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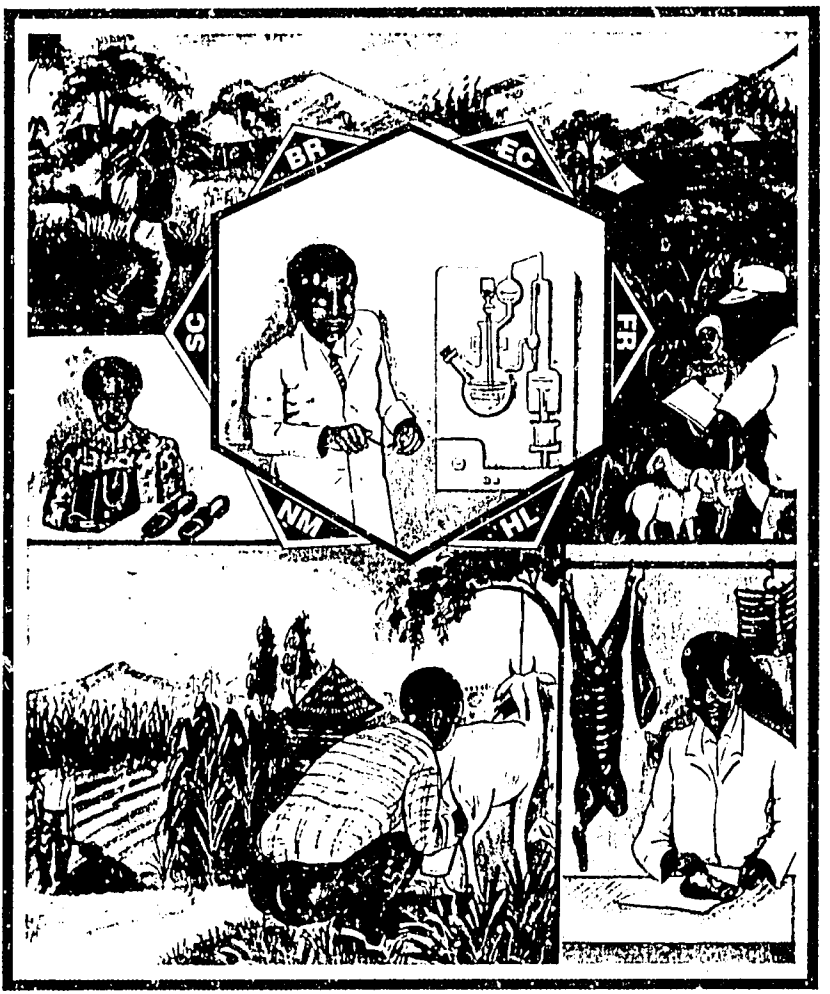
On-farm Research and Technology for Dual-purpose Goats



PATTERSON P. SEMENYE and THEODORE HUTCHCROFT - Editors

ON-FARM RESEARCH AND TECHNOLOGY FOR DUAL-PURPOSE GOATS

PATTERSON P. SEMENYE
AND
THEODORE HUTCHCROFT
EDITORS

SMALL RUMINANT COLLABORATIVE RESEARCH SUPPORT PROGRAM
KENYA

The Small Ruminant Collaborative Research Support Program (SR-CRSP) is a cooperative activity of university and research institutions of Brazil, Peru, Indonesia, Kenya, Morocco, Bolivia, and the United States. It began in 1979 and is jointly funded by the participating universities and institutions and the U.S. Agency for International Development.

The Kenya Agricultural Research Institute, Ministry of Livestock Development, and Ministry of Agriculture are the national collaborators. The participating U.S. institutions are Texas A&M University, Washington State University, University of Missouri, Winrock International Institute for Agricultural Development, and, most recently, Colorado State University. The management entity for the SR-CRSP is the University of California, Davis.

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The cover illustration by Mr. Nelson Omondi, depicting smallholder farming system in western Kenya, products of the dual-purpose goat and research conducted by Economics (EC), Feed Resources (FR), Health (HL), Nutrition and Management (NM), Sociology (SC) and Breeding (BR) projects.

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FOREWORD

During the last decade, the world goat population has gone up by about 13%. It has increased from around 465 million in 1980 to about 525 million in 1989. According to the Food and Agriculture Organization, about 94% of the world's goats are located in developing countries. In 1989, goats in the developing countries provided about 99% of the global supply of goat meat and 75% of the goat milk. These numbers indicate not only a sizable, but also an invaluable contribution of goats to the supply of high-quality protein for people who have limited access to balanced diets.

Because of the importance of goats and other small ruminants and the many constraints to their production, the Small Ruminant Collaborative Research Support Program (SR-CRSP) initiated a multidisciplinary and collaborative research effort to improve their utility and productivity. In Kenya, where the focus was on the goats, a memorandum of understanding was signed in 1978 between the Ministry of Agriculture and Livestock Development (MALD), a predecessor agency to the present Kenya Agricultural Research Institute (KARI), and the University of California, Davis, the management entity for the SR-CRSP.

To address the global objectives set forth at that time, the SR-CRSP initiated a series of subprojects which included: (a) systems analysis and animal breeding to design a composite dual-purpose goat (DPG) from indigenous and exotic sources of germplasm; (b) production systems to establish management interventions and evaluate the DPG under farm conditions; (c) sociology to assess the impact on the welfare of people, particularly the limited-resource goat owner; (d) economics to evaluate the viability of alternative systems; and (e) animal health to determine the disease and parasite constraints to the goat enterprise.

The results of the collaborative research for improving goat production technology, most of which have been tested on farms in western Kenya, form the basis for the recommendations contained in this manual. It is believed that the information will be useful to extension and research workers in-

volved with goat producers and also to lecturers in agricultural colleges and universities throughout the region.

The SR-CRSP accomplishments also demonstrate the appropriateness and the effectiveness of Title XII legislation which established the CRSP concept and laid the basis for collaboration among U.S. and overseas institutions. Funding and technical support from the U.S. Agency for International Development and matching resources from KARI, MOLD and the five U.S. institutions are acknowledged with great appreciation for without them the program and indeed this manual would not have been possible.

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PREFACE

In today's world, books are judged by different criteria. It can be the cover, the contents, or simply by the authorship. The authors prefer not to be judged by these parameters, but by how much the contents of this manual will be implemented by smallholder farmers. Although the manual is for the benefit of the smallholder farmer, it is designed for extension officers and other personnel engaged in the development and service of goat-production systems for that group will deliver the recommendations and production strategies to their clients. If the extension specialists convey these technical packages and they are adopted by smallholder farmers, then these objectives will have been met. Therefore, the usefulness of this manual is to be judged by the rate and frequency of adoption of the technical packages that are contained in it.

To give the extension officers confidence in using the technology packages, there are detailed descriptions of how these were generated. This should overcome any fears the extension personnel may harbour of the technical packages having been derived only from on-station experience. The shortcomings of technical packages derived entirely from on-station and textbook experience are obvious. These technical packages were generated from on-farm research. The authors were well aware of farmers' resource limitations and varied production practices. Several recommendations are given in this manual; extension specialists are encouraged, whenever appropriate, to adapt this information accordingly. These recommendations should be taken as guidelines for interacting with farmers raising goats.

This manual is also intended to inform researchers on how to minimize farmers' worries about new technologies. Without doubt, farmers need and admire outstanding goats or special seeds produced on research stations. But for sustainable practices to be developed, on-farm research is needed to resolve local and specific constraints. Without losing sight of the extension specialist, this manual attempts to illustrate the purposeful marriage between on-station and on-farm research. It is this marriage, with an in-built holistic approach, that can ensure agricultural-system sustainability.

ACKNOWLEDGMENTS

The SR-CRSP is appropriately named for it exemplifies an outstanding level of collaborative research support by the participating organizations and their personnel as well as by the staff of the projects.

The worldwide work of SR-CRSP is made possible by grants through Title XII of the Foreign Assistance Act. The U.S. Agency for International Development (USAID) administers the funds. Ms. Joyce Turk, S&T/AGR/AP, USAID, Washington, D. C., and Mr. Cecil McFarland of the USAID mission, Nairobi, have provided valuable counsel and encouragement.

The smooth coordination of the SR-CRSP is the responsibility of the Management Entity, University of California, Davis. Ex-program directors are Drs. D. Robinson, D. Robert-Shaw, J. W. Oxley, W. C. Weir, and M. L. Peterson. Most recently, Dr. John S. Glenn has taken the reins as director while Mr. James Scott serves as the assistant program director.

As the host country institution, the Kenya Agricultural Research Institute has provided leadership and infrastructure as well as facilities for the project. Dr. C. Ndiritu, KARI Director, and Dr. Samson Chema, formerly Deputy Director, KARI, have led and guided this program in Kenya with distinction. Lately, Dr. D. Wachira, in his capacity as the deputy director, KARI, has been providing valuable technical and administrative counsel.

Each of the participating U.S. institutions has made significant contributions of staff and other resources to their respective components as well as to the overall effectiveness of the project.

- Texas A&M University (breeding and systems analysis): Dr. T. C. Cartwright, professor emeritus; Dr. H. D. Blackburn, co-principal investigator breeding; Dr. F. Ruvuna, resident scientist (1983/89); and Dr. J. Taylor, professor and current principal investigator, breeding.

- Washington State University (health): Dr. Travis C. McGuire, professor and principal investigator.

- University of Missouri (sociology): Dr. Michael F. Nolan, associate dean

of agriculture and principal investigator; Dr. Eric Reynolds, resident scientist (1984/86); and Dr. W. Thomas Conelly, resident scientist (1986/87).

- Winrock International Institute for Agricultural Development (economics and production systems): Dr. H. A. Fitzhugh, now deputy director general (research), International Livestock Centre for Africa; Dr. Hendrik C. Knipscheer, director, Asia division; Dr. Will R. Getz, program officer, Africa and Middle East division; Dr. Pierre P. Antoine, director, Africa and Middle East division; Dr. Ned S. Raun, regional representative; Dr. Adrian Mukhebi, now agricultural economist, International Laboratory for Research on Animal Diseases; Dr. Dan Brown, resident scientist (1981/83); Dr. Sidahmed Ahmed, resident scientist (1983/85); Dr. Sandra Russo, resident scientist (1982/83); and Mr. Luke Oyugi, now agricultural economist, Ministry of Agriculture, Kenya.

The SR-CRSP personnel in Kenya have diligently carried out the field work for the DPG programme, conducting research experiments and testing the technical packages described in this manual.

- Breeding and Systems Project: Dr. B. Mwandotto, animal breeder, Texas A&M University; Mr. C. O. Ahuya, research officer, KARI, Mr. S. Mkuu, technical officer, KARI; and Mr. O. Mwai, research officer, now with the University of Nairobi.

- Economics Project: Dr. Fanny B. Nyaribo, agricultural economist, Winrock.

- Feed Resources Project: Dr. J. F. Moses Onim, agronomist, Winrock; Mr. Kenneth Otieno, forage agronomist, KARI; and Mr. M. Mathuva, forage agronomist, now with the International Council for Research in Agroforestry.

- Health Project: Dr. F. Rurangirwa, Washington State University, and Dr. Paul M. Rwambo, Colorado State University, both veterinary scientists; Dr. S. Waghela, veterinary scientist now with Texas A&M University, and Dr. P. S. Shompole, Dr. A. K. Kibor, and Dr. A. Wambugu, all veterinary research officers, KARI.

- Nutrition and Management Project: Dr. Patterson P. Semenye, animal scientist, Winrock; Dr. D. N. Siamba, research officer, KARI; Dr. L. Musalia, nutrition-health management, now with Egerton University; Mr.

Maurice Shisya, animal technician, MALD; and Mrs. Nelly Otiende, animal technician, KARI.

- Sociology Project: Dr. A. N. Mbabu, rural sociologist, now with the International Service for National Agricultural Research.

Logistical support was provided by Mr. Julius Mungai, program administrator, SR-CRSP, Kenya; Mrs. H. Ingati, administrative assistant at Maseno site, and Ms. Nancy Ngugi, secretary at Kabete site.

Special appreciation is given to those who assisted in preparing this manual. Dr. Patterson P. Semenye, edited and organized this publication on behalf of SR-CRSP scientists. Word-processing was by Ms. Philomena Pacha, Ms. Beatrice Lumadede and Mrs. Johnnie Frueauff, and artwork was prepared by Messrs. Nelson Omondi and R. Chonya. Dr. Theodore Hutchcroft of Winrock International was the editorial and production consultant.

Finally, special thanks go to those people who made this work possible. They are the support staff, the extension officers who made the vital link between researchers and the farmers, the administration officers for their tremendous support, the teachers in the study area for allowing use of their school facilities for meetings with farmers and extension officers, and the collaborating farmers for their total cooperation and assistance that has culminated in this publication.

LIST OF ABBREVIATIONS

asl	above sea level
°C	centigrade or Celsius
BCR	benefit: cost ratio
CCPP	contagious caprine pleuropneumonia
cm	centimetre
CP	crude protein
DAP	diammonium phosphate
DM	dry matter
DMD	dry matter digestibility
DMI	dry matter intake
DPG	dual-purpose goat
EPG	eggs per gram
F_1	first filial generation
FR	Feed Resources
FSR	farming systems research
ft	foot
g	gram
GM	gross margin
ha	hectare
IVDMD	invitro dry matter digestibility
K	potassium
KARI	Kenya Agricultural Research Institute
kg	kilogram
kg/ha	kilogram per hectare
kg/ha/yr	kilogram per hectare per year
kg/day	kilogram per day

kg/yr	kilogram per year
km	kilometre
km^2	square kilometre
Ksh.	Kenyan shilling
l	litre
LU	livestock unit
m	metre
m^2	square metre
mo or m	month
mc	moisture content
mm	millimetre
MALD	Ministry of Agriculture and Livestock Development
MOLD	Ministry of Livestock Development
mt	metric tonne
N	nitrogen
NM	Nutrition and Management
NPK	nitrogen, phosphorus, and potassium
pd	person day
PD	pregnancy diagnosis
pH	measure of hydrogen ion concentration
SE	standard error
SPV	sweet potato vines
SR-CRSP	Small Ruminant Collaborative Research Support Program
Techpacks	technology packages
t	tonne
t/day	tonne per day
t/ha	tonne per hectare
t/ha/yr	tonne per hectare per year
VC	variable cost
yr	year

CHAPTER 1

INTRODUCTION

Patterson P. Semenye

Ninety-four percent of the world's goats are in the developing countries and are owned primarily by smallholder farmers and pastoralists. Despite their low production, these animals contribute significantly to the economy and food supply. The demand for their products exceeds their availability. Improving the performance of goats and other small ruminants can directly improve the diet and standard of living of a great many people because these animals are inherently well suited to the needs of the smallholders and pastoralists and to conditions prevailing in the developing countries. For example, they

- have low initial and maintenance costs
- are able to utilize marginal land and crop residues
- produce milk and meat in small, readily usable quantities
- produce fibre and skins that sustain cottage industries
- are easily cared for by most members of the family
- enhance income, improve cash flow and employment opportunities, and reduce economic risk
- provide manure to maintain soil fertility and improve crop production.

In Kenya, research by the Small Ruminant Collaborative Research Support Program (SR-CRSP) is focused on a non-traditional role for goats, that of producing milk, meat, and manure on small farms in regions with high agricultural potential. Much of western Kenya is blessed with fertile soils and a bimodal rainfall pattern suitable for two cropping seasons each year. This has encouraged rapid human population growth, causing a decrease in average farm size. The prevailing agricultural systems can no longer fully meet the food and income needs of the families.

Adding dual-purpose goats (DPG) to their farming systems can increase the productivity of these smallholders. For example, DPGs can convert unused crop residues and browse to milk and meat. Keeping three to five does instead of a cow can add a small but year around supplement of milk protein to family diets. A typical doe can produce three kids in 2 years, substantially increasing offtake of farm market produce or providing meat for family consumption. Goat meat is a highly desired product, thus sale of excess animals can provide important cash income.

To meet the needs of the smallholders, DPG production systems must be based on low-cost, low-risk technology which is generally complementary to their cropping activities. Kenyan and U.S. institutions are collaborating to develop this technology. The Kenya Agricultural Research Institute (KARI), the Ministry of Livestock Development (MOLD), and the Ministry of Agriculture are the principal host-country institutions. The SR-CRSP also works with scientists from the universities of Nairobi, Egerton, and Baraton. Other institutions in Kenya are involved with specific aspects of the SR-CRSP.

The SR-CRSP has been implemented in three stages.

- 1980-1982: Characterizing the social, economic, and biological activities of traditional farming systems and performing on-station research in breeding, health, and nutrition of goats and in agronomy, thereby defining programme objectives and goals.

- 1983-1985: Monitoring limited numbers of DPGs on farms; conducting scientist-managed, on-farm research in agronomy and goat nutrition and in health management; performing on-station research in goat breeding, health, and nutrition and agronomy; and conducting preliminary cost-benefit and social feasibility analyses.

- 1986-1991: Performing large-scale technical, economic, and social evaluation of DPG production systems under farmer management and continuing research activities on both farms and experiment stations (breeding at Ol'Magogo; health at Kabete; and sociology, economics, nutrition, management, and feed production at Maseno).

The emphasis is on the farming systems approach to ensure that research results are relevant to the needs and resources of smallholder farmers in western Kenya (figure 1.1). The principles and many of the specific DPG technologies can be adapted to farming systems in other parts of the tropics.

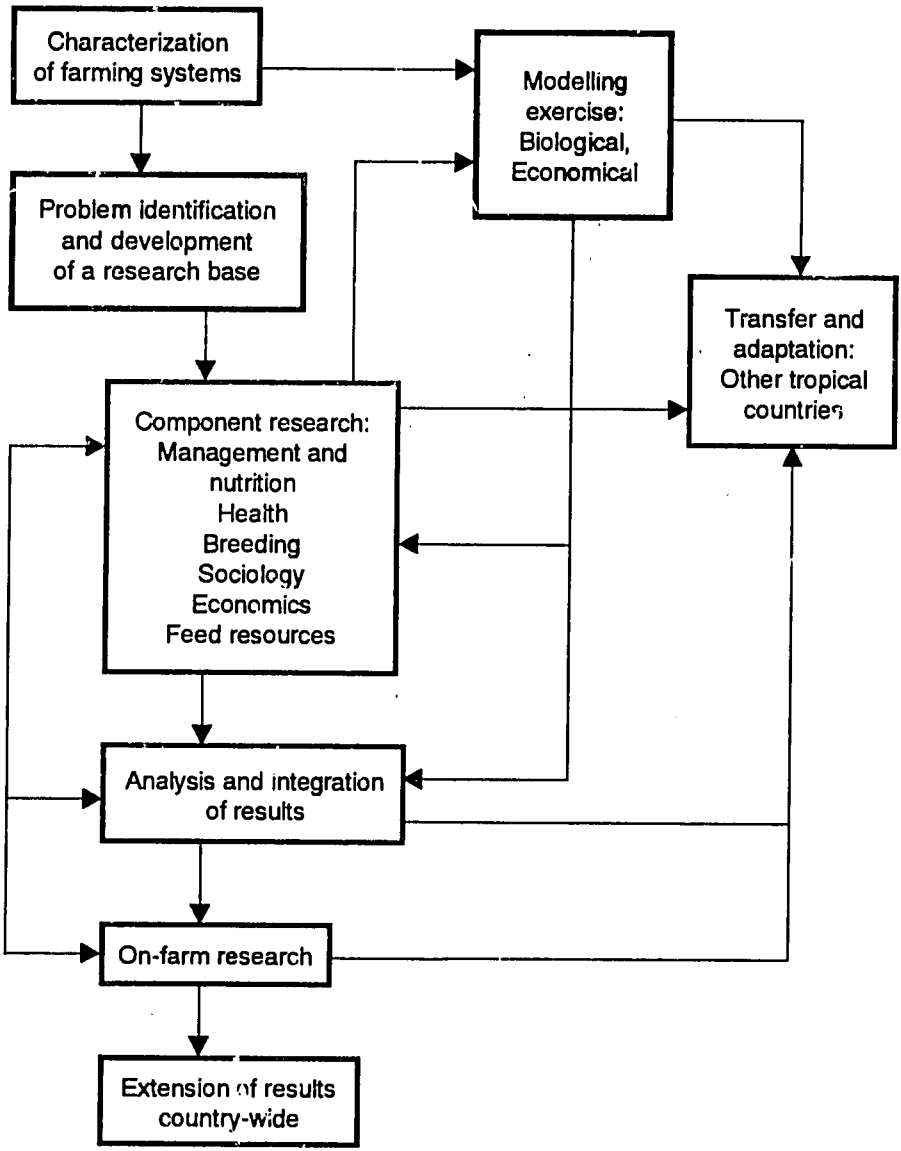

Figure 1.1. Strategy for implementing SR-CRSP research in western Kenya.

Source: Adapted from Sidahmed et al, 1985

INVESTING IN HOPE: A family prospers

In early 1977, then 27-year-old Odhiambo lost his job as a porter for East African Airways (EAA) in Nairobi, Kenya. He could find no other employment in the city and was forced to return to the village of Masumbi in his ancestral homeland, the Siaya District.

At first, Odhiambo took up peddling and well-digging to earn the cash he was used to having when he was employed by EAA, but these ventures were not very successful. Then in 1984, he was one of several farmers in the area randomly selected to participate in the farming systems research project of USAID's Small Ruminant Collaborative Research Support Program (SR-CRSP). He was given two does to raise on his tiny one-half hectare farm.

Odhiambo saw the potential in goat-herding and took better care of his goats than did his neighboring farmers in the program. The goats, fed entirely on forages and crop residues, soon multiplied. They yielded an average of one-half kilogram of milk each per day, almost twice the yield of other local does. By 1986, the milk produced was more than Odhiambo's family could consume, and he began selling the excess to fellow villagers. Through additional earnings from the sale of surplus adult goats and some of the offspring, he rented a plot for cultivation, purchase household items and food, paid debts and entertained visitors.

Farming and fishing are the two most common occupations in the Siaya District. In fact, on the horizon and within sight of Odhiambo's small farm is Lake Victoria, Africa's largest fresh-water lake. Yet, Odhiambo never thought of fishing as a business until he had a conversation about the commercial possibilities of fishing with his father-in-law. In 1987, he sold five goats and, after purchasing necessities, had 850 Kenyan shillings to invest. He remembered that conversation and invested the extra money in setting up his wife, Mary, as a fishmonger.

Although household, food-raising and social responsibilities take precedence over her business routine, through the farming systems research project, the SR-CKSP has indirectly transformed Mrs Odhiambo into an entrepreneur. Now Odhiambo has gained a business partner, and his wife has much more than just Lake Victoria on her horizon.

(This article by Patterson P. Semenye is reprinted from the March 1989 issue of the U.S. Agency for International Development publication, *Frontlines*.)

CHAPTER 2

AGRICULTURAL DEVELOPMENT OF WESTERN KENYA

Adiel N. Mbabu and Michael F. Nolan

Technology is often highly location-specific; its usefulness is determined by agro-ecological, socio-economic, and political environments. (International Service for National Agricultural Research, 1987.)

This assertion underscores the need to develop appropriate technology for specific circumstances. Indeed, no technology can be universally applicable to all people in all places at all times. Scientists should realize that every assumption made in the process of technology development will systematically include or exclude certain social categories in the general population. For example, when SR-CRSP determined to work on dual-purpose goats and not dairy cows, it began by isolating its clients from the general Kenyan population. The SR-CRSP pioneers were consciously seeking to assist smallholder farmers in humid zones where population pressures were rendering their land area too small for large stock production and whose economic circumstances did not allow for capital-intensive livestock management systems. With these attributes identified, western Kenya was considered a prime area for developing the technological package the programme was to produce. To be relevant to the needs of the region, SR-CRSP personnel decided to conduct on-farm research in addition to the controlled experiments conducted at existing experiment stations.

WHY WESTERN KENYA?

Throughout much of this century, western Kenya has experienced massive out-migration of males to other regions of the country. There has been little capital investment in agricultural production despite the high population density. As a result, western Kenya is characterized by limited agricultural intensification/innovation and a retarded differentiation process in the agrarian sector.

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Cash Crops

As early as 1904, a special report on selected agricultural districts in the East African Protectorate identified western Kenya as a potentially good area for cotton production (Wolff, 1974). However, the settlers who had formed a society to promote European migration into Kenya resisted Africans being involved in cotton production. They believed such participation would undermine the labour supply to European farmers and divert the scarce extension services provided by the Ministry of Agriculture. Partly as a result of this opposition, cotton production in Nyanza did not start to take hold until 1923 (Fearn, 1961), a time when cotton prices were plummeting because of the great depression. Cotton prices to the growers dropped by two-thirds, from 30 cents per pound to 10.5 cents per pound (Fearn, 1961). The higher prices paid for maize when World War II broke out further undermined the prospects for cotton production in the region. All of this was despite the pricing and marketing incentives of the colonial government.

This preference for maize persisted even with government interventions to suppress it. For example, in 1950 the "50% Maximum Cultivation Rule" was passed which prohibited cultivating land for more than five continuous years (KNA, 1951). Farmers grew maize for 3 years during the 5-year period allowed for cultivation.

Sugarcane has been an important cash crop in western Kenya since 1921 when the Victoria Nyanza Sugar Company began operations at Miwani. Sugar production has expanded in Nyanza in the post-colonial period but only in specified areas. For example, the Muhoroni high-density scheme was opened for the poor population. The required registration was only Ksh. 800. However, this scheme was meant to provide the labour needed in the large sugarcane plantations in Muhoroni (Anyang' Nyong'o, 1981).

Livestock Development

By 1947 the Department of Agriculture was proposing that goats for milk and meat be adapted in areas that were too densely populated to keep cattle (KNA, 1951). Western Kenya was a prime candidate but no plans materialized until the SR-CRSP began in the early 1980s.

A proposal to introduce high-grade cattle to the progressive farmers in Nyanza bogged down because of conditions attached to its implementation

(KNA, 1951). To buy a grade bull, a farmer either had to own a spraying pump or have access to a dip. Neighbours had to be persuaded to adopt the recommended livestock techniques to avoid tick infestation. These conditions proved to be a major setback to an early start in livestock development in the region.

Land Tenure System

The Young Kavirondo Association was pushing for individual land tenure in western Kenya as early as 1921. These calls were ignored by both the general indigenous population and the government (Anyang' Nyong'o, 1981). Unlike central Kenya during this period where intense political pressure was fermenting on land utilization and ownership, there was little land alienation and little commodity production in western Kenya. There was no sufficient political focus on issues to cause the colonial government to intervene in agricultural development. Furthermore, the region reaped only minimal benefits in the 1950s under the Swynerton Plan to intensify African agricultural production through privatization of land and provision of credit facilities.

Opposition to land consolidation and registration in Nyanza led the colonial government to adopt a self-help policy in 1958 (Dupre, 1968). Once again, the burden was passed to private individuals. Those interested in consolidating their land were expected to mobilize their neighbours to facilitate the process. When there was sufficient community interest, government officials would offer any required assistance. The self-help policy of 1958 in Nyanza was actually sanctioning the equivalent of the enclosure process that began in central Kenya in the 1920s. A negligible amount of land was consolidated, but not registered under the law. Once again, despite its high population density, western Kenya lost an opportunity for intensifying its agriculture.

Credit History

There are further indications that western Kenya did not receive a proportionate allocation of funds for intensification of agriculture. For example, the Nyanza agricultural officer wrote to the Director of agriculture:

"In my opinion Nyanza Province has not been fairly treated in regard to

its ultimate potential when considering development in that, far less funds have been allocated to us than, to Central and Southern provinces". (KNA, 1954).

The Swynerton Plan provided for three types of loans to African farmers: (1) long-term loans of up to 20 years to construct buildings and improve water supplies; (2) medium-term loans of up to 10 years for experiments in cash crops and purchase of implements and stocks; and (3) short-term loans of up to 5 years for production of cash crops, clearing and stumping, and employment of additional labour (KNA, 1958). Nevertheless, the policy in Nyanza was to give only short-term loans to farmers. Some reservations were made by members of the agricultural committee that, considering the potential returns per acre, the short-term repayment periods were a heavy burden to small-scale farmers. In fact, none of the capital loans to European farmers were for such a short repayment period (KNA, 1958).

CONTEMPORARY AGRARIAN SOCIAL STRUCTURE

A survey in 1983-1984 indicated that 57% of the 104 respondents in the divisions of Vihiga and Emuhaya in the Kakamega District, Maseno in the Kisumu District, and Boro in the Siaya District had access to less than 2 hectares (ha) of land (Sands et al., 1982). Only 4% had 6 ha or more available. Considering the Ministry of Agriculture's criterion that farmers working on less than 6 ha are smallholder farmers (Leys, 1975), it is apparent that western Kenya is predominantly small-scale in nature.

The survey found that 40% had access to at least one plot of land, 25% had two, 20% had 3, and about 14% had 4 or more plots. Recalling that the Luo people in western Kenya resisted land consolidation in the 1950s, these findings may reflect the compromise between the government and the people of the region to have land registration without necessarily consolidating the plots. Sands et al. (1982) also found that about 92% of the sample had registered their land.

The registration of land is geared to provide farmers with collateral to acquire loans, but only 10% of the respondents had acquired any loans. Of the 10 individuals who had taken loans, 4 were for farm development, 4 for building houses, 1 for home consumption, and 1 to start a business.

The respondents reported negligible use of agrochemicals. Only 8% used

chemical fertilizers and 7% purchased pesticides. However, 52% said they purchased extra inputs to maintain their livestock, such as drugs, minerals, tethers, and dipping treatments.

Temporary farm labour had been hired by 53% of the respondents in the previous 2 crop seasons compared with only 6% who had hired permanent labour. This underscores the relative importance of seasonal compared to permanent labour in western Kenya. The average workdays of hired seasonal labour for all respondents was only 10.8, which is very low. Ploughing, digging, and weeding were the most common tasks for seasonal labourers. Cash and meals were paid to their workers by 78% of the respondents, cash only by 20%, and a combination of cash, food, and accommodation by 2%. Only 11% used traditional reciprocal labour exchanges.

An overwhelming 78% of the respondents grew only what they considered to be food crops. Only 19% produced both food and cash crops; a mere 1% raised cash crops. The remaining 2% engaged in other activities. Despite their preference for food crops, farm families in western Kenya still have to buy additional foods from the market. Only 8% of the respondents were producing enough food to meet their household annual needs. On the average, they supplemented home-grown products with market purchases, an average of 5.5 months a year. Despite this deficiency, most of the households sold part of their harvests to meet household needs, then buying supplementary food supplies as occasion dictated.

Off-farm remittances were an important source of cash for these farmers. At least 59% received regular remittances. The households where women are the farm managers received off-farm remittances more often than those households headed by males. Of the 60 respondents who specified how they spent their remittances, 83% used them for household consumption needs. This indicates the dependence of farm families in western Kenya on the nonagrarian sectors of the economy for their livelihood. As Scheijtman (1984) pointed out, this process ultimately stratifies the peasants into three groups: (1) the poor who need off-farm income to survive; (2) the simple-reproduction peasants who barely subsist on farm produce; and (3) the surplus-producing peasants who have the potential for economic accumulation.

The agrarian social structures created in western Kenya retain part of the family members on individually owned small plots of land. They mainly produce for subsistence, using minimal farm inputs, hiring occasional seasonal labour, and substantially relying on off-farm income. To a large

extent the agrarian population falls under Scheijtman's (1984) category of poor peasants who require off-farm income to survive.

This is the point of reference that led the SR-CRSP to work with dual-purpose goats among the smallholder farmers in western Kenya. The concept was targeted to those in humid zones where population pressure was rendering their land area too small for large-stock production and whose economic circumstances did not allow for capital-intensive livestock management systems. The DPG project was designed to provide milk for household protein and energy requirements and for sale, yearlings for meat and/or for cash, and manure to improve soil fertility. Keenly aware of the subsistence nature of western Kenya's predominant production system, SR-CRSP research activities have produced interventions that are simple enough for use by the resource-poor farmers.

CHAPTER 3

THE SETTING: SMALL HOLDER AGRICULTURE

J. F. Moses Onim and Adiel N. Mbabu

The SR-CRSP Breeding Project is developing dual-purpose goats that are adapted to the economic and environmental conditions of smallholder farmers in western Kenya.

The work began in 1980 in four villages or clusters: Kaimosi and Hamisi in the Kakamega District and Masumbi and Bar Ding in the Siaya District. The Bar Ding cluster was later dropped and in 1988 three new villages were selected for development of the DPG technical packages: Muhanda in the Kakamega District, Rabuor between the Kakamega and Siaya districts, and Lela in the Kisumu District. The villages were selected to give as much representation as possible of the ecological zones and farming practices in the region.

CHARACTERISTICS OF THE PRODUCTION SYSTEMS

Kakamega District is located in Western Province and is considered a high potential agricultural zone. In the 1979 census (Kenya, 1979), the district had 1,031,000 inhabitants or about 7% of the Kenyan people. It is one of the most densely populated districts in the country. The Hamisi division, an SR-CRSP village, had a population of 94,747 persons. The division is 154 km^2, thus the population density was calculated to be 615 persons per km^2. The average household included 5.18 persons with 1.3 ha of agricultural land, i.e., 0.36 ha per person (Jaetozold and Schmidt, 1982).

The second SR-CRSP work site is in Siaya District, Nyanza Province on the shores of Lake Victoria. In 1979 the district contained 474,000 persons living on 2,522 km^2 of land or 188 persons per km^2. Agricultural land per household is 2.14 ha or 0.39 ha per person. While the land endowments are slightly more than for Kakamega District, there is a shortage of land for optimal stocking rates.

Farms in both Hamisi and Siaya, two extreme villages selected to show maximum variability among villages, are privately owned and operated. A problem which occurs in Hamisi is the subdivision among heirs of already small parcels of land. Decreasing farm sizes are aggravated by high population growth and by the lack of off-farm employment for a growing labour force. Average farm size among SR-CRSP collaborating farmers in Hamisi is about 1.3 ha with a range of 0.44 to 3.0 ha; 73% of the households own 1.5 ha or less. The supply of labour is high relative to the demand. With the increasing farm population, the amount of land per adult worker is declining. This has grave implications for employment, types of technical innovations that can be introduced, resource use, and crop-livestock patterns. Farm size is slightly larger in Siaya than in Hamisi, averaging 2.58 ha with a range of 0.99 to 5.63 ha. Land fragmentation is not as acute in Siaya due to the lower population density.

Smallholder farmers such as those in Hamisi and Siaya often have subsistence as well as monetary objectives so their production and consumption decisions are interdependent (Leys, 1975). The uncertainties inherent in agricultural production and the limited resource base of smallholders means that maintaining their subsistence requirements is very important. Multiple cropping is a practice with which these farmers can attain their crop production goals and yet protect against natural and economic risks. Multiple cropping provides diversification while recognizing complimentariness in the use of labour, sunlight, water, and nutrients.

The prevalent cropping systems in western Kenya are intercropping and sequential cropping. Both Hamisi and Siaya can be characterized as mixed crop-livestock farming systems with multiple cropping. These farmers intercrop field beans and maize, the staple food crop. The seasonally bimodal rainfall pattern allows the farmers to plant two crops a year, hence they also practice sequential cropping. As secondary crops they grow sweet potatoes, cassava, bananas, and a variety of green leafy vegetables. Tea and coffee are important cash crops in Hamisi while in Siaya farmers grow coffee, cotton, and sugarcane.

In Siaya, the average collaborating farmer has 4.6 head of cattle. In Hamisi, where farm sizes are smaller, the comparative number is 2.1 head. The larger number of cattle in Siaya reflects the historically pastoral orientation of these people, while Hamisi have been crop-oriented. The average number of indigenous East African goats and hair sheep is 0.2 per household in Hamisi, while in Siaya the averages are 2.13 East African goats and 1.63 hair sheep.

GEOGRAPHIC AND CLIMATIC CONDITIONS

Altitude

The mean altitudes of the villages range from nearly 1,300 m to almost 1,700 m (table 3.1) above sea level (asl).

Soils

How the soil was formed often determines its fertility and productivity. Alluvial soils that are derived from materials deposited from elsewhere often are more fertile than soils originating from parent rocks underlying an area. There are five soil groups in the SR-CRSP study area: (1) soils at high elevations with prominent outcrops of rocks, (2) red loamy soils at high elevations, (3) red loamy soils at medium elevations, (4) sandy/murrumy soils at low elevations of the Lake Victoria Basin, and (5) black cotton soils of the Lake Victoria Basin.

Table 3.1. Mean altitudes of SR-CRSP villages in western Kenya.

Village	Division	District	Sites sampled	Mean altitude asl (m)
Kaimosi	Hamisi	Kakamega	11	1,693
Hamisi	Hamisi	Kakamega	8	1,682
Muhanda	Vihiga	Vihiga	2	1,523
Rabuor	Yala/Emuhaya	Kakamega/Siaya	9	1,469
Maseno Station	Maseno	Kisumu	1	1,500
Lela	Maseno	Kisumu	7	1,440
Masumbi	Boro	Siaya	1	1,296

Source: Onim et al., 1986.

Soils at high elevations with prominent outcrops of rocks, 1,600 to 1,700 m asl. These soils are found on steep hills in the Kaimosi, Hamisi, and Muhanda clusters and are characterized by prominent outcrops of huge sandstone boulders. They are sandy, very shallow, and prone to severe soil erosion. The soils are infertile because high rainfall causes leaching and erosion. They have a pH range of 4.9 to 6.2. They are deficient in phosphorus, organic carbon, and nitrogen. Since they are continuously cultivated throughout the year, the soils need manure and inorganic fertilizer to achieve high crop yields.

Red loamy soils at high elevations, 1,600 to 1,700 m. These soils are found in the Kaimosi, Hamisi, and Muhanda clusters. They are derived from granitic basal rocks or lateritic (murrum) formations. They are usually deep and strongly leached with a pH as low as 4.4. This leads to acute phosphorus deficiency and high iron and aluminum toxicities for plants. They are also very deficient in organic carbon, nitrogen, magnesium, and sodium. These soils can be very productive when they are well managed because of the high rainfall and cool temperatures.

Red loamy soils at medium elevations, 1,500 to 1,600 m. These soils, found in the Maseno Research Station, Rabuor, and parts of the Lela cluster, have characteristics similar to those noted above except that they are shallow. They are not as leached because of slightly lower rainfall.

Sandy/murrumy soils at low elevations of the Lake Victoria Basin, 1,195 to 1,500 m. These soils, found in the Lela and Masumbi clusters, are usually very shallow with very low fertility levels. Their moisture-holding capacities are very low, hence they dry out quickly at the end of rainy season which leads to potential crop failures if there is inadequate rainfall. They are very low in organic matter content with the pH ranging between 5.0 and 5.8.

Black cotton soils of the Lake Victoria Basin, 1,195 to 1,500 m. These are the richest soils in western Kenya, but they have three major problems: water logging as they are prone to flooding, poor workability due to stickiness when wet, and too hard to work when dry. These soils are very productive when well managed.

Rainfall

The mean annual rainfall of representative sites around the SR-CRSP villages can be divided into three groups (table 3.2): (1) Kaimosi, Hamisi, and

Muhanda with 1,855 millimetres (mm); (2) Rabuor and Maseno with 1,678 mm; and (3) Lela and Masumbi with 1,243 mm. All villages receive bimodal rainfall. However, because of the high temperatures and evapotranspiration rates in the lower altitudes of the Lela and Masumbi villages, the second rainy season crop has a higher probability of failure than in the other villages.

Vegetation

The interactions of altitude, soil, and rainfall lead to certain types of natural vegetation growing in each of the areas. Kaimosi, Hamisi, and Muhanda villages are in areas with high tropical rain forests characterized by aggressive climbers that form solid canopies that can become several

Table 3.2. Mean rainfall of representative sites around SR-CRSP villages in western Kenya.

Village	Representative site	Rainfall (mm)		
		Long rains	Short rains	Total
Kaimosi	Tea estates	1,003	812	1,815
Hamisi	Vihiga	1,003	852	1,875
Muhanda	Vihiga	1,003	852	1,875
Rabuor[1]	Maseno Res. St.	858	820	1,678
Msn. Res. St.	Maseno Res. St.	858	820	1,678
Lela	Lela Railway St.	713	680	1,393
Masumbi	Pondo Town	588	518	1,106
	Siaya Town	638	592	1,230

[1]Rabuor Village has no meteorological station. Data from the nearby Maseno Research Station is used as a proxy.

storeys high. Some of the well-known tree species found here include Nandi flame tree (*Spathodea nilotica*), *Polyscious kikuyuensis*, *Trichilia roka*, *Prurius africanum*, Elgon teak, *Maesposis eminii*, and *Fogara macrophylla*. The thick canopies usually do not allow sufficient light for grasses to develop.

Rabuor, Maseno, and Masumbi areas have sparser trees which allow shrubs and grasses to develop. The major tree species include *Terminalia browuii*, Chrophora excelsa, *Olea vitax Albizia* spp. e.g., *Coriara*, *Croton megalocurpus*, *Markhamia intea*, *Ficus kigellia* africana (sausage tree), and many species of *Acacias*. This zone has a wide range of lower-storey species like Grewia and many leguminous shrubs like Sesbania species, and creeping or climbing species like *Tylossema fassoglensis*. Most of the trees, shrubs, and creepers in this area are excellent feed sources for many classes of livestock and wildlife, hence there are large herds of cattle, sheep, and goats towards the Lake Victoria plains.

Human activities have destroyed most of the natural vegetation so there are no noticeable differences between the tree vegetation of Kaimosi and Masumbi villages. These changes have created an interesting evolution of grasses and weeds in all the villages. The grasses at the highest elevations, that is, Kikuyu grass (*Pennisetum clandestinum*), Rhodes grass (*Chloris gayana*), and *Setaria* species, tend to have higher forage qualities than the natural grasses found in the Lake Basin, e.g., *Cymbopogon*, *Hyparrhenia*, *Andropogon*, and *Sporobolus* species.

LIVESTOCK EXTENSION SERVICES

Bridging the gap between research activities and the farming communities in western Kenya is the responsibility of the Extension Services and to a lesser extent of the nongovernmental organizations. The SR-CRSP studied extension capacities and capabilities with respect to dairy goat farming (Reynolds et al., 1984). All livestock development extension and technical personnel were interviewed in the five administrative divisions where the SR-CRSP established on-farm research activities: Emuhaya, Hamisi, and Vihiga in Kakamega District, Maseno in Kisumu District, and Boro in Siaya District. Sixty-two interviews were conducted with veterinary officers, animal production officers, assistant animal production officers, animal health assistants, and junior animal health assistants.

The findings indicated (1) there were limited numbers of extension staff

available to serve the population in these jurisdictions, (2) the extension staff did not always have the logistical support needed to make required farm visits, and (3) most of the livestock extension staff had received no systematic training to prepare them to advise farmers on dairy goat management. While this situation was by no means static, the findings did expose that a pathetic situation prevailed. This information guided SR-CRSP staff in developing strategies for releasing these technology packages to the general public.

At the time this study was conducted in the early 1980s, there were 62 extension staff of different levels of training and rank to serve 103,683 households in the area (see table 3.3).

The survey indicated the extension staff could visit 23.3 households in the course of a typical month. Taking this as a measure of coverage, it would take 4.3 years to make a complete cycle of farm visits given the present staff in the Maseno Division. That is the least time needed.

Table 3.3. Extension capacity in the five divisions of the SR-CRSP in western Kenya.

Division	Number of Ext. staff	Number of households	Years to cover households
Maseno	15	18,128	4.3
Vihiga-Emuhaya	23	47,739	7.4
Hamisi	13	17,032	4.7
Boro	11	20,784	6.8
Total or average	62	103,683	5.8

These figures relate to the total staff establishment in the divisions. The ratio of staff to potential client households becomes even more disproportionate when limited to those personnel who have received higher professional training at the diploma or degree levels. There were only eight of these qualified individuals in the five divisions to serve 103,683 households, a distribution of 1:12,960. While recognizing that these figures are sketchy, it is evident that the extension staff within the study area was outstretched at the time of survey. This finding called for making group contacts rather than individual extension visits.

Seventy-nine percent of the extension staff felt they were not able to visit "often enough" with the farmers on their respective farms. The livestock development staff believed this perceived failure was because they had too many farmers to serve across too great an area without adequate transportation. Sixty-eight percent of those surveyed cited lack of transport as the most critical problem hindering their work.

Most of the extension staff interviewed indicated they would require further training in goat management (table 3.4).

Only a negligible percentage of the extension staff felt confident with their skills in DPG management. The great need for such training underscores the important role of the SR-CRSP in preparing the extension personnel to train farmers in DPG management techniques. This manual provides such knowledge.

Table 3.4. Extension staff in the SR-CRSP area needing training on DPG management.

Responses	Number	%
Require further training	46	74.2
Need a refresher course	10	16.1
Can treat but not manage DPG	2	3.2
Need no further training	4	6.5
Totals	62	100.0

The study indicated that (1) there were too few extension staff to rely on individual farm visits in technology transfer, (2) adequate logistical support was not available for extension staff to make required farm visits, and (3) most livestock extension staff had been offered no systematic training for them to competently advise farmers on dairy goat management. Under these circumstances, recommendations for farmers should be made through group extension visits rather than individual farm visits. The SR-CRSP should produce as many materials and facilities as possible to prepare the extension staff to cope with training the farmers about dairy-goat production systems. While the techpacks contained in this manual can play a significant role in disseminating SR-CRSP findings on DPG management techniques to the extension staff, other training such as workshops and formal courses in agricultural training centres will be required.

More than 50,000 people have taken part in informal training conducted as part of the SR-CRSP, increasing the awareness of dual-purpose goats by farmers, students, technicians, extensionists, and development project workers. They have participated in open houses, field days, agricultural shows, farmers' workshops, and lectures at farmers' training centres and institutes. One result is an extremely high demand by many of these people to buy dual-purpose goats.

Thirty-seven Kenyans have earned their graduate degrees under sponsorship of the SR-CRSP since 1980, including 29 M.Sc. and 8 Ph.D. students. They pursued their academic courses in Kenya and in overseas universities, particularly the United States. These graduates are a valuable scientific resource in expanding the small ruminant research through collaborative projects and through their strong professional ties.

CHAPTER 4

ON-FARM RESEARCH METHODOLOGIES

Patterson P. Semenye, J. F. Moses Onim, and Fanny B. Nyaribo

PLANNING ON-FARM ANIMAL RESEARCH

Amir and Knipscheer (1989) described four stages in conducting on-farm animal research within the context of the farming systems research (FSR) approach.

Description and diagnosis. The process begins by describing the existing farming systems and practices of the client-farmer groups to identify and classify the production systems. These include the constraints limiting livestock productivity, farmers' resources, and institutional limitations. Secondary and baseline survey data are commonly used in this stage.

Design. Through research, specific technologies are designed to alleviate the key constraints identified through the description and diagnosis stage.

Testing. The third stage involves testing the technical interventions. This is accomplished through on-farm trials which measure technical and socioeconomic feasibility. Similar on-station trials are usually conducted to compare yields.

Verification. The final stage tests whether or not the new technologies are accepted by the client-farmers. It provides for communication with policymakers for implementation and with extension departments for wider dissemination.

There is considerable latitude within the FSR framework for planning on-farm animal research once the first stage is completed. Tripp and Woolley (1989) gave an excellent description of the stages involved in planning on-farm experimental trials (figure 4.1). They described it as a process whereby each stage coincides with either problem identification, cause, or solution.

Stage One. Once a study site and recommendation domain are identified, the constraints to livestock productivity must be clearly defined. These should address biological, socioeconomic, and institutional factors. Where possible, solutions to these problems should be noted as they will form the basis for exploratory and solution-finding experiments to be conducted on-farm and on-station.

Stage Two. This stage involves ranking the problems in the order of their importance to enable identifying research priorities. Not all of the constraints will be clearly defined and understood. Some of the emerging priorities are likely to require further diagnosis, lending themselves to long-term research priorities.

Stage Three. The causes of the problems identified in stage two need to be discovered before researchers can seek the solutions. For example, the cause of low animal productivity may be inadequate quantity and or quality of feed at certain times or throughout the year, poor management practices, or a combination of these. Tripp and Woolley (1989) pointed out that there must be enough information about the constraint to come up with suitable solutions. If the constraint or problem is not well understood it may be necessary to carry out exploratory experiments or surveys to clarify it. There should be periodic evaluation of the identified constraints as more information becomes available.

Stage Four. Many times constraints are interrelated. Lessening one or more can lead to alleviating or exacerbating others. The interactions among causes and problems must be fully understood so their implications on associated problems are given proper consideration.

Stage Five. A number of alternative trials should be designed to screen for the most promising technology for solving each problem. In this context, technology may be a new breed of livestock, a new livestock management practice, or some other improved production practice within existing enterprises. At this stage, the researchers should take the following steps (Amir and Knipscheer, 1989):

(a) Choose collaborating farmers and seek their cooperation if this was not done at the sampling stage.
(b) Determine the type or types of trials to be conducted and type of animals needed for the experiments.
(c) Determine whether to use researcher-managed trials, farmer-managed trials, or both.

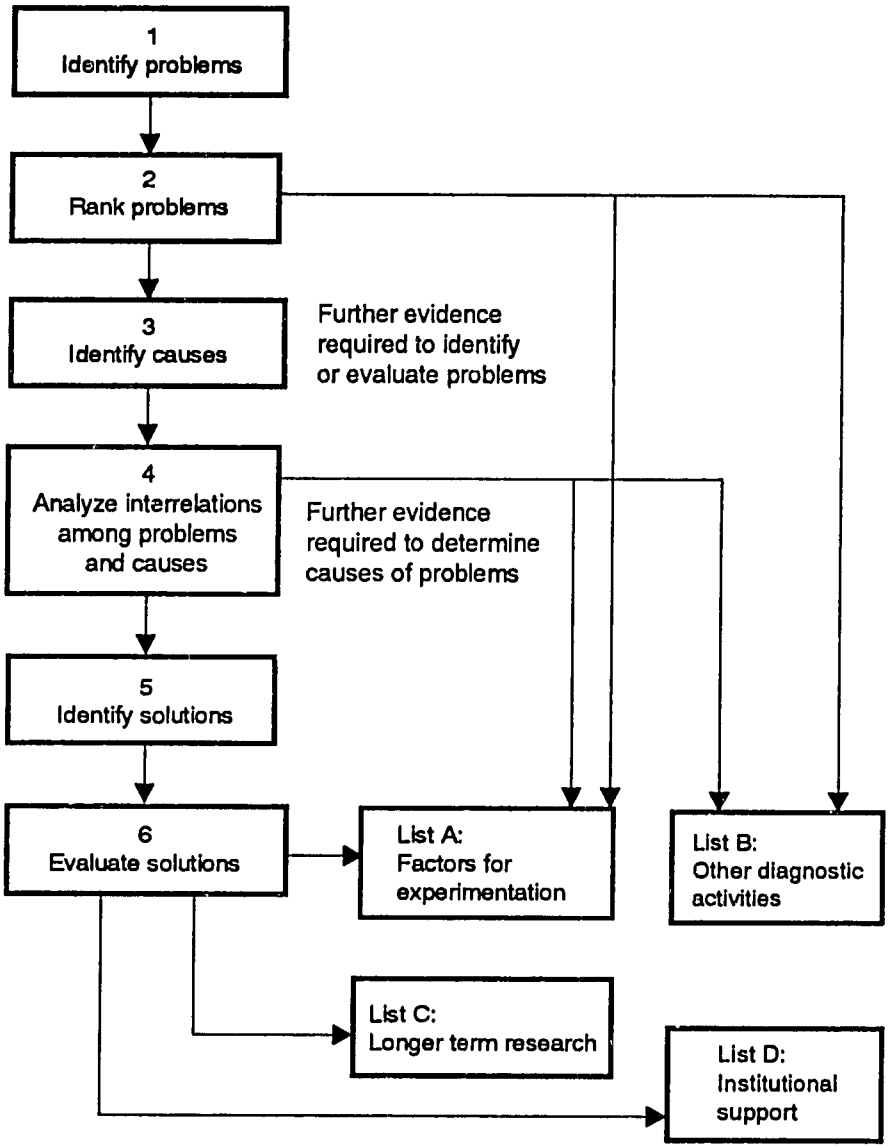


Figure 4.1. Steps in planning on-farm animal research.

Adapted from Tripp and Woolley, 1989

(d) Determine the relevant variables on which data will be generated.
(e) Determine the volume of data and collection frequency.
(f) Determine how to minimize the lag between data collection and analysis.

Stage Six. Each trial should be monitored and evaluated for its technical, economic, and social feasibility. Due to budget, time, and other limitations, only those trials with the largest probability of success should be conducted.

MEASURING ON-FARM PERFORMANCE OF DUAL-PURPOSE GOATS

On-farm animal research is a new approach of livestock research, hence the techniques for measuring the various parameters are those that have been used in the traditional on-station trials. These techniques have been adapted to suit the differences in the set-up and ownership of livestock that exist under on-farm conditions. The techniques discussed here were used to generate performance results of on-farm DPG in western Kenya. They should be adaptable for other areas with similar production characteristics.

Conducting either a static or a continuous survey can be accomplished by using the same research instrument. Following is information which is most often obtained through surveys:

- Age — chronological (actual) or physiological (proxy); for example, via incisor teeth
- Sex — female, entire male, or castrated male
- Type of birth — single, twins, or triplets
- Breed — phenotype
- Physiological status or stage — dry or lactating, pregnant or nonpregnant, kid, weaner, yearling, maiden doe, serving- or non-serving buck.
- Health status — sick or healthy
- Body condition (subjective) — good, fair, or poor. Develop own condition scoring index.

- Abnormality, if any — for example, mono-eyed, hermaphrodite, short- or long-jawed, and so forth
- Colour — predominant coat colour
- Origin — local, bought-in, or imported
- Production role — meat, milk, or fibre

Identification

Goats at the Maseno Station are identified by their tag numbers. On farms, they often have names or there are so few that identity is not a problem. With on-farm trials, however, each goat must be identified by a numbering system such as an ear tag, brand, or tattoo. Ear-tagging, which is used in western Kenya, is more humane, acceptable, and readily applicable.

Profitability

Profitability is the difference between outputs and inputs. Livestock production should also be assessed in monetary or biological terms. In western Kenya, on-farm DPGs were evaluated on the basis of their primary resource utilization (inputs) and secondary production (outputs).

Measuring Inputs

Dry Matter Intake. One of the most important inputs in livestock production is dry matter intake (DMI). For the DPG, it had to be determined whether performance matched feed intake.

It is easy to determine intake when DPG are fed cut and carry forage for it entails weighing the forage before and after feeding; the difference is the intake. DPGs in western Kenya spent only 21% of their grazing day on cut and carry while 47% was spent on grazing and browsing (see table 4.1). An indirect method was employed to measure DMI of the grazing and browsing portion: DMI = 100/(100-digestibility) x dry matter weight of feacal matter collected over 24 hours. Digestibility was determined *in vitro* from samples collected after mimicking DPG grazing. In earlier trials, forage samples

Table 4.1. Minutes taken on various activities by dual-purpose goats in western Kenya.

	Village							
	Hamisi		Masumbi		Kaimosi		Overall	
Event	n	Mean±SE	n	Mean±SE	n	Mean±SE	Mean±SE	
Resting standing	50	110±8	34	111±11	34	90±10	105±6	(19%)
Resting lying	49	65±7	32	75±10	33	68±12	69±5	(12%)
Playing	15	7^{ab}±2	2	10^{a}±6	5	5^{b}±2	7±1	(1%)
Grazing	30	109±20	33	145±15	26	135±20	130±11	(23%)
Grazing cut and carry	38	153^{a}±14	15	62^{b}±7	17	90^{b}±18	118±10	(21%)
Browsing	23	145^{ab}±20	32	109^{a}±14	27	168^{b}±28	138±12	(24%)
Duration	50	604±16	34	585±18	34	531±13	577±10	

Means in the same row bearing different superscripts are significantly different ($P \leq 0.05$)

collected after mimicking grazing were similar in quality and composition to those sampled by oesophageally fistulated DPG (Karimi et al., 1985). Feacal matter was collected with bags which were harnessed to DPG for 24 hours. The bags had sieved bottoms to allow the urine of does to percolate. This procedure is preferred to a marker which requires laboratory concentration analysis and regulated dosing of the marker. The DMI as determined by the total feacal collection procedure is given in table 4.2.

Diet Botanical Composition. The quality of the DMI is determined by the botanical composition of the diet. This can also alert a producer to the consumption of deleterious species by his livestock. The Five Minutes Method of Hancock (1953) and Semenye (1980) was used to determine the botanical composition of the diet of the DPG (see figure 4.2).

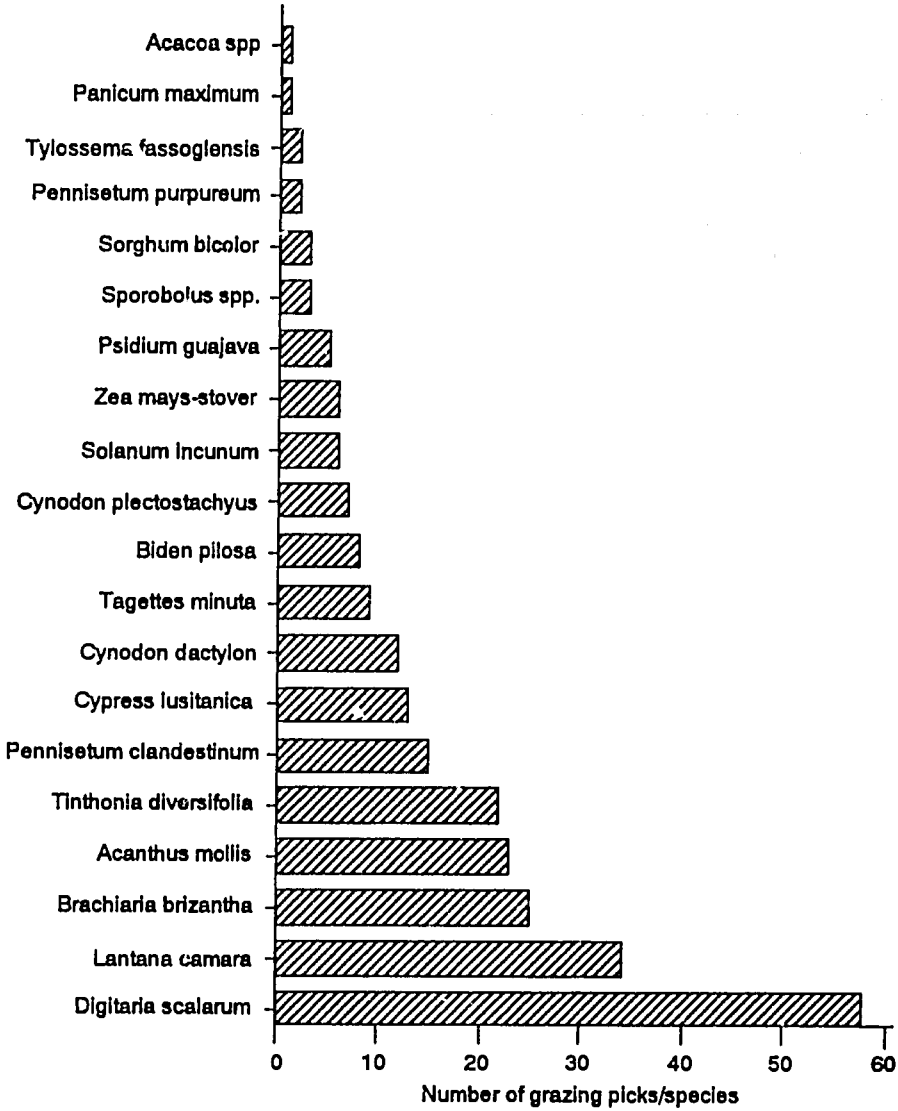


Figure 4.2. Grazing preferences of dual-purpose goats for herbage species in western Kenya.

Table 4.2. Mean nutritive values of the diets of dual-purpose goats in western Kenya.

	DM %	CP %	DMD %	DMI kg	BWT %	ME MCal
N	36	36	36.0	36.0	36.0	36.0
Mean	28	16	55.0	0.7	2.4	1.8
SD	12	3	6.5	0.3	0.8	0.6

This method is very tedious for the observer who must note what the goat does every 5 minutes. However, it captures other important events during grazing by DPG (see table 4.1). Other methods for determining the botanical composition of diets are microhistological analysis of faeces, extrusa from oesophageally fistulated goats, rumen canula technique, mimicking grazing, and pasture analysis before and after grazing.

Water. The free water intake is determined by measuring the amount offered before and after drinking. For convenience in on-farm research, water intake is weighed by the same spring scale used to weigh the DPG and forages. Measurements by volume are equally acceptable. A knowledge of watering frequency is also needed, usually ascertained from DPG owners.

Evaluation of the amount and frequency of water intake by DPG indicated they were not getting a sufficient supply. However, this conclusion was not valid because DPG indirectly take a lot of water through forage. Water content in forage can be as high as 90%.

Health. There were two aspects of DPG health to be monitored: (1) quantifying the inputs for prophylaxis and treatments and (2) measuring the parameters that reflect health status. A card was opened for each DPG and kept at the respective households. All treatments were entered on this card, including prophylactic measures, body weights, dates of kidding, weaning, abortion, sale, death, and so forth. On sale, slaughter, or death, the card was returned to Maseno. In the meantime, information on the cards was collected routinely for updating the records held at the office. Samples of blood, faeces, skin scrapings, and discharges were taken regularly for determinations of packed cell volume, helminths eggs per gram, and skin and bacterial diseases. Post-mortems were carried out whenever the need arose.

The health exercise indicated the following diseases and ailments for DPG in the order of their economic importance: pneumonia, helminthiasis, ectoparasitism of mange and ticks, diarrhoeas and scours, abscesses, trauma and wounds, malnutrition, and abortions.

Measuring outputs

Body weights. DPG body weights were regularly monitored using a spring scale, a sling, and a metal tripod. The sling goes around the belly of the goat from where it is suspended for weighing. The spring scales were graduated into half kilograms (kg) and with a range of up to 100 kilograms. DPG were always weighed in the morning before going out for grazing. It is best to weigh when they have fasted; for example, early in the morning, rather than after they have taken water. The scales used in western Kenya were inexpensive so they were not calibrated routinely. Instead, they were replaced yearly. Weighing of livestock must be under consistent conditions. The scales must be calibrated or replaced according to their accuracy.

Milk. The milk output from the DPG does was measured in volume. The milk was collected into either calibrated beakers or cylinders with a capacity of 1 litre (1). At each milking, the off-take was recorded in a duplicate notebook. The record was entered by a household member. Once a week and without prior notification, an enumerator made the recording. This was a check against recorders who may have been inclined to over or under-report. At this time, the enumerators removed the first-copy records from the duplicate notebook so the weights could be entered into the computer pending further processing. Milk off-take does not represent the total yield because farmers, more often than not, milked a quarter or a half of the total yield, then left the rest for the kid. Farmers appeared to look for a certain off-take regardless of the stage of the lactation. This could be the reason why the on-farm lactation curve is nearly horizontal, unlike the two other on-station curves (see figure 4.3). There are three possible techniques to be used to get the total milk yield when a doe will not let milk down without nursing: (1) weigh the kid before and after nursing, (2) administer oxytocin, or (3) convert kid growth into a liquid milk equivalent.

Reproduction. To capture the reproductive performance of livestock, the animal must be monitored for at least one parturition interval. Dates of kiddings, abortions, and weaning were taken for DPG. This was a continuous process over the duration of the on-farm research. Collection of

pre-natal reproductive wastage required close observation and a knowledge of whether or not the concerned animals had conceived. Pregnancy diagnosis (PD) determined if conception had taken place. PD procedures of palpation, of pregsonic equipment, or hormonal level determination can be used. The SR-CRSP research used the pregsonic procedure in combination with reproductive records. Dates were noted of mating and return to estrus if conception did not take place. With this information, a doe that did not kid within the gestation period was assumed to either have aborted or have a reproductive disorder. However, abortions were confirmed on notice of dropped foetus or related discharge.

Manure. Manure is measured directly and empirically. Direct measurement is from total feacal collection while empirically is indirectly from digestibility and DMI calculations. Empirically, a DPG doe in western Kenya produces 130 kg/yr of dry manure.

FEED RESOURCES RESEARCH METHODOLOGY

Several types of measures were used by the feed resources personnel to collect information including linear measurements, weights, soil sampling, grain and feed yield determinations, questionnaires and farmer interviews, and laboratory and statistical analyses.

Linear measurements. Tape measures and rulers, calibrated in metric, were used to determine plant heights, diametres, plot lengths and widths, and other linear measurements.

Weights measurements. Field spring-scales with capacities ranging from 2 to 100 kg were used to weigh feeds, grain, and fuelwood. Beam and digital electronic balances were used when more accurate measurements were required. Wet weights of samples were taken in the field. Dry matter (DM) determinations were made after drying the wet samples for at least 24 hours in an oven at 80°C until the samples attained constant weights. Samples for laboratory analyses were oven dried at 40°C for at least 24 hours, then milled for testing.

Plot and field yield measurements. Measurements of grain and feed yields were done on a plot basis. Quadrats variously covering areas of between 1 to 100 m^2 were used for sampling several representative areas of large fields before calculating the averages. Cereal and legume grain yields

were sun-dried to constant weights before determining their moisture content (mc) by a moisture metre. The grains were then weighed on an electronic balance and their weights adjusted to 12% mc.

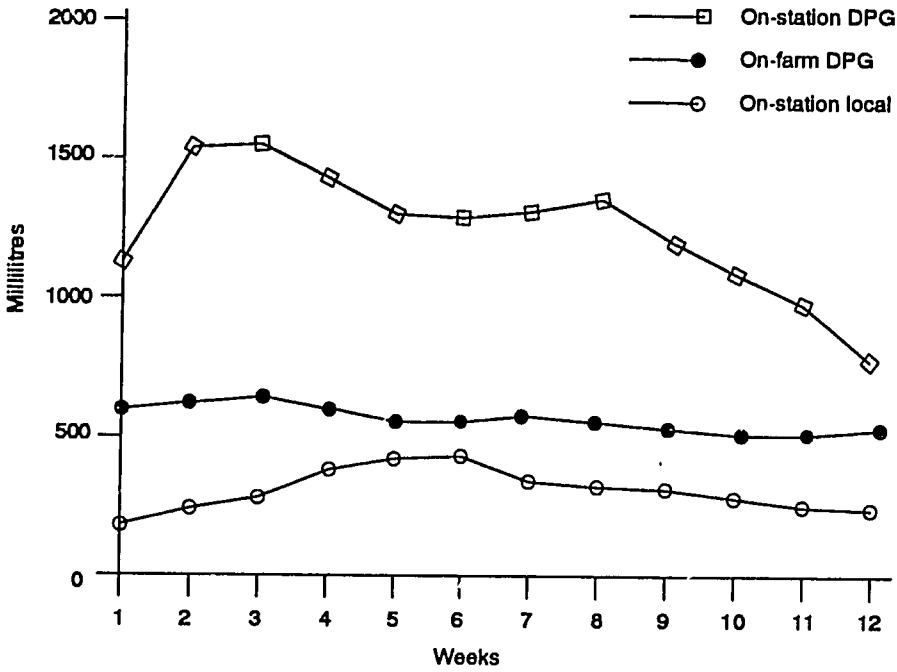


Figure 4.3 Comparative off-take milk yields of dual-purpose and local goats at on-station and on-farm sites in western Kenya.

Soil sampling and surveys; vegetation composition and quality. The soils in farmers' fields were surveyed and sampled for estimated land holdings and soil fertility. Farm sizes were estimated by the pacing method. Soil fertility was determined at depths from surface level to 30 centimetres (cm). Soils were sampled by auguring in at least three places in a plot; more in larger fields. The soil samples were well-mixed before taking a 1 kg subsample for laboratory drying, grinding, sieving, and analysis.

Soil and vegetation surveys were conducted through a transect of more than 200 kilometres (km), covering altitudes ranging from 1,170 m above sea level on the shores of Lake Victoria to 2,000 m at Kapsabet. Soils and vegetation were sampled at approximately 5 km intervals. Soils were augured and the broad soil types noted. Vegetation was sampled by identifying species composition of a 1 m^2 quadrat.

Daily rainfall records were kept using rain gauges installed in each village where SR-CRSP operated. These records were used to help personnel of biological science-based projects to interpret the effect of rainfall on the performance of crops and goats.

Questionnaires and farmer interviews. Farmers were interviewed by using questionnaires and through their frequent interactions with field staff and scientists. The farmers' wishes and aspirations on research problems were captured and research protocols prepared to address the relevant issues. Research findings were communicated to the farmers by the field assistants and scientists through individual contacts, on-farm group meetings, and annual field days at the Maseno Research Station.

Training. Field assistants were trained in the new technologies developed by SR-CRSP. Once they were familiar with these methods they received simple written descriptions of the methods which they used for training farmers. On-farm demonstrations and group meetings were held to facilitate interactions between farmers, field assistants, and scientists. Through question-and-answer sessions of farmers and scientists it became clear whether or not the farmers liked the new technologies and to what extent the field assistants had succeeded in their training. Scientists could then make appropriate adjustments in their research studies.

Local agricultural shows also were important venues through which SR-CRSP exhibited its achievements and observed the reactions of the general public.

CHAPTER 5

BREEDING STRATEGIES FOR GENETIC IMPROVEMENT

Bonfance A. J. Mwandotto, Francis Ruvuna, Jerry F. Taylor, and Tom C. Cartwright

INTRODUCTION TO GOAT BREEDING

Goat production, like any other livestock farming, is a complex operation involving the interaction of inherent genetic potential (genotype) with production resources and climatic conditions (environment). Goats of two different breeds represent two different genetic potentials or genotypes. Genetically identical does of the same breed given different feed (nutrition), exposed to different diseases and parasites (health), and bred at different times of the year (management) represent two different environmental effects. For milk, the most important measure of productivity is yield per year. For meat, the important measures are the number and weight of kids weaned per doe per year. For dual-purpose goats, offtake of milk and meat must be balanced. Likewise, the combined offtake must be balanced with the nutrient resources, climate, land, human resources and other conditions of the area.

An increase in goat productivity is usually achieved by a combination of genetic and environmental improvement, especially feeding practices. Heredity provides an individual with its genetic ability in certain characteristics. Environment provides an individual with the opportunity to express that ability. That is, environmental factors may modify the expression of potential abilities such that goats of similar abilities produce differently. Thus, productivity is dependent upon the two groups of factors working together. Good inheritance alone is not enough nor is a good environment alone. Whatever the case, improvement of all disciplines of animal husbandry, including management, health and nutrition (the animal environment), and improvement in the genotype, must be integrated for efficient goat production. Figure 5.1 illustrates the inputs and biological components that are included in total merit of a dual-purpose goat. Note the complex

genotype-environment interactions among the components, the biological components, and product outputs that determine net merit.

It is not easy to match environmental constraints with animals of appropriate genotypes in order to get optimum performance. Systems analysis techniques applied to livestock production are methods of conceptualizing a production system and modeling it in mathematical terms. Therefore, animal responses across time and space can be closely simulated by computer programmes. The SR-CRSP breeders took this approach and were able to determine the interactions within the system. The effects of various interventions were examined over the entire production system to identify unanticipated effects that could be counter-productive to biological or economic efficiency. Systems analysis simulations provided a method of identifying and examining optimal combinations and sequences of limiting new practices.

INHERITANCE AND SELECTION

It is not the purpose of this chapter to present detailed genetic principles applied to goat improvement because they can be found in animal breeding textbooks. Although there have been relatively few genetic studies on goats, the principles of their genetic improvement do not differ from those for other farm animals.

The word **inherit** means to receive something from relatives or friends. Often, we think of this in terms of money or property, but genetic inheritance refers to the genetic code received from parents. This code sets the potential of expression of all characteristics of any organism, including goats. These genes largely determine physical characteristics such as colour, shape, and size. Most of the genetic data available on economic traits of goats pertaining to milk, growth, size and adaptability indicate there are differences between animals and between breeds which can be used in breed improvement (Angwenyi, 1984; Devendra and Burns, 1983; Ruvuna et al., 1986). Many obvious characteristics of goats, such as colour, horned or polled, and ear shape are inherited by single genes. Characteristics such as milk production, growth rate, and size are controlled by many genes. A knowledge of an animal's genetic makeup is necessary to predict how that animal will perform, that is, how much milk a doe will produce or how it will perform.

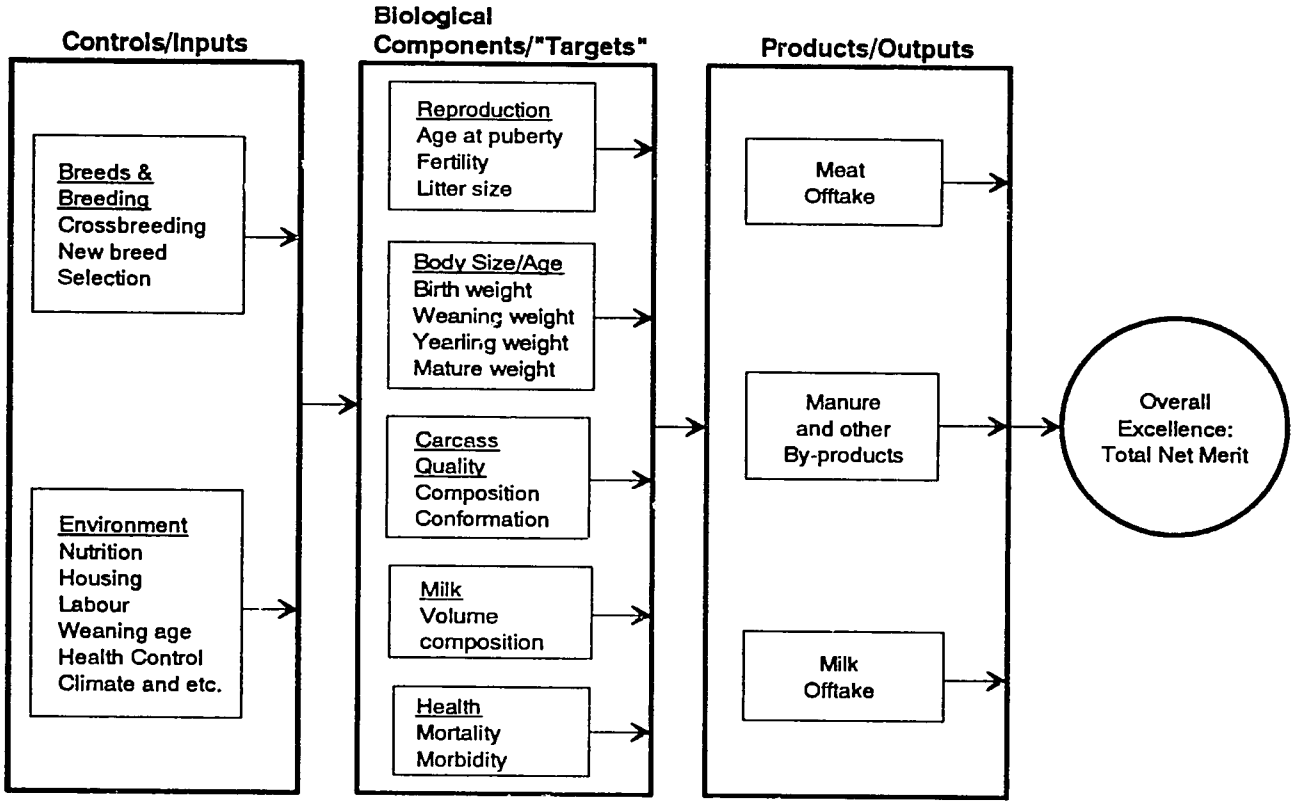


Figure 5.1. Inputs and targets for moulding biological components that define total merit of a dual-purpose goat.

When one sperm enters one egg and forms the embryo (which develops into the foetus), the inherited characteristics of that animal are established. It has half of its inheritance from the sire and half from the dam. For any one animal born in a flock, the sire and the dam are of equal importance in contributing to its genetic inheritance. However, even if two kids have the same sire and same dam, they get some but not all of the same genes, because there is a random process involved. That is why even close relatives will often be quite different.

Since one buck can have many daughters in a flock, most of them from different dams, we often say that the buck is half the flock. The greatest chance for flock improvement, therefore, lies in selection of the buck. The farmer can apply greater selectivity (selection intensity) for bucks because only a few are needed as sires. However, it is important not to underestimate the importance of the doe in selection because for any young buck- or doe-replacement in a herd, half of its genes come from its dam.

An important consideration when selecting a buck or a doe is that of their breeding value. The breeding value for milk yield of a buck is simply the milk yield expected from his daughters. Of course, breeding value can only be estimated based on the individual's performance and that of his sire, dam, half-sibs, and daughters. The point of discussing breeding value is to emphasize that selection of a sire or dam should be based on the estimated breeding value of the individual whether it is formally calculated or simply an informal opinion.

There are two main tools for genetic improvement, selection, which is choosing the parents of future generations, and mating systems, choosing which sire mates to which doe. The parents may come from genetically different breeds or strains. The combination of selection and mating systems is often referred to as a **breeding plan.**

Breeding Strategies

Livestock development breeding projects too often result in little if any positive new benefit. Two of the often-quoted reasons are (1) failure by administrators or project sponsors to realize that breeding programmes take a relatively long time to yield full benefits and (2) poorly designed breeding systems that have lacked long-term plans. Where imported temperate breeds have been advocated, the first imported animals have sometimes

been satisfactory, but subsequent generations have shown progressive degeneration brought about by the inability of farmers or government farm managers to maintain an appropriate environment. The limitations of the environment tend to cause high mortality, low growth rates, low reproductive performance, and low off-take rates.

Where crossbreeding systems of indigenous breeds with exotic breeds have been emphasized, quick benefits have been realized. This approach must be systematic and require a continual source of parental stock, that is males, females, or both. Sustainable systems based predominantly on crossbreds have not developed because purebreds of both parental strains and systematic crossing need to be maintained.

The genetic improvement strategy presented here has a high probability of success. It offers the advantage of blending traits of indigenous and exotic breeds, exploits and maintains some heterosis, and provides a population with a wide genetic base available for selection for production and fitness characteristics. The strategy includes strains for different geographical areas and different management practices.

DEVELOPMENT OF THE FOUR-BREED DUAL-PURPOSE GOAT

The SR-CRSP staff at the Ol'Magogo Estate is developing a synthetic breed of dual-purpose goat to meet the requirements of small-scale farm families. This synthetic goat is composed of equal proportions of two selected and adapted local goats, the East African and Galla, and two exotic dairy goats, the Toggenburg and Anglo-Nubian. The objective is to build a goat that has acceptable milk yield, growth rate, fertility, adaptation, and rate of survival under western Kenya conditions. To match the genetic potential, it is necessary to improve the resources and management capability of the farmers. Thereafter, the synthetic goat will be adapted to other high-potential zones of Kenya. It can also be bred and adapted to the low-production potential areas by varying the proportions of exotic and local genes in the DPG.

The base flock was formed at the National Animal Research Centre facility at Ol'Magogo Estate, selected from large flocks of the East African and Galla breeds. The Galla originated in the dry northeastern areas of Kenya while the East African comes from a wide area of the country. The goats were

selected for visible characteristics since no production data was available. Large and sound udders and teats and the local "milk-line" claim by the owners were the selection factors. The milk-line is a distinctive black stripe along the back of some Galla goats but this does not seem to indicate a realistic milk type in the breed (Skea, 1989).

Large populations were sampled in selecting the does for the breeding programme shown in figure 5.2. East African bucks were selected to produce a control flock of that breed. Imported Toggenburg, Anglo-Nubian, and Alpine bucks were used on the indigenous does through natural service and artificial insemination to produce the first filial generation (F_1). The performance of the Alpines was unsatisfactory, thus the breed was dropped from the programme. The Toggenburg and Anglo-Nubian crossing continued in the synthesis of the DPG.

A flock of dual-purpose does at Ol'Magogo Estate.

The synthetic dual-purpose does are now capable of producing 1.1 kg per milking in the morning while suckling a kid with the rest of the milk during the day (table 5.1). This production record is variable and based on a limited sample. However, the trend is toward meeting the objectives of the DPG development when compared side-by-side with production of indigenous breeds.

Following the mating of 4-way crosses (parents), their offspring termed the first composites, will be used to estimate heterosis loss. Subsequent within-generation crossing will stabilize the DPG breed. Continuous characterization and evaluation of the breed will be established at the Ol'Magogo open nucleus flock and at the farmers' level. A DPG society will be established with the Kenya Stud Book to popularize the breed. The research component of the SR-CRSP project will establish the selection criteria for the continuous improvement of the goats that will incorporate resistance to the stomach worm, *Haemonchus contortus*.

To meet these objectives, artificial insemination of does at Ol'Magogo will be stepped up to include oestrus synchronization and embryo transfer. This will increase the number of animals, thus enhancing selection intensity, reducing variation, and improving breeding. In the meantime, F_1 and 4-way bucks are being sold to farmers as a preamble to the DPG breed so that they may begin using them to cross with their indigenous flocks. This exposes the farmers to the idea of managing dual-purpose goats as they socially, economically, and technically prepare for the DPG.

Table 5.1. Daily milk yield means ± SE(g) for four goat breed types.

Breed types	Number	Mean	SE
East Africa	8	88.9	207.9
Galla	17	542.4	143.2
F_1's	32	709.0	98.4
4-way crosses	13	1,077.8	153.0

Source: Mwandotto et al., 1990.
Note: F_1 and 4-way crosses are pooled.

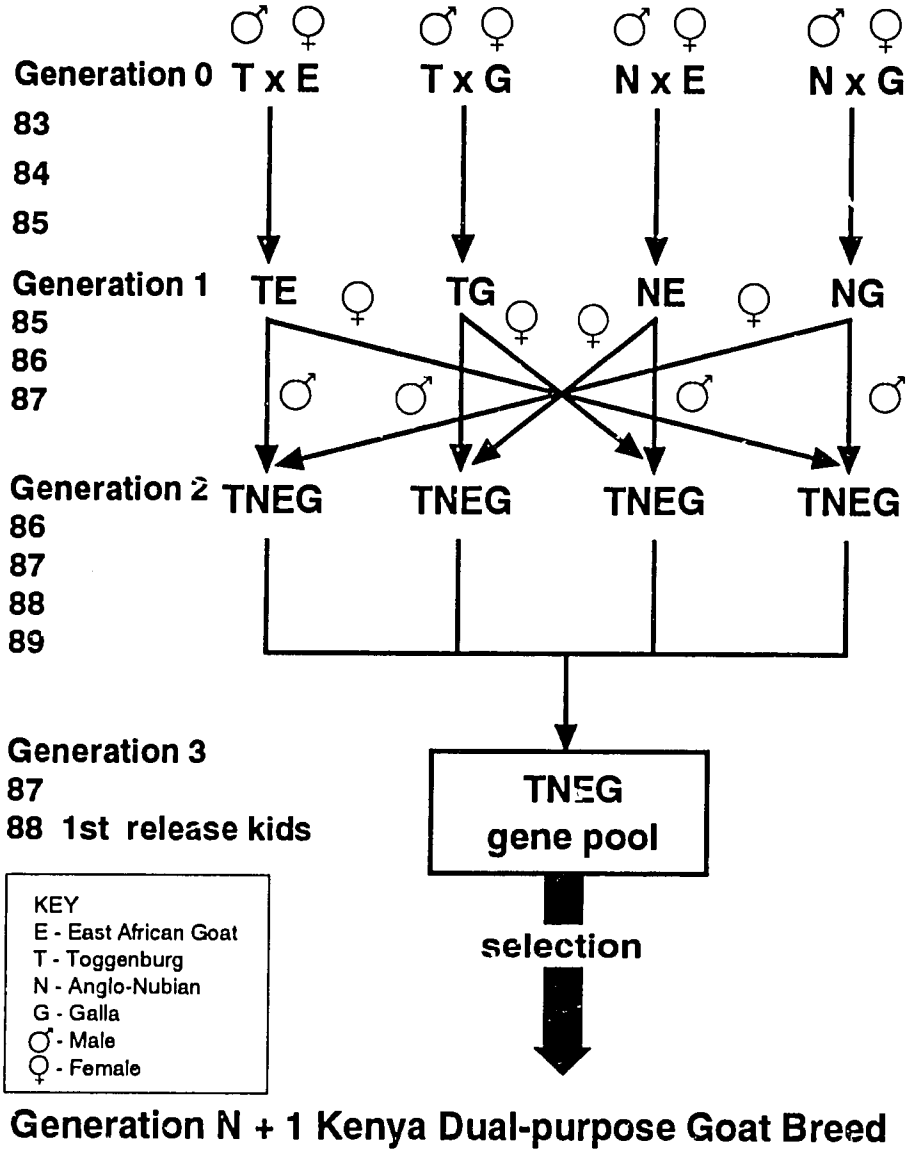


Figure 5.2. Breeding plan for evolving a composite dual-purpose goat breed for Kenya.

Source: Cartwright, 1984.

A female 4-breed cross of Toggenburg x Galla x Anglo-Nubian x East African Goat.

A male 4-breed cross of Toggenburg x Galla x Anglo-Nubian x East African Goat.

A composite, an offspring of 4-breeds crosses.

RECOMMENDED BREEDING STRATEGIES: ON-STATION PERSPECTIVE

Mating Strategy

The potential of genetic progress is reduced by extended kidding intervals, forced culling due to low fertility, and sterility. These are some recommendations to overcome those problems:

- Females should be bred first at 12 months of age when weighing at least 25 kg.
- Does should be bred within 18 hours after detection of heat as this ensures a 70% or greater conception rate.
- Remate does at 60 to 90 days after kidding; the optimum is 90 days without supplemental feeding. Does can be rebred at 60 days after kidding but such early mating requires supplemental feeding of kids, does, or both.
- Mating practices: (1) Breed the flock to the most productive buck but avoid mating closely related animals such as a buck to his daughter or a buck to a half-sister. (2) Castrate or sell all males not to be maintained for breeding. (3) Sell good bucks to neighbours; share or rotate bucks with nearby undiseased flocks. (4) Check all goats, especially bucks, for reproductive soundness to be sure they have no infection. Refer to Chapter 7 for an on-farm mating schedule.

Doe-culling Strategy

Genetic progress is most rapid when using only accurately evaluated, genetically elite bucks. Every doeling should be raised as a flock replacement. Few if any does should be involuntarily culled. Good doe-culling decisions require on-going, month-by-month, evaluation and comparison. Culling decisions should be based on the animal's past, present, and anticipated future production. The timing of an animal's removal from the flock should be planned to minimize periods of low productivity.

Feeding Strategy

Does must be properly fed and managed to achieve their genetic potential. Failure to give each animal the opportunity to express its genetic capability reduces the flock's potential productivity. Feeding levels that exceed an animal's genetic capability are inefficient and wasteful. (See Chapter 7 for on-farm feeding strategy.)

Identification Strategy

Positive, permanent, and accurate identification of each animal is essential to keeping good records and to genetic progress. It brings in money, saves time, and adds convenience in day-to-day flock management. A written record should be prepared for each kid containing the sire, dam, birth date, and permanent animal identification. There is little risk of mistaken identity when tagging is done at the time each kid is born or when a permanent name is given. By one week after birth, each kid must have a permanent eartag number or name that is maintained throughout the time the animal is in the flock.

Records Strategy

The risk of management error is reduced with good records to monitor and evaluate results, establish realistic goals, and provide the specific information needed for scheduling and carrying out management decisions. Accurate records are essential for auditing the flock and evaluating economic trends. Kidding dates, milk production amounts, health examination records, heat dates, and breeding dates are examples of the information needed in deciding when and which does to watch for heat, to check for pregnancy, to cull, to dry, to prepare for kidding, as well as how much to feed. Good records help the farmer exert better control over the management inputs. Production records, such as those cited below, are as fundamental to an effective management strategy as they are to genetic appraisal.

- Month-by-month accounting of individual doe production; accumulated lactation totals for comparing does and for evaluating management factors affecting production results at the end of the lactations.

- Dates for doe management such as kidding, drying-up, and breeding, are essential for preparing a management calendar.

Breeding Management Strategies

- Routinely keep records: permanent identification, milk yield, body weights, birth dates, mating, treatment, and any abnormalities.
- Use these records plus general experience to make routine decisions for culling and replacement and for mating.
- When there is no access to improved stock, select high producers from indigenous animals; continuously use top-notch stock and avoiding inbreeding.
- Start using the forerunners of DPG, that is, F_1 or 4-way bucks, while also improving management practices such as feeding, health care, housing, and so forth.
- Use a buck for a maximum of 2 years.
- Be prepared to deal with excess kids, especially when breeding round-the-year or using crossbreds and synthetics.
- Look beyond the station or farm for superior flocks and individual animals. Use them whenever they are available.
- Encourage forming clusters or societies to use and continuously improve superior animals or new and unique breeds.

CHAPTER 6

DEVELOPING AND USING FORAGES

J. F. Moses Onim, H. A. Fitzhugh, and Will R. Getz

FEED PRODUCTION FROM MAIZE-BASED CROPPING SYSTEMS

Background

Farmers in western Kenya experience feed shortages about 6 months each year. This can be overcome through feeds generated from maize-based cropping systems. These include (1) pure maize, (2) maize-beans, (3) maize-pigeon peas, (4) maize-sorghum, (5) maize-finger millet, and (6) maize-alley cropping. These cropping systems occupy about 90% of the farmer's land, particularly in Hamisi, and take about 50% of the farmer's resources. A maize crop can generate about 10 t/ha/yr of dry matter of feed.

Alley cropping of maize with legume forages can generate high quality feeds, overcoming the problem of low quality of maize stover alone. Intercropping increases the grain yield of maize by 18% but reduces the stover yield by 14% (see table 6.1). The grain and forage yields from the intercrop are additional advantages above the pure maize crop.

Recommendations

- Early preparation of land; ploughing and harrowing where necessary.
- Manure and fertilizer application:: Either spread manure uniformly on the land before ploughing, or apply 2 handfuls of well-decomposed manure in each planting hole; mix well before placing seeds. Use the same method for applying fertilizers in recommended dosages.
- Plant 2 seeds per hill of high-yielding, recommended varieties at the onset

Table 6.1. Comparative yields of maize-based cropping systems.

	Grain and forage yields (t/ha)			
	Maize		Intercrop component	
Crops	Grain	Stover/forage	Grain	Stover/forage
Pure maize	4.2	10.2	—	—
Maize/beans	6.3	9.2	0.6	0.3
Maize/pigeon peas	4.3	8.4	—	4.1
Maize/finger millet	5.8	8.3	0.6	1.3
Maize-alley cropping	3.4	9.2	—	4.0

of rains. Maize hybrid H614 is recommended for the long-rains and hybrids H512 and H511 for the short rains for lower Maseno and Siaya.

- Space the maize for intercrop at 90 cm x 30 cm.
- Plant 1 row of the pigeon pea or sesbania intercrops at 90 cm x 30 cm between the maize rows. Wider spacing for intercrops may be preferred.
- Plant 2 rows of beans and finger millet between the maize rows.
- Early weeding; once or twice as necessary.
- Thin weak seedlings at first weeding, removing 1 plant per hill. This practice can generate up to 500 kg/ha of DM of feed.
- Further thin to 1 plant per hill where more than 1 seedling was left at first thinning. More than 500 kg/ha of DM of feed can be realized by using this procedure.
- Weeds from the field should be gathered and fed to the livestock. This can also give about 500 kg/ha DM of feed.
- **Leaf stripping.** Remove 1 leaf per plant per week, starting with the lowest leaves, beginning from early milk stage. This can generate about 500 kg/ha DM of feed.

Mr Moses Mathuva demonstrates to a group of Hamisi farmers how to defoliate maize plants for fodder.

- **Topping.** Remove the top of the stalk above the cobs (ears) at the maize grain-hardening stage. About 2 t/ha DM of feed can be realized.

- **Remaining stover.** Gather the remaining stover for storage. This will be of lower quality than the other maize forage, yielding about 6.5 t/ha DM.

- **Intercrop components.**

√ **Beans.** After harvesting and threshing the pods, gather the haulms and split grains for later feeding to livestock. Approximately 300 kg/ha DM of feed can be obtained.

√ **Pigeon pea.** After harvesting the maize crop, the pigeon pea may be cut back (ratooned) and fed as needed as a protein supplement. About 4 t/ha DM of feed can be realized. The crop should be grown to maturity when grain is needed. After harvesting the pods, the crop can be cut back and fed as necessary. Threshed pods may also be fed. About 6 t/ha DM of forage can be realized.

√ **Finger millet.** This will be ready for harvesting before the maize crop. The chaff remaining after threshing the dry heads makes feed for livestock. The remaining straw should be cut, dried, and baled for later feeding. About 1.3 t/ha DM of feed can be realized.

√ **Alley cropping.** Several legume forages such as sesbania, leucaena, and calliandra can be alley cropped with maize. Plant a pair of rows of the legume forage 4 m apart. The maize crop is planted within the forage rows.

FEED PRODUCTION FROM CASSAVA-BASED CROPPING SYSTEMS

Background

Cassava does well in dry areas and in soils with low fertility. Its leaves contain up to 30% crude protein. The yield of tubers is up to 10 t/ha of DM in western Kenya.

The seasonal feed shortage in western Kenya can be partly overcome through cassava-based cropping systems, i.e., pure cassava, cassava-maize-sorghum system, and the cassava-sorghum system. High quality cassava leaves can be pruned for use as a protein supplement for low-quality diets. Pruning half the cassava leaves per stem per plant after every two months is the recommended practice (see table 6.2).

Recommendations

- Use intercropping in cassava-based cropping systems rather than pure cassava stands.

- Early preparation of land; ploughing and harrowing where necessary.

- **Maize:**

√ Manure and fertilizer application: Either spread manure uniformly before ploughing or apply 2 handfuls of well decomposed manure in each planting hole; mix well before placing seeds. Use the same method for applying fertilizer in recommended dosages.

√ Plant as described in the maize-based cropping system recommendations.

- **Cassava:**

√ Plant the sweet varieties, not the bitter types.

√ Various planting methods can be used, such as flat planting, mound planting, or ridging. Spacing should be 100 cm x 100 cm with each row of cassava being between two maize rows.

√ Planting material: The cassava cuttings should be free of diseases and pests.

Table 6.2. Comparative yields of cassava-maize cropping systems.

	Tuber and forage DM yields (t/ha)			
	Cassava		Intercrop component	
Crops	Tuber	Forage	Grain	Forage
Pure cassava	10.0*	1.0	—	—
Cassava/maize: no-pruning	11.0*	1.2	1.0	3.8
Cassava/maize: cassava pruned				
1/4**	2.8***	2.1	1.4	3.8
1/2	2.3	4.3	1.4	3.8
3/4	1.7	3.2	1.4	3.8
1	0.9	2.8	1.4	3.8

Notes:

*Yields for tubers harvested after 3 to 5 years.

** 1/4-1. This is proportion of leaves pruned from ground level per stem per plant. No.1 indicates pruning of all the leaves from a stem.

*** 2.8-0.9 These are the yields for tubers harvested after 1 year.

√ First weeding for cassava, which is the second for maize, should be when the cassava is established.

√ Cassava leaf pruning. Start after the maize crop has been harvested and the cassava will be about 3 months old. At 2 month intervals, prune half of the cassava leaves per stem from the ground level up until the roots are ready for harvesting. At that time harvest the rest of the leaves. About 4 t/ha/yr DM of feed can be realized.

√ Cooking, boiling, wilting, or drying of cassava tubers or leaves is essential to remove prussic acid toxicity.

FODDER CROPS AND TREE NURSERIES

Background

The quantity and quality of feeds available in western Kenya fluctuates in response to the rainfall pattern. The tree legumes can be high quality, supplemental feeds for the months when other feeds are not adequate (see table 6.3). These crops are also potential sources for fuelwood.

Recommendations

- Begin nursery preparation and planting 2 months before the rains start. A nursery has many advantages compared to direct planting.
- Site selection: Select a good site near a water source with well-drained and fertile soils. The soils should be loosened and raised. Fence the site away from livestock.

Table 6.3. Comparative yields of fodder and tree cropping systems.

Cropping systems	Leucaena	Sesbania	Pigeon pea
Intensive feed gardening (t\ha)	17.0	13.0	4.0
Hedge rows (t\ha)	17.0	13.0	4.0
Alley-cropping (t\ha)	—	6.0	—
Intercropping (t\ha)	11.0	5.0	4.1
Mean CP (%)	25.0	26.0	25.0
DM in vitro digestibility (mean %)	57.7	74.3	62.1

- Preparing the seeds for planting.
- Seeds such as leucaena must be scarified before planting. The best method is to clip off the seed coat on the side away from the embryo.
- Leguminous seeds such as leucaena should be inoculated with a suitable rhizobium for effective nodulation.
- **Plant in furrows.** The depth depends on the seed size; the larger the seed, the deeper the furrow.
- **Nursery management.**
- Water the nursery every morning and evening if there are no rains. Reduce this frequency as the seedlings become older.
- Keep the seedlings in the nursery for about 1 month before transplanting them into tubes.
- Seedlings may emerge under established trees of some fodder crops at the onset of rains. These can be transplanted directly into tubes or into the field. Examples of this are leucaena and sesbania.
- Fodder crops such as gliricidia may be raised from cuttings which can be planted directly in tubes or the field.

- Transplanting seedlings. Transplant the seedlings in the morning or evening. Spacing of seedlings in the field will depend on the cropping system used.

- **Spacings:**

√ **Hedgerows and feed-banks.** 90 cm between rows and 30 cm to 50 cm between plants within the row.

√ ,**Intercropping. 90 cm x 30 cm.**

√ **Alley cropping.** Plant one pair of rows of the legume forage 4 m apart. The maize or other crop is planted within the 4 m space between the fodder-crop rows.

- **Preparation of transplanting holes:** Dig a hole. Thoroughly mix 2 tablespoons of double or triple superphosphate fertilizer with the soil. Place the seedling in the hole. Firm the soil well around the seedling. When organic manure is used, take 2 handfuls of well-decomposed manure and mix it well with the soil before transplanting the seedlings.

- **Weeding:** Keep fodder crop seedlings weed-free.

- **Fodder harvesting:**

√ The time for harvesting of seedlings and trees for livestock feeding varies with the tree species and the type of management. For example, sesbania should be ready to harvest 2 months from planting under an intensive management system and in up to 4 months in alley-cropping systems.

√ For intensive management, cut at 60 cm above the ground whenever the regrowth is more than 30 cm above the cut canopy. This gives about six cuttings in a year. Pruning the branches may be preferred where the fodder trees are planted for other uses, such as wood for construction.

√ Feed the fodder directly to the livestock and conserve the excess as hay.

√ The roots and stems should be removed whenever over 50% of the fodder crops in the field die due to aging.

PASTURES AND FALLOW LAND

Background

Pastures and fallow land constitute between 50% to 80% of the feed resources on small farms but the quality and quantity of the forages fluctuates drastically. For example, crude protein in grasses may be as high as 21% or less than 7%. This variation is caused by rainfall, soil fertility, grazing management, and plant phenology. Goats are capable of selecting high quality feeds, thus the drastic quality fluctuations are not reflected in their diets as sampled by mimicking grazing goats (see table 6.4).

In four experiments at different sites, N-fertilizer application gave a mean increase of 193% in DM forage yield.

Some legume tree crops enhance the growth of grasses growing under them, for example, *Acacia albida.*

Recommendations

- Remove all weedy species that could suppress the growth of grasses, browse species, and fodder legume trees.
- Apply organic or inorganic fertilizers to increase quality and DM yields of pastures.
- Do not graze pastures below 4 cm sward height.

Table 6.4. Comparative value of natural forage for grazing goats.

	Major seasons in a year	
	Long rain	Short rain
DM yield (t/ha)	0.8	1.3
CP (%)	16.4	11.8
DM in vitro digestibility (%)	53.1	60.3

- Cut the excess growth when 50% of the forages in a sward reach flowering stage. Store this as hay for later feeding of livestock. Cut only when there is adequate sun for drying. This practice will improve the growth of pastures, maintaining higher quality for a longer time and increasing the yield of the forage directly grazed plus that conserved.

- Frequently change the sites of tethered livestock to avoid trampling the pastures and reducing the build-up of intestinal parasites (see Tethering, Chapter 7).

- Spread cattle dung over pasture to ensure uniform utilization. The pastures around cattle dung patches will grow tall but the animals will not eat them which results in pockets of grass surrounded by overgrazed areas.

- Avoid grazing in water-logged pastures to keep from trampling and suffocating the grass. In the dry season, reduce grazing pressure to avoid soil erosion.

- Broadcast legume seeds on the pastures during the rainy seasons. Scatter tree fodder legumes within or around the pastures.

- Lease out underused pastures and fallow land to neighbours or cut and sell the grass for cash. For example, the market price of mixed grasses is about Ksh. 2,000/t of DM in western Kenya. One gunny bag of fresh grass costs Ksh. 10 in the local markets.

FEED CONSERVATION AS HAY AND SILAGE

Background

Feeds must be conserved during periods of excess production to ensure a uniform supply throughout the year. Simple methods of hay and silage-making address this problem. Conservation ensures that feeds are harvested when the dry matter yields and quality are optimal (see table 6.5).

A farmer can cut 0.125 ha (1,250 m^2) of forage in about 4 to 5 hours. The amount of feed harvested per hour depends on the species and its fresh

forage yield. Generally it will be about 0.4 t/day of DM. This harvesting can be done 2 to 6 times per year.

Grasses require about 2 days between cutting and when they are ready for storage. Somewhat less time is needed for legumes.

Stored hay will maintain its quality for several months in western Kenya.

Several forage crops that are not suitable for hay can be conserved as silage, including green maize stalks, napier grass, sugarcane tops, green sorghum stalks, and most other grasses. Forage conserved as silage has a 42.3% increase in DM, a 5.4% increase in crude protein (CP) and a 12.0% decrease of in vitro dry matter digestibility (IVDMD) after 6 months when compared to the fresh-cut materials (see table 6.6).

One person using a machete (panga) can chop up to 150 kg of fresh material in 4 hours.

To produce good silage, the chopped material is packed in gunny bags and stored in air-tight trenches or pit silos. Silage stored in a silo will stay in good condition for several months. The fermentation quality of silage is greatly improved when molasses or jaggery sugar is used as an additional source of water soluble carbohydrates.

Table 6.5. Comparative drying rates and crude protein content of forages.

	Moisture content %		Crude protein %	
Forages[1]	Fresh	After 10 h	Fresh	Hay[2]
Sesbania	70	4	13.8	13.4
Pigeon pea	68	3	14.4	16.0
Bana grass	77	11	10.3	9.4
Leucaena	66	3	26.6	19.3
Sudan grass	66	21	28.2	36.7
Mixed grasses	78	8	26.9	36.0

[1]The forages were cut at Maseno on a sunny day with an average temperature of 32°C.
[2]The crude protein percentage of hay was taken 6 months after cutting.

Table 6.6. Comparative feed values of forage conserved as silage.

	% DM		% CP		% In vitro DM Digestibility	
Forages	Before ensiling	After 6 m.	Before ensiling	After 6 m.	Before ensiling	After 6 m.
Maize	22.6	20.8	6.1	9.3	51.1	47.3
Bana grass	15.9	16.9	12.6	10.4	69.0	56.3
Sugarcane tops	23.7	34.0	5.5	3.9	52.2	45.5

Recommendations

Hay making

The methods of storing hay are standing, stacking, and baling.

Cutting and drying

Cut the forage when it is at its best quality. Do the cutting on a sunny day during a dry period. For grasses this is when 50% of the plants are in flower. This is a compromise between quantity and quality. Grasses should be left in the field to dry. Most legumes should be gathered and carried away while the cut material is still wet to avoid shattering the leaves. Spread the forage thinly for drying, turning it over (tedding) in the evening. The moisture content of the forage should be below 20% before it is gathered for storage. This usually takes about 2 days of drying.

- **Gathering and storing.** Gather the dry grass and transport it to the storage site. Legumes can be gathered and stored, as in gunny bags, once the leaves have dropped. Two storage methods can be used.

- **Hay stacking.** Stack the hay on a raised platform to keep it away from termites. Compact the layers into a pyramid or conical shape. Thatch the top of the stack with a thin layer of grass. Cover the completed stack to keep off the rain.

- **Hay baling.** Use a simple haybaling box about 85 cm long x 55 cm wide x 45 cm deep (figure 9.1). Lay the cut twines lengthwise and crosswise inside the box. Gather the dried hay and compress it tightly into the box. Pull the twines hard, tighten, and tie. Lift the bale out and store it in an appropriate place.

- **Feeding hay.** Feed the hay in small quantities as a supplement during times of feed shortage.

An appropriate hay baling technology for resource-poor farmers.

Silage making

- Dig a trench about 5 m long x 3 m wide x 1.5 m deep.
- Harvest the forages at the appropriate physiological stages. For example, cut maize at 125 days after planting in western Kenya. Bana grass should be cut when about 1.5 m tall.
- Chop the harvested materials separately with a machete or a hand-powered chaff cutter, if available, to lengths of about 1.5 cm.
- Pack the chopped materials tightly into bags made of synthetic fibres with each crop species in a separate bag. A tightly packed bag will be about 35 kg green weight.
- Some crops require the addition of water soluble carbohydrates. For example, add 1.5 kg of molasses diluted with an equal amount of water to each bag containing chopped young bana grass harvested when it is less than 1 m tall.
- Tie bags tightly with twine and pack them horizontally in a dug trench or pit.
- Cover the bags with a polythene sheeting, then with a layer of the earth that was removed when digging the pit. Compact the soil by jumping on it.
- Remove each bag as required by opening one side of the pit. After removing each bag, replace the sheeting and the earth.
- Silage also can be made by putting the ensilage directly in the trench or pit without packing it in a bag but this method has a high spoilage rate when the feed is exposed to the air.

FEED STORAGE

Background

Small-scale farms in western Kenya lack adequate feed storage facilities and structures. The shortage is acute for hay. Various storage methods are

used such as stacking hay outdoors, stacking hay bales outdoors, hanging hay bales from eaves of roofs, and using multipurpose stores. Each of these has disadvantages such as cost of construction or high spoilage due to rainfall and termites. Bales hung on the eaves can pull down roofs.

Nevertheless, silage pits, hay stacks, multipurpose stores, and stacked hay bales are all cost-effective and suitable methods of storage for small-scale farmers.

Recommendations

Silage pit (Gunnybag method)

- Dig a pit of 5 m long x 3 m wide x 1.5 m deep on a sloping site that is away from any area that is subject to water logging.
- Use gunnybags and polythene sheeting for storing the forages. The details of the procedure are given in the section on hay and silage.
- The pit and the gunnybags can be reused several times.
- Direct ensiling into an open pit without using gunnybags is another option. Use oil drums filled with water to compact the ensiled material. Like other direct ensiling methods, there is a high probability of surface spoilage of the silage due to exposure to air at feedout time.

Loose haystack

- Stack the hay on a raised location so ground surface-water cannot reach it.
- Use a raised platform or a pile of stones to avoid termites.
- Platform stands should be made vermin- and termite-proof such as painting them with old engine oil or a wood preservative.
- Piled stones should be protected from termites by sprinkling with old engine oil on and between the stones or by using wood ash.
- Use cheap and readily available building materials to reduce the cost of construction.

- Stack and compact the hay into a pyramid or conical shape, then thatch the top to keep off rainwater. Construct the thatch on a framework of twigs so it can be lifted off and then replaced when hay is being removed.

Multipurpose storage

- Grain cribs and other structures can be used for storing hay when not being used for other purposes.

- Simple and appropriate building materials should be used to construct new stores. Two types of stores are available, the fixed and the large woven basket.

- Raise the store off the ground to be termite- and vermin-proof.

- Thatch the roof with suitable, cheap, and locally available materials such as grass or papyrus reeds.

- Stores can be used for hay storage for part of the year and for grain during other times.

Stacking baled hay

- Baled hay can also be stored on a raised platform and covered with a removable thatched roof.

- The platform should be 2.75 m x 2.55 m. This will accommodate about 15 bales in a single layer. Pile the bales up to five layers high to a height of 2.25 m. This will allow the roof to be placed on top. This stack will accommodate up to 75 bales of 20 kg each for a total of 1.5 t of DM of feed.

- The pitch of the roof should be at least 45 degrees to allow the rainwater to drip off.

- Use light weight materials to construct the roof, such as dry sorghum stalks, twigs of shrubs or trees as *Lantana camara*, or others such as *Phragites mauritianus*.

- Thatch the roof with light grass.

IMPROVING SOIL CONSERVATION AND FERTILITY

Background

Soil erosion caused by water runoff is common in western Kenya. Soil surveys of the area indicate there are deficiencies in several macro- and micro-nutrients.

Small-scale farmers often lack the cash for purchasing commercial fertilizers. The problems of soil conservation and improved fertility must be urgently addressed to increase the food and feed yields on these small farms.

Applications of fertilizers can easily increase yields by 200% in western Kenya. A green manure study was conducted at Maseno (table 6.7). Six times during the year green leaves and young stems of leucaena, sesbania, and pigeon pea legumes were incorporated into the soil as green manure. This practice was compared with incorporating maize stover and fallow land to determine the amounts of DM and nitrogen added to the soil.

The grain yield increase for maize, for instance, was 71% lower in the fallow plots than in those where sesbania was incorporated. The yield difference between the two treatments was 2.8 t/ha.

Table 6.7. Crop responses to green manure applications.

Treatments	Feed		Test crop responses	
			Maize grain	Bean grain
	DM yield (kg/ha)	N-yield (kg/ha)	yield (kg/ha)	yield (kg/ha)
Maize	7,793	120	5,156	596
Pigeon pea	4,806	161	6,378	389
Leucaena	16,659	643	6,578	478
Sesbania	13,603	448	6,667	433
Fallow			3,911	307

Recommendations

Soil conservation

- Establish strips and terraces across the field to prevent soil erosion. The number of bands will depend on the slope as the steeper the field, the more bands that are required. Examples of these bands are grass strips, tree strips, and trenches.
- Stabilize the bands with recommended fodder grasses and legumes such as napier grass and leucaena.
- Do not allow the bands of fodder to spread into the crop field. Cut them as appropriate for feeding to livestock.

Soil fertility improvement

There are several methods to improve soil fertility, such as using manure, manure from composed heaps, legume crops for nodulation, leaf litter and green manure, and applying inorganic fertilizers.

Livestock manure. Livestock manure from the homestead can be spread each day directly onto the field, then incorporated as the soil is being cultivated. However, this is not the most effective method as large quantities of manure are needed to achieve marked yield responses.

Livestock manure heaps. Collect the manure from livestock houses or bomas and place it in a heap at a particular site, preferably under shade within the homestead. Do this continuously until planting time, then spread the decomposed manure uniformly on the field before ploughing. Alternatively, the manure can be placed directly into individual planting holes, then mixed thoroughly with the soils before putting in the seeds.

Compost heaps. Collect the cleanings from the homestead and crop fields together at a site in the homestead. Turn the pile frequently to enhance decomposition. Well-decomposed compost can be applied at planting time in the same manner as livestock manure.

Legume crops

Leaf litter. Plant the recommended fodder legume trees. Over time, the leaf litter falling from the trees will improve the soil fertility.

Green manure. Plant fodder legumes at a high density spacing of 90 cm x 30 cm in a piece of land that will not be used that season for food crops. Once the crop has grown taller than 60 cm, cut it back to 60 cm above the ground and drop the cut material on the soil. Repeat this six times per year. Dig out the legumes after 1 year and plough the field. The stumps are good fuelwood. This practice can return up to 600 kg/ha/yr of nitrogen to the soil.

Inorganic fertilizers

Use the fertilizers as recommended. There are acute deficiencies of phosphorus and nitrogen in the western Kenyan soils, so compound fertilizers are recommended that are high in these nutrients, e.g., diammonium phosphate (DAP) which is 18 nitrogen (N), 46 P_2O_5, 0 potassium (K).

GRASS FODDER CROPS

Background

There is a need in western Kenya for high yielding fodder crops that will be productive and green during the dry periods. Such high yields and persistency of productivity depend on the frequency of cutting and the application of fertilizer.

Fodder crops are those grown for feeding and not often grazed in the field. They include napier grass derivatives such as bana, Pakistan hybrid, and clone 13; Guatemala grass; Sudan grass; and local and giant panicums.

The research on these fodder grasses conducted at Maseno indicates they have very high dry matter yields with up to 5 cuttings in a year, and have good protein content and digestibilities (table 6.8).

Table 6.8. Comparative qualities of selected fodder grasses.

Cultivars	Fodder DM yields (t/ha/yr)	Mean CP %	DM in vitro digestibility %	Palatability ranking[2]
Bana grass[1]	39.0	13.1	61.0	6
Clone 13[1]	33.0	9.7	59.0	2
Pakistan[1] hybrid	27.0	12.8	60.0	—
Sudan grass	22.0	12.0	64.0	—
Giant panicum	19.0	11.0	56.0	3
Local panicum	17.0	11.3	59.0	—
Guatemala grass	20.0	11.2	58.0	—

[1]Napier grass derivatives.
[2]Ranking based on palatability by goats of 6 grasses used in a cafeteria feeding system.

Recommendations

Each farmer is urged to cultivate 0.125 ha of fodder grasses. This will provide 3.2 t of DM of fodder annually. Fodder grasses can be cultivated in many different ways, including feed gardens, alley cropping, hedgerows, soil conservation and soil erosion bands, and in fields.

Land preparation. The field must be finely cultivated when planting seeds, but this is not needed for planting vegetative materials like cuttings or splits.

Field establishment. Cuttings and splits should be established at the beginning of the rains when the soils are wet. There are two methods: (1) direct field planting and (2) raising the seedlings in a nursery; for example, napier grass derivative cuttings.

- **Direct planting.** The planting materials are either cuttings or splits taken from mature plants.
  Splits: Each split should contain at least one stem to establish a large field with manageable quantities of planting material as these are bulky (for example, Guatemala and panicums).

- **Cuttings:** Each cutting should have at least three nodes and be pest-free, especially from mealy bugs and scales.
  Spacing: Napier derivatives and Guatemala should be spaced 50 cm x 100 cm. Sudan grass and panicums should be spaced 45 cm between rows with the seeds drilled within the rows. When splits are used, as in panicums, the spacing should be 45 cm between rows and 30 cm within rows.

- Nursery establishment of napier derivatives. Start planting a month or two ahead of the rains so the feed will quickly be available. Generate seedlings from single nodes as a few planting canes (stems) can produce 5 to 10 times more plants than direct field planting using cuttings. This practice avoids termites which are a common problem with cuttings. However, the seedling method is more labour-intensive and requires that more water be availabile. Follow these steps:

√ Use small polythene bags that are perforated at the bottom. Fill them with a good mixture of nursery soil and firm it well. The current cost (1992) of 100 polythene bags is Ksh. 10.00.

√ Water the tubes thoroughly, then plant the single-cut nodes in them right-side up.

√ Keep watering the cuttings until they germinate. Buds will usually start to grow within 1 week. Water once a day until the onset of rains.

Fertilizer application

Select one of these methods:

- Apply 1 handful of well-decomposed livestock or compost heap manure; mix thoroughly before planting the splits, cuttings, or nursery seedlings.

- Use compound fertilizers such as NPK or DAP. Apply 1 teaspoonful per hill; mix thoroughly with the soil before planting.

Weeding

A single weeding should be adequate.

Harvesting

The first harvest from the splits and cuttings can be done 3 months after planting. For nursery seedlings, the first harvest should be 3 weeks from planting depending on the size of the seedling when transplanted, soil fertility, and rainfall. Do not allow fodder grasses to develop hard stems. Napier grasses should be cut when 1 m high.

Top dressing

Stimulate growth by top dressing with organic or inorganic fertilizers at the onset of every rain.

Utilization

Fodder grasses are important feeds in cut and carry systems because of their high productivity and good quality. Surpluses of napier and Guatemala can be conserved by ensiling while sudan grass or panicums can be stored as silage or hay.

SWEET POTATO AS A FOOD AND FEED CROP

Background

There are acute fluctuations in both human food and livestock feeds every year in western Kenya. Since sweet potato tubers can remain in the field for some time before harvesting, this is an insurance crop a smallholder farmer can depend upon during periods of food shortage. The potential of a large tuber yield for human food is another asset.

Sweet potato vines can effectively overcome the regular fluctuations in feed quantity and quality. Their quality is the result of a high level of palatability, digestibility, and crude protein. These characteristics and the high water content of the fresh vines make them an effective milk replacer for goat kids, lambs, and calves (see Milk replacer for kids, Chapter 7). Young livestock fed on sweet potato vines can be weaned early, releasing sizable quantities of milk for human consumption.

The major feed quality parameters and fresh tuber yields of three sweet potato types were studied at Maseno (table 6.9). The experimental plots yielded up to 21 t/ha/yr of fresh tubers and 21% CP, 14 t/ha/yr of DM, and 77% digestibility in leaves and vines. This indicates that sweet potato leaves and vines provide adequate nitrogen in livestock diets in the same way as forage legumes.

Each farmer is encouraged to cultivate 0.125 ha of sweet potatoes that each year should provide 2.5 t of tubers and 1.3 t of DM of vines.

Recommendations

Sweet potatoes require deep cultivation for good tuber development. Ridging or mounding also helps good tuber development in areas with waterlogging and shallow soils. There are no major yield differences between flat planting and mounding where ploughing is deep and waterlogging and shallow soils are not a problem. Totally remove couch grass from the fields when ploughing.

Planting

- Plant at the onset of a rainy season. If labour is a constraint, plant sweet potatoes after the food crops. Sweet potatoes can be planted in a separate field or between the rows of food crops such as maize. Plant these sweet potatoes after weeding the main crop.

Table 6.9. Quality and yield of three types of sweet potatoes.

Cultivar types	Fresh tuber yield (t/ha/yr)	DM yield (t/ha/yr)	Leaves and vines composition		
			In vitro DM digestibility %	CP %	Moisture content %
Tubers	18.4	7.6	66.0	15.8	75.0
Dual-purpose	6.7	9.7	70.0	16.1	78.0
Leaves and vines	3.8	14.1	74.0	16.0	80.0

- Farmers should select varieties that are suitable for their needs: tuber, vine, or dual-purpose types. The planting materials should be disease-free, particularly of viral diseases.
- Spacing should be of 40 cm between rows and 30 cm between plants. Cut the planting vines at least 30 cm long. Bury 20 cm of it from the cut end in the soil.

Weeding

Keep sweet potatoes weed-free at all times. Ridge or mound the soil during weeding to encourage tuber development.

Harvesting

First tuber harvesting can begin 4 months from planting as tubers of the early maturing cultivars will have formed. Selective, piecemeal harvesting of vines should also begin at this time. Up to 40% of the leaves and vines can be removed from the canopy without significantly reducing tuber yields. However, fewer leaves and vines should be harvested during the dry season so tuber yields will not be affected. Yields of up to 10 t/ha/yr of DM of leaves and vines with 18 t/ha/yr of fresh tubers can easily be realized with suitable cultivars.

CHAPTER 7

NUTRITION AND MANAGEMENT

Patterson P. Semenye, H. A. Fitzhugh, and Will R. Getz

INTRODUCTION TO THE INTENSIVE DPG PRODUCTION SYSTEM

Goats are produced in Kenya and throughout East Africa under both extensive and intensive farming systems. The majority of goats are under extensive production sub-systems of pastoral, agropastoral, and commercial ranching. In the intensive system, the goats are integrated with crop production, deriving some of their feed from dual-purpose crops and crop residues and the balance from limited vegetation in fallow areas, roadsides, wooded areas and communal compounds. Most goats in western Kenya are under the intensive production system. They are tethered for limited access to free grazing and for receiving cut and carry fodder.

Mrs Nelly Otiende teaches farmers some of the key points of goat husbandry.

Management Calendar

For technical recommendations to be useful, they must fit a production management calendar. Figure 7.1 presents a management calendar for dual-purpose goats in western Kenya that considers the availability of production inputs and the environmental factors which affect goat production. Nutritional constraints limit the calendar to one kidding per year. When there is adequate nutrition, kidding every 8 months is optimal and will accrue the highest profits.

Kidding

The date a doe is mated determines when it will kid. The doe has high nutritional demands for the month before and after kidding. The kidding period should, therefore, coincide with a matching plane of nutrition. January is the ideal month for kidding in western Kenya as it is about 2 months after the short rains and in the beginning of a dry spell. Forage with high dry matter content is ample during the month. Grazing is uninterrupted due to lack of rainfall, thus the dry matter intake of does is boosted and converted to higher milk yields. Goats are reluctant to graze during rainfall. The enhanced lactating ability of does results in higher survival rates of kids. In addition, kids born in January are less susceptible to pneumonia.

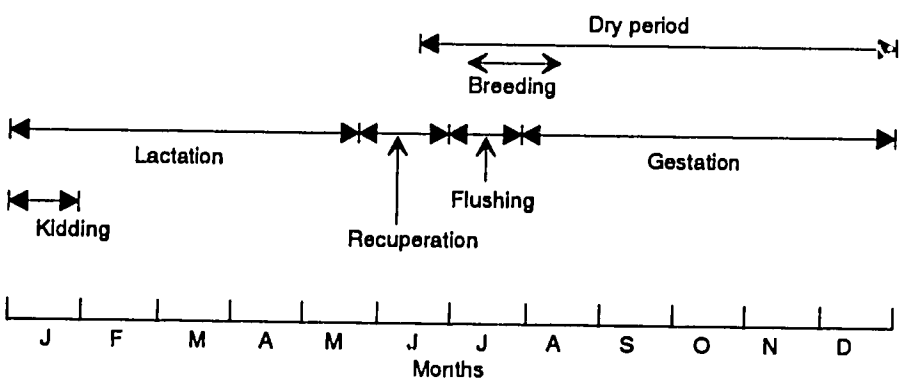


Figure 7.1. A management calendar for producing dual-purpose goats in western Kenya.

An option to farmers who are stall-feeding their does is to coincide kidding with the tasseling of maize. After maize has tasseled, the lowest leaves can be stripped at the rate of 1 leaf per plant per week without affecting grain yield. These leaves are high in nutritive value, thus are good feed for lactating does. A quarter hectare of maize can produce enough leaves to be the sole diet of 2 lactating does for 3 months.

Lactation

With the proposed management calendar, the length of the doe's lacation is restricted to 5 months by nutritional rather than biological constraints. Does managed with above-average nutrition are capable of lactating for over 1 year. A farmer with an optimum supply of feedstuffs to meet maintenance and production requirements can prolong the lactation of a doe to 2 months before the next kidding. The net energy requirements for lactation are proportional to the energy in the quantity of milk produced. The efficiency that metabolizable energy is converted into net energy for lactation is less than that for maintenance. These are important considerations in providing optimum feedstuffs.

The composition of milk varies with breed, lactation stage, and management practices such as feeding programme, milking frequency, length of the dry period, and the health status of a lactating doe. The average composition of goat milk is nutritively as good, if not better, than cow or human milk (table 7.1).

Goat milk is more readily digestible than cow milk as it has smaller fat globules. It is also more alkaline, hence is better nourishment for people with stomach ulcers.

Table 7.1. Average composition of goat, cow, and human milk.

Species	Water %	Fat %	Sugar %	Protein %	Ash %	Total solids %
Goat	85.2	4.9	5.1	4.0	0.8	14.8
Cow	86.0	4.7	4.8	5.8	0.7	14.0
Human	87.4	3.0	6.5	1.7	0.3	12.6

Source: NDRI, 1978; Boor et al 1984., and authors.

Recuperation and Flushing

Does often do not have enough feed offered, or are unable to consume enough, to meet their demands for body maintenance and milk production. Consequently, they mobilize their body reserves to meet this energy shortfall. They need a month of feeding above their body maintenance energy requirements to recover from this drain. That should be followed by another month at a slightly higher nutritional plane in the process of flushing.

A good snack at milking enhances milk flow in does.

Gestation

The next phase, the first 3 months of gestation, has a low nutritional demand. The same level of feeding provided at the recuperation phase should be repeated in the first 3 months of gestation. The last 2 months of gestation are critical in a doe's nutrition as this is when 70% of feotal growth occurs. Feedstuffs of not less than 12% crude protein should be offered to provide for this growth, particularly for twins or triplets and for conditioning does for adequate milk production.

The need for strategic feeding of does is illustrated in figure 7.2 which shows weight changes of does before and after kidding by breeds in western Kenya.

Care of the Buck

A buck is one-half the flock, so must receive proper care. It should always be in good physical condition through proper feeding and health care. Feeding, however, should be limited to just above maintenance requirements so it will not get fat. A fat buck will not be active; its weight may be too much for small does. As does are flushed for breeding, bucks should receive a similar treatment. Increasing the plane of nutrition for 2 months before and also during the breeding season will enhance production of quality sperm and sexual activity (libido). When a buck is serving many does, he should be isolated for approximately 2 hours per day for intensive feeding to compensate for feeding time lost while courting.

Hoof Trimming

Hooves of goats should be trimmed regularly. The hoof growth around and under the foot should be trimmed to the edge of the soft tissue. Be careful not to cut the soft tissue. If this happens, dress the cut with a broad-spectrum antibiotic spray or iodine. Tethered and stall-fed goats that walk a kilometre or less per day require more hoof trimming than do those under extensive production systems. Walking, especially on rocky ground, helps to keep goat feet in trim.

A foul-smelling foot is a symptom of foot rot. Isolate the affected goat for treatment. While trimming a foul-smelling foot, make sure the site of the

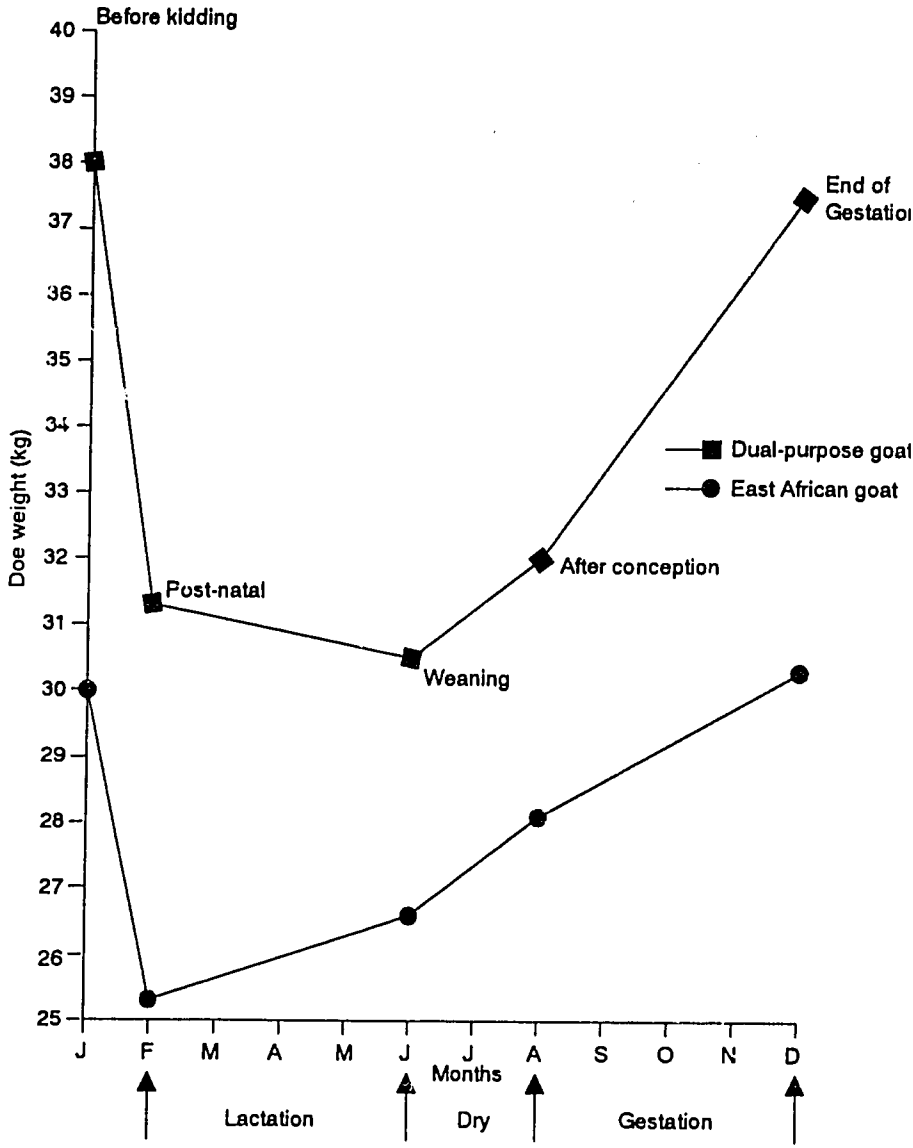


Figure 7.2. Comparative weight changes caused by physiological status of does of dual-purpose and East African goat breeds.

infection is exposed, cleaned, and treated with an antibiotic. While isolated and undergoing treatment, restrict the movement of the infected goat to the minimum. For treatment of foot rot, see Chapter 8.

FEEDING A DOE TO PRODUCE MILK AND KIDS

Problem: Farmers have inadequate knowledge of how goats and other livestock use feed energy.

Background

The first requirement for any animal is to use the available feed energy to keep itself alive. In this state, there is neither a net gain nor a loss of nutrients. The amount of feed energy necessary to achieve this equilibrium is called the maintenance requirement and varies with the animal's body size and daily activity. A cow, because of its bigger size, requires more energy for maintenance than a doe. A tethered doe has less demand for maintenance energy than one that is free ranging.

The feed energy that remains after maintenance needs have been met goes to production, which includes lactation, pregnancy, and growth. The conversion efficiency of feed energy into lactation is 60%, liveweight gain is 42%, and pregnancy falls between the two (MAFF, 1975; Konandreas and Anderson, 1982). When the energy derived from feed intake is insufficient to meet the total energy requirements, a balance is achieved by the mobilization of body reserves. This happens to a doe when only low quality and quantities of forage are available. Under such circumstances a doe will mobilize its body reserves to meet lactation, pregnancy, and maintenance requirements. This is an undesirable situation because it results in loss of body weight and because this energy is released less efficiently than the energy that originally went into its synthesis.

Recommendations

- Does should always be fed above their maintenance requirements to ensure high milk yields, good conception, and kidding rates and to avoid mobilization of body reserves.

- In addition to a full day's grazing, the doe should receive supplementary feed that has at least 12% in crude protein and is at least 55% digestible. The supplementary feed should be a third or more of its total ration of 1 to 1.5 kg dry matter per day. These feedstuffs are recommended for supplementary feeding.

  Sesbania — fresh or as hay, maximum 30% of basal diet

  Leucaena — fresh or as hay, maximum 30% of basal diet

  Maize — fresh stalks and leaves

  Tylossema — fresh leaves and vines

  Sweet potato — fresh leaves and vines

  Couch grass — fresh

FATHER CREDITS GOATS FOR SURVIVAL OF TWIN

In a small farm in the Siaya District of western Kenya, a pair of four-year-old twins are thriving on milk from their family's goats.

The father of the twins, 66-year-old Ogonjo, swears that had it not been for the goats provided by the Winrock Management Research Project of USAID's Small Ruminant Collaborative Research Support Program (SR-CRSP) his twins would not be alive today.

When the SR-CRSP first placed three female goats (does) on Ogonjo's two hectare (about five acres) farm, he accepted them with some reservation because in his culture, men do not usually raise goats.

Ogonjo already had four cows when he received the goats and did not immediately concern himself with the new animals. He also did not milk them to stimulate their ability to give milk. Not long after Ogonjo received the goats, however, his four cows were stolen. At that time, his wife was in the hospital. He was caring for the twins and wondered what he was going to feed them.

- When the appetite of a doe is not met following a day's grazing, the supplements can be fed as sole diets, except for leucaena and sesbania. Another supplemental feed source is to cut and carry napier grass. Farmers who anticipate a shortage of grazing pastures are advised to grow napier grass.

- When cash is available, bought-in concentrates can be used as supplementary feed to enhance production. Concentrates meant for cows are equally good for does.

- Supplements should be fed at least twice in a day for proper maintenance of rumen digestive properties. The ideal frequency is twice a day for a milking doe, at the morning and afternoon milkings. This also stimulates milk let-down.

Because the family could not afford to purchase other appropriate foods, the young twins still were nutritionally dependent on milk from the cows. Then, Ogonjo remembered the goats. The does' milk had not yet dried up, and he was able to collect one to two liters of milk per day from the goats to feed his twins.

After this incident Ogonjo completely changed his attitude toward goats. Of all the local farmers who received goats from the project, his now get the best care. To ensure that the animals have access to plenty of forage, he has adopted all of the feed resource recommendations offered by the SR-CRSP. In fact, he is cultivating one-quarter acre of sesbania, a highly nutritious leguminous tree, which he will harvest to feed the goats.

Ogonjo now has six goats, and they are reputed to be the best goats in the Siaya District.

The SR-CRSP, in collaboration with the Kenyan Ministry of Agriculture and Livestock Development (MALD), has placed over 200 improved goats on farms in western Kenya.

(This article is reprinted from the November 1986 issue of *Frontlines*, published by the U.S. Agency for International Development.)

- Does should be dried off in their last 2 months of gestation to avoid competition for available energy between pregnancy and lactation.

PROMOTING DRY MATTER INTAKE AND REDUCING ROUNDWORM PARASITISM

Problem: Low dry matter intake and high infestation with roundworms in wet seasons.

Background

In wet seasons, goats experience low intake of dry matter, shortened grazing time, and high infestation with internal parasites. Low dry matter intake is a result of a high water content in forage and reduced grazing time. Goats, unlike cattle, will not graze when rain drops are falling on their backs. Wet conditions, when moisture is high in the ground and grass blades, are conducive for larvae development. The coincidence of low dry matter intake and high incidence of infective larvae in wet seasons makes goats highly susceptible to internal parasites (helminthiasis).

The control of internal parasitism in goats is not solely dependent on treatment with antihelmintics. A trial was conducted at Maseno using good management practices to gain the same control. The hypothesis was that through wilting of forage before feeding to goats there would be increased dry matter intake and a reduced infestation rate of infective larvae. The wilting treatment proved to be effective in enhancing dry matter intake and in increasing body weight gain (table 7.2). The egg count per gram (EPG) of the bucklings on wilted forage was much lower, an indication of a lower infection rate as shown in figure 7.3.

Table 7.2. Dry matter intake of DPG bucklings at Maseno station.

Form of forage	As-fed (kg)	DMI (kg)	DMI $(kg)^{0.75}$	DMI % of Body wt.	Mean weight change (kg)
Fresh n=6	2.3	0.5	63	3.1	3
Wilted n=6	1.4	0.7	86	4.2	5

Recommendations

- Wilt forage or make hay from pastures that are contaminated with helminths eggs.
- Work toward a stall feeding programme using uncontaminated fodder banks.
- Prevent overstocking as it increases the contamination rate and ingestion of infective larvae.
- Institute a tethering sequence or a rotational grazing scheme according to susceptibility of various age groups.
- Drain stagnant water as soon as possible.
- Drench strategically when conditions demand (refer to Chapter 8).

NURSING STRATEGIES

Problem: Kids are starving.

Background

Once a kid is born, gets on its feet, and nurses, it has a good probability for survival. Conversely, if the mothering ability of a doe is poor, if there is a weak doe/kid bond, or there is low milk yield, the probability of survival is low. The mortality rate of kids in experiments both on-station and on-farm was highest in their first 2 months of life, the result of starvation and diseases. There can be a marked reduction in kid mortality through containment of the causes associated with starvation, such as doe/kid bond, blocked teats, low milk yield, milking regime, lack of colostrum, and eradication of draughty conditions.

Recommendations

- Ensure that the doe/kid bond is established soon after kidding. Does that

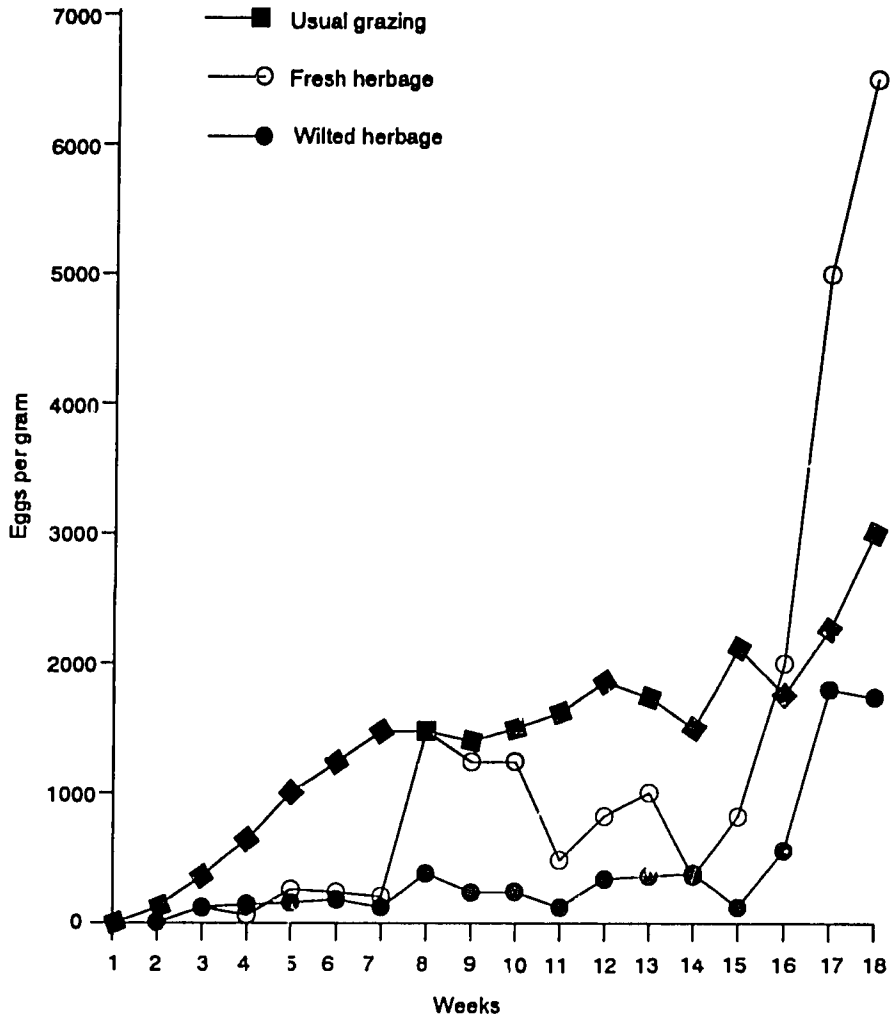


Figure 7.3. Mean weekly change of eggs per gram in faeces of dual-purpose goat bucklings in western Kenya.

tend to run away from their kid(s) before bonding is established should be restrained to remain in close contact with their offspring.

- Check the teats of the does following kidding. If they are blocked, unblock them through milking.
- Help a kid that is unable to suckle by milking directly into its mouth. The sweetness of the milk will psychologically urge the kid to suckle.
- Make sure the kid has suckled within 2 hours of birth and thereafter at increasing intervals. The first milk or colostrum is absolutely essential. It contains antibodies that are necessary for the early survival of the kid.
- A lactating and nursing doe that is not receiving supplementary feed of sesbania, leucaena, or other protein-rich forage is not likely to produce milk in excess of requirements for its kid. Under this circumstance, milk no more than half the udder in the first 30 days and thereafter a quarter per day until the kid attains the weight of 10 kg. At this time, the kid is weaned and the total milk extracted can be realized to the end of the lactation. In the case of twins, milk no more than a quarter of the udder in the first 30 days and thereafter none to weaning or attaining of 10 kg each. There should be no milking for does with triplets until the kids are weaned. Where a milk replacer is available, this recommendation is not applicable (refer this chapter: Milk replacer for kids).
- House the kids in draught- and excessive heat-free conditions. Cold draughts can lead to pneumonia and starvation both of which arise from over expenditure of energy to regulate body temperature.

GRADUAL WEANING

Problem: Kids get shocked by sudden weaning, leading to high mortality rates or reduced growth rates.

Background

Goat kids must be weaned to conform with the development of their digestive systems and to go into a ration that is cheaper than milk. Weaning must be planned to allow introduction of the new diet well in advance of the

weaning date. In the introductory period, the kids must be monitored to ascertain that intake and utilization of the ration is adequate to meet their energy requirements for maintenance plus growth. When not well-timed, this change can cause mortality or check growth, either temporarily or permanently. Starvation occurs when intake of the new ration is very low. Growth is checked when intake just meets maintenance requirements. Early exposure to grazing promotes rumen development, hence intake and utilization at weaning are adequate to prevent starvation or reduced growth rates. Early exposure to forage followed by gradual weaning when kids are denied their full share of milk is practical and beneficial (Semenye et al., 1986a). Gradual denial of milk or nursing forces the kids to have to forage more; sudden cessation has a negative impact on foraging. Live weight should be considered in addition to weaning procedures. Four times birth weight or 10 kg live weight at weaning are suitable standards for western Kenya conditions (Brown and Nderito, 1983).

Recommendations

- When weaning a kid to pasture, fodder, or milk replacer, start denying the kid its full share of milk 10 days before the planned date of weaning. This is easily done by taking more milk for the household. At the same time, the kid must gradually be exposed to its new ration, e.g., sweet potato vines. It is a good practice to introduce the future ration as early as possible.
- Prevent contact between the doe and its kid following weaning.
- Ensure that intake of the new ration, whether forage or a milk replacer, has adequate energy for maintenance and growth.
- Give kids early exposure to cut and carry forage when they are to be weaned to pastures.
- Wean a kid when it is approximately four times its birth weight or 10 kg.

MILK REPLACER FOR KIDS

Problem: Does are overmilked to satisfy home consumption needs, hence

These kids of dual-purpose goats are having a go at their favourite milk replacer, sweet potato leaves and vines.

kids are denied the milk they need which leads to stunted growth, starvation, and death.

Background

Research indicates there is no significant difference in growth performance between the kids that were weaned on sweet potato vines (SPV) and those with total access to their dams' milk (see table 7.3). A significant

Table 7.3. Comparison of kids and milk offtake under two management systems.

	Kid age (days)					
Management system	Birth	30	60	90	120	offtake kg
Total suckle (kg)	2.9	4.9	4.6	5.6	7.3	nil
SE	0.2	0.3	0.6	1.1	1.5	
Weaned on SPV (kg)	2.4	6.3	6.6	8.4	7.9	87
SE	0.3	0.6	0.8	1.0	1.1	

Notes: N = 8 in each management system. SE = standard error.

difference between the treatments was in the milk offtake for home use. The does whose kids were weaned to SPV each provided 87 kg of milk in 120 days. By using SPV, which is grown as a food crop, the accrued side benefit was 87 kg of milk valued at KSh. 609/= (US$ 29.82)(1992). Early weaning has the added advantage of enhancing rumen development (Semenye et al., 1986a).

SPV is an ideal milk substitute because of the chemical composition and as it is grown by nearly all farmers in western Kenya. Sweet potatoes are grown in small plots ranging from $4m^2$ to over $49m^2$. Sufficient SPV can be harvested from small plots without reducing the tuber yield (refer to Chapter 5). SPV will meet the requirement of a kid of 30g DM/kg body weight/day because the chemical composition of milk and SPV are comparable. Milk has a moisture content of 85% and digestibility of 86%, while for succulent SPV these are 80% and 72%, respectively.

Recommendation

- While observing the gradual weaning recommendations outlined above, offer SPV ad lib to kids from 2 weeks of age until 10 kg of weight.
- This will obtain optimal growth of the kids and of the milk offtake for home use. Assuming normal growth, a kid will reach 10 kg at 3 to 5 months in western Kenya. Continued feeding of SPV is recommended but is not mandatory.

PRESENTING FEEDSTUFFS TO GOATS

Problem: Too much waste of feedstuffs.

Background

Goats are very selective feeders. When presented with fodder of mixed species they will go first to the most palatable species much as children go for sweets or pudding. After eating the most palatable species, they are less inclined to eat those remaining. Whether the remaining forage is then eaten depends on the degree of hunger, soilage, and other contamination. Research was conducted at Maseno to determine the palatability preferences

of DPG for common forages, thus reducing the amount of leftovers from the cut and carry system (Semenye et al., 1986b). These are ranked in tables 7.4, 7.5, and 7.6.

Goats are browsers by nature. They often stand on their rear legs to nibble on shrubs and small trees. They will emulate their preferred stance for foraging when cut and carry forage is given in a hanging position. Tying and hanging forage also reduces wastage by decreasing contamination and soilage of the feedstuff. Cut and carry feedstuffs placed on the ground usually are contaminated by urination, defaecation, and salivation. They become soiled and are tramped upon. As goats are fussy in their feeding habits, soiled feedstuffs will not be eaten. However, what is left by goats may be cherished by cattle, thus it often works well to give cattle what the goats have refused.

Recommendations

- Feed the least palatable forages first and the most palatable last.

Tie the cut and carry forage in a bundle and hang it up to decrease the amount of leftovers and reduce worm infestation.

Table 7.4. DPG palatability preferences of six grass species.

Species	Rank	Daily intake(g)	CP %	DMD %
Digitaria scalarum	1	1,223[1]	17	65
Pennisetum purpureum (Napier)	2	1,080[1]	9	63
Panicum antidotale	3	890[2]	9	54
Brachiaria brizantha	4	741[2]	11	51
Chloris gayana	5	703[2]	8	50
Pennisetum purpureum (Bana)	6	672[2]	13	57

Notes: See table 7.6.

Table 7.5. DPG palatability preferences of six proteinous species.

Species	Rank	Daily intake(g)	CP %	DMD %
Ipomoea batatas	1	1,689[1]	17	68
Leucaena leucocephala	2	1,353[2]	21	65
Tylossema spp.	3	199[2]	14	55
Cajan cajanus	4	751[3]	21	69
Sesbania sesban	5	684[3]	21	68
Gliricidia spp.	6	187[4]	18	55

Notes: See table 7.6.

Table 7.6. DPG palatability preferences ranking of six grass and proteinous species[a].

Species	Rank	Daily intake(g)	CP %	DMD %
Ipomoea batatas	1	1,757[1]	17	68
Leucaena leucocephala	2	1,079[2]	21	65
Digitaria scalarum	3	754[3]	17	55
Tylossema spp	4	711[3]	14	69
Pennisetum purpureum (Napier)	5	570[4]	9	68
Panicum antidotale	6	480[4]	9	55

Notes: a = Composite table of the first 3 species from each of tables 7.4 and 7.5.
1,2,3,4 = Means not having the same number differ statistically at $P \leq 0.05$
CP = Crude protein
DMD = In vitro dry matter digestibility

CROP RESIDUES AS FEEDSTUFFS

Problem: Short-fall in feedstuffs needed for maintenance of weight and body condition.

Background

A seasonal shortage of forage in small farms of western Kenya is a constraint to goat production (Sands et al., 1982; Onim et al., 1984; Semenye et al., 1986c). This is a result of small farm size coupled with overstocking of livestock. These farms must also produce food to support large families. Whenever available, livestock graze homestead compounds and communal properties as these can be their only source of feed. These pasture areas, however, are not adequate for meeting the nutrient requirements for both maintenance and production. Using the conventional stocking-rate recommendations for the area, these farms are overstocked and family livestock is in danger of starvation. This danger can be avoided by appropriate use of crop residues. The nutritive values of the crop residues in western Kenya (table 7.7) are too low to support production beyond maintenance requirements but they can be enhanced with certain manipulations.

Feeding crop residues to livestock that have received physical treatment, such as chopping, grinding, and soaking in water, can enhance their intake and digestibility (Semenye et al., 1986c; Nour, 1987), while chemical treatments like urea, sodium hydroxide, and ammonia will enhance digestibility (Said, 1981). Treatment with salt or molasses is effective for increased palatability and intake. Satisfactory utilization of crop residues can be achieved through one or more of these treatments.

Recommendations

- Physically and chemically treat crop residues to enhance their palatability, intake, and utilization. Treatments suitable to smallholders are (1) chopping into lengths of approximately 5 cm or less, (2) soaking in clean water, and (3) sprinkling with molasses or common salt.

- Feed a goat about one-third more feedstuffs than it will eat, then feed the leftovers to cattle.

Table 7.7. Chemical composition of crop residues in western Kenya.

Crop residue	Dry matter %	Ash %	Crude protein %	Dry matter digestibility %
Maize stover	82	10	5	36
Sorghum stover	86	8	4	42
Bean haulms	90	7	6	42
Banana peelings	20	15	8	59
Mango peelings	—	—	7	—

- Maize stover that has been soaked in water and chopped into lengths of no more than 5 cm is sufficient for the nutritional demands of a doe that is neither pregnant nor lactating.
- Sprinkle molasses on stover to enhance its palatability and the energy intake. Occasional sprinkling of common table salt is also recommended for the same reasons.
- Sorghum, bean haulms, and other crop residues can be used in the same manner as maize stover.

Peelings of mangoes and bananas should not be wasted but fed to goats whenever available. As they are not routinely available in large quantities, use them to supplement the usual daily requirements.

MILKING AND MILK HYGIENE

Problem: Farmers have inadequate knowledge about the milking process and milk hygiene practices.

Background

Pre-milking preparations and milking procedures are vital in regulating milk yield. They are important considerations in on-farm research. For example, these managerial factors often cause variations in milk yields:

- Does refuse to let milk down when their regular milkers are away.

- Irregularity in milking frequency and interval, usually in homes that milk only on demand, causes lower yields and sometimes mastitis.

- A doe that was yielding 0.5 kg/day was transferred from a home where there was a domestic quarrel. The doe started yielding 1.2 kg/day in the new home, the result of receiving managerial attention that was conducive for maximum milk production.

- Does have failed to give their average yields during milking demonstrations.

Milk is a noble food but if not pasteurized it can be a source of infection to humans. Goat milk must be pasteurized as a standard practice to ensure it is safe for consumption and preservation. Unpasteurized milk from diseased goats can transmit brucellosis (Nicoletti, 1987). In India, goat milk is prescribed by doctors in cases of jaundice, peptic ulcers, and dyspepsia (NDRI, 1978). Goat milk is more digestible and richer in antibodies than cow milk. Collaborating farmers claim that less goat milk than cow milk is required when making tea because of its higher fat and sugar content. Despite these advantages, there are some prejudices against using goat milk. Random blind tests on the consumer preferences between goat and cow milk in western Kenya indicated no significant difference for either fresh or scured milk (Boor et al., 1984).

Recommendations

- Provide a conducive environment for milk letdown. This is characterized by uniformity, gentleness, quietness, and skill.

- Prepare a doe for milking by presenting her with a supplementary feed: Always wash the udder, preferably with lukewarm water.

- Use the most convenient method to restrain a doe (figures 7.4 and 7.5).

- Use the correct milking procedure as illustrated in figure 7.6. Milk by pulling the teats only when they are too small for using the preferred procedure. Nudge or push gently the udder during milking to mimic a kid sucking. This trick causes more milk let-down.

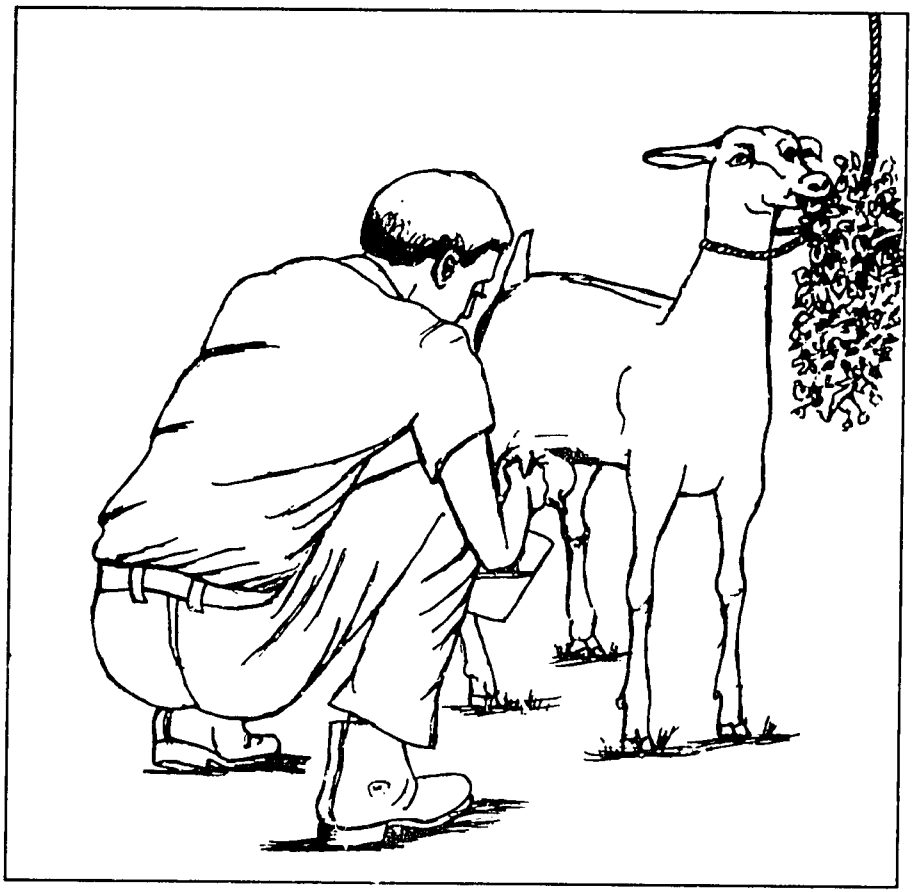


Figure 7.4. Restraining the doe during milking by using a shortened tether.

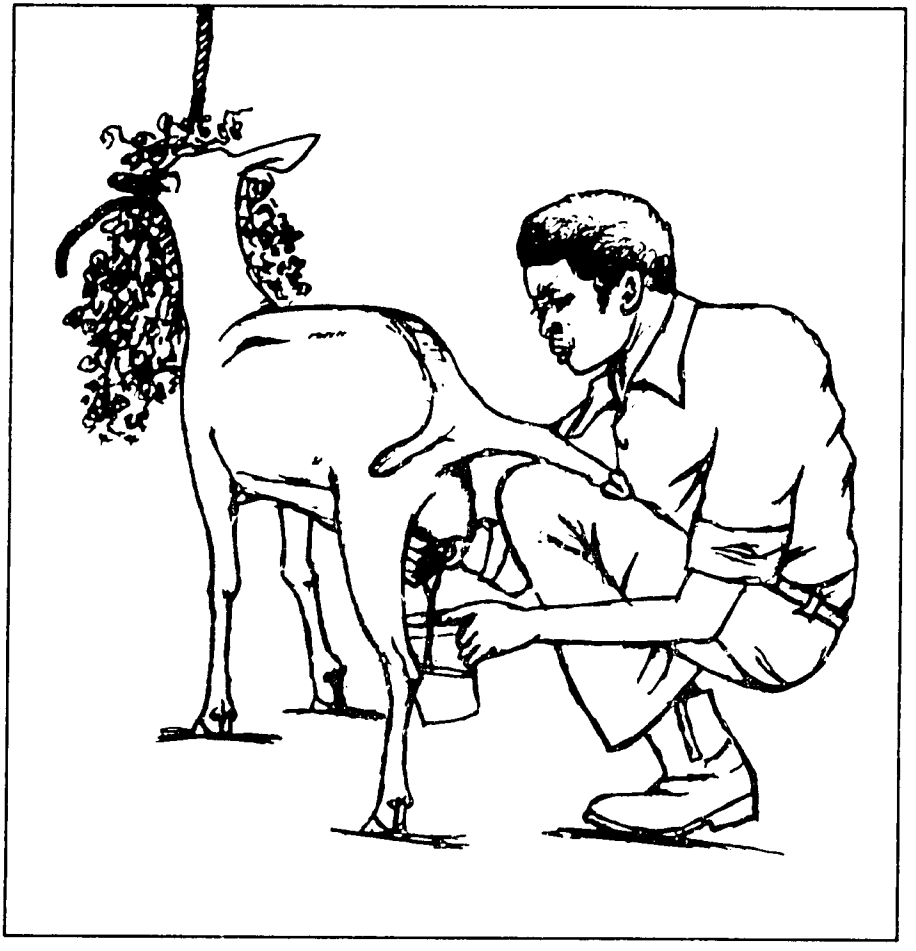
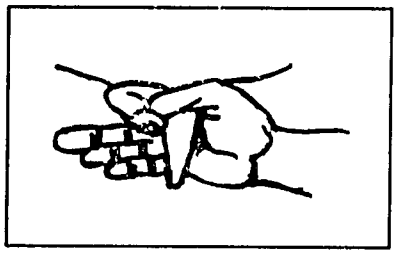
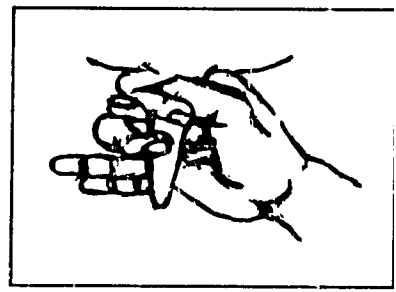


Figure 7.5. Restraining the doe during milking by stanchioning the right hind leg.



(a)



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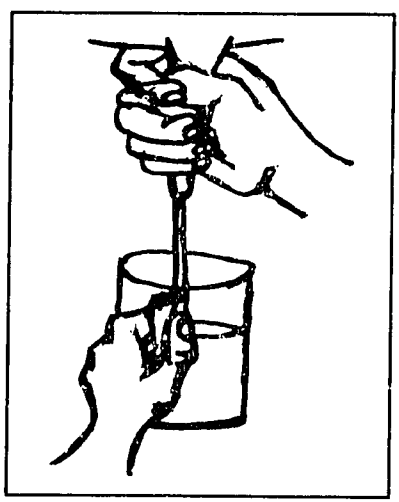

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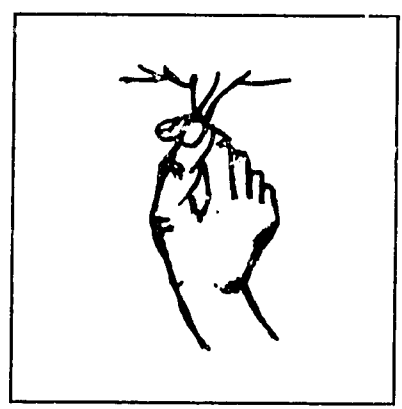

(d)

Figure 7.6. How to milk a goat: (a) Trap milk in the teat. (b) Begin to squeeze the teat. (c) Squeeze the teat, forcing the milk out. (d) Pulling is not recommended, used for small teats only.

- Discard the first squirt of milk from each teat because it may be contaminated.
- Discard all milk that is lumpy or has blood spots as this is an indication of mastitis; seek veterinary advice.
- Strip at all milkings to ensure the final drop of milk is out, thus avoiding a potential source of infection and premature drying up.
- Milk at regular intervals each day; use the same milker as much as possible.
- Be sure the milker's hands are clean and dry before starting to milk.
- Milk into a clean container.
- Record milk yields daily to know the production of the doe. A doe giving more than 1 kg of milk can be kept longer and her bucks saved.
- Measure milk yields either by weight or volume.
- Stop milking when a doe is 3 months pregnant.
- Pasteurize the milk by bringing it to the boiling point and holding it there for approximately 1 minute.

MATING SCHEDULE

Problem: Farmers lack knowledge regarding the age, appropriate nutritional status, and breeding frequency in order to increase the conception and kidding rates of DPGs.

Background

The age at first kidding and the subsequent frequency of kidding are important in determining a doe's lifetime production of kids. The nutritional status is an important factor in determining a doe's kidding frequency, litter size, and milk production. When a doe has a low plane of nutrition, the ovulation and conception rates drop proportionally. If nutrition drops during the period from conception to kidding and thereafter, high rates of abortions and mortality should be expected after kidding.

Recommendations

- As doelings may start to cycle as early as 2 months of age (Robinet, 1974), they could produce their first kid at 7 months. It is not a good practice to mate doelings at their first heat. The correct time is when they have attained 70% of their expected live weight so there is no danger of their being permanently stunted. A stunted doe has a low prolificacy rate and produces kids with low birth weight and viability.

- Flushing and steaming-up are recommended to maintain does in a good nutritional state and body condition. There are high and positive correlations between good body condition and conception or kidding rates. At Maseno, the does are in good body condition in the dry season when the dry matter content of forage is highest. This is the time for breeding because it is when flushing occurs naturally. The does will then drop their kids in the next dry season which provides a natural steaming-up effect as shown in figure 7.1.

- Accelerated kidding is recommended when concentrate feeding assures a good plane of nutrition. The kidding intervals are 8 months with the does bred in less than 3 months following kidding. Kidding once a year is appropriate when feedstuffs are pastures, crop residues, and marginal supplements with quality fodder.

- Where forage availability is assured, kidding should be timed to take advantage of natural flushing and steaming-up. In sub-humid areas this is 1 or 2 months after the rain peaks.

- Breed dual-purpose doelings for the first time when they weigh 25 kg and are in good body condition, usually attainable in western Kenya when these doelings are at least 1 year of age.

- Flush doelings and does 4 weeks before mating by using high quality fodder such as sesbania, *Tylossema* spp, leucaena, maize thinnings, green maize leaves, sweet potato vines, or similar feedstuffs.

- Buy or hire a dual-purpose buck that is in good condition and with a high libido.

- Ensure the doe is bred in its second day of heat (estrus) in order to overlap with ovulation. This occurs 18 to 36 hours after onset of the heat period.

- Be certain that tethering does not impede their courtship or mating.

TETHERING

Problem: Restricted grazing area, plant selection, and movement, thus reduced contact for courtship and mating.

Background

Tethering is the preferred method of animal control in western Kenya due to the small size of land holdings, double cropping in many areas, and lack of fences. It has several advantages, including close control, avoiding of crop damage (particularly of neighbours' plots), and convenience of feeding crop residues and cut and carry forages. Tethering must be carefully managed not to restrict grazing selection and area or contact with other goats for mating, and to avoid exposure to helminths and accidents.

Recommendations

- Tether goats with a rope of approximately 4 m in length or 2.5 times the body height of a man. Ropes that are too long can cause entanglement while short ones severely restrict the grazing area.
- Change the tethering station at least 4 times each day. This provides the goat with fresh pastures that are uncontaminated with faeces and urine.
- Base the tethering pattern upon (1) the movement of the sun, (2) herbage availability, and (3) large-stock tethering sequence. Always tether goats on sites ahead of cattle as this will help reduce infestation of internal parasites.
- When a DPG doe is in estrus and is to be mated, overlap her tethering area with that of the buck to facilitate contact, courtship, and mating. This is the only circumstance to allow any overlap of tethering areas as this can lead to tangled ropes and unnecessary stress as the goats try to free themselves.

- Do not tether where the rope can get entangled with other objects or near to cliffs as these situations can lead to accidents.

HOUSING OPTIONS

Problem: Lack of low-cost housing that provides optimum space in appropriate hygienic conditions for goats.

Background

Goats must be provided with housing as they are more susceptible than cattle to the effects of draughts, wetness, and sudden changes of weather. The house can be a planned or an adapted building or other farm structure. It must be well ventilated, draught-free, lockable, strategically placed to prevent thefts, and predator-proof.

Few farmers in western Kenya need a special structure for their goats because they convert their kitchens into goat houses for the night. This arrangement is adequate for up to 6 goats. Space is a major limitation when a kitchen is used as this can lead to crowding and injuries, trampling of the young, and pneumonia. Pneumonia in goats is triggered by inadequate ventilation and stress.

Recommendations

- A plan for constructing a goat house is illustrated in figure 9.2. Use locally available materials to reduce construction costs. For instance, use thatch grass for the roof where it is available. Corrugated iron sheets are the next best choice. The floor should be raised and slatted to allow seepage of urine and faeces. This plan is for housing 4 to 6 medium-sized goats for the night only. It is partionable so that goats can be separated. The building is versatile as it can also be used to store hay or other farm produce.

- Ensure that the house is adequately ventilated yet draught free. The slatted floor should be swept daily. The house should be predator- and theft-proof.

- There should be no crowding of the goats.

CHAPTER 8

MAINTAINING A HEALTHY FLOCK

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The goal of a health programme for a DPG flock is to improve the animals' productivity through proper nutrition, reproduction, and environmental management, and by cost-effective disease and parasite control. Accurate records are needed to know where the programme has been, how it is progressing, and how to challenge it in the future. For a flock health programme to succeed, it must suit the needs and goals of each farm. This chapter discusses some conditions commonly encountered in goats in Kenya and can be the basis for developing a health programme model for dual-purpose goats in this and other regions with similar environments and production systems.

GOOD HEALTH PRACTICES

A healthy goat has an alert expression, a bright but kindly eye, and a smooth hair coat. A goatkeeper must be observant to spot the first symptoms of ill health, such as loss of appetite, dullness, rough hair coat, alteration in the character of the droppings, failure to chew the cud, drop in milk yield, lameness, or cough. These observations will result in a timely assessment of the goats' health and form a basis for a decision on whether to call for veterinary help.

Like any other sick animal, a sick goat requires warmth and constant attention. This can be provided by placing the goat in a draught-free pen or box that is deeply bedded with clean straw or similar material. Sunlight and adequate fresh air without draught may be needed when the animal has a lung condition.

Ample fresh drinking water and mineral supplements should always be provided.

Maintaining a healthy flock is important to each of the 150 farmers cooperating in the SR-CRSP dual-purpose goat project.

COMMON HEALTH PROBLEMS

These recommendations cover 14 problems commonly encountered in managing DPGs in Kenya.

This list is not inclusive nor exhaustive. The procedures recommended require minimal cost while keeping the DPG flock in good health and high production. More detailed information is given in the handbooks that are cited and from district veterinary offices throughout Kenya. Veterinary services in Kenya are delivered through veterinary officers and animal health assistants. Government regulated fees are charged for services and drugs. However, the process of privatising veterinary services in Kenya is at an advanced stage.

PHYSICAL INJURIES

Cuts and Injuries

Solutions:

Minor cuts. Clean the cut with soap and water, then allow it to heal. Use antibiotic sprays on minor cuts and superficial wounds or bruises. When cuts require sutures, contact a veterinary assistant.

Thorns, ticks, and rocks between hooves. Clean between the hooves of the lame feet, then place the animal in a dry, clean enclosure.

Hairloss and itching that is easily noticed by excessive scratching.

Causes: Lice, mites, and fleas are the most common causes. Lice and mites cause dry, crusty skin. Fleas cause goats to scratch which irritates their skin. Fleas can be seen when the affected skin is examined.

Solutions:

Fleas: Spray the goats with a commercial flea spray. Dogs should also be sprayed as they are the usual source of fleas.

Lice and mites: Take the goats to the local tick-control dip. If the skin condition remains after 2 dippings, contact a veterinary assistant.

Blisters around the mouth and on teats, poor appetite, and depression.

Cause: Orf virus. This disease can affect kids as well as does.

Solution: There is no treatment or readily available vaccine. The goats will get over the disease in a few days. This is a zoonotic disease; always wear gloves when handling animals with blisters on the mouth and teats.

Lame goats having hooves with a bad odour.

Cause: Foot rot caused by bacterial infection.

Solution: Prevent foot rot by keeping the feet trimmed and housing the goats in a dry place. Isolate the infected goats. Walk the infected goats through a 10% copper sulphate solution once a day until the disease is cured.

INFESTATION WITH TICKS

Ticks.

Background: Most goats will have a few ticks.

Solutions: (1) Examine all goats in the herd 2 times per week. (2) Remove ticks by hand except those in sensitive areas such as between toes and on the eyelids. Ticks in these areas should be left on the goat and pierced with a sharp pin or thorn. The pierced ticks will die and drop off the goat without causing irritation and infection. Hand-removed ticks should be burned. (3) Goats with approximately 30 or more ticks per animal should be taken to a local tick control dip or sprayed.

Rationale: Dips and sprays are expensive. Complete control of ticks by regular dipping may cause goats to lose immunity to tick-borne diseases. When the tick control is relaxed, tick-borne diseases may occur.

INFESTATION WITH WORMS

Stomach worms or internal parasites.

Background: Goats and other young animals under 6 months are most susceptible to stomach worms and other endoparasites. Yearlings and 2-year olds are the second most susceptible as they are growing fast and are most likely to be malnourished. There are no reliable and economical indicators available to farmers on when to treat. However, untreated DPGs give less milk and lose weight. When parasites occur in conjunction with other diseases, death can occur.

Solutions: (1) Use antihelmintics to control stomach worm infections in DPG flocks. This is an important and essential part of the total herd health programme. The number of eggs hatching to infectious larvae is highest after

rain. Therefore, the drenching schedule in some areas should be based on the rain or rainy periods. In western Kenya, rainfall is too frequent to serve as a basis for treatment. Therefore, in this area drench goats every 6 to 8 weeks. (2) Wilt forage as discussed in Chapter 7.

Management recommendations: Animals receiving an adequate, balanced ration are less susceptible to parasite infection. Do not substitute antihelmintic drugs for good management in stomach worm control in a goat flock.

INFECTIOUS DISEASES

- **Abscesses (Caseous lymphadenitis, pseudotuberculosis).**

Background: This disease is considered the curse of the sheep and goat industry in the world and is very common among goats in Kenya. It is not given high prominence because it does not kill suddenly.

Cause: *Corynebacterium ovis*, also called *C. pseudotuberculosis*. The micro-organisms enter the body through body scratches or fighting wounds. Other micro-organisms such as *C. pyogenes*; *Streptococcus* spp. and *Staphylococcus* spp. may also cause abscesses as a result of contaminated lacerations or punctures.

Symptoms: Development of a painful swelling on any part of the goat's body should always be a suspect, especially if a healed or scabbed-over wound can be detected.

Solution: Never attempt to lance or open the swellings as they may be haematoma (blood swellings) caused by direct injury or bruising of the unbroken skin; only a veterinarian or his assistant will be able to tell the difference. Reduce the swelling by placing a cloth dipped in hot water on the abscess. Drain the encapsulated abscesses before they rupture to minimize contamination of the environment and pasture. Once it is established in a flock, caseous lymphadenitis is difficult to eliminate. Even goats that are properly treated will often have recurrences. Environmental contamination can lead to infection of kids. To remove caseous lymphadenitis as a flock problem, it is best to cull the chronically affected goats. Cleanliness of the goat house is also essential.

- **Scabs or crusts around the mouth, nose, skin between top of the foot and the knee, and the neck.**

Cause: Streptotricosis (*Dermatophilus congolensis*).

Solution: As prescribed drugs are needed, consult a veterinary officer. The treatment is with a mixture of penicillin and streptomycin combined with a local application of a mild caustic solution.

- **Swollen udder and clotted milk.**

Cause: Mastitis, a bacteria-caused inflammation of the udder that causes pain when touched and results in clotted milk.

RESEARCH IN HEALTH PROBLEMS

Before recommendations such as those outlined in this chapter can be made, research is carried out in various laboratories all over the world. Technology is employed to understand the complex biology of the causal organisms and to develop products that give a reliable diagnosis. The animal health component of SR-CRSP, in collaboration with KARI and NOLD, has contributed important findings on goat diseases prevalence and control. These achievements of veterinary research are a result of biotechnology conducted by SR-CRSP.

- Vaccination for contagious caprine pleuropneumonia. This disease is caused by a mycoplasma (strain F38). It occurs in outbreaks that result in high mortality. A CCPP vaccine has been developed and evaluated in on-farm trials. The vaccine has been rendered safe by inactivation. It is lyophilized and can be stored for 12 months at room temperature while maintaining high efficiency. Animals are protected for challenge for 12 months after vaccination.

- Development of a rapid diagnostic kit for CCPP. This diagnosis is based on the detection of antibodies against a contagious antigen from the causative mycoplasma.

Solution: Always wash the udder with soap and water before milking. Treat the infected goat by infusing antibiotic preparations into the teat. This can be administered by the farmer or a veterinary assistant.

- **Running eye.**

Symptoms: Both eyes may be affected; one or both may be closed. If neglected, the eye(s) will quickly film over, eventually filling with a yellowish pus and ulcerate leading to blindness. This is often called pinkeye (*Infectious keratoconjunctivitis*). Appears in hot dry weather; is spread by close contact and flies.

- **Classification and differentiation of F38. A monoclonal antibody has been developed which differentiates F38, the causative agent of CCPP, from other mycoplasmas. It is hoped this procedure will resolve world-wide controversies surrounding the classification of F38.**

- **Diagnosis of heartwater. This disease of all ruminants is caused by the rickettsia, *Cowdria ruminantium*. In the past, it could only be diagnosed by making a brain smear in the dead animal. A DNA probe has been developed for detecting *C. ruminantium* in ticks and infected goats. It will be invaluable in epidemiological studies of heartwater.**

- **Establishment of the presence of *Anaplasma ovis* in goats in Kenya. A specific DNA probe was developed to demonstrate there is a high prevalence of *Anaplasma ovis* in goats from various areas of Kenya.**

- **Established the presence of caprine arthritis encephalitis virus in imported goats in Kenya and helped eradicate the disease from the country.**

- **Identified a possible way of introducing goats into trypanosomiasis areas without significant disease effects.**

- **Defined areas of Kenya that are selenium deficient and where supplementation is necessary.**

Cause: Not definitely established for goats; rickettsia believed to be involved in some cases and mycoplasma in others. Can affect goats of any age.

Solution: Protect the animal from sunlight and give it good nursing care. Contact a veterinary assistant for eye ointment or ophthalmic powder.

- **Kids are sick during the first 3 weeks of life.**

Symptoms: They have signs of poor appetite, diarrhoea, coughing, or hard breathing.

Cause: Most cases are caused by failure to obtain colostrum in sufficient quantity or early enough following birth to prevent infections.

Solution: Make sure the kid suckles as much as possible and as soon as possible after birth. Weak kids should be assisted. Contact a veterinarian when kids show any of the signs described above so treatment can be started.

Rationale: Most infections in kids up to the age of 1 month result from inadequate transfer of antibodies from the colostrum. The time of first suckling and the amount of colostrum the kid gets after birth are the most crucial factors influencing transfer of antibodies. Absorption of antibodies by the kid starts to decrease at 6 hours after birth and very little will occur after 24 hours.

- **Profuse, watery, yellow diarrhoea in kids.**

Cause: Bacterial infection, possibly *Salmonella* spp.

Solution: Contact a veterinarian for treatment and advice on management practices.

- **Pasty diarrhoea leading to watery diarrhoea in kids 2 to 3 weeks after weaning.**

Cause: May be coccidiosis.

Solution: Contact a veterinarian for treatment of the affected kids. In a large flock, infection of kids should be prevented. Old bedding and manure should be removed from kidding pens before new kids are born. Except for protection of younger kids, it is a waste of time and money to treat older, apparently healthy animals that do not show diarrhoea. It is far better to separate the young kids from these older carriers.

Although most goats carry coccidia and will be positive on faecal examination, normally only the young kids become sick with coccidiosis resulting in deaths or stunted kids. Raising kids separately from adults, keeping pens clean and dry, preventing faecal contamination of water and feed, and, in some cases, continuous preventative medication, are necessary to prevent coccidiosis. It is neither possible nor desirable to completely eradicate coccidia from the adult goats. A low-level infection with the parasite will keep goats immune to the disease.

- **Respiratory tract diseases which cause hard breathing, coughing, and poor appetite.**

Causes: These signs of pneumonia are caused by *Pasteurella* and other bacterial pneumonias and by *Mycoplasma* that causes contagious caprine pleuropneumonia (CCPP). Pneumonia in goats is almost always preceded by stress factors such as weaning, long distance hauling, weather conditions, poorly ventilated housing, overcrowding, malnutrition, and parasitism and worming.

Solution: Prevent bacterial pneumonia in kids and does by reducing stress factors. Use clean, dry housing and keep goats out of the rain. Contact a veterinarian in case of pneumonia. Administering antibiotics will help reduce the severity and incidence of the disease. Vaccinate goats for CCPP.

This disease occurs in epidemics and can be devastating to goats on small or large farms and to multiplication centres. The mortality rate is high. The surviving goats have low productivity, are weak, and have pneumonia lesions.

Follow these procedures when goats are purchased or transferred from other stations: (1) Seek advice from a veterinarian at the source of the goats and at the destination. (2) Vaccinate new goats for CCPP. (3) Quarantine the goats for 6 weeks in facilities that are physically separated from other goats; carefully observe them. Goats that become sick should not be mixed with other goats unless treated and cured. Release the goats after 6 weeks if no incidence of disease is observed.

REPRODUCTIVE DISORDERS

Abortion

Cause: The cause of abortion in goats is often unknown, but may be due to fighting, shock, intestinal upset, or any form of stress. Some abortions can be prevented by keeping pregnant goats separate from the rest of the flock. Abortions due to infections may occur; the most common and serious is caused by *Brucella melitensis*. Brucellosis can be avoided by buying only screened breeding stock.

Solution: Consult a veterinarian when there is premature birth of a foetus whether with or without retained placenta. Apart from checking the foetus, the veterinarian will treat the affected doe with antibiotics at least until the afterbirth is voided. Failure to do this will often result in septicaemia and death of the goat. Do not handle aborted foetuses without rubber gloves.

CHAPTER 9

ECONOMICS OF DUAL-PURPOSE GOAT PRODUCTION

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INTRODUCTION

The DPG provides a mechanism for converting feed, labour, and other inputs into useful products for human consumption or sale. Profitability of the DPG enterprise depends on goat health, feeding practices, genetic potential, production role, and on the input and output prices associated with the venture. The economic elements of this conversion process are important in maintaining and improving the financial returns from the goat enterprise.

Inputs are usually obtained by investing scarce resources that must be efficiently used to ensure increased animal productivity. Whether the end product(s) are used for home consumption or sale, they must be produced at minimal cost while maintaining a desirable level of output. Farmers in western Kenya are highly diversified; therefore, the DPG will be one of their several enterprises. This being the case, farmers need to pay attention to both technical and economic factors in DPG production to ensure overall farm efficiency. Efficient production means using the least input to achieve maximum output. This includes using by-products and crop residues as feed, manure, or mulch. There is competition among farm production activities for available but minimal quantities of land, capital, and management skills. Appropriate use of these resources is required to ensure sustainability to those activities that are both technically and economically worthwhile and socially acceptable.

The techniques most commonly used to analyze enterprise profitability include partial budgeting, enterprise budgeting, and gross margin analysis. They are easy to use and can be constructed if the farmer has the relevant production and price data. This section illustrates how extensionists and farmers can use these concepts to assess economic profitability. The examples explain general guidelines for determining the economics of rearing

DPGs. They are not designed to illustrate the production condition of individual farmers. An accurate analysis for a particular flock must take into account the farm's unique production and environmental circumstances such as land size; number of animals owned; milk, meat, and forage yields; market input; and output prices. But individual farmers can compare their yields and price data with those given here and interpret the results of the analysis accordingly.

The model farm experiment at Maseno Station demonstrates several crops and forages that small-scale farmers can use to feed dual-purpose goats.

PARTIAL BUDGETING TECHNIQUES

The partial budget model is used to determine the economic effects that will occur if a small change is made in an enterprise. For example, a farmer might want to know the gains or losses that would occur when intercropping maize with a forage crop, such as pigeon peas, compared with maize grown alone. The partial budget procedure could project the change in income, or marginal net benefit, attributable to intercropping the pigeon peas with maize. This technique of analysis focuses on added costs and/or returns, as well as the reduced costs and/or returns of the proposed change. The net benefit or loss is the difference between the total added returns less the total added costs.

Partial budgeting can be used when these conditions are present:

- When small or minor changes occur in a production practice or technique.
- The change being analyzed does not involve complex interactions among several other inputs and/or outputs on the farm.
- The inputs are measurable and easy to value.
- Profitability is the main concern rather than issues of equity or income distribution.
- The fixed costs do not change.

The partial budget model is presented in table 9.1

Table 9.1. Partial budget model.

Debits (Ksh.)	Credits (Ksh.)
(a) Added costs:	(d) Added returns:
(b) Reduced returns:	(e) Reduced costs:
(c) Incremental loss = (a + b)	(f) Incremental gain = (d + e)
(g) Marginal net benefit (or loss): Ksh. (f - c)	
Benefit-cost (B:C) ratio = g/c	

More complex analytical techniques are required when a new technology is expected to have a major impact on other farm activities or when the farmer wishes to reorganize several or all of the farming activities.

Economics of Forage Production: Examples of Partial Budgeting

Table 9.2 is a partial budget to determine the profitability of intercropping pigeon peas with maize. In this example, the farmer previously grew maize in a monoculture. The pigeon peas are used as forage for the DPG while the maize is for human consumption.

The added costs and returns are calculated on a per hectare basis. On the debit side, the added costs of the maize + pigeon pea intercrop come from the pigeon pea seeds and the extra labour to plant the forage. There are no reduced returns. Therefore, the total additional costs are Ksh. 420.00.On the credit side, an additional 680 kg of maize and 11.6 mt of DM are realized due to intercropping. This additional DM can support 18.26 doe-kid units that yield 1,184 kg of milk and 263.1 kg of weaner liveweight. There are no reduced costs due to this practice. Therefore, the total additional gain is Ksh. 9116.90. The marginal net benefit is Ksh. 8,696.90 with a benefit-cost ratio of 20.71.

Based on this analysis and assuming a normal season, appropriate preservation of the forage so it is available throughout the year, and prevailing prices, it is recommended that the farmer intercrop maize with pigeon peas since it generates greater economic returns than growing maize in monoculture. Table 9.3 shows yield data from on-farm forage trials and table 9.4 shows the resulting economic analysis using partial budgeting.

The results indicate that when no fertilizer is applied, leguminous forages such as sesbania and pigeon peas yield greater economic returns than planting a pure stand of maize. When fertilizer is applied, intercropping maize with Sudan grass or pigeon peas (in that order) yields higher returns than growing maize alone.

Lastly, intercropping maize and forages with or without fertilizer is more economical than growing maize alone. On the basis of above economic analyses, it is recommended:

- Always intercrop maize with forages or dual-purpose crops.

Table 9.2. Partial budget analysis of intercropping pigeon peas with maize without fertilizer application versus planting maize in monoculture.

Debits		Credits	
Additional costs/ha	Ksh.	**Additional returns/ha**	Ksh.
Pigeon pea seeds[1] 6 kg @ Ksh. 10.00	60.00	Increased maize yield 680 kg @ Ksh. 3.25[1]	2,210.00
Extra labour[2] 20 pd @ Ksh. 18.00	360.00	Extra dry matter output of 11.6 mt which yields 1,184.04 kg milk for human consumption[4] @ Ksh. 4.00[5]	4,736.16
		Weaners 263.12 kg @ Ksh. 8.25[6]	2,170.74
Reduced cost/ha	none	**Reduced returns/ha**	none
Incremental costs/ha	420.00	Incremental benefit/ha	9,116.90
Marginal net benefit/ha	8,696.90	B:C ratio =	20.71

Source: Mukhebi and Onim, 1985.

Notes:
[1]Applied at 6 kg/ha @ Ksh 10.00/kg.
[2]SR-CRSP Economics Project data (1987).
[3]Pure stands of maize require 72 person days (pd) (where 1 pd = 8 hrs) per ha and mean wage rate in Kaimosi is Ksh. 18.00/pd. It is assumed that the pigeon pea-maize intercrop would require 20 pd of labour more than the pure-stand maize crop.
[4]The following assumptions are made in regard to dry matter yield and its effect:
(1)Only 2/3 of the DM produced is actually consumed by dual-purpose doe-kid units. Therefore, of the 11,600 kg extra DM produced, only 7,656 kg is consumed. The remaining 1/3 of the DM is waste.
(2)The kid is fed on milk that is supplemented with pigeon pea leaves. The DM intake per doe-kid unit per year is 393.75 kg/doe plus 25.50 kg/kid, totaling 419.25 kg of DM/doe kid unit/yr.
(3)The number of doe-kid units supported based on (1) and (2) is 18.26.
(4)Milk in excess of that needed by kids and available for human consumption is 64.35 kg/doe/yr (based on unpublished systems simulation data). There is an output of 14.3 kg weaner liveweight/doe/yr.
(5)Official Kenya Creameries Cooperative farm gate price, 1990.
(6)Annual mean price per kg liveweight in western Kenya livestock markets plus a 25% mark-up (Oyugi et al., 1986).

- Farmers who do not use fertilizer should intercrop maize with leguminous forages such as sesbania or pigeon peas.
- Maize-Sudan grass and pigeon pea intercrops should be used by farmers who apply fertilizer.

Economics of Kid-feeding Practices: Example of Partial Budgeting

Many farmers want to let the kid suckle all of the doe's milk to accelerate its weight gain, especially when a doe gives birth to twins. Research indicates that, depending on the kid-feeding strategy pursued, kids can grow well and milk can be provided for family consumption as well.

A partial budget can be used to choose between two pre-weaning kid practices (table 9.5). One allows the kid(s) to suckle all the doe's milk and the other allows the kid(s) to suckle half the doe's milk and receive sweet potato vines as a feed supplement. The decision is to choose the practice with the highest marginal net benefit.

Table 9.3. Dry maize grain and dry matter forage yields per hectare from on-farm trials.

		Yield	
Treatment	Crop mixture	Dry maize grain (mt)	Dry matter (mt)
Without fertilizer	Maize pure stand	1.7	10.1
	Maize-Sudan grass	0.7	17.2
	Maize-Sesbania	2.5	17.5
	Maize-Pigeon pea	3.3	21.7
With fertilizer	Maize pure stand	2.0	23.1
	Maize-Sudan grass	2.8	34.1
	Maize-Sesbania	1.6	30.2
	Maize-Pigeon pea	3.3	23.5

Source: Onim et al., 1984.

Table 9.4. Partial budget results of intercropping maize with forage crops with and without fertilizer application.

	Without fertilizer			With fertilizer		
Intercrop	Increm. benefit[1]	Increm. cost[1]	Marginal net benefit or cost	Increm. benefit	Increm. cost	Marginal net benefit or cost
	Ksh./ha					
Maize pure stand	Control					
Maize-Sudan grass	3,433	3,138	+295 (0.1)[2]	7,109	1,129	+5,980 (5.3)
Maize-Sesbania	5,521	428	+5,093 (11.9)	3,433	1,741	+1,692 (1.0)
Maize-Pigeon peas	7,215	420	+6,795 (16.2)	2,644	658	+1,986 (3.0)
Mean benefit or cost	5,390	1,329	+4,061 (3.1)	4,395	1,176	+3,219 (2.7)

Source: Mukhebi and Onim, 1985.
[1]Incremental benefit (or cost) as compared to pure-stand maize is used as the control practice.
[2]Figures in parenthesis are benefit:cost ratios computed as ratio of marginal net benefit or cost to total incremental cost.

This partial budget indicates that feeding the kid 1/2 of the mother's milk supplemented with sweet potato vines is economically superior to allowing the kid to suckle all the doe's milk.

Other Example of the Application of Partial Budgeting Kid-feeding Practices

Based on the data in table 9.6, an economic analysis was carried out to determine the costs and benefits associated with each preweaning kid feeding practice (table 9.7).

The results indicate that when a forage supplement is not available, feeding only the mother's milk generates the highest economic returns. Feeding one-half mother's milk provides the second best return. When forage supplement is available, feeding one-half of the mother's milk is the superior practice followed by feeding about half mother's milk and by feeding mother's milk only. This latter result is supported by the analysis in table 9.5.

Table 9.5. Partial budget analysis of weaning DPG kids on sweet potato vines and half the mother's milk versus total suckling.

Debits		Credits	
Additional costs/kid	Ksh.	**Additional returns/kid**	Ksh.
Forage cost[1]	24.00	Increased growth rate[3] @ 0.275 kg/mth x 4 month x Ksh. 8.25[4]	9.08
Extra labour, 4 pd @ Kshs 16.00[2]	64.00		
Reduced returns/kid	none	Reduced costs/kid Reduced kid milk intake, 44 kg[5] x Ksh. 6.67/kg[6]	290.15
Incremental cost/kid	88.00	Incremental benefit/kid	299.23
Marginal net benefit/ kid	211.23	B:C ratio 2.4	

[1]3,200 stem cuttings/ha @ Ksh. 160.00. A kid up to 1 year is counted as 0.15 livestock unit (LU). Based on a carrying capacity of 1 ha/LU, one kid for one year requires 0.15 ha; therefore, 0.15 ha x 160.00/ = Ksh. 24.00.

[2]Each doe-kid unit requires 26 pd of labor per year; 48.4% of that time is allocated to cut and carry activities. Therefore, (26/12) x 4 x 48 x Ksh. 16.00/pd = Ksh. 64.00.

[3]The average monthly weight gain of a kid is 1.1 kg for the kids getting only milk and 1.375 kg for the kids offered sweet potato vines. Thus, additional weight gain due to the use of limited milk and sweet potato vines is (1.375 kg less 1.1 kg) 0.275 kg/mo.

[4]Annual mean price/kg liveweight.

[5]Semenye et al., 1986a.

[6]Observed local price for fresh unprocessed milk in Hamisi division, 1990.

Table 9.6. Milk and forage consumption and growth performance of pre-weaning kids.

Item	Unit	Kids raised on milk only				Kids raised on milk & forage			
		Treatment				Treatment			
		1	2	3	4	1	2	3	4
Total milk consumed	kg	67	86	68	—	61	47	43	46
Milk cnsmd. per day	kg	1.18	0.56	0.37	—	0.56	0.53	0 26	0.24
Growth rate per day	gm	129	53	40	—	82	86	45	30
Age at 10 kg weaning weight	days	57	154	185	—	109	89	147	183
Kid Mortality	%	20	0	25	100	50	40	20	17
Kids in trial	No	5	4	4	2	6	5	5	5

Mukhebi and Sidahmed, 1985.

Notes: Treatment 1 = Feeding mother's and other does milk ad lib.
2 = Feeding mother's milk only.
3 = Feeding one-half mother's milk.
4 = Feeding about one-half mother's milk.

From these results it is recommended that:

- **Feeding kids milk ad lib should not be encouraged with or without forage supplementation.**
- **Feeding unweaned kids half mother's milk supplemented with forage, such as sweet potato vines, should be encouraged.**

Table 9.7 Partial budget analysis of practices feeding kids milk with and without forage, 1984.

Feeding practice	Feeding milk only			Feeding milk + forage		
	Total gain[1]	Total loss[1]	Net gain(+) loss(-)	Total gain	Total loss	Net gain(+) loss(-)
	Ksh per weaned kid					
Feeding milk ad lib	Control					
Feeding mother's milk only	328.77	108.03	+220.74 (2.0)[1]	56.27	43.47	13.1 (0.3)
Feeding half mother's milk	400.10	170.43	+229.67 (1.3)	244.42	90.96	+153.46 (1.7)
Feeding about 1/2 mother's milk				334.22	131.30	+202.92 (1.5)
Mean gain or loss	364.44	139.23	+225.21 (1.6)	211.74	88.58	123.16 (1.4)

Source: Mukhebi and Sidahmed, 1985.
[1]Incremental gain (or loss) as compared to feeding milk ad lib used as control.
[2]Figures in parenthesis are benefit:cost ratios computed as ratio of marginal net benefit (or cost) to total incremental cost.

ENTERPRISE BUDGETS AND GROSS MARGIN ANALYSIS

Enterprise budgeting summarizes the cost and return projections of an enterprise so they can be used in making management decisions. Examples of such decisions are (1) which system or technique to use in dual-purpose production? (2) which food/forage crop combinations to plant? (3) which is the most profitable investment? The enterprise budget, along with production records, can be used to monitor the efficiency of DPG production. The budgets also link production and financial aspects of the DPG enterprise so the farmer can evaluate both the production levels and the economic returns generated.

It is commonly accepted that farmers seek to produce "more output" or "as much as possible" or "attain a good standard of living." However, such general objectives are not sufficient to specify precise quantitative standards for comparing actual animal performance. Each farmer must establish performance standards or production goals as a reference for comparing actual performance of his flock. For example, the standards or goals can be based on past performance on the farm, on levels achieved by neighbour farmers who keep DPGs, or from on-farm experimental results. A comparison of an enterprise budget for average DPG management to one for above average management would show the differences in milk and meat yields, labour requirements, capital requirements, and expected returns. When actual perfomance does not meet the standards set by the farmer, remedial action can be taken. Livestock technical assistants and/or extension personnel should be able to help.

Gross margins (GM) are derived directly from enterprise budgets. However, the farmer is not only interested in total gross margins, which are the total returns less variable costs, but also in the gross margin per unit of scarce resources on the farm. Two examples of this are the gross margin per ha of land and the gross margin per person of labour day. In western Kenya, both land and capital are scarce resources. Labour is a constraint during peak-demand seasons such as weeding and harvesting. Therefore, farmers should estimate their gross margins per ha and per Ksh. invested in their DPG enterprises. Gross margins are used for comparative analysis between (1) different production activities, (2) different production techniques to produce the same thing, or (3) difference between farms in similar environments. If the gross margin of a farmer's DPG enterprise is Ksh. 1,000 per ha and that of his neighbour is Ksh. 2,200, then he should seek advice on the reasons for his poorer economic performance and take action for improvement.

Calculating Gross Margins

The gross margin of a DPG enterprise is the difference between gross income and total variable costs. Gross income is made up of all sales of animals and of products such as milk, manure, or skins. The products consumed at home are included in gross income to indicate the true economic value of the enterprise. The variable costs (VC) in this case could include forage production, purchased feed, maintaining improved pastures,

hired labour, payment for grazing, and husbandry costs such as medicines, veterinary services, cleaning materials, and breeding. Marketing costs such as transport, and selling are also variable costs which increase or decrease in proportion to the level of production.

The gross margin, for example, of an enterprise is calculated as follows:

(1) Determination of gross income
(a) Milk sales
(b) Weaner sales
(c) Cull sales
(d) Value of breeding stock
(e) Manure credit

Items (a) to (e) should include value of products consumed at home. The value of a breeder replacement and a manure credit should be included whether cash revenue is realized or not.

(2) Gross income = (a) + (b) + (c) + (d) + (e)

MINUS

(3) Cost of feed, husbandry, and marketing

(4) Cost of replacement animals bought or reared

(5) Variable cost = (3) + (4)

(6) Interest on variable cost = i * (3 + 4) where i denotes interest rate

(7) Total variable cost = (3) + (4) + (6)

GROSS MARGINS

(8) Gross margin per doe-kid unit = (2) - (7)

(9) Gross margin per Ksh. variable cost invested = (8)/(7)

(10) Gross margin per ha (1 ha will support 5 doe-kid units) = (8) × 5

DPG Management and Yield Levels: Examples of Gross Margins

Tables 9.8 and 9.9 show example calculations of gross margins for the DPG enterprise assuming average and above average rearing practices. Since these illustrations are calculated on the basis of doe-kid units, changes in value of flock inventory are not included.

With diligent management, DPG milk and meat yields can be improved without increased financial inputs. In some cases, the amount of capital spent on inputs such as veterinary drugs and other treatments may actually decline. The profit margin is increased by cutting costs while increasing offtake. This is demonstrated in the tables using data from SR-CRSP on-farm trials in western Kenya.

With improved management, the veterinary costs are 15% of total VC instead of the 21% used under average management. Due to lower mortality rates, stock replacement costs with improved management are 32% of total VC compared to 43% under average DPG management. As a result of better management, the gross margins are 80% per doe-kid unit, 114% per Ksh. VC, and 80% per ha higher than those under average management.

To maintain above average productivity, a farmer must follow the recommended feeding, breeding, health, and other management practices outlined in other chapters of this book.

VALUE OF GOAT PRODUCTS

Perhaps the DPG is more correctly a multi-purpose animal due to the many useful products it generates: milk, meat, manure, and skins. All of these products are used at the homestead or are sold on the market. It is impossible to overemphasize the importance of milk consumption by household members, especially by children and lactating mothers. In households with both DPGs and cows, it is recommended that the goat milk be consumed at home so the cow milk can be sold for cash. There is no seasonal milk price variability for fresh, unprocessed milk so farmers can sell it at any time during the year. The time of sale of animals depends on several factors:

(1) The value of the animal as a milk producer versus its value as a meat animal.

(2) The length of the animal's natural or productive life.

(3) The family's need for cash.

(4) The availability of a replacement animal.

When slaughter value is equal or nearly equal to production value, a farmer can keep a goat indefinitely depending on changing market prices.

Table 9.8. Annual costs and returns for one doe-kid unit under average management.

Output	Unit	Quantity	Value/cost
Milk yield[1] per doe/yr	kg	70.0	
Milk value @ Ksh. 6.67[2]	Ksh.		466.90
Weaner liveweight produced per doe/yr[3]	kg	9.6	
Value of weaner @ Ksh. 7.89[4] per kg.	Ksh.		75.74
Weight of culls[5]/doe/yr.	kg	7.65	
Value of culls @ Ksh. 7.89	Ksh.		60.36
Total value of output	Ksh.		603.00
Variable costs[6]			
Drenching	Ksh.		26.00
Vaccinations	Ksh.		1.50
Antibiotics	Ksh.		15.00
Minerals (salt)	Ksh.		46.00
Doe replacement[7]	Ksh.		88.37
Ropes	Ksh.		18.00
Interest on variable costs @5%	Ksh.		9.74
			204.61
Gross margin/doe-kid unit	Ksh.		398.39
Gross margin/unit of variable cost	Ksh.		1.95
Gross margin/ha	Ksh.		1991.95

[1]Mean milk yield from study area in western Kenya, nutrition and management records.
[2]Mean unprocessed milk price in western Kenya, 1990.
[3]Total weight of kids weaned per doe over 12 months period* weaning weight price/kg liveweight.
[4]Annual mean price/kg liveweight in western Kenyan livestock markets, plus a 25% mark-up. SR-CRSP Economics Project, Marketing Study, 1986.
[5]Weight of does culled plus weight of does that die 1/(cull rate + doe mortality rate) = productive life; therefore, mature doe liveweight divided by productive life less (cull liveweight per year * doe mortality rate) * by price/kilogram liveweight.
[6]Annual basis computed from SR-CRSP, Nutrition and Management Project Records (1988).
[7]Cull rate plus doe mortality * price/kilogram.

Table 9.9 Annual costs and returns per doe-kid unit with improved DPG management.

Output	Unit	Quantity	Value cost
Milk yield/doe/yr	kg	105.0	
Milk value @ Ksh. 6.67	Ksh.		700.35
Weaner liveweight per doe	kg	16.2	
Value of weaners @ Ksh. 7.89	Ksh.		127.82
Cull liveweight/doe/year	kg	7.46	
Value of culls @ Ksh. 7.89	Ksh.		58.86
Total value of output	Ksh.		887.03
Variable costs			
Drenching	Ksh.		19.00
Vaccination	Ksh.		2.00
Antibiotics	Ksh.		5.00
Mineral (salt)	Ksh.		46.00
Doe replacement	Ksh.		55.23
Ropes	Ksh.		36.00
Interest on VC @ 5%	Ksh.		8.16
			171.39
Gross margin/doe kid unit	Ksh.		715.64
Gross margin/VC	Ksh.		4.18
Gross margin/ha	Ksh.		3,578.20

Hay Baling Box

The plan for constructing a hay baling box is shown in figure 9.1. The materials required are:

Timber: 23 cm x 2.5 cm x 6 running metres

31 cm x 2.5 cm x 2 running metres

Nails: 1.2 kg of 2.5 inch size

Metal band: 1 cm wide x 11 running metres

Labour: Either own or hired carpenter

The internal dimensions of the wooden box are 86 cm x 57 cm x 44 cm. It is made of cypress timber; other qualities of timber can be used but cypress is one of the cheapest. The box makes a bale weighing 20 kg, the average size of a grass hay bale. The useful life of the box is estimated to be 10 years with minimum maintenance costs. The material costs are shown in table 9.10.

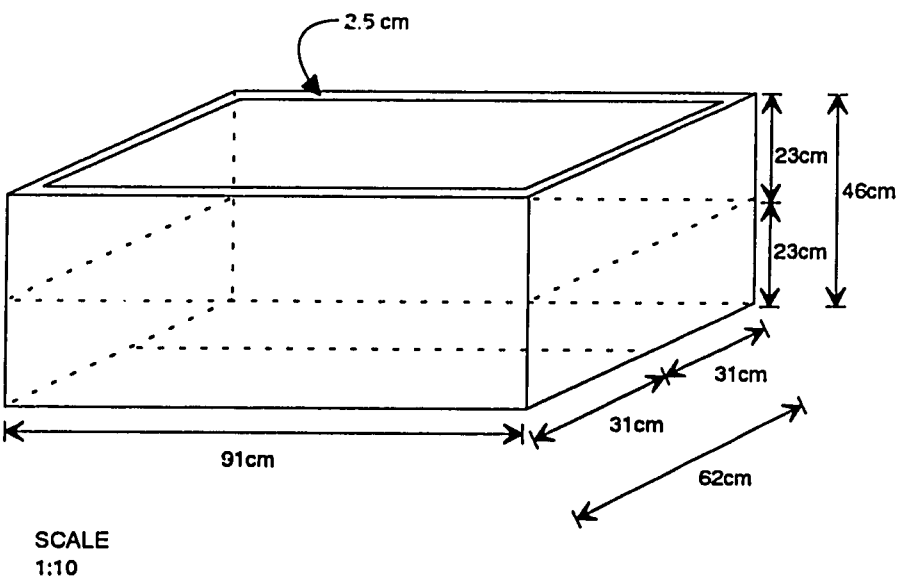


Figure 9.1. Plan for a hay baling box.

Table 9.10. Material costs for a hay baling box.

Item	Unit	Price per unit (Ksh.)[1]	Total Quantity	Total Cost (Ksh.)
Timber (size 23 cm x 2.5 cm)	m	8.00	20.00	160.00
Timber (size 31 cm x 2.5 cm)	m	12.00	6.00	72.00
Nails (size 2.5")	kg	23.40	1.17	27.38
Metal band (1 cm wide)	m	11.00	10.97	109.97
Labour charge[2]	—	—	—	18.29
Total material and labour cost	—	—	—	387.64

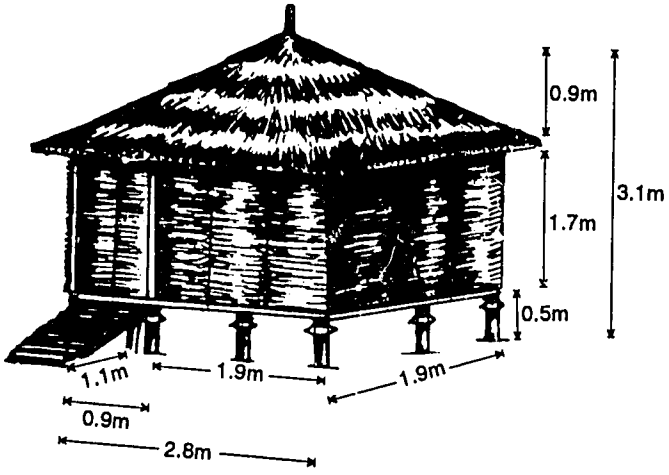
[1]Prices quoted from local hardware shops.
[2]Labour charge for making the box was computed by calculating the arithmetic mean of the charges quoted by 10 carpenters in Luanda and Maseno, Kenya, when all construction materials are provided.

Houses for Goats

Table 9.11. Material and labour cost for a grass-thatched goat house. (See figure 9.2).

Inputs	Unit	Price per unit[1] (Ksh.)	Total quantity	Total Cost (Ksh.)
Materials				
Thatching grass	bundle	4.00	30 bundles	120.00
Logs and droppers	—	—	15 logs + 10 droppers	187.00
Weaving twine	bundle	1.00	72 bundles	72.00
Papyrus strings (5 cm x 5 cm)	bundle	50.00	1 bundle	50.00
Cypress timber	ft	2.40	48.5 ft	116.40
Cypress timber (2.5 cm x 5cm)	ft	1.45	15 ft	21.75
Wire nails (4", 5" & 6")	ft	23.40	4 kg	93.60
Total material cost				660.75
Foundation measurement & digging of pole holes	pd	18.00	0.75	13.50
Cutting of thatching grass	pd	18.00	2.25	40.50
Grass, logs and droppers transportation	pd	18.00	4.0	72.00
Cutting the wall post and erecting the walls	pd	18.00	3.0	54.00
Constructing and thatching the roof	pd	18.00	2.0	36.00
Cutting more thatching grass and twigs (for weaving)	pd	18.00	8.0	144.00
Thatching of the roof grass	pd	18.00	2.75	49.50
Chopping and splitting of logs	pd	18.00	2.0	36.00
Weaving of the walls (with twigs)	pd	18.00	7.0	126.00
Total labour cost				571.50
Total input cost				1,232.25

[1]April 1990 prices.



Scale
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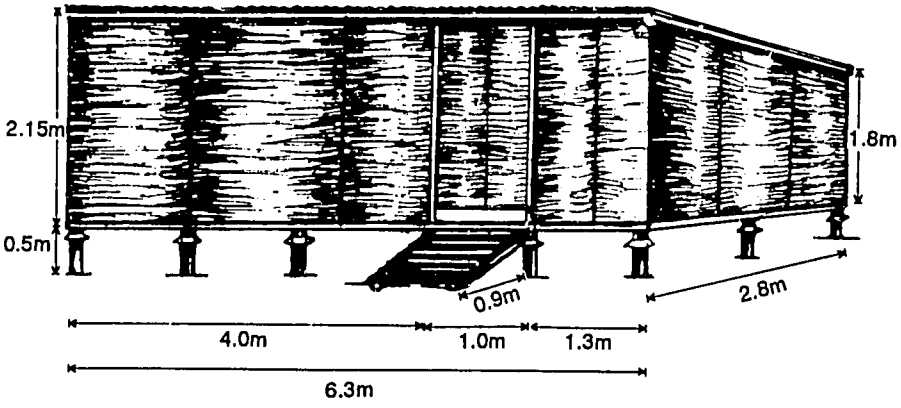
Grass Thatched



Iron Roofed

Figure 9.2. Plans for goat houses.

Table 9.12. Material and labour costs for an iron roofed goat house (See figure 9.2).

Inputs	Unit	Price per unit[1]	Total quantity	Total cost (Ksh.)
Cedar posts	ft	3.25	141 R.ft	458.25
Cypress timber (2" x 2")	ft	2.40	303.3 R.ft	727.92
Cypress timber (3" x 2")	ft	3.20	195.6 R ft	625.92
Cypress timber (4" x 2")	ft	4.55	117 R. ft	532.35
Wire nails	kg	23.40	6 kg	140.40
Roofing nails	kg	36.00	2 kg	72.00
Corrugated iron sheets gauge 30 @ 3 m	m	69.00	8 (24 R.m)	1,656.00
Weaving twigs	bundle	1.00	157 bundles	157.00
Total material cost				4,369.84
Foundation measurement & digging of holes	pd	18.00	2.0	36.00
Erection of the walls	pd	18.00	0.5	9.00
Roof construction	pd	18.00	3.0	54.00
Construction of raised wooden floor	pd	18.00	3.0	54.00
Cutting of twigs & taking to goat barn	pd	18.00	8.0	144.00
Weaving of the barn wall	pd	18.00	10.75	193.50
Weaving of the barn door	pd	18.00	0.06	1.08
Construction of raised wooden floor	pd	18.00	1.0	18.00
Total labour input				509.58
Total input cost				4,879.42

[1]April 1990 prices

CHAPTER 10

FARMERS' VIEWS ABOUT THE DUAL-PURPOSE GOAT TECHNOLOGY PACKAGES

Adiel N. Mbabu and Michael F. Nolan

The SR-CRSP recognized the diversity of the region by selecting a sample of farmers from both the Luo and Luhya communities of western Kenya to develop and to test its dual-purpose goat technology packages.

The SR-CRSP program Kenya began in 1980. By 1988, some techpacks were ready for expanded testing. This section reports on how the new practices based on SR-CRSP research have been accepted by farmers. The data were collected from two of the old clusters, 21 households in Hamisi and 14 in Masumbi, and from three new clusters, 34 households in Muhanda, 27 in Rabuor, and 10 in Lela (table 10.1).

TESTING THE TECHNOLOGY PACKAGES

The SR-CRSP techpacks for dual-purpose goat enterprises are based on a four-way cross goat composed of equal parts of two exotic breeds, Toggenburg and Anglo-Nubian, and two indigenous breeds, East African and Galla. The resulting dual-purpose breed is expected to have good milk production with fast growth under the contrasting conditions of the semi-arid lowlands and sub-humid highlands found in western Kenya. Because the breeding programme is long term, relatively few foundation four-way crosses were available to farmers. Therefore, the majority of the dual-purpose type goats tested in on-farm trials are the two-way crosses which lead to the four-way composites. Goats have been placed with farmers in the five villages (table 10.2).

Each participating farmer in the old villages received one doe to start a DPG flock, so Masumbi's mean household flock size of 2.6 DPGs and Hamisi's of 3.0 indicates the increase in numbers of goats the farmers have maintained. Participants in the new villages each received two does in 1988.

Table 10.1. Characteristics of five of the SR-CRSP sample villages.

Village	Ethnicity	Annual ave. no. participants	Old/New[1]	Land size(ha)[2]
Hamisi	Luhya	21	Old	1.0
Masumbi	Luo	14	Old	2.2
Muhanda	Luhya	34	New	1.4
Rabuor	Luhya/Luo	27	New	1.4
Lela	Luo	10	New	1.9

[1]The old villages were selected in 1982 and the new villages in 1988.
[2]Includes arable land and land occupied by homesteads and prominent outcrops of rocks.

Table 10.2. Distribution of dual-purpose test animals by villages and households (1989).

	Dual-purpose goats	
Village	No. per village	Mean no. per household
Hamisi	65	3.0
Masumbi	37	2.6
Muhanda	85	2.5
Rabuor	78	2.9
Lela	22	2.2
Total/Mean	287	2.6

Table 10.2 indicates herd sizes have increased by an average of 30% through subsequent kiddings.

Forage Package

The SR-CRSP Feed Resources (FR) Group designed a DPG forage package expected to fit into existing farming systems without causing adverse effects. Since most farmers in the research area have very little land, the recommendation is to feed DPGs as many crop residues and by-products as possible. Farmers also are encouraged to grow leucaena, sesbania, napier grass, and sweet potato vines as feed supplements. Project personnel provide both planting materials and technical support to farmers for these supplemental species (table 10.3).

Muhanda has the highest proportion of participating farmers growing the recommended forages but Hamisi is not far behind. The percentages are lowest in Lela and Masumbi. The only conspicuous difference in the number of forage trees grown per household is between Muhanda, the cluster with the most, and Masumbi, the least. Lela has the greatest area under napier grass and sweet potato vines. Hamisi and Muhanda both plant a respectable area of these two forages, and Masumbi devotes the least.

In summary, the Luhya villages of Muhanda and Hamisi have the highest percentage of participants growing all the recommended forages plus the largest average number of forage trees and a substantial area under napier and sweet potatoes. The old Luo lowland village of Masumbi consistently lags behind the other sites in all of these measures. In Lela, the new Luo lowland village, the relatively low proportion of participating farmers growing the recommended forages is offset by the number of forage trees and the area in napier grass and sweet potatoes. However, these farmers do not normally feed these forages to DPGs.

It was anticipated that the participating farmers might not take good care of the forages, once planted, as they were required to grow them only to signal their collaboration in the programme. Records were kept on whether or not participants kept their forages free of weeds (table 10.4) and fenced their plantings to protect them from livestock (table 10.5).

Once again, Muhanda and Hamisi had the highest percentages of participants who regularly weed their forages. The percentages were lowest in Lela and Masumbi. Only Muhanda and Hamisi have significant numbers of farmers that fenced their forages. By contrast, nobody does so in Masumbi, probably due to less intensive agriculture.

Table 10.3: Supplemental forages grown by participating households.

	Within participating households							
	Leucaena		Sesbania		Napier grass		Sweet potato vines	
Village	Trees (number)	Households %	Trees (number)	Households %	(sq m)	Households %	(sq m)	Households %
Hamisi	22.2	81.0	56.4	74.0	195.3	98.0	231.6	94.0
Masumbi	18.4	37.0	27.8	25.0	54.6	39.0	74.9	60.0
Muhanda	51.4	98.0	55.9	99.0	238.4	99.6	153.2	86.0
Rabuor	22.8	90.0	49.4	28.0	198.3	97.0	81.3	89.0
Lela	27.7	84.0	46.9	43.0	380.9	76.0	685.8	77.0

Table 10.4. Participants adoption of the forage weeding practice.

	Participants weeding forages		
Cluster	Leucaena %	Sesbania %	Napier grass %
Hamisi	72.7	68.0	69.9
Masumbi	28.3	23.7	7.5
Muhanda	98.4	96.8	99.2
Rabuor	52.7	57.4	46.9
Lela	13.2	15.6	8.8

Table 10.5. Participants adoption of the forage-fencing practices.

	Participants fencing forages			
Cluster	Leucaena %	Sesbania %	SPV %	Napier grass %
Hamisi	84.3	78.6	72.7	69.1
Masumbi	0.0	0.0	0.0	0.0
Muhanda	99.9	100.0	100.0	99.0
Rabuor	0.0	0.0	0.0	0.0
Lela	1.3	0.0	11.6	0.0

Nutrition and Management Package

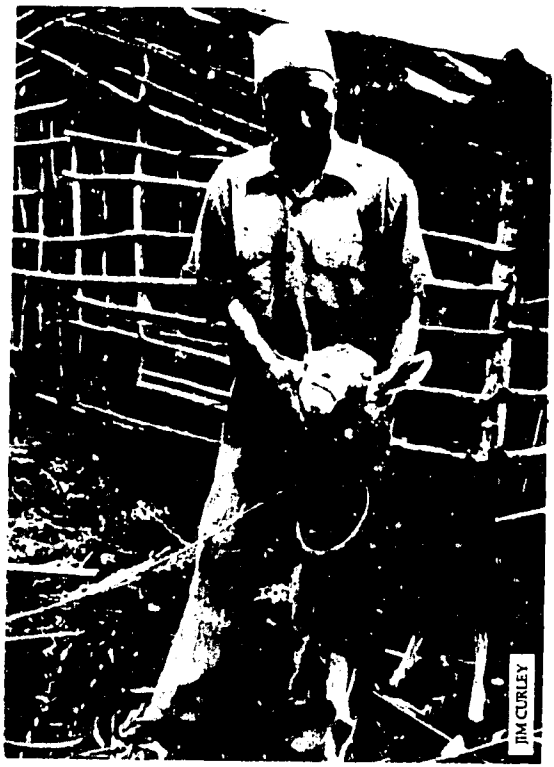
Ordinarily, livestock in western Kenya are either grazed in open pastures or tethered in fallow fields. The introduction of cultivated forages is a major contribution of the SR-CRSP to livestock management in the region. An important recommendation in DPG-rearing is to tether the goats and to cut and carry the cultivated forage to them. Participant management strategies were monitored to assess their adoption of this recommendation (table 10.6).

The recommended cut-and-carry strategy is practiced by all participants in Muhanda and by less than half in Lela. Recalling that Muhanda has the participants who are growing the various types and the greatest amounts of forages, it is understandable why cut and carry should be so popular with these farmers. What is not clear is why Lela has so few participants doing cut and carry when large amounts of forage are grown there. Nearly three-fourths of Lela farmers prefer to graze their DPGs, saving their cultivated forage for marketing in the neighbourhood. Equally intriguing is the high proportion of Masumbi participants who cut and carry despite the minimal amount of forage raised there. What appears to be cut and carry in Masumbi is in fact a tendency to feed cuttings from fallow-land shrubbery to the tethered DPG.

Not surprising, Muhanda, Hamisi, and, to some extent, Rabuor, the villages most enthusiastic about growing forages, are the ones following the cut and carry recommendation.

Table 10.6. Participants adoption of the cut and carry and open grazing practices.

Cluster	Participant adoption	
	Cut and carry %	Open grazing %
Hamisi	69.6	10.1
Masumbi	53.8	15.0
Muhanda	100.0	0.0
Rabuor	69.3	24.3
Lela	45.6	73.3



A farmer from Rabuor village with his favourite goat.

CONCLUSION

The SR-CRSP set out to work with dual-purpose goats in the densely populated medium- and high-potential agricultural areas of western Kenya, thus assisting farmers who are under increasing land pressure from the rapidly increasing population. The programme envisaged that as farm sizes got smaller these parcels would become too small for a dairy cow but could support DPGs. Even though it was anticipated that the DPGs would depend largely on available crop residues, it was recognized that substantial forage supplements would be required to maintain the herd in good health and to sustain lactation. The techpacks therefore embody appropriate recommendations for DPG production.

Socioeconomic monitoring revealed the techpacks are most enthusiastically adopted to date by farmers in the relatively higher elevation, higher rainfall, and more densely populated Luhya villages and least by those in the relatively lower elevation, lower rainfall, and less densely populated Luo villages. The Luhya villages not only have a high percentage of participants growing all the recommended forages but also the greatest average amount of cultivated forages. The Luo villages lag behind on both counts. Similarly, the Luhya villages consistently feed these forages to their DPGs. By contrast, Luo often graze their goats or feed them cuttings from wild shrubs. To some extent the ecological variation in western Kenya overlaps with ethnic identities.

These findings suggest that the SR-CRSP techpacks are attractive to the Luhya farmers in the highlands where higher rainfall and acute population pressure favour intensified agriculture. In the lowlands where the Luo live, the tendency is toward extensive farming as the average farm size is twice as large as in the highlands while the rainfall is only half as much. To respond to the needs of both Luo and Luhya it appears that a dual technological package for the DPG is necessary.

Though the SR-CRSP is committed to the densely populated and high-medium potential agricultural areas and to adopting the on-farm research methodology to be more responsive to the needs of the farmers, the programme has unwittingly incorporated a systematic bias favouring the high elevation zones where intensified agriculture is prevalent. Had this bias been recognized from the beginning, a dual set of technology recommendations could have been developed to meet the needs of both communities.

This leads to urging that all scientists working in development should always identify the assumptions or values of their research because these influence the character of the resulting technology, rendering it attractive to some social categories but not to others.

ANNEX

MEMORANDUM OF UNDERSTANDING BETWEEN SR-CRSP AND COLLABORATING FARMERS

1. Partners

First and foremost farmers must collaborate with SR-CRSP and the Ministry of Livestock Development staff in all matters pertaining to DPG husbandry, management and health.

2. Handouts to the Farmers (Drugs, Planting Material, etc.)

The new clusters established in 1988 are intended to be part of a farmer-managed trial of the DPGs. It was agreed, therefore, that the handout of free supplies, equipment, and drugs that were given to farmers in the previous phase of research will be eliminated. The only exception to this is that Feed Resources will supply seedlings to farmers to help them establish a forage nursery.

Drugs

The major role of the feed resources and nutrition and management field assistants is to advise the farmers concerning the recommendations in the "techpack" for managing the DPGs. Drugs will not be supplied free to the farmers nor will the SR-CRSP staff treat the animals for illnesses. The NM field assistants will carry a supply of non-prescription drugs (e.g., for drenching the animals as per recommendation) but these drugs must be purchased at a fair local price by the farmers. Prescription drugs (such as injections, antibiotics) must be prescribed by veterinary officers.

Though the SR-CRSP encourages the use of the available veterinary services, farmers may use local herbal medicines to treat their DPGs if they wish. The field assistants should be informed of this treatment, however,

and they should keep a record of the disease symptoms, the type of herbal medicines used, and the outcome of the treatment.

3. DPG Ownership

Does placed on farms in the clusters are jointly owned by the farmer and SR-CRSP. To obtain full ownership of the does, farmers must be willing to co-operate with project staff and take care of the DPGs according to the recommendations contained in the "techpacks". This includes attendance at group meetings, willingness to allow SR-CRSP personnel to visit the farm and take measurements and do periodic interviews, and adherence to the health, nutrition management, and feed resource recommendations of the SR-CRSP. If farmers follow these procedures, they will obtain full ownership of the does after two successful kiddings or in September 1990, whichever comes first.

If farmers are unwilling to follow the techpack recommendations, the DPGs will be withdrawn by the project and the farmer will not be paid any compensation for the upkeep of the goats. A DPG buck placed on farm becomes the farmer's property after 10 successful services (conceptions) or in September 1990, whichever comes first.

The first batch of DPGs will arrive in the Clusters in September 1988. Each farmer will receive one pregnant doe and one female weaner.

4. Mating service

Owners of the DPG bucks will be expected to make them available for breeding DPG does owned by other farmers in the cluster. Buck owners should be compensated for mating services according to existing local practices. DPG bucks may be used to service local does as well.

5. Utilization and disposal

All male kids and any female kids born after the first crop become the property of the farmer one year after the initial arrival of the DPG does (e.g., if the does arrive September 1988, male kids and females become the proper-

ty of the farmer in September 1989). After this date, the farmer may dispose of the kids as he/she wishes, but should report the disposal to the SR-CRSP.

All milk offtake from the DPG does may be utilized according to the farmers' wishes.

Course outline for collaborating farmers

1. **Introduction of participants**
   a. SR-CRSP staff
   b. Farmers

2. **Introductory remarks on**
   a. Maseno station
   b. SR-CRSP (Morocco, Brazil, Indonesia, and Peru)
   c. Farming systems research
      (1) Descriptive
      (2) Diagnostic
      (3) Researcher-managed and -executed
      (4) Testing farmer-managed and -executed
      (5) Extension

3. **Nutrition and management techpacks**
   a. Nursing strategy (problem starvation)
      (1) Doe/kid bond
      (2) Milk letdown
      (3) Assist kids to suckle
      (4) Colostrum
      (5) Milking offtake schedule
      (6) Stress avoidance (draught, cold, or heat)
   b. Milk and milk hygiene
      (1) Conducive environment (uniformity, gentleness, quietness, and skill)
      (2) Prepare your doe (supplementary feed)
      (3) Correct milking procedure (discard first squirt)
      (4) Check for mastitis (lumpy or with blood clots)
      (5) Stripping is essential
      (6) Dry-off when your doe is 3 months in-kid
      (7) Pasteurize milk by boiling
   c. Sweet potato vines as a milk replacer for kids
   d. Partitioning of feed energy
      (1) Maintenance
      (2) Production (growth, lactation, and pregnancy)
      (3) Supplementary feeding
   e. Crop residue
      (1) For maintenance alone (maize stover, sorghum, bean haulms)
      (2) Treatment necessary
      (3) Peelings of mangoes, bananas, etc. (appetite)
   f. Weaning
      (1) Gradual weaning
      (2) Monitor intake of a new ration
      (3) Wean when 10 kg or more

g. Breeding strategy
   (1) Breed doelings when 25 kg or more and in good body condition
   (2) Flushing at least 3 weeks before mating
   (3) Use bucks with high libido
   (4) Breed/mate second day of heat
   (5) Ensure tethering does not impede courtship or mating
h. Pregnancy diagnosis (indicators)
   (1) Estrous cycle 17-21 days
   (2) Change of shape and size
   (3) Gestation period 150 days plus or minus 5 days
i. Feedstuffs presentation
   (1) Hang your cut and carry feedstuff
   (2) Give least palatable feed first
   (3) Treat to enhance palatability and intake
j. Tethering
   (1) Use rope 4 m long
   (2) Change tethering station at least four times a day
   (3) Tethering pattern (other livestock, sun, and herbage)
   (4) Avoid overlap of tethering areas
   (5) Avoid entanglement and accidents due to tethering
k. Goat house
   (1) Ventilated, draught-free, dry floor, predator-and theft-proof
   (2) Not crowded
   (3) Plan available for a multipurpose house

4. Preventive medicine
   a. Identification of a sick goat
   b. Ectoparasite control (ticks, fleas, lice, etc.)
   c. Endoparasite control
   d. Injuries/lameness
   e. Poisoning
   f. Unprofessional practice

5. Feed resources
   a. Production
      (1) Planting material
      (2) Planting preparations
      (3) Nurseries
      (4) When and how to harvest
      (5) Dual-purpose crops
   b. Preservation
      (1) Hay
      (2) Silage

6. Testing phase: Monitoring methodology
   (1) Tagging
   (2) Weighing
   (3) Sampling of forage, faeces, and blood
   (4) Feedstuff and water intake
   (5) Recording of milk yields and treatments
   (6) Group meetings
   (7) Visitors
   (8) Memorandum of understanding

REFERENCES

Amir, P. and H. C. Knipscheer. 1989. Conducting on-farm animal research: Procedures and economic analysis. Winrock International Institute for Agricultural Development, Morrilton, Ark., USA, and International Development Research Centre, Ottawa, Canada.

Angwenyi, G. N. 1984. Effects of crossbreeding East Africa, Galla and Boer goats on body size, growth rate and kid survivability in Kenya. M.Sc. thesis, Texas A&M University, College Station, Texas, USA.

Anyang' Nyong'o, P. 1981. The development of a middle peasantry in Nyanza. Review of African Political Economy, # 20.

Boor, K. J., D. L. Brown, and H. A. Fitzhugh. 1984. Consumer acceptance of goat milk products in western Kenya. Working Document No. 41. Winrock International, Morrilton, Ark., USA.

Brown, D., M. W. and M. Nderito. 1983. Performance and milk requirements of Toggenburg x East African kids weaned at two months of age or ten kilograms body weight. Proceedings, 2nd Annual Small Ruminant-CRSP Workshop.

Cartwright, T. C. 1984. A strategy for breeding dual purpose goats for Kenya. Proceedings, 3rd Small Ruminant-CRSP Workshop, Nairobi, Kenya.

Devendra, C. and M. Burns. 1983. Goat production in the tropics. Commonwealth Agricultural Bureaux, Farmham Royal, England.

Dupre, C. E. 1968. The Luo of Kenya: An annotated bibliography. Institute for Cross-Cultural Research, Operations & Policy Research, Washington, D.C., USA.

Fearn, H. 1961. An African economy: A study of the economic development of the Nyanza Province of Kenya. Oxford University Press, London, England.

Hancock, J. 1953. Grazing behaviour of cattle. Animal Breed Abstracts 21:1.

International Service for National Agricultural Research. 1987. Working to Strengthen National Agricultural Research Systems: ISNAR and its Strategy. The Hague, Netherlands.

Jaetozold R., and H. Schmidt. 1982. Farm Management Handbook of Kenya V. II, Natural Conditions and Farm Management Information, Part A. West Kenya, Nyanza and Western Provinces. Kenya Ministry of Agriculture and the German Agricultural Team, Nairobi, Kenya.

Karimi, S. K., P. P. Semenye, A. E. Sidahmed, H. A. Fitzhugh, and J. F. M. Onim. 1985. Feed consumption and selection by dual-purpose goats and local goats from Masumbi cluster in Siaya District, western Kenya. Proceedings of the 4th Small Runinant-CRSP Workshop.

Kenya National Archives (KNA). 1951. Agriculture Department, Agriculture programme for Nyanza Province. AGR.KSM/1/498, 1947-51, Nairobi, Kenya.

Kenya National Archives (KNA). 1954. Agriculture Department: Plan to intensify the developent of African agriculture. AGR.KSM/1/525, 1951-54, Nairobi, Kenya.

Kenya National Archives (KNA). 1958. Agriculture Ordinance Nyanza Province, Agricultural committee meeting. DC/KMGA/1/2/9 1956-58, Nairobi, Kenya.

Kenya, Republic of. 1979. Population census, Volume II analytical report. Central Bureau of Statistics, Ministry of Finance and Planning, Nairobi, Kenya.

Konandreas, P. A. and F. M. Anderson. 1982. Cattle herd dynamics: an integer and stochastic model for evaluating production alternatives. International Livestock Centre for Africa, Addis Ababa, Ethiopia.

Leys, Colin. 1975. Underdevelopment in Kenya: The political economy of neo-colonialism. University of California Press, Berkeley, Calif., USA.

Ministry of Agriculture, Fisheries and Food. 1975. Energy allowance and feeding systems for ruminants. Tech. Bull. No. 33. Her Majesty's Stationery Office, London, England.

Mukhebi, A. W. and J. F. M. Onim. 1985. Economics of intercropping forage crops with maize in Kaimosi, Western Kenya. Proceedings of the 4th Small Ruminant-CRSP Workshop.

Mukhebi, A. W. and A. E. Sidahmed. 1985. Economics of pre-weaning kid feeding practices at Maseno Research Station, Western Kenya. Proceedings of the 4th Small Ruminant-CRSP Workshop.

Mwandotto, B. A. J., C. O. Ahuya, F. Ruvuna, and J. F. Taylor. 1990. Milk yield potential of the Kenya Dual-purpose Goat (DPG). Proceedings of the 8th Small Ruminant-CRSP Workshop, Nairobi, Kenya.

National Dairy Research Institute (NDRI). 1978. Management practices for goats. Publication No. 147, Nairobi, Kenya.

Nicoletti, P. 1987. Goat diseases and human health. Proceedings of the IV International Conference on Goats, Brasilia, Brazil.

Nour, A. M. 1987. Rice straw and rice hulls in feeding ruminants in Egypt. In: Utilization of agricultural by-products as livestock feeds in Africa. Proceedings of a workshop held at Ryall's Hotel, Blantyre, Malawi, September 1986. African Research Network for Agricultural Byproducts.

Onim, J. F. M., K. Otieno, and H. A. Fitzhugh. 1986. Recommendation domains for dual purpose goat research in Nyanza and Western provinces of Kenya. Proceedings of the 3rd Small Ruminant-CRSP Workshop, Nairobi, Kenya.

Onim, J. F. M., R. Hart, K. Otieno, and H. A. Fitzhugh, 1984. Potentials of intercropping forage with maize in western Kenya. (Unpublished).

Oyugi, L. A., A. W. Mukhebi, H. K. Ogada, and H. Knipscheer. 1986. Demand and supply quantities of milk and small ruminants in selected markets in Western Kenya. Proceedings of the 5th Small Runinant-CRSP Workshop.

Reynolds, J. E., A. N. Mbabu, and M. F. Nolan. 1984. Extension services and the smallholder: A report of preliminary findings. Proceedings of the 3rd Small Runinant-CRSP Workshop, Nairobi, Kenya.

Robinet, A. H. 1974. The Maradi goat and goat breeding in Nigeria. ABA 42, 1646.

Ruvuna, F., T. C. Cartwright, M. A. Okeyo, H. D. Blackburn, and S. Chema. 1986. Characterization of indigenous goats of Kenya for dual-purpose potential. 1. Pre and postweaning growth and 2. Weights and postpartum interval. Proceedings of the IV International Conference on Goats, Brasilia, Brazil. (abstract).

Said, A. N. 1981. Sodium hydroxide and ammonia treated maize stover as a roughage supplement to sheep and beef feedlot cattle. Proceedings of Symposium of Workshop on Utilization of Low Quality Roughage in Africa. Tanzania.

Sands, M. W., H. A. Fitzhugh, R. E. McDowell, and S. Chema. 1982. Mixed crop-animal systems on small farms in western Kenya. Small Ruminant Collaborative Research Support Program. Technical Report series Number 17.

Scheijtman, A. 1984. The peasant economy: Internal logic, articulation and persistence In: C. K. Wilber, (ed.). The political economy of development and underdevelopment. Random House, New York, N.Y., USA. pp. 274-298.

Semenye, P. P. 1980. A study of Maasai herds on Elangata Was Group Ranch in Kajiado District, Kenya. ILCA/Kenya Working Document No. 14. International Livestock Centre for Africa, Addis Ababa, Ethiopia.

Semenye, P. P., L. Musalia, and H. A. Fitzhugh. 1986a. Performance of kids and does under different milking and creep feeding systems. Proceedings of the 5th Small Ruminant-CRSP Workshop.

Semenye, P. P., L. M. Musalia, and H. A. Fitzhugh. 1986b. Preference ranking of forages by goats. Proceedings of the 5th Small Ruminant-CRSP Workshop.

Semenye, P. P., L. Musalia, and H. A. Fitzhugh. 1986c. Dual-purpose goat nutrition and management on-station and on-farm in western Kenya. Proceedings of the 5th Small Ruminant-CRSP Workshop.

Sidahmed, A. E., J. F. M. Onim, A. W. Mukhebi, R. S. Shavulimo, A. J. DeBoer, and H. A. Fitzhugh. 1985. On-farm trials with dual-purpose goats on small farms in Western Kenya. Proceedings of the Workshop on Research Methodology for Livestock On-farm Trials, Aleppo, Syria. pp. 101-132.

Skea, I. W. 1989. A comparison between the Deguin and the Borana Galla goats over four years, with reference to fertility, fecundity and kid growth rates and milk production during the first 42 days. Proceedings of the 7th Small Ruminant-CRSP Scientific Workshop, Nairobi, Kenya.

Tripp, R., and J. Woolley. 1989. The planning stage of on-farm research: Identifying factors for experimentation. International Maize and Wheat Improvement Center, Mexico, D. F., Mexico, and International Center for Tropical Agriculture, Cali, Colombia.

Wolff, R. D. 1974. Britain and Kenya, 1870 - 1930. The Economics of colonialism. Transafrica Publishers, Ltd., Nairobi, Kenya.