

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THE COST OF TICK CONTROL IN MAASAI HERDS IN EASTERN KAJIADO DISTRICT, KENYA

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INTRODUCTION

Dipping of livestock as a means to control tick-borne disease has been an integral part of livestock development in Kajiado District. In both phases of Kenya Livestock Development Project (KLPD), development loans were allocated for dip construction. Both commercial firms and the veterinary service assisted in acaricide supplies and maintenance of dips and their acaricide strength. Part of the rationale was that Maasai were encouraged to get improved bucks for crossbreeding (Sahiwal, Boran) and the purchase of steers from the North, the survival of which was only possible with regular dipping. Agricultural Finance Corporation (AFC) would not finance steer fattening without the assurance of efficient and regular dipping.

Since the early 1980's many dips have fallen in disuse (Grandin 1981) and hand-spraying has become a common practice (Peacock, 1984). Also, the need for rigorous tick control in the more semi-arid parts of Kajiado has been questioned on the grounds that it reduces the chances of young stock to develop partial immunity and that the tick challenge was not sufficiently high to warrant high expenditures on its control (Tarchel, 1987).

To throw some light on this somewhat controversial situation, it seemed justified to analyse the tick control practices in three group ranches in E. Kajiado located along a gradient from 550-300 mm of annual rainfall. The paper will describe tick distribution and its potential risk as a disease vector, annual expenditures on dipping and spraying as incurred by Maasai households in relation to herd size and location. Attention will be given to the shift from dipping to hand-spraying and the implications for the efficiency of tick control.

METHODS OF DATA COLLECTION

As part of ILCA's studies of the Maasai Livestock Production System, a general disease survey was carried out from September 1982 to May 1983, involving forty households in the three group ranches. Some 1200 cattle and 1000 smallstock were subjected to a rigorous assessment of their health status including comprehensive tests for disease incidence, as described in Waghela *et al* (1983). During this survey tick counts were done on close to 900 cattle and some 1200 ticks were identified by species to determine the frequency distribution of the major species.

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In 70 households, expenditure on health care inputs were collected over 17 months from September 1981 to February 1983. Monthly visits were paid to each household by trained enumerators using questionnaires. In addition to expenditure on health care, data collected on mortality, disease incidence, cause of death, frequency of spraying and dipping (Peacock, 1984; ILCA 1981).

Following the change from dipping to hand-spraying in mid 1980's, a survey was conducted in 1986 to determine the procedures and costs of hand-spraying operations. In total 55 groups of animals were involved (24 groups of adult cattle, 18 of calves and weaners and 13 of smallstock) in both Olkarkar and Mbirikani group ranches. The recording included costs in time and labour, water and acaricide use (de Leeuw and Ole Pasha, 1986).

RESULTS

Tick Distribution and Burdens

The incidence of tick-borne disease was low; from 600 examinations of blood smears of cattle, 20 (3.3%) were positive for anaplasmosis, one for babesia and 21 (3.5%) for Theileria, while the latter was found in 5.3% of the 500 lymph-node smears analysed. Some of the cattle that were positive for Theileria were found in Mbirikani after their return from the Chyulu hills further south to which they migrated during the minor drought in 1982.

The tick distribution in the 3 ranches was not statistically different; *R. evertsi*, *R. pulchellus* and *A. gemma* accounted for 88-94% of the total collected (table 1). *R. appendiculatus* which is the major carrier of Theileria was rare in all ranches. This distribution is consistent with data presented by Newson and Punyua (1978) for a similar environment in Western Kajiado.

Tick burdens were generally low, less than 5 ticks per head accounting for 58 to 73% of the total (table 2). Tick burdens were highest in the driest ranch Mbirikani, probably because the survey was done during September - November 1982 at the end of a minor drought and the beginning of the heavy short rains that broke towards the end of October, resulting in a rapid increase in tick infestation (which also caused a serious outbreak of Nairobi Sheep Disease (Peacock 1984; ILCA 1988).

Cost of Acaricides during 1981-83

The cost of acaricides as calculated from reported questionnaire data varied from 19 Ksh/TLU for medium-sized producers in Olkarkar to 1.4 Ksh/TLU for large-scale operators in Merushi group ranch (table 3). Total annual cost per household was in the order of KSh. 170-250 for small herds, Ksh.650-1150 for medium-sized herds and KSh. 800-2400 for large herds. On average, expenditure in Olkarkar was higher than in the other ranches mainly because producers recognised the risk of East Coast Fever (ECF) in this relatively high rainfall area and as a

result had a dip that was functioning most of the time in contrast to the situation in Merueshi and Mbirikani. Expenditures of the owners with smaller herds fell within a narrow range, but producers with large herds in Merueshi spend much less than those in Olkarkar and Mbirikani. This is due to the break-down of the dip and the inability of some of the very large herd owners (there were 3 sample herds with over 100 herds each) to organise hand-spraying due to their unwillingness to incur a high outlay of money on acaricide.

In the two Northern group ranches, Olkarkar and Merueshi, the expenditure on acaricide alone accounted for about 70% of all the cash outlay on livestock production which included drugs (mainly antihelmintics and antibiotics) and salt. In Mbirikani these costs were only 38% of the total due to a much higher outlay on antibiotic drug purchases (Peacock 1984)

Cost of Acaricides in Hand-spraying

The main characteristic of tick control by hand-spraying is that it is labour intensive and low volume. The high demand for labour derives from the number of operations that are required, such as separating the herd into small groups (up to 45 mature cattle, up to 75 calves, up to 150 smallstock), driving them to the enclosure, guarding the entrance to prevent escape, collecting water for spraying, mixing the spray solution, pumping and spraying and finally segregating and guarding the animals to be sprayed and those that have been sprayed. As a result, at least 3 herders, two spray operators and one water carrier are required. Although the time of spraying depended on the skill and endurance of the operators, it was fairly uniform; it ranged from 0.6-0.7 hrs for groups of cattle and calves and 0.4-0.6 per group of small stock.[1] To spray a herd of 200 adult cattle took at least 24 man hours during a span of c.4 hours.

The amount of spray-solution applied was low and increased with animal body size from 0.5 l for smallstock to 1.4 l for adult cattle. Although proportion of solution landed on the upper parts as it is difficult to in a fully packed enclosure.

The two major acaricides used were Delnav DFF, used mostly in Olkarkar and Coopertox predominantly in Mbirikani (and allegedly purchased in Tanzania). Delnav DFF was applied either at the recommended solution of 0.05% or double this strength[2]. Coopertox was applied at the recommended rate of 0.2% and occasionally at 0.3%.

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1) The Gloria pump imported by Welcome is foot-operated and has two spray-handles and therefore needed three operators. It was 30-40% faster than the upright stirrup pump but required 20% more labour (de Leeuw and Ole Pasha, 1986)

2) Operators in Olkarkar sprayed mainly at 0.05% and those in the adjacent Kiboko Ranch at 0.1%. The reason for this difference was not clear.

The cost for a single application depended on the type of acaricides, its concentration and the amount of solution per head. At the recommended rate Coopertox (at Nairobi price) was 50% more expensive than Delnav DFF the latter costing Ksh.0.26 for adult cattle and Ksh. 0.09 for smallstock (table 5).

The other major cost element is the frequency of spraying. Although most Maasai herd owners in Olkarkar, when questioned stated that weekly spraying is practised during the rains tailing off to every 3 weeks during dry seasons, such a regime would result in c.30 operations per year. This frequency is much higher than that recorded in 1981-83, which was 13 operations per year in Olkarkar consisting mainly of dipping and 16 in Mbirikani mainly by hand-spraying (Peacock 1984,p.244). To indicate potential costs three likely spraying regimes have been listed in table 6 resulting in 18, 32 and 40 operations per annum. Using the recorded quantities of spray-solutions from table 4 and the recommended concentration of Delnav (DFF), total annual cost for different classes of stock and frequencies was calculated. This implies that a medium-sized producer with 100 cattle and 100 smallstock spraying 32 times a year would spend to Ksh.2200 per annum (or Ksh.27/TLU) per year reducing these costs to Ksh.1200 or 15 Ksh/TLU at a lower frequency of 18 times per year. At 2 hours per operation a total of 216 man-hours per year would be required at this lower frequency.

DISCUSSION

Based on the surveys carried out in 1982-3, it is evident that Eastern Kajiado is an area of low thick challenge and the risk of tick-borne disease is relatively small. In line with this low disease incidence, it is not surprising that in general dipping and spraying was infrequent (13-16 times per year) and that the urgency to keep local dips functional was slight.

Since AFC issued loans to ranch committees rather than to individual producers and insisted that steers be managed as separate units, the upkeep of dips was required as an essential pre-requisite for a loan agreement. At present AFC has changed its loan policy in that individuals can now purchase steers on loan and held responsible for their management including tick control. This change obviates the need for communally managed dips and has accelerated the change to hand-spraying.

The overall weighted mean of 69 households for dipping and acaricide costs was 965 Ksh out of a total expenditure of 9400 Ksh during 1981-3 (ILCA, 1988).

Evangelou (1984) provided estimate of acaricide (Delnav and Coopertox) use in liters per annum and also listed number of cattle and smallstock on each ranch. By converting total livestock into 250-kg unit (cattle - 0.7 TLU, Smallstock - 0.1 TLU), acaricide cost derived from table 5 were calculated.

Expenditure on dipping and acaricide was high when taken as a proportion of the total cash expenditure of the livestock enterprise, and comprised 10% of overall household expenditure for goods and services purchased from outside the system.

Acaricide cost of hand-spraying even at the low frequency of 18 times per annum are at least 50% higher than those recorded in 1981-3 but much lower than the cost of tick control incurred by individual ranchers. Evangelou (1984) recorded acaricide use by seven individual ranchers in Kajiado which averaged c.100 Ksh/TLU (range 70-170 Ksh) whereas in 5 ranches in Narok District (west of Kilgoris) these costs were 58 Ksh/TLU (range 10-114 Ksh)[4]. However, this high expenditure was believed justified because these ranches are located in higher rainfall areas and herds included susceptible breeds (Sahiwals, Boran and exotics).

Considering the low volume of solution applied at hand-spraying, its cost effectiveness may be questioned, in particular since a large proportion of the acaricide is unlikely to reach the parts of the body most infested with ticks. Tatchel (personal communication) recommended that for effective sprayed in enclosures.

To reduce costs and increase the effectiveness of hand-spraying, it is recommended that:

1. The frequency is geared to observe tick burdens which depends on the rainfall distribution and grazing location. Since Maasai managers inspect their animals almost daily, they have no problem with assessing such burdens.

2. Rather than increasing frequency, quantity of spray should be increased and applied only to the body parts most likely to be infested with ticks. Although this change will increase labour and cash per treatment it will reduce the frequency as a trade-off.

3. As hand-spraying is flexible and under direct control of manager, tick control can be geared to the differential need of animal classes. For instance, crossbreed cattle could be sprayed more frequently than pure Zebu, while the regimes for calves could be adapted to achieve maximum immunity against tick-borne diseases.

Table 1: Frequency distribution of major tick species in three group ranches

Species/Ranch	% of Total Collected			
	Olkarkar	Merueshi	Mbirikani	All
Rhipicephalus evertsi	25	19	17	21
R. pulchellus	37	48	50	44
R. appendiculatus	7	2	5	4
Amblyomma gemma	26	27	21	25
Others	5	4	7	6
(Total collected)	(515)	(508)	(210)	(1233)

Source: Waghela *et al* (1983 p. 57)

Table 2: Frequency of tick burdens per head of cattle in three group ranches

Number /head	% of total cattle sampled		
	Olkarkar	Merueshi	Mbirikani
Over 20	3	15	30
10 - 20	24	13	12
1 - 5	67	66	58
0	6	6	-
N sampled	(388)	(406)	(106)

Table 3: Cost of dipping and spraying in three group ranches by scale of producer (1981-1983)

(in Ksh per TLU annum)

	Small	Medium	Large	Weighted Mean
Olkarkar				
Cost (Ksh/TLU)	8.8	18.6	8.8	10.5
Herd size (TLU)	29	62	272	
Meruoshi				
Cost (Ksh/TLU)	6.5	8.3	1.4	2.5
Herd size (TLU)	32	79	558	
Mbirikani				
Cost (Ksh/TLU)	4.8	7.3	4.5	5.5
Herd size (TLU)	37	120	240	

Adapted from Peacock (1984,p. 338 and ILCA (1988,p.10)

Table 4: Water application by hand-spraying for two pump types for three age groups of cattle

(in l of water per head)

Pump Type	Local	Gloria
Adults	1.3 (7)	1.40 (10)
Weaners	0.85 (1)	0.74 (2)
Calves	0.88 (3)	1.36 (3)

Number of groups sprayed in parentheses

Table 5: Cost of Spray by Acaricide Type and Concentration for Different Stock Types

(Ksh/head/spraying operation)

		Adult Cattle	Calves & Weaners	Small stock
	Water (l/head)	1.4	1.0	0.05
Delnav (DFF	Conc. - 0.05%	0.26	0.19	0.09
	- 0.10%	0.52	0.38	0.19
Coopertox	Conc. - 0.20%	0.39	0.28	0.14
	0.30%	-	-	0.21

Prices: Delnay (DFF) - 375 Ksh/l
Coopertox - 140 Ksh/l

Table 6: Annual Cost for Three levels of spraying intensity by livestock class[1/]

Season	Month	Number of Treatments per Month Low	Medium	High
Dry/wet	October	1	2	3
Wet	November	2	3	4
Wet	December	2	4	4
Wet/dry	January	2	4	4
Dry	February	1	2	4
Dry/wet	March	1	2	3
Wet	April	2	4	4
Wet	May	2	3	4
Wet/dry	June	2	2	3
Dry	July	1	2	3
Dry	August	1	2	3
Dry	September	1	2	3
	Total	18	32	40
	Costs, Ksh/head/annum			
	Adult cattle	9.4	16.6	20.8
	Weaners/calves	6.8	12.2	15.2
	Smallstock	3.4	6.1	7.6

1/ 0.1% solution of Delnav (DFF), see table 5.

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FACTORS AFFECTING SURVIVAL IN ADULT DOES ON A SEMI ARID THORNBUSH SAVANNAH AT ISIOLO

C.K. Gachuiri[1], A.B. Carles[1] and H.J. Schwartz[1]

INTRODUCTION

Of Kenya's land mass, 80% is not suitable for agriculture. The pressure on the remaining 20% is getting high, due to high population growth, therefore production of food from the semi-arid areas has to be intensified to feed the increasing population.

At the present level of technology and infrastructure in the country, the only feasible way to produce food for human consumption from these areas is through domestic ruminants i.e. cattle, camels, sheep and goats.

Although sheep and goats are commonly herded together and receive identical management inputs, there is an increasing proportion of goats with increasing aridity of the environment, which indicates that goats are better adapted to the conditions of the arid rangeland.

Does play a very important part in maintaining a herd and increasing it's size. Their survival is, therefore, an important component of performance of the system. This implies that their mortality should be minimised.

This study examined factors which affect survival of does during a very dry period. This is important in that it is the surviving does after a drought that restore the herd.

MATERIALS AND METHODS.

Environment.

The studies were carried out at a research station situated on a holding ground of the Livestock Marketing Division near Isiolo, 300 km. north of Nairobi.

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The altitude is 1100 m.a.s.l. and the mean annual rainfall is 510 mm. in two rainy seasons (March to May and October to November). The soils are volcanic in origin with some alluvial flood plains along seasonal water courses. The main vegetation type is a thornbush savannah dominated by various *Acacia* species with a sparse ground cover of annual grasses, herbs and dwarf shrubs. Along the seasonal watercourses, *Acacia* woodland and dense bush dominated by *Grewia* species occur and perennial grassland is found on the flood plains.

Herd management

There are no fenced paddocks and animals are herded throughout the year. A normal grazing day starts at 0700hr, is interrupted for watering from a deep borehole which is a part of the station, with a midday rest between 1300hr and 1500hr and ends at 1800hr, when the animals return to the night enclosure.

The animals are drenched twice a year before the rains using Ranide and are vaccinated once a year against contagious caprine pleuropneumonia (CCPP). Injuries are treated as they occur and Pye Grease is applied to animals affected by ticks. Rock salt (which is easily available in the local markets) is supplied in the night enclosure.

About 75% of the adult deaths occurred over a relatively short period of time. This period was associated with the drought and therefore some characteristics were analysed to evaluate factors affecting survival during this drought. Since the studies were carried out in a dry area, survival during the dry period was considered to be very important . Due to the herd structure, males were very few, therefore only females were considered in this analysis.

The factors analysed were ;

Age

At the start of the dry period.

Weight

At the start of the dry period.

Weight change

Weight change for the survivors was calculated as the difference in weight at the start and end of the dry period. For non-survivors this was calculated as the change between the start of the dry period and time of death.

Reproductive status

This was a scale to represent the stress during the dry period due to reproduction, either lactation or pregnancy.

The scale took values from 0-40 in weeks. The value 0 was equivalent to sixteen weeks before the start of the dry season. All animals that kidded between point 0 and 40 were assigned a value on the scale equal to the number of weeks they kidded after the origin of the scale. All other animals not kidding over that period of 40 weeks were assigned 0 on the scale. Stress due to lactation was assumed to be minimal at 16 weeks since the highest stress is normally during the first sixteen weeks when most does are dry while others are drying off. The higher the number the more stress the animal had since it had kidded just before the dry season or during the dry season or immediately after.

ANALYSIS

For all the factors, both the linear and curvilinear effects were analysed.

Due to the binomial nature of the dependent variable, a two stage least squares procedure, where the regression model was fitted using the ordinary least squares in stage one; and for a weighted least square analysis weights were estimated using these results in stage two (Neter and Wasserman, 1974).

RESULTS AND DISCUSSION

The results indicate that the curvilinear component of age was significant ($P < 0.01$) but not the linear ($P > 0.05$). The weight, weight change and reproductive status were significant both linearly and curvilinearly ($P < 0.001$) (Table 1).

Age and weight change were both highly correlated with weight and since weight was more significant neither age nor weight change were considered any further. The correlation coefficient between weight and age was 0.72 ($P < 0.001$) while that between weight and weight change was -0.79 ($P < 0.001$).

The probability of survival falls as kidding approaches the onset of the drought, reaching the lowest value when kidding occurs around the onset of the drought and lactation is confined to the drought period.

Table 1. Weighted analysis of variance for factors affecting mortality in adults.

Source of variation	DF	Mean Square	F value	
Age linear	1	0.0465	1.50	
Age quadratic	1	0.1899	6.11	*
Weight linear	1	0.3853	12.40	***
Weight quadratic	1	0.3898	12.55	***
Reproductive status linear	1	1.2851	41.36	***
Reproductive status quadratic	1	1.2319	39.65	***
Weight change linear	1	0.9329	30.02	***
Weight change quadratic	1	0.6457	20.78	***
Error	107	0.0311		

* $P<0.05$, *** $P<0.001$

With kidding towards the end of the drought (and pregnancy throughout the drought period) the probability of survival is equivalent to that for does that were neither lactating nor pregnant during this period (although the latter all had low body weights).

The highest probability of survival was for those kidding just after the end of the drought. These were the does with highest body weight.

Light animals had a higher probability of survival but these were also the animals with no reproductive stress. Middle weight animals had lowest probability of survival but these were the same animals with the highest reproductive stress. Heavy animals though under some reproductive stress had a higher probability of survival.

The two most important factors affecting mortality in adults and immatures over the drought, from this study, were the body weight of

the animal at start of dry season and the reproductive stress the animal is exposed to during the dry period. However the reproductive stress was of relatively more importance than the weight.

Heavy animals were able to overcome the reproductive stress more than the average weight animals. All the light animals in the study were not under any reproductive stress since they were neither lactating nor pregnant. Heavy animals would be expected to survive better during the dry season since they have body reserves which they can utilise. Middle weight animals had a lower survival than light weight animals and this would be explained by the close relationship between reproductive stress and body weight. The middle weight animals were under reproductive stress while the light animals were not.

Reproductive stress referred to both lactation and pregnancy. The results indicate that animals kidding just before or at the start of the dry season, thus having their lactation over the dry period, had lower probability of survival than animals which were pregnant over the dry season and kidded at the end of the dry season. Since reproductive stress has a highly significant effect on survival we can assume that animals lactating over the dry period were more stressed. This observation would be important when considering seasonal mating. To reduce mortality does should be mated such that they do not kid before the onset of the rains. It must be pointed out that good forage condition during final stages of gestation is important to increase birth weight of the kids which increases their survival.

This conflict is of practical importance and a compromise between the two desirable effects should be attained. This is so because it is important that kids survive since they are the product of the system and also dams have to survive to nurse the kids and produce more kids.

One way of doing this would be to let does kid at the start of the wet season and supplement them during the last days of gestation to increase birth weight of kids. The other alternative is to let the does kid in the middle of the wet season and supplement them at the start of the dry season if they are still lactating heavily. Supplementation in this environment cannot be by commercial feeds (high protein and energy feeds) due to the economics and sometimes unavailability. It is however possible to plan grazing such that a portion near the homestead is preserved for these animals. Also the highly nutritious *Acacia* pods can be harvested and stored to be used as a supplement for these animals.

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A COMPARISON OF GOAT MORTALITY IN TWO PASTORAL HERDS IN KENYA

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INTRODUCTION

Until comparatively recently good estimates of the levels and causes of goat mortality in African pastoral systems have been very rare. Most frequently the best that has been available has been rather general impressions, and these have often been conflicting.

This situation has begun to change, with reports from both Eastern Africa (Wilson, Peacock, and Sayers; 1985) and Western Africa (Traore', 1985; and Wilson, 1986), although the latter tend to have been from agro-pastoral systems. Two recent studies in Northern Kenya have provided precise estimates of both levels and causes of mortality in typical pastoral areas. These two studies used very similar systems for the collection of data, and while they were both in pastoral areas, the vegetation types were deferent. This has enabled the two to be compared, which has revealed some interesting similarities, and some important differences.

MATERIALS AND METHODS

The first environment was at Ngurunit in Northern Kenya, in a semi-arid wooded dwarf shrubland, with a considerable bush component. The principal components were *Acacia tortilis, duosperma eremophilum,* and *Acacia bush.* The rainfall was bi-modal with a mean of 425 mm per annum and an altitude of 1000 m asl.

The second environment was situated in a semi-arid thornbush savannah, some 25 kms east of Isiolo in Northern Kenya. The rainfall was bimodal with a mean of 510 mm per annum and the altitude was 1100 m asl.

In both cases the foundation stock were selected from a population of Small East African goats in a similar environment. They were managed in the traditional system, with herding out during the day and returned to an enclosure for the night. In the first environment the herd was subdivided into two. The first group had no interventions to the traditional system of management. In the second there was an annual vaccination against contagious caprine pleuropneumonia, strategic dosing with an anthelmintic, and the provision of a mineral supplement in the night enclosure. In the second environment the whole herd was treated similarly to the previous second group.

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In both environments fortnightly records were taken of body weight, dentition, milk yield and forage condition, the latter being classified upon abundance and greenness of the herb layer. All births and deaths were recorded as they occurred.

Whenever possible a post-mortem examination was carried out on the death of an animal. Only very occasionally was a veterinarian present, and so the field staff were trained to carry out a systematic examination and description of the carcass, using a standard form. This enabled almost all post-mortem examinations to be made on fresh carcasses. The final diagnosis was made subsequently by a veterinarian.

The causes of death were then grouped as follows - "unknown" for those without any post-mortem examination, "doubtful" for those examined but where a diagnosis was not considered possible, "emaciation", "pneumonia", "parasites", "predators", and "miscellaneous" for a variety of sporadic conditions of low incidence.

RESULTS

A detailed analysis of the incidence of deaths at Ngurunit, using a log linear model, showed that the health program did not result in any significant decrease in mortality, and so for the purposes of the present study the two groups are treated together. The general levels of deaths for different age groups, for each location, is given in Table 1, from which can be seen that in both locations the level was high, but particularly so at Ngurunit. The normal pattern of decreasing mortality with increasing age, until the females enter the breeding stage, is shown at Isiolo. However at Ngurunit there is a remarkable reversal between the two youngest age groups, although at weaning (around 20 weeks of age) there is little difference between the two.

Table 2 gives the distribution of the deaths amongst the various causal categories. In general the similarities are more marked than the difference. Possibly the main difference is in the deaths due to parasites. The principal cause of this was due to a high incidence of coenuriasis at Ngurunit, which was only observed in two cases at Isiolo. The higher number of "unknown" cases at Isiolo was largely associated with a high incidence of deaths during a very severe drought at this location, for which there was not really a comparable year at Ngurunit. Likewise the cases of "emaciation" were all associated with this period.

The effect of age upon the incidence of the various causes is shown in Table 3. This shows more clearly that the effect of the drought at Isiolo was most severe for the breeding does. The main differences appear to be the age distribution of the pneumonias, parasitism, and the high incidence of deaths in the adults at Isiolo. While the similarities are the susceptibility of the post weaning stage to predation, and the tendency for the incidental conditions to be of the order of 10% in most age groups.

DISCUSSION

At Ngurunit the traditional system protects the very young kids in a basket like construction for about the first 6 weeks of life. The only release from this is for suckling twice a day. This is clearly most effective in decreasing mortality, but also results in very severe stunting, and must delay the processes of adaptation to the external environment. In fact at 6 weeks the weight has only doubled that at birth; whereas in the Maasai pastoral system this stage has usually been reached at 4 weeks (Peacock, 1984). However, by the stage of weaning, the effect of this practice was not beneficial, due to the very high levels of mortality on leaving the basket phase. This may have been biased by an acute epidemic of pneumonia at Ngurunit, before any vaccination cover was provided. A longer period of observation would be required before being able to adequately evaluate this situation.

The incidence of pneumonia at Isiolo was the reverse of that at Ngurunit, and was much more chronic, with adults appearing to breakdown to earlier infections, when under stress.

One of the most striking differences between these two environments was the incidence of coenuriasis, being high at Ngurunit but almost absent at Isiolo. The incidence of wild carnivores appeared to be similar, and the only difference that was observed that might have accounted for this was the incidence of domestic dogs, which were prevalent in the former, but rare in the latter.

The high incidence of death amongst the adults at Isiolo, was almost entirely confined to the does that were lactating at the time of the drought. Low body weight was not too serious providing it was not associated with either lactation or pregnancy. Lowest mortality was observed amongst does that entered the drought with moderate body condition, and did not conceive until around the end of the drought.

CONCLUSIONS

The general levels of mortality for these periods at Ngurunit and Isiolo were quite high, at 40 and 28% respectively; as usual this was most marked pre-weaning (24 and 15% respectively). The traditional system at Ngurunit, of protecting the kids up to 6 weeks of age in baskets, needs more thorough evaluation, particularly over the longer term. The severe drought at Isiolo clearly showed the dangers of lactation and late pregnancy at such a time, and the importance of adequate body reserves at the onset. The incidence of coenuriasis may indicate that the domestic dog is a much more important host of the adult tape worm, than is the wild carnivore.

Table 1: Proportionate incidence (%) of deaths amongst age groups and locations

Location	Age Group (wk) and % deaths					Total deaths
Ngurunit	0-3	4-21	22-53	>53	All	
	6	53	12	29	40	352
Isiolo	0-2	2-22	23-52	>52	All	
	30	23	14	33	28	296

Table 2: Proportionate incidence (%) of different causes of death amongst locations

Cause of death	Ngurunit	Isiolo
Unknown	44	61
Doubtful	14	3
Emaciation	-	7
Pneumonia	10	8
Parasites	11	2
Predators	16	14
Miscellaneous	5	5
	100	100

Table 3: Proportionate incidence (%) of different causes of death amongst locations and age groups (wks)

Death cause	Ngurunit				Isiolo		
	0-3	4-21	22-53	>53	0-22	23-52	>52
Unknown	75	51	24	34	98	8	21
Doubtful	-	24	12	-	2	-	7
Emaciation					-	8	18
Pneumonia		15	12	3	-	8	21
Parasites	-	2	17	27	-	-	7
Predators	12	8	24	27		67	14
Misc.	13		12	10	-	8	11
	100	100	101	101	100	99	99

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RESPIRATORY DISEASES OF GOATS AND SHEEP IN KENYA: AN OVERVIEW

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INTRODUCTION

Goat and sheep are important sources of red meat. Although the goats feed in the open during the day time, they have to be confined in enclosures at night to protect them against wild carnivores and rustlers. This system predisposes the animals to disease outbreaks, sometimes with serious losses.

The Diseases:

The pneumonic diseases of goats and sheep in Kenya fall into two major categories:

(1) Bacterial diseases

(a) *Pasteurella haemolytica* serotype A_1 (Mwangota *et al.*, 1978) which can be a major problem in both species.

(b) *Mycoplasma mycoides*, "strain F38" and *Mycoplasma mycoides* subspecies *capri*, mainly pathogenic for goats.

(c) *Corynebacterium pyogenes* and occasionally *Corynebacterium pseudotuberculosis*.

(2) Viral diseases - Slow (chronic) Progressive Lung Diseases.

(a) Progressive interstitial pneumonia caused by a retrovirus - maedi/Visna virus.

(b) Sheep pulmonary adenomatosis (SPA) a transmissible lung cancer, caused by a virus suspected to be a retrovirus - though still unable to grow it *in vitro*.

Both SPA and Maedi/Visna affect sheep over 3 years old and are endemic in most countries with substantial sheep population except Australasia. There is no clear evidence to date that goats suffer from the two diseases. The two diseases may be present in the same flock of sheep and can occur concurrently in individual animals.

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Pathological Aspects

Pneumonia associated with *Pasteurella haemolytica* and Mycoplasmal species is characterised by marked fibrinous exudation both in the lungs and the pleura. The two diseases cannot be differentiated on the basis of gross postmortem picture or even on histopathological picture. The histopathological variations are more related to the time it took the animals to die after showing signs of disease. In a number of cases fibrinous pericarditis may be encountered.

The pathological changes of Maedi/Visna are dependent on the stage of the disease. The lungs may either appear pale gray and emphysematous or heavier, weighing 4-5 times the normal weight and diffusely mottled with gray and brown consolidated areas. The lungs do not collapse when the thorax is opened. They have a dense, rubbery but less elastic consistency. In some cases all lobes have a uniform colour and consistency while in others, anterior lobes may show more prominent consolidation with the rest being emphysematous. The cut surface is usually dry. No exudate can be expressed. Mucus can be expressed from large brochioles and brochi in advanced cases. Pulmonary lymph nodes are usually enlarged and almost neoplastic. Microscopically Maedi/Visna shows increased thickness of interalveolar septa due to lymphocyte infiltration and extension of hyperplastic alveolar duct smooth muscle fibres. There is often lymphoid hyperplasia associated with bronchi, bronchioles and blood vessels. Alveolar spaces are empty. The changes are typical of interstitial pneumonia. In a few cases, there may be involvement of the brain, characterised by non-suppurative meningoencephalitis.

Sheep pulmonary adenomatosis (SPA) is essentially a lung cancer. Grossly the lesions start as several white and scattered foci, spreading throughout the lungs. They later fuse forming large gray-white fleshy lesions. Often the anterior lobes are involved first though cases spreading throughout the lung lobes may be encountered. The cut surface of affected lobes is wet. Histologically the neoplastic cells may be cuboidal, columnar and compacted together or as papilliform growths lining the alveoli, bronchioles or even bronchi. Ultrastructural studies have shown them to be type II alveolar cells. Occasionally there are metastases to pulmonary lymph nodes.

Diagnosis and Control

Sheep lungs with fibrinous pneumonia and pleurisy are almost certain to be due to *Pasteurella haemolytica*. Goat lungs with similar pathology need bacteriological culturing, even in cases of outbreaks, to differentiate between pasteurellosis and pneumonic mycoplasmosis, as both of them show similar clinical signs.

The slow infections of Maedi/Visna and SPA require histopathology for confirmatory diagnosis. However, there is profuse fluid production by the neoplastic lungs in cases of SPA which may be detected when one lifts the hind limbs. This finding is diagnostic, except in cases where there is concurrent infection with Maedi/Visna.

There is an effective vaccine against fibrinous pneumonia in goats caused by "strain F38" (Rurangirwa et al. 1987). Where outbreaks occur in an already vaccinated goat flock, most likely the cause could be other types of *Mycoplasma* or *Pasteurella haemolytica*. There is no suitable means of controlling pneumonic pasteurellosis in goats and sheep. Good management which keeps out stressing factors can be useful. Both Maedi/Visna and SPA have been known in Kenya since the 1920's (Wandera, 1971). The incidence has dropped from 20% on different large sheep farms to between 2-5%. This is largely due to culling.

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ALTERNATIVE APPROACH TO RESEARCH REPRODUCTIVE PROBLEMS OF SHEEP

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INTRODUCTION

Africa has about 192 million sheep and 155 million goats (FAO, 1985). About 103 millions of the sheep are located in the sub saharan region but are not evenly distributed. It is estimated that 35.7% are located in the arid, 22.2% in the semi-arid, 13.6% in the sub-humid, 7.9% in the humid and 20.6% in the highlands zone (Jahnke, 1982; Table 1).

Sheep are primarily raised for meat and skin production. Since they are often bigger than goats, their contribution to meat production tends to be higher. Most African sheep are covered by hair which is woven into carpets in some areas while specialized apparel wool production is mainly limited to some commercial enterprises. Sheep milk is only consumed in a quantity by a few pastoral societies. This presentation identifies some of the constraints to sheep production using the Ethiopian experience. Ethiopia has a small ruminant population of about 40 million (23 million and 17 million goats; FAO, 1985).

Eighty per cent of sheep in Ethiopia are concentrated on small scale holdings of peasant farmers in the highlands, areas above 1500m a.s.l (Amare, 1978). The highlands are heavily cropped and carry over 80% of the 27 million cattle and about 20% of the goats. In some areas, over 90% of the land available for cropping is cultivated annually with little tendency for any fallow.

Sheep are raised as an adjunct to crops and cattle production. Cattle are kept for the draught power oxen provided in crop cultivation and threshing (Mukasa-Mugerwa *et al.*, 1987a). Inventories range from 1 to 50 sheep. Livestock depend on pasture grazing and crop residues for feed. Specialized forage production and supplementary livestock feeding and animal health management are inadequate. All these factors contribute to depress productivity. The same situation is reported elsewhere. Average litter size in Africa is consequently low (Table 2).

Sheep reproduction is influenced by several genetic and environmental factors (Turner, 1966; MacFarlane, 1968). The breed between variation in reproductive rates principally arises from differences in ovulation rates the main determinant of fecundity. The physiological mechanisms involved are not very clear but, they probably depend on complex relationships between endogenous gonadotrophins and ovarian sensitivity to these hormones.

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Data collected in the vicinity of the ILCA station at Debra berhan showed that a number of ewes were producing twins more frequently in a population with an average litter size of only 1.04 and a twinning rate of just 4%. Efforts were initiated to select and produce a "prolific flock" similar to the Booroola gene in some Australian Merino sheep. Since ovulation rate is more heritable than litter size implying that the latter is more subject to environmental variation the problem was addressed before parturition.

A slaughterhouse study showed that over 70% of 608 ewes sampled over a year (Figure 1) were pregnant, and 24% of them with twins. This was higher than actual twinning rates of 4 to 10% reported under field conditions (Agyemang *et al.*, 1985). Pregnant sheep were slaughtered throughout the year indicating year-round breeding. We realised from the crown rump length (Noden and Lahunta, 1985) that most conceptions coincided with periods of better feed availability (Mukasa-Mugerwa and Tekelye, 1987). The observed disparity between pregnancy and parturition rates suggests high prenatal reproductive wastage.

An earlier production systems study undertaken in the Central highlands had shown that the average peasant had 7.2 livestock: 4.2 (range 1-14) cattle, 1.2 (1-17) sheep, one goat and an equine for transport purposes (Mukasa-Mugerwa *et al.*, 1987b). Their biomass equivalent was 1010 kg with an annual dry matter (DM) requirements of 9.3 t. Average land holding was only 2.5 ha. Available dry matter including what was derived from communal grazing pastures was calculated at only 6.2 t, or 67% of requirement. The quality of available DM was also very low.

The other important causes of reproductive wastage in sheep are systemic and genital diseases. Field experience has shown that campylobacteriosis (due to *Campylobacter fetus* var *intestinalis*), salmonellosis (due to *Salmonella abortus-ovis*), listeriosis, chlamydiosis (Enzootic abortion of ewes), toxoplasmosis and brucellosis are present in the Ethiopian population. Some of these diseases and others not presented here also cause lamb mortality which may reach 35% especially during the first few months of life (Njau *et al.*, 1987 and figure 2 and Table 3). The combined result is that fewer lambs are weaned per ewe per year, Figure 3.

OTHER POINTS TO CONSIDER

Several studies have demonstrated the advantages of supplementary feeding and proper health control. But, traditional farmers, who own the majority of the population, have limited resources. Under their production environment, nutritional inadequacy and poor health have to be averted through strategic supplementation and treatment. The challenge is for research to find out how this can be economically implemented.

Logical solutions, for the Ethiopian situation at least, have to take cognizance of three points. These are: (1) that livestock are an integral part of the rural farming system; (2) that the need to meet the food needs of a fast-growing human population is steadily encroaching on traditional grazing lands. Yet, although this might improve energy food supplies, livestock will continue as the backbone for meeting human protein needs (meat and milk), and (3) that cattle are usually given priority in traditional farming and are likely to benefit more from any specialized forage production or conservation than sheep.

THE PROPOSED APPROACH

The two problem areas where more information is required are prenatal reproductive wastages and lamb mortality. Activities need to be undertaken to find answers to the following:

1. For Reducing Prenatal Losses

1.1 To what extent do pregnancy rates differ from actual lambing rates?

1.2 What are the critical stages during gestation when prenatal losses occur?

1.3 What are the causes of prenatal reproductive wastages?

1.4 Can remedies be found?

1.5 What is the cost-effectiveness of the remedies prior to recommending them for introduction into the production systems.

2. For Reducing Lamb Mortality

2.1 What are the roles of early maternal environment and nutrition in lamb morbidity and mortality?

2.2 What are the major causes of peri and post-natal lamb morbidity and mortality?

2.3 Are remedies possible? and if so, what is the cost-effectiveness of the remedies? This is a prerequisite prior to recommending these remedies for introduction into the traditional farming systems.

Research will have to be undertaken in a multi-disciplinary manner. For lack of time only the role of the Animal Reproduction and Health Section of ILCA will be highlighted. Our work is being undertaken at the Addis Ababa abattoir, the ILCA research stations and on animals owned by, peasant farmers. We are or will shortly be:

1. studying the progesterone profiles of Ethiopian indigenous sheep over the oestrous cycle to establish minimum levels that could be used in pregnancy diagnosis.

2. assessing if progesterone, alone or combined with esterone sulphate, can accurately be used for pregnancy diagnosis and litter size determination.

3. quantifying ovulation, fertilization, implantation and early embryonic rates in indigenous sheep and establishing the role of nutrition, disease (in particular endoparasites), breed and season.

4. assessing the possible use of glucose, alone or in combination with B-hydroxybutyrate, to predict by 90-120 days of gestation ewes likely to produce lambs that may suffer early lamb morbidity and mortality.

5. determining the effect of dam nutrition and health management on the survival and subsequent performance of the lambs.

6. finding out if early lamb weaning strategies can be developed to allow dams chance to recoup, cycle and reconceive (self flushing) during periods when rains improve the natural pastures.

FINAL REMARKS

Are we moving in the right direction, i.e., is this a viable alternative for research into the reproductive problems of sheep? Is there a need for the simultaneous performance of this work in different locations? If so, are there willing partners?

Table 1: Ruminant livestock population by species and ecological zones

Ecological zone	Cattle 1,000 (%)	Sheep 1,000 (%)	Goats 1,000 (%)	Ruminants 1,000[1] (%)
Arid	31 462 (21.3)	37 063 (35.7)	48 287 (38.6)	41 697 (30.4)
Semi-arid	45 454 (30.8)	27 071 (22.2)	33 215 (26.5)	37 446 (27.3)
Sub-humid	32 758 (22.2)	14 153 (13.6)	20 266 (16.2)	26 370 (19.2)
Humid	8 814 (6.0)	8 177 (7.9)	11 586 (9.2)	8 148 (5.9)
Highlands	29 022 (19.7)	21 401 (20.6)	11 933 (9.5)	23 646 (17.2)
Total	147 510 (100.0)	103 865 (100.0)	125 287 (100.0)	137 308 (100.0)

1 = Including camels

Source: Jahnke, 1982

Table 2: Litter size of sheep in the tropics.

Breed	Location	S	Source
Abyssinian	Ethiopia	1.05	Wilson 1982
Highland	Ethiopia	1.04	Agyemang *et al.*, 1985
Awassi	Egypt	1.12	El-Wishy *et al.*, 1971
Baggara	Sudan	1.14	Wilson 1982
Barki	Egypt	1.05	Aboul-Naga 1976
Bornu	Mali	1.05	Wilson 1982
Desert Sudanese	Sudan	1.30	Suliman *et al.*, 1978
Dorper	Botswana	1.10	Botswana 1978
Fulani	Chad	1.07	Dumas 1980
Masai	Kenya	1.02	Wilson 1982
Maure	Chad	1.02	Dumas 1980
Maure	Chad	1.07	Wilson 1982
Mayo-Kebbi	Chad	1.64	Dumas 1980
Nungua Blackhead	Ghana	1.41	Asiedu and Appiah 1983
Ossimi	Egypt	1.14	El-Wishy *et al.*, 1971
West African	Venezuela	1.43	Bodisco *et al.*, 1973
West African	Ghana	1.29	Asiedu and Appiah 1983
West African	Ivory Coast	1.00-1.31	Gerger and Ginisty 1980
West African	Chad	1.24-1.53	Dumas 1980
West African	Togo	1.49	Amegee 1983
Abyssinian	Ethiopia	1.24	Mukasa and Tekelye 1987
Yankasa	Nigeria	1.23	Molokwu and Umunna 1980
West African	Ghana	1.64	Ngere and Aboagye 1981

Table 3: Age specific cause of ovine mortality at Debre Berhan, 1982 - 1987

Cause	No. of animals	% of total	Average age months	Range
Fascioliasis	471	45.86	17.47	6.87-49.57
Perinatal mortality*	219	21.86	0.06	<0.03-00.10
Mismothering/starvations	143	13.92	1.08	0.13- 2.73
Coenurosis	67	6.52	13.34	7.03-24.00
Pneumonia	26	2.53	11.24	1.00-31.50
Unknown	23	2.24	15.71	0.03-23.00
Diarrhoea	20	1.94	2.75	0.30- 8.67
Accident	15	1.46	4.39	0.03- 7.23
Bloat	9	0.88	16.89	5.00-41.00
Abomasal impaction	9	0.88	0.98	0.17- 2.40
G.I. parasites	7	0.68	5.2	0.80-14.57
Congenital defects	4	0.40	3.53	0.03- 8.23
Pulpy kidney disease	4	0.40	4.44	2.50-11.25
Lung worms	3	0.29	NA	
Swayback	3	0.29	5.95	3.80- 8.30
Lactic acidosis	2	0.19	4.87	4.67- 5.07
Predation	1	0.10	NA	
Dystocia	1	0.10	NA	
	1027	100.00		

*Stillbirths + abortions included
NA - Not available

Figure 1 Main sources of supply of highland sheep to Addis Ababa

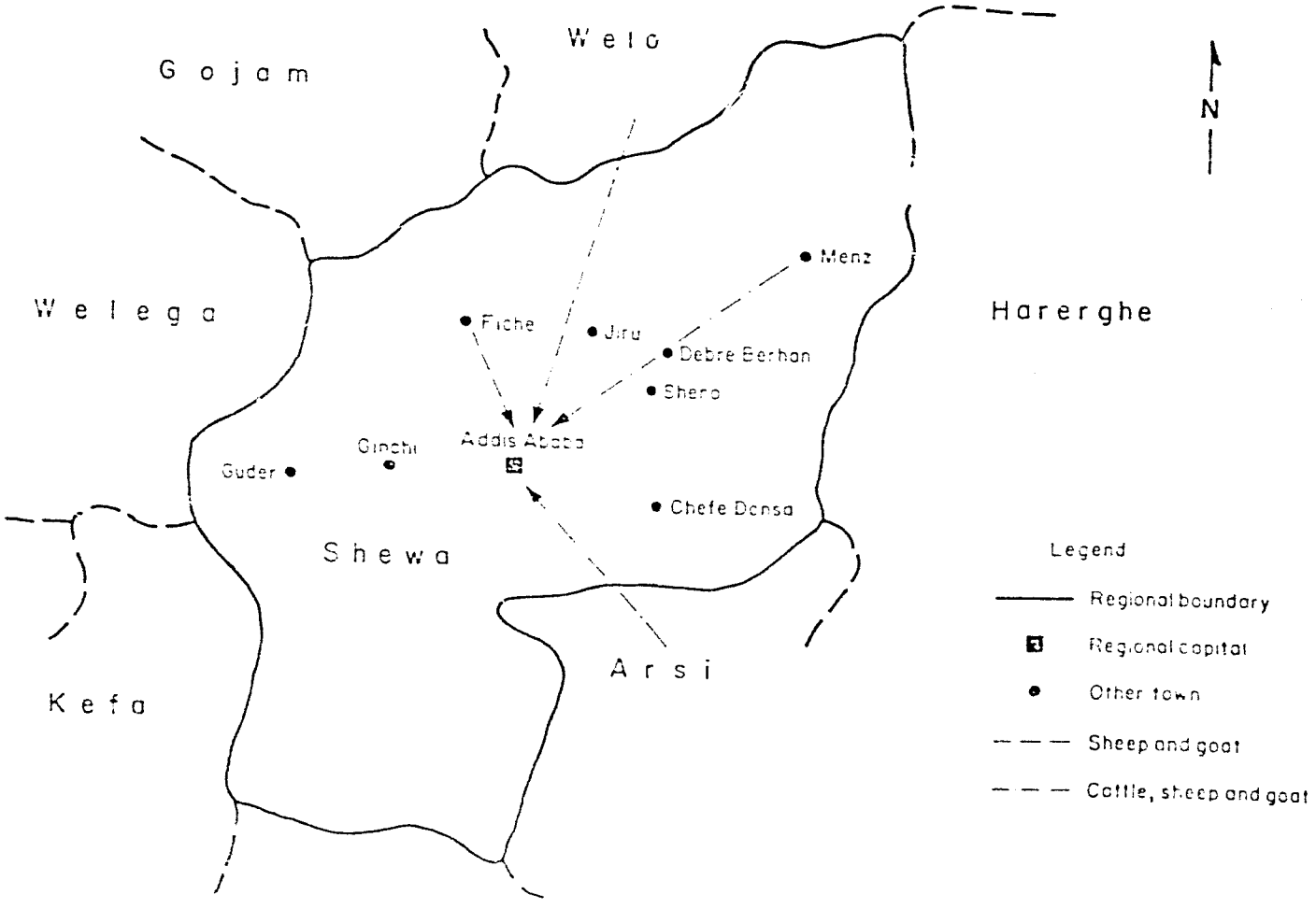


Figure 2:

Schematic of causes of poor reproductive performance of sheep

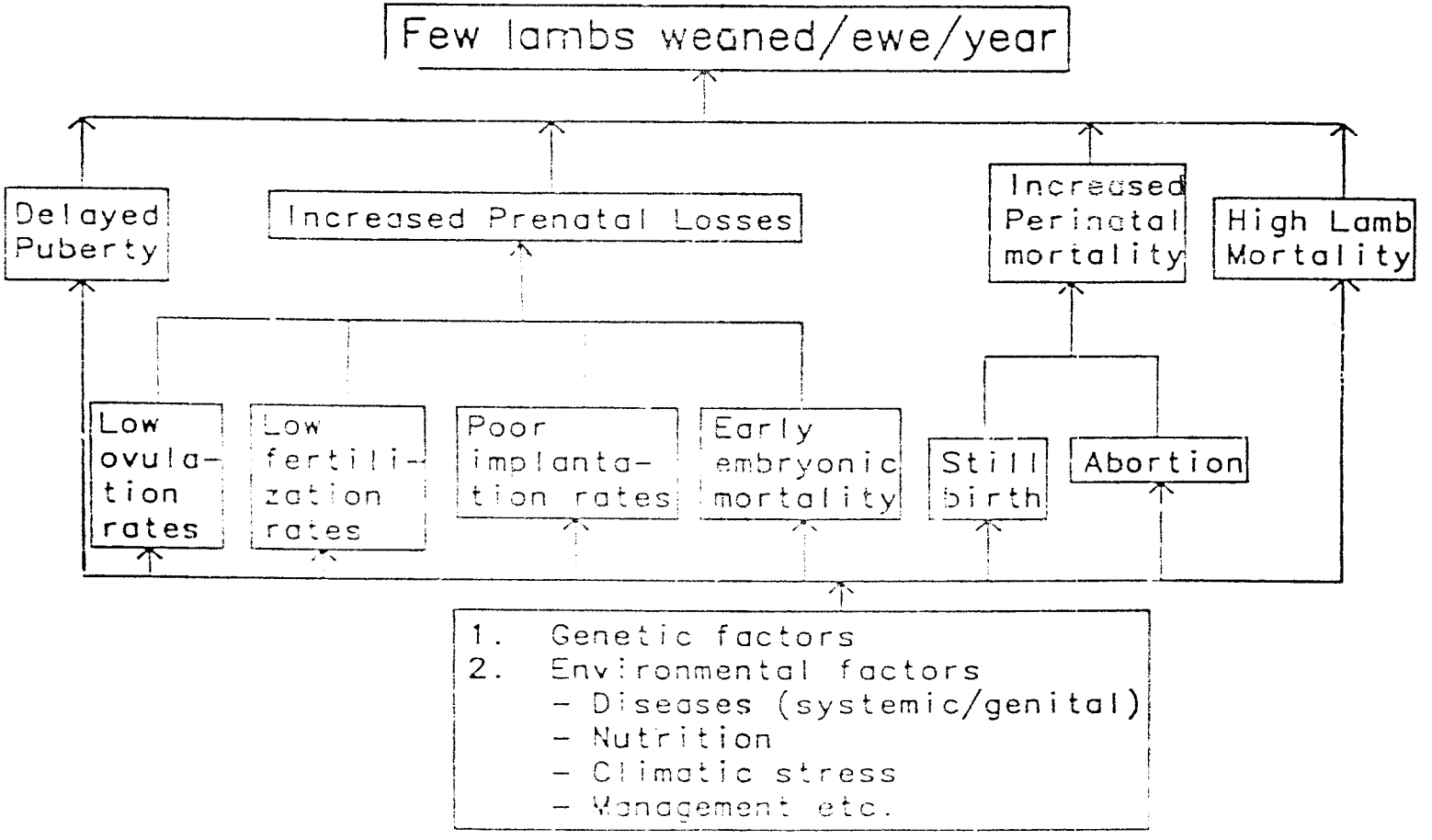
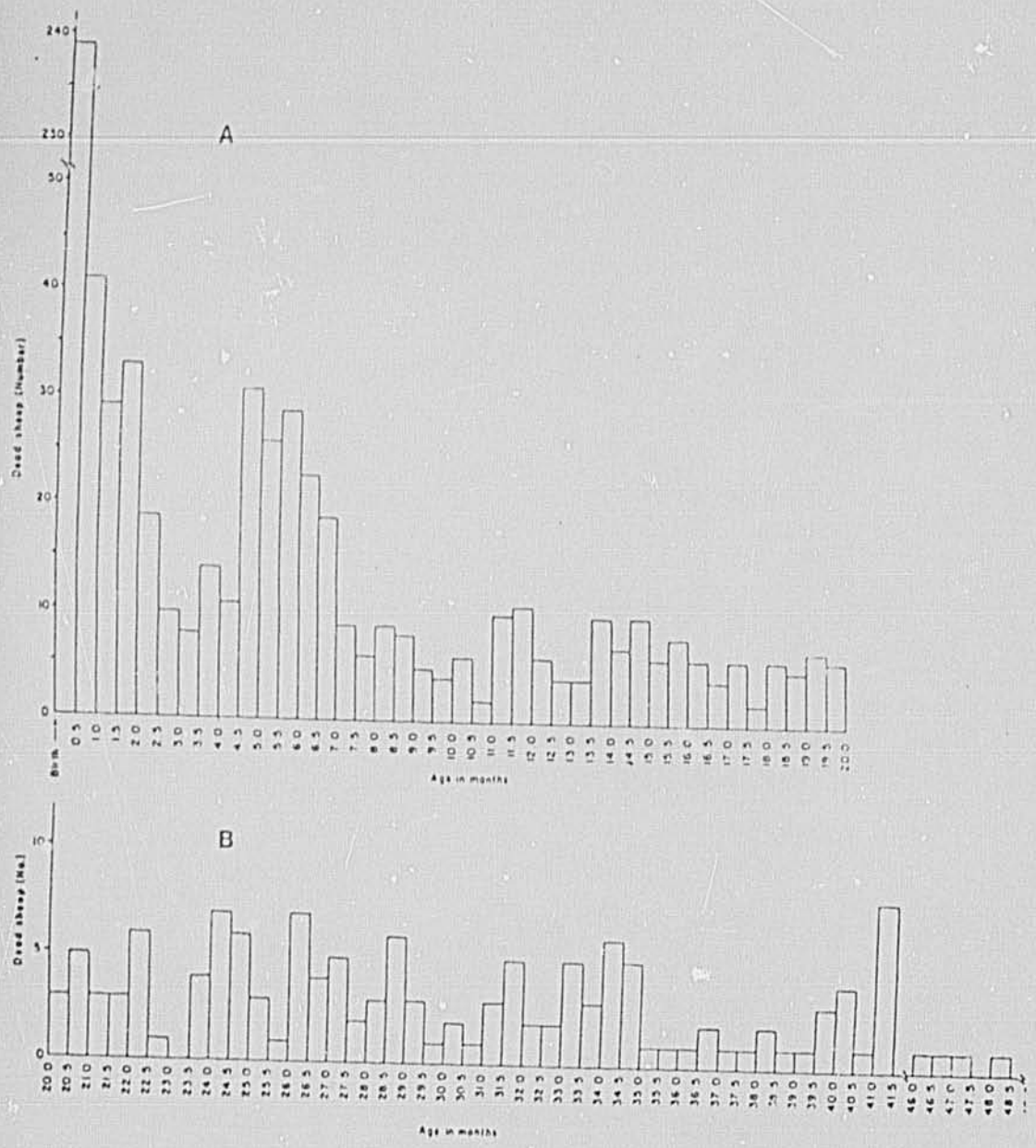


Figure 3: Cumulative ovine mortality at ILCA Debre Berhan station from June 1982 to June 1987



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RECENT ADVANCES IN VIROLOGY AT KABETE RELEVANT TO SMALL RUMINANT PRODUCTION

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INTRODUCTION

Virus diseases of small ruminants in East Africa have frequently determined the success or failure of an enterprise. Bluetongue and Akabane virus are widespread in all ecological zones of Kenya (Davies and Walker, 1974 Davies and Jesset 1985) but cause no problems in the indigenous small ruminant populations. Exotic wool sheep and their crosses do however suffer losses due to bluetongue unless a vaccination programme is followed. Exotic goat breeds do not appear to be as susceptible. Antibody to Akabane virus is present in cattle and sheep and goat sera but no foetal pathology has been identified and attributed to this cause. It is likely that the indigenous animals are relatively resistant to this virus in the endemic areas in Africa.

Epidemic diseases such as Rift Valley fever, and sheep and goat pox have historically been shown to cause significant losses in small ruminant populations, particularly in sheep. A tick borne disease, Nairobi sheep disease, is by far the most pathogenic virus for small ruminants in Kenya. Losses of 80-90% of the flock occur in indigenous sheep and goats (Davies 1976, Terpstra, 1970 Davies 1988). Some aspects of the natural history of these diseases which are relevant to their control will be discussed.

I. Sheep and Goat Pox

Epidemics of sheep and goat pox follow introductions of infected or recovered animals into susceptible flocks or intermitting at water holes. Movement of stock for grazing or trade purposes is often accompanied by outbreaks of this disease where they come into contact with recently infected animals. Spread through flocks of 300-500 animals is rapid, and occurs in a period of 6-10 weeks. Aerosol transmission has been shown to take place under experimental conditions and there is evidence that haematophagous insects may effect transmission. The close night herding of animals under most pastoral conditions facilitates spread by both these routes. Morbidity and mortality rates vary and it is thought they relate to the age structure and disease history of the flock. A mortality rate of over 40% has frequently been encountered although 3-10% is more usual. Young animals suffer greatest mortality.

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A modified live virus vaccine has been developed at Kabete which has been shown to be immunogenic and completely safe (Davies and Mbugua, 1985). Animals may be vaccinated at 12 weeks, and the immunity lasts for at least 2 years, it is probably lifelong. The vaccine has been shown to be safe for all exotic and indigenous small ruminants.

The capripox virus strains found in Kenya are pathogenic for both sheep and goats, unlike some found in the Middle and Far East which appear to show levels of host adaptation. These strains from the Middle East were however serologically identical with the Kenya strains in fluorescent antibody and serum neutralisation tests carried out at Kabete (Davies and Otema 1981). This vaccine strain has potential for much wider use in the Middle and Far East. It has already been successfully used in both these areas.

II. Rift Valley Fever

This disease occurs as epizootics in Kenya and during these many thousands of cattle sheep and goats abort and die (Daubney *et al.* 1931). The disease is caused by a Phlebovirus which is mosquito transmitted, but other haematophagous dipterans such as Culicoides may also transmit it (Davies and Highton, 1980). The epizootics occur at 5-15 year intervals and appear to be related to rainfall (Davies *et al.*, 1985). A modified live virus vaccine is available which is widely used. However the strategic use of this in the face of an epizootic would clearly be more cost-effective than the annual vaccination programme which is generally followed. Efforts have been made at Kabete in recent years to analyse the epizootic conditions and their relationship to the generation of epizootics of Rift Valley Fever. This has involved the extensive study of the biology of *Aedes* mosquitoes breeding in dambos or grassland depressions which flood during Rift Valley Fever epizootics (Davies 1975, Linthicum *et al.*, 1984). These studies have been correlated with the vegetation indices in epizootic areas monitored by satellite remote sensing imagery (Linthicum *et al.*, 1987). The analysis of rainfall and satellite imagery does allow the pre-epizootic conditions for Rift Valley Fever to be identified and strategic vaccination programmes to be instituted.

Initial artificial flooding of grassland depression in a Rift Valley Fever epizootic area resulted in the emergence of very large numbers of *Aedes* mosquito larvae (Linthicum *et al.*, 1984). This species feeds extensively upon the disease hosts (Linthicum *et al.*, 1985). Larvae were taken to the laboratory and allowed to develop to the adult stage. These adults were then assayed for Rift Valley Fever virus by the inoculation of hamsters. Virus was isolated from laboratory reared adults thus suggesting that the mode of inter-epizootic maintenance of Rift Valley Fever virus was by trans-ovarial transmission (Linthicum, Davies and Kairo 1985).

A very high titre of Rift Valley Fever virus is attained in the blood of the susceptible disease hosts, which are commonly the exotic cattle and sheep in Kenya. Other species of mosquito, in particular various *Aedes* (*Neomelanicovinium* and *Stegomyia*) and *Culex* species become infected after feeding upon the viraemic hosts and establish transmission cycles. *Culicoides* species occur in large numbers in Rift Valley Fever epizootics and may play a role in the transmission of the virus by mechanical means (Davies and Highton 1980). They have been shown to be capable of transmission experimentally after interrupted feeds. Aspects of the generation and propagation of a Rift Valley Fever epizootic require further study.

III. Blue Tongue

Blue tongue is a disease principally of wool sheep, but losses are regularly encountered amongst the cross breeds which comprise a large part of the commercial sheep industry in Kenya. The Dorper breed and the Suffolk or Hampshire cross Maasai or Somali type sheep are susceptible. Pure Red Maasai or Black Headed Persian sheep are insusceptible.

Some 10-11 of the known 24 serotype of Bluetongue have been isolated from clinical cases of the disease in Kenya. One strain has been isolated which is distinct from any other known world serotype. At present, a single pack vaccine is produced which contains 7 of the most commonly isolated strains. The highly pathogenic Kenyan strain has also been attenuated and is included in the vaccine. At the laboratory, it is generally found that the vaccination of sero-negative sheep results in production of virus neutralising antibody to 2-4 of the constituent attenuated virus strains. Challenge of the vaccinated animals suggests that there is a level of group specific immunity, for the responses to virulent strains in sheep with no detectable neutralising antibody, is qualitatively much less severe than in controls. In the field, the results of vaccination are far more successful than the laboratory testing of the vaccine would suggest. Farmers are adamant that breakdowns in vaccinated flocks are rare. Annual re-vaccination is recommended, and at present it is considered that the production of a two stage vaccine, each of 3-4 strains is not necessary.

IV. Nairobi Sheep Disease

This virus is transmitted in Kenya by *Rhipicephalus appendiculatus* (Neuman) (Montgomery 1917). Most outbreaks of the disease occur in known *R. appendiculatus* endemic areas but some have occurred beyond these. In some instances, this has been due to ecological changes which have favoured the extension of the vector tick beyond its normal range (Davies 1988), while in others it has been suggested that *Amblyomma variegatum* might be involved (Daubney and Hudson 1934). Experimentally this tick was shown to be an inefficient vector of the virus. *R. appendiculatus* transmits the virus trans-ovarially and trans-stadially and the ticks are not sterilised following feeds upon immune or insusceptible hosts (Davies

and Mwakima 1982) as had earlier been suggested (Montgomery 1917). *R. pulchellus* does not transmit the virus trans-stadially nor trans-ovarially in Kenya but there is evidence to suggest that it may do so in Somalia (Pelligrini 1950). Nairobi Sheep Disease is not endemic in areas where *R. pulchellus* occurs in Kenya (Davies 1978a).

Outbreaks of Nairobi Sheep Disease occur following the movement of susceptible sheep into Nairobi Sheep Disease endemic areas (Davies 1978b), or where attempted tick control regimes have broken down. Local changes in the vegetation ecology within and at the margins of *R. appendiculatus* endemic zones are induced by the periodic high rainfall cycles (Davies *et al.*, 1985) and very large tick populations build up in areas where only occasional specimens would have been found earlier. Here, the small ruminant populations are highly susceptible and 2/3 to 3/4 of all the animals may die of Nairobi Sheep Disease. Where the tick populations are maintained at a higher level at all times, virtually all animals will be found to be immune to Nairobi Sheep Disease and no disease occurs (Davies 1978a).

The changes which produce the extension from the *R. appendiculatus* endemic areas would be detectable by remote sensing satellite imagery. The detection of such areas is of paramount importance and would provide the basis for a vaccination or tick control strategy. In truly endemic areas for Nairobi Sheep Disease it is not recommended that this stable state of endemicity be in any way altered.

V. Akabane Virus

This virus is pathogenic for foetuses in small ruminants (Hartley 1977) and problems have been reported from Japan, Israel and Australia. The virus has been isolated in Kenya (Metselaar 1976) and a recent host and ecological study of the distribution of antibody to the virus has been made (Davies and Jessett 1985). This showed that there was an apparent endemic state for the virus in Kenya. Very high proportions of the cattle populations in all the different ecological zones from high altitude grasslands to the dry Acacia savannah have antibody to the virus. Sheep and goats were shown to have antibody also (40-60%) but no arthrogryposis of the new born has been encountered to suggest that this virus is pathogenic in Kenya. It may be that the breeds are relatively resistant.

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PASTORAL SMALLSTOCK DEVELOPMENT

C.R. Field[1] and A. Lesuan[1]

INTRODUCTION

In direct response to the ongoing Sahelian drought of the early 1970's, the United Nations Enviromental Programme (UNEP) and Education, Scientific and Cultural Organisation (UNESCO), joined forces with the Kenya Government in 1976 to initiate a programme for research called the Integrated Project in Arid Lands (IPAL) into the causes of desert encroachment and solutions to the problem.

The International Desertification Conference of UNEP was held in the following year. There then ensued a decade of research involving description, experimentation, synthesis of conclusions into management guidelines for the study area which was about 12000km^2 of Rendille country in Marsabit District. A considerable body of information was amassed (see IPAL Technical Reports 1979-1986), not least on livestock of which smallstock are just one component.

Following on the publication of management guidelines the West Marsabit integrated Development Pilot Project (WMIDPP) was initiated in 1984 in three communities, in part of the area where it has been making considerable progress.

Meanwhile however, the greater part of the smallstock population and their owners remained unaffected by the work which had been done which was inaccessible to them in somewhat erudite scientific publications. At the same time the trend of declining productivity which has been begun during the Sahelian drought a decade earlier steepened. The following contributory factors in probable order of importance are listed:

(i) Increasing human population

(ii) Increasing sedentarization of nomads and their livestock

(iii) Increasing disease among livestock especially those in settlements

(iv) The disastrous drought of 1983/4

This trend is on a collision course with the decreasing carrying capacity of the environment in the vicinity of settlements which will inevitably lead to more serious famine than hitherto seen in northern Kenya.

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1. Livestock Development Motivator and Facilitator in Chief Development Office, Diocese of Masarbit, BOX 281, NANYUKI

In 1983 the Development Office of the Catholic Diocese of Marsabit initiated a programme of Development Education in cooperation with the Kenya Government and various parish priests. The programme has operated throughout Samburu and in parts of Marsabit District. It involves Adult Literacy, Leadership and Awareness programmes. After the first two years it became apparent that the pastoralists in the Diocese also needed urgent help with their livestock both to rehabilitate those who had fallen below the subsistence level in terms of stock holdings during the drought and to raise the long term productivity of the flocks of those who had stock but which were producing well below their potential.

In March 1986 we therefore initiated a programme of Famine Rehabilitation and Livestock Development aimed at using the results of the aforementation research for the benefit of the people and their stock. This report reflects on the first 20 months of operation of livestock Development Programme.

MATERIALS AND METHODS

Smallstock are fundamental to the existence of pastoralists in Samburu and Marsabit Districts. They provide food - e.g. milk, meat, blood and hides and are used for many social activities such as cementing bond relationships, blessing camels, (Soriu), dowry, etc. More recently they have become increasingly more important for the purchase of goods, in particular supplementary food (carbohydrates) and even as contributions to attend our courses!

Prior to the drought it was estimated (Peden, 1984) that there were the following humans and smallstock in the two Districts. (See Table 1).

Table 1: Smallstock and human numbers and Densities in Marsabit and Samburu

	MARSABIT	SAMBURU	TOTAL
Moisture Index	7.0	5.7	
Area km^2	73,952	17,521	91,473
Human pop^n Density	1.3	4.4	
Smallstock	533,071	245,943	779,014
Density	7.2	14.0	
Livestock TLU per person	2.5	1.8	
Cattle-Shoats TLU's	2.6	5.8	

From table 1, it can be seen that the whole area is dry, with Samburu District being semi arid and Marsabit arid. The area under study is large (91473km^2) and comprises 16% of the surface area of Kenya. It is quite inaccessible with poor roads none of which are metalled.

The human density is low in Marsabit, but is more than three times that of Samburu. Although the density of small stock in Samburu is twice that of Marsabit, the number of livestock TLU's per person is less. The ratio of cattle to sheep and goats in terms of TLU is more than twice in Samburu when compared with Marsabit which reflects the availability of water and perennial pasture in Samburu although these are rapidly disappearing.

The main method of approach has involved Development Education for Leadership Teams in Action (DELTA). Discussions were first of all held with elders, Chiefs and Government Officers at the community level to determine their needs and priorities regarding livestock development.

The first priority was for improved supply of animal health products which was non-existent in many areas. We responded to this by inviting the communities to choose and send potential livestock Development leaders for training courses held in their areas. The criteria for participants was that they should be livestock owners with their roots in the community; youth should be accompanied by elders and women were encouraged to attend. Each community was required to support their candidates with a contribution towards the food consumed during the course. This may take the form of either cash, a sheep or goats.

The main emphasis on the courses is to use the Psycho Social Method of problem posing rather than the more traditional approach of 'filling empty vessels with knowledge' i.e., banking method. Practical examples with living animals are given throughout and participants are encouraged to handle animals (camels, cattle) and smallstock in particular.

We believe very strongly in the two following statements:

a) A degraded environment can only lead to a poor animal.
'Kutotunza mazingara utazorotesha afya mbaya kwa mifugo'

b) It is better to prevent disease than to cure.
'Heri kuzuia ugonjwa kuliko kutibu'

The main topics are as follows:

i) Enviromental Conservation
ii) Animal Nutrition
iii) Animal Husbandry
iv) Animal Health
v) Livestock Breeding
vi) Livestock Marketing

The courses last for one week. Despite our emphasis on animal husbandry and preventative medicine, the main need expressed by almost all of the participants in the courses is for veterinary supplies. In due course we hope to steer pastoralists gradually away from this tunnel vision of the problems of their livestock but meanwhile we have established several drug sales outlets which have for the time being, received priority over other forms of livestock development at the community level.

After the courses we follow up the participants with meetings at the community level and elders are invited to choose one of their candidates who have attended the course and who is considered trustworthy, etc., to sell the drugs.

We obtain drugs, minerals, etc. direct from the pharmaceutical companies with whom we have negotiated wholesale prices. About thirty different drugs are available from five companies. Before supplying the operators of the outlets we add 10% which becomes the commission or reward for the operator when he retires the funds satisfactorily after checking his accounts and balance in stock. Any shortfall of the latter is paid for from the 10%. If the shortfall exceeds 10% in value, the supply is automatically withheld. Since there is such a demand for animal health products we find that if the supply is stopped the community bring pressure to bear on the operator to pay outstanding debts and then the supply is resumed. By supplying drugs on the retirement of cash we have been able to establish a revolving fund at each outlet.

In a few cases, a community has itself paid for a defaulters debts and then replaced him with someone more reliable

Additional checks on the sales are made by insisting on signing delivery notes for all drugs supplied, issuing cash sale receipts for all drugs sold, maintaining proper accounts ledgers and posting of price lists.

The Government supply of restricted drugs (Part 1 Poisons) has been inadequate in many areas, so we have been involved in this also. We have done this reluctantly and are now limiting supplies of these drugs to operators who have attended at least one preliminary and one follow up course.

The capital for the initial supply of drugs (approx. KShs 3000) is supplied by us and we estimate that in all from 80,000 to 100,000 KShs worth are in circulation at any one time. Since there is a rather casual approach to the use and misuse of such 'loans', we have decided that any new communities must raise the capital themselves in future. This has been done two places recently where committees have been elected to supervise the sales which in one case elected their Parish Priest as treasurer.

Other aspects of smallstock improvement have involved breeding and marketing. In the case of the former the gradual introduction of improved but tried genes is underway. This takes time and we have done little more than initiate this part of the programme to assess the potential and the problems.

With regard to marketing the main input is to provide loans to cover the cost of initial marketing expenses. (e.g. transport, accommodation, etc.).

RESULTS

1. Training:

A total of 11 courses have been held as follows:

- Three preliminary courses among Gabra in 1984, 1985, 1986.
- Three follow up courses among Gabra at Gus, Bubisa and Dukana.
- One preliminary course among Samburu in 1986.
- Three follow up courses among Samburu at Lodokejek, Lesirikan and Horr.
- One preliminary course among Rendille in 1986.
- Three follow up courses among Rendille are planned.

The courses have been attended by a total of about 350 persons.

2. Animal Health:

Twenty six communities have been supplied with drugs although two of these have only recently begun under the new scheme. Figure 1 shows the distribution of these outlets and Table 2 their relative successes and failures of the past 18 months.

Table 2: Summary of Veterinary Drug Sales Outlets:
(Excluding two established recently)

Ethnic Group	Outlets	Successes	Intermittent Operation	Failures
Gabbra	6	4	2	0
Rendille	6	4	0	2
Samburu	10	5	2	3
Turkana	2	0	0	2
Total	24	13	4	7

At present 18 outlets are operating. From the Figure and Table 1, the following conclusions are drawn - The most successful communities are also those which are in the most remote areas, e.g, Gabbra and among the Rendille at Kargi and Koiya and Samburu at Gatab, Barsaloi, latakwen, etc. We believe that there are two main reasons. Persons living in such areas have elected to do so for the good of their stock and indirectly themselves. Those living closer to towns e.g, Maralal, Marsabit, Laisamis and Baragoi have some alternative forms of subsistence and are also subject to the temptations of town life. (The three R's are not reading, writing and 'rithmetic but Bussa, Chang'a and Miraa'). Another factor in the success of the Gabbra outlets has been the strong supportive role of the Parish Priests.

It is our policy to complement rather than compete with Government or other NGO's in this field. Reference to Figure 1, shows that very few of our outlets occur within the areas of the WMIDPP and FSP/ASAL (Wamba Division), also we do not operate within the main centres themselves e.g, Wamba, Maralal, Baragoi, Loiyangalani, Marsabit and Moyale; indeed some communities such as Dukana are best reached by air as travel by road is much slower and more expensive. Although MOLD veterinarians are posted to all Divisional headquarters and some AHA's are found in remoter communities, they have great difficulty in reaching the people through lack of supplies and transport. We therefore believed that our programme is truly complementary to Government and it encourages people to keep their smallstock in the better pastures away from major centres all of which show signs of desert encroachment to one degree or another.

Since the drought of 1984, smallstock have suffered several diseases which have prevented a full recovery of their original numbers. It should be noted that during the drought all kids and lambs were slaughtered at birth as a matter of policy to reduce the burden on their mothers. This means that a whole age group is missing from the recruitment to the population. Such animals would normally be breeding by now.

Major diseases of smallstock are:

1. Helminthiasis
2. Contagious Caprine pleuropneumonia (CCPP in goats
3. Enterotoxaemia (mostly in sheep)

We supply six different types of anthemintics for smallstock but prefer available in bolus form as they cannot be diluted.

CCPP has been endemic among the Gabbra goats since late 1985 and they have suffered enormous losses. We obtained 5,000 doses of CCPP vaccine with great difficulty from the GK Vetlabs at Kabete but it is estimated that we were able to cover less that 5% of the population at risk before the supply ran out. Furthermore, the efficacy of the vaccine was questioned and it was difficult to deliver to remote areas without an aircraft and refrigeration. We have therefore had to resort to using 20% oxytetracycline at about the 7 time the cost of the vaccine per animal as virtually the only effective cure.

With regard to Enterotoxaemia, supply and administration of the vaccine to remote populations of sheep has presented major problem which we have not fully overcome. Apart from the need for refrigeration which again necessitates the use of an aircraft, the vaccine is administered by two injections six weeks apart. The logistics of finding the same flock in a nomadic population after such a period have proved almost insurmountable although it has helped to charge for both injections initially and to brand animals at the first instance.

In more humid areas ticks are a problem to smallstock and four different acaricides are on offer. So far Sevin powder, tick grease and Delnav are quite adequate as regular dipping has not been possible, and there is little or no resistance to the less potent acaricides.

A total of over 194,663.40 KShs of drugs have been sold in 26 communities and the funds brought to account. If all this was spent on smallstock this would only amount to 16 cents per animal, but it is considerably less as much as spent on cattle and a little less on camels.

3. Livestock Breeding

Improvement in productivity may also be achieved by introduction of improved but tried breeds. Blackburn and Cartwright (1987) used data from Marsabit District to show that the sheep could be more productive per unit of pasture if a larger animal was used. His simulations did not include goats but the occurence of the Somali Galla which is about 10kg heavier, in the adjacent North Eastern Province tends to support this idea for goats also.

We have to date introduced/or translocated 190 sheep and goats for breeding purposes as follows: (See Fig 2):-

i) Eight crossbred dairy bucks from the GK Farm, Naivasha, to Baragoi, Gatab and Dukana. Six remain and have offspring.

ii) Twenty Boran Sheep (mostly) from Maikona to Baragoi. Most survived and have offspring.

iii) Twelve Dorper ram lambs from Nanyuki to Marsabit and Mt Kulal. They contacted pasteurellosis and then died. Two at Kulal have offspring.

iv) One hundred and fifty Somali fat rumped sheep and Somali Galla goats from Malka Daka (Isiolo) to Gas. The males for immediate sale but a breeding flock of animals are kept to produce pure offspring within the District. It is too early for results.

4. Livestock Marketing:

In 1985 a number of loans were given to assist pastoralists to initiate marketing. The programme was not well planned and very few of them have been repaid as the money was often mis-spent.

Meanwhile we are assisting one marketing group at Mt. Kulal and three others are in the planning stage. However, we are much more cautions in issuing loans and now demand more stringent assurances before entering into such arrangements again.

Nevertheless, we are reassured that offtake of smallstock is increasing both through the activities of the WMIDPP and also a number of traders who have initiated marketing in particular among Gabbra of their own accord.

CONCLUSIONS AND FUTURE PLANS

The programme is both popular and viable. There is need for regular follow up which has hitherto not been achieved fully. Plans to hand over this programme to Kenyans from the Diocese are underway and should be completed within the next six months, and we have every confidence in its future success. The senior author will then initiate a parallel programme called FARM - CAMELS (Food and Agriculture Research and Management; Camel Advisory, Management, Extension and Liasion Service), which will concentrate on improving camel productivity in the same communities where we have already established contact.

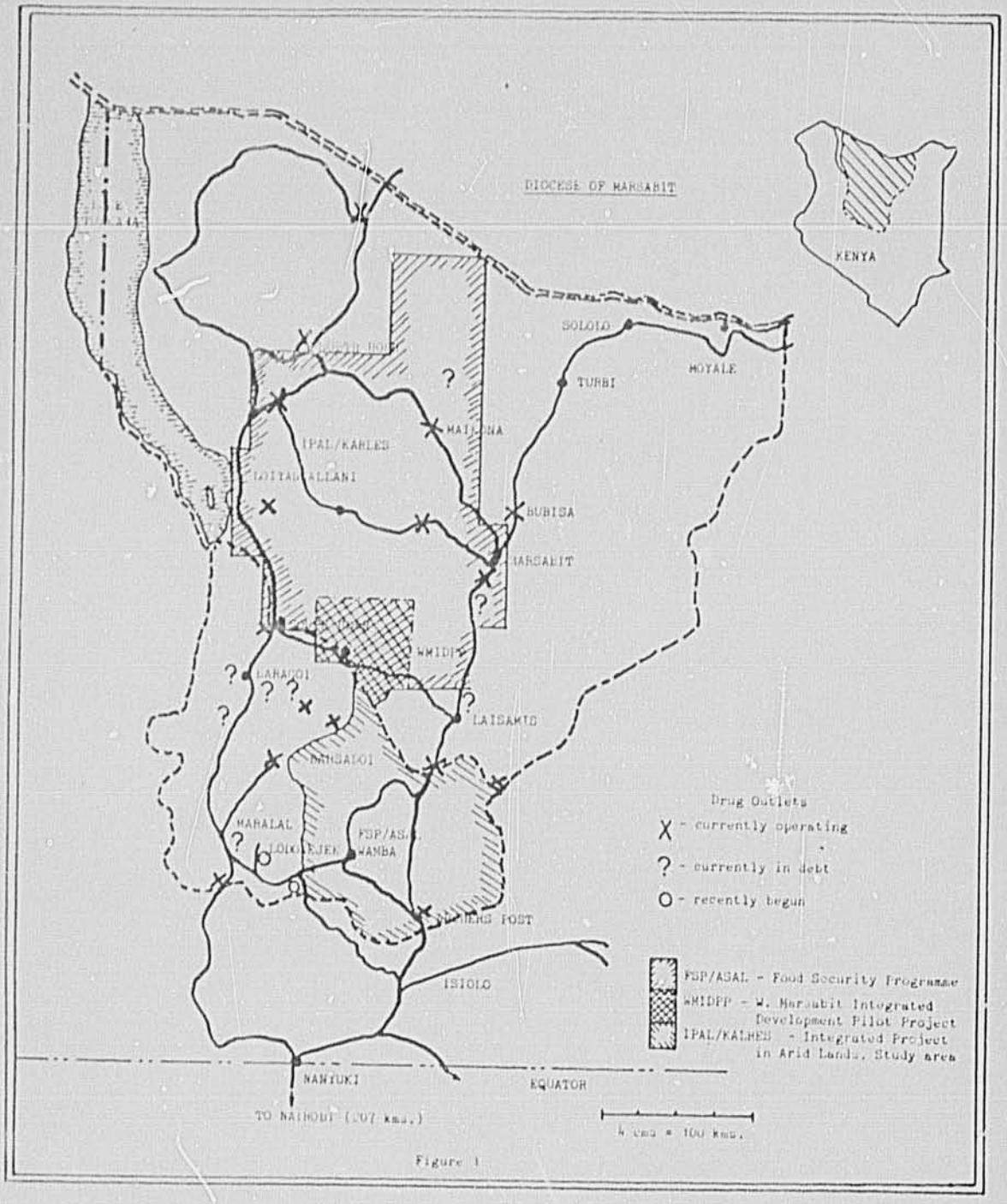
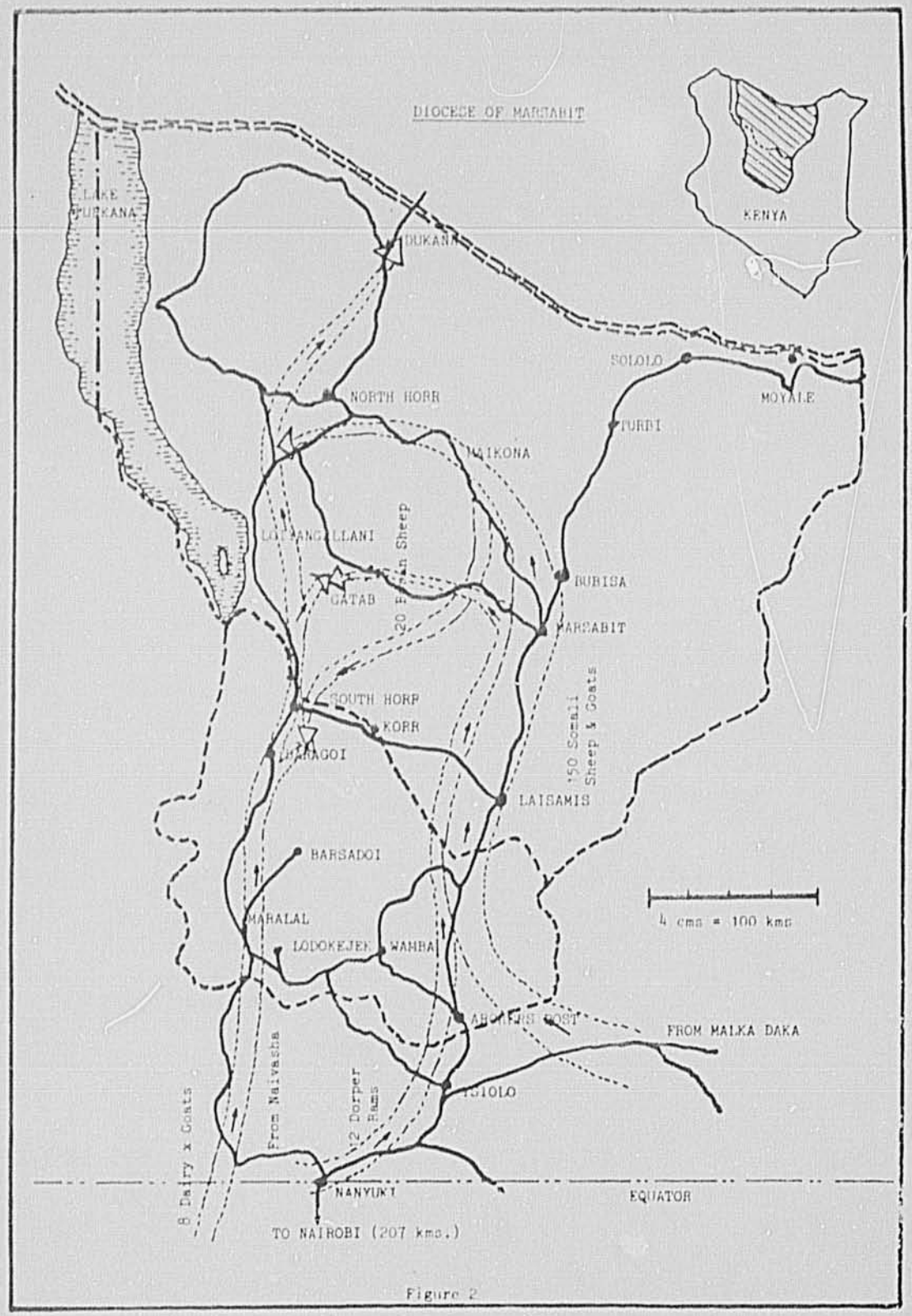

DIOCESE OF MARSABIT
KENYA
SOLOLO
MOYALE
TURBI
IPAL/KAHLES
BUBISA
MARSABIT
WMIDPP
LAISAMIS
MARALAL
ISIOLO
NANYUKI
EQUATOR
TO NAIROBI (207 kms.)
Drug Outlets
X - currently operating
? - currently in debt
O - recently begun
FSP/ASAL - Food Security Programme
WMIDPP - W. Marsabit Integrated Development Pilot Project
IPAL/KAHLES - Integrated Project in Arid Lands. Study area
4 cms = 100 kms.

Figure 1


DIOCESE OF MARSABIT
KENYA
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MAIKONA
LOYANGALANI
GATAB
BUBISA
MARSABIT
SOUTH HORR
KORR
LAISAMIS
BARSADOI
MARALAL
LODOKEJEK
WAMBA
ISIOLO
NANYUKI
EQUATOR
TO NAIROBI (207 kms.)
FROM MALKA DAKA
4 cms = 100 kms

Figure 2

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