PROCEEDINGS OF THE FIFTH SMALL RUMINANT CRSP WORKSHOP

KENYA 1986

SMALL RUMINANT
COLLABORATIVE RESEARCH
SUPPORT PROGRAM
(SR-CRSP)

P.O. Box 58137, Nairobi
Telephone 592231 Ext 5

PROCEEDINGS
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KENYA MINISTRY OF AGRICULTURE AND LIVESTOCK DEVELOPMENT

SMALL RUMINANT COLLABORATIVE RESEARCH SUPPORT PROGRAMME

P.O. BOX 58137, NAIROBI
P.O. BOX 252, MASENO

Edited by the SR CRSP Resident Scientists in Kenya
and the Investigators, Breeding/Systems Projects,
Texas A&M University, College Station, Texas

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OPENING ADDRESS BY THE HON. JULIUS MUTHAMIA, M.P. FOR
MERU SOUTH WEST, ASSISTANT MINISTER FOR
AGRICULTURE AND LIVESTOCK DEVELOPMENT

Ladies and Gentlemen:

It gives me great pleasure to address such a distinguished group of scientists.

As some of you may know, the Government has recently launched the Sessional Paper No. 1 of 1986 on Economic Management for Renewed Growth. The theme of the paper is how the country can provide adequate basic needs for the rapidly rising population through accelerated economic growth between now and the year 2000.

Mr. Chairman, since Agriculture is the backbone of the economy, the nation's farmers must continue to lead the country to achieve this desired growth. Agricultural productivity has to be increased to provide food security for an expected population of 35 million in the year 2000 as compared to 21 million now, provide the bulk of jobs for a labour force of 14 million then as compared to 8 million now, generate higher farm income and increased foreign exchange from exports, and stimulate growth and expansion of off-farm rural income and employment activities.

This places a heavy responsibility on our farmers, most of whom are small scale with farm size averaging merely 2 hectares. They must intensify production through the application of new technologies geared towards high yielding crop and livestock.

Mr. Chairman, this is where the work of the Small Ruminant CRSP comes in. By working with farmers, developing and testing dual purpose goat technologies specially tailored for them, your contribution to the Sessional Paper No. 1 of 1986 is quite clear.

Mr. Chairman, my Ministry has long recognized the important role small rumiants play in our farming systems and economy. They are a vital source of protein food and cash flow, not to mention their social and aesthetic value as gifts. Kenyans consume about 60,000 tons of sheep and goat meat a year, almost a third of total meat consumption. Sheep and goats provide a major source of food to pastoralists especially during prolonged droughts when cattle tend to die off.

The Ministry of Agriculture and Livestock Development (MALD) successfully implemented the Sheep and Goat Project with the assistance of FAO/UNDP from 1972 to 1983.

The Ministry also initiated and has continued to support since 1980 the Small Rumiant CRSP with the assistance of the USAID and several USA institutions which I will mention later and which are represented by many of you in the audience at this Workshop.

Mr. Chairman, I note with much satisfaction that since 1980, only six years ago, the SR-CRSP has achieved commendable results in the development and testing of dual purpose goat (DPG) technologies in close collaboration with farmers. The programme has developed a new breed of goats high in milk and meat production that is undergoing on-farm testing; has developed a vaccine against the terrible pneumonia of goats (contagious caprine pleuropneumonia - CCPP); this is the most important epidemic disease of goats in our region; and has embarked on developing a diagnostic test and if possible a vaccine for the deadly Heartwater disease that affects not only goats but sheep and cattle as well.

Furthermore, the programme has developed a variety of suitable food-feed forages. Farmers can grow them partly for their own food and partly as feed for goats and other livestock. Techniques have also been developed for preserving and storing these forages for critical dry season feeding to enable continuous year round production of livestock products especially milk. In addition, new management practices for improving the condition and productivity of small ruminants have been developed and are being tested on-farm.

I am happy to note, Mr. Chairman, that all these DPG technologies are being developed by a team of well trained scientists of diverse disciplines, both biological and socioeconomic, and more importantly, in close collaboration with the final consumer of the technologies, namely, the farmer.

This will ensure that when the technologies are fully tested and evaluated, they will be most relevant to the needs of the farmer they are meant to assist, in the sense that they will work for him, pay him for his efforts and expended scarce resources, and fit into his social set up. I must commend SR-CRSP, Mr. Chairman, for taking this approach which other projects overlook and end up with dismal results.

The success of SR-CRSP is demonstrated by the overwhelming requests from farmers throughout the country for CRSP goats for breeding purposes, as well as the large crowds of curious and inquisitive agricultural showgoers that CRSP stands attract at the Kakamega, Kisumu and Siaya District shows. Indeed, your results have a wider application beyond the farmers of Western Kenya that you are working with. Both the small and large farmer, rancher or pastoralist in high potential, semi-arid and arid areas of Kenya and throughout the tropics stands to benefit from this worthy venture.

Another significant achievement of the SR-CRSP has been its training component. To date, 3 Kenyan research officers are being trained at Ph.D level in the USA and 17 others have trained at the M.Sc level. Besides, many participating research officers have been sponsored to national, regional and international training workshops and conferences. All this has greatly contributed towards the building of research capacity for my Ministry and for the country as a whole that will remain useful many years beyond the life of the SR-CRSP.

Mr. Chairman, I understand that the next and final phase of the programme is the wide scale on-farm testing of the new breed of goats which has been developed, together with the Veterinary and other component technologies that go with it, and the preparation of final technological packages that farmers can adopt in the wide spread production of DPGs.

This should be a very exciting phase and has the full backing of my Ministry.

I realise that most SR-CRSP research results have been written up in many scientific papers and reports. Mr. Chairman, what becomes critical now, as the final phase of the programme is implemented, is the translation of the research results into forms that extension officers and farmers can readily read, understand and adopt. In this regard, I understand that the SR-CRSP scientists have began writting a book and preparing simple field hand-books on the production and management of goats. Both the farmers and my Ministry extension officers in the field will gratly welcome these documents, and we await them with much anticipation.

In conclusion, Mr. Chairman, I would like to recognize with much appreciation, the generous support we have received and continue to receive from our friends in the USA.

In particular, I would like to thank the USAID Mission in Kenya through the Director, Dr. Stephen Sinding who is here in the audience, the Universities of California, Missouri, Washington State and Texas A&M and Winrock International for their continued support. I wish all of you great success in your deliberations during this Workshop.

With great pleasure, Mr. Chairman, I now declare this Fifth SR-CRSP Kenya Scientific Workshop Open.

USAID'S INVOLVEMENT IN AGRICULTURAL RESEARCH IN KENYA

By

Dr. S. Sinding,
Director, USAID Mission in Kenya

I am pleased to be at the Small Ruminant CRSP Fifth Kenya Workshop and to be meeting with this group of distinguished agricultural scientists.

Although new to Kenya, while preparing for my assignment here and based on what I have seen during my initial 2 1/2 months, I am convinced that agricultural development is the key to Kenya's future.

Within the agricultural sectors we in USAID view agricultural technology development -- agricultural research -- as one of the highest priorities.

USAID Research Involvement:

USAID has had a long history of agricultural research involvement in Kenya.

Bilateral Program has included:

Food Crops Project (Kitale Maize) with EAFRO - 1960's early 70's.

Drylands Cropping Systems at KARI-Muguga - 1978-1987 (Cropping Systems and Maize breeding).

Kiboko Range Research Project (Range Research) - 1979-1986.

Regional Programs of International Research Centers:

CIMMYT economics - (training in farming systems methodology).

CIMMYT - (maize and wheat research) (breeding and agronomy).

SAFGRAD/ICISAT - (Sorghum/millet research).

CIP - (potato improvement).

ICIPE - (resistance breeding for maize and sorghum pests) and tick ecology and control.

ISNAR - conducted several studies and analysis.

Programs that are centrally funded out of our Washington Headquarters:

CRSP (Collaborative Research Support Programs) Bean/Cowpea - University of Nairobi 1980-1986 and the Small Ruminants CRSP with the Ministry of Agriculture and Livestock Development (MALD).

Our support to agricultural research has been substantial.

Problems:

As I noted earlier USAID views agricultural research with the highest priority -- but there have been problems.

1. The Government of Kenya has made attempts to improve the organization and management of agricultural research but implementation has been poor.

2. There is a lack of a comprehensive management system to ensure effective utilization of available research resources and facilities.

3. There is a proliferation of donor financed projects, each with a different management system, and different research priorities and objectives. This has been permitted by the lack of coordinated priority setting in agricultural research and the fractured nature of the agricultural research institutions.

4. There is an absence of a rationalized basis for the establishment of research facilities, there has been uncoordinated staff recruitment and deployment as well as inadequate training of research staff.

5. There is a need for improving internal research management procedures. Procedures for supervising, monitoring and evaluating research programs and research staff are deficient. Information dissemination is inadequate.

6. Finally, there is need for improved contacts within the MALD such as with the extension service; and with outside institutions such as the University community, International research centers, and the private sector.

These problems have resulted in a gradual decline in the quantity and quality of agricultural research produced in Kenya. The problem is essentially one of orgainization and management.

Government Action:

It appears that these problems may soon be overcome.

The current efforts, led by His Excellency, the President of Kenya; Hon. Daniel Arap Moi and MALD are to be commended. Plans to institutionalize a national agricultural research system that is developing and adapting food and agricultural technologies responsive to the local agroclimatic, economic and social conditions faced by Kenyan farmers are exactly what is needed.

USAID'S Action:

The Government of Kenya's plans to establish a restructured Kenya Agricultural Research Institution (KARI) have my full support. My first official act after arriving in Kenya was to commit the United States to support of the resturctured KARI. I have committed the United States government to a 10 year project -- with the expectation that it will take at least 15 to 20 years assistance. I have agreed to a grant of US$ 15.2 million for the first four years of the project. The project consists of support for the institutional development of the Kenyan agricultural research system, including:

the design and installation of improved planning and management systems,

the expansion of technical capacity to produce improved technologies for Kenyan farmers, particularly for maizez sorghum and millets and,

the improvement of research linkages between the public sector and the academic and private sector.

USAID will supply funds for technical assistance, training, logistical support, commodities, evaluation, and a research fund. We feel very strongly that for this important program to succeed Kenya has to be in charge -- USAID's role will be one of support that further develops Kenyan capacity. In this regard training will receive major emphasis. Over the initial 10 years we plan on:

55 Ph.D's trained in the U.S. 88 Masters (1/2 in the U.S. and 1/2 in Kenyan Universities), and extensive in-country training short courses.

A substantial fund will be available to encourage much greater university and private sector research involvement in the new national agricultural research system. We have been working closely with the MALD and other donors on the development of the program. We will be one of what we hope will be many donors joining together to assist the Government of Kenya with this program.

In summary -- agricultural research is one of USAID's highest priorities and we are committed to continued substantial assistance in the years to come.

I wish you well in your workshop.

SR-CRSP CONTRIBUTION TOWARDS INCREASED GLOBAL FOOD PRODUCTION

BY
David Robertshaw
Program Director, Small Ruminant CRSP
University of California, Davis, U.S.A.

The Small Ruminant Collaborative Research Support Program (SR-CRSP) is directed towards conducting research on small ruminants which includes sheep, goats, and, in South American, alpacas. The purpose of concentrating on small ruminants is that they represent the domestic species of the poorer farmers in developing parts of the world. In terms of the global production of meat and milk, sheep and goats probably contribute less than five per cent when compared to other ruminant species. Thus by concentrating on small ruminants the effects of our research in global terms will be relatively small. However, population growth in developing countries is at the center of the world food problem. In terms of meeting the ever-worsening malnutrition in the world resulting from population growth the impact of improved technology on the productivity of small ruminants would have a significant effect on the well being of the poor majority of the world population. Greater population growth in developing countries has not been not matched by an increase in animal production. During the years 1972-1981 there was a 20 to 23 per cent increase in the number of sheep and goats in developing countries, but this was matched by an increase in population growth within these countries. Thus the problem of malnutrition still stands and will remain unless control of population growth occurs or a significant improvement in animal production can be achieved.

Of the ruminants being studied, i.e. sheep, goats, and alpacas, goats exceed the other species in terms of their prevalence in developing countries. For example 96 per cent of the world goat population is found in developing countries, whereas, only 56 per cent in the sheep population is located in these areas.

The type of research that is being conducted by the Small Ruminant CRSP may be termed "adaptive research" since it applies the results of some of the "basic research" or what has been termed "original research" which can be conducted in either the International Agricultural Research Centers or in the more prosperous countries. "Adaptive research" offers a shorter term pay off and requires a multidisciplinary approach in order to overcome the inefficiencies in production systems associated with the production of milk, meat, and fiber. It has to be multidisciplinary in that a development in one area, for example disease control, may have a severe effect on another area, such as range management. The impact of new technology has to be assessed in terms of the economic and social benefits that may be derived from the application of this research. It is therefore in this context that the Small Ruminant Collaborative Research Support Program is multidisciplinary in approach with research objectives directed to the areas of breeding and reproduction, nutrition, health, sociology, economics, range management and farming systems analysis.

The Small Ruminant Collaborative Research Support Program serves regions of the world rather than being identified to any specific country. It is expected that the outcome of this research will have regional or possibly global significance. Thus our range management studies will probably only be of significance in areas with a similar ecosystem, whereas our work on health problems could have a much broader, and possibly a global impact. Research, therefore is carried out in five countries, Morocco, Kenya, Indonesia, Peru and Brazil and is linked to 10 U.S. institutions.

What has been achieved so far? By their very nature the most dramatic results are to be expected from health improvements. For example, it has been estimated that treatment for internal parasites in areas of heavy parasite burden will increase the annual income by four dollars per head per year. However, such treatment requires a financial outlay for the drugs involved and unless farmers can budget for the initial capital investment they are unlikely to benefit from such a technology. Although a credit system could be established, it may be difficult to manage. In general, improved management practices, whether they be breeding, health, or nutrition will cost the farmer 25-50% of the increased earnings associated with the improved productivity. Thus we are beginning to obtain an idea of the ways in which we can improve the efficiency of small ruminant production from a multidisciplinary approach and we are approaching the stage where we can put this information together in a so called "technological package" which can be presented to the educated farmer or to the extension service. It is not our charge to become involved in extension activities since these are unique to each country and every country knows the best approach for extension activities.

A significant part of our collaboration is that both the institutions in developing countries and the United States should benefit from this collaboration and as with all types of research, students trained in all institutions represent the new agricultural scientist of the next generation. The training superimposed on the research is often overlooked as one of the major contributions that the SR-CRSP can make to institutions in both developing and developed countries, hopefully towards the greater benefit of man and animals in general.

COMPARING SOME MAIZE POPULATIONS TO STANDARD VARIETIES FOR THEIR FEED AND GRAIN YIELDS IN WESTERN KENYA

By

J.F.M. Onim[1], M. Mathuva,[2] K. Otieno[2]
and H.A. Fitzhugh[1]
SR-CRSP P.O. Box 252
MASENO

Maize (Zea mays L.) is the staple food in Kenya. In Western Kenya, it is grown in 679.000 ha in the first rainy season (Anon. 1985). Jeatzold and Schmidt (1982) estimated that in the first rainy season 69% and 31% of the area are planted in pure and mixture with food beans (Phaseolus vulgaris L.) respectively. In the short rains, 83% of maize crop is in pure while 17% is intercropped with beans.

Maize is grown as a food crop, however, its stover can be fed to the livestock. As human population increases rapidly in Western Kenya, pasture land is decreasing and many livestock farmers purchase forage from local markets for supplemental feeding to their livestock. In the village markets in Western Kenya, maize stover costs Kshs. 112** per tonne of dry matter (DM) (Onim et al., 1985). Surveys and field experiments in Westeren Kenya show that average stover yields are 9 mt/ha (Russo 1983 and Onim et al., 1986). This means that annual stover DM production in Western Kenya is estimated at 6.1 million tonnes, and it is worth Kshs. 6.85 million.

Because differences in various forage qualities and grain yields between farmers local maize populations and standard varieties have not been reported in Kenya, a study was conducted to investigate if there were such differences. This paper reports results of this study.

Materials and Methods

First Trial:

Local open pollinated maize populations were selected for two cobs in farmers fields in Kaimosi, Hamisi, Nyahera and Masumbi in August, 1985. The number of plants selected per location were 24, 21, 27 and 16 for Kaimosi, Hamisi, Nyahera and Masumbi, respectively, plants were selected from between 10 and 15 farmers' fields at each location. The cobs were shelled and equal number of seeds were taken from each plant and these were composited to constitute double cobber (DC) population for that location. Farmers were

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[1]Winrock International Institute for Agricultural Development.

[2]Ministry of Livestock Development, Kenya.

*Current exchange rate: Kshs. 16.00 = US$ 1.00.

asked to compare grain yield and forage yields between their local maize cultivars and the recommended commercial hybrids.

These selected local populations were compared in a replicated yield trial to a standard hybrid maize variety (H512). H512 is one of the recommended maize varieties for areas with altitudes of approximately 1540m (5000 ft). Each was planted at Maseno Research Station on 5th September, 1985 in plots measuring 1.8 m x 30 m with five replicates, at a spacing of 30 cm between plants within row and 90 cm between rows. The plots were fertilized with a single dose of Diammonium phosphate (DAP) at the rate of 200 kg of compound per ha. The plots were weeded twice before harvesting. Five plant characteristics that contribute to feed yield and quality and four that contribute to grain yields were estimated. For feed yield and quality, invitro digestibility of dry matter (IVDDM) and crude protein (CP) of leaves, were estimated when the crop was 96 and 127 days from planting, respectively. Plant heights, DM stover yields and stover IVDDM were estimated at harvesting when the crop was 168 days old. Double cobber frequency in the population were also estimated.

Second Trials

Because the results of the first trial were very interesting, it was decided that the first trial be repeated and expanded in the first rains of 1986. Three groups of maize cultivars were included in this trial.

These were:

1) The selected seed only from DC plants from each of the four double cobber farmers' populations.

2) Four population hybrids between the farmers' DC populations and H512, and

3) Four recommended commercial hybrids, namely H614, H622, H511 and H5010. The first two are recommended for highlands (1846 m altitude - 6000 ft) while the last two are for medium altitudes - (1540 m altitude - 5000 ft).

H512 was not available in the market and so it was not included in the second trial, however, its earlier version - H511 - was included.

The trial was planted in Maseno Research Station on 11th March, 1986 in plots measuring 2.7 m x 5.0 m in three replicates. A spacing of 30 cm between plants within row and 90 cm between rows was used. The plants were fertilized once at planting with DAP at the rate of 200 kg/ha of the compound. The plots were also weeded twice before harvesting.

Since two seeds were planted in each hill, one plant was thinned out after 30 days from planting at the first weeding. The DM, CP contents and IVDDM of the seedlings were estimated. When the crop was mature at 156 days old, mean number of leaves per plant were counted, leaf CP and IVDDM were also analysed for. Similarly four stover characteristics, namely plant height, DM, CP and IVDDM were estimated at harvesting at 156 days from planting.

Maize grain yields, as well as double cobber frequencies, number of days to flowering and ratios of top cob grain yields to that of bottom cobs were calculated for eight maize cultivars in the trial.

Results and Discussion

The views of about 50 farmers from four clusters who supplied the DC local maize cultivars are presented in Table 1. These views show that some farmers consider that their local maize cultivars have several good qualities above some of the recommended commercial maize varieties. Problems like higher damage on grains of commercial maize varieties by storage pests could easily be overcome by application of appropriate storage pesticides. The other comments were quite interesting and it may be necessary that maize improvement programmes pay attention to these.

First trials

Forage charcteristics

The forage characteristics of the four farmers' DC maize populations and H512 are presented in Table 2. There were significant differences (P = 0.01) in plant height among the maize cultivars. Nyahera DC cultivar was significantly (P = 0.01) taller than all the other populations. H512 was the shortest cultivar. All the farmers' maize cultivars were significantly (P = 0.01) taller than H512.

Dry matter stover yields shown in Table 2 indicate that Nyahera DC was by far the highest yielder (17 mt/ha). The other three farmers' DC cultivars had a mean stover yield of 9.7 mt/ha as compared to 4.7 mt/ha of the commercial variety - H512. These results show that H512 is unsuitable as a good stover yielder. Livestock farmers who grow H512 would therefore forego 146% of potential stover yields which they should realize by growing their local maize populations (mean farmer's stover yields of 11.55 mt/ha cf 4.7 mt/ha from H512). Because one tonne DM of maize stover costs Kshs. 1123 (Onim <u>et al</u>., 1985), the mean difference between farmers' DC maize populations and H512 of 6.85 mt/ha has cash value of shs. 7,693/ha. However, livestock farmers who grow Nyahera DC rather than H512 would realize extra stover DM yields of 12.4 mt/ha with an extra cash value of shs. 13,825.

There were no significant differences (P = 0.05) among the maize cultivars with respect to their CP in leaves at 127 days old, IVDDM in leaves at 96 days old and stovers at harvesting at 168 days old. It is, however, important to note that leaves of 127 days old maize plants still had a mean CP level of 13.5%. It is further interesting to note that IVDDM of 96 days old leaves and that of stover at harvesting at 168 days were virtually the same (57.5% for leaves and 59.9% for stovers). These forage qualities show that maize leaves and its stover at the time the crop has matured are still a good source of acceptable quality of livestock feed.

Grain yields and some of its components

Grain yields and some of its components for the five maize cultivars are presented in Table 3. The mean grain yield of the four farmers DC populations of 3930 kg/ha means that these populations outyielded H512 by

2771 kg/ha (239%). However, Hamisi DC that significantly (P - 0.05) outyielded all the other populations performed better than H512 by 4107 kg/ha (354%). Although these results were from one season's trial at only one site, the magnitude of grain yield differences between the farmer's DC populations and H512 looked rather surprising. Another trial would be essential for making further observations.

There were significant (P - 0.001) differences among the maize populations with respect to all the three grain yield components of DC frequencies, number of rows per cob and weight of 100 grains. Because the farmers' maize populations were selected for double cobbing, it is not surprising to note that the mean DC frequency of the farmers' population was much higher than that of H512 (21.8% cf 4.0%). Results in Table 3 further suggest that farmers in Nyahera, Kaimosi and Hamisi - all densily populated - were already selecting their maize for DC (18.4%, 31.6% and 27.6%, respectively) as compared to those in Masumbi - relatively lower population density (9.4%).

Second Trial

Forage characteristics

The forage characteristics of the 12 cultivars that were tested in the second trial were subdivided into seedlings, leaves and stovers and these are presented in Table 4.

Seedling thinnings

Dry matter yields of the 30 day old seedlings showed no significant differences (P - 0.05) among the maize cultivars. The lowest DM yielder was a population hybrid (Nyahera x H512) with 237 kg/ha as compared to the highest yielder which was H5010 with 509 kg/ha.

The cultivars showed significant differences (P - 0.01) in CP level (23.6%) while H511 had the lowest (16.1%). The farmers' DC populations had a mean CP of 20.5%, populations hybrids had a mean of 20.7%, while commercial hybrids had a mean of 20.8%. These CP levels show that there were no differences among the three groups, however, there were large variations within any group.

Similarly, there were significant differences (P - 0.01) in IVDDM among the cultivars. The highest IVDDM value of 67.3% was observed in a population hybrid (Kaimosi x H512), while the lowest value of 47.7% was observed in Kaimosi DC. Again as groups, the farmers DC had a mean IVDDM value of 57.8%, population hybrids had 60.6% and commercial hybrids had 61.4%. These results show lower IVDDM values than was expected for such tender forages like seedling thinnings.

Leaves at cob harvesting time (156 days old)

There were significant differences (P - 0.05) in number of leaves per plant (Table 4). H614 had the largest number of leaves per plant (17.4) while H511 had the lowest number. The number of leaves per cultivar does not only indicate the number of nodes that each maize cultivar has to produce before it tassels, it is also a good indicator of the relative time each cultivar requires to mature. The fewer the number of leaves the earlier the maturity.

As the case in the first trial, there were no significant differences (P = 0.05) in CP in leaves at harvesting time (156 days old) among the 12 maize cultivars (Table 4). Population hybrid (Kaimosi x H512) had the highest IVDDM value for leaves at harvesting time (62.0%), while H511 had the lowest (47.0%). The mean IVDDM values for the farmers' DC populations was 51.6%, population hybrids was 56.7% and commercial hybrids was 53.2%. These forage quality values indicate that old maize leaves at harvesting can still be a useful feed to livestock.

Stover at harvesting time (156 days old)

The 12 maize cultivars differed significantly (P = 0.05) in plant height. H614 was the tallest cultivar with a mean height of 340 cm, while the population hybrid (Masumbi x H512) was the shortest with a mean height of 305 cm. Although taller maize cultivars may yield more stover than shorter ones, the taller types are more prone to lodging than shorter ones.

Stover DM yields shown in Table 4 indicate significant (P = 0.01) differences among the maize populations. The highest stover DM yielder was H614 (10.2 mt/ha) while the lowest yielder was Masumbi DC (5.8 mt/ha). The mean stover DM yields of the three groups were: 6.8 mt/ha for farmers DC populations, 8.8 mt/ha for population hybrids and 7.8 mt/ha for commercial hybrids. These results indicate that population hybrids outyielded farmers' DC populations and commercial hybrids by 2.0 mt/ha and 1.0 mt/ha, respectively.

Finally, CP yields in the stover were expressed in terms of CP yields/ha for each cultivar (Table 4). CP yields/ha showed significant (P = 0.01) differences among the 12 cultivars. H614 had the highest CP yield (604 kg/ha) while the lowest yielder was H622 (138 kg/ha). The mean CP yields for the three groups were 293 kg/ha for farmers' DC populations, 399 kg/ha for population hybrids, and 374 kg/ha for commercial hybrids. The wide variability shown in this character shows that maize improvement programmes should screen for CP levels in stover as they develop new maize varieties. Livestock owners who grow maize cultivars with superior CP levels in stover would, no doubt, increase productivity of their livestock by feeding the good quality stovers.

IVDDM of stover was not yet analysed by the time this paper was prepared.

Grain yields and some of its components in the second trial

Grain yields of the 12 cultivars are presented in Table 5. These results show that there were significant yield differences (P = 0.01) among the populations. H614 gave the highest grain yields (7395 kg/ha) while H511 gave the lowest yield (4926 kg/ha). Mean performance of the three groups were: 5281 kg/ha for the farmers' DC populations, 6475 kg/ha for population hybrids, and 5861 kg/ha for commercial hybrids. The four top grain yielders in this trial were H614 (7395 kg/ha), Hamisi DC (7136 kg/ha), population hybrid (Hamisi x H512) (7074 kg/ha) another population hybrid (Nyahera x H512) (6938 kg/ha).

The performance in grain yield of Hamisi DC supports what was observed in the first trial - that this is no doubt asuperior maize cultivar. Looking at Hamisi DC with the knowledge that H614 is recorded as the second highest grain yielding commercial hybrid in Kenya, after another commercial hybrid - H625, makes this new double cobber population something to look at again. Its superiority is supported in its population hybrid with H512 that ranked third in the 12 cultivar maize trial.

The other grain yield components that were considered also reveal some very interesting observations. The DC frequencies in the farmers' DC populations and their population hybrids are significantly higher (P = 0.01) than those of commercial hybrids (27.6%, 18.5% and 10.9%, respectively). This has been achieved with only two cycles of mass selection for DC. This is very exciting to note. Mass selection is a method farmers have used in maize improvement for time immemorial. It works well.

Although number of days to flowering differed significantly (P = 0.001) among individual entiries, there was no significant difference (P = 0.05) among the three groups - farmers' DC population (75.4 days), population hybrids (74.9 days) and commercial hybrids (75.5 days). All the cultivars were harvested at the same time and the ears were uniformly dry. This observation requires further experimentation especially because the medium altitude commercial maize hybrids like H511, H512 and H5010 have done rather poorly in the trials reported in this paper.

Conclusions

1. There were large variations in forage yields and qualities of the maize cultivars that were tested in this study. This potential should be exploited and high forage and grain yielding cultivars should be developed during variety development in maize improvement programmes.

2. When given the recommended fertilizer levels and good weeding, farmers' local maize populations have surprisingly done just as well as the commercial hybrids. If farmers'populations were screened from a wider area, the genetic potential hidden in villages could revolutionize maize improvement in Kenya.

3. Performance of population hybrids in forage yields and quality as well as grain yields indicates that it is a rapid maize improvement approach that has a good potential.

4. The grain yield potential of three commercial hybrids namely H511, H512 and H5010 were shown to be rather low in this study. This calls for rapid re-evaluation and should these results be confirmed, then their future as recommended commercial hybrids for wide cultivation by farmers should be reviewed.

5. Finally, this study has shown that the commercial hybrids H614, farmers DC population (Hamisi DC) and its population hybrid (Hamisi x H512) have shown excellent forage yields and quality, but especially grain yields.

The two test cultivars require urgent further testing and should their good performance persist, they should be released as new varieties for the medium altitude areas of Western Kenya.

Acknowledgements

My sincere thanks go to the Director of Agriculture, Mr. S. Muturi who found time to visit and offer valuable suggestions about this trial when he visited Maseno in the second rains of 1985. I am extremely thankful to the many farmers who contributed their local maize cultivars and participated in discussions during field days at Maseno in the course of this trial. Finally, I wish to thank the personnel of the research and extension divisions in Nyanza and Western provinces who visited these trials and gave valuable suggestions.

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Table 1. Farmers' comments about their local maize cultivars as compared to most commercial varieties

Parameters	Local farmers' maize cultivar	Commercial hybrids
1. Cost and availability of seed	Keep own therefore available	Costly and sometimes not available in time
2. Roasting and cooking qualities as green ears	Sugary and more palatable*	Dull and less palatable
3. Grain yields	Low but steady under low input farming situations	High only under high input farming situations
4. Yields and quality of stovers for livestock feeding	Low yields but stems are more sugary	High yields but stems are less sugary
5. Damage by storage pests	Comparatively lower because of harder kernels	Comparatively higher because of softer kernels

* Green maize market is well established and Ksh. 1.00 is paid to the farmer per ear. Farmers get between 25,000 and 35,000 per ha. as compared to about 17,000 per ha. of grain (5000 kg/ha).

Table 2. Major forage characteristics of farmers' maize populations when compared to H512 in the second rainy season of 1985 at Maseno

Maize cultivars	Forage characteristics: Plant height (cm)	DM stover yield (kg/ha)	CP in leaves (at 127 days) (%)	Invitro digestibility of: 96 day old leaves	stovers at 168 days
Nyahera DC(1)	301.4	17,081	13.7	59.2	59.0
Kaimosi DC	269.6	10,899	12.2	56.6	56.1
Hamisi DC	263.3	9,328	15.0	59.2	59.9
Masumbi DC	273.0	8.904	13.4	55.2	62.2
H512	228.4	4,713	13.2	57.1	62.5
LSD 0.05	20.5	3,101	-	-	-
LSD 0.01	28.3	4,272	-	-	-
Level of significance	***	**	NS	NS	NS

DC(1) - Double cobber

NS - Not significant at P - 0.05

** - Significant at P - 0.01

*** - Significant at P - 0.001

Table 3. Major grain yield characteristics of farmers' maize populations compared to H512 in the second rainy season of 1985 at Maseno

Maize cultivars	Yield (kg/ha)	DC(1) frequency (%)	Grain characteristics: Number of rows/ear	Weight of 100 grains (g)
Nyahera DC	2742	18.4	12.2	47.7
Kaimosi DC	4103	31.6	12.1	45.1
Hamisi DC	5266	27.6	10.2	55.2
Masumbi DC	3608	9.4	12.8	46.1
H512	1159	4.0	12.4	47.5
LSD 0.05	1124	7.7	0.33	3.01
LSD 0.01	1548	10.6	0.44	4.18
Level of significance	***	***	***	***

DC(1) - Double cobber

*** - Significant at P = 0.001

Table 4. Comparison among major forage characteristics in four commercial maize hybrids, four experimental population bybrids and four farmers' populations in the first rainy season of 1986 at Maseno

Maize cultivars	Forage characteristics: Seedling thinnings			Leaves 156 days old			Stover at harvesting at 156 days old		
	DM (kg/ha)	CP (%)	IVD (%)	No/plant	CP (%)	IVD (%)	Plant ht. (cm)	DM (kg/ha)	CP Yield (kg/ha)
Kaimosi DC(1)	351.6	19.9	47.7	15.9	10.7	47.67	320.0	7269.1	394.3
Hamisi DC	395.8	22.3	66.2	16.5	11.7	48.26	319.3	6777.8	287.9
Nyahera DC	248.8	17.6	65.7	16.8	11.5	55.61	337.3	7176.5	274.5
Masumbi DC	251.9	22.3	51.6	16.0	12.6	55.04	307.3	5765.4	214.0
Kaimosi x H512	324.2	20.1	67.3	16.6	13.9	61.97	325.3	9530.9	509.5
Hamisi x H512	329.0	21.5	54.4	16.0	11.0	56.13	318.7	9312.3	458.3
Nyahera x H512	236.9	19.1	62.6	16.3	12.8	55.19	313.0	8828.4	365.0
Masumbi x H512	362.1	22.0	58.3	15.7	14.1	50.89	305.3	7680.2	260.7
H614	394.9	21.1	66.5	17.4	12.4	53.76	340.3	10233.3	603.8
H511	299.7	16.1	62.7	15.0	12.4	47.00	308.7	6223.7	307.7
H622	427.5	23.6	60.3	16.1	11.4	61.47	310.7	6602.5	138.3
H5010	508.8	22.2	56.0	15.4	10.9	50.38	319.0	8230.9	447.3
LSD 0.05	-	3.45	10.3	1.20	-	6.80	296.2	2357.1	180.0
LSD 0.01	-	4.69	14.0	-	-	9.24	-	3203.8	244.7
Level of significance	NS	**	**	*	NS	**	*	**	**

DC(1) - Double cobber

NS - Not significant at P - 0.05

* - Significant at P - 0.05

** - Significant at P - 0.01

Table 5. Comparison among major factors that lead to grain yields in four commercial maize hybrids, four experimental population hybrids and four farmers' populations in the first rainy season of 1986 at Maseno.

Maize cultivars	Grain characteristics			
	Yield (kg/ha)	DC[1] frequency (%)	No. of days to flowering	Ratio of TC.BC
Kaimosi DC(1)	6493.8	23.0	76.3	1.35
Hamisi DC	7135.8	32.3	73.0	1.12
Nyahera DC	5691.4	28.0	78.3	1.58
Masumbi DC	5802.5	27.1	74.0	1.87
	X - 6281	X - 27.6	X - 75.4	X - 1.48
Kaimosi x H512	5469.1	17.1	78.0	2.00
Hamisi x H512	7074.1	16.0	73.0	1.80
Nyahera x H512	6938.3	18.8	74.0	1.02
Masumbi x H512	6419.8	21.5	74.7	2.74
	X - 6475	X - 18.5	X - 74.9	X - 1.89
H614	7395.1	17.4	79.0	-
H511	4925.9	5.1	71.3	-
H622	5901.0	14.4	79.0	-
H5010	5222.2	6.8	72.7	-
	X - 5861	X - 10.9	X - 75.5	
LSD 0.05	1355.5	8.4	1.37	-
0.01	1842.3	11.4	1.87	-
Level of significance	**	***	***	*

DC(1) - Double cobber
NS - Not significant at P - 0.05
* - Significant at P - 0.05
** - Significant at P - 0.01
*** - Significant at P - 0.001

TC - Top Cob
BC - Bottom Cob

THE EFFECT OF ENVIRONMENT ON BIOMASS PRODUCTIVITY OF INTERCROPPED MAIZE WITH FOOD BEANS, FINGER MILLET, PIGEON PEA AND SESBANIA IN MAIZE CROPPING SYSTEM

By

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

Small scale farming is the main farming system in Western Kenya where most of the land is under food crops, leaving very little land for growing animal feeds. Grain production is the major agricultural activity in Western Kenya. This system produces a lot of cereal crop residues which could be used as animal feeds. Food crop residues are obtained at a critical time when the availability of green forage is low. Although the nutrient value of crop residues is generally low, they could be supplemented with energy from molasses and protein from sesbania, pigeon pea leaves, urea etc. Crop residues have high dry matter (DM) percentage and thus can be conserved in the form of hay. Although sesbania is not a food crop, planting it in a maize crop improves soil fertility through nitrogen fixation. Sesbania and pigeon pea have an average crude protein (CP) of 24%.

Materials and Methods

All crops were planted at the same time using different spacings. Maize, sesbania and pigeon pea were planted at a spacing of 90 cm between rows and 30 cm between plants within row, while food beans were planted at 25 cm x 20 cm. Finger millet was drilled at 40 cm between rows.

Experimental plots measured 5.4 m x 4.0 m and the area sampled was 4.0 m x 2.7 m. In intercropped plots, maize was planted at a spacing of 90 cm x 30 cm then single rows of sesbania or pigeon pea were planted between maize rows also at a spacing of 90 cm x 30 cm; the intercrop rows were 45 cm from maize rows. Two rows of beans and finger millet were intercropped between maize rows, allowing 25 cm from maize rows from rows of intercrops. Each crop was also planted in a pure stand using the spacings shown above.

The plots were split so that one received 40 kg of P_2O_5/ha as triple supper phosphate alone (F_0) while the other received 40 kg of P_2O_5/ha as triple super-phosphate and 60 kg N/ha from Calcium Ammonium Nitrate (C.A.N.) (F_1). Fertilizer was applied during planting. After harvesting grain, stovers were weighed for DM and CP determination. Sesbania and pigeon pea were cut at ground level and forage separated from stem for DM and CP determination. This experiment was replicated three times and planted in three sites, namely Maseno, Masumbi and Kaimosi. The experiment was a randomised split plot design.

[1]Ministry of Livestock Development, Kenya.

[2]Winrock International Institute for Agricultural Development.

Results

There was significant difference in grain yield of the individual crops in the cropping system at Maseno site (Table 1), ($P < 0.01$). Maize intercropped with pigeon pea showed significantly higher grain yield in both F_0 and F_1 than pure maize. Pigeon pea in this site established slowly and probably the maize crop may have benefited from fertilizer applied to pigeon pea. Intercropping maize with sesbania significantly ($P - 0.05$) increased maize grain yield (under F_1) as compared to pure maize. Intercropping maize with beans showed significantly higher grain yield under F_1 than pure maize. Grain yield from finger millet and beans were reduced by intercropping with maize but such intercrops boosted total grain yield. Fertilizer effect was not significant probably due to the high fertiltiy of soils at Maseno. There was significant effect of treatment on total grain yield from intercropping systems ($P < 0.01$). Pure finger millet and beans showed significantly lower grain yield compared to the other treatments. Other croppings did not show significant differences in total grain yield although intercropping maize with cereal crop tended to incrase total grain yield.

At Masumbi pure maize showed higher grain yield but not significantly different from intercropped maize with finger millet (Table 2). Unlike Maseno, Masumbi has low rainfall and sandy soils. Grain yields from finger millet and beans were reduced but not significantly when intercropped with maize. Except for pure beans other croppings did not show significant differences in total grain yield. Intercropping maize with beans or finger millet tended to promote total grain yield. Fertilizer combinations showed significant effects ($P < 0.01$) indicating that nitrogen and phosphorus are required elements in these soils.

Table 3 shows individual and total grain yield in various croppings at Kaimosi. Kaimosi is of higher altitude (1800 m) and heavier rainfall (1700 mm/yr) than other sites. The soils are mainly forest ones. Pure maize was the highest yielder but not significantly different from intercropped maize. Finger millet and beans were destroyed by hailstones. In this site there was no strong positive effect of intercropping on total grain yield. Fertilizer effect was significant ($P <$ o.05). Soils in Kaimosi also required nitrogen. At Kaimosi site pure maize and maize-pigeon pea intercrop gave the highest forage DM yield (Table 4). However, this was not significant compared with pure pigeon pea and other maize croppings. Fertilizer combinations did not show significant effect on forage production.

Intercropping maize with pigeon pea gave the highest forage DM yield at Maseno site (Table 5). This yield was significantly different from other maize cropping systems. All monocultures showed lower forage DM yields as compared to maize intercropping systems. Fertilizer effect on DM yield was not significant ($P < 0.05$).

At Masumbi site maize-pigeon pea intercrop gave significantly higher forage DM yields (Table 6). Intercropping maize tended to increase total forage DM production. At Masumbi, phosphate and nitrogen fertilizer combinations gave a significant effect by increasing DM production. Forages from Maseno and Masumbi were analysed for CP (Table 7). It was found that in absence of nitrogen fertilizer forage CP was higher. This is because phosphate fertilizer alone tended to delay the maturity of graminae such that at harvesting there was more green tissue. Intercropping reduced CP. Application of nitrogen fertilizer increased CP especially in non-leguminous plants in poorer soil conditions at Masumbi. Pure sesbania and pigeon pea showed the highest CP content.

In summary, it is clear in this study that maize is the most important crop for both grain and forage DM production. At all sites, pure maize showed the same trend of grain and forage yields. At each site, forage yield was higher than grain. Intercropping maize with other crops gave varying results. Intercropping maize with finger millet showed no significant ($P < 0.05$) effect on total grain yield but increased total forage production at Maseno site; it reduced total grain and forage yields at Kaimosi and increased total grain and forage yield at Masumbi. Intercropping maize with pigeon pea increased total grain and forage production at Maseno; had very little effect on grain and forage production at Kaimosi; and reduced total grain yield and increased total forage yield at Masumbi. Intercropping with sesbania showed little effect on maize grain production, but increased total forage yield at Maseno, reduced grain and forage yield at Kaimosi, and reduced grain yield but increased total forage production at Masumbi. Intercropping maize and beans showed an increase in both total grain and forage yields at Maseno, reduced grain and forage yield at Kaimosi (where beans were destroyed by hailstorms); and increased both grain and forage production at Masumbi. Pure finger millet has a potential for both grain and forage at Maseno but when intercropped with maize its grain production is substantially suppressed by maize. In such situations, total grain yield was slightly increased and total forage yield much more increased. At Kaimosi pure finger millet showed mainly vegetative growth and poor grain yield. In this site vegetative growth and grain production were reduced by maize intercrop. At Masumbi pure finger millet showed a balance of both grain and forage production.

Pure beans have low potential for forage yield mainly due to the shedding of leaves at ripening stage. This is why forage yield from pure beans was lower than grain yield. Beans are susceptible to hailstorms. Pure sesbania and pigeon pea showed potential for forage production at all sites and especially at medium (1500 m) and lower altitudes (1200 m). At high altitudes 1800 m, pigeon pea showed early flowering thus inhibiting vegetative growth.

Discussion

There was a tendency of intercropping to increase yields. In this study, maize ranked first in both grain and forage DM production. Finger millet and beans showed good results when intercropped with maize. This was so in the medium and lower altitudes. Pigeon pea was compatible with maize and it could replace beans at all sites as a grain crop and forage producer. Pigeon pea could be allowed to fruit then harvested later for forage and firewood production. Intercropping maize with sesbania has potential, however, this would deprive the farmer of his grain legume yield. For better yields, compound fertlilzer containing N and P should be applied especially in poor soils. Food crop residues yield more forage than fallow land. Food crop residues can form an important diet of ruminants (Preston and Leng, 1985). Legumes e.g. pigeon pea and sesbania could be used to supplement straw based diets. Work has proved that the foliage of *Sesbania sesban* contain low levels of phenolic compounds with low molecular weights and when added to straw diets of sheep, there was a liveweight gain of 48 g/day (ILCA. 1985/86). Sidahmed et al., (1984) reported that sesbania has a high potential as livestock feed in Western Kenya. They reported that its leaves has IVADDM* of 74% and CP of 26%. Hence sesbania and pigeon pea forage could be used assupplements to crop residues eg. cereal straws and stovers. Such quality forages can better be preserved as hays using simplified hay making methods (Onim, J.F.M., et al. 1985). There is need to let pigeon pea produce grain and then compare its role as a grain and forage producer with bean and finger millet under pure and maize intercropping systems. There is need to do comprehensive feeding trials with goats and other ruminants using straw based diets supplemented with sesbania, pigeon pea, molasses, urea, fish meal, meat and bone meal, poultry manure, sun flower cake, cotton seed cake and brewers waste.

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*Invitro apparent digestibility of dry matter.

Table 1. Grain yield of crops and total grain yield from the intercrop at Maseno site (Mton. ha-1).

TREATMENT	INDIVIDUAL CROP			TOTAL GRAIN		
	Fo	F1	Mean	Fo	F1	Mean
Maize Pure	9.35	8.86	9.10	9.35	9.96	9.10
Maize + Finger Millet	9.51+0.49 (10.00)	8.36+1.07 (9.43)	8.93+0.78 (9.71)	10.00	9.43	9.15
Maize + Pigeon Pea	10.49	10.54	10.52	10.43	10.54	10.52
Maize + Sesbania	9.07	9.35	9.21	9.07	9.35	9.21
Maize + Beans	9.27+0.80 (10.07)	9.72+0.94 (10.66)	9.50+0.77 (10.27)	10.07	10.46	10.27
Finger Millet Pure	2.10	2.28	2.19	2.10	2.28	2.19
Beans Pure	1.41	1.49	1.45	1.41	1.49	1.45
Fertilizer Means	5.80	5.82		7.50	7.49	

Table 2. Grain yield of crops and total grain yield from the Intercrop at Masumbi site (Mton. ha-1).

TREATMENT	INDIVIDUAL CROP			TOTAL GRAIN		
	Fo	F1	Mean	Fo	F1	Mean
Maize Pure	2.39	3.79	3.09	2.37	3.79	3.09
Maize + Finger Millet	1.52+0.29 (1.81)	4.49+1.21 (5.70)	3.01+0.75 (3.76)	1.82	5.70	3.76
Maize + Pigeon Pea	1.64	3.67	2.66	1.64	3.67	2.66
Maize + Sesbania	2.31	2.88	2.68	2.31	2.88	2.60
Maize + Beans	1.64+0.16 (1.80)	4.41+0.40 (4.81)	3.02+0.28 (3.30)	1.80	4.81	3.30
Finger Millet Pure	0.56	1.56	1.07	0.56	1.55	1.07
Beans Pure	0.41	0.84	0.62	0.41	0.84	0.62
Fertilizer Means	1.81	2.59		1.56	3.32	

Table 3. Grain yield of crop and total grain yield from the intercrop at Kaimosi site (Mton. ha-1).

TREATMENT	INDIVIDUAL CROP			TOTAL GRAIN		
	Fo	F1	Mean	Fo	F1	Mean
Maize Pure	4.76	7.79	6.79	4.79	7.79	6.28
Maize + Finger Millet	4.52+0.14 (4.66)	6.07+0.28 (6.35)	5.30+0.21 (5.51)	4.66	6.35	5.51
Maize + Pigeon Pea	5.74	6.33	6.93	5.74	6.33	6.93
Maize + Sesbania	3.31	5.93	4.62	3.31	5.93	4.62
Maize + Beans	5.03+0.00 (5.03)	6.91+0.00 (6.91)	5.97+0.00 (5.97)	5.03	6.91	5.97
Finger Millet Pure	0.18	0.23	0.20	0.18	0.23	0.20
Beans Pure	0.00	0.00	0.00	0.00	0.00	0.00
Fertilizer Means	3.38	4.80		3.94	5.59	

Table 4. Forage Dry Matter yield of crop and total forage Dry Matter yield from the intercrop at Kaimosi site (Mton. ha-1).

TREATMENT	INDIVIDUAL CROP			TOTAL DRY MATTER		
	Fo	Fl	Mean	Fo	Fl	Mean
Maize Pure	6.28	8.79	7.53	6.28	8.79	7.53
Maize + Finger Millet	5.85+0.40 (6.25)	9.12+1.24 (10.36)	8.31	6.25	10.36	8.31
Maize + Pigeon Pea	4.61+2.82 (7.43)	5.02+2.18 (7.20)	7.32	7.43	7.20	7.32
Maize + Sesbania	6.40+1.23 (7.63)	8.84+0.56 (9.40)	8.52	7.63	9.40	8.52
Maize + Beans	5.04+0.00 (5.04)	7.74+0.00 (7.74)	6.39	5.04	7.74	6.39
Finger Millet Pure	1.47	2.03	1.75	1.47	2.03	1.75
Sesbania Pure	2.73	4.63	3.68	2.73	4.63	3.68
Beans Pure	0.00	0.00	0.00	0.00	0.00	0.00
Pigeon Pea Pure	4.82	4.98	4.90	4.82	4.98	4.90
Fertilizer Means						

Table 5. Forage Dry Matter yield of crop and total forage Dry Matter yield from the intercrop at Maseno site (Mton. ha-1).

TREATMENT	INDIVIDUAL CROP			TOTAL DRY MATTER		
	Fo	F1	Mean	Fo	F1	Mean
Maize Pure	10.43	12.08	11.26	10.43	12.08	11.26
Maize + Finger Millet	13.28+1.52 (14.80)	13.92+1.78 (15.70)	15.25	14.80	15.70	15.25
Maize + Pigeon Pea	13.77+3.62 (17.39)	18.35+2.62 (20.97)	19.18	17.39	20.97	19.18
Maize + Sesbania	14.05+0.92 (14.97)	16.18+0.59 (16.77)	15.87	14.97	16.77	15.87
Maize + Beans	18.37+0.32 (18.69)	13.95+0.34 (14.29)	16.49	18.69	14.29	16.49
Finger Millet Pure	5.89	6.59	6.24	5.89	6.59	6.24
Sesbania Pure	4.11	4.93	4.52	4.11	4.93	4.52
Beans Pure	0.55	0.81	0.68	0.55	0.81	0.68
Pigeon Pea Pure	5.76	5.56	3.66	5.76	5.56	5.66
Fertilizer Means				10.29	10.85	

Table 6. Forage Dry Matter yield of crop and total forage Dry Matter yield from the intercrop at Masumbi site (Mton. ha-1).

TREATMENT	INDIVIDUAL CROP			TOTAL DRY MATTER		
	Fo	F1	Mean	Fo	F1	Mean
Maize Pure	3.16	5.91	4.54	3.16	5.91	4.54
Maize + Finger Millet	2.18+0.41 (2.59)	5.55+2.03 (7.58)	5.09	2.59	7.58	5.09
Maize + Pigeon Pea	2.88+7.62 (10.50)	6.13+5.80 (11.93)	11.24	10.50	11.93	11.24
Maize + Sesbania	3.29+1.89 (5.18)	6.01+1.02 (7.03)	6.11	5.18	7.03	6.11
Maize + Beans	3.15+0.32 (3.47)	6.60+0.32 (6.92)	5.20	3.47	6.92	5.20
Finger Millet Pure	1.25	2.62	1.94	1.25	2.62	1.94
Sesbania Pure	3.57	4.70	4.14	3.57	4.70	4.14
Beans Pure	0.45	0.70	0.55	0.45	0.70	0.55
Pigeon Pea Pure	5.64	6.15	5.89	5.64	6.15	5.89
Fertilizer Means						

Table 7. Percent crude protein in forage Dry Matter at Maseno and Masumbi

Treatment	Maseno		Masumbi	
	Fo	F1	Fo	F1
Maize* - Pure	5.33	4.60	4.41	3.60
Maize + Finger Millet	4.04	3.72	4.09	5.03
Maize + Pigeon Pea	4.88	4.01	2.46	2.91
Maize + Sesbania	5.20	4.33	3.06	5.52
Maize + Beans	5.61	4.92	3.77	4.89
Finger Millet - Pure	7.75	6.59	6.21	5.63
F. Millet + Maize	6.40	5.43	3.79	5.75
Pigeon pea Pure	25.01	24.27	22.37	23.12
Pigeon pea + Maize	23.37	21.89	22.06	22.70
Sesbania Pure	26.60	27.74	23.71	25.60
Sesbania + Maize	18.72	16.33	19.33	19.26
Beans Pure (haulms)	4.95	5.74	4.67	4.82
Beans + Maize (haulms)	4.10	5.26	3.90	3.70

* The underlining indicates the crop in pure or in combination whose CP value is presented.

EVALUATION OF SMALL-SCALE SILAGE PREPARATION USING MOLASSES AS AN ADDITIVE

By

Otieno, K.,[1] Onim, J.F.M.,[2] Semenye, P.P.[2]
and Mathuva M.N.[1]

Introduction

It has been established that the major constraint to livestock production in Western Kenya is inadequate nutrition (Sands et al., 1982). Using a computer model, Hart et al. (1984) showed that the difference between feed availability and feed demand is primarily a problem of seasonal distribution, and it is possible to fill in the feed gaps occuring during the periods of drought through feed conservation thereby, stabilizing feed available throughout the year or even increasing herd size on a given farm.

The Feed Resources (FR) project of the Small Ruminants Collaborative Research Support Programme (SR-CRSP) working in Western Kenya has been able to develop a simple hay baling box (Onim et al., 1985). The alternative to hay baling would be ensiling some forages which would not be very suitable to conserve as hay. However, no simple method of ensiling has been developed that would be suitable for small-scale farmers, and thus there is a technological gap that needs researching.

Material and Methods

Crops ensiled

Maize

Whole maize plant with ears (cobs) is a popular crop to ensile not only because of high dry matter (DM) yields but also because of the ease of producing a high quality silage. It is high in fermentable carbohydrate in the ears and stalks and with low resistance to PH reduction (low buffering capacity) and butyric acid ($CH_3.CH_2.CH_2COOH$) is not a dorminant problem over a wide range of moisture levels (Stoskopf, 1981). These advantages have been adequately exploited in the developed countries and particularly under large-scale livestock operations. In the developing countries the high demand for grain for human consumption ethically rules out the use of whole maize plant with ears in silage making especially under smallholder conditions. The only solution left is to strike a balance between harvesting the green ears for human consumption and utilizing the remaining stalks for silage. A lot of maize ears in Western Kenya are often harvested green for

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[1]Ministry of Livestock Development, Kenya.

[2]Winrock International Institute for Agricultural Development.

sale or for home consumption as roasted or boiled maize. The ears are often harvested at early dough to hard dough stage which is also the time recommended for cutting maize for silage making in Western Kenya (Sheldrick 1975). The maize used for this study was harvested 125 days from planting and the stalks used for ensiling after removing the ears.

Sorghum

This is a popular crop in lower parts of Western Kenya (alt. below 1300 m) particularly in South Nyanza, Kisumu, Busia and Siaya districts. It is often made available to livestock as feed either by defoliating the leaves which are then fed to the livestock while tethered or by grazing the livestock in the sorghum fields after harvesting grain. The effect of defoliation on grain yield of the crop in Western Kenya has been reported by Russo et al., (1982).

An alternative to leaf stripping and field grazing would be to conserve the stalks plus the accompanying leaves as silage. This can, however, only be done after harvesting the heads. The sorghum that was used in this study was obtained from a local farmer near Maseno Station after he had harvested the heads. This was approximately 150 days from planting.

Bana Grass

This is the most widely grown fodder grass in Kenya. In Western Kenya where SR-CRSP operates, it is more common in Kaimosi and Hamisi in Kakamega District than in Masumbi in Siaya District. It is normally cut when 1 m high and carried to livestock under semi-zero grazing conditions. DM yields of up to 7 tons/cut/ha can be achieved during the rainy season. The problem facing farmers is how to conserve any excess forage because, when left in the field for a longer time it overgrows into canes which are of little use to livestock. When conserved as hay the leaves are rough and brittle and not very palatable especially to small stock. For this study the grass was cut at 101 days from planting when they were at a mean height of 0.84 m high.

Sugarcane tops

Western Kenya is a major sugarcane growing area in the country. When the cane is harvested the tops are often thrown to waste. Fresh cane tops can be used for feeding livestock. However, since this material is often available in large quantities when sugarcane is being harvested it would be desirable to conserve the excess and use it during periods of feed deficit. In this study the canetops were obtained from a small-scale sugarcane farmer near Maseno Station when he was cutting his cane for sale to a nearby jaggery factory.

Trench Silo

The trenches were dug 5 m long, 3 m wide and 1.5 m deep giving a volume of 18 sq.m as recommeded by Stotz (1983).

Molasses

The use of molasses in livestock feeding systems dates back to the late sixties when molasses - based fattening systems was first established in Cuba (Preston and Willis, 1974). It is widely used in the industrial countries where it improves the palatability, binding properties of pelleted feed as well as reducing dustiness. In the tropics it is the only "concentrated" source of fermentable carbohydrate which is widely available and which is not a staple of the human diet (Preston and Leng, 1985). It was thus used in this study to provide fermentable carbohydrates for lactic acid fermentation which is essential in preserving the silage. It was also hoped that by acting as a source of trace minerals and some micro-elements such as sulphur, calcium and potassium, it would improve the overall quality of the silage.

Synthetic gunny bags

These are commonly available in shops where they are used for packing sugar, salt and maize flour. Once the contents have been sold the bags are separately sold especially in the local open markets at a price of about Kshs. 7.00 (1 US $ = 16 Kshs). The points that we considered in deciding to use the bags for ensiling rather than directly ensiling into the trenches were that:-

a. It would be easier to ration the silage when ensiled in small batches of known weight.

b. Spoilage at feed out due to aerobic deterioration would be reduced since the easy removal of the bags would reduce the length of exposure to air.

c. It is easier to apply the right amount of molasses when dealing with small batches of known weight and volume.

d. Since different crops reach physiological maturity at different times use of the gunny bags would allow each to be ensiled.

e. In case of excess spoilage it will be confined in one bag, thus reducing widespread spoilage.

f. Soil contamination of the silage is reduced.

Methods

The different crops were chopped using a double-bladed hand powered chaff cutter and subsequently tightly packed into the synthetic gunny bags. For each of the crops used, half of the bags received molasses while others did not. The treatments were replicated three times.

Once each bag was filled up it was weighed using a spring balance. The molasses was added to the relevant bags at 5% by weight of the materials in the bag on green matter basis. Before applying the molasses it was diluted with an equal amount of water. This was to ensure uniform spread since molasses is thick and viscous and would not spread easily without dilution. Each bag was then tightly knotted using twines and then arranged in rows in the pre-dug trench. A polythene sheeting was used for covering the bags before covering with the soil that was removed at the time of digging the trench. The soil was then tightly pressed down by trampling on it. The silo was left undisturbed for two months after which it was opened for the first sampling of the silages. Duplicate samples were taken per crop and treatment, one sample being dried in an oven at 100 deg.C for dry matter determination and the second sample sun-dried for four days and used for laboratory analyses.

Samples were a;sp taken from the crops before ensiling and treated in the same way as the silage samples.

Nitrogen determination on the samples was done in duplicate according to the Association of Official Analytical Chemists (A.D.A.C.) (1975) methods. Neutral detergent fibre (NDF), acid detergent fibre (ADF), sulphuric acid lignin and cellulose were determined according to the procedures described by Goering and Van Soest (1970). The digestibility was determined by the in vitro technique of Tilley and Terry (1963). The percentage of lignin in ADF was calculated and compared with other results obtained in Western Kenya for other forages and the commercial dairy meal (Sands et al., 1982).

At the time of sampling the silage, the entire contents of a bag were poured out and divided into "good" and "bad" portions, the "bad" portions being those parts that were charred and mouldy. These constituted the amount of spoilage. The "bad" portions were weighed and percentage spoilage by ewight of the total ensiled material calculated.

The PH of the silage was determined by soaking 20 g of the materials overnight in 100 ml of distilled water. This was then divided into three portions, filtered and PH determined using a PH meter.

Results and Discussions

Table 1 shows a summary of the mean values of quality parameters for the ensiled treatments two months after ensiling. The crops were harvested at different stages of growth and this is reflected in the differences in quality. Sorghum which was harvested at a very advanced stage (150 days after planting) had the highest %DM. Although the sugarcane was much older than the rest it still had a high content of water. In terms of its in vitro dry matter digestibility (IVDMD), the results here agree with those reported earlier by Onim et al., (1985) for the top ten commercial sugarcane varieties in Western Kenya. However, Devile et al., (1978) reported a higher DM digestibility figure (66-69%) for fresh canetops and canetops silage with an addition of molasses at 5% and ammonia at 0.2% N in a digestibility study using goats. The disparity here could be attributed to environmental and varietal differences. Variations in percentage crude protein (%CP) followed a reverse trend to that of %DM with sorghum stalk having the lowest value of 4.68% followed by sugarcane tops, maize stalk and bana grass with 5.52%, 6.08% and 12.59% respectively. It is not clear why bana grass which had the highest lignin/ADF(%) also had the highest IVDMD, because the former and the latter have been reported in Western Kenya (Sands et al., 1982) to be negatively related. It could also be due to the poor association between cellulose and lignin in tropical feeds (Van Soest, 1982), and/or the level of tannin and silica.

Table 2 shows the percentage spoilage by weight of the silages. The means for the molassed and the unmolassed silages were not significantly ($P > 0.05$) different.

The PH of the silages was in the range expected for good silages except that of unmolassed bana grass silage (Table 1). The high PH value for this silage as opposed to that for the molassed bana silage can be explained in terms of the water soluble carbohydrate levels and water content. Generally grasses are inherently low in water soluble carbohydrates and thus there is less substrate for lactic acid fermentation. The addition of molasses thus improved the quality of the fermentation. Indeed the unmolassed bana silage had a foul smell attributable to putrefaction. Sufficient acidity is necessary in inhibiting the activity of the bacteria that cause putrefaction. When acidity is not sufficient clostridial bacteria develop and these are responsible for the secondary fermentation of lactic acid to butyric acid and for extensive detamination and decarboxylation of amino acids. The PH level at which clostridial activity is prevented varies with water content of the ensiled crop. At a water content of 50% silage may be well preserved at a PH of 5.0 whereas secondary aerobic fermentation may occur in silage with 85% water content even when the PH is below 4.0 (Thomas and Young eds). With moist materials the content of water tends to counteract the preservative action of the primary fermentation acids. Thus for the bana grass which had a %DM of about 16.0 we required a PH below 3.5 to achieve an excellent fermentation quality as illustrated in Figure 1.

Conclusions

The results of this experiment demonstrate the technical feasibility of ensiling crops using gunny-bags. However, it would not be possible to ensile sorghum stalks since at the time of harvesting the heads the remaining ensilable portions are too dry to make good silage. The decision to use molasses would depend on whether it is for improving the water-soluble carbohydrate content of the materials only or for improving the quality of the silage as well. If it is for the former only, then it may not be necessary to apply it for the maize silage. In the case of canetops it may be necessary for both reasons.

Bana grass appears to be too wet at the stage used in this experiment. Molasses was therefore necessary in maintaining a desirable PH to counteract the effect of the clostridial bacteria. However, it may also be necessary to investigate the possibility of achieving an improved fermentation by using materials cut at an older age without an addition of molasses. It would be necessary to investigate the effect of ensiling for a longer period than reported in this paper and also to investigate the effect of ensiling a mixture of crops.

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Table 1. Mean values of quality parameters for the ensiled and their respective silages (1st sampling).

CROPS	%DM	%CP	INVITRO DIGEST	LIGNIN	ADF	LIGN/ ADF%	NDF	PH
Maize stover								
Material ensiled	22.58	6.08	51.05	10.83	49.70	0.22	77.82	-
Silage without Mol.	20.83	9.28	37.31	7.25	43.48	0.17	64.31	4.50
Silage with Mol.	22.77	6.85	50.00	7.29	37.34	0.20	66.49	4.10
Bana grass								
Material ensiled	15.90	12.59	68.97	15.71	47.19	0.33	78.48	-
Silage without Mol.	16.94	10.38	56.28	5.52	40.54	0.14	59.46	5.18
Silage with Mol.	19.77	11.94	65.86	9.11	34.61	0.26	56.47	4.18
Sugar-cane tops								
Material ensiled	23.67	5.52	52.24	11.32	47.27	0.24	77.31	-
Silage without Mol.	33.97	3.88	45.51	11.61	42.86	0.27	71.43	4.70
Silage with Mol.	36.12	4.85	42.06	10.77	42.19	0.26	75.41	4.00
Sorghum stover								
Material ensiled	35.55	4.68	48.13	13.54	46.76	0.29	75.88	-
Silage without Mol.	43.06	6.47	53.16	10.77	40.40	0.27	64.64	4.13
Silage with Mol.	41.10	3.88	44.93	7.11	43.52	0.16	64.84	4.20

Table 2. Percent Spoilage by Weight of the Silage.

Crops	% Spoilage by Wt. of Silage	
	No Molasses	+ Molasses
Maize stover	28.00	21.00
Bana grass	16.30	19.23
Sugar-cane tops	17.75	13.40
Sorghum stover	24.82	16.94
Mean	21.72	17.64

RECOMMENDATION DOMAINS FOR DUAL PURPOSE GOAT RESEARCH IN NYANZA AND WESTERN PROVINCES OF KENYA

By

Onim, J.F.M., Mathuva, M.N., Hart, R., Fitzhugh, H.A.
and K. Otieno

Abstract

A survey was conducted on soils, vegetations, rainfall and altitude through a transect of 300 km in Western Rift Valley, Western and Nyanza Provinces. There were more grasses than legumes in the pastures at altitude ranging between 1600 m and 2000 m, and the reverse at altitudes between 1195 m and 1600 m. Feed quality of the vegetations was surprisingly higher than anticipated - being better in higher than in low lands. The soils were generally deficient in sodium, potassium, magnessium, phosphorus and organic carbon, and ranged from moderate to high acidity. Rainfall ranged between 707 and 1875 mm per year. The observed conditions in the study area prevail in approximately 50% of agricultural land area of Kenya. It was concluded that the results obtained from the various research projects conducted on the DPGs in Western Kenya will be relevant and beneficial to goat and other livestock farmers in many parts of Kenya.

Introduction

When agricultural research is done to find solutions to farming problems, it is hoped that such results should be applicable to large areas within the country and even in neighbouring countries. Research results on the Dual Purpose Goats (DPGs) in Kenya that have been generated since the inseption of SR-CRSP in 1980 have been specific to the humid and sub-humid zones of Western Kenya. The SR-CRSP is currently developing recommendation packages as general guide lines for DPG farmers in Western Kenya. Several of the packages for example, simplified feed conservation eg. by box baling of hay (Onim et al. 1985) will not only have application in Western Kenya but also in other parts of Kenya and other countries with similar ecozones and socio-economic practices.

A survey was conducted in Western Kenya in 1985 to characterize soil fertility, rainfall, vegetation and farming practices in a transect that ran from Kapsabet town in the Rift Valley Province at an altitude of 1965 m to Asembo Bay in Siaya district of Nyanza Province. Asembo Bay is on Lake Victoria at an altitude of 1195 m. This transect was 300 km long. This paper reports the results of this survey and highlights on similarities observed on this transect to those found elsewhere in Kenya and other neighbouring countries. Research results obtained in one site could be applicable elsewhere if those areas have similar environments. Hence a recommendation made for one site may be suitable to a wider area or zone, hence the concept of "Recommendation Domains".

Materials and Methods

An altimeter was used to determine altitudes of sites where samples were collected. Because altimeters operate on air pressures, adjustments were made for different times of the day by recalibrating at known altitudes eg. at Railway Stations. Vegetation and soil samples were collected along road sides and fallow lands at distances ranging between five and 10 km apart. A quadrat measuring 80 cm x 80 cm was randomly thrown onto representative parts of the pastures. Enclosed vegetation was carefully checked for species association before the vegetation was clipped, weighed fresh and later oven dry weights were recorded.

The sampled vegetation was analyzed in the nutrition laboratory at Maseno Research Station for Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF), Acid Detergent Lignin (ADL), Hemicelluloses (HC) and Crude Protein (CP). Effects of altitude on NDF, ADF, ADL, HC and CP were estimated by regression analysis.

Soils were augered to a depth of 30 cm in three spots at one site. The three soil samples were then mixed well before a sub-sample was taken for chemical analyses. The soils were analyzed at the National Sugar Research Station laboratories at Kibos in Kisumu for pH, Sodium (Na), Potassium (K), Magnesium (Mg), Manganese (Mn), Phosphorus (P), Nitrogen (N) and organic carbon content.

Farming activities were observed along the transect. Rainfall figures for 10 year periods from selected sites in Kenya were compiled from national meteriological data. These were compared to rainfall figures in the clusters (Kaimosi, Hamisi and Masumbi) where SR-CRSP is doing research in Western Kenya.

Results and Discussion

Vegetaion composition and quality

The first 10 vegetation samples from Kapsabet town at an altitude of 1965 m to Kaimosi cluster (alt. 1730 m) showed no legumes in their composition. The grass species in the mixture were also few, namely Kikuyu grass (Pennisetum clandestinum), star grass (Cyanodon dactylon), Digitaria miligiana and sedges. Between altitudes of 1730 m and 1520 m, the vegetation composition increased in the number of grass species and pasture legumes. Additional grasses that were observed in this complex included Brachiaria brizantha, Digitaria scalarum and Sporobolus spp. Pasture legumes that were observed in these samples were Desmodium intortum, Glycine spp., Indigofera spp. and Tylosema fasseglensis. Between altitudes of 1520 m and 1195 m, five other grass species were observed. These were Cymbopogon validus, Andropogon spp., Chloris gayana, Panicum maximum and Hyparrhenia rufa. The density of Glycine spp. in the pastures was quite high.

Effect of altitude on mean fibre, HC and CP of pastures on roadsides and fallow lands is presented in Table 1. Analysis of variance of regression estimates betweem mean altitudes and NDF, ADF, ADL, HC and CP is presented in Table 2. These results show that NDF was not affected by altitude. However, all the other forage qualities seemed to be influenced by altitude. ADF was significantly ($P < 0.05$) and negatively influenced by altitude ($r = -0.73$). Forages in higher altitudes had lower ADF values. Similarly, altitude affected ADL negatively ($r = -0.69$). Hemicelluloses and CP in forages increased with altitude, $r = +0.57$ and $r = +0.48$ respectively. These observations indicate that forages in higher altitudes were of higher quality as compared to those in the lowlands. This observation has implications on growth and productivity of livestock raised in different altitudes. Livestock in lowlands will receive lower quality diets and their productivity will perhaps be lower.

The problem with clipped forage samples is that their quality will be lower than that foraged by livestock because the animals often select for high quality plant parts (Clark et al. 1982). This therefore means that even livestock in the lowlands may still be able to select for a reasonably high quality diet.

Soil Analyses

Results from soil analyses are presented in Table 3. Of the 38 soil samples, PH was rather low with a range of 4.8 to 6.5, indicating that all the soils were acidic. Such soils would generally have high concetrations, or even toxic levels, of iron and aluminium. Soils with low pH are often deficient in certain plant nutrients like P. Sodium levels were adequate in 26 and deficient in 12 samples. Potassium was deficient in 40% of the samples. Magnesium was inadequate in 10 cases out of 38. Manganese and nitrogen were adequate in all cases while organic carbon was inadequate in seven out of 38 samples. The most deficient nutrient was P. It was deficient in 34 out of 38 cases (89.5%). Since P is a macromutrient, its deficiency in these soils would retard plant growth, especially that of legumes. It therefore means that productivity of pastures would be seriously lowered by soil fertility factors. The soils in the lower altitudes (1195 m to 1500 m) were less fertile as compared to those in higher altitudes. Similar soil fertility problems have been reported in the central highlands of Kenya (Ssali and Keya, 1983 and 1986). It is therefore important to note that research results obtained in Western Kenya will be applicable to the Central Kenya highlands and Kisii area.

Rainfall

Rainfall statistics of several selected sites in Western Kenya including those where DPGs research is based are shown in Table 4. In all of the sites shown in Table 4, the rainfall pattern is bimodal with annual rainfall means ranging between 707 mm and 1875 mm. According to Jaetzold and Schmidt (1982), this rainfall range covers all of Western Kenya and approximately 50% of agricultural crop land in Kenya. It is therefore important to note that the DPG research packages developed in Western Kenya will be applicable in similar agro-ecological zones in other parts of Kenya.

In the last five years, DPGs projects have also been started in Rwanda (Kamatali, 1985) and in Arusha region of northern Tanzania (Personal Comm). The population density in areas where DPGs have been introduced in Western Kenya, Rwanda and Tanzania is very high and pressure on land is high too. Shortage of grazing land and livestock feed is common in all cases. Feed resources technologies developed in Western Kenya, for example simplified hay making (Onim et al. 1985) will have wide applications in other countries as well.

Other technology packages being developed by socio-economics, health, breeding and systems analysis and nutrition and management of the SR-CRSP will equally be applicable in other parts of Kenya and elsewhere where DPGs are being introduced.

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Table 1. Effect of altitude on the mean fibre and CP contents of roadside and fallow land pastures in Western Kenya.

Sample size	District	Alt. range (m)	Fibre (%)				
			NDF	ADF	ADL	HC	CP
3	Nandi	1865-1965	67.3	24.3	4.6	42.7	16.0
1	Nandi	1765-1855	77.0	30.8	11.8	46.2	20.7
12	Kakamega	1665-1765	80.0	32.2	11.6	41.9	12.2
2	Kakamega	1565-1665	68.3	34.3	7.9	36.5	7.5
2	Kakamega	1465-1565	57.9	26.7	10.1	31.2	12.7
4	Siaya & Kisumu	1365-1465	63.8	33.4	12.0	30.4	10.3
1	Siaya & Kisumu	1265-1365	74.3	35.3	14.5	39.0	15.4
2	Siaya & Kisumu	1165-1255	75.3	37.3	12.6	38.3	10.0

Table 2. Analysis of variance of regression estimates between mean altitudes and NDF, ADF, ADL, HC and CP of forages in Nandi, Kakamega, Kisumu and Siaya districts.

Feed quality parameters		df.	ms.	F	r
NDF:	regression	1	2.13	0.03	2.29 Nt
	residual	6	67.06	---	
ADF:	regression	1	71.37	6.76*	-0.73*
	residual	6	10.56	---	
ADL:	regression	1	31.63	5.35	-0.69
	residual	6	5.92	---	
HC:	regression	1	67.64	2.83	+0.57
	residual	6	23.94	---	
CP:	regression	1	28.34	1.83	+0.48
	residual	6	15.48	---	

* Significant at $P < 0.05$

Nt No trend

.nt nutrients in the surveyed soils.

0.2%	1%	0.1%	20	0.20	1%
K	Mg	Mn	P	N	Organic C
me%	me%	me%	ppm	%	%
38	38	38	38	38	38
23	28	38	3	38	31
15	10	0	34	0	7
0	0	0	1	0	0
0.09-0.94	0.5-4.9	0.7-1.9	4.0-101.0	0.28-1.19	0.87-4.60

Table 4. Rainfall figures from selected sites of Kenya.

Site	Type of rainfall	Amount (mm) in		Total Annual Rainfall (mm)
		Long rains	Short rains	
Maseno Station*	Bimodal	858	820	1678
Bondo (Lake Region)	"	588	518	1106
Vihiga (Highlands)*	"	1023	852	1875
Kaimosi (Highlands)*	"	1003	812	1815
Ahero (Lake Region)	"	642	577	1219
Macalder (Lake Region)	"	506	391	897
Katumani (South of NBI)	"	362	345	707
Siaya Town (Lake Region)*	"	638	592	1230

* Sites where SR-CRSP DPGs research is conducted in Western Kenya.

PERFORMANCE OF KIDS AND DOES UNDER DIFFERENT MILKING AND CREEP FEEDING SYSTEMS

by

P.P. Semenye,[1] L. Musalia[1] and H. Fitzhugh[2]

Introduction

Milk yield of a doe is dependent upon its genotype, environment and net energy availability. Depending on these factors a doe can produce milk above or below its kid's requirements. When milk is produced in excess of the kid's requirements, man can milk the surplus without injuring the welfare of the kid. On the other hand, when there is no surplus milk and man claims a share then the welfare of the kid is in danger. A kid can be starved to death and if not its growth can be retarded to affect its lifetime performance. In commercial production systems surplus milk is produced, but in subsistence systems surplus milk is hardly produced and whenever it is produced it is only marginally. Therefore in subsistence production systems as the one in Western Kenya, rational sharing of milk is a must for the short and long term benefit of man and goat production. Goats in subsistence systems produce less milk mainly due to lack of adequate nutrition, necessistated by inadequate pastures and lack of cash for purchase of concentrates. This situation prevails in Western Kenya, where due to rapidly increasing population pastures have been taken for growing food crops and farmers have no cash for purchase of concentrates (Mukhebi et al 1986). Consequently this experiment was designed to formulate a rational scheme of milk sharing along with creep feeding.

Materials and Methods

Crossbred (Small East African x 3/4 Toggenburg) kids and dams were assigned randomly into five treatments. The treatments were:

1) Forage + total suckling + rumen liquor drenching

2) Forage + total suckling

3) Forage + three quarters suckling

4) Forage + one half suckling

5) Total suckling

Kids and does were weighed weekly and monthly respectively. kids were weighed before suckling. No supplementary feed was given to the does, however all the experimental animals had access to water and mineral salt _ad lib_. Kids in Treatments 1 to 4 were given a creep feed made of fresh sweet potato leaves and vines (SPV) daily at 8 am and 4 pm. In the aternoons the

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[1]Dual-Purpose Goat Production Systems Project, P.O. Box 252, Maseno, Kenya.

[2]Winrock International, Route 3, Morrillton, AR 72110, U.S.A.

same kids were allowed to go out for grazing. Kids in Treatment 5 were kept indoors throughout the experiment and had no access to any forage. Milk yield measurements were taken by volume for Treatments 3 and 4, and 1,2 and 5 were taken daily and weekly respectively. Laboratory analysis for CP and in-vitro digestibility by Kjeldahl and, Tilley and Terry (1963) respectively.

The statistical analysis was done by the systems for statistics (SYSTAT) programme.

Results and discussion

The results of kids birth weights and their dams postpartum weights are shown in Table 1. These results are comparable to what was reported by sidahmed et al (1984). There was no significant difference between the postpartum weights of 30 and 120 days. It means during this period of the lactation, the does did not mobilize their body reserves for milk production. The does therefore were able to meet their requirements for both maintenance and production from grazing alone.

Figure 1 depicts growth curves of the different treatments. Although no significant differences were observed between the treatments interesting trends of the curves emerged. Kids in treatment one started slowly up to the second month. Thereafter they picked up probably because of the effect of the rumen liquor. After the age of two months it is assumed the kids in Treatment 1 were able to supplement their milk intake with forage more efficiently than the other treatments. It is probable these kids utilized forage on offer more effectively, because of their advanced rumen development following rumen liquor treatment. The flattening of Treatment 5 curve between the ages of three and four months suggests, milk intake of the kids was not adequate to meet energy requirements beyond maintenance level. Due to this shortfall of net energy the kids stopped growing.

Milk offtake by treatment is shown in Table 2. Milk offtake is here defined as milk taken by man for his own use. it is very obvious that Treatments 3 and 4 out-performed the others in milk offtake for man benefitted by getting 120 and 185 kg of milk in four months respectively. Offtake of milk by man from these treatments did not affect the growth of the kids, as discussed above. Therefore it is justifiable to advocate for milk offtake, when goat kids are on a suitable creep feed such as SPV. The kids dry matter intake of the creep feed (SPV) was 308 g. per day or 5% of their mean body weight. The kids also exhibited selectivity from the time they started on the creep feed. They fed on the leaves. leaving the vines as orts. Nutritively the quality of the feed and the orts were 20 and 14% crude protein and 72 and 63% in-vitro dry matter digestibility respectively.

Going by the results of this experiment, it is probable surplus milk was not produced due to lack of significant difference between the treatments in kid growth. On the other hand if it was produced it was not utilized efficiently. This could be due to low metabolic efficiency of milk-fed kids (Jagusch et al 1983). Sidahmed et al (1984) also observed a similar trend of kids having access to all of their dams' milk failing to out- perform their contemporaries with limited access. As provision of milk beyond a certain threshold does not promote kid growth, any excess should be used by man. Treatment 4 in which kids had access only to a half of their dams' milk is a pointer of where the threshold lies. Deniل ι of full access to milk apart from beneffiting man it acted as a catalyst for rumen development. As a result there is no need of drenching kids as in Treatment 1 with rumen liquor to promote rumen development. It must however, be pointed out that, where does are on concentrates their higher milk production should lower the threshold accordingly.

In conclusion man should not feel he is denying kids their rightful share of milk by taking half of it, if from the age of three weeks onwards they are provided with a high quality forage such as SPV ad lib. Then after weaning of a kid at three times its birth weight or when weighing approximately ten kg, man should feel free to harvest all the milk to the end of the lactation.

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Table 1: Birth and postpartum weights of kids and does (Kg)

Treatment	n	Birth weight ± SE	30 Days Postpartum ± SE	120 days Postpartum ± SE
1	5	2.7 ± 0.36	28.9 ± 2.50	30.0 ± 1.70
2	5	2.5 ± 0.13	31.0 ± 2.05	29.8 ± 1.16
3	5	3.5 ± 0.3 0.13	32.3 ± 2.46	31.5 ± 1.07
4	5	3.0 ± 0.0	30.2 ± 1.61	30.0 ± 1.12
5	5	2.9 ± 0.18	31.6 ± 3.66	33.3 ± 1.61
Overall Mean	25	2.9 ± 0.1	30.8 ± 1.04	30.9 ± 1.34

Table 2: **Milk offtake and total yield in four months per treatment (kg)**

Treatment	Offtake	Estimated total yield
1	0	375[a]
2	0	315[a]
3	120	465
4	185	370
5	0	300[a]

[a] Yields are probably underestimated because of poor milk let-down due to weekly milkings.

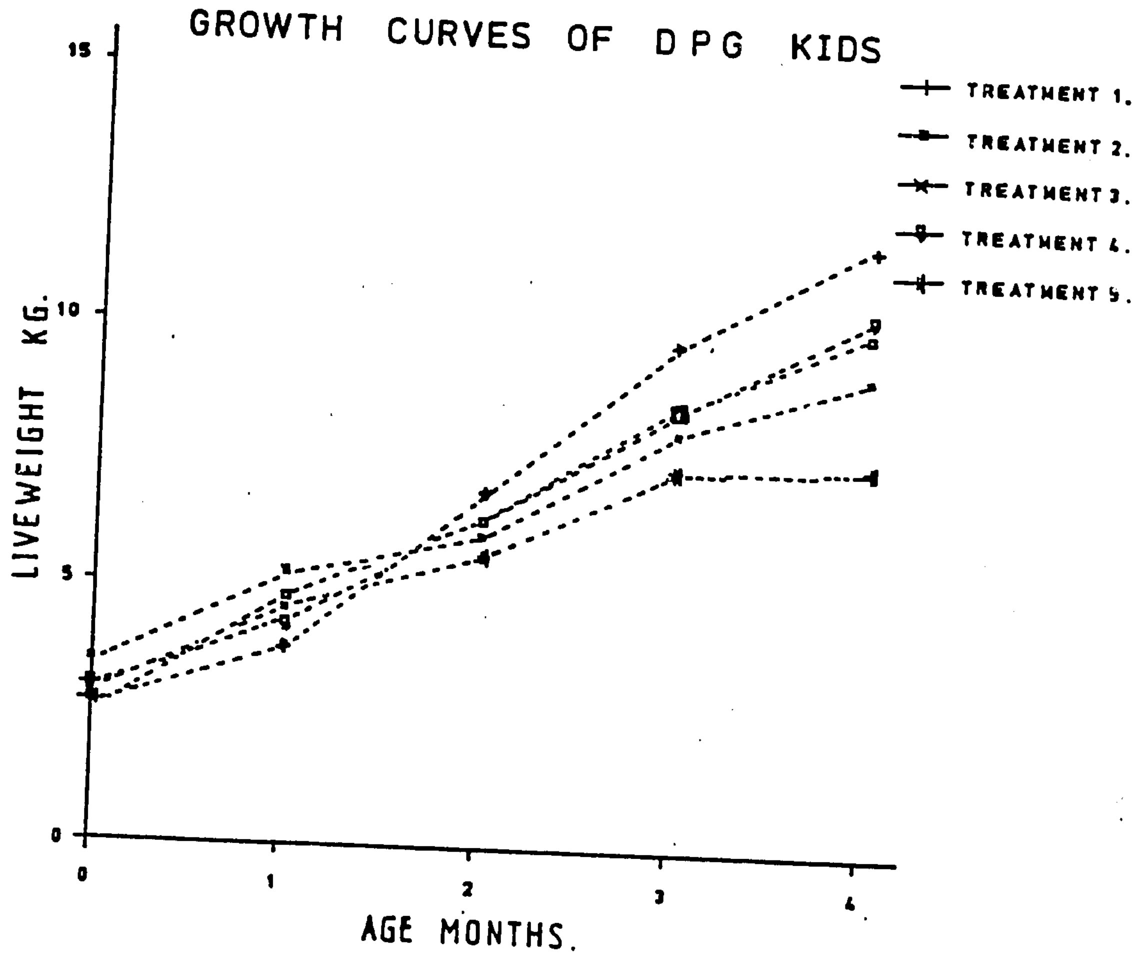
GROWTH CURVES OF DPG KIDS
LIVEWEIGHT KG.
15
10
5
0
0
1
2
3
4
AGE MONTHS.
TREATMENT 1.
TREATMENT 2.
TREATMENT 3.
TREATMENT 4.
TREATMENT 5.

FIGURE 1.

MINERAL STATUS OF DUAL PURPOSE GOATS AND FORAGE IN WESTERN KENYA

by

L. M. Musalia,[1] P. P. Semenye,[1] H. Fitzhugh[2]

Summary

Mineral levels of dual purpose goats and forages commonly consumed by the goats in Western Kenya were analysed. This was to help in designing a mineral supplementation regime for the genetically superior dual purpose goats (DPGs) in the area. In forage, calcium, magnesium, potassium, manganese, and copper levels were within the normal range recommended for goats while iron (253 PPM) was exceptionally high. Sodium (0.02%), phosphorus (0.11%) and zinc (28 PPM) levels were low and may be one of the limiting factors of animal production in the area. Browse species had higher levels of calcium ($P < 0.01$) and copper ($P < 0.001$) than grass species. Blood mineral levels were within the normal range. The daily mineral intake from forage was estimated using the daily dry matter intake of DPGs in the area (3% body wt). Supplementation of 3.6 g Ca, 3.4 g P and 1.75 g Na per day was estimated to support milk yields of 1.5 kg/day. For body gains of 150 g/day, only 1.9 g of P/day was needed.

Introduction

Mineral deficiency and imbalance in the forage has been shown to affect animal production, where livestock exclusively subsist on forages (Conrad, McDowell, Ellis, and Loosli,1984). This is hard to establish especially in marginally deficient areas where the only clinical signs may be poor growth rate, production and fertility or general unthriftness. Consequently it is advisable to analyse forages for elements in an area where animal production is low. This should be taken as a prerequisite for effective and low cost mineral supplementation. In Kenya, mineral deficiency has been demonstrated in forage from different regions of the country. The major deficiency problems are sodium (Howard, 1963; Doughall, Drysdale, 1964; Said, 1971 and Whittington and Ward, 1983) and phosphorus (Howard, 1963; Whittington et al, 1983). Low copper levels in forage has also been observed (Howard, 1963) and cobalt deficiency was demonstrated by workers from Rowett Research institute as early as 1920 (Howard, 1963) and Chamberlain (1959).

In Western Kenya, livestock are tethered or grazed on natural unimproved pastures. Cut and carry forages may be fed depending on their availability which closely follow the pattern of rainfall. However, no mineral supplement is given to livestock except for a few farmers who own exotic dairy cattle. Common salt is occassionally supplemented with an aim of increasing water intake or improving palatability of maize stover and

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[1]SR-CRSP Kenyz, P.O. Box 252, Maseno, Kenya.

[2]Winrock International, Petit Jean Mt, Morrilton, AR 72110, U.S.A.

portions of pasture which livestock do not graze. In trying to overcome the nutritional constrains to animal production in this area, most studies have been directed towards energy and protein deficiency with little attention being paid to minerals. Initiation ot a practical mineral supplementation programme in this area, needs an accurate assessment of the mineral status of pastures and fodders. This requires determination of chemical composition of forage and amount of forage consumed by livestock. Therefore, this study was undertaken to evaluate the extent to which the mineral levels in forage can support milk production and growth and to determine the likely levels at which to supplement the dual purpose goats in Western Kenya, which are crosses of Toggenburg and local East African goats (mostly 1/2 to 3/4 Toggenburg crosses).

Materials and Methods

The different forage samples collected were:-

a) Edible parts of commonly consumed browse and grass forages

b) Samples of mimicked grazing and browsing

c) Cut and carry forages

Commonly consumed browse was exclusively Lantana camara, Leonitis spp, Solanum incunum, Acanthus spp (Mexican thistle) and Euphorbia spp while the grass was Cynodon dactylon, Brachiaria spp, and Pennisetum clandestinum. Pennisetum purpureum (Napier grass), Zea mays (green maize stover) Ipomea batatas (sweet potato vines), Sesbania sesban (sesbania) and Cajanus cajan (pigeon pea) formed a good portion of cut and carry forages. These samples were collected from four different sites where Small Ruminant Collaborative Research Support Programme (SR-CRSP) have on-farm activities. This was done on a monthly basis from April to August which was supposed to cover both the dry and wet seasons. The samples were wet digested using a mixture of concentrated nitric and perchloric acids in the ratio of two to one and phosphorus (P) level determined by colorimetric method; potassium (K) and sodium (Na) by flame photometry; and magnesium (Mg), calcium (Ca), iron (Fe), zinc (Zn), copper (Cu) and manganese (Mn) by atomic absorption spectrophotometry method as described by Fick, McDowell, Miles, Wilkinson, Funk and Conrad, (1979). The results were expressed on a dry matter basis.

Blood was collected from all the goats by jugular puncture and serum collected after twelve hours. Calcium, Mg, P and Cu levels were determined as described by Fick et al, (1979).

Results and Discussion

The mean mineral levels of grazing/tethering spots, where forage was plucked by mimicking grazing goats in the four study sites is summarized in Table 1. In comparison with the recommended levels given in the same table, Ca (0.56%), Mg (0.30%), K (0.6%), Mn (139 ppm) and Cu (9 ppm) were within the normal range while Fe (253 ppm) was exceptionally high. Na (0.02%) and P (0.11%) levels were low and consistent with studies on forages in Latin

America (Conrad, McDowell and Loosli, 1982), Kiboko in Eastern Kenya (Whittington et al, 1983) and forage samples from all over Kenya (Howard 1963). The later author found that the Na level in 77% of the samples were lower than 0.01% and P was low in most samples especially those collected during the dry period.

Trace elements were adequate (Tables 1 and 2) except for Zn which was marginal. Deficiency signs have been observed in livestock on forages containing less than 40 ppm Zn (Conrad et al, 1984). The Zn level in the commonly grazed grasses (28 ppm) and browse (33 ppm) species (Table 2) was marginal according to the recommendation of 45 ppm by Mba (1982). This marginal level (Mba, 1982) coupled with the high worm infestation in the area that give rise to excessive endogenous loss of Zn from the animals (Musalia, 1985),may contribute to Zn deficiency. High levels of Fe affects utilization of Cu (SARI/SAC, 1982). This is probably why some anaemic kids suffering from worm infestation have failed to recover following treatment with antihelmintic and iron. Following high blood loss in the worm infested kids, the high Fe in the forage inhibits Cu utilization and hence hemopoiesis.

Mineral levels in blood were within the normal range for Ca (97 ug/ml), Mg (27 ug/ml), P (59 ug/ml) and Cu (0.98 ug/ml) as shown in Table 3. Adequacy of Ca, Mg and Cu both in the blood and the forage should be interpreted with caution, because concentrations of a mineral in the blood could be due to mobilization of body reserves or physiological anomally. For example P level in the blood was adequate despite being inadequate in the forage. It is possible the goats mobilised their own body reserves.

The four study areas showed no difference ($P > 0.10$) in the mean mineral level (Table 1) indicating that a similar supplementation regime could be provided. Browse species had higher levels of Ca ($P < 0.01$) and Cu ($P < 0.001$) than grass species (Table 2). Except for Pennisetum clandestinum (0.25%) all grass species had Mg levels of less than 0.17%, while for browse species all were above 0.25% except for Solanum incunum (0.19%) and Euphorbia spp (0.16%). Although the difference between grass and browse species was not significant ($P > 0.10$), a trend emerged in which K and P were higher in the former than the latter. This showed a similar trend as in the study by whittington et al. (1983). Browse is readily available along fences, roadsides and riversides which can ensure adequate supply of Mg, Cu and Ca to animals if a good fraction is included in the ration. This has an added advantage of having higher levels of protein than the grass species in dry season. Due to sporadic rains received in the dry period (July-August) it rendered seasonal mineral analysis invalid.

An average goat in this area (30 kg) with a mean intake of 3% body weight (Semenye, Musalia and Fitzhugh, 1986) gets enough Ca from pastures to support milk yields of 0.5 kg/day (Table 4). However for milk yields of 1 kg/day which is the mean for the area requires 1.3 g Ca/day to be supplied to avoid mobilization of body reserves. Supplementation at the rate of 3.6 g Ca/day is necessary to cover animals with yields of over 1 kg/day and animals that depend exclusively on grass species, which had lower calcium level (0.36%) than the mimicked forage (0.56%). Phosphorus available in forage was inadequate to supply the maintenance requirements (Table 4), so supplementation for both maintenance and milk yields must be given at the rate of 3.4 g P/day for yields of 1.5 kg/day. The Na available from forage is negligible relative to the requirements for maintenance and it would be advisable to supplement the total daily requirement of 1.75 g Na/day. Magnesium levels in pastures were enough to support yields of upto 2 kg/day.

Weight gains upto 150 g/day could be supported by Ca from pastures unlike P where gains of 50 g/day and 150 g/day will require 1.2 and 1.9 g P/day respectively. Magnesium level was adequate for daily gains of over 200 g/day.

Phosphorus, Na and Zn may be the elements limiting production in this area, However minerals not analysed, including cobalt and molybdenum may also have a role in limiting animal performance. Selenium has been shown to be adequate in the area (Mbwiria, Dickison and Bell, 1984). Supplementation studies must be carried out before confidently concluding that P, Na and Zn are deficient. Animal respense to these or other elements is what is definative.

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Table 1 Mean Mineral levels of grazing or tethering spots for each study area in Western Kenya and the mineral requirement for goats.

		% DM					ppm		
Study area	n	Ca	Mg	P	K	Na	Fe	Mn	Cu
Masumbi		.526	.321	.117	.665	.017	309	116	8
SE	8	.06	.01	.02	.06	.001	103	15	1
Hamisi		.508	.290	.087	.606	.016	258	159	11
SE	8	.06	.02	.02	.06	.002	59	22	1
Kaimosi		.661	.304	.112	.649	.016	223	123	9
SE	7	.10	.03	.01	.07	.002	55	25	1
Maseno		.600	.236	-	-	-	160	182	8
SE	4	.13	.04				17	13	1
OVERALL	27	.563	.297	.106	.634	.016	253	139	9
SE		.04	.01	.008	.04	.0009	39	11	1
Significant Test of Difference between areas		NS	NS	NS	NS	NS	NS	NS	NS
Recommended for Goat (1)		0.36	0.09	0.27		0.09	15	45	7

(1) Mba A.U., 1982; Proceedings, Third International Conference of Goat Production and Disease.

NS - Not Significant.

n - Number of samples

Table 2 Mean mineral composition of grass and browse consumed by goats in Western Kenya

Type of forage	n	DM%					PPM			
		Ca	Mg	P	K	Na	Fe	Mn	Cu	Zn
Grass		.360	.178	.156	.512	.020	222	118	7	28
SE	21	.02	.02	.01	.12	.003	62	26	1	6
Browse		.628	.214	.134	.342	.019	317	111	13	33
SE	35	.07	.03	.008	.04	.002	34	15	1	2
Significant test of diff.		**	NS	NS	NS	NS	NS	NS	***	NS

NS - Not significant

** - Significant, P < 0.01

*** - Significant, P < 0.001

n - mumber of samples

Table 3 The mineral composition in blood of dual purpose goats in Western Kenya. (kg/ml).

Study area	No. of Samples	Ca	Mg	P	Cu
Masumbi		88.6	27.4	67.7	1.16
SE	22	2	0.5	2.4	.11
Hamisi		89.6	27.6	61.4	1.21
SE	26	3	0.5	2.2	.13

Table 4 Availability of minerals for dual purpose goats from Pastures in Western Kenya and the requirements for lactation and growth.

Element	Forage % DM	Daily Intake (a) (g)	Daily Requirements (g)				
			Maintenance (b)	Growth 150/day	Lactation Yield kg/day (c)		
					0.5	1	1.5
Ca	0.56	5.04	2.0	2.0	2.2	4.4	6.6
P	0.11	0.99	1.4	1.4	0.9	1.7	2.6
Na	0.02	0.15	(d) 1.0	(d) 1.1	0.25	0.5	0.75
Mg	0.30	2.70	(d) 0.66	(d) 0.9	0.35	0.7	1.05

(a) Based on an intake of 3% by a 30 kg goat.

(b) NRC 1981, Nutrient Requirements of goats

(c) Mba 1982 + NRC 1984 Using Factorial method with Digestibilities of 50% and 85% for Ca and P respectively.

(d) SAC 1984 (growing Sheep with gains of 50 g/day)

PREFERENCE RANKING OF FORAGES BY GOATS

by

P.P. Semenye,[1] M.S. Khainga,[1] L. Musalia and H. Fitzhugh[2]

Introduction

Where land size is shrinking, at a fast rate and inparticular that reserved for grazing as in Western Kenya, cut and carry of forage becomes increasingly important. So whatever a farmer plants for eventual cut and carry must be utilized efficiently because of its opportunity cost on land and labour. The situation in Western Kenya does not make the decision by the farmer on what to grow any easier, because the climate and the soils are suitable for a wide range of fodders and dual purpose crops. Furthermore, on the animal front, the goats are known for their selectivity. consequently there is need for ranking cut and carry forages according to preference, inorder to guide farmers on what to grow and on the order of feeding. With this knowledge intake of forage could be maximized at the expense of orts.

Materials and methods

Six grade Toggenburg does were used that had an average liveweight of 36 kg. The experiment consisted of three phases. The first phase was grass species alone, the second was proteinaceous species and the third was a combination of the above two, for the first three ranked species of each phase. Each phase was represented by six species, presented in two hanging bundles of one kg each. So for each feeding, which was presented in a cafeteria style consisted of a total of 12 bundles, with each species represented by two bundles. The forages offered were in the same vegetative stage. The goats were offered leaves only incase of grass species and leaves plus succulent stems in case of proteinaceous species. There were two cafeteria sessions for one hour each at 9.00 to 10.00 am and 4.00 to 5.00 pm each day. The adaptation and the experimental period consisted of five days each. The orts were collected weighed and discarded after each feeding session. What was eaten was taken as a measure of preference ranking. The laboratory analysis consisted of dry matter and crude protein determinations.

Results

The preference ranking of grass forages is presented in Table 1, in which couch (Digitaria scalarum) and bana grass were ranked first and last respectively. The mean intake of bana grass was lower than that of couch grass by 551 g. Although bana grass had the second highest content of crude protein (CP) it ranked below other grass species with lower crude protein content.

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[1]Dual-Purpose Goat Production Systems Project, P.O. Box 252, Maseno, Kenya.

[2]Winrock, International, Route 3, Morrillton, AR 72110, U.S.A.

The preference ranking of proteinaceous forages is presented in Table 2. Sweet potato vines (SPV) ranked first and Gliricidia spp last. The SPV was consumed eight more times than Gliricidia spp.

The preference ranking of the first three species of grass and proteinaceous forage is presented in Table 3. The intake of SFV which ranked first in phase 3 is comparable to phase 2 of proteinaceous species alone at 1757 and 1689 g respectively. However, for couch grass which ranked first among the grass species was third in phase 3, with a substantial reduction which may be due to presence of more palatable forages. The rank order for phase 3 did not change from that of grass and proteinaceous species of Phases 1 and 2 respectively. However, what is noteworthy is that couch grass managed to rank above Tylossema spp a proteinaceous species.

The time of feeding (AM Vs PM) and the interaction of time of feeding by forage species, were not significant sources of variation for any of the three phases of the study.

Discussion

Lack of significant difference between the feeding sessions demonstrates the fact that selective feeding of goats was not dependent on hunger or rumen fill. Prior to the morning and afternoon feeding sessions the goat had been fasting or grazing for 16 and 6 hours respectively.

Goats are known to prefer browsing rather than grazing (Devendra 1986). This preference was obvious in phase 3 as the goats went for proteinaceous species, which are comparable to browse in CP and digestibility. It is also evident from the results of this experiment, that preference for forage is not influenced by CP content when it is more than 14%. As an example, SPV ranked fifth in CP content but first in preference ranking.

Dual purpose crops or food crops with a potential for livestock feeding is what is preferred by small scale farmers in Western Kenya (Mukhebi et al 1986). This ushers well for a dual purpose crop as the sweet potato, which ranked first out of the twelve forages included in the experiment. The palatability of SPV is also high as it has been used as a milk substitute for early weaned kids (Semenye et al 1986). Couch grass is reputed as the most troublesome of all East African weeds (Ivens 1967). For it having been ranked first among the grass species is a blessing in disguise. Farmers as they weed it, should be encouraged to take the aerial portions of it to their livestock. Tylossema spp which is an indigenous creeper for having ranked third among the proteinaceous species deserves more attention. It is noteworthy it ranked above the more established species namely, pigeon pea, Sesbania ssp and Gliricidia spp.

The recommendation to farmers from this experiment is to grow more of the species with the highest preference; and where a farmer has access to more than one species to feed the ones of lower preference first. Feeding order is important in minimization of orts.

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Table 1: Preference Ranking of Grass Species

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

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

DMD - In vitro dry matter digestibility

Table 2: Preference Ranking of Proteinaceous Species

Species	Rank	Intake g.	CP%	DMD%
Sweet potato vines	1	1689a)	17	68
Leucaena	2	1353b)	21	65
Tylossema spp	3	1199b)	14	55
Pigeon pea	4	751c)	21	69
Sesbania spp	5	684c)	21	68
Gliricidia	6	187d)	18	55

abcd) Means not having the same superscript in common deffer at $P \leq 0.05$

DMD - In vitro dry matter digestibility

Table 3: Preference Ranking of Grass and Proteinaceous species

Species	Rank	Intake g.	CP%	DMD%
Sweet potato vines	1	1757	17	68
Leucaena L.	2	1079	21	65
Couch grass	3	754	17	55
Tylossema spp	4	711	14	69
Napier (13)	5	570	9	68
Giant panicum	6	480	9	55

DMD - In vitro dry matter digestibility

DUAL PURPOSE GOAT NUTRITION AND MANAGEMENT ON-STATION AND ON-FARM IN WESTERN KENYA.

by

P.P. Semenye[1], L. Musalia[1] and H. Fitzhugh[2]

Abstract

A comparative study following the farming systems research (FSR) approach was conducted in Western Kenya. It compared the performance of dual purpose goats (DPGs) on-station and on-farm. Differences in management, labour supply, carrying capacity, water consumption, cut and carry ,forage intake and productivity are reported and discussed. On-station DPGs were more productive than on-farm DPGs by 33%.

Introduction

In order to develop and adapt an intervention in a production system to the needs of smallholder agriculturists, the farming systems research (FSR) approach holds alot of promise. Otherwise going with an intervention into a production system without researched knowledge on constraints, enhancing factors and the risk level unique to the system, more than often leads to failure than success. The first two phases of FSR are designed for this purpose. So with the constraints, enhancing factors and the level of risk known, experiments can be designed on-station and on-farm aimed at solving the problems or lowering the risk level of the intervention. It should be noted that subsistence production systems have survived and are of low productivity because of their risk avoidance strategies. So farmers in these production systems only accept interventions with very low risk levels. One way of reducing the risk level of an intervention is through its integration with other enterprises belonging to the system.

The Small Ruminant Collaborative Support Research Programme (SR- CRSP) in Western Kenya therefore adopted the FSR approach, to develop and adapt dual purpose goat (DPG) production systems to the needs of smallholder agriculturists, inorder to improve the nutrition of the people and to generate cash through sales of goat products. Towards these goals research on the first two phases of FSR have been carried out (Sands et al 1982). This paper therefore reports on the third phase of design,in which DPGs were compared on-station and on-farm.

Materials and Methods

Dual purpose Toggenburg and Small East African crossbred goats were used on-station and on-farm, to generate data on liveweights, milk production, survival, reproduction, digestibility and intake. Milk yields and liveweights measurements were taken daily and monthly respectively. Nutritive parameters for forage were measured with respect to quality and

[1]Dual-purpose Goat Production Systems Project, P.O. Box 252, Maseno, Kenya.

[2]Winrock International, Route 3, Morrilton, AR 72110, U.S.A.

quantity of forage intake. Quality of the forage was accessed through chemical composition and quantity of forage intake by total fecal collection in conjuction with in-vitro digestiblity. Once a month the goats were observed for the whole day on-station and on-farm to ascertain the duration and frequency of their different activities.
For statistical analysis the system for statistics (SYSTAT) was used.

Results

Inorder to compare the performance of DPGs on-station and on- farm, it is important to know the characteristics of the two production systems. The salient features of the systems are summarized in Table 1. From the table indications are, the farms have a higher stocking pressure than the station. However, overstocking was not apparent on-farm because goats and other livestock got compensated through cut and carry of forages from the farms or elsewhere and through feeding of crop residues and maize thinnings.

Unlike the on-farm DPGs, the on-station ones did not have their grazing areas restricted by the length of the tethering rope. On-station DPGs therefore had more grazing area and greater opportunity for selection. The on-farm DPGs had access to grazing areas ranging in size from 32 to 55 sq metres. However, the actual area utilized depended on the number of times the tethering position was changed as shown in Table 2.

The results on labour supply for tethering, and cut and carry activities shown in Table 2 were expected. On-station labour for herding, which is equated to tethering was supplied by adults, who were employees of the station. The sharing of labour by adults and children on-farm was in conformity with the fact that, smallstock are more adaptable to being handled by people of varying strength.

Access to water on-station was by piped water, hence the DPGs had water ad lib. On the farms they depended on fetched water from varied sources. Between the on-farm clusters Kaimosi DPGs got the least amount of water.

On-station DPGs were given cut and carry only as a snack following a full days grazing. Consequently, what was offered and taken amounted to no more than 100g dry matter per goat. On the other hand on-farm goats were given as much as was available to compensate for the grazing shortfall. Hamisi farmers with the smallest farm size,gave more cut and carry than Masumbi and Kaimosi farmers.

The quality and quantity of forage intake in Table 4 was comparable for both on-station and on-farm goats. Intake expressed as a percentage of the body weight was low. The percentage intake was low because of a high water content average of 70% and restrictions of grazing time through herding and tethering. An explanation to the grazing time restriction is provided by the results of an intake study, whereby DPG's intake in 24 hrs was 4.7% of their mean body weight. Water content of the forage in this trial was 73%. The high water content as a constraint is further illustrated in Table 5. As a result goats and other livestock in wet zones, have to graze a higher percentage of their body weights, to meet their maintenance requirements.

Table 6 is a presentation of production parameters used to derive productivity indices shown in Table 7. The parameters for goats were obtained from the continuing monitoring exercise. The differences between the on-station and on-farm does were 9 and 0.5 kg or 39 and 33% of the on-station mean respectively.

Discussion

Estimates of stocking rates for small holder mixed farms are of no importance because of the substantial reliance of livestock on crop residues, cut and carry fodder and grazing on communal properties for example, school and church compounds and road sides. As the control for these feed resources are not entirely, in the hands of the farmer more than often a deficit in feedstuffs results. Consequently this leads into poor performance.

The chemical composition of forages in terms of nutrients is well appreciated. However, water content of the forage as- grazed or fed requires special attention due to the gut-fill theory (Van Soest 1982). As the results of this study showed, high water content in the forage limits intake. Goats forage intake is limited by their grazing time, forage quality and quantity at their disposal and by their processing capacities. Consequently when forage of over 70% water content is fed as the sole diet of goats they fail to meet their requirements after grazing for 10 to 12 hours. This is why farmers in wet zones know their goats lose condition in lush seasons. The same is not entirely true with cattle presumably because of their larger capacity for processing forage. Another constraining factor is rainfall that falls when the forage is lush. Goats unlike cattle stop grazing once rain starts to fall. This reduces their grazing duration and hence forage intake. Nutritional inadequacy as prompted by overstocking could lead to big differences in the performance of on-station and on-farm goats as discussed above. This however, does not appear to have been the major cause of the difference between the on-station and on-farm DPGs. Differences in the doe and kid survival and in the kidding rate must have been more constraining than nutrition because of management and outlook differences. Kid survival was low on the farm, because some producers may have overmilked their does in an effort to satisfy their homes' milk demands. Overmilking of does results in insufficient milk left for the kid to meet its nutritional requirements. The kidding rate on-farm was lower because of insufficient bucks to go round each farm. Due to lack of sufficient bucks, and the reluctance of farmers to keep bucks because of opportunity cost on feed, farmers opt for buck sharing, which is not entirely satisfactory. Furthermore, the tethering practice interferes with courtship and mating. Another source of variation between the on-station and on-farm is management. On-station goats were under one manager, while on-farm managers were as many as the number of farms.

Due to the shrinking land size in Western Kenya as a consequence of rapidly increasing population, adequate land resource to provide sufficent feed for a cow is getting scarce.

As a result farmers have resulted into buying expensive tetra- packed milk because cows are being phased out of the farming system. Consequently due to the lower maintenance requirements of the dual-purpose goat, it is taken as the most logical replacer of the cow for milk production.

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Table 1: DPGs Production Characteristics On-station and On-farm

Variable	Station	Farm
Land size	150 ha.	0.5 - 6 ha.
Flock size	400	1 - 10
Herding	free grazing	tethering
Browsing	5 - 10%	10 - 20%
Cut and carry	insignificant	significant
Crop residues	none	significant
Water	ad lib	as offered
Time out-doors	7 - 9 hrs	6 - 10 hrs
Breeding	Seasonal	Open

Table 2: Tethering and cut and carry activities.

Variable	Maseno (on-station)	Hamisi (on-farm)	Masumbi (on-farm)	Kaimosi (on-farm)
No. of goats	0	24	15	15
No. of farms	1	10	5	5
Rope length metres	Nil	4.2 ± 1.0	3.8 ± 0.9	3.2 ± 0.6
Thethering position changes	Nil	1.5 ± 0.2 a)	2.8 ± 0.3 b)	1.7 ± 0.1 a)
Labour supply 1)				
Adults only	100%	30%	20%	40%
Children only	NIL	30%	20%	NIL
Shared (Adults + Children	NIL	60%	60%	60%

ab) Means within the same row having no letter in common differ at $P \leq 0.05$

1) Labour for tethering + cut and carry activities only.

± Standard error

Table 3: Water and fodder consumption of DPGs

Variable	Maseno (on-station)	Hamisi (on-farm)	Masumbi (on-farm)	Kaimosi (on-farm)
No. of goats	400	24	15	15
No. of farms	1	10	5	5
Water consumption (ml)	ad lib	608 ± 89 a)	656 ± 141 a)	345 ± 6 b)
Fodder Cut and carry (kg)	insignificant	3.3 ± 0.4 a)	1.8 ± 0.2 b)	1.3 ± 0.2 b)

ab) Means within the same row having no letter in common differ at $P < 0.05$

± Standard error

Table 4: Chemical composition and dry matter intake for DPGs forage

Variable	on-station		on-farm	
Season	Green	Dry	Green	Dry
Dry matter	27	35	27	29
Crude Protein	14	11	11	21
Digestiable dry matter	68	56	57	59
Intake DM (kg)	0.9	0.8	0.7	0.8
Intake % of BWt (DM)	2.6	2.0	2.2	2.9
Intake % of BWt (DM) (for 24 hrs	4.7	-	-	-

DM - Dry matter BWt - Body weight

Table 5: Restriction of intake due to water content

Zone	sub - humid		semi - arid
Season	Wet	Dry	Dry
Dry matter %	20	35	65
Intake kg [a)]	0.9	0.9	0.9
Intake % BWt as-fed	15	9	5

a) Intake requirements for maintenance of a 30 kg goat.

BWt = Body weight

Table 6: Productivity coefficients of DPGs on-station and on-farm

on-station on-farm Variable DPGs DPGs Cattle	on-station	on-farm
Doe survival %	95	83
Kidding %	78	65
Kid survival %	90	80
Kid weight at the age of one year	26	24
Milk Offtake kg	38	35
Average doe weight	38	35

Table 7: Productivity indices of DPGs on-station and on-farm

	Production system	
Index	on-station	on-farm
Per doe or cow per year kg	23	14
Per unit metabolic body weight kg	1.5	1.0

TOWARDS DEVELOPMENT OF A VACCINE AGAINST CONTAGIOUS CAPRINE PLEUROPNEUMONIA CAUSED BY F-38

F.R. Rurangirwa,[1,2] T.C. McGuire[1] and S. Chema[2]

Abstract

Goats were immunised against contagious caprine pleuropneumonia (CCPP) using lyophilised F-38 strain of mycoplasma. 0.15 mg of the lyophilised F-38 in saponin as an adjuvant was the minimum immunising dose that induced solid immunity. In contrast, goats immunised with two doses ten times (1.5 mg) the minimum immunising dose without saponin were not protected, like the control goats injected with saponin only. The minimum immunising dose was still effective after storing the lyophilised F-38 at 4C and 22C for 14 months. The duration of immunity induced by a single dose of the lyophilised F-38 was at least 12 months.

Contagious caprine pleuropneumonia (CCPP) is a disease of major economic importance in countries where it occurs (mainly Africa, Middle East, Mediterranean Littoral, India and Pakistan), posing a major constraint to goat production due to high mortalities. It has been suggested that the disease was first described in detail and called contagious caprine pleuropneumonia in 1889 in South Africa (1). Other reports indicate that the disease was described as early as 1831 in Kazakhstan, Russia (2).

Several species or subspecies of mycoplasma: *Mycoplasma mycoides* subsp. *capri* (3,4) *M. mycoides* subsp. *mycoides*, Large Colony (5,6,7,8,9), and more recently F-38 (10) have been incriminated as agents of a pleuropneumonia in goats which has been called CCPP. However, only F-38 has been shown to cause a disease that fits the original description of CCPP (10,1,11). Besides the typical pathological lesions, a) the disease caused by F-38 is readily contagious to susceptible goats; b) sheep and cattle are not affected; and c) no local aedematous reactions in goats when infective F-38 is given subcutaneously. Thus the very acute disease caused by F-38 is now known as "the classical CCPP".

F-38 was originally isolated in Kenya (10) and has since been isolated in Sudan (12) Libya and Tunisia (13). It is the main causative agent of CCPP in Kenya and is associated with acute CCPP outbreaks with sometimes 100% morbidity and mortality rates. Isolation of the F-38 opened opportunities for studies towards development of a vaccine and this paper elucidates to-date results on immunisation trials.

Earlier immunisation trials

Two years after isolation of F-38, goats were immunised intratracheally with a high passage of the organism. On contact challenge of the immunised

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[1]Department of Veterinary Microbiology and Pathology, Washington State University, Pullman, Washington, U.S.A., and

[2]Veterinary Research Laboratory, Kabete, Kenya.

goats one month later, 11 out of 20 vaccinated goats were protected whereas all of the controls (20 goats) contracted CCPP (14).

While investigating the effect of streptomycin in goats suffering from natural and experimental CCPP caused by F-38 (15), it was found that goats treated with streptomycin on third day of temperature reaction (40C or higher), recovered from the disease, and became completely immune to re-infection with F-38 (15). Serum samples from such recovered goats had growth inhibiting activity against F-38 (15). This observation led to immunisation of goats with sonicated F-38 antigens initially emulsified in Freund's complete adjuvant and two weeks later given a booster dose of the F-38 antigens emulsified in Freund's incomplete adjuvant. The objective of this experiement was to induce, first of all, growth inhibiting antibody and, secondly, to assess whether goats with such antibody induced by immunisation with sonicated F-38 would withstand contact challenge (16). The immunised goats with or without detectable growth inhibiting antibody were protected while the controls which had been immunised with adjuvants alone contracted and died of CCPP (16). This finding strongly suggested the possibility of a dead vaccine for CCPP caused by F-38.

A follow up using mineral oil and aluminium hydroxide as separate adjuvants was carried out. The results demonstrated that protective immunity in goats could be induced using sonicated F-38 antigens in mineral oil (Freund's incomplete) adjuvant. The immunity was still solid 6 months after vaccination (17). Aluminium hydroxide, like antigen alone, provided only 20% protection (17). Thus an unequivocal protection of goats against CCPP with sonicated F-38 antigens in an oil adjuvant was demonstrated (17).

Oil-based adjuvants, are not usually appropriate for use in animals intended for human consumption, as the oil may track through fascial planes and spoil the meat. Freund's complete adjuvant is particularly unacceptable in food animals, not only because of the mineral oil, but also because the mycobacteria in the adjuvant will render animals positive to tuberlin test, a critical drawback in any area where tuberculosis is under control. The Freund's complete and Freund's incomplete adjuvants were only used to demonstrate that in presence of appropriate adjuvant sonicated F-38 antigens could induce protective immunity in goats against CCPP (16).

A trial using saponin as adjuvant was carried out. It was found that saponin, like the oil adjuvant induced protective immunity in goats when challenged 6 months after immunisation (Mulira, Masiga and Rurangirwa, unpublished data). This finding was very important in that saponin does not leave fascial tracks which spoil meat. A series of trials were carried out using saponin as adjuvant to assess a) immunogenicity of F-38 after lyophilisation; b) immunogenicity after storage at 22C and 4C for upto 14 months and c) the duration of immunity induced by various single dose regiment of the lyophilised F-38.

<u>Lyophilisation trials</u>

Since lyophilised vaccines are easy to store and transport, a preliminary study was undertaken to find out if lyophilised F- 38 will induce protective immunity in goats against CCPP. Washed F-38 cells (17) were lyophilised in vials at a concentration of 8 mg/ml and stored at 4C. After

36 days of storage it was used to immunize eight goats at the dose rate of 8 mg/dose in a mixture of saponin and aluminium hydroxide as adjuvants. The goats received a similar booster dose 21 days later. Sixty four days after initial immunisation the vaccinated and control were challenged by contact exposure. Six out of eight control goats and only one out of eight vaccinated goat died of CCPP. These results led to the conclusion that lyophilised F-38 antigens will protect goats against CCPP caused by F-38 if and when optimal immunising dose together with an appropriate adjuvant are used.

Determination of minimum immunising does of the lyophilised F-38 natigens

Eight groups of 5 goats each were immunised with different doses containing 0.015, 0.075, 0.15, 0.200, 0.375, 0.750, 1.50 and 1.50 mg protein of lyophilised F-38. The first seven groups were immunised with the F-38 using saponin as an adjuvant. The remaining one group was immunised with the highest dose (1.50 mg) without adjuvant. The control goats were immunised with saponin in PBS, pH 7.4. All the goats were given booster doses 3 weeks later. The immunised goats along with controls were contact challenged 3 weeks after the booster dose.

The controls developed pyrexia of 40C at 14±1.5 days after exposure to infected goats and died of CCPP 8 days later. The goats that were immunised with a dose of 1.5 mg without saponin had an incubation period similar to that of the controls. Two goats immunised with the lowest amount of lyophilised F-38 (0.015 mg in saponin) developed pyrexia at 36 and 43 days. One goat given 0.075 mg in saponin had a pyrexia at 43 days. The three goats from the two groups later died of CCPP. There was no pyrexia nor any sign of illness in the goats that were immunised with ≥ 0.15 mg in saponin except that one of 5 goats immunised with 0.375 mg had a temperature reaction 40 days after contact exposure and died of CCPP 6 days later. Thus, the minimum immunising dose was 0.15 mg which protected all 5 goats given this amount.

Immunogenic stability of lyophilised F-38 at 22C and 4C for 3,9 and 14 months

Groups of goats were immunised with two doses of the minimum immunising dose (0.15 mg) of the lyophilised F-38 after storage for 3 and 14 months at 22C and 4C. Only F-38 stored at 4C was used after storage for 9 months. The immunised goats together with corresponding controls were challenged by contact exposure three weeks after the booster dose. Lyophilised F-38 kept for 3,9, and 14 months induced protective immunity to all the immunised goats. The prepatent periods of the control goats for the three test periods were 15, 17 and 22 days after exposure to the infected goats respectively. There was no indication of ill health in the immunised goats.

Duration of immunity induced by a single dose

Four groups of 30 goats each were immunised with single doses of 0.15, 0.30 and 1.2 mg of the lyophilised F-38 containing saponin as an adjuvant. The fourth group was injected with saponin in PBS. Ten goats from each group were exposed to virulent challenge by contact 3,6 and 12 months later. All the goats immunised with a single dose containing 0.15 mg and challenged 3,6 and 12 months after immunisation were protected. The goats immunised with a single dose containing 0.3 mg and challenged 3,6 and 12 months were protected except at 12 months when one goat reacted and died of CCPP. Two goats in the group immunised with 1.2 mg also died of CCPP. One died out of the group challenged at 6 months and the other one was from the group challenged at 12 months.

Some conclusions can be drawn from the results of these immunisation trials: 1) Lyophilisation and storage of F-38 at 22C or 4C do not affect its immunogenicity. 2) Large quantities of lyophilised F-38 can be produced and stored at either temperature for up to 14 months without affecting their immunogenicity. 3) Duration of immunity induced by a single minimum immunising dose of 0.15 mg lyophilised F-38 is over 12 months. Thus a stage is set for large scale production of a lyophilised vaccine against CCPP with a minimum dose of 0.15 mg, shelf life of over 14 months when stored at 22C or 4C and inducing immunity lasting over 12 months.

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A LATEX AGGLUTINATION TEST FOR FIELD DIAGONOIS OF CONTAGIOUS CAPRINE PHEUROPNEUMONIA

By

F.R. Rurangirwa,[1] T.C McGuire,[1] A. Kibor,[2] S. Chema,[2]

LATEX beads were sensitized with a polysaccharide isolated from F38 culture supernatant and used in a slide agglutination test to detect serum antibodies in goats with CCPP. The latex agglutination test (LAT) detected antibodies in the sera of goats by 22 ± 2 (mean ± 1 SD) days after contact exposure to CCPP. The complement fixation test (CFT) detected antibodies by 24 ± 4 (mean ± 1 SD) days after contact exposure. Both tests were negative with 181 sera from a farm free of CCPP. When the same tests were done on 763 sera from two different farms with outbreaks of classical CCPP, 63% were positive by LAT while 23% were positive by CFT. Besides being more sensitive than CFT, the LAT can be performed in the field using undiluted serum or whole blood and read within 2 minutes.

Introduction

CONTAGIOUS caprine pleuropneumonia (CCPP) is one of the most important diseases of goats occuring in Africa, the Middle East and Western Asia where extensive goat rearing is practised. Morbidity and mortality rates range from 60 to 80% in susceptible flocks (MacOwan, 1976; Anon, 1979). The F38 strain of mycoplasma has been demonstrated to be the aetological agent of CCPP in Kenya (MacOwan and Minnete, 1976) and Sudan (Harbi and others, 1981). Rapid diagnosis of this devastating disease is essential for immediate treatment of sick goats (Rurangirwa and others, 1981), or vaccination of goats at risk (ref) and screening of goats for purchase. Several serological tests, which include complement-fixation (MacOwan, 1976), passive haemagglutination (Muthomi and Rurangirwa, 1983) and enzyme-linked immunosorbent assay (Bari, 1984), have been developed for the diagnosis of CCPP. Unfortunately, all these tests require special equipment and trained personnel. Therefore, a simple test, suitable for use in the field, is needed for detection of CCPP infected goats. This paper describes development of a latex agglutination test (LAT) using a polysaccharide isolated from F38 mycoplasma (Rurangirwa and others, 1987) which can be used as a field test to detect antibody to CCPP.

Materials and Methods

F38 Strain of Mycoplasma

The F38 strain of mycoplasma was derived from a goat which died of fibrinous pleuropneumonia and was identical to the F38 prototype strain (MacOwan and Minette, 1976) by growth inhibition assay (Davies and Read, 1968).

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[1]Department of Veterinary Microbiology and Pathology, Washington State University, Pullman, Washington, U.S.A.

[2]Veterinary Research Laboratory, Kabete, Kenya.

F38 Polysaccharide

The polysaccharide, consisting mainly of 4 neutral sugars (glucose, galatose, mannose and fucose) and 2 amino sugars (glucosamine and galactosamine), was isolated from culture supernatant of F38 after 3 to 4 days at 37 C (Rurangirwa and others, 1987). Briefly, the supernatant pH was adjusted to 5.0 with glacial acetic acid, boiled for 1 hour, and filtered through Whatman filter paper No. 1. Two volumes of ethyl alcohol were added to the filtrate, thoroughly mixed and kept at 4 C for 24 hours. The precipitate was collected by centrifugation (1000x g, 15 minutes) and extracted with aqueous phenol as previously described (Hudson et al 1967; Rurangirwa and others, 1987). The phenol extract was separated on an ACA 44 column (Utrogel-LKB) the carbohydrate containing void volume concentrated and used for coating latex particles.

Animals

Ten goats were purchased from a single farm with no history of CCPP. The goats were kept at the laboratory premises for 2 weeks during which they were bled four times and screened for antibodies to F38 by complement fixation test (MacOwan, 1976). These susceptible goats were put in contact with goats having CCPP and bled twice a week for 2 months.

Field Serum Samples

A total of 1231 goat sera from different farms in and outside Kenya were obtained. One hundred and eighty-one sera were from a farm in Kenya which had no history of CCPP. Seven hundred and sixty-three were from two Kenya farms located in non- adjacent districts with active CCPP: 256 were from Farm 1 and 507 were from Farm 2. Another 154 sera were obtained from goats from different parts of Northern Kenya collected for sale at Marsabit. The remaining goat sera were submitted to the Veterinary Research Laboratory, Kabete, Kenya from Somalia (87) and Kalamoja, Uganda (47).

Another 205 goats from herds with a history of CCPP were bled. Whole blood was tested by LAT at the time of bleeding. The blood was taken to the laboratory, serum collected and tested by LAT.

Sensitization of Latex Beads with F38 Polysaccharide

Latex beads (1.08 u) were purchased from Sigma Chemicals as a 10% suspension. One ml of the latex beads was mixed with 1 mg polysaccharide in 1 ml phosphate buffered saline pH 7.4 containing 0.2% sodium EDTA and 0.01% sodium azide (PBSEA). This concentration was arrived at by preliminary tests using known positive and negative sera. The mixture was shaken and incubated at 37 C for 1 hr. Then, 8 ml of PBSEA was added.

Latex Slide Agglutination (LAT)

Ten microliters of undiluted serum or whole blood were mixed with 10 ul of the polysaccharide sensitized latex beads on a slide, shaken and agglutination read visually after 2 minutes. Samples causing any visible agglutination were recorded as positive.

Shelf Life of the Sensitized Latex Beads

The sensitized beads were divided into four portions. The first three portions were stored at 4 C, room temperature and 37 C respectively. 10 ul of each of these portions were tested weekly for reaction with antibodies in standard positive and negative sera. The fourth portion was incubated at 60 C for 2 hrs and tested for reactivity against the standard sera after standing at room temperature for 2 hrs.

Complement-Fixation Test

A CFT using F38 antigens (MacOwan, 1976) was performed on all of the serum samples.

Results

LAT and CFT of Sera from Experimentally Exposed Goats

Temperature increases (≥40 C) were observed at a mean of 15±3 days after CCPP contact exposure of normal goats and the LAT was positive at a mean of 22±2 days after contact exposure in 8 of the 10 goats. The remaining two goats died 5 and 7 days after a febrile reaction and did not have detectable serum antibodies.

Complement-fixing antibodies to F38 were detected at a mean of 24±4 days after contact exposure. As with the LAT, no complement-fixing antibodies were detected in the 2 animals which died 5 and 7 days after a febrile reaction.

LAT and CFT of Field Serum Samples

Sera obtained from a farm with no history of CCPP were LAT negative (Table 1). Two farms had outbreaks of CCPP; 59% of sera from farm 1 were LAT positive and 65% farm 2. All the samples from Somalia were negative, whereas, 19% of the samples from Uganda (Kalamoja) and 5% of the samples from Kenya (Marsabit) contained antibodies to the F38 polysaccharide.

As with LAT, all the sera from the CCPP free farm and Somalia were negative by the CFT (Table 1). Only 27% of the animals from Farm 1 and 20% from Farm 2 had complement-fixing antibodies to F38. None of the samples from Uganda and Kenya (Marsabit) were positive.

Comparison of LAT with whole blood and serum

Ninety percent of 205 samples gave the same LAT result with whole blood and serum (Table 2). The remaining 10% were equally divided between whole blood positive, serum negative and *vice versa*.

Storage of Sensitized Latex Beads

Incubation of the sensitized latex beads at different temperatures did not alter their activity. The portions kept at 4 C, room temperature and 37 C were still active after storage for 6 months. Also, incubation at 60 C had no effect on the agglutination.

Discussion

Isolated polysaccharide from F38 mycoplasma sensitized latex beads and was the basis for a LAT which detected serum antibodies from CCPP infected goats. The specificity of the LAT was demonstrated by the appearance of antibody in goats 24 days after experimental exposure to CCPP. The time of antibody detection by LAT was similar to CFT which is commonly used to assess the presence of antibodies to F38 mycoplasma and to evaluate other tests (Muthomi and Rurangirwa, 1983; Bari, 1984).

Both LAT and CFT gave negative results with sera obtained from farms with no history of CCPP. However, results with serum samples from farms with an outbreak of CCPP demonstrated that LAT was more sensitive than CFT by detecting antibodies in more than twice the number of animals. Neither test detected antibody in two animals dying of acute CCPP 5 and 7 days after temperature increases.

The sensitized latex beads did not show any change in reactivity after being held at 4 C, room temperature and 37 C for 6 months. Even when they were incubated at 60 C for 2 hours, the beads did not show any change in reactivity. The shelf-life of the sensitized beads at different temperatures makes it possible to prepare large amounts which can be easily stored until used.

In conclusion, the LAT can be run in 2 minutes on whole blood or serum, requires no equipment or storage facilities and is adaptable to any laboratory or field situation. Therefore, LAT is an excellent procedure for screening large numbers of sera or for use in field diagnosis of CCPP.

Acknowledgements

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Table 1. Antibody detection by LAT and CFT in field sera

Source of Samples	No. of Positive/Tested	
	LAT	CFT
Kenya (CCPP Free Farm)	0/181	0/181
Kenya (CCPP Active Farm 1)	151/256 (59%)	70/256 (27%)
Kenya (CCPP Active Farm 2)	331/506 (65%)	103/506 (20%)
Kenya (Marsabit)	7/154 (5%)	0/154
Somalia	0/87	0/87
Uganda (Kalamoja)	9/47 (19%)	0/47

Table 2. Comparison of LAT on Whole Blood and Serum

		Serum		Total
		Positive	Negative	
Whole blood	Positive	52	9	61
	Negative	10	134	144
	Total	62	143	205

EFFECT OF COLOSTRUM FROM GOATS IMMUNIZED WITH A CLONE OF *TRYPANOSOMA CONGOLENSE* ON SURVIVAL OF KIDS INFECTED WITH THE SAME CLONE

By

D.M. Mwamachi,[1] F.R. Rurangirwa,[2] T.C. McGuire[2] and S. Chema[1]

Introduction

After successful introduction of the dual purpose goat in Western Kenya, there will be need to introduce it into other areas of the country. Some of these areas such as parts of Machakos and Coast Provinces are trypanosome endemic and the introduction of the goat into such areas may result in considerable economic losses through poor performance and death due to trypanosomiasis.

It has been demonstrated that local breeds of sheep and goats survive an experimental infection with *T. congolense* better than exotic breeds (Griffin and Allonby, 1979). Such a characteristic has also been observed in N'dama cattle in West Africa and is referred to as trypanotolerance. The mechanism behind the reduced susceptibility of these breeds to trypanosomiasis is not clearly understood but several contributory factors have been suggested including genetic constitution, superior immune response, coat colour and skin thickness (Murray *et al*, 1979). However the loss of trypanotolerance on moving trypanotolerant cattle from one geographical location to another would suggest an environmental influence (Ikomi, 1981). In this work we demonstrate that kids fed on colostrum from goats immunized with a clone of *T. congolense* increases the chances of the kids surviving an infection with the same clone.

Materials and Methods

Galla goats without any evidence of prior exposure to trypanosomiasis were immunized with the variant specific glycoprotein (VSG) of *T. congolense* clone 1180 when they were 3-4 months pregnant. After birth, the kids were allowed to obtain colostrum from their dams, and 8 days after birth 17 such kids (test kids) and 9 others born of unimmunized dams (control kids) were infected intravenously with 103 parasites of *T. congolense* clone 1180. Starting 5 days post-infection, the course of infection was monitored by recording rectal temperatures, packed cell volumes (PCV) and parasitemia three times a week.

The kids were also bled for serum and weighed once per week. Body weights and PCVs of uninfected kids (uninfected controls) were recorded for comparison. The serum was used to monitor the humoral immune response to the trypanosome clone by enzyme linked immunosorbent assay.

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[1]Ministry of Livestock Development, Kenya.

[2]Washington State University (CRSP).

Results

Parasitemia became patent 5-9 days post-infection in both the test and control kids. Mean parasitemia was significantly lower ($p \leq 0.05$) in the test kids than in the control kids except for the early and late stages of the experiment (Fig. 1).

The PCV started dropping in the test as well as control kids as soon as parasitemia was patent. The mean PCV drop was significantly smaller ($p \leq 0.05$) in the test kids than in the control kids after two weeks post-infection. However the mean PCV of the test kids was significantly lower ($p \leq 0.05$) than for the uninfected control kids (Fig. 2).

The test kids showed a better mean weight gain than the control kids. By the second week post-infection the difference in weight gain was significant ($p \leq 0.01$). For the whole experimental period the test kids gained an average of 0.43 kg/week which was equal to the average weight gain for the uninfected controls. On the other hand the control kids gained an average of only 0.20 kg/week (Fig. 3).

Twenty four to 48 hours after birth alltestkids had detectable antibodies. In two such kids the titers exceeded those of corresponding dams whereas in two others the titers were lower. One week after infection all except two control kids developed detectable antibodies. In the course of infection, the test kids developed higher antibody titers than the controls, the highest titer for test kids being 5120 compared to 2560 for control kids.

On average the test kids survived the infection significantly longer ($p \leq 0.05$) than the control kids. For the test kids the survival time was 89 ± 37 days while for the control kids it was 42 ± 6 days. Forty-eight days post-infection 1 of 17 test kids had died compared to 14 of the 15 control kids. By the time all control kids had died, (day 51), 15 test kids were still alive. All kids died by day 159 post-infection (Table 1).

Discussion and Conclusions

The lower levels of parasitemia and lower degrees of anemia, the higher growth rates and the longer survival times exhibited by the test kids compared to the control kids, indicate that colostrum from immunized dams improved the chances of survival of the test kids. The mode of action was not elucidated. The presence of specific antibodies in colostrum could have acted in unison with phagocytes and complement to effect longer survival of the test kids. It has been shown in mice that reduced susceptibility to T. congolense infection is associated with an enhanced quantitatively superior immune response (Morrison and Murray, 1985)The lack of circulating antibodies to the parasites in the control kids at the time of infection permitted the parasites to multiply with pronounced pathogenic effects and enhanced death. Failure to completely clear the parasites may have been due to a small fraction of the parasites having changed their variant specific glycoprotein thus evading destruction by specific antibody. This phenomenon known as antigenic variation (Vickerman, 1978) may have led to the eventual death of the test kids by the emergence of antigenic variants completely dissimilar to T. congolense clone 1180. In such a situation the test kids will be as susceptible as the control kids. Therefore, immunization of dams with several variants as would occur in trypanosome endemic areas should lead to longer survival periods than recorded in this study. Antibodies to several variants contacted by such dams should be passed to the offspring through colostrum giving the latter some protection against the disease early in life. As a strategy for the introduction of goats (especially exotic breeds) into trypanosome endemic areas, as kids they should get access to colostrum from dams from that area.

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Legends (Footnotes) to Figures

Fig. 1: Mean parasitemia in the test kids (+-+-+-) and infected control kids ( ) following infection with T. congolense clone 1180.

Fig. 2: Mean packed cell volume in the test kids (+-+-+-), infected controls ( ) and non-infected controls (x-x-x-) following infection with T. congolense clone 1180.

Fig. 3: Mean body weights of the test kids (+-+-+-), infected controls ( ) and non-infected controls (x-x- x-) following infection with T. congolense clone 1180.

Table 1: Survival times for test as well as control kids followinginfection with *T. congolense* clone 1180.

Test Kids		Control Kids	
Kid No.	Days	Kid No.	Days
2201	74	2240	42
2202	55	2241	42
2203	63	2242	33
2204	64	2243	37
2210	113	2245	41
2211	162	2246	51
2212	101	2247	48
2213	36	2250	46
2215	75		
2216	75		
2219	65		
2221	118		
2222	51		
2223	111		
2224	133		
2225	158		
2230	159		
MEAN ± S.D.	89 ± 37		42 ± 6

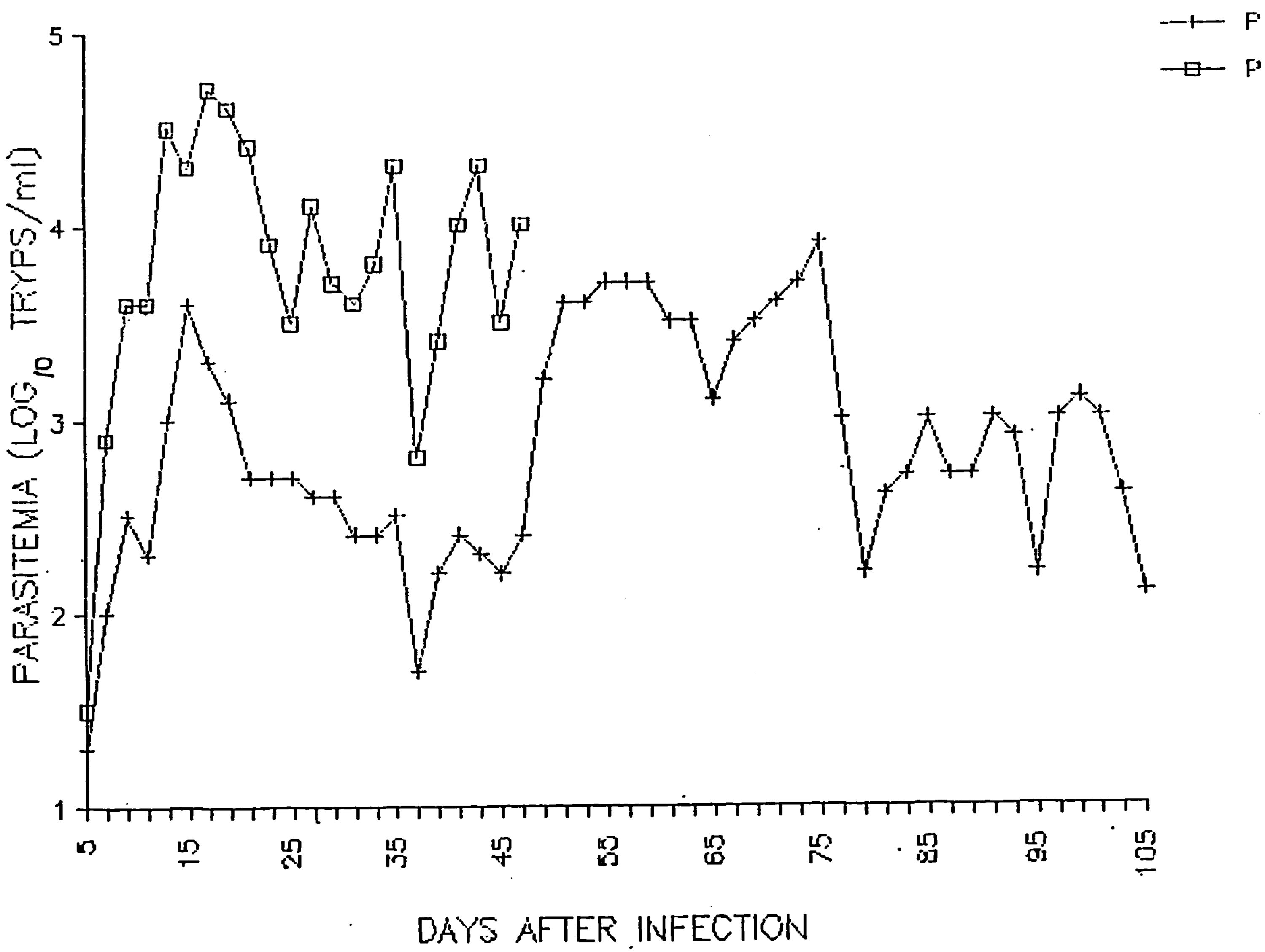
F
P
PARASITEMIA (LOG10 TRYPS/ml)
1
2
3
4
5
5
15
25
35
45
55
65
75
85
95
105
DAYS AFTER INFECTION

FIGURE 1.

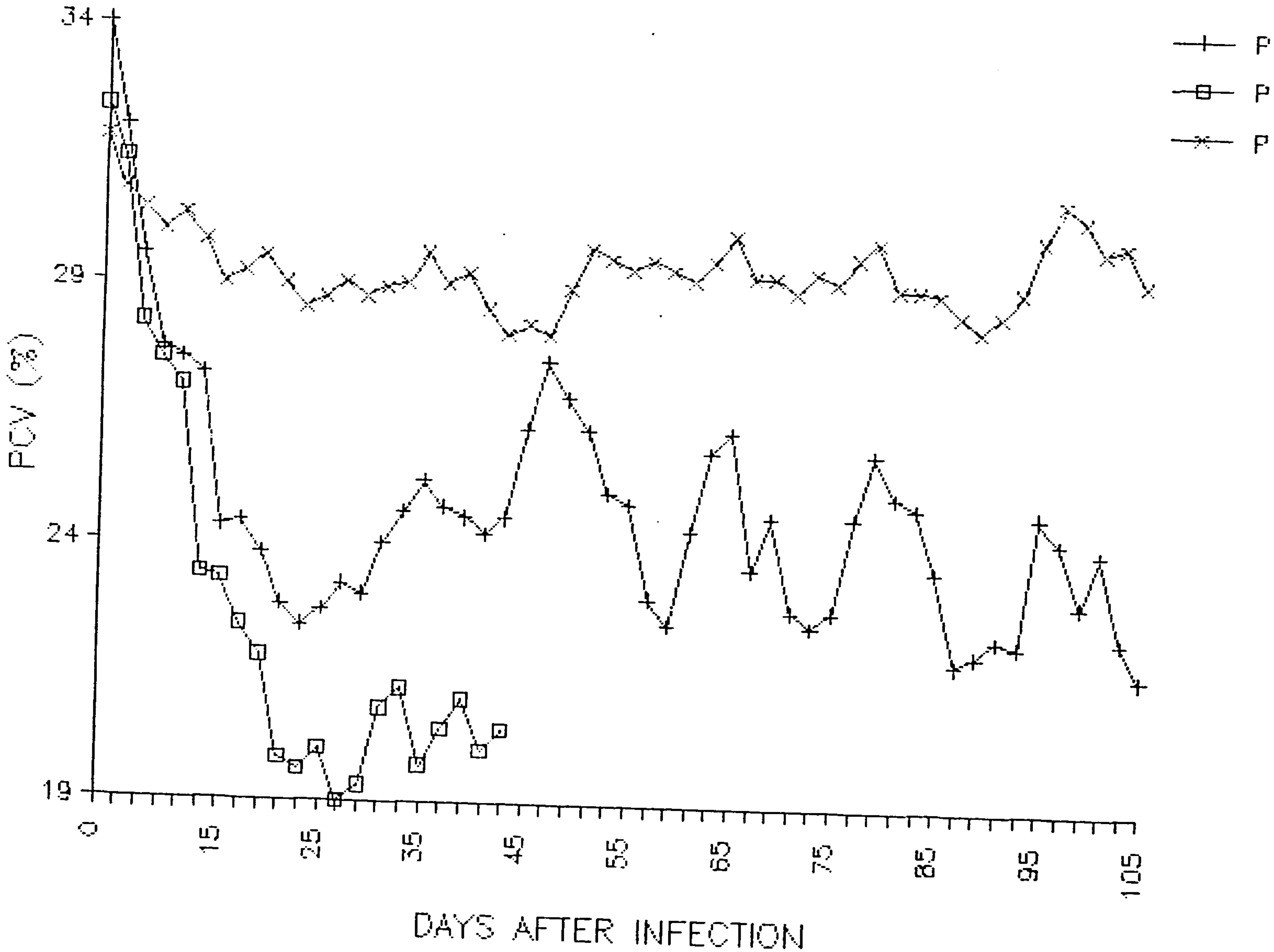
P
P
P
34
29
24
19
PCV (%)
0
15
25
35
45
55
65
75
85
95
105
DAYS AFTER INFECTION

FIGURE 2.

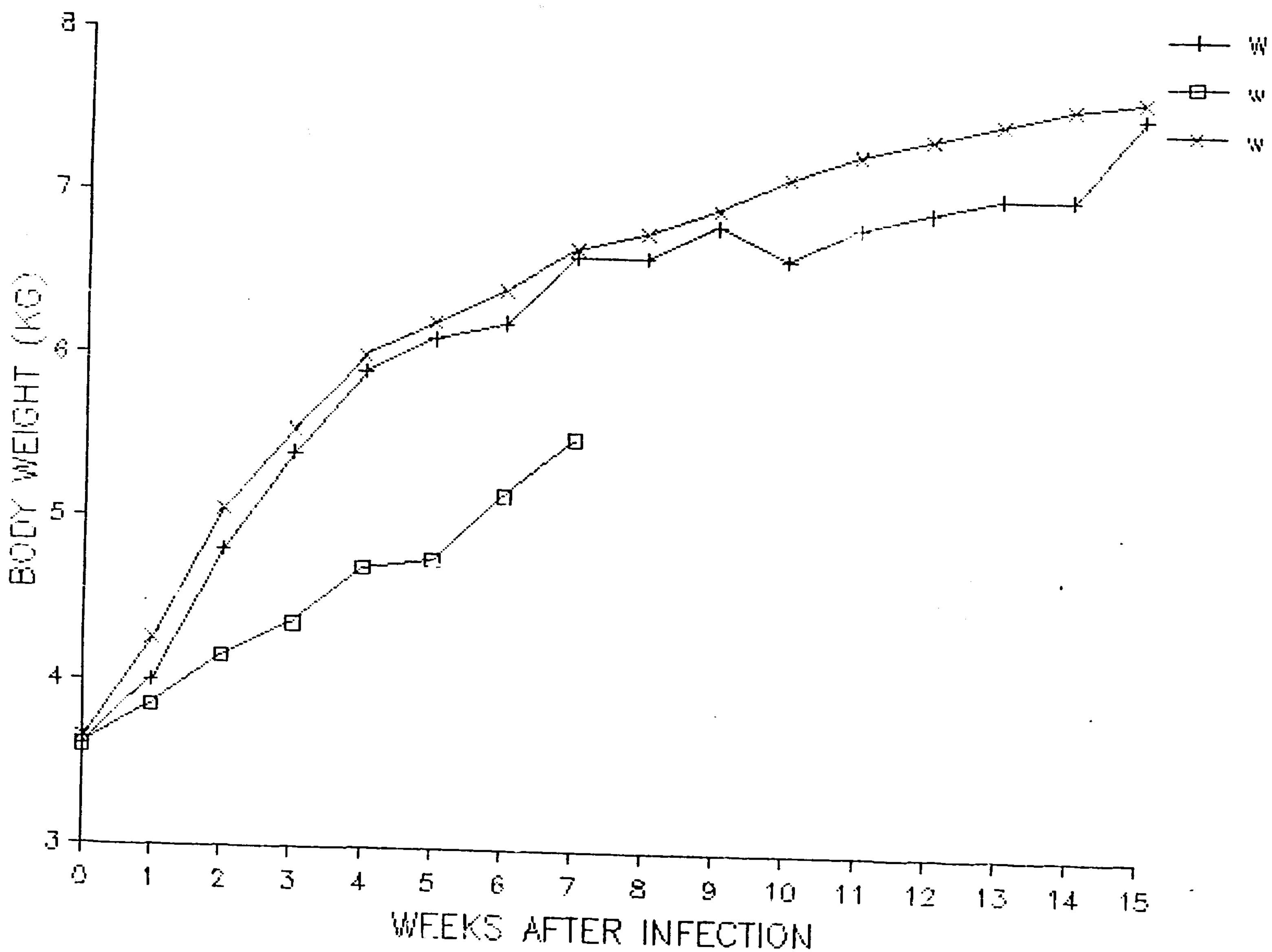
BODY WEIGHT (KG)
3
4
5
6
7
8
WEEKS AFTER INFECTION
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
W
w
w

FIGURE 3.

DISEASE AS A CONSTRAINT TO THE INTRODUCTION OF EXOTIC GOATS ON SMALLHOLDER FARMS IN WESTERN KENYA

by

Shavulimo, R.S.,[1] Rurangirwa, F.,[2] McGuire, T.,[2] Chema, S.[1]

Summary

The Small Ruminant Collaborative Research Support Programme has undertaken to evaluate the potential of dual purpose (milk and meat) goat production on smallholder farms in Western Kenya. The animal health project mounted a health monitoring exercise lasting eight months to determine the important health problems affecting the newly introduced dual purpose goats.

Differential egg counts were done monthly and faeces from each site were cultured to identify the genera of nematodes. Egg counts indicated that strongyles were predominant while strongyloides and tapeworms ranked second and third respectively. Faecal cultures indicated the Haemonchus contortus larvae were the most dominant (51%), followed by Trichostrongylus sp (40%) Oesophagostomum sp (8%) and Strongyloides sp (1%). Discharge of eggs persisted throughout the study inspite of a regular treatment with a broad spectrum anthelmintic.

The mean haematocrit values also monitored throughout the study remained within normal range. Amongst the infectious conditions mastitis, caused mostly by Streptococcus agalactiae, and bacterial pneumonia, caused mainly by Pasturella haemolytica, were the most important. Other infectious conditions that occured are indicated. Of the non-infectious conditions, mineral deficiencies in the does was the most significant. Other non- infectious diseases are discussed. Tables and figures accompany the description on the above diseases.

Introduction

The population of goats in Kenya stands at about eight million, compared to five million sheep and nine million cattle. Four million of the goats are found on smallholder farms in the pastoral areas and highlands and amongst these there appear to be only about six thousand which can be classed as improved goats (Stotz, 1983).

Little research had been done on goats in the early days of livestock development in Africa and almost none on the dairy goats adapted to the climatic and health stresses of the humid tropics (Fitzhugh, 1982). Devendra and Burns (1983) observed that there were rapid advances in animal production research in the tropics, but the veterinary aspects, especially in intensive husbandry in the tropical climates, remained neglected.

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[1]Veterinary Department, Maseno Research Station, P. O. Box 25, MASENO, KENYA.

[2]Washington State University, Pullman, U.S.A.

Goats are an important component of the economy of the small farmer in Kenya. Increasing the efficiency of goat milk and meat production through crossbreeding exotic with native goats will result in higher incomes and increased availability of animal proteins. Disease problems would, however, be a constraint to the introduction of exotic goat breeds. The Small Ruminant Collaborative Research Support Programme (SR-CRSP) has therefore undertaken multidisciplinary research in Western Kenya to evaluate the potential of dual-purpose (milk and meat) goat production on smallholder subsistence farms. As a prelude to determining the strategies for reducing disease problems, the health project of the SR-CRSP did a one year health survey in the local goats onfarms in Western Kenya (Abinanti et al, 1982). Some crossbred goats were introduced on farms in late 1982. In 1983 th health project initiated a herd health programme. The results reported here cover a period of eight months from June, 1983 to February, 1984.

Materials and methods

Location:

The study was conducted in four clusters of farms in Western Kenya where SR-CRSP had placed goats. Masumbi is one of the clusters in Siaya District, Kaimosi and Hamisi are in Kakamega district, while Maseno is in Kisumu district. Figure 1 is the map of Western Kenya showing the study areas.

All the sites have a bimodal rainfall pattern with an annual mean ranging 1000 and 1300 mm for the medium potential areas of Siaya district and 1750 to 2100 mm for the high potential areas of Kakamega and Kisumu districts (Sands et al, 1982). The farm sizes range between 0.9 and 1.09 hectares (Sands et al, 1982; DeBoer et al, 1984).

Animals:

Most of the goats were crosses of 3/4 Toggenburg with 1/4 East Africa, a few were 1/2 crosses of the same breeds (Khainga et al, 1984). The mean population of the goats during the study period was 135, composing does and 30 bucks of mixed ages.

Design:

a) Routine specimen collection was undertaken in order to screen for various disease condition. This was based on the finding of the 1980/81 health survey (Abinanti et al, 1982). Every month five grams of faeces was collected from each goat. A differential worm egg count was done usingthe modified McMaster technique (Whitlock, 1960). Along with screening for worms, whole blood was collected for determination of haematocrit using the microhaematocrit centrifuge.

Every three months 10 ml of serum from each goat were submitted to the laboratory for screening for contagious caprine pleuropneumonia by complement fixation test (MacOwan, 1976), caprine arthritis encephalitis by agar gel immunodiffusion test (Sherman, 1984) and brucellosis by serum agglutination test.

b) There was a clinical case follow-up whereby every sick goat was reported by the field staff to the project veterinarian. A clinical examination was made, specimens were collected for further laboratory tests and then an appropriate treatment was administered on the basis of a clinical diagnosis. All dead goats were autopsied and specimen were taken for laboratory confirmation of the diagnosis.

Results:

Endoparasites:

Table 1 summarises the laboratory results for differential egg counts. The mean egg count was highest for strongyles, 460±52.6 EPG, while the strongyloides, then mean count was 257±281.0 EPG and the lowest count 20±27.5 EPG was tapeworms.

Table 1: Means of differential egg counts for eight months for all the four sites in the dual-purpose goats

	Average Size	Mean EPG	Proportion with >500 EPG	EPG Range
Strongyles	93	460±52.6	20.9%	100-9200
Strongyloides	93	257±28.1	11.9%	100-8000
Tapeworms	93	20±27.5	1.3	100-4900

The strongyle eggs were predominant, they were detected throughout the eight months of the study with the lowest monthly mean value of 282 EPG. The monthly mean EPG for strongyloides remained low until October 1983 when there was a sudden rise to 668 EPG. Figure 2 illustrates the monthly egg counts for strongyles, strongyloides and tapeworms. Figures 3a and b show the rainfall distribution for the whole year.

The results of faecal culture for identification of larvae are summarised in Table 2.

Table 2: Differential larvae counts

	Haemonchus	Trichos-trongylus	Oesopha-gostonum	Strongy-loides	Others	TOTAL
Masumbi	61.36	36.36	2.28	-	-	100
Kaimosi	57.14	41.43	1.43	-	-	100
Hamisi	41.25	36.25	20.00	2.50	-	100
Maseno	42.76	46.05	10.53	0.66	-	100
Mean	50.63	40.02	8.56	0.79	-	100

Haemonchus sp was the predominant strongyle nematode constituting 50.63%, Trichostrongylus was 40.2% while 8.5% of the larvae were Oesophagostomum sp and 0.8% Strongyloides.

Out of 365 whole blood specimen analysed for PCV 32 (8.8%) had a PCV level of less than 20%. The mean PCV for all the samples was 28.6%. Thus only 8.8% of the goats could be said to be anaemic. The lowest PCV recorded in the study was 10%. Table 3 shows the mean values of PCV.

Table 3: Mean Values of Packed Cell Volume (PCV)

	Herd size	Mean PCV	Range
July 1983 First Sample	77	28.4	10-46
October 1983 Second Sample	143	29.3	10-42
January 1984 Third Sample	145	28.1	10-41
Mean	121	28.6	28.2-29.3

Bacterial infections:

(a) Mastitis: Out of 50 lactating does 18(36%) had clinical and subclinical mastitis detected by physical examination of the udder, California mastitis test and laboratory culture of milk samples. (Guss, 1984). Streptococcus agalactiae was the commonest cause of mastitis in these does. Other bacteria identified were S. dysagalactiae, Staphylococcus aureus, E. coli and, in only one case, Bacillus coagulans.

(b) Pneumonia: A total of 35 cases, constituting a morbidity rate of 25.7%, of pneumonia were diagnosed clinically, most of them in the young pre-weaned kids. A mortality rate of 2.2% was associated with pneumonia. Bacteriological culture identified Pasteurella haemolytica, it was isolated in nearly all the cases.

There were, however, very few cases where Klebsiella spp, E. coli and Corynebacteria pyogenes were isolated.

(c) Brucellosis: During the eight months a total of 152 sera from only does were submitted to the laboratory for brucellosis screening. Three were positive on SAT and all were negative on CFT and RBPT. The three were negative on repeat SAT.

(b) Contagious caprine pleuropneumonia (CCPP). A total of 152 serum were submitted for CCPP screening they were all negative.

Viral infectious:

Caprine arthritis (CAE). Screening for this disease was done and all of the 152 serum samples which were negative.

Contagious ecthyma (Orf):

Throughout the monitoring period only four clinical cases confirmed in the laboratory occured on one farm in Masumbi. These constituted a morbidity rate of 3%. There was no mortality associated with this condition.

Fungal infections:

Cutaneous streptothricosis (Dermatophilosis) caused by *Dermatophilus congolensis*. Three animals showed clinical dermatophilosis. The organisms wre identified from the skin scrapings.

Ectoparasites:

Sarcoptic mange: 13 clinical cases were observed in Maseno while two cases occured in Masumbi. The 15 cases were confirmed in the laboratory. These constituted 11.1% morbidity. Only one animal died with severe cutaneous lesions.

Fleas: Dog fleas, were observed on goats on most farms, but they caused no concern and no quantitative study was done since the numbers observed were small.

Ticks: A separate tick survey was carried out (Mwangi et al, 1983) where a low infestation was reported.

Table 4 is a summary of all the infections conditions - excluding endoparasites. The overall morbidity due to infectious conditions was 57.8% and a mortality rate of 3%.

Table 4: Infectious conditions in goats in all the four locations

	Maseno	Masumbi	Hamisi	Kaimosi	Total/ Morbidity	Total Mortality
Bacterial Mastitis	17	-	1	1	18 out of 50 36%	-
Pneumonias	30	5	-	-	35 out of 135 25.9%	3 2.2%
Brucellosis	2 on first SAT	1 on first SAT	-	-	3 2.2%	-
CCPP	-	-	-	-	-	-
Viral Contagious Ecthyma	-	4	-	-	4 2.9%	-
CAE	-	-	-	-	-	-
Fungal	1	-	2	-	3 2.2%	-
Ectoparasites Sarcoptic Mange	13	2	-	-	15 11.1%	1 0.74%
Total	63	12	3	0	78 57.8%	4

Non-infectious conditions:

Table 6 summarises the conditions attributed to causes other than the infectious organisms or parasites.

Metabolic:

Mineral deficiency was one ofthe conditions observed exclusively in the lactating does, a total of 12 (8.9%) were observed clinically, with a mortality rate of 3%. There was no laboratory confirmation of any of these cases, however, the response to treatment gave a strong indication of magnesium, calcium and phosphorus deficiencies. In the category of metabolic conditions malnutrition was the other problem observed with 7 cases constituting a morbidity rate of 5.2% and a mortality of 2 (1.2%). From observations these were cases where farmers unintentionally starved the animals either by giving them too little fodder or just tethering them in one place for the whole day every day. Rapid improvement was always observed when the animals were put on concentrates and high protein fodders.

Plant poisoning:

3 animals died all with a history of having eaten the posisonous variety of cassava, commonly found in Masumbi.

Abortions:

Amongst 50 pregnant does 5 (10%) had abortions. In all the cases no bacteria were isolated from the foetuses and serological tests were negative for brucellosis.

Wounds and Trauma:

An accident cause a fracture of the right carpus bones in one goat and two had serious barbed wire wounds, one on the teat and the other on the hind limb. These three cases made up a morbidity rate of 2.2%. There were no deaths.

Table 5: Disease of non-infectious causes in all the four sites

Disease	Maseno	Masumbi	Hamisi	Kaimosi	Total/ Morbidity	Total/ Mortality	REMARKS
Metabolic Mineral Deficiencies	6	2	3	1	12 8.9%	4 3%	Magnesium Calcium Phosphorus
Malnutrition	3	2	1	1	7 5.2%	2 1.5%	
Plant Poisoning		3	-	-	3		Poisonous variety cassava
Abortion Non-Specific Causes	3	1	1	-	5 out of 50 10.0%	-	Stress factors suspected
Wounds/ Trauma	2	-	-	1	30 2.2%	-	
TOTAL	14	8	5	3	30 22.2%	9 6.7%	

A total of 108 animals were sick throughout the period of the study constituting a morbidity rate of 80% 13 (9.6%) died during the same period. Infectious conditions with a predominance of bacterial pneumonias caused the highest morbidity. Mortality was fairly low throughout the period. All this excludes endoparasites.

Discussion:

The results of the differential egg counts and faecal cultures indicate the Haemonchus contortus is the most dominant endoparasite in this region. According to estimates by Preston and Allonby (1979) there was a loss of 26 million dollars in Kenya's agricultural sector due to haemonchosis in sheep. Although most of the information available on haemonchosis in on sheep, there is increasing evidence that the infection is equally important in goats in the tropics (Obi, 1982; Yadav and Sengar, 1982; and Hernandez Nauz, 1982).

Studies in Kenya have supported this view (Preston and Allonby 1978; Abinanti, Carles and Schwartz, 1982; and Njanja 1985). Although throughout the period of the study all the goats were on a monthly drenching in the dry months of July to September during time when one would have expected in reinfection rates to be low.

The mean egg count of 460 for strongyles could not be regarded as high, but some workers have demonstrated that even subclinical infestation, defined as levels of infestation which do not show apparent symptoms of disease, do significantly affect productivity (Spedding, 1957, Todd, 1974).

These results together with the results of the earlier survey (Abinanti et al, 1982) point to the importance of helminth infections. There is need to study further the susceptibility of the newly introduced dual purpose goats to helminths and the possibility of selecting for resistance to helminths

The bacterial pneumonias and mastitis in the does caused serious concern among the farmers. The goats were kept in the same houses as cattle at night and during the day they were grazed together. This may be one reason why the commonest aetiological agent for mastitis was S. agalactiae, also a widespread cause of mastitis in cattle. With the expansion of the SR-CRSP work on the farms in Western Kenya, there is a need to incorporate simple hygiene for mastitis control in the herd health package. The pneumonias affected mostly the young of pre- weaned age. It was an interesting finding that, both in the earlier study (Abinanti et al, 1982) and the present one, none of the animals screened were positive for CCPP, a widespread and great killer of goats elsewhere in Kenya. This freedom is probably due to limited contact amongst goats on smallholder farms. These bacterial conditions are likely to affect productivity to a greater extent in the exotic goats. In both cases management will paly an important role in their control.

Viral and fungal infections did not appear to be persistent problems. This result confirmed the finding by Abinanti et al (1982). Although Orf was observed only once, there was fear that if it was ignored and spread to the kids it might have affected them more seriously by preventing them from feeding. Orf vaccine is available in Kenya, a vaccination programme will minimize the incidence of the disease.

Sarcoptic mange occured in one very serious outbreak in Maseno resulting in mortality. If it is not detected early and treated it could cause serious losses. In the various categories of non-infectious diseases, the mostoutstanding were the metabolic diseases. Mineral deficiency diagnosis was arrived at from clinical manifestations and dramatic response to therapy with electrolytes. It was observed only in lactating does. Magnesium - calcium - phosphorus complex was regarded as the cause. Malnutrition was observed mostly in lactating does on the farms and was associated with poor feeding regimes by the farmers. Plant poisoning was in all cases caused by the poisonous variety of cassava. All goats that died had a history of eating this plant.

There was no established cause of abortion. The present study has revealed to an extent the dynamism of some important diseases like helminthiasis, bacterial pneumonias, mastitis and mineral deficiencies. Further monitoring may indicate variations from one location to another and the seasonal pattern of the diseases. These changing patterns must be monitored as the programme expands for effective prophylactic interventions of the known diseases and detection of the emergent ones.

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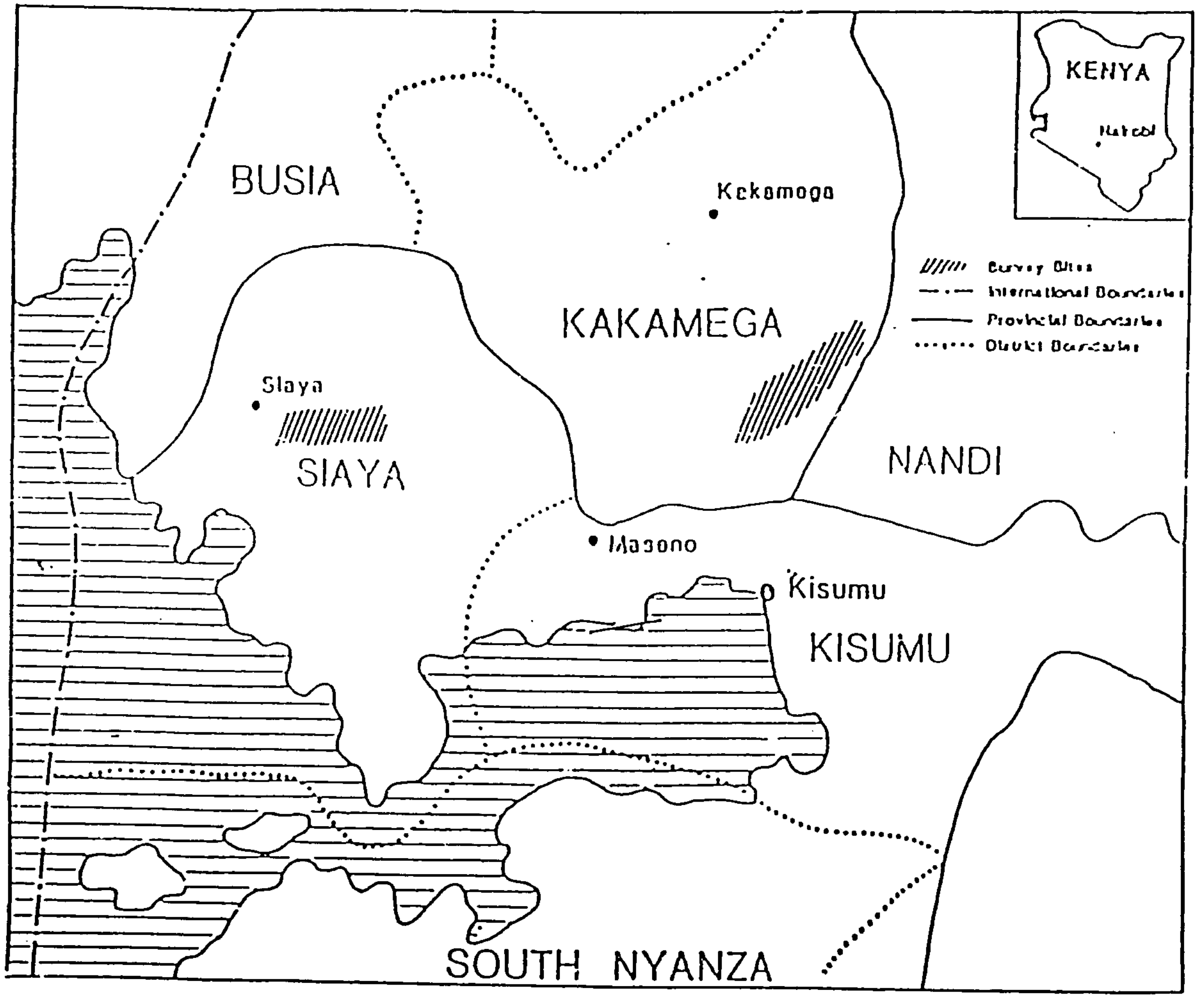

Figure 1 Map of Western Kenya

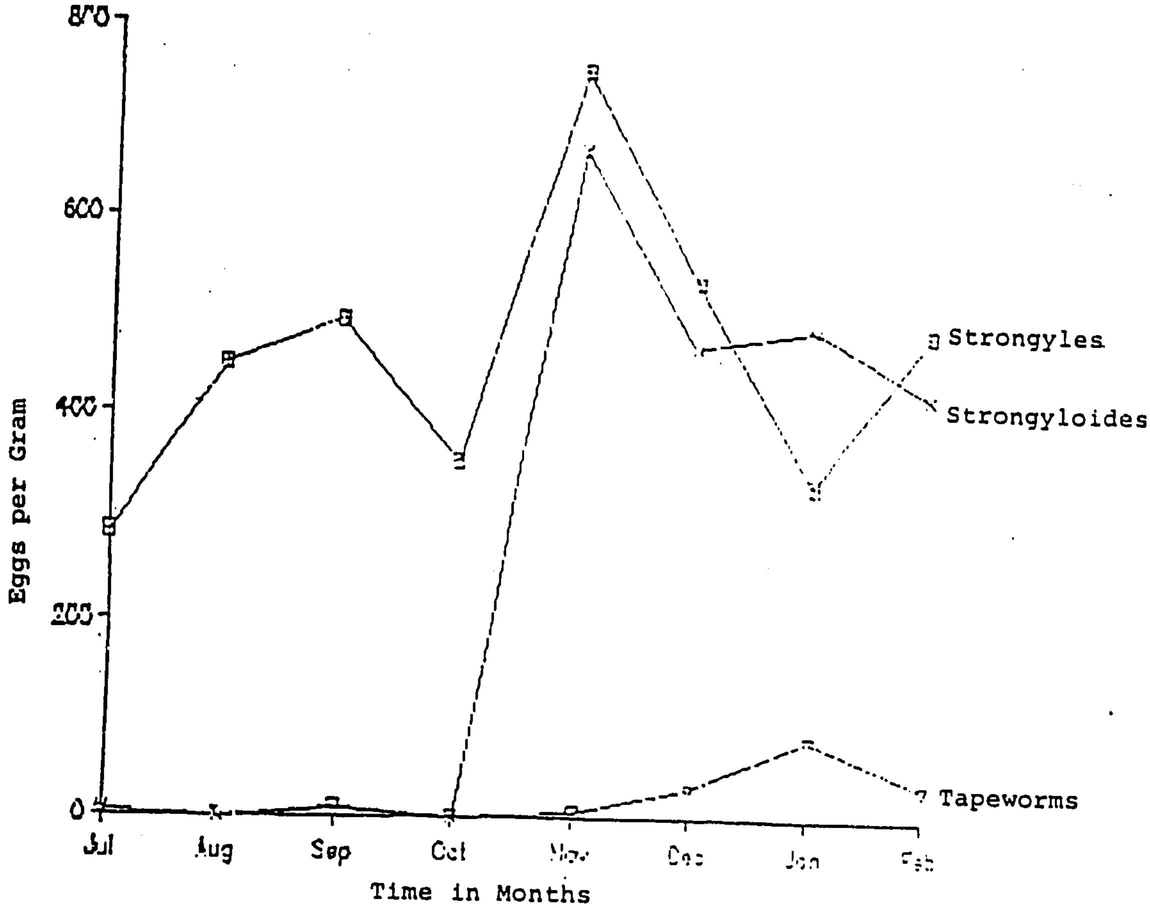

Figure 2. Monthly means of E.P.G. from the Farm Health Monitoring.

HEALTH PROBLEMS OF GOATS IN WESTERN KENYA

by

J.W. Wachira and R.S. Shavulimo
Ministry of Livestock Development

Introduction

Health monitoring in dual-purpose goats has been an on-going activity since June 1983. The exercise has helped in the identification of most common diseases which affect the dual- purpose goats in Western Kenya. The work reported here covers the period from September 1985 to end of September 1986.

Materials and methods

Health monitoring was carried out in the five sites namely, Masumbi in Siaya District, Hamisi and Kaimosi in Kakamega District, Lela Multiplication Centra and Maseno Research Station in Kisumu District.

The number of goats used in this exercise were 320 and included local East African goats; East African x Toggenburg and Anglo Nubian x East African crosses (dual purpose goats).

Sick goats from the five sites were reported by the field staff stationed in these sites to the Veterinary Officer. A clinical examination was carried out, and specimens were submitted to the laboratory when necessary, for confirmation of diagnosis. Treatment was then adminsitered.

Post-mortem examination was carried out on most of the goats that died in the Station and when possible, on goats that died in each of the other sites. Each field staff maintained a diary for health recording.

Results and discussion

Table 1 shows the infectious diseases diagnosed during the period under study. They have been classified as Bacterial, Viral and Parasitic.

Bacterial cases:

1. Mastitis:

A total of 10 cases out of 200 does showed clinical mastitis and most of it was corynebacterial type.

2. Pneumonias:

A total of 59 cases were diagnosed, 20 of them being diagnosed at post-mortem. This was observed mainly in young goats of the preweaning age.

3. Diarrhoeas/Scours:

17 cases were reported during the study period. Most of these cases were of newborn kids whose dams were producing a lot of milk. The minority were adult goats whose faeces revealed a very high count of strongyle eggs, and after deworming, they recovered. Some diarrhoeas also occurred when the grass was lush during the rainy seasons. A mortality rate of 1.2% was recorded.

4. Foot-rot:

34 cases were diagnosed during the wet months. The goats affected were the goats that were stationed in Maseno Research Station and housed in barns with stone floors.

5. Abscesses:

A total of 24 sporadic cases were treated most of the abscesses resembled those caused by *Corynebacterium pyogenes*, but no laboratory confirmation was made.

Viral cases:

1. Contagious pustular dermatitis (Orf):

This was first observed at Maseno Research Station in 9 bucks that were bought from Mombasa in October 1985. Another outbreak occurred in March 1986 in the newly purchased local East African does. 45 animals were affected and 7 of them died (a mortality rate of 2.1%).

Parasitic cases:

1. Helminthiasis:

These cases were diagnosed throughout the year. Clinical cases were dewormed. Preventive deworming is done at 4 weeks interval, using a broad spectrum antihelmintic. A mortality rate of 4.6% was attributed to helminthiasis.

Table 2 summarises non-infectious conditions and are categorised as Metabolic, Abortions and Wound/trauma.

1. Mineral deficiency:

17 cases were recorded (5.3%), most of them were lactating does and 3 bucks which were bought from Mombasa. A mortality rate of 0.3% occurred. There was no conclusive laboratory confirmation. Calcium and phosphorus were highly suspected due to therapeutic responses.

2. Malnutrition:

A total of 23 cases (7%) were recorded. Most of the cases were recorded in June 1986. Soon after the animals suffered from orf, foot-rot and pink-eye. Malnutrition caused a mortality of 2.5% (8 cases) most of the animals improved after being fed on concentrates, sweet potato vines and mineral licks.

3. Abortions:

A total of 24 cases (12%) were recorded. Most of these abortions occurred when pregnant animals were being distributed to the farmers. The most probable cause of these abortions was stress.

4. Wounds/Trauma:

Accidents leading to fractures and barbed wire wounds accounted for 16 cases (5%) and a mortality rate of 2%.

Table 1: Infectious diseases September 1985 - September 1986

Disease	Sites: Maseno		Masumbi		Hamisi		Kaimosi		Lela		Total Out of 320 Goats	Mortality Rate
Bacterial:												
	A	D	A	D	A	D	A	D	A	D	10/200	-
Mastitis	3	-	2	-	4	-	1	-	-	-	5%	
Pneumonias	15	14	8	2	6	-	5	-	7	2	59/320 18%	20/320 6.2%
Diarrhoeas and Scours	8	4	2	-	2	-	-	-	1	-	17/320 5.3%	4/320 1.2%
Foot-rot	23	-	5	-	2	-	3	-	1	-	34/320 10.6%	-
Abscesses	7	-	2	-	3	-	4	-	8	-	24/320 7.5%	-
Viral:												
Orf	26	7	1	-	-	-	1	-	10	-	45/320 14%	7/320 2.1%
Parasitic:												
Helminthiasis	21	15	4	-	-	-	-	-	-	-	40/320 12%	15/320 4.6%
Eye infection	16	-	4	-	1	-	3	-	12	-	36/320 11.2%	-
Fungal	-	-	1	-	-	-	-	-	-	-	1/320	-

Key: A = Alive
D = Dead

Table 2: Non-infectious diseases September 1985 - September 1986

Disease	Maseno		Masumbi		Hamisi		Kaimosi		Lela		Total Out of 320 Goats	Mortality Rate
	A	D	A	D	A	D	A	D	A	D		
Metabolic:												
Mineral Deficiency	6	1	4	-	3	-	1	-	2	-	17/320 5.3%	1/320 0.3%
Malnutrition and loss of condition	12	7	2	-	-	-	-	-	1	1	23/320 7%	8/320 2.5%
Abortion:												
Non-specific causes	7	-	8	-	3	-	4	-	2	-	24/200 12%	
Wounds/Trauma:	3	5	4	-	-	-	-	-	2	2	16/320 5%	7/320 2%

Key: A = Alive
D = Dead

AN EVALUATION OF RESISTANCE AGAINST HAEMONCHUS CONTORTUS IN THREE GOAT BREEDS, EAST AFRICAN, GALLA AND EAST AFRICAN X TOGGENBURG

by

Shavulimo, R.S., Rurangirwa, F., Ruvuna, F., James, A.D., Ellis, P.R., McGuire, T.

Summary

An experiment was carried out to evaluate the genetic resistance against *Haemonchus contortus* infection in three breeds of goats, East African (EA), Galla (G) and East African x Toggenburg (EAxT). They were infected with a dose of 500 infective larvae per kg. bodyweight. Body weights, packed cell volume (PCV) and eggs per gram (EPG) were determined twice a week for 13 weeks. Clinical signs were recorded and postmortem and worm counts done for animals which died.

The mortality was lowest for the EA (25%), highest for the Galla (67%) while in the EAxT it was intermediate (46%). The results of the weight loss, as a percentage of the average weight of the controls, were similar, with the EA having the lowest loss (7.3%), Galla the highest (17.6%) while the EAxT was again in between (13.8%). The mean drop in PCV was 17.7% for EA, 17.1% for Galla and 15.1% for EAxT. These results demonstrated a relatively lower susceptibility to haemonchosis in the EA than the other two breeds.

Introduction

The number of goats in Kenya is 7.7 million compared to 5.0 million sheep and 9 million cattle (Stotz, 1983). If improved for dual-purpose (meat and milk) production, goats would be an important source of the much needed animal protein in the rural populations (Fitzhugh, 1982).

Efforts have been made in recent years to identify livestock breeds which are inherently more resistant to disease which will form the nucleus for breeding or be the basis for stock improvement through cross breeding with more productive exotic breeds (Preston & Allonby, 1978; Whitlaw 1983). In some parts of the world selective breeding for resistance against haemonchosis in sheep has been going on for some time (Le Jambre et al 1974; Le Jambre, 1978; Albers, 1984). Trail (1984) observed that exploitation of genetic resistance to infectious diseases is being given increasing attention in the developing countries.

Gastrointestinal nematodes, especially *Haemonchus contortus*, have been recognised as an important constraint in sheep and goat production in the tropics (Allonby and Urguhart 1975). According to Preston and Allonby (1979) there was a loss of 26 million dollars in Kenya's agricultural sector due to haemonchosis in sheep.

It is well recognised that certain breeds of sheep are able to survive in *Haemonchus* endemic areas with little or no Veterinary attention, of particular significance in this regard is the Red Masai of Kenya (Allonby & Urquhart, 1973; Allonby, 1974; Allonby & Urquhart 1975, 1976. Preston & Allonby 1978, 1979). In contrast to the amount of information that has become available on sheep, the status of goats is much less clear. While sheep and goats are considered to share a common susceptibility to many diseases, Smith et al (Unpublished) observed that there were significant differences in disease resisrance between the two small ruminants. Dunn (1978) also noted that sheep helminths were infective to goats but goats appeared to be more susceptible that sheep to a similar challenge.

The objective of the present study was to extend the original observations in Kenya aimed at identifying breed resistance amongs goats and the mechanisms involved.

Materials & methods

Location of the experiment:

The experiment was carried out in Western Kenya, at Maseno Research Station where SR-CRSP is based.

Experiment animals

The animals used in this study were all born and raised at O'lmagogo Farm, near Naivasha. They were 17 East African, 13 Galla and 19 corsses of Toggenburg (3/4) x East African (1/4). All were males aged between nine and eleven months at the beginning of the study. Goats were randomly allocated to different treatments by breed.

Experimental design:

Breed	Experimental	Control	Total
1. East African	12	5	17
2. Galla	9	4	13
3. Toggenburg/East African	14	5	19
Total	35	14	49

Three months before infection, the goats were confined in a parasite free barn with a concrete floor. They were treated with oxyclozanide + Levamisole (NilzanR) at the rate of 0.5 gm per kg bodyweight every three weeks to remove the residual worms and prevent re-infection. They were fed *sorghum sudanense*, (Sudan grass). *Ipomoea batata* (sweet potato vines) and *Pennisetum purperium* (elephant grass) ad libitum.

The experimental animals wre infected with 500 larvae per kg bodyweight harvested from faecal cultures. Twice a week, five gm of faeces and two ml of whole blood were collected from each animal for determination of EPG and PCV. Bodyweights were measured once a week. Deaths were recorded and worm counts done for all the dead animals. The cause of death was determined from clinical and postmortem findings (Allonby and Urquhart, 1975; Roberts and Swan, 1982).

Laboratory techniques:

Worm egg counts were done by the modified McMaster technique (Manual of Veterinary Parasitological Laboratory Techniques, 1979). Infective larvae used were recovered from faecal cultures, identified to generic level and quantified for infecting the experimental animals (Roberts and O'Sullivan, 1950, Whitlock, Blitz and Gibbs, 1972; Georgi, 1974, Soulsby, 1982, Njanja, 1985).

Worm recovery and counting of adult worms was done in all animals which died (Dineen et al, 1965; O'Sullivan and Donald, 1970; Roberts and Swan, 1982). The PCV was done by use of Microhaematocrit method described by Fissher (1962).

Results

The main clinical symptoms were, pale mucous membranes, loss of body condition, lethargy, submandibular oedema and loss of appetite, indicative of the predominance of haemonchosis.

Fifteen of the experimental animals died, three of them in the acute phase; all of them Galla. The rest died in the chronic phase, 6 to 13 weeks. In total six Galla, six EAxT, and only three EA died, constituting mortality rates of 67%, 46% and 25% in the respective breed groups.

The postmortem lesions were predominantly gastritis, generalised oedema, fat degeneration and pale organs. Except in one animal which had a low count of 103 adult H. contortus, all dead animals had worm counts ranging between 1130 and 3624. Only two animals, both of Galla breed, had 272 and 383 Oesophagostomum.

Table 1 shows the dead animal for each breed, their worm counts and calculated establishment rates

Breed/Tag No.	Haemonchus	Oesophagostomum	Establishment Rates
East African			
E.A. -2	1007	-	19.2%
E.A. -3	1950	-	39.0%
E.A. -6	3624	-	53.7%
Mean	2194	-	37.3%
Galla			
G-2	103	272	2.1%
G-3	2154	-	45.4%
G-7	1968	-	34.2%
G-8	2613	-	55.0%
G-11	1735	-	33.1%
G-12	2917	383	64.8%
Mean	1915	-	39.1%
Toggenburg/E.African			
T/E.A.-7	1130	-	20.6%
T/E.A.-8	1848	-	37.6%
T/E.A.-10	3710	-	57.1%
T/E.A.-14	2902	-	55.3%
T/E.A.-16	3010	-	60.2%
T/E.A.-18	2230	-	27.0%
Mean	2472	-	42.9%

The mortality was analysed using the exact test (Bailey, 1983) for a 2x2 contingency table. Table2 shows that the infection had a significant effect on survival (p=0.0025). From the original total of 49 goats two died from other causes and were excluded from this calculation.

Table 2: Comparison of mortality for infected and control animals in all the breeds

	Died	Survived	Probability
Control	0	13	-
Infected	15	34	-
TOTAL	15	47	p=0.0025

Out of the 12 experimental goats of the EA breed three died constituting a mortality rate of 25%, the lowest amongst the breeds, followed by six out of 13 (46%) for EAxT and six out of nine (67%) for Galla.

Analyses of bodyweight change and PCV depression indicated the effect of the infection was significant. Table 3 summarises the mean values of all the parameters by breed. On th basis of mortality, bodyweight change and PCV depression the EA breed would appear less susceptible to haemonchosis than the other two breeds. The EA breed, however, had a slightly higher drop in PCV by 35.2%, but compared to 32.1% of the Galla breed the difference was not significant.

Table 3: Comparison of the breeds for establishment rates, mortality rates bodyweights and PCV

Trait/Category		EA	G	EAxT
Mean Larvae dose/kg		6333	5417	5714
Establishment (%of total)		37%	39%	43%
Mortality after 13 weeks (%of total)		25%	67%	46%
Beginning wt. (wk-0)	Control (C)	11.7%	10.7	11.5
	Infected (1)	12.7	10.8	11.9
	Difference (%C)	-8.5%	-0.9%	-3.5%
End wt. (wk-13)	C	12.3	13.6	11.2
	1	11.4	11.3	11.2
	Difference (%C)	7.3%	17.6%	13.8%
Mean PCV% (wk-13)	C	12.3	25.2	27.0
	1	17.7	17.1	15.1
	% Drop	35.2%	32.1%	44.1

For each experimental animal the mean EPG was calculated over the 13 weeks of the study. The resulting mean EPG for each breed is indicated in Table 4.

Table 4: Mean EPG for all breeds for the whole study period

	EA	G	EAxT	Aggregate
	Mean SE	Mean SE	Mean SE	Mean SE
All infected	3015±343	4804±1252	4303±685	3982±443
Surviving	2560±230	3358±1015	3829±602	3154±304

The infection became patent simultaneously in all the breeds on the 20th day. The Galla breed showed the highest mean EPG rise to 11,586 in the fifth week. The second highest rise was for EAxT of 8642 EPG, while EA breed recorded the lowest EPG of 4267. The EA had the lowest mean EPG for the 13 weeks both in all the experimental and only in the surviving animals.

Discussion and Conclusion

There is increasing evidence that *H. contortus* infection in goats in the tropics is the most predominant of the gastrointestinal nematodes (Obi, 1982;

Yadav and Sengar, 1982; Hernandez Naus, 1982). Studies conducted in Kenya have supported this view (Prston and Allonby, 1978; Abinanti et al, 1982; Carles and Schwartz, 1982; Njanja, 1985; Shavulimo, 1985).

In a study of genetic resistance to H. contortus in three breeds of goats, Preston and Allonby (1978) established that the Saanen, an exotic breed in Kenya, had lower mortality, egg counts and worm establishment than the two local breeds, the EA and Galla. In a similar study by Njanja (1985) the EA tended to have lower worm counts than the Galla and the EAxT.

In the present study the EA breed had lower mortality rate, least change in bodyweight, lower egg counts and establishment rates compared to the Galla and the EAxT.

The EA breed is very widely distributed all over the East Africa region, including areas of high worm challenge (Stotz, 1983; Devendra and Burns, 1983). This breed has been able to survive in endemic areas of H. contortus. Although little work has been done to demonstrate the mechanisms by which they survive in such areas, Stotz (1983) and Devendra and McLeroy (1982) have shown that goats are selective feeders (browsers) and as much as 80% of browse could be eaten relative to grasses.

The Galla breed on the other hand has its origin in the semi arid areas of East Africa (Devendra and Burns, 1983). In these areas helminthiasis are not a major health problem (Wilson, 1984). This breed, although regarded as local breed in the region, i__ exposure to helminthiasis is limited by the environmental factors.

The Toggenbur is an exotic breed in the region. Stotz (1983) observed that this dairy breed is kept under highly intensive management, mostly in zero grazing systems with regular anthelmintic therapy. Exposure to gastrointestinal nematodes is therefore expected to be minimal.

Selection for disease resistance has become an important aspect of livestock development programmes. In goats much less work has been done compared to sheep and cattle. In the present study the EA breed demonstrated superior characteristics in its susceptibility to H. contortus infection. It might be worth undertaking a large scale test on the EA breed.

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A REVIEW OF HELMINTHIASIS IN GOATS IN HIGH, MEDIUM AND LOW RAINFALL AREAS OF KENYA

By

Shavulimo, R.S.,[1] Rurangirwa, F.,[2] McGuire, T.,[2] Chema, S.[1]

Introduction

A farm health survey by Abinanti et al (1982) and a preliminary health evaluation of the dual purpose goats placed on farms in Western Kenya (Shavulimo et al, 1984) indicated that helminthiasis was an important health problem in goats, and *Haemonchus contortus* was the most dominant helminth. The infections were severe enough to require a control programme.

An understanding of the epidemiology of helminth infections in goats in Western Kenya is necessary before effective control measures are decided upon. Management exerts a crucial effect on the course of helminthiasis, therefore it is possible and necessary to consider their epidemiology within the context of particular systems of management and to design control measures specific to that particular farm enterprise (Michel, 1985). It must be recognised that control of helminth infections is only, one consideration influencing management decisions and control plans must make economic sense since helminthiasis in food, otherwise it will have no validity.

This article reviews two year studies done to establish the important species of helminths, their prevalence and seasonality in Western Kenya.

Materials and Methods

Location:

The study was conducted on three sites in Western Kenya, ranging from high potential to medium potential with rainfall varying from 1000 mm to 2100 mm per annum (Sands et al, 1982; Onim et al, 1984). The whole area consists of smallholder subsistence farms whose sizes vary from 0.9 to 1.09 hectares (Sands et al, 1982; DeBoer et al, 1984). The fourth study area is Olmagogo farm near Naivasha. This is a semi arid area. The annual rainfall averages about 600-700 mm (Allonby & Urquhart, 1975). In all the four sites the rainfall distribution is bi- modal with the March to June peak (long rains) and the September to November peak (short rains).

Animals:

All the three Western Kenya sites, Maseno, Masumbi and Kaimosi had a mean population of 150 adult dual purpose goats over the study period of 15 months. Most of the dual purpose goats were 3/4 Toggenburg and 1/4 East

[1]Veterinary Department, Maseno Research Station, P. O. Box 25, MASENO, KENYA.

[2]Washington State University, Pullman, U.S.A.

African crosses and a few 1/2 crosses of the two breeds (Khainga et al, 1984).

At the fourth site, Olmagogo farm, 90 does were used in the study. 30 East African, 30 Galla and 30 Toggenburg. All the animals were treated with an anthelmintic (Oxyclozanide + levamisote) every month.

Sample collection and processing:

Every month five gm of faecal specimen was collected from each animal into a plastic container, labelled and immediately delivered to the laboratory for processing. Differential egg counts were performed by a modified McMaster technique (Whitlock 1948). Infective larvae were recovered from faecal cultures periodically (Roberts & O'Sullivan, 1950) and their identification performed (Whitlock, 1960).

Meteorological data:

The rainfall data were obtained from Government meteorological stations situated within the study sites or less than three kilometers from the study sites.

Results

Table 1 is a summary of the strongyle egg per gram (EPG) for the study period. Kaimosi recorded the highest mean followed by Masumbi, Maseno and Olmagogo. The highest monthly mean of 2021 EPG however was recorded in Masumbi. Figures 1 to 4 show EPGs and rainfall curves for each study sites. The trends for EPG and rainfall for Kaimosi and Masumbi do not appear to be related. While those for Maseno have fairly similar trends with two prominent peaks for the rainfall in October to December, 1984 and February to May, 1985, while the mean egg counts had peaks in October to December in 1984 and May to August in 1985, lagging slightly behind the rainfall.

Multiple regression analysis for the three locations, however showed that there was no significant correlation between rainfall pattern and EPG.

Rainfall and EPG trends for Olmagogo were strikingly similar. The rainfall had one prominent peak between January and June, 1985 while the EPG lagged between May and August the same year. A regression analysis, lagging EPG by one month showed a significant correlation (P=0.04).

The Tables and Figures generally show that EPG was high in the higher rainfall areas of Kaimosi, Masumbi and Maseno, all with annual means of between 1400 mm and 2250 mm. Olmagogo a semi arid area, on the other hand had the lowest annual mean of 522.2 m and the lowest EPG of slightly over 100.

Discussion and Conclusion

The results, as revealed in Figures 1 to 3, show that in the high and medium potential areas the monthly anthelmintic treatment did not eliminate the worm burden. Previous work (Shavulimo 1985) indicated similar results. The role of management in the control of helminths infections cannot be over emphasized. After anthelmintic treatment, the animals need to be grazed on clean pasture to avoid rapid reinfection - and contamination of the pasture.

The effect of climatic factors, especially rainfall, in providing the required moisture and appropriate temperatures for the survival of the free-living stages of helminths is known. It is clear from Figure 1 to 4 that rainfall played a significant role. In the medium and high potential areas where there was the minimum climatic conditions required for the survival of the free-living stages all the year round, it would appear that other factors such as stocking densities, which in turn influenced rates of contamination of the pasture, were important such that the rainfall did not appear to influence directly the level of worm infection. In Olmagogo, however, the rainfall appeared to be the most important factor in determining the level of infection as seen from the trends of the curves in Figure 4a and b and the significant correlation on regression analysis.

Conclusions:

1. Anthelmintic treatment is most effective where appropriate management practices are also undertaken.

2. In high and medium potential areas there are factors of management such as stocking densities and rotational grazing which play an equally significant role as the rainfall in determining the level of worm infection.

3. There is a need to study the influence of the various management factors together with anthelmintic regimes to determine the best combination cost wise for various regions.

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Table 1: Strongyle worm egg counts for all the four sites

Site	Mean Herd Size	Mean EPG	Range
Kaimosi	20	894±510.9	100-1760
Masumbi	19	861±644.4	0-2021
Maseno	111	352±279	0-1022
Olmagogo	90	119±206.5	0-740
Aggregate	240	557	0-2021

Table 2: Monthly and annual rainfall values for the four sites

Site	Monthly Mean	Annual Mean	Range mm
Kaimosi	173.7±85.0	2084.4	48.2-390.9
Masumbi	118.3±83.04	1419.4	20-288.3
Maseno	185.5±118.49	2225.9	55-539.7
Olmagogo	43.5±44.6	522.2	1-195.5

FIGURE 1a. RAIN FALL IN KAIMOSI 1984-85

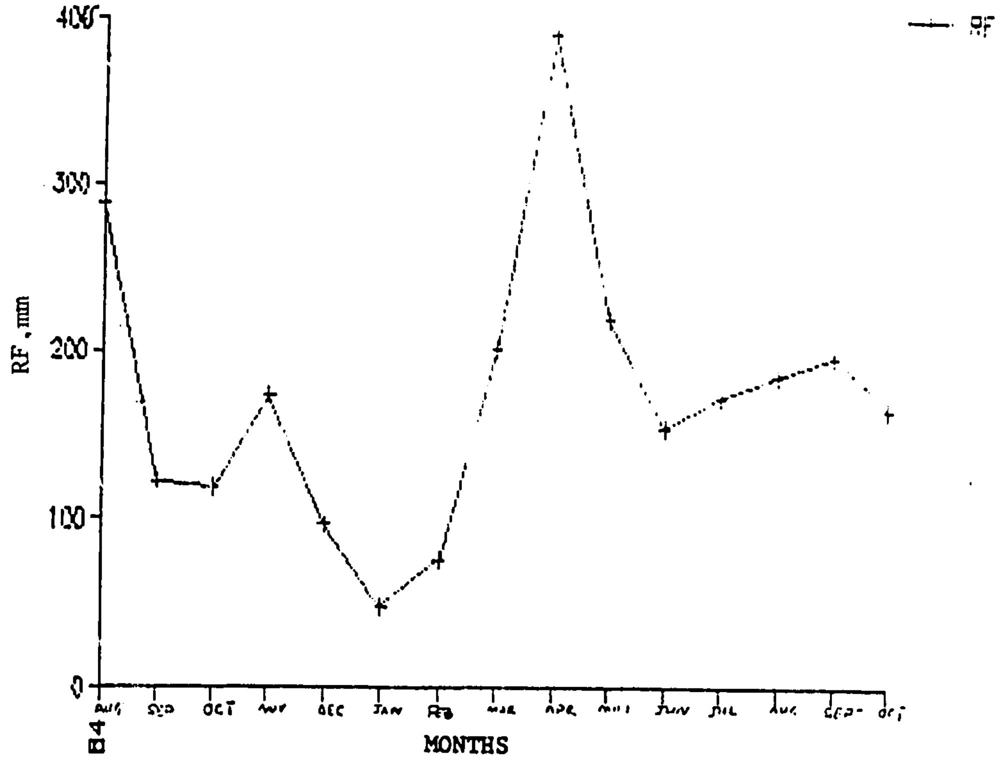


FIGURE 1b. WORM EGG COUNTS IN KAIMOSI 1984-85

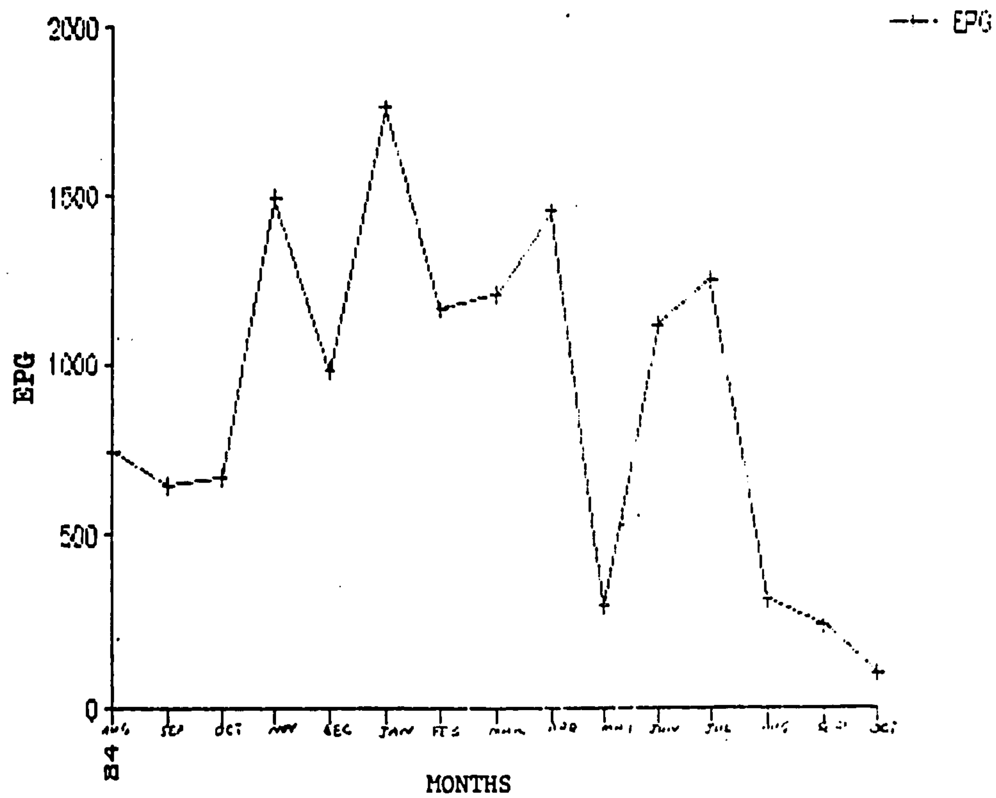


FIGURE 2a. RAIN FALL IN MASUMBI

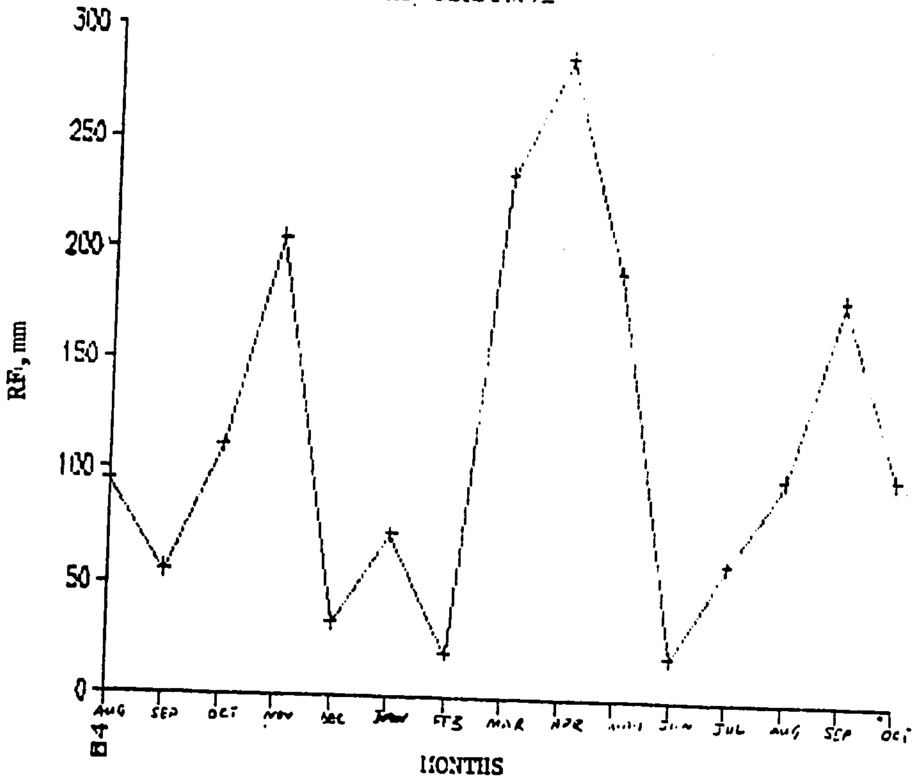


FIGURE 2b. EGG WORM COUNTS IN MASUMBI

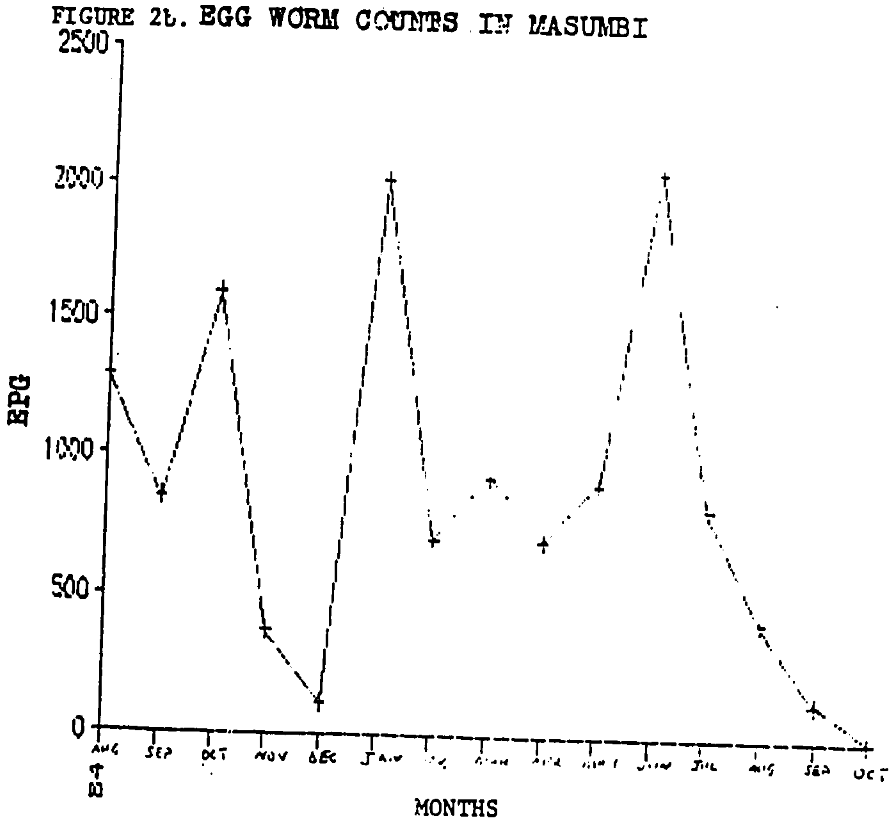


FIGURE 3a. RAIN FALL IN MASENO 1984-85

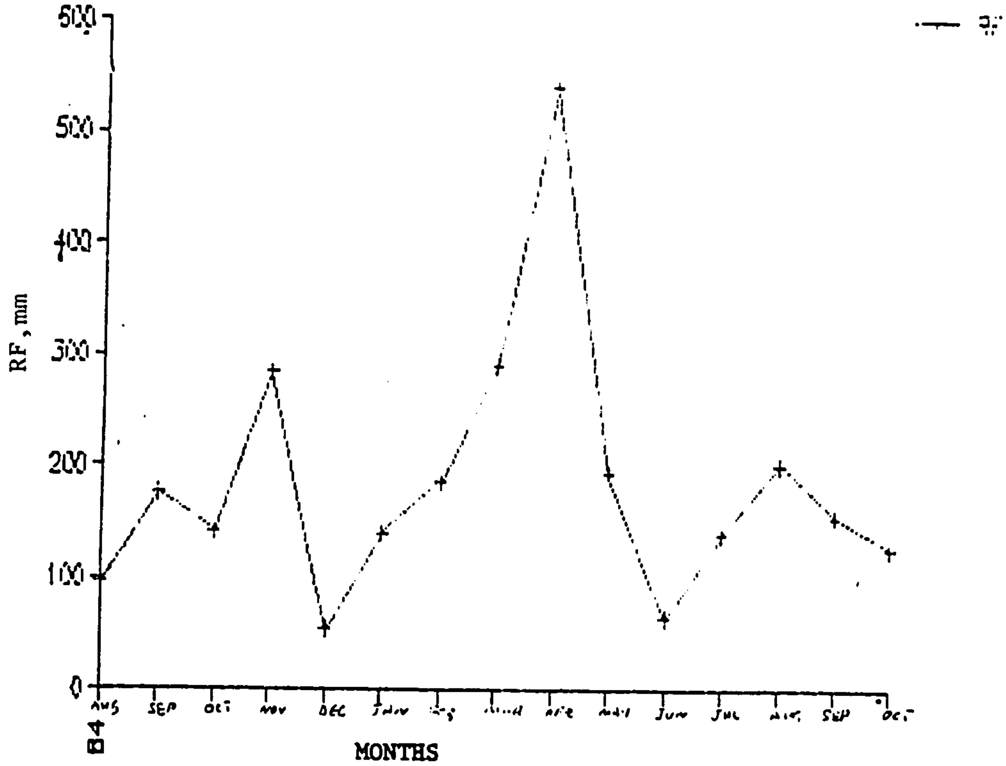


FIGURE 3b. WORM EGG COUNTS IN MASENO 1984-85

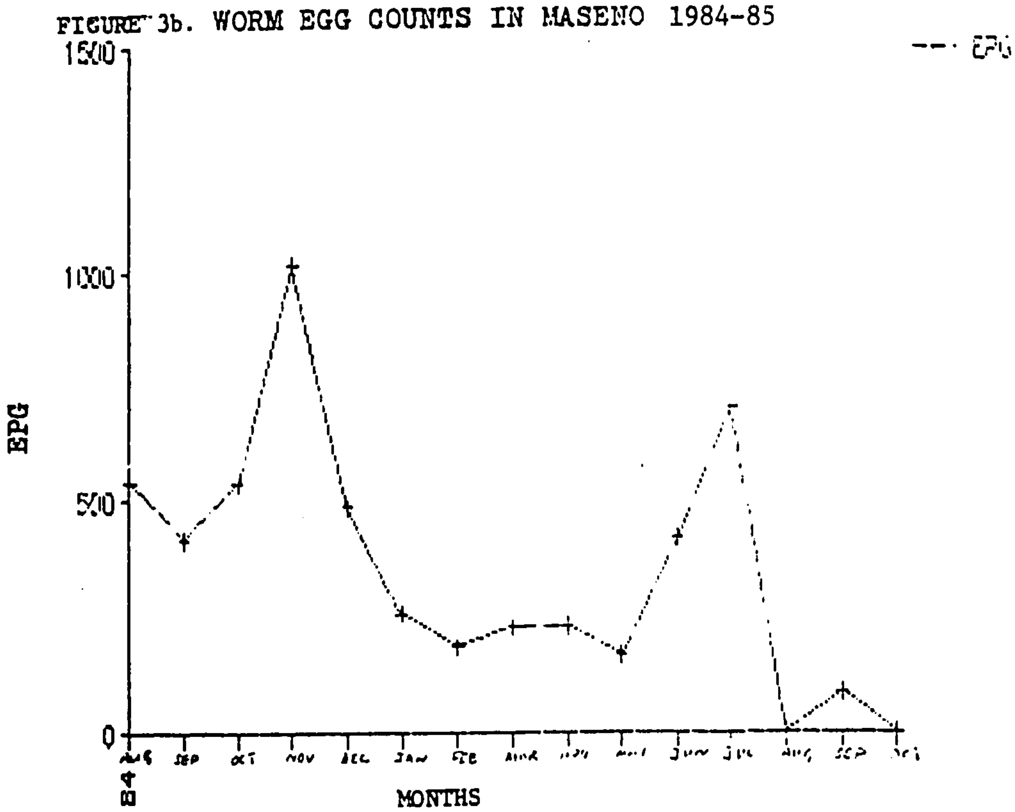
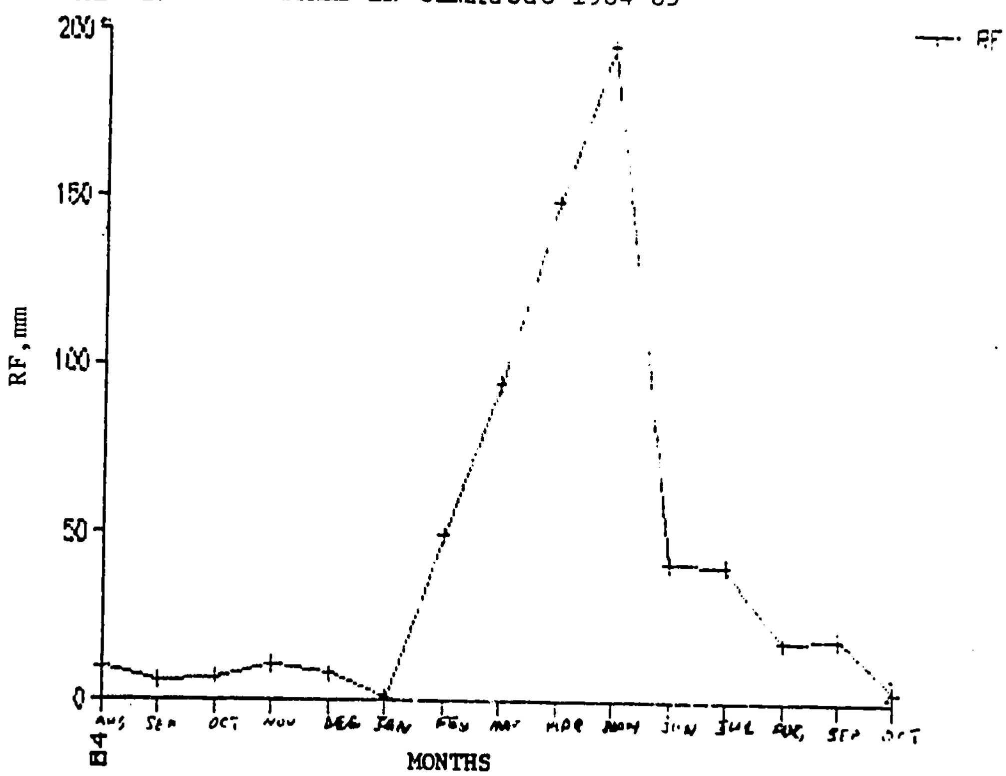
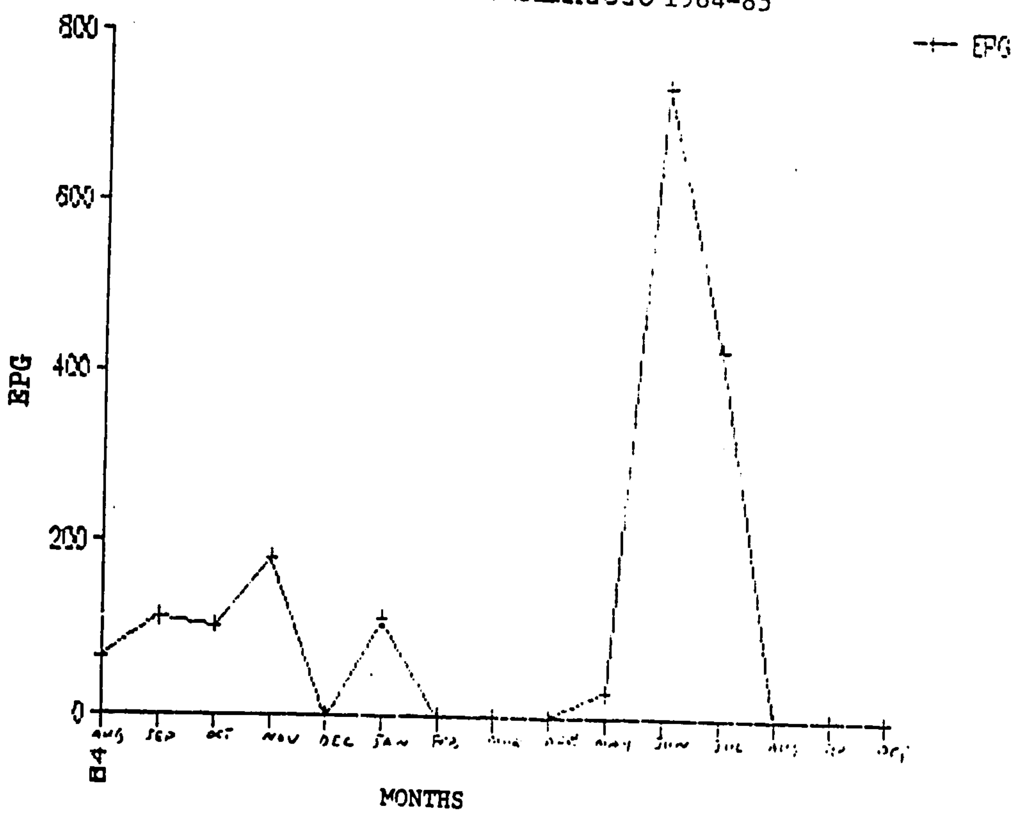


FIGURE 4a. RAIN FALL IN OLMAGOGO 1984-85



IGURE 4b. WORM EGG COUNTS IN OLMAGOGO 1984-85



BREEDING GOALS TOWARDS MOULDING THE BIOLOGICAL COMPONENTS THAT DEFINE OVERALL EXCELLENCE OF A DUAL PURPOSE GOAT

By

Ruvuna, F., T.C. Cartwright, A.M. Okeyo, J. Kariuki and S. Gichora[1]

Introduction

Realised productivity is the result of two sets of factors, one set related to production potential and the other set related to resistances to environmental stresses such as heat, internal and external parasites, disease and nutritional fluctuations. Accurate choice of breeds and a breeding system require clear definition of biological objectives and management strategies followed by moulding the biological components that define total economic merit or overall excellence to match the environment.

Productivity of dual purpose goat potential is really the summat`on of many different phenotypic expressions of a genotype in a particular environment. The concern should be on moulding the economically important facets of performance which are capable of genetic modification. Figure 1 shows a schematic presentation of inputs and targets for moulding biological components that define total merit of a Dual Purpose Goat (DPG). It is important to note the complex genotype environment interactions, the many control biological components that contribute to "total merit" or "overall excellence", the relationship between many biological components that need to be measured, and what the consumer or producer sees as the output.

Maximum output/input requires identifying, screening and combining genotypes that are optimal for dual purpose potential. This paper assesses and summarises dual purpose potential of different genotypes in view of applying genetic improvement strategies for moulding the biological components for optimum productivity.

Materials and Methods

The breeding flock comprised of about 1000 goats is kept at the Ol'Magogo division of the Naivasha National Animal Husbandry Research Station. General management and feeding of the whole flock is similar. Grazing of mature goats is practiced throughout the year from 0900 to 1700 h. daily. The grazing area is a thornbush savannah with a sparse groundcover of annual grasses, herbs and soft dwarf shrubs which fluctuate in quality and quantity with the rainfall pattern. Newborn kids are kept with their dams indoors for one week. All animals are subject to a prophylactic herd health programme to secure undisturbed performance. A mineral lick is supplied ad libitum in the night enclosure.

Data collection is concentrated on fitness, reproductive and productive performance. Over four years of continuous data collection has led to results on the following aspects:

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[1]Texas Agricultural Experiment Station, College Station, TX 77843; Ministry of Livestock Development, Kabete, Kenya.

(1) Growth performance
(2) Mature size
(3) Milk yield
(4) Reproductive performance
(5) Survival

Statistical analyses have been performed to evaluate and rank different genotypes on the basis of these important economic traits that define overall excellence for dual purpose potential.

Results on productivity estimates

1. Weight

The kid growth rates of different breed groups are in Table 1 and Figure 2. Indigenous breeds had lower weights and daily gain to weaning than crosses. Average mature body weight for G does was estimated to be 34kg and EA 29kg. Comparison of ranks at birth, weaning and 9 mo. weights showed changes in breed group rankings at each stage of growth. Birth weight rankings (heaviest to lightest) were: NxG, TxG, G, NxEA, TxEA and EA; weaning weight rankings: NxG, TxG, TxEA, NxEA, G and EA; 270d weight rankings: NxG, TxEA, TxG, G, NxEA and EA; and preweaning growth rate ranking: NxG, TxEA, TxG, NxEA, EA, and G. The NxG cross was heaviest at all stages with EA the lightest. Generally, the results point to an advantage of crosses over the indigenous straightbreds for weight and pre and postweaning growth. The superiority of the crossbred kids over the main suckling period would appear to be due to superior potentials for growth rates. The decreased growth and change in rankings postweaning would indicate differential effects of environmental stress on the different breed groups of kids that limited expression of inherent capabilities for growth.

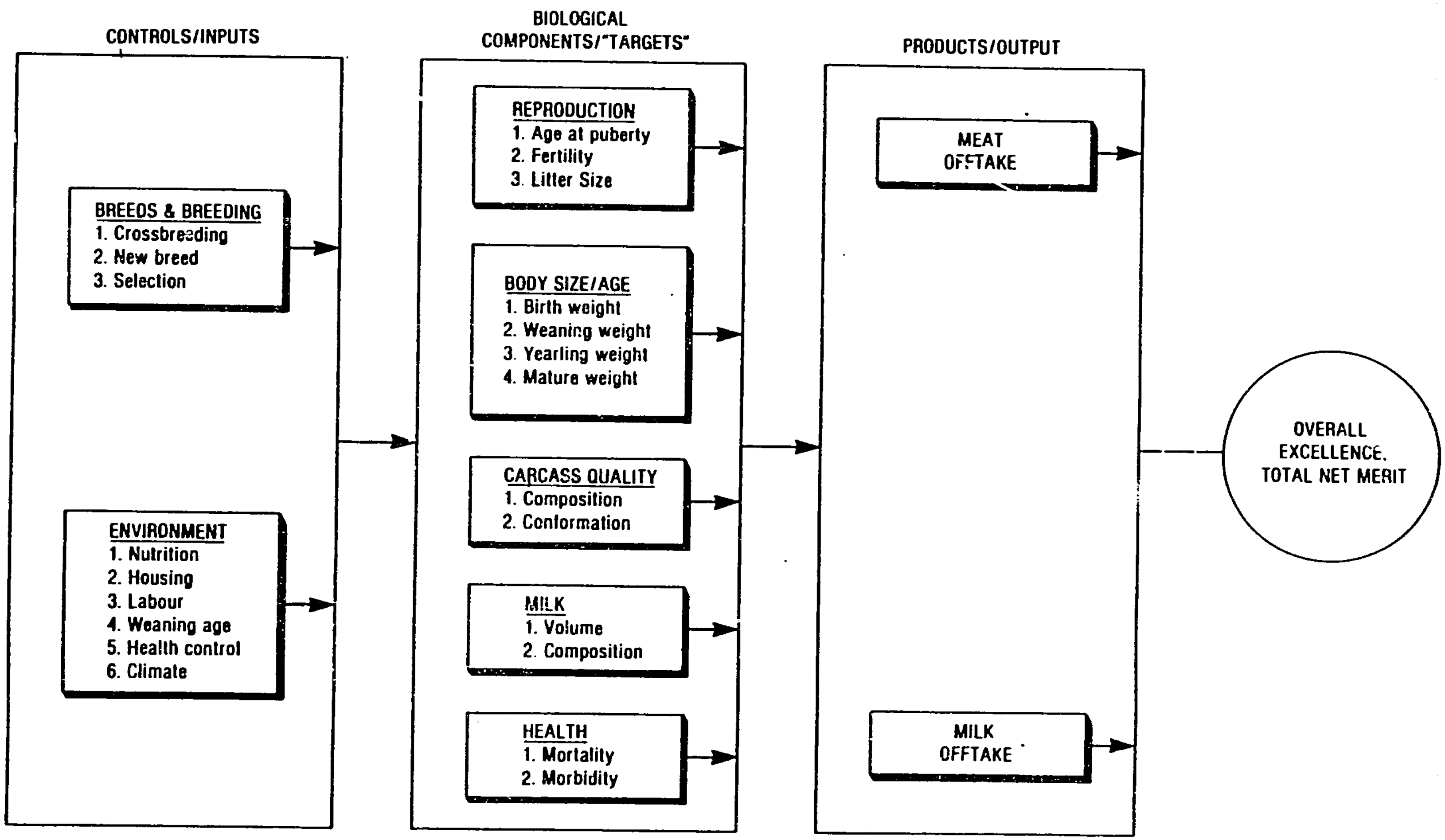
The N sired kids had heavier average birth weight than the T (2.3 v. 2.4 kg) but preweaning growth rates and weights after birth to 9 mo. were not significantly different for both sire breeds. The crossbred kids from Galla dams were significantly heavier than crossbred kids from East African dams. The weight difference ranged from 0.3 kg to 0.9 kg at different stages. The preweaning kid growth for both dam breeds were similar (0.060 kg/d).

Type of birth significantly affected all the stages of growth. Singles were significantly heavier than twins at all stages and averaged higher daily gain to weaning (62 v. 58g) than twins. The differences between the singles and twins were minimum at birth (.7 kg) and progressively increased to 2.0 kg at 9 mo. of age.

Male kids were significantly heavier and had higher daily gain to weaning than females at any stage from birth to 9 mo. of age. The differences increased steadily with stage of growth from a minimum of 0.2 kg at birth to 2.1 kg at 9 mo. of age. The daily gain to weaning differences was 7g/day in favour of males.

Age of dam significantly affected kid weights at all stages of growth. Kids from 1 yr old dams averaged lightest from birth to 9 mo. of age (2.1 to 12.0 kg) and kids from 4 yr old dams were heaviest (2.6 to 14.4 kg).

Figure 1: **Schematic Presentation of Inputs and Targets for Moulding Biological Components That Define Tatal Merit**



2. Milk Production

Milk yield is shown in Table 2. Galla does exhibited higher average daily milk yield than East African does. Average daily milk yields for East African and Galla were 385 and 409 g/day, respectively. Of the small numbers of crosses available, the average daily milk yields were much higher than the indigenous breeds. Average daily yield were estimated to be 800 gm/day. The composition of milk seems to be different for different breeds. Estimated crude protein for EA and Galla was 5.4% and 4.63%; estimated fat was 3.34% and 4.57%.

3. Reproduction

Reproductive parameters are in Table 3. Does were randomly exposed to EA, T and N bucks for a mating period lasting 6 weeks each time. Two weeks postpartum, vasectomised bucks were left to run with the females and time of oestrus manifested in the form of accepted mounting was recorded for each doe. The proportion of does joined that kidded (fertility) was higher among the EA does than the G within and across the two years of study: 90% for EA and 75% for G respectively. Average litter size, a measure of twinning rate, was 1.2 kids per doe kidding. Twinning rate of EA does was higher (29%) than of G (10%).

Gestation length results showed twins tended to be dropped earlier (146d) than singles (148d). This could be attributed to the fact that twins tend to be heavy (total birth weight) and thus presented a heavier physiological demand on the dam and thus were expelled earlier than single birth. Comparison of EA and G does indicated similar gestation length for both breeds (148 for EA versus 149d for G).

4. Fitness (Adaptability)

Survivability of kids is one of the most important production traits being measured. Kid mortality has been high on average (23%) and would be expected to be higher for smallholder production. The EA consistently has had lowest kid mortality (10%), followed in order by G (17%), T (29%) and T crosses (24%). Death among multiple birth kids was higher than death among single birth kids. The commonest disease has been Pneumonia accounting for 60% of total kid deaths followed by scours (Ruvuna et al., 1983).

Evaluation of genetic resistance against Haemoncus contortus (Table 4) in three goat breed groups (EA,G,EAxT) artificially infected at the rate of 500 larvae/kg body weight, demonstrated lower susceptibility and higher resilience to H. contortus of the EA than the other breed groups (Table 4) based on lower mortality: EA (25%), G (67%); and TxEA (40%).

Summary and Conclusions

1. Weight

(a) Crosses were heavier and grew faster than indigenous Galla and East African kids;

(b) Twin born kids weighed less at all ages of growth than single born kids;

(c) Male kids grew faster and were heavier than female kids at all stages of growth;

(d) Crossbred kids from Galla dams are heavier than EA dams;

(e) The mature size of G exceeded that of EA (34 vs. 30 kg).

2. Milk

Crosses produced more milk than indigenous EA x G does.

3. Reproduction

(a) Higher twinning rate for EA than G;

(b) High fertility of the indigenous EA and Galla does (over 70%);

(c)Gestation length for EA and G was 5 mo. and was independent of sex and breed of fetus carried by the dam. Dams carrying twins kidded 2 days earlier than does carrying singles.

4. Fitness

(a) Survival of EA kids better than Galla kids;

(b) The EA showed higher resilience to _H. contortus_ than Galla and crosses.

5. A synthesis of the breed and type comparisons for "overall excellence" indicate no breed or type excells in all the economic performance traits. An "index" using relative economic weightings based on optimising the biological components (Figure 1) is proposed for selecting appropriate DPG for smallholders.

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Table 1: Least Square Means (kg) of Factors Affecting Growth

Classification	Birth Weight	4 mo. Weight	9 mo. Weight	ADGa	WMA
Breed:					
EA	2.0	8.8	11.9	56	29.5
G	2.6	9.1	13.1	55	34.1
TxEA	2.2	9.7	14.2	63	-
NxEA	2.2	9.5	13.0	60	-
TxG	2.6	10.2	13.9	63	-
NxG	2.8	10.4	15.1	64	-
Type of Birth:					
Single	2.8	10.3	14.5	62	-
Multiple	2.1	9.0	12.5	58	-
Sex of Kid:					
Female	2.3	9.2	12.3	57	-
Male	2.5	10.1	14.7	64	-
Crossing Effect:					
T - Sire	2.3	9.7	14.6	61	-
N - Sire	2.4	9.5	14.7	59	-
EA- Dam	2.1	9.4	14.2	60	-
G - Dam	2.6	9.8	15.1	60	-
No. of Records	810	392	142	392	

a ADG = Average daily gain (g) to weaning (4 mo.)

Table 2: Milk Production of Different Goat Breeds

	EA	G	Crosses
Lactation length (days)	120	120	120
Milk yield (g/day)a	385 (110)	409 (80)	826 (11)
Composition:			
Crude protein %	5.41	4.63	-
Fat (%)	3.34	4.57	-

Values in parenthesis represent no. of records

Table 3: Reproductive Performance of Indigenous Goat Breeds

	EA	G
Fertility, %	90 (345)	75 (249)
Litter size	1.3 (261)	1.1 (140)
Postpartum interval to 1st estrus (days)	68 (118)	77 (39)
Gestation length (days)	148 (451)	149 (250)

Values in parenthesis represent no of records

Source: Okeyo et al. (1984, 1985); Ruvuna et al. (1983)

Table 4: Comparison of Survival of Indigenous Goats and their Crosses

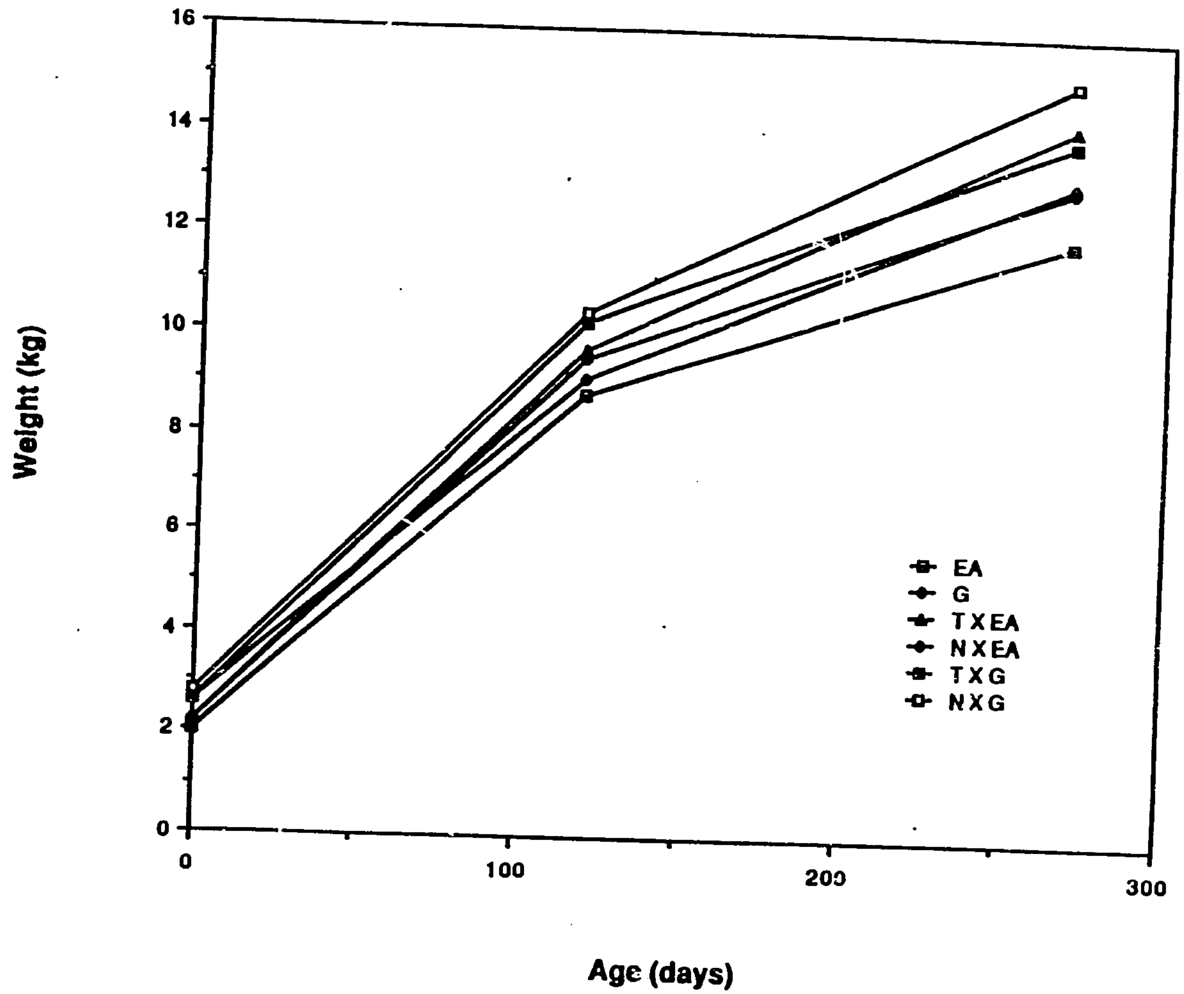
Fitness

	EA	G	Crosses
a) Kid Survival (% of total kids born)	90% (96)	83% (49)	81% (247)
b) Adult survival (% of total does)	93% (241)	88% (147)	86% (45)
c) Artificial infection with *H. contortus*:			
i) Larvae establishment (%)	6364 (37%)	5417 (39%)	5714 (43%)
ii) Mortality 13 weeks postinfection:			
a) Control	0% (5)	0% (4)	0% (5)
b) Infected	25% (12)	67% (9)	46% (13)

Values in parenthesis represent no of records

Source: Shavulimo et al (1985); Ruvuna et al. (1983,1984,1985); Okeyo et al. (1984)

Figure 2: Growth of Kids from Birth to Nine Months of Age



PRODUCTIVITY PARAMETER ESTIMATES OF GALLA AND EAST AFRICAN GOATS AT OLMAGOGO

By

Okeyo, A.M., F. Ruvuna, T.C. Cartwright and S. Gichora

Introduction

The Galla and the East African are the two main goat breeds indigenous to Kenya. Under traditional management systems the two breeds are not often seen grazing side by side within a flock because the Galla is predominantly found in its place of origin, the North Eastern province. Where the two breeds are flocked together traditionally, as found in Eastern, Rift Valley and Coast Provinces, there has been indiscriminate crossing between the two.

Recently there has been increased interest in the improvement of small stock in the tropics especially in Africa and Kenya in particular due to their comparative advantages over cattle (Wilson, T.R. 1984). In order to determine inherent potential of these goat types, consistent and rigorous comparative studies are needed to derive overall productivity indices. The results presented herein were obtained as part of the Small Ruminant CRSP (Breeding Project - Kenya) effort to characterise as fully as possible the Galla and African goats as a genetic resource in the eventual development of a synthetic dual purpose goat based on 4-breeds (East African, Galla, Toggenburg and Anglo-Nubian).

Materials and Methods

A total of over 518 mature (4 years old and over) East African and Galla does were equally and randomly bred to Anglo- Nubian and Toggenburg bucks during a period of 2 years (1984 and 1985). The kidding period was grouped into three different seasons: June - August (I), September - November (II), and January - May (III). The kids were let to suckle for 4 months before weaning. Weighing of the kids was done at 2 weeks intervals before weaning and monthly thereafter. The mature does were weighed monthly and at mating.

All the does were flocked together throughout and drenched and dipped against endo-parasites and ecto-parasites. Lactating does were supplemented during times of inadequate natural forage at the rate of approximately 0.25 kg of lucerne per day.

The average birth weight (TWB) and weight at 4 months of age (T4MKWD) of kids per doe kidding were computed. Statistical analysis was done using a fixed model that included effects of year of birth (1984, 1985), seasons of kidding (I, II and III), type of birth (singles, twins) and breed of doe (East African, Galla).

Results and Discussion

The source of variation and their respective means for T4MKWD are given in Table 1. The means for weights are given in Tables 2 and 3 and for seasons for T4MKWD in Table 4.

Effects of Breed and Type of Birth on TWBD

There were no significant breed differences in total weight born per doe kidding (TWBD) (Table 2). However the twins had higher TWBD values than the singles (4.5 kg versus 3.1 kg).

The average birth weights of kid(s) per doe kidding was 3.4 kg for the East African and 3.5 kg for the Galla. The average rate of kidding was 0.9 for the East African and 0.8 for the Galla as reported by Okeyo et al. (1985). When these kidding rates were multiplied by average birth weights of kid(s), the average birth weight per doe was estiamted as 3.06 kg for the East African and 2.80 kg for the Galla. These differences may have economic significance (Dickerson, 1978).

Effects of Season on T4MKWD

The season of kidding had a significant effect on the total weight at 4 months per doe kidding (T4MKWD), (Tables 1 and 4). Season III kid weights were the heaviest for both breeds and season 1 the lightest. This trend is expected and is consistent with the results of Wilson (1985). Kids born in September - November are nursed and weaned during the periods of (January - March) of lowest forage availability and qualities. The periods of rains and colder temperatures follow (March - May) and the weaned kids suffer environment stress (low temperatures, high humidity and lush forage). The opposite conditions affect those kids born during season III (January - March).

Effects of Type of Birth on T4MKWD

The lower prolificacy of the Galla than East African lowered its T4MKWD (Table 3). However the breed differences were not statistically significant (Table 1). The type of birth reduced T4MKWD among twins, contrary to its effect on TWBD. This is because fewer twins survived to weaning and those that survived weighed less on average (total market weight) than singles at six months. Unless management is good, higher twinning rates may lead to lower biological efficiency resulting from high pre- weaning kid mortalities (not marketed).

Higher fertility may, to some extent compensate effectively for loss due to higher prolificacy. The breed means (Table 3) weighted by fertility factors (0.9 for the East African and 0.8 for the Galla) changed from 11.3 and 11.7 to 10.2 and 9.4, respectively; thus causing the East African to outperform the Galla. The East African has higher mothering instinct than the Galla (personal observation) while the latter has higher mothering ability. During the first 24 - 36 hrs post-partum, the mothering instinct as opposed to the overall mothering ability is the most important for kid survival, especially in a large doe flock situation.

Effect of Mature Weight on the Productivity Indices

When T4MKWD estimates (Table 3) were weighted (divided) by the metabolic doe body weights (12.66 kg and 14.11 kg for East African and Galla in that order, the breed indices were 0.89 and 0.83 for East African and Galla, respectively. These indices are close to those reported by Wilson and Light

1986, and do suggest that assuming similar longevity among does of both breeds, the East African was better than the Galla in productivity efficiency (Dickerson 1978). However, if milk production index outweights disease tolerance (survival), then the Galla may outperform the East African overall. The latter two indices (for tolerance and milk production) and perhaps longevity are yet to be developed for conclusive comparative overall efficiency indices.

Preliminary Conclusions

1. The East African doe seem to outperform the Galla on biological efficiency if meat is the only product of interest.

2. Further work needs to be done in so far as development of reliable and effective indices for disease tolerance and milk production especially so for evaluation of dual purpose goats.

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Table 1: Mean Squares for 4 month kid(s) Weight per Doe Kidding (T4MKWD)

Source	df	Mean squares	F
Year of crop	1	1330.05	27.8***
Season of kidding	2	2149.1	44.8***
Breed of doe	1	15.4	0.32
Type of birth	1	862.83	18.02***
Residual	510	47.88	

*** P<0.001

Table 2: Means for Birth Weight (TWBD) by Breed and Birth Type

	Singles			Twins			Average		
Breed	n	x	s	n	x	s	n	x	s
East African	218	2.9	0.65	48	4.4	1.01	266	3.2	0.71
Galla	220	3.3	0.82	30	4.7	1.22	250	3.5	0.9
Average	438	3.1	0.75	78	4.5	1.1	518	3.5	1.01

Table 3: Means for 4 month kid(s) Weights (T4MKWD) by Breed, and Birth Type

	Singles		Twins		Average	
Breed	x	s	x	s	x	s
East African	10.6	2.6	14.9	3.9	11.3	3.3
Galla	11.4	0.2	13.2	6.4	11.7	3.6
Average	11.0		14.3		11.4	

Table 4: Means for T4MKWD by Breed and Season

Breed	Season I	Season II	Season III	Average
East African	8.7	10.3	14.3	11.5
Galla	8.4	9.9	12.6	10.8
Average	8.6	10.2	13.5	11.1

Current Status And Perspective For Breeding The Kenya Dual Purpose Goat

T. C. Cartwright[1], F. Ruvuna[2] and S. Chema[3]

The rationale for the multi-disciplinary SR CRSP in Kenya is that developing dual purpose goat production was recognized to require coordinated effort in order to attain viable production by smallholder farmers. There must be sufficient feed for goats that have sufficient capacity to grow, reproduce, and produce milk. To do this the goats must be kept healthy and managed properly. To make it attractive it must pay returns on investment and be socially feasible. If any one of these parts fails, the entire process fails.

Thus, the niche of the Breeding Project in this scheme is to breed goats with the capability to live, grow, reproduce, and produce milk given an improved but practical, environment that is within the constraints of the farmers. Although no quantitative goals were set, native goats were evaluated (Ruvuna et al., 1986) and shown not to have the production potential required for dual purpose production. Imported dairy breeds have dairy and growth potential but do not produce and survive well in Kenya under the targeted farm conditions. The dilemma is that adaptability to stressing environmental conditions is mediated in part by low growth rate, slow maturing, and low milk production. In general, animals that have greater genetic potential than the environment will support, especially the nutritional environment, are poorly adapted and disadvantaged. There are, of course, other factors conditioning adaptability, but production potential is a major contribution.

Results of systems analysis reported separately (Cartwright and Ruvuna, 1985) led to the conclusion that a goat with a production potential intermediate between the native breeds and dairy breeds would be near the optimal (most desired) level. Thus, the decision to breed goats that are 1/2 native and 1/2 dairy. Two breeds of each were chosen to widen the genetic base and selection potential and to enhance heterosis retention (Cartwright et al., 1984). The breeding plan is based on developing a composite synthetic breed using equal parts of East African (E), Galla (G), Toggenburg (T) and Anglo-Nubian (N).The first stage is to produce the four-breed combination. The second stage is more challenging; that is developing this composite, in which resides a wealth of genetic diversity, into a breed that has desirable characteristics for a dual purpose goat for the tropics. At the present time we refer to this composite breed as the Kenya DPG but a more appropriate name is being sought - preferably a Swahili name. The operational objectives, breeding goals, breeding tactics, breeding plan, and selection criteria may be summarized as follows:

Project Objectives:

Primary: Establish a sizeable flock of Kenya DPG
Secondary: Conduct relevant experiments with the DPG
Supply goats for use by other SR-CRSP projects

[1] Animal Science Department, Texas A&M University, College Station, Texas
[2] Animal Science Department, Texas A&M University, Kabete, Kenya
[3] Kenya Agricultural Research Institute

Breeding Goals:
Survivability - adapted to area
Genetic potential for milk and meat production synchronized with the production resource
Maximal flock offtake in terms of inputs

Breeding tactics:
Target specific area
Limit selection criteria
Exploit breed selection
Screen native breeds
Exploit heterosis
Use individual records and progeny testing
Maximize selection differential
Select consistently and persistently

Breeding Plan: (male x female)
1st set of matings: T x E, T x G, N x E, N x G
2nd set of matings: (T x E) x (N x G)
(T x G) x (N x E)
(N x E) x (T x G)
(N x G) x (T x E)
3rd set of matings: TNEG mated inter se for generations 1,2,3...

Selection Criteria:
Survivability, adaptability
Growth, optimal
Milk production, optimal
Reproduction

The primary objective of establishing a large Kenya DPG flock is necessary if a breed is to be developed since genetic success is very dependent on numbers. The secondary objective includes experiments that relate to providing information for breeding such as the amount of milk necessary for kids, carcass and meat characteristics, and parasite and disease resistance.

The breeding goals place emphasis on the flock to return maximal amounts of dairy milk and sale liveweight given the production inputs and constraints. This emphasis on the whole flock productivity requires adaptability. Flock productivity may be used as the measure of adaptability.

The breeding strategy emphasizes taking advantage of the desired characteristics of existing characteristics of existing herds and retaining and enhancing them. Use of four breeds, as compared to two, has advantages for both selection potential and retaining heterosis. At this point, we do not have data that can be used to quantitatively evaluate the importance of heterosis, but generally heterosis has major contribution to fitness characters and we anticipate that heterosis will be an important feature of the Kenya DPG. The maximal selection differential has reference to using state-of-the-art statistical techniques in genetic evaluation. This evaluation will include use of progeny testing and information from relatives. Evaluation, of course, implies a competent system of collecting, recording and analyzing data.

The current status of the breeding herd is an inventory of about 1400 goats that will increase to about 1700 by the end of 1986. We are still mating to produce the F1's , but this will phase out during 1987. Major emphasis is currently on mating complementary F1's to produce the four-breed crosses. At present we have 430 of the four F1's. The oldest four-breed crosses will be first mated in January 1987, but these four-breed crosses will begin arriving in significant numbers in late 1986. The current inventory is only 34 head past the weaning stage. We began release of F1 bucks (29 total) to farmers during the fourth quarter of 1986. Also, F1's have been released to farmers through the Production System Project; there were 150 does and 4 bucks in 1986. The feed-back information from the performance of these individuals and their progeny will be mostly informal, but valuable, information. We plan to continue these preliminary releases and include four-way bucks in 1987. We anticipate that some four-way does will be available in 1990.

Selection criteria refer to the traits measured on the goats and the use made of these data to accomplish the goals. Selection of the four-way crosses to produce the composite synthetic Kenya DPG will initially be based on growth rate, milk production, reproduction and general soundness. As many bucks as feasible, selected from the top one-half for growth rate up to one year of age, will be bred initially. The basis for selecting bucks will shift from individual records to progeny test records of the daughters for milk production and reproduction, and of their sons for growth and adaptability.

Doe selection will emphasize their own lactation and reproduction; few does will be culled until after their second lactation. The average level of milk production potential of the F1 does is approximately 3.0 kg/day at the peak day of a mature doe's lactation if she has had no nutritional or health stresses. The goal for the Kenya DPG is to increase this level to an optimal 4.0 kg/day (Cartwright et al., 1985). The average weight/age (growth) potential is approximately 40 kg mature weight of a doe. The goal for the Kenya DPG is an optimal weight of 40 kg mature doe weight; therefore, little selection emphasis needs to be placed on size/age except to reduce variability and emphasize early growth which indicates adaptability. The genetic potential for size/milk, characterized as 40/4.0, may be slightly above the optimal potential for current conditions, but as conditions are improved, this potential is expected to be optimal. Also, since release of the Kenya DPG, especially in the early years, must be largely via bucks to be mated to native does, the genetic potential of these sires should be above that derived in the their progeny.

Adaptability is difficult to measure in quantatitive terms, but it is given emphasis in our selection. One component that clearly has a large impact on adaptability is parasitism. The SR CRSP Health Project plans to initiate research with the Kenya DPG breeding flock to evaluate natural resistance and/or tolerance to haemonchus. This evaluation will be designed to progeny test the F1 and four-way cross bucks used as sires. The tests will include egg counts and PCV of untreated male kids during their postweaning period to one year of age. These progeny test data will be incorporated in the data used for selecting sires.

There are no plans at this time to place selection emphasis on conformation except for unsoundnesses. Color is useful for breed identification, but until we obtain more observations on color and color patterns of the four-way crosses, and determine the inheritance involved, selection intensity should not be compromised by including color in the selection criteria.

When Toggenburg and Nubian bucks were not available, AI was used. There is a need to increase expertise in AI of goats in general and especially for the Breeding Project for possible use in distribution to farmers and to increase selection differentials. The same applies for embryo transfer (ET). ET requires more expertise than AI, but it would be more useful for transporting the Kenya DPG for export. We do not have active AI and ET research but have submitted a proposal for funding outside the SR CRSP.

Future plans for the breeding project include multiplication and stabilization of the Kenya DPG as a breed. The purpose is to make this breed available for use by multiplier flocks and farmers. This use by farmers will be best served in the long term if breeding the Kenya DPG is organized via a breed association with responsibilities for recording both genealogical and performance records for the purpose of maintaining and improving the genetic structure of the breed. Also, modern breed organizations perform valuable sire evaluation sevices which require processing, as well as recording, performance data. These procedures will be drafted in detail.

The stabilized four-way synthetic composite is being developed as a genetic base. Modern utilization of breeds is conceptualized more as the breed constituting a genetic pool or genetic resource rather than as a genetic sanctuary. Tallam et al. (1986) and Cartwright et al. (1986) have simulated production from more intensive dairy flocks as a potential "cash crop". The results indicate that a more intensive goat dairy has promise as a competitive enterprize. After the current year we plan to initiate the use of Kenya DPG as a base for an intensively managed goat dairy through a cooperating institution. This intensive dairy use is expected to require sires and perhaps does resulting from mating dairy breed bucks to Kenya DPG does to obtain 5/8 dairy - 3/8 native breeding. An example is the following:

Alpine sires x four-way cross does = five-way cross
Five way cross sires x four-way cross does = 5/8 Dairy - 3/8 Native

Likewise, use of the Kenya DPG for dual purpose production in semi-arid areas may require the use of more indigenous breeding for optimal performance. An example of adapting a DPG for this use is as follows:

Galla sires x Kenya DPG (or TE and NE F_1 does) = 3/4 native 1/4 dairy

Supplying these specialized sires and assisting in synthesizing optimal breed combinations, as well as breeding the Kenya DPG, are part of the continuing goals of the Breeding Project. That is, the goals include making use of the DPG genetic resource in an optimal way, using modern practices and techniques adapted to traditional and changing production environments.

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USE OF TEETHING TECHNIQUE TO ESTIMATE AGE IN GOATS

Okeyo, A.M., F. Ruvuna, T.C. Cartwright and J.N. Maleche

Introduction

The majority of Kenyan small stock owners do not keep precise records of birth dates and the subsequent animal performance. These stock keepers rely heavily on their own memories, based mainly on seasons of the year, in their estimation of livestock ages. This practice is unlikely to change in the near future and large scale assessment of small stock performance among pastoralist must either continue to rely on this imprecise ageing procedure or newly developed more reliable standards.

Examination of the individual animals teeth can be used to estimate their ages (Carles, 1977). This method combines the evidence of the number of temporary and permanent incisors and the wear on the teeth.

The standards used to estimate the ages of goats from 1 to 4 and more years of age have been borrowed from those derived from European sheep on assumption that the two species have similar dental development patterns. This assumption of similarity however, is not correct (Wilson and Durkins, 1984). Also to be resolved is whether the dental development patterns vary between goat breed types and whether other factors such as sex, diet types are also important determinants as is the case with cattle (Carles, 1977).

This study was undertaken to develop local standards and to compare these results with standards developed for sheep.

Materials and Methods

A total of 800 goats between 6 months and 5 years of age were mouthed and number of incisors (permanent and temporary) recorded on every 28th day of the month for one year beginning July, 1985. For age calculation purposes only 200 animals of two indigenous goat breeds (Galla and East African) and their respective F1 crossbreeds sired by Toggenburg and Anglo-Nubians which had eruptions of the subsequent incisor (pairs or single) within one month intervals were used.

Results and Discussion

Breed Type Effects

The mean ages in days by breed for each permanent incisor pair are shown in Table 1. The two indigenous breeds, East African and Galla, had their permanent teeth erupting relatively later than their Toggenburg and Anglo-Nubian crossbreeds, with the East African's teeth erupting relatively later than every other group as expected. The East African F1 crossbreds offsprings irrespective of sire breed erupted earlier than those of the Galla F1 crossbred offspring irrespective of the sire breed (Table 1).

As expected, the number of permanent incisors in goats was related to the goat age (days). The relationship seems to depend on other factors possibly breed type and more likely dietary type and composition. It is possible that the breed effect may manifest itself indirectly through differential dietary pattern (herbage species selection) (Okeyo et al 1985). In this study the relationship between teeth number (stage of eruption inclusive) and age was not a perfect one (correlation = 0.71). This is in agreement with similar results of studies done in cattle where stage of growth was shown to have an effect on the relationship (Carles, 1977).

The ages at eruption in this study were higher than those reported by Wilson and Durkins (1984) indicating that use of sheep standards for ageing goats is likely to underestimate goat ages, (for each erupted permanent incisor pair, the goat is much older than would be the case with European sheep).

Further work needs to be done especially to clearly separate the magnitude and direction of dietary factors stage of growth and managemental effects on teeth eruption in local goats and probably in sheep too.

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Table 1: Mean Age (Days) by Breed and Eruption of each Incisor Pair

Breed Type	Incisor Pair					
	1st	(s)	2nd	(s)	3rd	(s)
East African	547	(135)	1044	(137)	1217	(86)
Galla	745	(20)	798	(36)	1173	(77)
Tog x E. African	518	(69)	801	(175)	944	(56)
Nub x E. African	489	(28)	760	(76)	897	(53)
Nub x Galla	510	(46)	758	(153)	897	(99)
Tog x Galla	590	(44)	782	(96)	917	(103)
Average	564	(108)	87[illegible]	(117)	1014	(78)

* Tog - Toggenburg; Nub - Anglo-Nubian

EFFECTS OF EARLY WEANING KIDS FOR DUAL PURPOSE GOAT PRODUCTION IN WESTERN KENYA

By

S.K.Tallam, F.Ruvuna, T.C. Cartwright and J.F.M. Onim

Introduction

In addition to efforts to improve the genetic potential by breeding and improving the forage resources in order to meet the animal production potential, there is need to investigate management regimens that tend to optimize milk and meat offtake. The growth rate of kids is a major function of dual purpose goat production. High kid growth rates facilitate early weaning and thus insure higher levels of milk for human consumption per lactation. Meat animals can also be ready for slaughter at an early age facilitating higher turnover rates in meat production.

Kids are almost completely dependent on milk until 7 or 8 wk of age when the rumen begins to function (Devendra and Burns, 1983). According to Fehr (1981) early weaning may be practiced from the age of 35 d and even earlier if the kid live weight has increased 2.5 fold from birth. Early weaning often causes shock which momentarily results in reduction of weight gain. The earlier the weaning the more marked the reaction. A study on Alpine kids (Fehr, 1981) indicated that weaning at 3 wk caused interruption of growth for 1 wk while weaning at 7 wk resulted in negligible growth retardation. Growth retardation was more related to weaning weight than age.

The major objectives of this study were to investigate the effects of early weaning on kid growth and identify early weaning practices that are biologically viable under Western Kenya smallholder forage resources and management. The objectives were accomplished by employing a goat simulation model developed by SR-CRSP Systems Analysis Project (Blackburn et al., 1984; Blackburn et al; 1986).

Experimental Design and Assumptions

A 3x5 factorial design was used in the simulation experiment. Five kid weaning practices at 30, 60, 90, 120 and 150 d of age were considered under three forage regimens. The forage parameters constituting two of the regimens were obtained from work reported by Hart et al. (1984) for Hamisi, Kakamega. These were designated Base and Improved. The Base forages consisted of fence row vegetation, fallow and off-farm grasses and food crop by-products. Improved forages consisted of Base plus supplemental forage from sudan grass and pigeon pea intercropped with maize.

In order to determine effects of weaning under adequate nutrition an ideal forage regimen was introduced. This was assumed to be a diet of 70% digestibility and 20% crude protein.

It was assumed that kids were allowed 0.5 kg milk per day till weaning and have access to doe forage. Kids are weaned onto doe forage and growth monitored until 1 yr of age. Dry matter availability was assumed to be non-limiting. The DPG genetic potential was 40 kg mature size and 4.0 kg milk on peak day of lactation under nonlimiting nutritional conditions.

Simulations were performed with the Single Animal Version (SAV) of the Goat Simulation Model (Blackburn et al., 1984). Computing was done using an IBM-PC-XT located at Veterinary Laboratories, Kabete. Traits examined were growth of kid in live weight and structural size up to 1 yr of age. Dairy milk offtake for a lactation length of 14 periods of 15 days each (total of 210 days) was also examined.

Results and Discussion

Live Weight

As expected, weaning weights ranked according to ages at weaning. Kids weaned the latest (150 days) had the highest weaning weights within a forage regimen. The results are summarised in Table 1.

Table 1: Weaning and Yearling Weights of DPG Kids by Weaning Age and Forage Regimen

	Age at weaning, d				
Forage Regimen	30	60	90	120	150
Weaning weight, kg					
Base	4.8	7.1	9.4	11.6	14.3
Improved	4.8	7.1	9.4	11.8	14.5
Ideal	4.8	7.1	9.4	11.9	14.8
Yearling weight, kg					
Base	8.2	9.9	11.6	13.6	18.2
Improved	13.5	20.6	25.4	28.1	30.4
Ideal	36.0	36.4	36.5	36.7	36.8

No differences were observed in weaning weights within a weaning practice; i.e., during the preweaning period, growth was similar across a given forage regimen at a given weaning age. Milk intake and available forage met all energy requirements for the kids in all cases. Preweaning dry matter intake levels are summarized in Table 2.

Table 2: Preweaning Kid Total Dry Matter Intake (kg) by Weaning Age and Forage Regimen

Forage Regimen	Age at weaning, d				
	30	60	90	120	150
Base	1.4	5.6	13.4	24.0	36.6
Improved	1.4	5.6	12.3	21.9	34.4
Ideal	1.1	3.9	8.1	14.0	21.3

Not all the protein requirements for growth were met. The similarity in weaning weights is an indication that the milk and dry matter allowed for kid consumption was sufficient such that differences in forage quality did not result in variation in growth rates. On low quality feed, kids consumed relatively higher amounts of dry matter to meet the nutrient requirements.

Yearling weights are summarized in Table 1. Yearling weights ranked according to weaning age within a forage regimen (Figures 1 to 3). Kids weaned the latest had the highest yearling weights. Unlike the weaning weights, yearling weights varied across a forage regimen. Kids weaned onto Base forages had the lowest weights while those on the Ideal forage attained the highest live weights. Yearling weights on Base forages ranged from 8.2 to 18.2 kg. These results indicate that early weaning of kids on to Base forages is not a viable practice. On Improved forages the weights ranged from 13.5 to 30.4 kg. At 1 yr of age the kids are expected to be over 50% of their mature weight under nonlimiting nutritional conditions. Weaning at an age less than 60 days under the Improved forages would therefore be detrimental to growth.

For kids weaned on to Ideal forages, yearling weights were the same across weaning practices. Those kids weaned earlier had gained to the same level as those weaned the latest due to the high quality feed (Figures 3).

Structural Size and Degree of Maturity

Results on growth in structural size and degree of maturity are summarized in Table 3 and further illustrated in Figures 4 to 6. The degree of maturity is expressed as a ratio of size potential at a given age (WM) to size at maturity (WMA). This is expressed as a percentage.

Table 3: Weaning and Yearling Structural Size and Degree of Maturity of DPG Kids by Weaning Age and Forage Regimen

Forage Regimen	Age at weaning, d				
	30	60	90	120	150
Weaning size, kg					
Base	3.9(9.8)*	5.3(13.3)	6.7(16.8)	8.0(20.0)	10.0(25.0)
Improved	3.9(9.8)	5.3(13.3)	6.7(16.8)	8.0(20.0)	10.0(25.0)
Ideal	3.9(9.8)	5.3(13.3)	6.7(16.8)	8.0(20.0)	10.0(25.0)
Yearling size, kg					
Base	3.9(9.8)	5.5(13.8)	7.3(18.3)	9.4(23.5)	16.5(41.3)
Improved	13.5(33.8)	17.4(43.5)	23.4(58.5)	26.6(66.5)	28.9(72.3)
Ideal	31.9(79.8)	32.4(81.0)	32.4(81.0)	32.5(81.3)	32.9(82.3)

*Degree of maturity (WM/WMAx100) structural size expressed as a percentage of mature size of the breed.

The results further confirm the detrimental effects of early weaning under Base forage regimen. The kids failed to mature at their genetic potential due to low quality of the feed. Growth and maturity on Improved forages was higher although for kids weaned at less than 60 days of age, growth after 1 yr was still too low. Growth and maturity under Ideal forage regimen was adequate for yearlings on all weaning practices (Figure 6).

Dairy Milk Offtake

Dairymilk offtake and total yields are summarized in Table 4.

Table 4: Dairy Milk Offtake (kg) of DPG by Weaning Practice and Forage Regimen

Forage Regimen	Weaning practice (age, d)					
	30	60	90	120	150	Total yield[a]
Base	170.7	155.7	140.7	125.7	110.7	185.7
Improved	226.4	211.4	196.4	181.4	166.4	241.4
Ideal	438.5	423.5	408.5	393.5	378.5	453.5

a Dairy milk plus kid consumption.

Total milk yields increased with improvement of forage quality. Yield on Ideal forages was more than twice that obtained on Base forages (185.7 vs. 453.5 kg). Within a forage regimen, early weaning practices facilitated more milk for human consumption.

Summary and Conclusions

Improvement in forage quality increased production of milk and kid growth significantly. It is evident from the simulation results that Base forages are inadequate for dual purpose goat production. Early weaning on such quality feed is not a viable practice.

Improved forages increased milk production and growth rates of kids. However, weaning at an age less than 60 days was still detrimental to kid growth. Under this regimen kids can be weaned at 60 to 90 days of age without adversely affecting kid weight at 1 yr of age.

Forage quality at the level of the Ideal forage regimen can adequately meet doe milk production requirements. Kids weaned on to this quality of feed performed satisfactorily in growth and maturing rates.

For early weaning to be a viable practice in small holder farms there is need to improve feed resources to a quality higher than that of the Improved forage regimen. Improvement in forage quality will not only insure high total milk yield per lactation but also make early weaning a viable practice. There needs to be a balance between the amount of milk taken for household use and that left for kid consumption such that the benefits of early weaning are not outweighed by low kid growth. Economic analysis on the simulation input and output data can be done to determine feasible practices.

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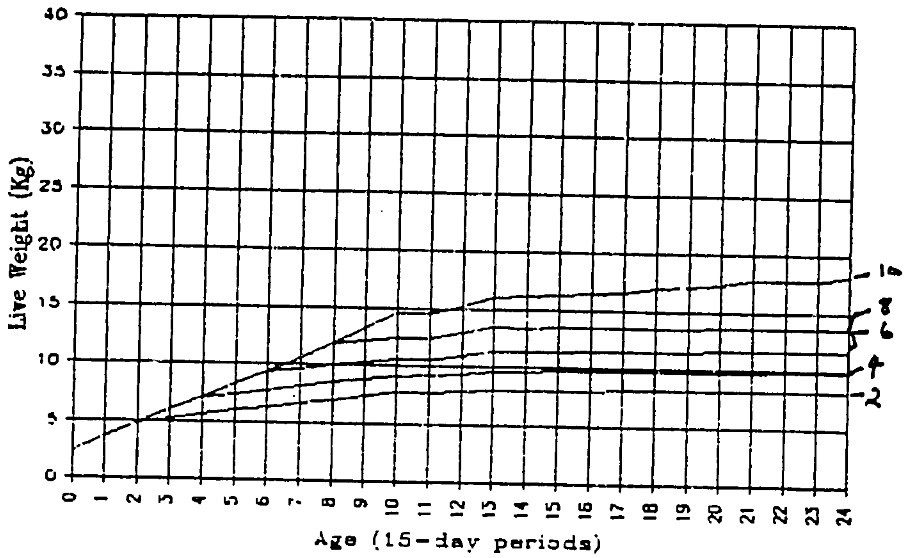

Figure 1. Kid Growth in Live Weight by Weaning Age on Base Forage Regimen

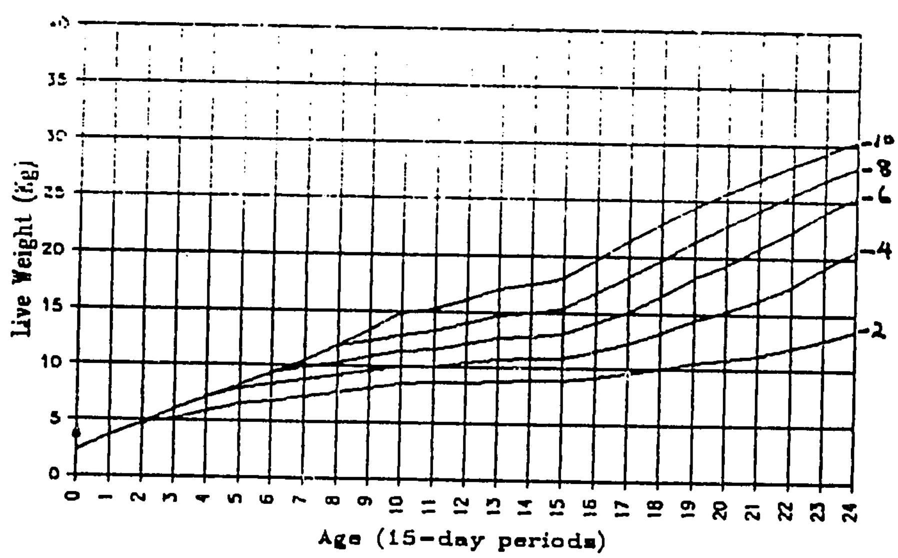

Figure 2. Kid Growth in Live Weight by Weaning Age on Improved Forage Regimen

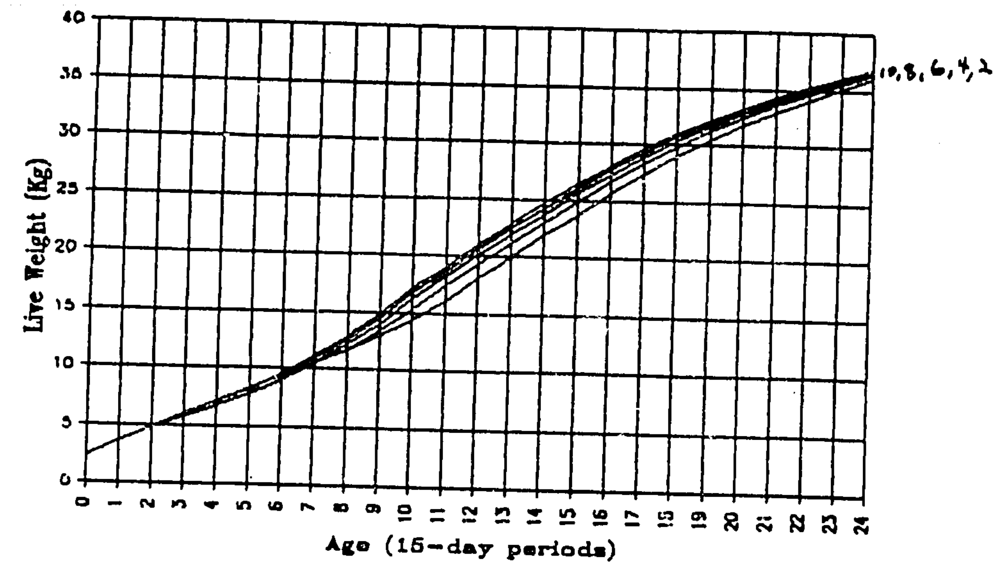

Figure 3. Kid Growth in Live Weight by Weaning Age on Ideal Forage Regimen

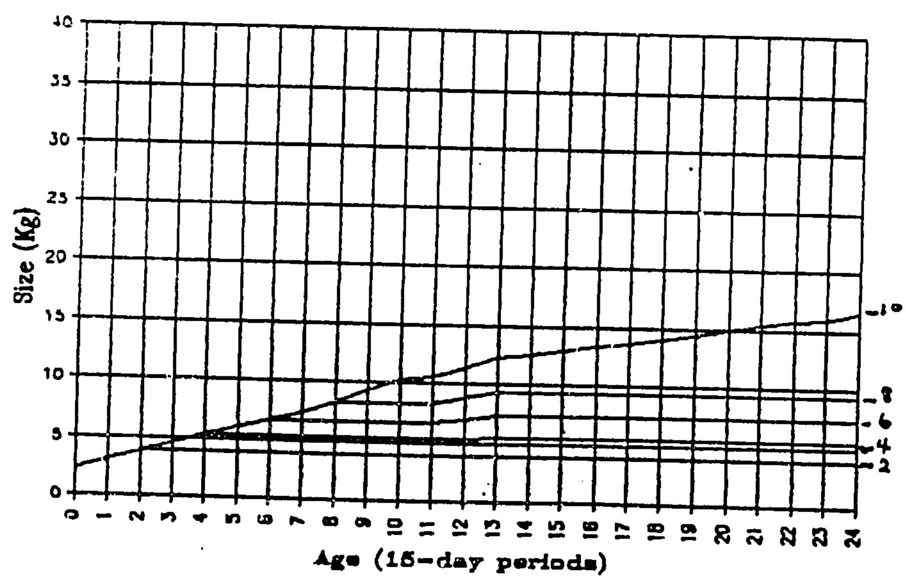

Figure 4. Kid Growth in Structural Size by Weaning Age on Base Forage Regimen

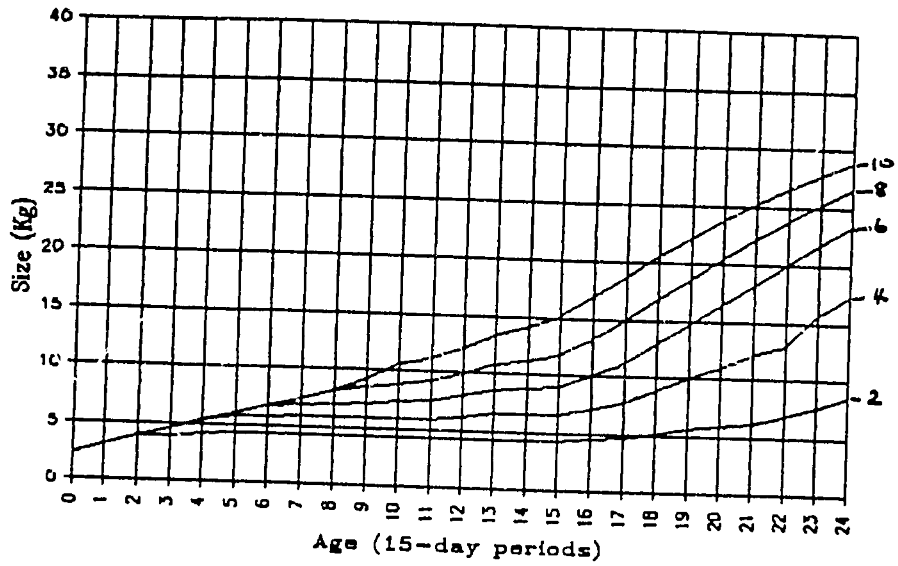

Figure 5. Kid Growth in Structural Size by Weaning Age on Improved Forage Regimen

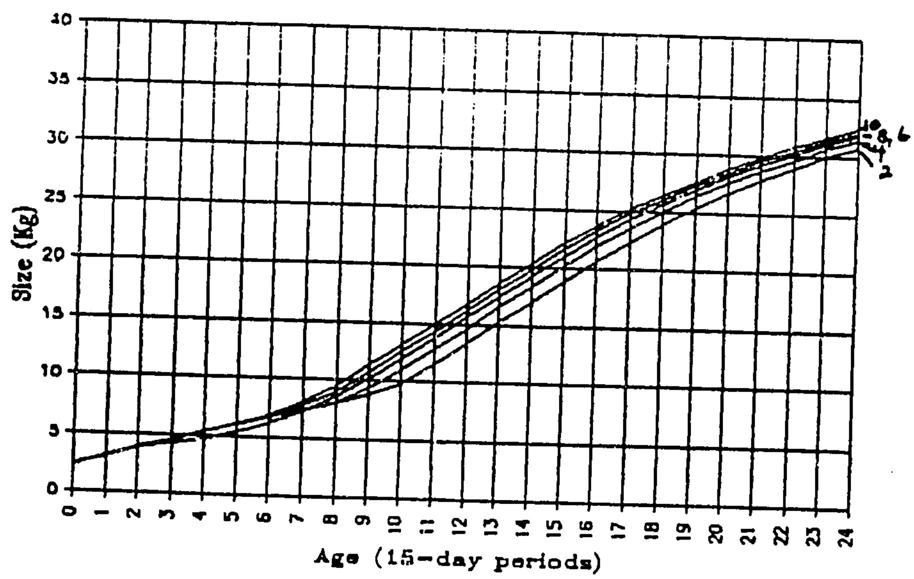

Figure 6. Kid Growth in Structural Size by Weaning Age on Ideal Forage Regimen

Viability of Dual Purpose Goat Production in Western Kenya-Systems Analysis Perspective

T. C. Cartwright,[1] P. J. Howard,[1] H. D. Blackburn,[1] E. L. Lentz[1] and S. K. Tallam[2]

Results from the collaborative SR CRSP project confirms that dual purpose goat production by smallholders in western Kenya is feasible. Community interest and request for dual purpose goats with 1/2 dairy breeding are high. Simulation results reported in 1984 and 1985 also indicated the feasibility of DPG production on smallholder farms and also quantified inputs and outputs (Cartwright et al., 1984; Blackburn et al, 1985; Cartwright et al., 1985). Further, a proposed production package was presented (Cartwright et al., 1984) that outlined practices that were required to insure that dual purpose production would be biologically feasible. Attention is now focused on the viability of the DPG program, viability in the sense of a program capable of development, given the constraints of smallholder production in western Kenya.

The feed resource base, as identified by Hart et al. (1984), Ruvuna et al. (1984) and Cartwright et al. (1984; 1985), is limiting in terms of amount and quality. The low genetic potentials for growth and milk of local goats (Ruvuna et al., 1986) is also limiting. Also, smallholders must deal with the problems of parasites and diseases (Cartwright et al., 1985).

One of the advantages of conducting systems analyses via computer simulation, other than including total system effects, is that "experiments" can be simulated in order to examine various options and sort out by sequential simulation, sets of production practices that tend to be optimal. Previous simulations have shown that the Kenya DPG is a feasible and desirable alternative to the indigenous stock when the goal is dual purpose production (Cartwright et al. 1985; Blackburn et al., 1985). Similarly, past simulations have shown that a flock of two mature does is unable to meet minimal dairy milk production (200 grams per day per person) for an average farm family (Cartwright et al., 1985). The previous work has not clearly indicated the flock size that is optimal in meeting the overall SR-CRSP Kenya goals given the constraints of feed resources and other limitations of the farmers. Improvement in the base forage was confirmed as a high priority objective for the forage project; quality was limiting for levels of productivity sought and especially during the dry season it interfered with stable production.

In order to refine answers to questions related to developing a viable dual purpose goat program in western Kenya a further simulation experiment was designed to examine constraints to smallholder production and to quantify feed required and meat and milk offtake for various practices. These simulations included the stresses typical of smallholder production. Included in the design were three flock sizes (maximum of 4, 5 or 6 mature does); two genetic potentials for milk, the Kenya DPG and a dairy-native crossbred; and two diets, the base diet described by Hart (1984) and the base diet plus stored forage.

The SR CRSP Kenya literature is not decisive on the most appropriate doe flock size for recommendation and implementation (Cartwright et al., 1985; H. A. Fitzhugh, Jr., personal communication; Job, 1982). The current systems analysis

[1]Animal Science Department, Texas A&M University, College Station, Texas
[2]Kenya Agricultural Research Institute

was based on the most recent data to provide quantitative production information for use in establishing an optimal target for doe flock size.

The growing demand for dairy crossbreds in Kenya indicates that an intermediate genotype should be examined for productive capabilities. The Kenya DPG is characterized by a genetic potential of 40 kg mature doe weight in good condition and 4.0 kg of milk at peak day of lactation at maturity (40/4.0). The intermediate is a dairy breed crossed with native breeds and is characterized by genetic potential for 40 kg mature weight and 3.0 kg peak day milk (40/3.0). The supply of the Kenya DPG in the near future is limited, and the use of dairy crossbred goats would give smallholders ready access to a higher producing type of goat. Goats with the intermediate genotype are available now from private breeders as well as from the SR-CRSP Breeding Project.

Experimental Methods and Assumptions

The simulated experiment, a 2x2x3 factorial, was designed to examine the interactions between forage inputs (2) and genetic potential for milk production (2), and to quantify input/output relationships of different flock sizes (3). Forage inputs were taken from work reported by Hart et al. (1985) for Hamisi, Kakamega. The traditional forage production practices outlined by Hart et al. (1984) were the input parameters used and are designated as the Base diet. Forage parameters designated as Base-Plus were taken from a proposed alternative that includes production of pigeon pea (Hart et al., 1984) or similar forage and includes storage for short periods. Data from the Breeding Project supplied the parameters for the two genotypes (Ruvuna et al., 1986). Flock sizes of 4, 5 or 6 does (maximum number of does in a flock) were based on previous simulations that demonstrated that this range was feasible.

Several management assumptions were used to simulate smallholder production. It was assumed that all kids would be kept until one year of age, and that one doe kid per flock would be kept for an additional 3 months to insure availability of suitable doe replacements. Culling level was 5%, and occurred the last of December. Replacement does were allowed to enter the breeding flock at 15 months of age, given that they had attained a weight of 14 kg.

Worm loads and worming policy were given in Cartwright et al. (1985). The assumed larvae intake varied with the season; larvae intake increased in the wet season and decreased in the dry season. Use of an anthelmintic was assumed to correspond to the expected build up and decline in larvae intake. The efficacy of the drug was set at 80%. Natural immunity was set at 35%, intermediate between exotic dairy and indigenous breeds.

Since both meat and milk are produced, standards had to be imposed on milk taken for dairy purposes. If the body condition of a kid does not fall below 75%, then 1/2 of the dam's milk production is taken for dairy use. If a kid's body condition falls below 75%, then its dam's milk production is reserved only for the kid (Cartwright et al., 1985). Body condition is the kid's weight as a percentage of the weight it would have attained with unrestricted nutrition. If a doe is nursing twins, no dairy milk is taken.

Results and Discussion

Nutrition. The simulated production and characteristics for a Kenya DPG flock (genetic potential of 40 kg mature size and 4.0 kg peak daily milk) are summarized in table 1. Within diet and across flock size, production is expected to be nearly constant on a per doe basis except for stochastic effects in the model. The annual number of births per doe was 1.7 on Base and 2.1 on Base-Plus (24% difference). The live weight sold annually per doe was 18 kg vs. 41 kg for Base vs. Base-Plus (128% difference). The annual amount of dairy production was also greater on Base-Plus; does on the Base diet produced, 74 kg of dairy milk, while similar does on the Base-Plus diet produced 113 kg (53% difference).

This greater production on Base-Plus was accomplished by a 45% greater dry matter consumption. The number of followers (i.e., replacement does, weaned kids and nursing kids) was 25% greater. Degree of maturity (fraction of potential mature weight) of the weaned kids was, on average, 25% for Base nutrition and 35% on Base-Plus.

Dairy production per flock on a per day basis, averaged over 10 years, is illustrated in figure 1 for the Base diet. In general, lactation patterns tend to follow the forage quality. Figure 2 shows the simulated dairy production on the Base-Plus diet for the three different flock sizes. Only at two points does the 4-doe flock produce as much milk as the 5-doe flock. Figure 2 clearly shows the advantage of the 5-doe flock over the 4-doe flock on the Base-Plus diet. The 6-doe flock produced more milk than the 5-doe flock on the Base diet; this difference was increased on the Base-Plue diet.

Variability of dairy production during the year is illustrated in figure 3. The most desirable pattern is one where there are no periods with zero dairy production and most periods are over 1.0 kg of dairy production. The Base-Plus diet has a desirable pattern for the 6-doe flock where, for 71% of the periods, dairy production exceeds 1.0 kg per day. The Base diet does not show this same pattern; i.e., there is more variability in milk production. The 4-doe flock on the Base diet has almost as many periods with zero dairy production as periods with dairy production of 1.0 kg or more. Variability of dairy production has important implications for smallholders when it falls below family needs.

Genetic Potential. Systems analyses have been used to establish the goals for selecting the Kenya DPG. As indicated earlier, growth potential as characterized by mature size, was determined to be 40 kg. This optimal size was rather definite with narrow limits. Likewise, milk potential, characterized by peak day potential at maturity, was determined to be 4.0 kg. This optimal milk potential had broad limits indicating a wide range of nearly optimal milk potential. This goal was designed with the expectation that as the dual purpose goat program progressed, methods to improve nutrition, health and management would be improved. The simulation results reported here were designed to more closely reflect current smallholder production conditions. Under these conditions the goats with 40/3.0 potential performed very similar to those with 40/4.0 potential. Although the performance was similar, the 40/4.0 goats were more efficient in using DM (feed) for milk production by 10 to 25% and for sale liveweight by 1 to 16%.

Generally, the genetic potential for growth and milk that is best adapted does not greatly exceed the genetic potential that the nutritional environment will support. That is, for the present, the doe that is approximately 1/2 dairy breeding and 1/2 native has near optimal performance. The Kenya DPG is 1/2 dairy - 1/2 native, but it is based on native screened for high milk potential and is selected for growth, milk production and survivability (Cartwright et al., 1986). The similarity of productivity is seen in tables 1, 2 and 3 by comparing dairy production/doe, weight sold/doe, DM intake/doe, average weaning weight, dairy milk and live weight sale. The 40/4.0 might be expected to perform relatively better on the Base-Plus diet and the 40/3.0 relatively better on the Base diet, but this interaction is not indicated in the results. This lack of interaction indicates that the Base Plus diet is below the quality required for the Kenya DPG to produce close to its potential or at the desired level.

As a separate simulation the effect of complete control of helminths was examined. Offtake of the kid weight sold from the 40/4.0 flocks increased about 20% on the Base diet and about 10% on the Base-Plus diet.

To examine the potential of the Kenya DPG on a smallholder farm, a further simulation was run. The same input parameters, management, etc. were used as for the 6-doe flocks, 40/4.0 and Base-Plus diet except that any doe falling below 75% body condition received a supplement of .5 kg/day of sesbania leaves which were 72% digestibility and 22% crude protein. This is a practice that is feasible, easily employed by a farmer within reasonably close limits and is good "dairy husbandry". Under this minimal selective doe supplementation, productivity was, as expected, greater than for the Base and Base-Plus. The total amount of supplement fed to the thin does was only 206 kg, yet dairy milk production was substantially higher. The supplemented doe flock produced 57% more dairy milk (1013 kg vs 644 kg). Also other flock productivity was greater; e.g. sale liveweight was 13% greater (281 kg vs. 248 kg).

Flock size. The production data for different flock sizes provide input requirements and offtake values in quantitative terms (tables 2 and 3) which can be used for further analysis and planning. There is some non-linearity associated with the different flocks sizes due to stochastic elements of the model is similar to variability found in real flocks. The added increment between Base and Base-Plus adds almost directly to production since the flock is being maintained on the Base. That is, adding the Plus to Base is a minimal nutrition intervention for viable dual purpose goat production. Figure 3 provides a vivid example: the 4-doe flock on Base-Plus produces about equally to the 6-doe flock on Base. Of course DM consumption and offtake increased with flock size, but the DM intake for all flock sizes did not exceed that which is available; that is, the base forage quantity that is available is sufficient for 6-doe flocks. Variability of milk supply is of concern for the smallholder family (figure 3). Values of zero, less than 1 kg, and greater than 1 kg were chosen as convenient points to examine. One kilogram provides 200 grams/family member (FAO recommended minimum) for a family of five. Only 6-doe flocks on Base-Plus have satisfactory stability of dairy milk supply.

Summary

A major value of the simulations reported here is the production input/ output data for use in planning and formulating recommendations.

Nutrition. These simulations reiterate the need for improved forage quality over the Base. A diet equivalent to the Base-Plus is minimal for a viable dual purpose goat program. In addition, selective supplementation of lactating does appears to be very "cost" or "resource use" effective.

Genetic Potential. The 40/3.0 crossbred is effective in utilizing the current forage resource and should be encouraged as a basis for initiating dual purpose goat production. The Kenya DPG (40/4.0) is essential to utilize a more adequate diet and produce at the desired level.

Flock Size. In order to provide minimal amounts of milk for families, 6-doe flocks fed Base-Plus diets are required. The liveweight offtake of these flocks is a very substantial item.

Viability of the Dual Purpose Goat Program. The simulation results show that for the program to be viable the following are required:

1. A forage program that will increase forage quality throughout the year so that it is no less than the Base-Plus.

2. Management which provides sufficient care to permit individual supplementation of does.

3. Genetic potential of 40/3.0 increasing to 40/4.0.

4. Veterinary care to insure health standards including use of anthelmintics with at least 80% efficacy.

In general, it is clear that the returns to the dual purpose flocks can be very substantial. For example, 6-doe flocks can produce 250+ kg liveweight offtake and 600+ kg dairy milk as a supplementary enterprize to farming; the cash value of these products is estimated to be over KSh4000. A flock of goats, matched in number to the forage resource and managed for productivity appears to be viable. The viability disappears if either the nutrition, the potential of the goats, the health care or the management care fails.

Development Of Dual Purpose Goat Production
In Western Kenya - A Systems Analysis Paradigm

T. C. Cartwright[1], H. D. Blackburn[1] and F. Ruvuna[2]

Introduction

Far less is known about the goat scientifically than other meat and dairy livestock species, and little attention has been given to the best ways to exploit the potential benefits of the goat in production systems. That is, we have put little effort into the planning process even though it could return benefits for goat production as it has for other species. Even though the goat is a survivor and is often the last livestock species to remain in an abused environment, it is also responsive to a good environment. But a good environment for the goat is not identical to a good environment for sheep or cattle. The goat is unique in its nutrient requirements, grazing behavior, response to nutritional stress for survival and other physiological processes.

Although the goat appears to be a highly plastic species, genetic improvement in most of the population has been limited. One reason is that the goat is usually kept in an environment that limits production and a major concern is survival in which case slow maturing rates and low levels of milk production may be advantageous. Whatever the environment (E), it should be matched with animals of the appropriate genetic potential (G), and vice versa; i.e., it is not simply matching one with the other but rather simultaneously adjusting each within practical limits to obtain a best fit between G and E.

Although the effects mediating the net offtake from a production system form a complex network, scientists often examine each part separately in order to better understand each of the functions. The classical approach, a simplifying approach, is effective and necessary to advance science, but when the parts are put together as a whole, a different approach is required.

Systems Analysis

Systems analysis is the designation of the field of science that examines both inputs and outputs of more or less complex systems. The behavior of a system results from the inputs provided from outside the boundary of the system, and the interaction of the mechanisms operating within that boundary. The interactions within the boundary of the system are mediated by feedback mechanisms. Systems analysis applied to livestock production is a method of conceptualizing a production system and modeling it in mathematical terms so that animal responses across time are closely simulated by a computer program. With this approach, interactions within the system and output from the production system can be evaluated.

As part of the systems analysis project of the SR CRSP, we developed a goat simulation model for use in conducting systems analyses in Kenya. We considered systems analysis as a method of organizing information about the individual biological components of the goat into a unified structure and dynamic form. The model is used to examine how the goat reacts in different production

[1]Animal Science Department, Texas A&M University, College Station, Texas
[2]Animal Science Department, Texas A&M University, Kabete, Kenya

situations. Without such a model to interrelate the different biological components it would be difficult to determine how factors affecting one part of the goat or flock would affect another seemingly unrelated biological process within the goat or flock. By using a systems analysis approach it is possible to test numerous options such as the response of different breeds or the effects of supplemental feeding. Employing conventional experimentation to examine the effects of a large number of options would require commitments of personnel, time and financial resources which are usually limited or not available.

Simulation Model

An initial goal of our systems analysis project was to quantify and characterize the biological interactions which occur within the goat and program these in mathematical terms into a computer model. This model enables us to examine how goats respond to changing environmental conditions or how different breeds or types of goats respond to the same environment where the environment consists of the physical and managerial conditions of the production system. The model was constructed in such a way that almost any production situation can be simulated, if the forage (diet), management and breed parameters can be correctly specified (Blackburn et al., 1986).

The simulation model was developed to integrate the different biological components (age, maturity, lactation status, etc.) of a goat into a unit (or animal). The flow of nutrients is determined by the physiological status of the animal being simulated. The physiological status is altered by the auxiliaries: age, lactation status, sex, gestation status, maturity and body condition. The physiological status for any two animals will likely be different. These factors exert an effect on the physiological status which in turn determines where nutrients flow and the amounts of nutrients which are divided between the various requirements. The model simulates one animal at a time, with biological factors updated every 15th day. Assume a mature, nonpregnant, lactating doe is being simulated. First, her physiological status determines the level of the available feed that she will consume; the feed consumed will go into the nutrient pool. Protein and energy from the feed will leave the nutrient pool and be partitioned between lactation, maintenance and body stores. Other levels such as gestation and body growth have been shut off by the controlling auxiliary physiological status. If the doe is not able to consume sufficient feed, she will catabolize her body weight to provide protein, energy or both to meet her maintenance requirements and lactation requirements. If there is still a nutritional deficiency, production is decreased proportionally to represent the deficit.

Three types of data (input parameters) are required for simulations: genetic potentials of the goats, feed resources and management practices. The input parameters for genetic potential are mature weight, maturing rate, peak day milk production, seasonality of breeding and ovulation rate. The feed resources, specified for each period (15 days), are digestibility and crude protein content of the forage diet, availability of forage (kg/head/day), and the same for any supplement fed. The management practices currently used in the system or those which are to be tested must also be specified. These include:

breeding season, weaning policy, sales policy, flock health program, selection and culling practices and dairy practices. Model results provide estimates of growth, lactation and reproduction of every animal in the flock and their dry matter consumption. Because of the number of different options the goat model can simulate, the output is useful for economic analysis.

Application

To evaluate DPG production in various physical environments and superimpose a layer of different management and nutritional tactics would extend live animal experiments past financial, physical and time constraints of the SR CRSP. Alternative management, nutrition and breeding practices were evaluated by systems analysis as a basis for formulating sets of practices most likely to succeed under practical conditions based on scientific knowledge (Cartwright, 1984). Results from systems analyses that were performed document the steps involved in (1) the choice of a genotype for the DPG, (2) the examination of potential productivity of DPG flocks on smallholder farms, (3) the examination of the effect of nutritional interventions and (4) matching of management practices to nutrition and genetic potential.

Genetics (Target DPG Genotype)

The two indigenous breeds, East African (EA) and Galla (G), were shown to be lower in milk production (200 g/day) than Toggenburg crosses (670 g/day) at peak lactation (Ruvuna et al., 1983). However, indigenous breeds had higher levels of survival. If a goal of 200 g milk per day for each family member was to be met, goats with the higher levels of milk yield were required. There are three basic functions which must be incorporated into breeding and selecting a DPG for smallholders: growth, reproduction and lactation, and survival (Cartwright, 1984). An effective way to combine these three functions was to develop a synthetic breed comprised of two exotic dairy breeds (Toggenburg and Nubian) and the two indigenous breeds (East African and Galla). This procedure would take advantage of the milk and growth potential of the dairy breeds, and the disease resistance and survival characteristics of the indigenous population while retaining a high level of heterosis. However, the genetic potential to select as an optimal combination in the new breed for western Kenya was unknown and no research information was available on which to base an opinion. Therefore simulations were performed to determine optimal genetic potentials for size (growth rate), maturing rate and milk production.

Initial simulations were performed for a western Kenya production situation, using parameter inputs for available forage (Sands, 1983) and different genetic potentials for mature size (GSIZE) and peak daily milk production (GMILK) of a mature doe (Cartwright et al., 1984). Genetic potentials, expressed as GSIZE/GMILK, for the breeds were: EA 30/2.5, G 35/3.0 and TOG 55/6.0. The crossbreds were slightly above the average of these potentials (Ruvuna et al., 1983). Genotypes of crosses chosen for testing were 35/3.0, 35/4.5, 45/3.0 and 45/4.5. Simulation results indicated that the environment was capable of sustaining genotypes other than the indigenous type of goat (35/3.0). The 35/4.5, 45/3.0 and 45/4.5 could survive and produce more milk and wean heavier kids than the 35/3.0 indigenous type. More extended evaluations of genotypes included 50/6.0, 45/4.5, 40/4.0, 35/3.0 and 30/2.0. These genotypes represent expectations of the size and milk production of indigenous goats selected out of the Kenya population for dairy potential and their crosses mated to the exotic breeds. The 30/2.0 genotype was not suitable for use as a DPG since the 30/2.0 doe was not able to produce dairy milk, grow and reproduce. The 50/6.0, 45/4.5 and 35/3.0 proved to be unsuitable potentials for a DPG because body condition of does declined to critically low levels. These stressed does were more susceptible to debilitating effects of disease and parasites and could not reproduce regularly. Does of genotype 40/4.0 maintained a higher minimum body condition, had more kids over the 5-year period and produced a more continuous supply of milk. However, in terms of quantity of milk yield and weight of kids weaned, the 50/6.0 and 45/4.5 were most productive. Nevertheless, the combination of performance characters make the 40/4.0 the most appealing choice since it had an acceptable production level and retained robustness. The extra body reserves indicate that, if the production conditions of the smallholder periodically deteriorated, the 40/4.0 DPG would have the resiliency to continue producing, while the 45/4.5 and 50/6.0 would not.

Ruvuna et al. (1984) showed that a doe with a mature size of 40 kg can be selected and bred from existing stocks. The length of time to select for a GMILK of 4.0 kg would be at least several generations. Due to the time required to develop a 4-breed synthetic DPG, with the 40/4.0 genotype, the question was whether an up-graded intermediate goat could be used until the DPG could be produced. Therefore, the performance of a goat with a 40/3.0 genotype was evaluated since it was almost immediately available. Simulations were performed with a 4-doe flock of the 40/3.0 genotype to compare with a 4-doe flock of 40/4.0 (table 2). For most characters studied, the 40/4.0 produced more milk and salable kids. However, the 40/3.0 was similar to the 40/4.0 in many respects. The most undesirable characteristic of the 40/3.0 genotype was that the total number of goats in the flock had to be increased to remain stable in number. That is, more kids had to be kept to assure replacement of does and increased dry matter consumption, labor and space requirements, but the 40/3.0 is an effective intermediate genotype.

Nutrition

Dual purpose goat production in Kenya is dependent on forage which varies in quantity and quality throughout the year. Flocks may be managed so that fluctuating nutrient demands that vary with the growth, pregnancy and lactation status of each individual tend to best coincide with the seasonal forage variation of the basal diet (Hart et al., 1984). The degree to which this can be done and meet the needs of the smallholder families for a continuous supply of milk is limited. Simulations showed that this stability requires short term storing of feedstuffs for use during critically deficient periods and development of additional feed resources.

During the nonlactating phases, the protein and energy requirements of the doe were met (Blackburn et al., 1985) by the available diet (Hart et al., 1984). However, during lactation the diet did not have sufficient protein and energy to meet lactation requirements plus maintenance requirements. Both energy and protein limited production, but energy was the most limiting nutrient. Simulations were then conducted to provide an objective, quantitative basis for examining management practices that would eliminate or minimize the nutritional deficit.

The basal diet supplemented with modest amounts of sudangrass plus pigeon pea was used for simulation. These results indicated that when sudangrass and pigeon pea are incorporated into the diet, the energy deficit is reduced by approximately 20%; however, a nutritional impediment to production remained during early lactation. A diet designed to alleviate some of the nutritional limitations to milk production was based on limited use of harvested sesbania leaves which appears to be a practical alternative (Sidahmed et al., 1984).

These simulations were extended with the objectives to compare DPG productivity on the basal diet with productivity on this diet plus stored forage fed when a shortfall of the existing forage base occurred. Stored forage was assumed to be composed of maize stover and other crop residues readily available, stored in a manner similar to stacking hay and were fed in September, October and November (Cartwright et al., 1984). In addition to the stored forage, small amounts of sudangrass obtained from inter-cropping with maize was selectively fed as a supplement (.25 kg/day) during months when crude protein of feed fell below 7%. Simulations were performed to examine response in growth, lactation and reproduction. Forage availability (amount) was identified as the determin- ing factor for the number of does that a farm could support. Only three does/ farm could be supported without use of stored forage, and continuous year-round supply of 200 g milk/day for each family member would not be possible. However, with stored forage, six does could be supported. The average lifetime milk production of a DPG doe was 117 kg per lactation and average weaning weight of kids was 14 kg. Further simulations identified three viable feeding practices for smallholders to raise DPGs.

Management

Milking Strategies. A major management consideration for DPG production is determining the optimal amount of dairy milk to extract and its impact on kid performance (Ruvuna et al., 1984). Cartwright et al. (1983) documented the effects of extracting 1/2 of the milk on kid weaning weight for indigenous and dairy breeds. This led to experiments (Ruvuna et al., 1984) where different types of milking strategies were tested. Further quantification of milk division strategies (Blackburn et al., 1985) are summarized here. Four milking procedures were simulated using forage input parameters typical of the area, with and without stored forage supplement (Hart et al., 1984). The four milking procedures were 1) unlimited access by the kid to dam's milk and the remainder, if any, is used for dairy; 2) kid consumes 1/2 of the milk and the remaining 1/2 is used for dairy throughout lactation; 3) kid consumes .5 kg milk and the remainder, if any, is used for dairy; 4) kid consumes .3 kg milk and remainder, if any, for dairy. Simulated results indicate that treatment 1 weaned the heaviest kid while treatment 4 weaned the smallest (17.4 vs 10.0 kg). Intermediate weaning weights were obtained for treatments 2 and 3 (12.8 and 13.1 kg). Using base forage plus supplement increased weaning weights for treatments 1, 2 and 3 (10.3 to 11.7%) but had little effect on kid weaning weight in treatment 4 (10.0 vs 10.7 kg). Kids on treatment 4 were under stress, growth was stunted and the kids could not recover. The percentages of milk used for dairy were 10, 50, 46 and 61% for treatments 1, 2, 3 and 4, respectively. Treatments 2 and 3 provided an intermediate combination of weight of kids for sale and dairy milk yield. The treatment a smallholder selects may be dependent upon the number of does he owns. Farmers with few does may opt for treatment 2 which would provide milk from a doe for a longer period of time. Conversely, a farmer with more does, may switch to a shorter lactation which yields more milk/day but for a shorter period of time, without going through a "dry" period.

Flock Size. Flock size and replacement policy are difficult areas to assess with real goat flocks and limited resources but can be realistically simulated (Cartwright et al., 1985). Initial simulations demonstrated that the forage resource (Hart et al., 1984) was capable of sustaining 6 does. Further simulations were designed to examine 2, 4 and 6-doe flocks under management typical of a smallholder. A critical point of flock size in addition to amount of milk is consistency of milk supply; i.e., the frequency with which milk yield falls to zero. Each year is simulated to have 24 periods that are 15 days in length. Over a span of 5 years, milk yield fell to zero at least once for 42% of these 24 periods for a 2-doe flocks while it fell to zero only 17% of these periods for 6-doe flocks. A 6-doe flock is required for a high level of dairy milk availability; during five years, a family would expect to be without milk during only 4 periods (2 months).

Replacement Policy. Simulations were performed with two types of replacement policies: 1) keeping female replacements after weaning only if a doe had died or was sold, and 2) keeping all kids to 1 year of age before selling them or adding them to the flock (Cartwright et al., 1984; Hart et al., 1984; Cartwright et al., 1985). These simulations showed that in the first option the flock milk yield was erratic and milk yield often fell to zero. Periods of low productivity were caused by not having a replacement doe kid which was old enough to breed and begin lactation, after a short interval, when an older doe died or was culled. Keeping doe kids to 1 year of age allowed a smoother transition of does exiting and entering the flock. At least 1 weaned doe kid should be kept as a replacement at all times even though this practice results in a somewhat lower efficiency of conversion of the feed resource by the flock.

Summary

Systems analysis simulation studies of DPG production by western Kenya smallholders indicate the following:

Optimal breeding and selection goal is a genetic potential of 40 kg mature doe size and 4.0 kg peak day milk yield (40/4.0); however, a 40/3.0 is a satisfactory genetic potential for an initial flock.
The base forage production potential is not sufficient, without specific intervening practices, to support viable DPG production.

Supplementation of the base forage with stored forage can alleviate deficiencies of the base forage sufficiently for viable DPG production.

Optimal dairy milking practices are either 1/2 of doe's milk or .5 kg milk/day provided for the kid.

A flock size of 6 does is required to meet minimal milk supply for an average family.

Economic analyses should be conducted on all simulation results that are used as a basis for formulating recommendations for production practices. Experience with application of economic analyses to systems analysis results (Doren et al., 1985), indicates that biological measures of production efficiency such as output/input ratios are inadequate economic indicators and may be quite misleading. Economic evaluation of DPG simulations have been initiated (Mukhebi et al., 1985) and will be continued.

A PROSPECTIVE ANALYSIS OF SEMI-INTENSIVE DAIRY GOAT PRODUCTION

By

S.K.Tallam, T.C. Cartwright, J.T.M. Onim and M.N. Mathuva

Introduction

Goat production systems can be classified into four categories: (i) tethering (ii) extensive production (iii) intensive production and (iv) integration into crop agriculture (Devendra, 1981). Tethering is often associated with limited labour input. Farmers on this system often shift animals from one grazing area to another once or more times daily. Extensive production is usually practised in medium to low forage production areas and often involve a large number of animals grazing on natural grasslands or range lands. In intensive production systems, goats are fed in confinement with limited access to land. Intensive systems involve high labour and cash input. Feed resources for intensive production are usually from cultivated grasses and food-feed by-products. Concentrate feeding may also be included. In small scale farms where subsistence is often the goal, integration of goats into crop agriculture is the major system of production.

Most of the feed for small scale farming in Western Kenya comes from (i) communally grazed land (ii) fallow land on the farm (iii) crop thinnings, toppings, leaf strippings, stover and residues and (iv) cut-and-carry fodder from planted forages (Onim et al., 1985). The most practical system of goat production in these farms is that which integrates animals into crop agriculture. Several methods of improving feed resources have been investigated (Onim et al., 1984). These include alley cropping or intercropping forage with food crops and hedge row cut-and-carry forages. A major constraint to continuous goat productivity levels is the seasonality of forage resources. This fluctuation in feed resources can be overcome by forage preservation through hay baling methods. Studies by the Feed Resources Project have shown that hay baling is a viable practice for small scale farming in Western Kenya (Onim et al., 1985). Fluctuations in forage resource can thus be overcome and continuous animal productivity level maintained throughout the year. By improving feed resources and employing preservation methods farmers have the potential of intensifying production.

The objective of this study was to explore the prospects of semi-intensive dual purpose goat production in Western Kenya using a goat simulation model. Assuming that the appropriate feed preservation can be employed, and that in addition to the traditional forage resources, a farmer dedicates a portion of land for forage production, this study sought to quantify the level of production that could be realized in small scale farms.

Experimental Design and Assumptions

Several potential forages have been identified and evaluated for incorporation into goat production systems in Western Kenya (Sidahmed et al., 1984; Onim et al., 1985; Mathuva et al., 1985). Among these are sudan grass, Leucaena, sesbania, pigeon pea and Pennisetum derivatives. Dry matter yields of sudan grass of up to 20 metric tons per hectare on an annual basis have been realized under western Kenya conditions (Mathuva et al., 1985). This forage has been determined to have in vitro digestibility of 64% and crude protein level of 13.8% (Mathuva et al., 1985). Six-month old sudan grass hay had 13.4% crude protein. Pennisetum derivatives such as bana grass, clone 13 and Pakistan hybrid are also high yielding forages. Banagrass dry matter yields of up to 40 metric tons per hectare per year have been demonstrated at Maseno Research Station. Analysis of quality of the forage indicated 13.3% crude protein and in vitro digestibility of 61% (Mathuva et al., 1985). As hay, it retains its quality (Onim et al., 1985). Clone 13 can yield up to 33 metric tons/ha per year. Sesbania has higher crude protein level (26.9%) compared to the Pennisetum derivatives. It should be noted that the yield and quality of the forages reported have been demonstrated at the research station with the input of fertilizer. Yields at the small holder farms may differ from these.

For this simulation study it was assumed that a farmer in Kakamega would dedicate 0.1 ha of land for a suitable forage or forage combination to be incorporated into the traditional forage resource. It was assumed that the farmer would preserve any forage surplus from the traditional forage resource and dedicated area by hay baling so as to evenly distribute it throughout the year. This would solve the problem of seasonal fluctuation in the forage resource. Forage from the dedicated area was assumed to have in vitro digestibility of 64% and crude protein level of 13.8%. Dry matter yield at the 0.1 ha was estimated to be 2 metric tons per year. These estimates were based on data of potential forages (Sidahmed et al., 1984; Onim et al., 1985; Mathuva et al., 1985), assuming that yields similar to those at the research station could be realized on the farms. Forage input parameters for the traditional forage resource (Base) were obtained from Hart et al.(1984).

Three goat genotypes were considered. One is the Kenya DPG; described as a genetic potential of 40 kg mature doe weight in good condition and 4.0 kg milk at peak day of lactation at maturity (40/4.0). The second is an intermediate breed of genetic potential of 40 kg mature weight and 3.0 kg milk (40/3.0). A higher genetic potential animal having a mature weight of 50 kg and 5.0 kg milk at peak day of lactation was also considered.

The does were bred at the beginning of the year. In addition to traditional forages, the dedicated forage was added to supplement the diet 60 days prepartum. During lactation, dedicated forage available per doe was increased such that the doe met all nutrient requirements and was able to produce close to her genetic potential during the 210-day lactation period. Kids were allowed 0.5 kg milk/day until weaning at 90 days of age. They were also fed the dedicated forage until they were 210 days old.

The simulations were done using the Single Animal Version (SAV) of the goat model (Blackburn et al., 1984) on an IBM-PC-XT located at Veterinary Laboratories, Kabete. Dry matter consumption, kid live weights, and milk production levels were simulated for 1 year. Based on the data from these individual animal simulations, estimates of flock size and productivity that could be realized when a 0.1 ha of land is dedicated to forage production were determined.

Table 1: Annual dry matter consumption and productivity by genetic potential for doe and kid

DM Consumption and Productivity	Genetic Potential		
	40/3.0	40/4.0	50/5.0
Dairy milk yield, kg	295.2	408.2	521.7
Kid live weight (210 days) kg	28.2	28.2	33.3
Dedicated forage consumption, kg Dm	382.5	445.5	531.0
Base consumption, kg Dm	262.9	261.8	327.9

Table 2. Annual flock characteristics by genetic potential

Characteristic	Genetic Potential		
	40/3.0	40/4.0	50/5.0
Flock size (No. of doe-kid units)	5.2	4.5	3.8
Total Dairy milk yield, kg	1535.0	1836.9	1982.5
Total kid live weight (210 days), kg	146.6	126.9	126.5
Dedicated forage, kg Dm	2000.0	2000.0	2000.0
Base forage, kg Dm	1367.1	1178.1	1246.0
Total Dm demand, kg	3367.1	3178.1	3246.0

Results and Discussion

Results on the individual doe simulations are summarised in Table 1. Sudan grass dry matter consumption increased with genetic potential. The 40/4.0 and 40/3.0 genotypes consumed similar amounts of Base forages. The 50/5.0 genotype consumed the highest amounts of both dedicated forage and Base forages, and also produced the highest level of dairy milk and kid live weight. All doe nutrient requirements were met such that each genotype produced close to its genetic potential. However, during the first 3 months protein requirements for kid growth were not adequately met for all genotypes. Kid growth was not adversely affected by this deficiency.

Simulation results from the doe-kid units were used to estimate flock size and productivity sustainable when the farmer incorporated 0.1 ha of dedicated forage into his forage resource. From the forage demand of one doe-kid unit, flock size was determined assuming that the 0.1 ha land could yield 2000 kg dry matter per year, which would be additional to Base forage resource. It was assumed that at the age of 210 days, weaned kids were either sold or used as replacements. Bucks needed for breeding were not taken into account.

Results of flock productivity are summarized in Table 2. With increasing genetic size and milk potential, forage demand became higher such that the greatest number of doe kid units could be raised on the farm where genetic potentials were lowest (40/3.0). For the 40/3.0 genetic potential 5.2 doe-kid units could be sustained with the animals producing close to their genetic potential. Due to high forage demand per doe-kid unit for the 50/5.0 genetic potential, the lowest number (3.8) of doe- kid units could be sustained.

On a per farm basis, keeping the 50/5.0 genotype realized the highest dairy milk production (1982.5 kg) but similar live weight offtake as the 40/4.0 genotype. Live weight offtake was highest where the 40/3.0 genetic potential was used. The 40/3.0 flock utilised the greatest amount of Base forage such that overall dry matter consumption for this flock was highest.

Summary and Conclusions

Given that the improved forage interventions could be employed, high amounts of feed resources could be made available per unit farm in Western Kenya. The quality of the feed and distribution could also be improved. With these resources, a semi-intensive goat production system could prove profitable for the small scale farmers not only in meeting family nutritional needs but also as a source of cash income.

By dedicating some portion of land (0.1 ha) for forage production and perserving forage resources, an even distribution of an adequate amount of feed could be made available for goat production throughout the year. The simulation results indicate that relatively high levels of milk and live weight offtake can be realized in a semi-intentive production system. Depending on the genotype used, milk production levels of up to 1982.5 kg per year could be produced. For a 40/3.0 animal genetic potential, kid live weight offtake of up to 146.6 kg per year could be obtained by keeping a flock of 5.2 doe-kid units.

Forage species singly or in combination with other forage or food-feed crops could be incorporated into the forage resource and better productivity realized per unit farm. Since this was only a prospective analysis, more conclusive studies need to be done with animal production on alternative forages and combinations being evaluated using the flock simulation model and including economic analysis of the input and output data.

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CASH FLOW PATTERNS OF SMALL SCALE FARM HOUSEHOLDS IN WESTERN KENYA

By

A.W. Mukhebi,[1] F. Nyaribo,[2] L. Oyugi,[2] and H. Knipscheer[1]

Introduction:

Evidence from earlier SR-CRSP Economics Project studies (Nyaribo, 1983; Nyaribo et al 1984) indicates that over 50% of foods consumed by farm households in Kakamega and Siaya districts in Western Kenya are purchased from the market. What was not ascertained from these studies are the sources of cash that enable these relatively large food purchases to be made. This study was therefore conducted to identify sources, levels and patterns of cash in-flows and out-flows of the farm households in the SR-CRSP cluster areas in W. Kenya and explore their implication for the DPG technology adoption.

Methods:

A daily record of cash in-flow and out-flow was kept by 11 farmers in Kaimosi; 13 farmers in Hamisi and 13 farmers in Masumbi clusters for the period April 1, 1984 to April 30, 1985. A ruled hardcover note book plus writing materials were provided to the farmers by the Economics Project. The farmers were requested and instructed to keep a daily record that included the date, description of the cash flow (sale, purchase receipt/gift), quantity of the item involved, unit price and total cash received or spent on the item. Farmers who were unable to read were assisted by literate household members. The records were checked twice weekly by an enumerator living in the cluster and regularly reviewed by the SR-CRSP Economists. Data were transfered from the farm record books weekly for storage in the computer at Maseno Research Station.

Items of cash receipts and cash expenditures were classified into broad categories and monthly cash in-flows and out-flows were summarized by category. Data were collected for a complete year in order to identify seasonal patterns.

Results:

By the end of data collection period in April 1985, only one farmer from each cluster had dropped out of the study-due to migration in Kaimosi, divorce in Hamisi and employment away from home in Masumbi. Reported results therefore pertain to the mean cash flows of 10 households in Kaimosi, 12 in Hamisi and 12 in Masumbi. Furthermore, the first month of data collection,

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[1]Agricultural Economist, Winrock International Institute for Agricultural Development.

[2]Agricultural Economist, Ministry of Agriculture and Livestock Development, Kenya.

April 1984, was regarded as a training period for the record keeping exercise hence the data for this month are omitted from the analysis.

Cash In-Flow

Cash in-flow represents all receipts of cash by the household. It is classified into three categories namely crop sales, livestock sales and off-farm sources.

Crop Sales:

Table 1 summarizes cash in-flows from sales of food and cash crops as a proportion of total household cash income for each cluster. Food crops include mainly maize, beans, bananas and vegetables in Kaimosi and Hamisi clusters and maize, millet, cassava, bananas and vegetables in Masumbi cluster. Main cash crops are tea, coffee and trees in Hamisi, cotton in Masumbi and none in Kaimosi.

The contribution of food crops to total household cash receipts is higher than that of cash crops in each cluster and for all the clusters. On average, 20 percent of household cash in-flow is generated from sales of food crops and 5 percent from cash crops. The contribution of food crops, cash crops and total crops to household cash in-flow is highest in Hamisi, followed by Masumbi and least in Kaimosi. Overall, crops generate 25 percent of total household cash receipts.

Livestock Sales:

Livestock sales include sale of (cow) milk, live cattle, goats, sheep and poultry. Table 2 summarizes percentage contribution of various livestock sales to total household cash in-flow in each cluster and for all the clusters.

Milk sales are the most important source of livestock cash receipts in Kaimosi and Hamisi, generating 5 percent total cash in-flow in the former and 4 percent in the latter cluster. In Masumbi, poultry generates the highest livestock cash of 5 percent to total cash in-flow. Cattle sales are the second largest source of cash receipts in each cluster contributing 3 percent of total cash in-flow for each cluster. For all the clusters, cattle (milk and live animal sales) contribute 6 percent of all the cash in-flow and small stock (sheep and goats) and poultry each contribute 2 percent. Total livestock sales amount to 10 percent of household cash in-flow on average for all the clusters, with 8 percent in both Kaimosi and Hamisi and 12 percent in Masumbi.

Off-Farm Sources:

Off-farm sources of household cash-in-flow include off-farm employment, business activities off-farm, remittances and gifts from household members and relatives living away from home, and loans.

Table 3 shows that for all three clusters, an average of 66 percent of total household cash receipts is derived off-farm. Off-farm cash in-flow varies from 50 percent in Hamisi, 71 percent in Masumbi and as much as 83 percent in Kaimosi. Off- farm employment is the highest source of cash in-flow in Kaimosi and Masumbi generating 56 and 34 percent of household cash receipts respectively followed by remittances with 27 and 20 percent respectively. In Hamisi, remittances are the highest source of cash in-flow, followed by business at 27 and 14 percent respectively. For the three clusters combined, off-farm employment leads with 29 percent of total household cash in-flow, followed by remittances with 25 percent, business with 7 percent and loans with 5 percent. Loans are a significant source of cash in Masumbi amounting to 15 percent of total cash receipts.

Total Cash In-Flow

Total household cash in-flow (Table 1) per farm averages KShs. 3,373 (US$ 211) in Kaimosi, KShs. 5,465 (US$ 342) in Hamisi, KShs. 3,756 (US$ 235) in Masumbi, with an average of KShs 4,198 (US$ 262) for all the clusters. The total cash in-flow is highest in Hamisi and lowest in Kaimosi. This may be attributed to the higher intensity of farming observed in Hamisi, as well as to the fact that it is in Hamisi that the high cash earning tea and coffee crops are grown. There are no cash crops observed on respondent farms in Kaimosi cluster whereas only a limited amount of cotton is grown in Masumbi.

It can not be claimed that respondents reported all their cash receipts. It is estimated that 50 percent of cash in-flow was unreported for a variety of reasons including fear of disclosing cash from illicit activities (such as local alcohol, mineral prospecting), unauthorized farm produce sales (by wives), and unwillingness to disclose salary income from husband's wage employment or children's remittances.

It is important to note that the reported cash in-flow figures are not the total farm income accruing to the households. Non-cash income such as the value of farm produce consumed by the household or given away to relatives and the annual changes in the value of farm assets such as crops and livestock would have to be added to the cash receipts to yield total farm income. Derivation of total farm income figures is outside the scope of this paper.

The relative cash in-flow from crop and livestock sales, total on-farm and total off-farm sources is summarized in Table 4. For of all the clusters on average, about two-thirds of the total household cash in-flow is derived from off-farm sources and the remaining one-third from on-farm sources. This may be explained by the fact that the low land and capital resource base of these small scale farms is insufficient to employ fully at all times during the year the relatively large labour resource base of these farms. Consequently, a substantial amount of household labour seeks off-farm employment, especially the young and educated people. This is reflected in Table 3, where off-farm employment is the major source of off-farm cash contributing 27 percent to total cash in-flow, followed by remittances from household members working in urban centres contributing 25 percent of the cash in-flow.

The dominance of off-farm cash generation is more pronounced in Masumbi and particularly in Kaimosi, where as much as 71 and 83 percent of cash in-flow is derived off-farm respectively. In Kaimosi cluster, the existence of wage employment opportunities in nearby tea estates exerts a pulling influence on household labour.

For the on-farm sources, crops contribute a higher proportion (25%) than livestock (10%) to total cash in-flow. Crop products are usually available in small divisible quantities that are more easily marketable, especially by women, than livestock products excepting milk. Besides, crop enterprises dominate livestock enterprises in intensive small scale farming systems such as those in cluster areas. This is because subsistence plant food production takes precedence over (substitutes for) the traditionally rather extensive livestock production in the utilization of the scarce land resource. The relatively high (42%) contribution of crops to household cash in- flow in Hamisi again reflects the more intensive farming systems observed in this cluster compared to those in Kaimosi or Masumbi clusters.

Cash Out-Flow

Cash out-flow consists of all cash outlays from the household. It is divided into two main groups: food and non- food expenditures.

Food Expenditures:

Food expenditures are further grouped into five sub-classes: milk, meat (includes red meat, poultry, fish), maize (includes grain and flour), beverages (include tea, coffee, sugar, bread), and other foods (include vegetables, cooking fat, potatoes, bananas, cassava, millets, sorghum, etc). Sugar and bread are included in the beverages category only because they are consumed when tea or coffee is taken.

Table 5 shows cash expenditures on various food items as proportions of total household cash out-flow. In Kaimosi, beverages claim the highest proportion (16 percent) of cash expenditure, followed by maize and meat at 14 percent each, other foods at 12 percent and milk at 3 percent. In Hamisi, the highest cash expenditure food item is maize (staple food), taking 21 percent of cash outlays, followed by beverages (17 percent), meat (13 percent), other foods (11 percent) and milk (4 percent). In Masumbi, meat, beverages, other foods, maize and milk in that order claim 21, 11, 9, 6 and 1 percent of total household cash out-flow.

For all the clusters, 59 percent of the total household cash out-flow is allocated to food purchases. Meat, maize and beverages each take 15 percent of the cash expenditures, while other foods and milk take 11 and 3 percent respectively. Among the clusters, 48, 59 and 65 percent of cash expenditures are allocated to food purchases in Masumbi, Kaimosi and Hamisi respectively.

Non-Food Expenditures:

Non-food expenditure items are aggregated into children's education (school fees,uniforms, books, etc), hired farm labour, other farm inputs (includes seed, fertilizer, animal health, etc), and other household needs (includes clothing, health, housing, transport, harambee donations, entertainment, loan repayment and business).

Table 6 summarizes cash out-flows for various non-food items as percentages of total household cash expenditures. For all the clusters, 41 percent of cash out-flow goes for non-food expenditures. This varies from 35 percent in Hamisi, 41 percent in Kaimosi to 52 percent in Masumbi. Farm inputs including hired labour claim only 7 percent of all the cash expenditures.

Total Cash Out-Flow:

The mean total household cash expenditures per farm (Table 7) is KShs. 10,309 (US$ 644) in Kaimosi, KShs 10,164 (US$ 635) in Hamisi and KShs. 5,503 (US$ 344) in Masumbi. Again, it cannot be claimed that all cash expenditures were recorded. For instance, expenditures for things like away from home drinks, food and entertainment may have been deliberately concealed. On the other hand, certain expenditures for items such as meat and beverages may have been exaggerated by some respondents to create a favourable welfare impression. However it was difficult to make an estimate of such under- or over- expenditures.

In Kaimosi and Hamisi clusters, a higher proportion of cash out-flow is spent on food (59 and 65 percent respectively) than on non-food items (41 and 35 percent respectively). Only in Masumbi cluster is the proportion of cash out-flow allocated to non-food items (52 percent) greater than that spent on food purchases (48 percent). Due to relatively larger farm sizes, households in Masumbi produce more of theirsubsistence food supplies than those in Kaimosi and Hamisi. For all the clusters, 59 percent of total cash expenditures are for food and 41 percent for non-food items.

Seasonality of Cash Flow:

Seasonal patterns of cash in-flow and out-flow are depicted in figures 1 and 2 respectively. The figures show mean monthly cash in-flow and out-flow per household for each cluster from May 1984 to April 1985.

For all clusters, cash in-flow pattern (Figure 1) appears to be high during May to July, a period of long rains crop harvest. It tapers off from August to November and rises slightly from December to February. Most of the cash income from remittances is received from December to February for Christmas festivities and school fees at the beginning of the year. Generally, the seasonal cash in-flow pattern is more pronounced in Hamisi cluster where more intensive cropping is undertaken, and less marked in Kaimosi and Masumbi clusters where less intensive cropping is practiced.

The pattern of cash out-flow is shown in figure 2. It appears to follow the pattern of cash in-flow, generally rising and falling simultaneously. That is, when cash in-flow is high, cash expenditure is also high and vice versa. The exceptionally high cash expenditure in November for Kaimosi was due to high medical expenses in a couple of households and payment of dowry in one household.

Cash Surplus/Deficit and Implications for DPG Production:

Cash out-flow exceeds cash in-flow yielding cash deficit for all months in all the clusters except in Hamisi where a surplus was recorded for July (figures 3,4 and 5).

The existence of a cash deficit implies that on average, households spent more cash than they receive each month. What this means, as has been pointed out earlier is that some cash receipts were not reported. If it is assumed that the cash in- flow is at least equal to the cash out-flow, then cash in-flow is under-reported by 50 percent. Nonetheless, this assumption notwithstanding, it is clear that there is little or no savings for substantial household investment. Households would require access to credit to enable such investment. Agricultural credit availability and use is the subject a planned study by the Economics Project.

Table 5 shows that the proportion of cash out-flow spent on milk purchases per household per annum ranges from 1 percent in Masumbi (KShs. 55), to 3 percent in Kaimosi (KShs 309), and to 4 percent in Hamisi (KShs 407).

Assuming a liveweight DPG price of KShs.8.26 per kg[a], these levels of cash would purchase one unweaned kid in Masumbi, one mature doe in Kaimosi, and one mature doe and a weaned kid in Hamisi[b]. However, cash for milk purchases does not come in one lampsum but in small amounts throughout the year. Households can thus not be expected to forego milk purchases for a whole year in order to save enough cash to enable these DPG purchases. What these figures represent are costs that would be saved by a household per year if it purchased a DPG doe to supply milk that would otherwise be purchased. These saved costs would be added to extra revenue generated by the doe from dairy milk production and kid liveweight to yield incremental benefits from the doe investment. This would have the effect of improving the Benefit: Cost Ratio (BCR), or the marginal rate of return (MRR) on DPG doe investment. Determination of BCR or MRR are outside the scope of this paper but are the subject of an underway study by the SR- CRSP Economics Project.

Quantities of purchased milk can be derived from cash expenditures on milk. Assuming a price of KShs. 5.50 per litre of milk (Oyugi et al; 1986), an average household purchases an annual amount of 56 lt in Kaimosi. 74 lt in Hamisi and 10 lt in Masumbi. More recent data (Conelly and Nolan, 1986) suggest even higher quantities(172 lt for Hamisi and 83 lt for Masumbi[c]). These amounts of milk can be met from one DPG doe yielding an average of 1.2 lt per day for a 150 day lactation period. This amount of milk yield is within some observed on-farm DPG production levels in the clusters.

Summary and Conclusions

Small farm households in Western Kenya have little or no savings for substantial on-farm investment. Such investment would require access to credit. Return on investment into the dual purpose goat enterprise would be enhanced by cash savings from current expenditures on milk purchases. Quantities of milk purchased per household are within on-farm DPG production levels per doe observed in SR CRSP research clusters.

The existence of cash deficit implies that households spent more cash than they receive each month. But this is not logical, since the study attempted to record cash in-flow from all sources. What this means, as has been pointed out earlier in this paper, is that some cash receipts were not reported. If it is assumed that the cash in-flow is at least equal to the cash out-flow, then cash in-flow is under-reported by 50 percent. Nonetheless, this assumption notwithstanding, it is clear that there is little or no savings for substantial household investment.

Table 6 shows that total cash expenditure per form for farm inputs including labour amounts to 7 percent of total cash out- flow or KShs. 600 for all clusters. This amount would purchase one DPG doe per household. Thus, if the DPG enterprise was more profitable than the other farm enterprises, and assuming that farmers were profit motivated, then on average, each household could afford to purchase one DPG doe from current resources. Otherwise, additional sources of cash would have to be forthcoming if household were to invest in a new DPG enterprise.

Notes

a) Local East African Goats (EAG) fetch an average price of KShs 6.61 per kg liveweight (Oyugi et al 1986). Assuming DPGs are more productive in milk and meat than the EAG, a 25% mark up on EAG price is used: KShs. 61 x 1.25 = 8.26.

b) Assumes a mature DPG doe liveweight of 33 kg and a weaner weight of 10 kg.

c) T. Conelly and M. Nolan data (Conelly and Nolan, 1986) collected for 3 months July - September 1986 extrapolated to a 12 month period.

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Table 1: Cash In-Flow from Crop Sales in Kaimosi Hamisi and Masumbi Clusters, Western Kenya, May 1984 - April 1985:

Crop Type	Kaimosi	Hamisi	Masumbi	All Clusters
	Cluster			
	% of Total Household Cash In-flow			
Food Crops	8	32	13	20
Cash Crops	0	10	3	5
Total Crops	8	42	16	25

Total Household Cash In-flow for: Kaimosi - KShs 3,373 (US$ 211)
Hamisi - KShs 5,465 (US$ 342)
Masumbi - KShs 3,756 (US$ 235)
Mean - KShs 4,198 (US$ 262)

Table 2: Cash In-Flow from Livestock Sales in Kaimosi Hamisi and Masumbi Clusters, Western Kenya, May 1984 - April 1985

Livestock Product	Kaimosi	Hamisi	Masumbi	All Clusters
	Cluster			
	---% of Total Household Cash In-flow			
Milk	5	4	1	3
Cattle	3	3	3	3
Goats	1	0	2	1
Sheep	1	0	1	1
Poultry	0	1	5	2
Total Livestock	8	8	12	10

Total Household Cash In-flow for: Kaimosi - KShs 3,373 (US$ 211)
Hamisi - KShs 5,465 (US$ 342)
Masumbi - KShs 3,756 (US$ 235)
Mean - KShs 4,198 (US$ 262)

Table 3: Cash In-Flow from Off-Farm Sources in Kaimosi, Hamisi and Masumbi Clusters, Western Kenya, May 1984 - April 1985

	Cluster			
Off-farm Source	Kaimosi	Hamisi	Masumbi	All Clusters
	---% of Total Household Cash In-flow			
Employment	56	8	34	29
Business	0	14	2	7
Remittances	27	27	20	25
Loans	0	1	15	5
Total Off-Farm	83	50	71	66

Total Household Cash In-flow for: Kaimosi - KShs 3,373 (US$ 211)
Hamisi - KShs 5,465 (US$ 342)
Masumbi - KShs 3,756 (US$ 235)
Mean - KShs 4,198 (US$ 262)

Table 4: Total Household Cash In-Flow in Kaimosi, Hamisi and Masumbi Clusters, Western Kenya, May 1984 - April 1985

	Cluster			
Source	Kaimosi	Hamisi	Masumbi	All Clusters
	---% of Total Household Cash In-flow			
Crops	8	42	16	25
Livestock	8	8	12	10
Total on-farm	17	50	28	35
Off-Farm	83	50	71	66
Total	100	100	99	101

Total Household Cash In-flow for: Kaimosi - KShs 3,373 (US$ 211)
Hamisi - KShs 5,465 (US$ 342)
Masumbi - KShs 3,756 (US$ 235)
Mean - KShs 4,198 (US$ 262)

Total may not add to 100% due to rounding error

Table 5: Cash Out-Flow for Food Expenditures in Kaimosi, Hamisi and Masumbi Clusters, Western Kenya, May 1984 - April 1985

Food Item	Kaimosi	Hamisi	Masumbi	All Clusters
	Cluster			
	---% of Total Household Cash Out-flow			
Milk	3	4	1	3
Meat	14	13	21	15
Maize	14	21	6	15
Beverages	16	17	11	15
Other Foods	12	11	9	11
Total Foods	59	65	48	59

Total Household Cash out-flow for: Kaimosi - KShs 10,309 (US$ 644)
Hamisi - KShs 10,164 (US$ 635)
Masumbi - KShs 5,503 (US$ 344)
Mean - KShs 8,659 (US$ 541)

Table 6: Cash Out-Flow for Non-Food Expenditures in Kaimosi, Hamisi and Masumbi Clusters, Western Kenya, May 1984 - April 1985

Item	Kaimosi	Hamisi	Masumbi	All Clusters
	Cluster			
	---% of Total Household Cash Out-flow			
Children Education	2	3	5	3
Farm Labour	1	2	10	3
Other Farm Inputs	5	3	7	4
Other Household Needs (Clothing, housing, health, etc)	33	27	30	30
Total Non-Food	41	35	52	41

Total Household Cash Out-flow for: Kaimosi - KShs 10,309 (US$ 644)
Hamisi - KShs 10,164 (US$ 635)
Masumbi - KShs 5,503 (US$ 344)
Mean - KShs 8,659 (US$ 541)

Table 7: Total Household Cash Out-Flow in Kaimosi, Hamisi and MasumbiClusters, Western Kenya, May 1984 - April 1985

Item	Kaimosi	Hamisi	Masumbi	All Clusters
	Cluster			
	---% of Total Household Cash Out-flow			
Food	59	65	48	59
Non-Food	41	35	52	41
Total	100	100	100	100

Total Household Cash Out-flow for:
Kaimosi - KShs 10,309 (US$ 644)
Hamisi - KShs 10,164 (US$ 635)
Masumbi - KShs 5,503 (US$ 344)
Mean - KShs 8,659 (US$ 541)

DEMAND AND SUPPLY QUANTITIES OF MILK AND SMALL RUMINANTS IN SELECTED MARKETS IN WESTERN KENYA

By

L.A. Oyugi [1], A.W. Mukhebi [1,3], H.K. Ogada [2] and H. Knipscheer [3]

Introduction

Small Ruminant Collaborative Research Support Program (SR-CRSP) is conducting research to develop Dual Purpose Goats (DPG) for small scale farmers to provide increased production of food protein through milk and meat and improved cash flow through marketable goats and goat products. With population growth rate of about 4% per annum in Kenya, average small scale farm size is diminishing to a level too low to provide sufficient feed for a lactating cow but may support several lactating goats. It is in this context that SR-CRSP addresses itself in the development of DPGs. From a baseline survey in 1980-81, several potential constraints to farmer adoption of DPGs were identified (Sands, 1982). Among the constraints was, inadequate livestock marketing infrastructure. To study this constraint in some detail, the SR-CRSP Economics Project undertook a study to assess the capacity of livestock markets in Western Kenya to absorb additional milk and meat from potential DPG production.

This paper provides an evaluation of quantities of milk and small ruminants (sheep and goats) demanded and supplied in Kakamega District, one of SR-CRSP target areas. Implications for DPG production are explored.

Materials and methods

This study was carried out from January 1985 to January 1986 in Kakamega District in Western Kenya which is one of the operation sites of SR-CRSP projects. A sample of seven livestock markets, regional markets and local markets, were selected purposively for the study. Regional markets are Serem and Nambacha. Local markets are Luanda, Mahanga, Mbale, Shikulu and Lubao. Reasons for inclusion of regional markets and local markets are to determine direction of flow of livestock and quantify supply, demand and prices of livestock at various levels of markets. A map showing the distribution of livestock markets in the study area is given in Figure 1. For Lubao and Nambacha, data were collected for twelve consecutive months whereas the

[1] Agricultural Economist, Ministry of Agriculture and Livestock Development, SR-CRSP, P.O. Box 252, Maseno, Kenya

[2] Graduate Student, Department of Agricultural Economics, University of Nairobi, P.O. Box 29053, Kabete, Kenya

[3] Agricultural Economist, Winrock Internationa Institute for Agricultural Development, Morrilton, Arkansas, U.S.A.

remaining markets were non-operational for some months due to Foot and Mouth disease quarantine.

A preliminary survey of all livestock markets was undertaken with the assistance of District Agricultural and County Council Officers. A total of 19 livestock markets were identified. This was followed by a selection of five sample markets as mentioned. When Serem and Luanda markets were put under Foot and Mouth disease quarantine, they were substituted for by Mbale and Mahanga respectively.

Two field assistants were hired with the assistance of County Council market staff of respective markets from each sample markets. The appointment criteria was based on proximity of the field assistant residence to the sample markets, and also the field assistant must have attained a minimum of four years secondary education. This was expected to be advatageous in two ways. First, the field assistants were expected to be familiar with the local market staff and most of the respondents, to allow information generation without suspicion. Second, the field assistants were expected to be conversant with the social set up of the environment in addition to being capable of understanding the structure of the questionnaire. The hired field assistnats were trained together for two weeks on techniques of data collection before they were dispatched to their respective markets. Training sessions included going over the questionnaire explaining the intent of each question, filling out questionnaire and techniques of weighing sheep and goats using a hand held scale. The questionnaire was then pretested and adjusted accordingly. At each market, weekly data on supply and demand quantities and prices for sheep and goats were collected. The data included their sample weights, sex and prices in terms of Kg. liveweight.

Similarly, data on supply and demand quantities and prices of cow milk were collected. Cow milk is the only commercially traded milk in the area. Data were collected on fresh processed milk from Kenya Co-operative Creameries (KCC) milk processing plants with brand name "KCC"; fresh unprocessed milk sold as whole milk either through vending or local dairy co-operative societies; and sour milk, the milk which has undergone fermentation and sold through vendors.

Results and Discussion

The results of the study indicate pronounced seasonal fluctuations in quantities supplied and demanded and prices of sheep and goats within and across the markets (Tables 1 and 2). Graphical presentations in appendix figures 2-7 illustrate the fluctuations in Lubao and Nambacha markets. Quantities of sheep and goats supplied and demanded are high in March to July, and September to December. March-July period represents the season when food is scarce, therefore many farmers sell their animals in order to get cash to purchase foodstuffs. September to December period represents the season for festivities such as Christmas. Farmers therefore sell animals for cash to purchase other foodstuffs not grown on their farms or normally not consumed in large quantities during non-festive seasons. Cash flow studies conducted from 1984 to 1985 on small scale farm household in Western Kenya (Mukhebi et al. 1986) reveal that farmers spend 59% of their household cash income on food purchases. In all the markets throughout the year, the quantitiy of sheep and goats supplied exceeds the quantity sold of each type of animal.

This is because it was observed that some of the buyers and sellers, in a bid to evade paying market cess for each animal bought or sold, do not record the selling/buying transaction. Hence tha animals leave the auction ring as unsold but change hands a short distance from the ring. This explains the existence of a wide gap in numbers of animals supplied and bought in each market day throughout the year. Sheep and goat prices per Kg liveweight show little variation across the markets. The weekly mean goat price ranges from Kshs. 5.51 in Mahanga to Kshs. 6.69 in Nambacha (Table 3) during the study period. Similarly the weekly mean sheep price ranges from Kshs. 6.11 in Shikulu to Kshs. 6.73 in Lubao over the same period. Sheep and goat prices at Serem, Kshs. 9.41 and Kshs. 11.57 per Kg liveweight respectively, are however higher than any other market under study. This is apparently because of the high value the local community in Nandi/Kakamega border attaches to the meat from the small stock. The popular view in the area is that small stock meat, particularly goat meat, is more tender than beef. This view is supported by the large number of goats slaughtered compared to other markets.

The supply of milk in Western Kenya is restricted by the Kenya Dairy Board. The restriction in some areas is to encourage the development of local dairy co-operative societies. For example at Lubao, the sale of KCC milk is only allowed during the periods when the local dairy co-operative is unable to supply the market adequately. In all the markets under study, the results show excess demand for fresh milk, both processed and unprocessed milk. In fact as the field assistants arrived to collect the data at 10 am most of the milk if not all the milk had been sold by that time.

The supplied quantities and demanded within and across the markets are examined throughout the year (Table 4 and 5). The availability of fresh unprocessed milk sold by vendors and local dairy co-operatives follows the rainfall pattern. No milk vendors are seen in the markets during the dry sasons. Milk supply to the local co-operatives also drop to a minimum. It is during these dry spells that KCC milk would be sold, if available, to a market like Lubao. But KCC milk supply during such periods also dwindles and the quantity supplied to a market falls far short of the quantity demanded. Unlike KCC milk whose price is controlled by the government to protect consumers, the price of unprocessed fresh milk fluctuates and across the markets throughout the year depending on demand and supply. The mean consumer price of fresh milk varied from Kshs. 3.41 to Kshs. 7.68 per litre while KCC milk sold at Kshs. 5.50 during the study period. KCC milk price increased from Kshs. 4.90 per litre in January 1985 to Kshs. 5.50 per litre during the study period. The current (November 1986) consumer price of KCC milk is Kshs. 6.00 per litre. When the consumer price of KCC milk is increased, the government also adjusts the producer price in a bid to provide incentive to farmers to produce more milk.

Implications for DPG Production

From the results and discussion above it may be concluded as follows:

1. The information available is not conclusive enough to assess the demand, supply and prices for Dual Purpose Goats (DPG) since the goats under study were Small East African Goats which are mainly meat goats. Therefore the demand for the Small East African Goat does not necessarily reflect the demand for DPGs. The DPG market will be better assessed when these goats become available commercially.

2. Since DPGs have the capacity to produce extra milk for human consumption in addition to meat, the introduction of these goats would go a long way in alleviating the existing excess demand for milk in Western Kenya. Earlier SR-CRSP studies have revealed that consumer acceptability of goat milk products would not be a constraint to the establishment of DPG produccion systems in Western Kenya.

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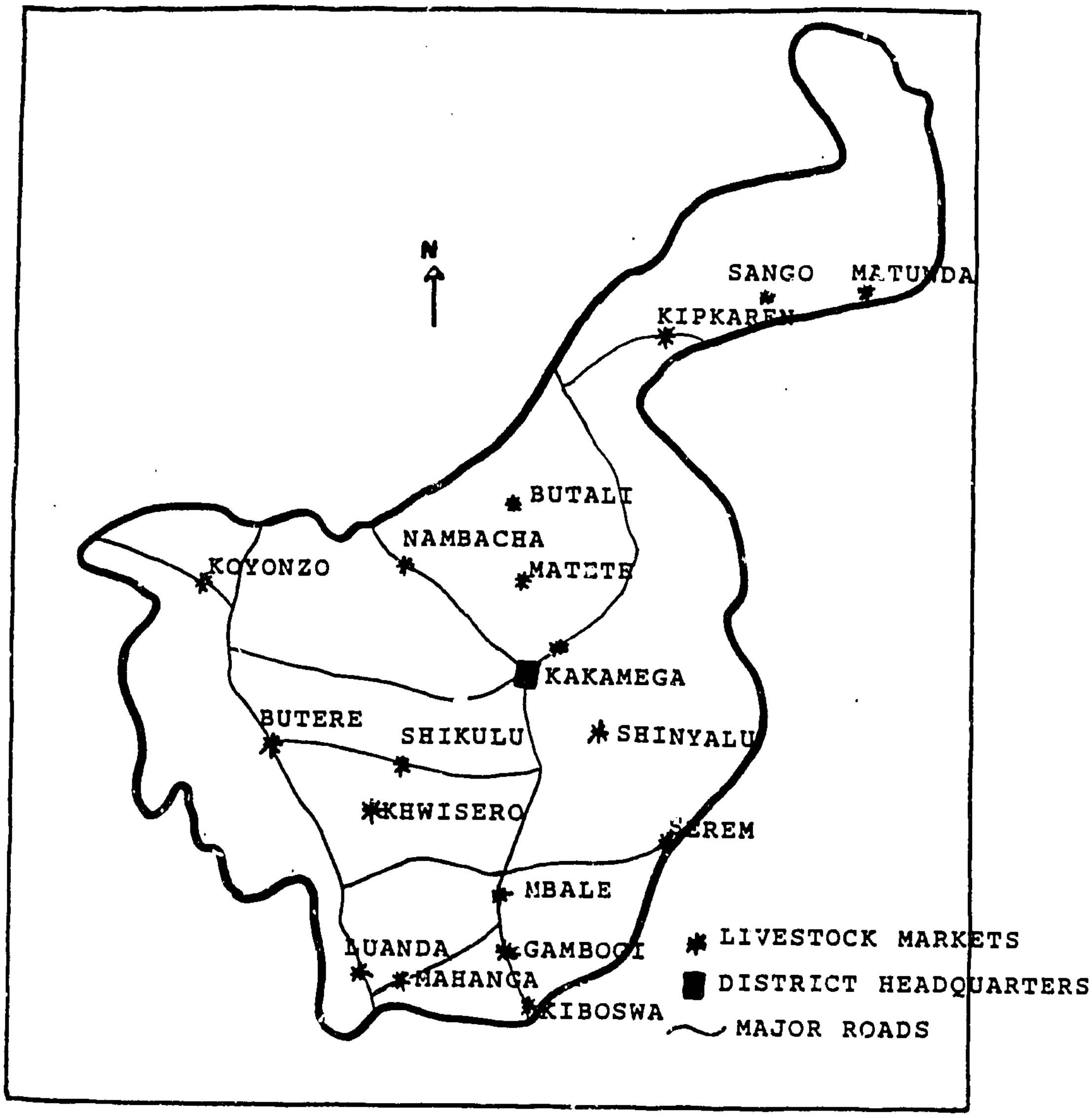

Fig. 1 Distribution of Livestock markets in Kakamega District

Fig. 2

Quantity Supplied & demanded for goats in Lubao, 1985/86

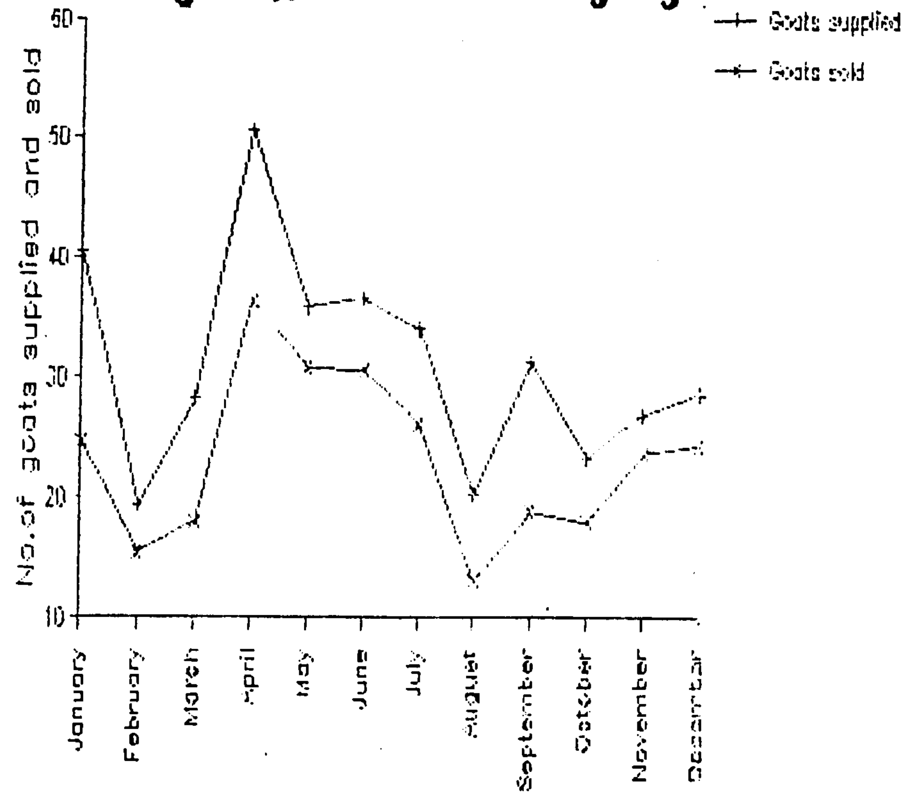

Fig. 3

Quantity supplied & demanded for sheep, Lubao -1985/86

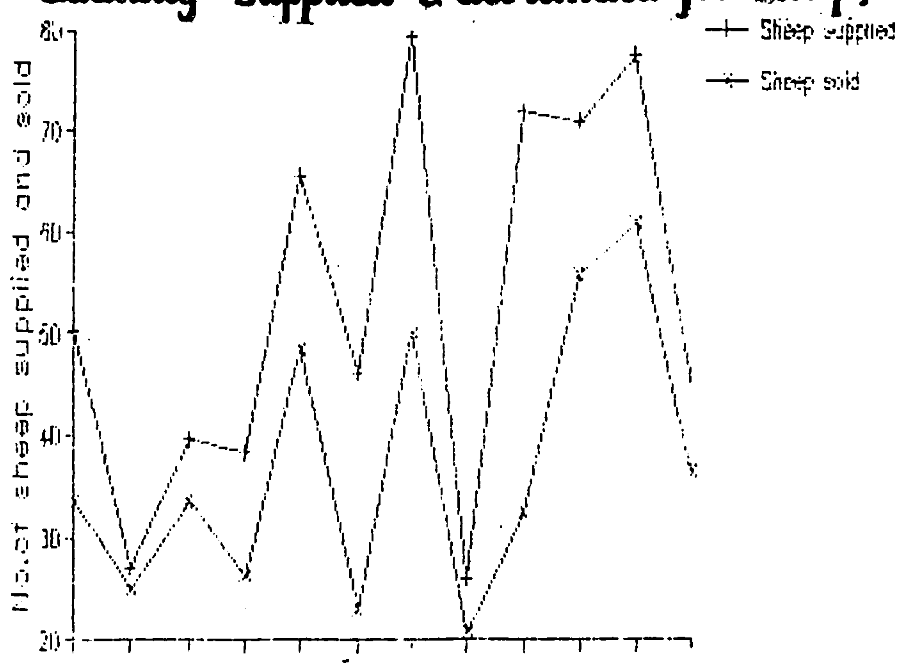

Fig. 4

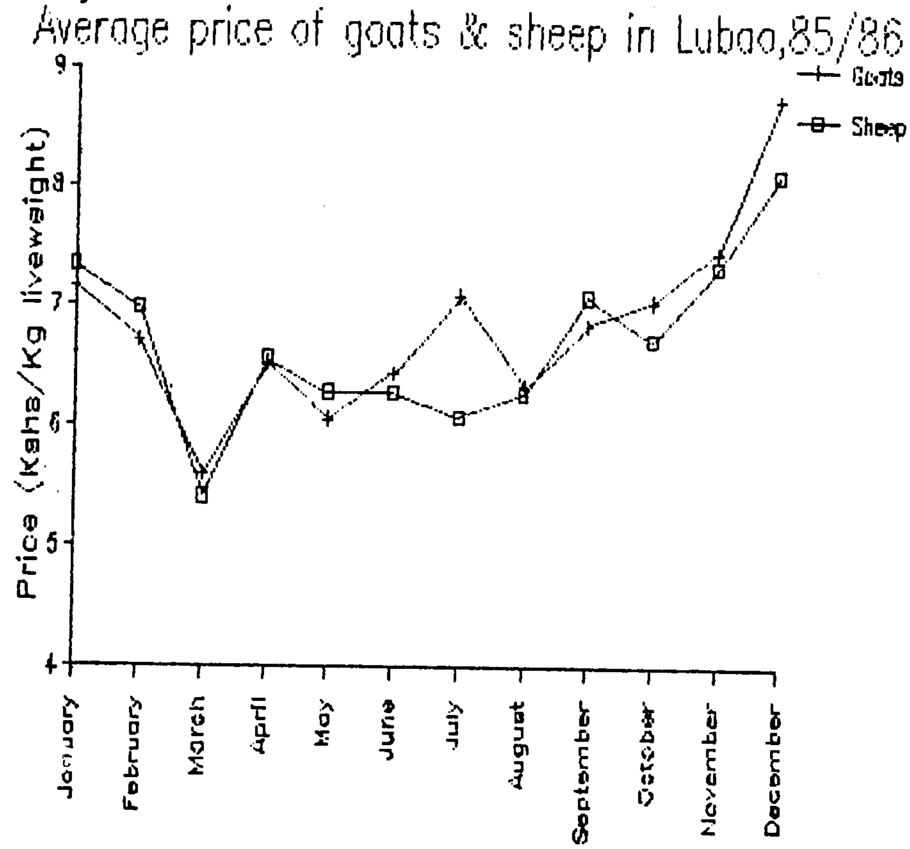
Average price of goats & sheep in Lubao,85/86
Goats
Sheep
Price (Kshs/Kg liveweight)
9
8
7
6
5
4
January
February
March
April
May
June
July
August
September
October
November
December

Fig. 5

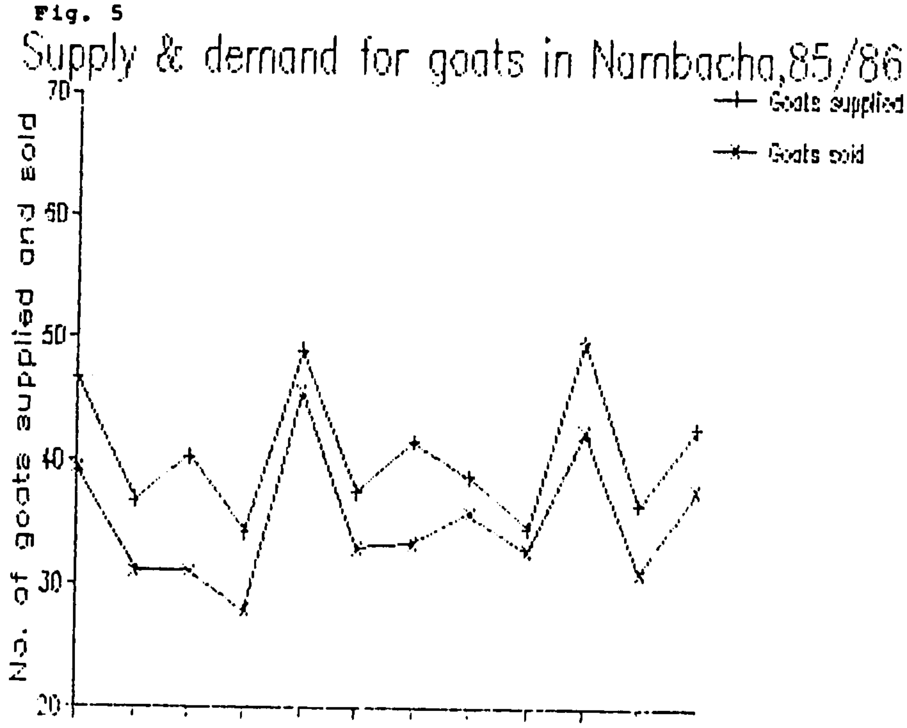
Supply & demand for goats in Nambacha,85/86
Goats supplied
Goats sold
No. of goats supplied and sold
70
60
50
40
30
20

Fig. 6

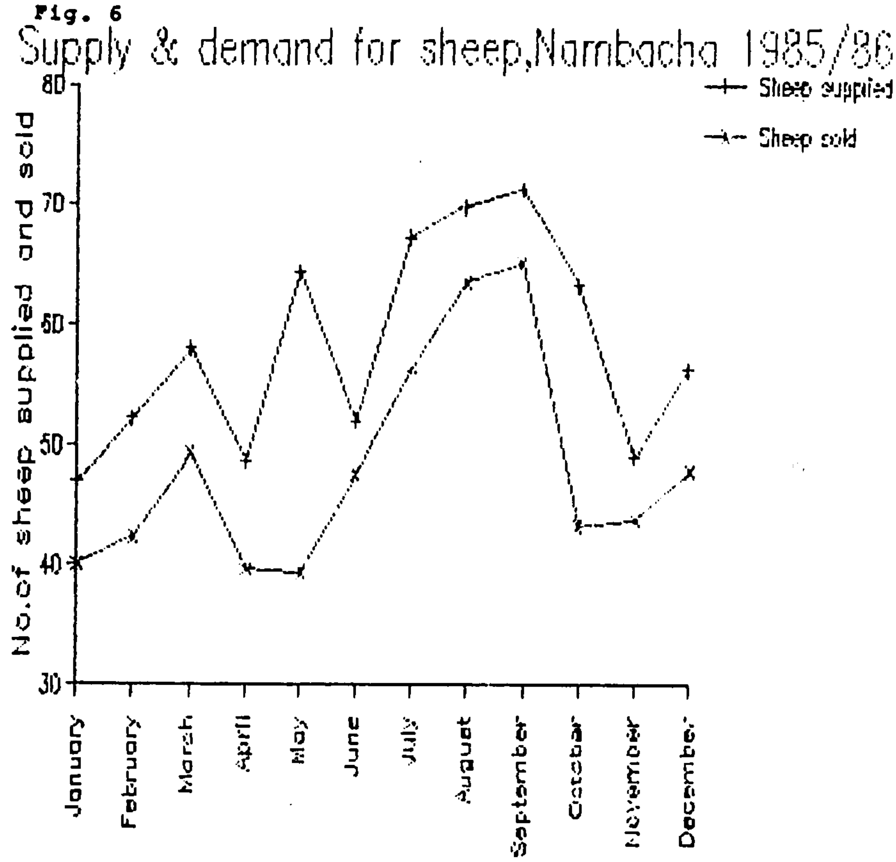
Supply & demand for sheep,Nambacha 1985/86
Sheep supplied
Sheep sold
No.of sheep supplied and sold
80
70
60
50
40
30
January
February
March
April
May
June
July
August
September
October
November
December

Fig. 7

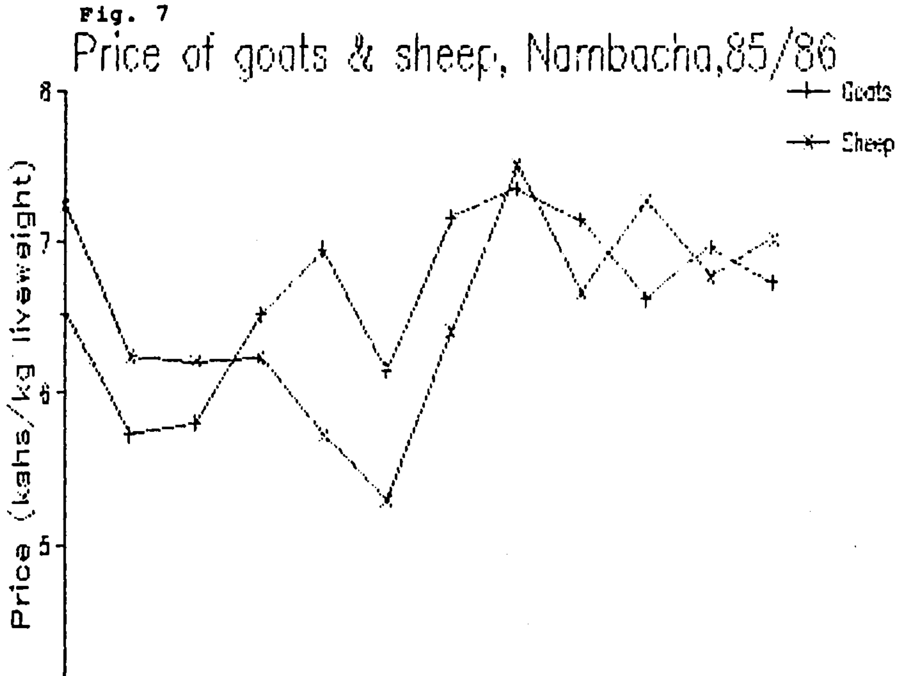
Price of goats & sheep, Nambacha,85/86
Goats
Sheep
Price (kshs/kg liveweight)
8
7
6
5
4

Table 1 Monthly Quantity Supplied and Demanded and prices of Goats in selected markets in Western Kenya, 1985/86

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Mbale	S	49.75	-	-	-	-	-	76.25	65.6	78.75	65.0	67.6	51.5
	D	29.25	-	-	-	-	-	28.25	33.6	38.25	32.25	35.8	26.0
	P	6.02	-	-	-	-	-	7.15	6.15	6.74	6.78	6.22	6.35
Luanda	S	74.2	-	-	-	-	133	111.75	134.4	82.5	119.0	166.25	170.75
	D	17.2	-	-	-	-	32	26.0	24.6	20.25	12.75	15.5	14.00
	P	6.76	-	-	-	-	4.73	5.33	5.77	6.44	6.93	6.53	7.28
Lubao	S	27.0	19.33	28.25	50.5	37.75	36.5	34.00	20.2	31.25	23.2	26.75	28.5
	D	12.0	15.33	18.00	36.25	30.75	30.5	26.00	13.0	18.75	18.00	23.5	24.25
	P	6.41	6.70	5.60	6.53	6.44	7.09	6.32	6.32	6.84	7.04	7.45	8.73
Mahanga	S	59.5	65.33	61.00	62.20	57.5	46.50	48.8	42.75	51.50	43.20	60.00	61.80
	D	0.5	22.33	13.5	20.4	26.75	23.5	10.6	10.00	10.25	6.0	5.00	6.25
	P	7.08	4.64	5.58	6.00	5.48	4.86	5.13	5.82	5.80	5.35	-	5.57
Serem	S	10.00	19.17	35.25	21.33	-	-	-	-	-	-	-	-
	D	7.00	7.17	26.25	15.67	-	-	-	-	-	-	-	-
	P	10.29	15.42	9.98	11.60	-	-	-	-	-	-	-	-
Shikulu	S	9.25	10.25	47.67	-	88	-	8.0	10.5	6.5	4.5	16.5	8.6
	D	3.5	7.0	12.67	-	40	-	2.0	5.0	4.5	2.5	8.75	4.8
	P	5.31	5.82	6.01	-	-	-	5.0	5.93	5.61	6.11	6.52	5.88
Nambacha	S	46.0	36.75	40.25	34.2	49	37.5	41.6	38.75	34.6	49.75	36.5	42.75
	D	40.0	31.0	31.0	28	45.67	33	33.4	35.75	32.8	42.5	31.0	37.75
	P	5.94	5.94	5.80	6.52	6.95	6.15	7.16	7.35	7.14	6.62	6.96	6.93

Source: Market survey

Key: S - Mean Number Supplied
D - Mean Number Demanded (Sold)
P - Mean Price per kg liveweight in Kshs.

Notes: Livestock markets are held once a week. Blanks indicate periods during which the respective markets were non operational.

Table 2 Monthly Quantity supplied, and Demanded and prices of Sheep in Selected markets in Western Kenya, 1985/86

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Mbale	S	42,5	-	-	-	-	-	58.75	49	51.25	44.75	46	41.5
	D	28.0	-	-	-	-	-	21.25	28.2	27	22	30.8	25.40
	P	6.34	-	-	-	-	-	6.11	6.71	6.56	6.67	6.45	6.40
Luanda	S	69.4	-	-	-	-	170	67	109.8	99.5	79.75	121	121.75
	D	10.6	-	-	-	-	5	13.5	14	9	10.25	8.25	9.25
	P	7.37	-	-	-	-	5.36	6.20	6.87	6.16	7.34	7.86	8.16
Lubao	S	27	27	39.5	38.25	65.5	46	79.25	26	72	71	77.5	45.75
	D	22	25	33.5	26.25	48.5	23	50	20.8	32.5	55.8	60.75	36.5
	P	7.34	6.98	5.42	6.57	6.29	6.28	6.07	6.27	7.08	6.72	7.32	8.10
Mahanga	S	48.25	47.33	38.5	33.6	45.0	20.25	25.0	46.5	33.25	29.8	32.25	54.40
	D	-	14.33	5.75	8	9.75	4.75	3.6	5.0	5.0	2.0	4.0	4.4
	P	6.78	6.35	6.32	5.97	6.11	5.58	5.48	6.39	7.58	7.23	7.58	7.11
Serem	S	20	34.5	51	20.33	-	-	-	-	-	-	-	-
	D	13	21.33	33	15.67	-	-	-	-	-	-	-	-
	P	9.59	8.22	9.61	10.12	-	-	-	-	-	-	-	-
Shikulu	S	45.5	63.0	33	-	50	-	55	66.25	34.25	52.2	63.25	49.40
	D	25.0	18.75	7	-	10	-	21	23.6	25.5	31.75	30.75	29.0
	P	6.12	5.29	5.83	-	-	-	5.78	6.17	6.29	6.77	6.30	6.49
Nambacha	S	44.25	52.25	58	48.6	64.33	52	67.2	69.75	71.2	63.25	49	56.25
	D	38.75	42.25	49.25	38.6	39.33	47.5	56.4	63.5	65.0	43.25	43.75	47.75
	P	7.24	6.25	6.21	6.23	5.72	5.29	6.41	7.50	6.66	7.27	6.76	7.02

Source: Market Survey

Key: S- Mean Number supplied
D- Mean Number Demanded (sold)
P- Mean price per kg liveweight in Kshs.

Notes: Livestock markets are held once a week. Blanks indicate periods during which data were not collected from the respective markets.

Table 3 The weekly Mean Quantities supplied, and Demanded and Prices of Sheep and Goats in selected Markets in Western Kenya, 1985/86

	Markets						
	Mbale	Luanda	Lubao	Mahanga	Serem	Shikulu	Nambacha
No. of Goats Supplied	65.03 (15.01)	121.81 (47.84)	31.44 (14.47)	54.73 (17.12)	26.17 (20.50)	15.77 (18.71	40.53 (11.66)
No. of Goats Sold	37.17 (8.00)	19.19 (9.38)	22.04 (11.75)	15.57 (11.15)	16.57 (14.08)	8.96 (10.65)	34.44 (10.92)
Goat Price (Kshs/kg Lwt)	6.50 (0.57)	6.36 (0.98)	6.80 (1.06)	5.51 (0.94)	11.57 (6.89)	5.90 (0 .67)	6.69 (0.84)
No. of sheep supplied	47.67 (11.20)	97.48 (46.45)	53.62 (26.35)	37.49 (17.68)	38.67 (23.94)	51 (17.55)	51.90 (22.18)
No. of Sheep Sold	26.14 (3.45)	9.98 (2.89)	36.37 (13.51)	5.55 (3.72)	20.75 (8.87)	23.40 (8.79)	47.55 (8 .73)
Sheep Price (Kshs./kg LWT)	6.47 (0.48)	6.36 (1.21)	6.73 (0.96)	6.45 (1.11)	9.41 (5.27)	6.11 (0.45)	6.60 (1.03)
n	30	31	50	51	18	35	49

Source: Survey data

Note: Figures in parenthesis are standard Deviation.

Table 4 Monthly Quantity supplied and, Demanded and Price of Processed (KCC) Fresh cow milk in selected Markets in Western Kenya, 1985/86

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Mbale	S	-	-	-	-	-	-	135	132.75	138.60	123.75	117.0	142.20
	D	-	-	-	-	-	-	132.75	132.75	138.60	123.75	117.0	142.20
	P	-	-	-	-	-	-	5.50	5.50	5.0	5.0	5.0	5.0
Luanda	S	138	76.75	52.75	147.6	122.4	112.5	123.43	83.57	96.43	99	155.25	76.4
	D	138	69.75	52.75	140.6	112.4	109.5	115.0	81.0	98.86	99	155.25	76.4
	P	4.90	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
Lubao	S	-	-	-	-	-	24.31	19.64	27	25.5	28.8	18	20.57
	D	-	-	-	-	-	23.75	19.64	27	25.5	28.8	18	20.57
	P	-	-	-	-	-	5.50	5.50	5.50	5.50	5.50	5.50	5.50
Serem	S	-	63	90	-	-	-	-	-	-	-	-	-
	D	-	63	90	-	-	-	-	-	-	-	-	-
	P	-	5.50	5.50	-	-	-	-	-	-	-	-	-
Shikulu	S	15	211.10	141.50	-	44.18	-	-	11.25	-	9	9	9
	D	15	195.20	137.50	-	42.0	-	-	11.25	-	9	9	9
	P	4.90	5.50	5.50	-	5.50	-	-	5.50	-	5.50	5.50	5.50
Nambacha	S	8	-	-	-	-	-	-	-	43	-	-	-
	D	8	-	-	-	-	-	-	-	43	-	-	-
	P	4.90	-	-	-	-	-	-	-	5.50	-	-	-

Source : Market survey

Key : S = Daily mean supply in litres.
D = Daily mean demand in litres.
P = Price per litre in Kshs. (Government Controlled)

Note: Blanks indicate No. Supply of KCC milk.

Table 5 Monthly Quantity supplied, and Demanded and Unprocessed Fresh cow milk in selected markets in Western Kenya, 1985/86

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Luanda	S	-	22	9.33	16.8	13.25	-	-	-	-	-	-	-
	D	-	20	7.67	16.8	13.25	-	-	-	-	-	-	-
	P	-	4.60	4.70	4.47	4.60	-	-	-	-	-	-	-
Lubao	S	48.43	34.83	49.8	70.67	40.2	38.29	26.39	36.83	31.25	38	25.56	34.57
	D	48.43	33.83	49.8	66	40.2	37.57	26.11	36	31.25	38	25.56	34.57
	P	5.45	5.43	7.68	7.49	6.97	5.40	4.97	5.38	6	5.86	5.23	5.95
Serem	S	-	96.8	82.05	76.0	-	-	-	-	-	-	-	-
	D	-	94	81.7	76.0	-	-	-	-	-	-	-	-
	P	-	4.61	3.89	3.29	-	-	-	-	-	-	-	-
Nambacha	S	-	4.5	9.15	19.06	27.95	13.13	24.99	30.19	33.64	46.43	74	41.83
	D	-	4.5	9.15	18.17	27.95	38.81	24.70	30	32.93	45.11	74	41.83
	P	-	3.57	3.57	3.57	5.19	3.51	3.49	3.57	3.41	3.57	3.57	3.57

Source: Market Survey

Key: S - Daily mean supply in litres
D - Daily mean demand in litres
P - Daily mean price per litre in Kshs.

Notes: Fresh milk was not sold in Mbale and Shikulu markets.
Blanks indicate No supply of milk.

PRELIMINARY ASSESSMENT OF HOUSEHOLD DIETARY PATTERNS AND UTILIZATION OF MILK PRODUCTS IN WESTERN KENYA

By
W.T. Conelly,[1] A.W. Mukhebi,[2] and M. Nolan[3]

Introduction

Improved human nutrition through increased milk consumption is one of the major goals of the SR-CRSP dual-purpose goat (DPG) research program in Western Kenya. Traditionally, milk products have been an important source of protein in the diet of the Luo and Luhya peoples living in the Lake Victoria Basin. In recent decades, however, rapid population growth and the resulting decline in farm size have severely restricted access to grazing lands and led to a steady decrease in the size of cattle herds and a reduction in milk yields. As a result, farmers report that milk consumption has declined and the provision of adequate amounts of milk in the diet has become increasingly difficult and expensive.

It is hoped that the widespread adoption of milk producing DPGs will help alleviate this shortfall in production and increase the availability of milk in the diet of smallholder farm households in the region. In July 1986, 150 pregnant DPG does were distributed to 75 farmers living in three research clusters in Kakamega and Siaya Districts. As part of an integrated experiment to monitor the performance of these goats and assess their impact on household welfare the SR-CRSP Kenya Sociology and Economics projects have initiated a year-long survey of food consumption patterns and the utilization of dairy products in the Hamisi and Masumbi research clusters.

The goals of the research[1] are to:

- assess the significance of milk products as a source of high quality protein in the diet;

- identify the relative importance of farm produced and purchased milk for household consumption and assess the impact of cash expenditures for milk on the household budget;

- identify variations in the pattern of milk production, purchases, and consumption between the two clusters and among different households within the clusters (e.g. upper vs. lower income groups, male vs. female farm managers);

- monitor the impact of the introduction of DPGs on levels of milk consumption and purchases at the household level.

This paper provides some preliminary results covering the period July through September 1986.

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[1]Winrock International and University of Missouri.

[2]Winrock International.

[3]University of Missouri.

Methodology

A multiple visit survey[2] of a sample of 25 households in Hamisi and 20 households in Masumbi was initiated in July 1986 to obtain information on dietary intake and the utilization of milk products. The sample includes 28 households with DPGs as well as a control group of 17 households (38%) without DPGs. A total of 122 interviews have been completed in Hamisi and 112 in Masumbi. The data on food consumption are based on 24 hour recall inter- views conducted by resident enumerators with female heads of household that identify all foods consumed in the household the previous day. Data on production of milk by the family's livestock as well as household consumption and purchases of milk during the previous week are also collected during the interview.

The period July through September follows the harvest of the long rains maize crop. At this time household grain supplies are at their maximum and on-farm production of milk is relatively high. The household milk data reported in the first part of the paper include two months (July and August) when DPG milk yields were insignificant and one month (September) when availability of DPG milk began to increase as many of the recently distributed does gave birth and began to lactate, particularly in Masumbi.

Results

Sources of protein in the diet

The dietary data show that the protein in the diet of the sample households during the period July through September 1986 was derived from four sources:

- starches (or energy foods), especially maize and sorghum
- grain legumes, particularly beans
- animal protein including fish, meat, and chicken
- milk products

Ugali (maize and/or sorghum meal) is the dietary staple in Western Kenya and was consumed virtually every day by the sample households. Maize was also frequently consumed at this time as a porridge (uji) and as fresh green maize (Table 1).

Table 1. Energy foods consumed in Hamisi and Masumbi clusters (July - September 1986)

	% days food eaten within household	
Food	Hamisi (n=122)	Masumbi (n=112)
Maize or sorghum meal (ugali)	99.2	97.3
Maize	21.3	46.4
Porridge (uji)	31.1	41.1
Cassava	2.5	23.2
Sweet potato	8.2	17.0

Though maize is important in the diet and has a fairly high protein content, it is not a complete source of protein. Like many foods of plant origin, it is low in certain "essential" amino acids necessary for complete utilization of protein in the body. Without a full complement of these required amino acids, maize consumed by itself loses much of its protein value and is metabolized as energy. Foods of animal origin, such as milk, meat, and fish, are complete proteins with a better balance of amino acids. For this reason, it is important that maize be consumed in combination with high quality protein foods of animal origin or with other plant foods such as beans that have a high protein content and a complementary balance of amino acids (Latham 1979, WHO 1974).

As indicated in Table 2, there is considerable variation in the consumption of protein foods between the two clusters. In Masumbi, fish and beans, both good complements to maize, were a regular part of the diet, each being consumed on over 40% of the days. In contrast, in Hamisi consumption of fish fell to 30% and beans (which are often sold for cash) to only 14% of the days surveyed. In both clusters meat was consumed on average only about one day per week and chicken was eaten only rarely, generally being reserved for days when the family had an important visitor.

Table 2. Protein foods consumed in Hamisi and Masumbi clusters (July - September 1986)

Food	% days food eaten within household	
	Hamisi (n=122)	Masumbi (n=112)
Fish	29.5	47.3
Meat (beef)	15.6	13.4
Chicken	0.8	7.1
Beans	13.9	41.1
Milk	95.9	85.7
% days no protein consumed	3.3	2.7
% days milk only protein	43.4	12.5

Role of milk in the diet

In both Hamisi and Masumbi milk is considered to be an essential part of the diet and is the most consistent source of protein, being consumed on nearly every day monitored in the study. Milk is taken most frequently in tea but is also used in cooking vegetables and fish and is sometimes consumed as sour milk. Significantly, in Hamisi milk was the <u>only</u> protein food consumed on 43.4% of the days - indicating the degree to which farmers are dependent on milk as a source of high quality protein.

Though milk is a very common source of protein in the diet of Hamisi and Masumbi households the <u>quantities</u> consumed are low. Average daily consumption of milk during the period July through September 1986 ranged from 643 ml per household in Hamisi to 829 ml per household in Masumbi. With a mean household size of 6.9 consumers in Hamisi (including residents and guests who eat with the family) and 5.7 persons in Masumbi the average daily per capita consumption of milk was only 93 ml in Hamisi and 145 ml in Masumbi

(Table 3). These figures include both farm produced and purchased cow's milk as well as some DPG milk, particularly in Masumbi during September when many of the recently distributed DPGs had kidded and begun to lactate.

Table 3. Milk consumption in Hamisi and Masumbi clusters (July - September 1986)

	Hamisi (n=122)	Masumbi (n=112)
Ave. daily consumption of milk per household (ml)	643	829
Ave. number people eating per household	6.9	5.7
Ave. daily per capita milk consumption (ml)	93	145

Household members include visitors and workers eating meals.

Inter-household variation in milk production and utilization

Cluster averages such as those reported above are informative but they conceal important inter-household variations in milk production and utilization that should not be overlooked in the analysis. Looking at the situation before the introduction of the DPGs, for example, it is apparent that the relative economic status of households has had an important influence on levels of farm milk production. As might be expected, households in the lower income group own few cattle and, consequently, have been producing little of their own milk.

Table 4 shows the relation between economic status[3], cattle herd size, and farm cow milk production in Hamisi and Masumbi. This shows production dropping off sharply on the farms of poorer farmers leaving them highly dependent on purchased milk.

Table 4. Average number of cattle and cow milk production per household in Hamisi and Masumbi clusters, by economic status (July - September 1986)

Household economic status	Hamisi		Masumbi	
	no. cattle	milk (lt/wk)	no. cattle	milk (lt/wk)
Upper group (n=31)	3.1	1.3	5.2	12.6
Middle group (n=45)	1.8	1.8	1.7	1.8
Lower group (n=36)	0.6	0.3	0.4	0.0
All households	1.7	1.2	2.1	4.2

Purchase of milk products

With the exception of a few upper group households in Masumbi, levels of farm milk production were inadequate to meet household requirements. As a result, many families spent a significant amount of money each month during the survey period on the purchase of milk. Some milk can be purchased from local farmers, but demand is much greater than the supply and most people buy milk produced commercially by the Kenya Creameries Cooperative (KCC) which is available in local markets and shops (Oyugi et.al. 1986). KCC milk currently costs Ksh 3.00 for regular and Ksh 4.00 for ultra heat treated (UHT) per half litre. Table 5 shows the average amount of milk purchased and the Kenya shillings expended per week by farmers in each economic category (cf. Mukhebi et.al. 1986). The table also indicates the percent of total milk consumed that is purchased rather than produced on farm. This shows that reliance on purchased milk is much greater in Hamisi than in Masumbi and that lower group households in both clusters are more heavily dependent on commercial milk supplies.

Table 5. Household purchases of milk in Hamisi and Masumbi clusters (July - September 1986)

Household economic status	Hamisi			Masumbi		
	lt/wk	Ksh/wk	% bought	lt/wk	Ksh/wk	% bought
Upper group	3.4	21	59.6	1.9	11	14.3
Middle group	3.0	16	69.8	1.4	9	46.7
Lower group	3.7	22	94.9	1.5	9	51.7
All households	3.3	19	73.3	1.6	9	27.6

U.S.$ 1.00 = Ksh. 16

Milk consumption by economic status

As shown in Table 6, average household and per capita milk consumption in Masumbi was very high for upper group families but dropped significantly for middle and lower group households.

Table 6. Average daily household and per capita milk consumption by economic status in Masumbi cluster (July - September 1986)

Household economic status	Household milk consumed/day	Ave.Household size	Per capita milk consumed/day
Upper group (n=31)	1900 ml	6.7	284 ml
Middle group (n=45)	429	5.1	84
Lower group (n=36)	414	5.7	73
All households (n=112)	829	5.7	145

Household size includes visitors and workers who eat with family.

In Hamisi household milk consumption also increased with economic status but average *per capita* milk consumption was highest among lower group households, averaging 113 ml per day, compared to only 93 and 82 ml per person respectively in middle and upper group households. This is because in Hamisi upper group and middle group households on average are significantly larger in size and more frequently have visitors or workers eating with the family (Table 7).

Table 7. Average daily household and per capita milk consumption by economic status in Hamisi cluster (July - September 1986)

Household economic status	Household milk consumed/day	Ave.House-hold size	Per capita milk consumed/day
Upper group (n=31)	814 ml	9.9	82 ml
Middle group (n=53)	614	6.6	93
Lower group (n=33)	557	4.9	113
All households (n=117)	643	6.9	93

Household size includes visitors and workers who eat with family.

Impact of the DPGs on household milk utilization

The data reported above provide a baseline of information on milk consumption and utilization in Hamisi and Masumbi clusters before the newly distributed DPG does came into production. In Masumbi, where many of the new DPG does gave birth and began to lactate during September it is possible to do an initial evaluation of the impact of the DPGs on household welfare. A comparison of DPG yields, levels of total milk consumption, and milk purchases between the baseline months July and August and the period September and October shows encouraging results. Among Masumbi households that own a DPG, milk consumption levels have risen and the amount of milk purchased has declined as the newly distributed goats have begun to come into production during September and October.

Among the 14 households owning DPGs in the Masumbi sample, the average litres per week of surplus DPG milk that was reported to be available for family use rose from only 0.1 during July and August to 4.7 in September and the first weeks of October. During this time on-farm production of cow's milk in Masumbi also increased and as a result overall consumption of milk has risen and dependence on purchased milk has been reduced.

In Table 8, the effect of increased production of DPG milk is isolated by looking at households that have DPGs but did not own any cows that were producing milk during July - October 1986 (this includes all lower income households in the sample). For these households, daily milk consumption almost doubled from 60 to 110 ml per person while the amount and cost of milk purchased declined by more than one-half.

Table 8. Changes in average milk production, purchases, and consumption for DPG households with no milk cows in Masumbi cluster

	July-August (n=47)	September-October (n=23)
DPG milk production (lt/wk/household)	0.1	3.8
Milk purchases per week (lt/household)	2.3	0.7
Milk purchases per week (Ksh/household)	12	5
Daily per capita milk consumption (ml)	60	110

Discussion

The evidence available from the first months of the dietary and milk utilization survey indicates that:

1. Milk is clearly an important source of protein in the diet, being consumed in most households every day in both Masumbi and Hamisi. Milk is especially significant in Hamisi where alternative sources of protein foods (needed to complement consumption of the staple maize) such as beans, meat, and fish are not regularly eaten. A measure of the significance of milk in the Hamisi diet is the fact that milk was the only protein food consumed on 43% of the days surveyed during July - September 1986.

2. Though milk is a regular and important part of the diet, actual levels of consumption are low, averaging only 93 ml per person per day in Hamisi and 145 ml per day in Masumbi.

3. Farmers perceive their current levels of milk as too low. In a recent survey, 18 women in Hamisi and Masumbi were asked the amount of milk they would like to have for their families if cost and availability were not a problem. The responses ranged from 800 ml to 3200 ml per day for each household with an average of 1900 ml in Hamisi and 1320 ml in Masumbi. This is an average of 275 ml per person each day in Hamisi and 230 ml per person in Masumbi. The desired amount of milk in Hamisi is three times the average actually consumed.

4. It would be misleading to view Hamisi and Masumbi as a collection of homogenous "smallholder" farmers all of whom have similar access to resources and who pursue comparable livestock management strategies. The preliminary data from this survey indicate that there is a group of poorer households that own few livestock, suffer from low farm production of milk, and that are highly dependent on purchases of commercial milk. In Hamisi, these lower group households are all headed by young female farm managers whose husbands are wage laborers engaged in off-farm employment. This sub-group of low income, cattle- poor farmers may have substantially more to gain by adopting

the DPG enterprise than would better off households in the community that own larger cattle herds and have more income for the purchase of milk. A question remains, however, as to whether these lower income households could manage the costs of purchasing and maintaining DPGs and whether they would be able to absorb the increased labor costs associated with the DPG enterprise. Further research on this issue is warranted.

5. The low levels of farm milk production and consumption combined with the high demand for milk and large household expenditures on commercial milk in the clusters indicate that the DPG enterprise has the potential for making an important contribution to the nutritional and economic welfare of farmers in Western Kenya.

Though levels of milk consumption are still low, the preliminary survey findings indicate that the DPGs are having a positive impact on nutritional and economic welfare in Masumbi. We recognize, however, the need for continued research to provide a larger set of data and to confirm that this positive trend is maintained over an extended period of time. Current plans call for continued monitoring of dietary intake and milk utilization over an entire year in order to measure seasonal variation in patterns of milk production and consumption and to assess the long-term impact of the DPG enterprise on household welfare.

Notes

1 This study builds on earlier research by the Economics Project on general patterns of food consumption and the importance of market purchased foods in the diet (Nyaribo et.al. 1984) and work by Boor (1983) on goat milk products in Western Kenya.

2 The dietary survey provides a qualitative overview of dietary patterns as well as quantifiable data on the frequencies with which particular foods are eaten. It can also assess the relative importance of different foods and highlight variations in the adequacy of diet between communities or among different households within a community. The technique provides household level data and does not indicate individual differences in food consumption within the household. It also does not permit a detailed quantitative analysis of caloric intake or grams of protein consumed per day. Nor was an attempt made to evaluate nutritional status in the communities through anthropometric measurements. Such a detailed analysis would be a full-time undertaking requiring a specialist in nutrition or nutritional anthropology.

A daily record of DPG milk production is being kept by farmers with the assistance of resident enumerators for the Nutrition Management project. Farmers report levels of cow milk production by indicating the number of local containers that have been filled. The volume of these containers is then measured using a calibrated cylinder. Cow milk production is generally constant over a seven day period and is therefore usually not difficult for the farmer to recall. The enumerators periodically witness DPG and cow milkings to verify the accuracy of the reports by farmers.

3 The economic status ranking of households is based on a score derived from three indicators of wealth: house type, the number and type of household possessions and productive equipment owned, and livestock holdings.

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TIME ALLOCATION AND THE ORGANIZATION OF HOUSEHOLD LABOR IN SMALLHOLDER FARMING SYSTEMS IN WESTERN KENYA

By

W.T. Conelly[1] and M. Nolan[2]

Introduction

The allocation of time and the organization of household labor are key factors in the effective management of smallholder farming systems. Labor constraints and scheduling conflicts with other farm and off-farm activities pose a potential obstacle to the adoption of new livestock enterprises. An understanding of existing patterns of livestock management, labor allocation, and the division of labor by sex and age will be helpful in planning and evaluating the SR-CRSP dual-purpose goat (DPG) enterprise. This paper summarizes preliminary data on livestock management strategies and the allocation and organization of household labor in Western Kenya. The research builds on previous work completed by the SR-CRSP Economics Project on the labor supply and demands of the DPG enterprise (Nyaribo et.al. 1984)

The study has the following objectives:

1. To describe recent changes in the system of livestock management in two research clusters - Masumbi in Siaya District and Hamisi in Kakamega District.

2. To measure the labor expended on livestock enterprises as well as the time allocated to activities that may compete for labor with livestock care - including food and cash crop labor, off-farm labor, household tasks, community activities, and school attendance.

3. To identify the division of labor by sex and age in the two clusters and evaluate the role of women and children in livestock management

4. To assess the implications of time allocation patterns and the organization of household labor for the adoption of the DPG enterprise.

Recent changes in livestock management practices

Interviews with 20 farmers in Masumbi and Hamisi clusters indicate that that there have been important changes in livestock management practices and labor allocation over the past several decades. As a consequence of a decrease in the availability of communal grazing land, resulting from rapid population growth and a government program to demarcate land and establish individual land tenure, there has been a progressive decline in the importance of herding and an increase in tethering and cut and carry provision of feed resources for livestock.

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[1]Winrock International and University of Missouri.

[2]University of Missouri.

This process has progressed further in Hamisi where land pressure is now extreme (population over 700 persons/sq.km.) and fallow land for grazing has become very scarce. Continuous animal tethering and cut and carry feeding of livestock with a variety of cultivated and wild plant species is now common. In Masumbi, where land size and availability of fallow grazing areas are not yet so restricted (population about 200 persons/sq.km.), many farmers still have sufficient land to permit continued grazing on a limited scale. Nevertheless, cut and carry feeding of animals that are tethered much of the day has become more important since the 1960's.

Tables 1 and 2, based on random observations[1] of livestock management practices made during the period May - September 1986, illustrate the decline of herding and the growing importance of tethering and cut and carry feed resources in Masumbi and Hamisi. The data are based on the combined observations for all livestock including cattle, DPGs, local goats, and sheep.

Table 1 illustrates the importance of tethering, particularly in Hamisi where animals were observed to be tethered 90% of the time. It also shows that livestock were herded during this period (which coincided with the middle and end of the long rains) less than 1% of the time in Hamisi and only 7% in Masumbi. Herding is more common with cattle and is expected to increase somewhat in importance during the dry season.

Table 2 summarizes the main types of feed resources utilized in the two clusters. In Masumbi, where the use of cut and carry feeds is still not common, grasses grazed in the compound or on fallow land accounted for over 70% of the feed resources eaten by livestock. In contrast, in Hamisi, where cut and carry resources are used frequently, grazing represented only 38% of the total feeds. Maize thinnings and stover provided one-third of the feed while other sources of cut and carry accounted for 23% of the feed resources in Hamisi. In both clusters, the use of cut and carry feeds is most common with cattle and DPGs while local goats and, especially, sheep generally survive by grazing and browsing.

In addition to changes in the management of feed resources, a second change that has occurred in livestock management over the past several decades has been a decline in the size of animal herds. Farmers report that this has come about partly because of a decline in the availability of grazing land and partly because of a greater need for a source of cash income resulting from their increasing participation in the regional market economy and stronger government influence at the local community level. The need for cash in order to pay school fees and the escalating cost of market purchased foods, for example, have increased the pressure to sell livestock to meet household expenses. Average herd size of all animals (including cattle, DPGs, local goats, and sheep) among the sample farmers is now 5.9 per household in Masumbi (range 0-22) and 4.5 in Hamisi (range 0- 11). The average Tropical Livestock Units per household among the respondent farmers is 2.1 in Masumbi and 1.9 in Hamisi.

The use of labor from outside the household to assist in the management of animals has also declined. Cooperative group herding of livestock, in which the combined herds of several households were herded by individuals on a rotation basis, is reported to have been practiced in Masumbi (and to a lesser extent in Hamisi) in the past. Today this practice has completely disappeared in Hamisi and is continued on only a limited basis in Masumbi. Likewise, the use of hired herders to look after livestock has also dcreased in importance.

Household time allocation survey methodology

Data on the labor costs of the current system of livestock management and how animal care is integrated into the overall pattern of time allocation will provide useful information for planning and evaluating the DPG enterprise. To obtain such data, a time allocation and livestock management survey was initiated by the Sociology project in Masumbi and Hamisi clusters beginning in May 1986. The survey is based on a random spot check method of observations adopted by anthropologists to obtain quantified data on household time allocation that minimizes the errors likely to occur in time use studies that rely on informant recall (Grandin 1982, Johnson 1975).

In this method, households in both Masumbi and Hamisi are regularly visited by enumerators at randomly chosen daylight hours when the activities of all household members at the moment the observer first sees them are recorded. If an individual is away from the compound or nearby fields, another household member is asked to report on his/her whereabouts and activity. Whenever possible these reports are checked in person by the enumerator and cases where information is unknown or uncertain are discarded.

The communities are divided into several neighborhood clusters each containing five households with a total sample of 25 households in Hamisi and 20 in Masumbi. Each month 40 cluster visits are made, resulting in 200 household visits and approximately 800 individual observations per month in each cluster. It is assumed from this large number of observations that the relative frequency with which a particular activity is observed closely approximates the actual amount of time spent on that activity.

The following section reports on the preliminary findings of the time allocation survey covering the period May through September 1986. This period includes two months prior to the large-scale distribution of DPGs that took place in the two clusters during July 1986. Of the 45 households in the sample, 28 have DPGs while a control group of 17 households do not. The data on livestock labor reported below represent the combined labor expended on all livestock including cattle, DPGs, local goats, and sheep.

Household time allocation data

For analysis, household time allocation data have been divided into eight major categories: livestock care, subsistence farming, cash crop farm labor, off-farm income producing activities, household maintenance tasks, community activities, inactive, and school attendance. Tables 3 and 4 show the overall allocation of time for adults and children during daylight hours in Masumbi and Hamisi clusters.

Table 3 indicates that in Masumbi adult males spent an average of slightly more than two hours and women about 20 minutes per day on animal care tasks. By comparison, in Hamisi, both men and women spent an average of only 20 minutes per day on livestock care. Table 4 shows a similar pattern for children's labor. Male children in Masumbi expended an average of approximately 1.2 hours per day on animal care while girls spent only about 5 minutes. In Hamisi, male children spent on average about 20 minutes and females about 10 minutes per day on livestock care.

Taking into account the greater number of animals per household in Masumbi (average 5.9 vs. 4.5 in Hamisi), these figures suggest that farmers spend less time in managing their animals in the "intensive" livestock system in Hamisi than in the semi-intensive system in Masumbi. This appears to be the result of the change in the type of livestock labor that is required as the transition is made from a semi-intensive tethering and herding system to an intensive cut and carry system. A task-specific breakdown of the labor allocated to livestock maintenance (Table 5) shows that close to 75% of the livestock labor in Masumbi involves either herding (usually cattle) or frequent tethering. In contrast, tethering and herding account for only about 20% of the livestock labor in Hamisi while collecting and feeding of fodder utilizes close to 50% and the provision of water to animals in the compound another 20% of the livestock labor.

Provision of feeds by herding is relatively labor intensive, particularly with the small herd sizes now common in the area. Herding requires walking either to fallow fields or to pastures near the river - both often some distance from the homestead in Masumbi - and may take up to several hours for each trip. In contrast, cut and carry feeds such as maize and napier are often obtained from fields close to the compound with each "trip" requiring only 5-20 minutes. With a low frequency of cut and carry feeds in Masumbi, farmers spend 40% of their livestock labor tethering their animals which are moved several times during the day. In contrast, changing the location at which livestock are tethered is not as frequent in Hamisi because feeds are generally brought to the animals in the compound.

This comparison of livestock labor costs in the two systems considers only direct animal care tasks. In addition it is also necessary to calculate <u>indirect</u> livestock labor costs, particularly the labor expended in producing crops such as maize that are grown as both food crops and as animal feed. In Hamisi, where cut and carry feeding of cultivated crops is common this would add significantly to the overall labor costs of raising livestock, especially for women who have primary responsibility for food crop production (Table 3). The labor requirements of producing such feed crops (e.g. calculated as a proportion of the total labor expended to produce a maize field) cannot be estimated until a full year of data has been collected. Including such indirect labor costs in the calculation may indicate that the <u>overall</u> labor requirement for animal care is greater in the cut and carry management system in Hamisi than in the tethering/herding system practiced in Masumbi.

In addition to livestock labor, farmers schedule many other farm and off-farm activities into their day. For adults (Table 3), total economic activities in Masumbi, including agricultural and off-farm labor, accounted for an average of 5 hours per day for men and 3 hours for women. In Hamisi, adult males spent an average of 5.5 hours per day on these economic activities while women spent about 3.6 hours. In addition, work required for maintaining the household - including childcare, cleaning, food preparation, and collecting fuelwood and water - accounted for 1 to 2 hours per day for men in the two clusters while women spent 4 to 5 hours per day on household chores. Thus, overall work days averaged 6.7 hours for Hamisi men, 7.2 hours for Masumbi men, 7.7 hours for Hamisi women and 8.4 hours for Masumbi women. This work pattern leaves about 4 to 5 hours per day for community and leisure activities - about the same schedule as an urban office worker.

The Role of Women and Children in Livestock Management

Survey data and casual observations reported in previous SR- CRSP studies (Nyaribo et.al. 1984; Mukhebi et.al. 1984) have indicated that women, and to a lesser extent children, appear to make a substantial contribution to the care of livestock in Western Kenya. The time allocation data and interviews with farmers provide additional information on the important role played by women and children in livestock management.

Twenty farmers - both men and women - were interviewed concerning changes they have observed over the past 20 years or so in the organization of household labor for livestock care. In Hamisi, two trends in household labor utilization were reported: (1) a decline in the contribution of children to livestock care because of increasing school attendance, and (2) an increase in the amount of livestock work done by women owing to the frequent absence of male household heads working away from the farm. Women are reported to be involved in all aspects of animal care including tethering, occasional herding, water collection, provision of cut and carry feeds, and milking.

In contrast, farmers in Masumbi did not report major changes, indicating that, as in the past, the male household head has primary responsibility for animal care. Sons are expected to do much of the labor such as herding and tethering under the direction of the father. Women may sometimes help with many of the tasks but the only work that is seen as primarily a female responsibility is collecting water for the animals, usually goats, in the compound. The decline in the availability of child labor, because of the necessity of school attendance, was also mentioned, but not emphasized by the respondents. Increasing livestock labor by women was mentioned only in the case of a few older women whose husbands had died.

In general, the time allocation data for the period May through September 1986 support these reports on the organization of household labor for the care of livestock. In Masumbi, livestock management is primarily a male activity with males accounting for 87.5% of the livestock labor observations. Female children make almost no contribution to the care of animals and women account for only 11.2% of the observations. In Hamisi, the contribution of males - both children and adults - dropped to 54.8% while the labor expenditure on livestock by females rose significantly to 45% of all observations (Table 6).

Table 6 also indicates that children's labor[2], despite the increase in school attendance in recent years, still makes a significant contribution to livestock management in Western Kenya. In Masumbi, children (mostly male) account for 46% of all the animal labor observations while in Hamisi they contribute 41%. In Masumbi, most livestock labor by children is herding and tethering done by males under the age of 20 (Table 7). This work is accomplished by younger boys in Standard 1-3 who attend school only in the mornings and by male children of all ages late in the afternoon upon returning from school and on weekends. In Hamisi, most of the livestock labor of children (both male and female) is focused on procuring cut and carry feeds and collecting water for the animals (Table 8).

As seen in Tables 6 through 8, female labor is much more important in the intensive livestock management system in Hamisi than in Masumbi. This is partly due to the very high rate of off-farm employment by males, leaving the women to cope with most of the farm work. It is also related to the change from a semi-intensive system of livestock management in which tethering and herding dominate to an intensive system in which cut and carry feeding is more prevalent. While herding, and to a lesser extent tethering, are usually seen as male tasks, cutting feed crops is viewed as work appropriate to women and girls as well as men, while collecting water is seen as primarily a female responsibility. In Hamisi, for example, 84% of the cases of water collection for livestock were done by females - the remaining 16% by male children. Males in Hamisi do a large share of the work of obtaining cut and carry feeds. In general, however, men are responsible for collecting wild feeds away from the immediate area of the farm while women do much of the work collecting cultivated feeds grown in nearby fields.

Conclusions

The preliminary information provided by the study of livestock management practices and time allocation strategies in Masumbi and Hamisi clusters during May - September 1986 indicate that:

1. Over the past several decades farmers in both clusters have experienced major changes in the their livestock management practices. Rapid population growth and declining farm size combined with a new system of individual land tenure have led to a decrease in reliance on herding and grazing and an increase in the use of tethering and cut and carry feeds. This process has progressed further in Hamisi than in Masumbi.

2. Direct labor requirements for animal care appear to be higher in the semi-intensive livestock system in Masumbi than in the cut and carry system in Hamisi. Calculating in the "indirect" livestock labor costs of producing feed crops such as maize, however, adds significantly to the labor requirements of raising livestock in Hamisi.

3. Analysis of the division of livestock labor by age shows that children, despite high levels of school attendance, make a substantial contribution to animal care accounting for over 40% of the livestock labor observations in both clusters. In contrast, children are responsible for only 20% of the total labor for food crop production in Masumbi and 30% in Hamisi. This continued reliance on the labor of children for livestock care should be considered in planning management recommendations for the DPG enterprise.

4. Females contribute proportionately more labor in the cut and carry livestock system in Hamisi (45% of total) than in Masumbi (12% of total). This suggests that the package of DPG management practices being developed by SR-CRSP, which encourages the production of dual-purpose food/feed crops, will rely heavily on female labor - particularly as food crops such as maize

and sweet potatoes (as opposed to wild feeds) are seen as primarily the responsibility of women (Table 3).

While the DPG enterprise may require a considerable investment of labor by women, the time allocation data (Table 3) show that women have less inactive or "leisure" time available than do men - 3.4 vs. 3.9 hours per day in Masumbi and 3.5 vs. 4.6 hours in Hamisi. This leisure time is not simply spent in idleness but includes activities such as visiting with relatives and neighbors, recreation, traveling, and illness. The time in which women were observed to be <u>idle</u> averaged only 20.8% of the day in Hamisi and 17.0% in Masumbi. This represents an average of about 2 to 2.5 hours of discretionary time per day that women potentially could invest in the care of DPGs. The decision to actually invest this surplus time in DPGs will depend in part on whether women view the goats as a profitable enterprise that compares favorably with other economic opportunities available to them.

These conclusions, based on preliminary data covering only five months, are provisional. Seasonal variations in labor supply and demand (cf. Nyaribo et.al. 1984), which will be analyzed when data covering a full year are available, may alter somewhat the assessment of household labor allocation and organization presented in this paper.

Notes

[1] The random observations of livestock were made as part of a larger study of household time allocation described below. On average, about 800 livestock observations were made each month between May and September in both clusters. During each household visit the location, activity (feeding, ruminating, inactive, etc.), and method of control (tethered, herded, etc.) for all livestock were noted. The availability of cut and carry feeds and the type of feed resource being utilized were also recorded.

[2] The discussion of the contribution of children to livestock care is based on the percent of the total observations of livestock labor in the survey that were accomplished by children. In this preliminary analysis, which focuses on the amount of time individuals spend on different activities, the labor of children and adults is weighted equally - no attempt has been made to give a relative weight or value to children's work as opposed to that of adults. This point will discussed in the final report that will be prepared when the survey is complete.

Acknowledgements

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Table 1. Method of controlling livestock in Masumbi and Hamisi clusters (May - September 1986)

Control method	Percent of observations Masumbi (n=2991)	Hamisi (n=2808)
Tethered	43.1	90.2
Tied	29.5	8.0
Loose	20.4	1.1
Herded	7.0	0.7
	100.0	100.0

Note: Tethered = with access to feed, Tied = no access to feed

Table 2. Feed resource utilization in Masumbi and Hamisi clusters (May - September 1986)

Feed resource	Percent of all feed resources observed Masumbi (n=1850)	Hamisi (n=3036)
Grasses, general	70.6	38.0
Maize thinnings and stover	4.9	32.5
Napier	3.4	8.8
Other cultivated[a]	3.6	4.3
Other wild	17.4	16.3

[a] Other cultivated include bean leaves, pigeon pea, Sesbania, sweet potato vines, banana leaves. Other wild feed resources include couch grass, thistle, lantana, blackjack, and *Grewia trichocarpa*.

Table 3. Adult Time allocation by sex in Masumbi and Hamisi clusters (May - September 1986)

	Masumbi (n=1798)		Hamisi (n=1876)	
Activity	Male	Female	Male	Female
	% of observations (hours/day)			
Livestock	16.5 (2.1)	2.2 (0.3)	3.5 (0.4)	2.5 (0.3)
Food crop	9.8 (1.2)	16.2 (2.0)	5.9 (0.7)	17.4 (2.2)
Cash crop	1.3 (0.2)	0.7 (0.1)	13.3 (1.7)	6.4 (0.8)
Off-farm	12.6 (1.6)	5.1 (0.6)	21.8 (2.7)	2.7 (0.3)
Household	17.3 (2.2)	42.9 (5.4)	9.5 (1.2)	32.6 (4.1)
Community	11.5 (1.4)	5.7 (0.7)	5.8 (0.7)	10.5 (1.3)
Inactive	30.9 (3.9)	27.3 (3.4)	36.7 (4.6)	27.9 (3.5)
School	0.0 (0.0)	0.0 (0.0)	3.5 (0.4)	0.0 (0.0)
TOTAL	100.0 12.5	100.0 12.5	100.0 12.5	100.0 12.5

Note: Adult includes individuals of age 20 and above

Table 4. Child Time allocation by sex in Masumbi and Hamisi clusters (May - September 1986)

	Masumbi (n=1879)		Hamisi (n=1926)	
Activity	Male	Female	Male	Female
	% of observations (ave. hours/day)			
Livestock	9.6 (1.2)	0.4 (0.1)	2.5 (0.3)	1.5 (0.2)
Food crop	3.8 (0.5)	2.8 (0.3)	5.0 (0.6)	5.2 (0.6)
Cash crop	0.6 (0.1)	0.1 (0.0)	3.9 (0.5)	1.8 (0.2)
Off-farm	0.8 (0.1)	0.6 (0.1)	1.3 (0.2)	1.0 (0.1)
Household	12.7 (1.6)	23.0 (2.9)	12.3 (1.5)	25.4 (3.2)
Community	3.3 (0.4)	3.9 (0.5)	0.7 (0.1)	1.4 (0.2)
Inactive	24.2 (3.0)	27.3 (3.4)	35.9 (4.5)	26.2 (3.3)
School	45.0 (5.6)	41.8 (5.2)	38.4 (4.8)	37.6 (4.7)
TOTAL	100.0 12.5	100.0 12.5	100.0 12.5	100.0 12.5

Note: Child includes individuals of ages 7-19.

Table 5. Livestock labor by task in Masumbi and Hamisi clusters (May - September 1986)

Task	Percent of all livestock labor	
	Masumbi (n=232)	Hamisi (n=93)
Tethering	40.1	9.7
Herding - for grazing	29.3	10.8
Herding - for water	6.0	0.0
Cut and carry	5.2	48.4
Watering in compound	5.6	20.4
Housing/equipment	6.0	3.2
Other	7.8	7.5
	100.0	100.0

Table 6. Livestock labor by age and sex in Masumbi and Hamisi clusters (May - September 1986)

Age and sex	Masumbi (n=232)		Hamisi (n=93)	
	# cases	% of total	# cases	% of total
Adult male	99	42.7	28	30.1
Adult female	26	11.2	27	29.0
Male child	104	44.8	23	24.7
Female child	3	1.3	15	16.1
	232	100.0	93	100.0

Adults = age 20 and above, Child = ages 7-19.

Table 7. Task specific livestock labor by age and sex in Masumbi cluster (n=232) (May - September 1986)

Livestock task	Adults male	Adults female	Children male	Children female	Total
	% of livestock labor observations				
Cut and carry	3.4	0.4	0.9	0.4	5.2
Tethering	19.0	4.7	16.4	0.0	40.1
Herding	10.8	1.3	23.3	0.0	35.3
Water	1.3	1.7	1.7	0.9	5.6
Other	8.2	3.0	2.6	0.0	13.8
TOTAL	42.7	11.1	44.9	1.3	100.0

Table 8. Task specific livestock labor by age and sex in Hamisi cluster (n=93) (May - September 1986)

Livestock task	Adults male	Adults female	Children male	Children female	Total
	% of livestock labor observations				
Cut and carry	22.6	12.9	9.7	3.2	48.4
Tethering	1.1	4.3	2.2	2.2	9.7
Herding	2.2	2.2	4.3	2.2	10.8
Water	0.0	8.6	3.2	8.6	20.4
Other	4.3	1.1	5.4	0.0	10.7
TOTAL	30.2	29.1	24.8	16.2	100.0

EFFECTS OF SEASONAL FORAGE SUPPLY OF SEMI-ARID PASTURES ON HERD PRODUCTIVITY IN THE SMALL EAST AFRICAN GOAT

By

H.J. Schwartz and A.B. Carles
Department of Animal Production
University of Nairobi
P.O. Box 29053, Kabete

Abstract

The effects of seasonal changes of quantity and quality of available forage of a semi-arid thornbush savannah on productivity levels in Small East African Goats (SEAGs) were studied using a systematic aseasonal breeding programme. Records taken of abortions, births, birthweights, pre-weaning survival, weaning weights, pre- and post-partum weights of dams, dam survival and milk off-take for human consumption were used to calculate productivity indices for 10 breeding groups of 18 does each with distinctly different pasture conditions during various stages of the reproductive cycle. The mean productivity index for all breeding groups was 294+102.7g/kg breeding doe maintained and 713+257.3g/$kg^{.75}$ breeding doe maintained. The values for the breeding groups ranged from 134g/kg and 303g/$kg^{.75}$ to 447g/kg and 1069g/$kg^{.75}$ respectively. The most important factors determining productivity were weaning rate (R^2 = .83), weight of dam post partum (R^2 = .73) and weaning weight (R^2 = .55). Conception rates, abortion rates, birth rates, birth weights and age of dam at parturition had only marginal effects on productivity.

Introduction

To determine the optimal breeding season for Small East African Goats (SEAGs) on semi-arid pastures in Northern Kenya a study of the effects of seasonal forage supply on herd fertility and productivity was initiated in January 1984. Breeding groups of 18 does each, with a balanced age structure, were established. Into the first group a buck was introduced for two months and afterwards transferred to consecutive groups for the same duration to achieve year-round mating, kidding and weaning. The breeding programme will be carried out until the end of December 1986, ending with breeding group 18. Observations on the reproductive performance of this last breeding group will be concluded by October 1987, when the off-spring of this group is due to be weaned. This paper reports preliminary results for the first 10 breeding groups which have completed one gestation and one lactation to date.

The programme is carried out on a semi-arid thornbush savannah, situated on a holding ground of the Livestock Marketing Division (LMD) in Isiolo District. The annual rainfall is approx. 500 mm. The predominant pasture types are annual grassland, dwarf shrub land and Acacia Spp. dominated thornbush of medium density. Limited areas of riverine woodlands and perennial grassland on a floodplai.. serve as dry season reserve.

Results

Group productivity is described using three productivity indices (ILCA, 1979 and King, 1983). Weight of weaner plus live weight equivalent of milk off-take is expressed per head (I), per kg live weight (II) and per kg metabolic body weight (III) of breeding females maintained.

Figure 1 shows a calendar of events in the first 5 breeding groups in relation to forage availability and forage quality on the experimental pastures. Conditions for breeding groups 6 to 10 were similar with the exception that the long dry season in 1985 was less severe than in 1984 and the forage supply remained higher throughout the year. Table 1 summarises pasture conditions experienced by the 10 breeding groups at mating, birth and weaning and relates these to the observed group productivity (Productivity index 11).

Table 2 shows some values for herd fertility observed in the 10 breeding groups. Highest conception rates were noted when mating took place at good pasture conditions, i.e. during the growing season, whereas the lowest conception rate was recorded in group 4 which was mated towards the end of the long dry season in 1984. Abortion rates do not appear to be related closely to pasture condition and have been of any importance only in 2 groups. Birth rates are positively correlated with conception rates (Table 3) and follow a similar pattern. Preweaning survival appears to be affected most by pasture condition at birth, most likely through the effect on milk yields during the first part of the lactation. Weaning rate as a product of pre-weaning survival and birth rate is positively correlated to the former and negatively correlated to the latter (Table 3) but appears to be affected more by pasture condition at birth and the pasture condition trend from birth to weaning than by pasture condition at mating. The evaluation of the effects of pasture condition is still subject to further analysis using two-weekly pasture condition scores and forage quality measurements for the assessment.

Group means of post partum live weights and metabolic body weights of females (Table 4) show a trend which may contain an age effect, which was unavoidable in the experimental set-up. Further analysis will be carried out, using body weights adjusted for age. Milk yields have not been calculated yet. However, milk off-take for human consumption (Table 4), which represents approximately 15-20% of the total yield, is positively correlated to weaning weights (r = .66). It can be assumed that further analysis, relating milk yields and weaning weights to forage availability and forage quality during lactation, will result in high positive correlations.

Table 5 lists the calculated productivity indices for the 10 breeding groups. Slight shifts in rank indicate that the different indices indeed relate to different aspects of herd productivity, although they are very closely related in the material presented. Mean values are lower than reported by King (1983) for SEAGs under ranching conditions, but are higher for some groups. Maximum values were obtained for breeding groups 5 and 9 (Figure 2). In both cases pasture condition was good at birth and remained so throughout the full lactation period.

Determination coefficients for linear regressions of herd fertility parameters on the productivity indices (Table 6) show that conception, abortion and birth rates had only negligible effect on group productivity. Weaning rate and live weight of females post partum, followed by pre-weaning survival and weaning weight were the important factor affecting group productivity.

Preliminary Conclusions

Preliminary results from an ongoing study of the effects of seasonal changes in forage supply of semi-arid pastures in Northern Kenya, on the productivity of SEAGs, indicate that highest herd productivity is achieved, when mating takes place at the end of the long dry season, so that birth and weaning coincide with the beginning of the long rains and the beginning of the next long dry season respectively, although conception and birth rates will not reach maximum values.

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Table 1. Productivity in 10 Breeding Groups of Small East African Goats at Different Forage Supply Patterns During the Reproductive Cycle.

Breeding Group #	Pasture Condition at mating	at birth	at weaning	Productivity index II (g/kg female live wt]
1	good	medium	poor	134.0
2	good	poor	medium	150.8
3	medium	medium	good	210.8
4	poor	good	medium	294.0
5	good	good	good	447.2
6	good	good	medium	345.6
7	poor	good	medium	306.9
8	good	medium	good	318.4
9	medium	good	good	413.9
10	good	medium	good	317.5
Mean				293.9
SD				±102.7

Table 2. Some Parameters of Herd Fertility Observed in 10 Breeding Groups of Small East African Goats.

Breeding Group #	Conception rate [%]*	Abortion rate [%]*	Birth rate [%]*	Preweaning survival rate [%]**	Weaning rate [%]*
1	100		167	30	50
2	94		111	45	50
3	78	11	89	63	56
4	50	22	61	100	61
5	88	17	100	94	94
6	100	6	128	78	100
7	88		89	94	83
8	88		131	76	100
9	100		172	81	139
10	100	6	122	68	83

* of breeding females joined

** of kids born

Table 3. Correlation Coefficients (r) for some Parameters of Herd Fertility in 10 Breeding Groups of Small East African Goats.

	Conception rate	Birth rate	Pre-weaning survival	Weaning rate
Conception rate	1.0	.79*	-.49	-.36
Birth rate		1.0	-.51	-.44
Pre-weaning survival			1.0	.50
Weaning rate				1.0

* P = 0.05

Table 4. Group Means of Body Weights Recorded in 10 Breeding Groups of Small East African Goats and Estimated Milk Off-Take for Human Consumption.

Breeding Group #	Live wt of females* [kg]	Metabolic body wt of females* [kg]	Estimated milk off-take** [l]	Weaning wt *** [kg]
1	26.0	11.5	5	5.1
2	28.0	12.2	5	6.5
3	30.0	12.8	5	10.5
4	31.5	13.3	7	13.5
5	32.6	13.6	9	14.6
6	35.4	14.5	5	10.9
7	39.0	15.6	6	13.6
8	36.9	15.0	6	10.5
9	38.9	15.6	5	10.9
10	33.7	14.0	5	11.7

* immediately post partum

** for 4 months lactation

*** at 4 months of age

Table 5. Productivity indices for 10 Breeding Groups of Small East African Goats Calculated for a Time Period of 9 Months (from conception to weaning at 4 months post partum).

Breeding Group #	Productivity index I [kg/hd]	II [g/kg live wt]	III [g/kg metab wt]
1	3.49 (10)	134.0 (10)	303.2 (10)
2	4.22 (9)	150.8 (9)	346.8 (9)
3	6.32 (8)	210.8 (8)	519.3 (8)
4	9.36 (7)	294.0 (7)	703.8 (7)
5	14.60 (2)	447.2 (1)	1068.9 (1)
6	12.20 (3)	345.6 (3)	843.7 (3)
7	12.00 (4)	306.9 (6)	767.3 (5)
8	11.75 (5)	318.4 (4)	783.2 (4)
9	16.10 (1)	413.9 (2)	1032.0 (2)
10	10.70 (6)	317.5 (5)	764.3 (6)
Mean	10.07	293.9	713.3
SD	+4.22	+102.7	+257.3

Rank in brackets

Table 6. Determination Coefficients (R^2) for Linear Regressions of some Parameters of Herd Productivity Indices in 10 Breeding Groups of Small East African Goats.

Parameter	Productivity Index		
	I [kg/hd]	II [g/kg live wt]	III [g/kg metab wt]
Conception rate [%]*	.01	.00	.00
Abortion rate [%]*	.01	.08	.07
Birth rate [%]*	.01	.00	.00
Preweaning survival [%]**	.61	.63	.64
Weaning rate [%]*	.83	.70	.74
Weaning weight [kg]	.55	.60	.60
Live wt of females [kg]***	.74	.83	.60

* of breeding females joined

** of kids born

*** immediately post partum

THE IMPORTANCE OF ACACIA TORTILIS POD FEEDING IN SMALLSTOCK MANAGEMENT IN MBIRIKANI GROUP RANCH, KAJIADO DISTRICT

By

P.N. de Leeuw[1], C. Peacock[2] and M. Cisse[3]

Introduction

Movement of cattle and smallstock across group ranch boundaries is common during periods of drought throughout Kajiado district as was demonstrated during the severe 1984 drought (Grandin, 1986, de Leeuw, 1986). However, during normal times, stock and households in group ranches in the semi-arid parts of the district are fairly sedentary, most movements being confined within the ranch boundaries. In the more arid parts of the district, mobility is much greater. In Mbirikani, for instance, most livestock remain within the confines of the ranch only in above average rainfall years, whereas during drier periods movements to better watered areas is a regularly occuring management strategy. Details of the various movement patterns employed by Mbirikani producers during the minor drought in 1982 and the major one in 1984 were described elsewhere by Peacock et al (1982) and de Leeuw (1986).

Small stock flocks are often moved independently of cattle herds, as their requirements for grazing differ because they tend to rely more on woody vegetation than do cattle (de Leeuw and Chara, 1986). As many areas in Mbirikani Group Ranch are low in browse resources, smallstock are taken to specific areas with better woody cover. Generally, the prime objective is to provide better feeding, but during the long dry season there is an additional reason: to improve conception rates during the breeding season, which normally falls from July to September. During this time, many flocks are driven to the Acacia tortilis wooded grassland to harvest pods that mature and are shed during this time. Given the low reproductive performance of smallstock during 1981-84 in Mbirikani, the contribution of pod feeding during the breeding season warranted special study, as it would further highlight the constraints posed by poor nutrition in this arid environment.

The study consisted of the following components:

(i) The Availability of Pods

To determine this quantity, there was a need (a) to assess the abundance of Acacia tortilis trees in the Kimana are; (b) to quantify the number of

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[1]ILCA, P.O. Box 46847, Mairobi, Kenya.

[2]PARD, POB 123, Bogor, Indonesia.

[3]ILCA, BP 60, Bamako, Mali.

pod-bearing trees per unit area; (c) to assess the quantity of pod per tree. This part of the study was reported elsewhere (Cisse, 1983).

(ii) Pod harvesting by smallstock

This component aimed at studying the exploitation system of Maasai herders and their flocks. This was done in three parts: (a) Eating rates of pods were determined on confined sheep and goats; (b) pod harvesting rates were determined on flocks grazing pods during herding; (c) grazing behaviour of flocks was recorded to extrapolate the findings found in parts (a) and (b).

(iii) Effect of pod grazing on smallstock performance

Comparative studies were done on flocks that moved to Kimana and those that remained in Mbirikani. Parameters measured included reproductive performance and growth rates of female stock.

This paper reports on the second and third components of the study.

Materials and Methods

Most of the fieldwork for this study was carried out in August 1982. The work on smallstock productivity was part of longer term research in Eastern Kajiado during 1981-1984 for a doctoral dissertation by C. Peacock (Peacock 1984). The *Acacia totilis* woodlands are located 10 km to the south of the southern boundary of Mbirikani group ranch.

Pod Intake (confined animals)

Three groups of mature animals were selected from a flock of 200 head: 10 goats, 10 sheep and another group of 5 of each species. Weights were estimated at 25 kg for goats and 30 kg for sheep. Each group was penned in a coral 12-15 m in size fenced with thorn shrub and located in a Maasai boma within the Kimana area.

Pod feeding was carried out during 5 consecutive feeding periods: two during the first and three during the second day. Weighed quantities of pods were spread on sacks (75 x 180 cm) so that pod disappearance rate could be assessed. Observations were made at 1-2 minutes intervals to estimate the proportion of pods left and the number of animals eating.

Pod Grazing of Herded Flocks

A mixed Maasai flock of 205 head was used for this purpose during two mornings. Pod numbers were shaken off and sampled as described by Cisse (1983). However, instead of relating yield to the entire crown area of each sample tree, the area where the pods had fallen was measured and used to calculate the total number of pod available to the grazing flock. When the flock finished grazing each tree, proportion of left-overs were estimated so that number of pods harvested by stock could be quantified. For each of the 18 trees (or groups of trees), starting and finishing time of the grazing flock was recorded as well as the proportion of smallstock engaged in pod consumption.

Grazing Behaviour

Grazing behaviour of flocks were recorded over 2 days in 1982 and 3 days in 1983 in order to extrapolate from the findings generated by the pod intake studies. The method employed was described by de Leeuw and Peacock (1982).

Nutrient Analysis

Seven samples of pods of different maturity were analysed for nitrogen (N%), in vitro dry matter digestibility (IVDMD) and neutral detergent fibre (NDF) at the nutrition laboratory at ILCA headquarters in Addis Ababa. Another set of samples was sent to the Department of Pathological Biochemistry, University of Glasgow to test the pods for oestrogenic properties.

Smallstock Performance

Reproductive performance parameters were recorded in 1982 and 1983 on two flocks that moved to the Acacia tortilis woodlands and on four flocks that remained on Mbirikani group ranch. Mating behaviour was recorded by herdboys who assessed the number of services for each breeding female. Other reproductive parameters were established by recording of birth events. As all stock were tagged, weight changes were recorded monthly.

Results

Intake Rate of Pods

Confined Animals

Recorded intake of confined animals across periods varied from 8 g to a maximum of 27 g/head/minute (Fig 1). The general trend over periods was a rising one and was most pronounced for sheep. Initially sheep did not touch the pods at all until a more enterprising goat was put among them to show them what to do. However, once they got used to consuming pods spread on jute bags, their appetite was greater than that of goats, who were often distracted by intersex play thereby reducing their intake rate. Intake was highest at the fifth feeding period probably because the pods were greener than those fed in the earlier batches.

The mixed group during the second day was given a total of 0.45 kg. of pods over 3 feeding periods which was consumed within 24 minutes at an average rate of 19 g/head/minute or equivalent to hourly intake of 1.1 kg. The average rates for sheep and goats alone were 22 and 14/g/head/minute and the quantity of pods fed 0.45 and 0.30 kg respectively.

Grazing Animals

Both the quantity of pods and its density varied between trees, due to tree size, and the intensity and duration of shaking. Quantity of pods per tree ranged from 1.5 to 22 kg (mean 8.0 ± 1.6 kg), if 1000-pod weight was standardized at 1 kg.[1] Pod density was 16-100 pods/sq m. with a mean of 54 ± 6 pods/sq m. (Fig 2).

Pod intake rate varied from 5-24 g/head/minute with a mean of 12.7 ± 1.3 g. During 4 sampling periods, intake rates were 20 g or higher. However, these high rates were sustained only for very short periods (1-3 minutes) and were recorded under small trees with a below average density of pods. Overall pod consumption rates (expressed as grazing time x number of stock ingesting pods) increased with quantity of pods available on the ground. The regression shows that 10 kg of pods would feed a flock of 100 head for 9 minutes and 20 kg for 17 minutes provided all animals were fully engaged in eating. The equation also indicates that intake rates increased from 10 to 13 g/head/minute when 5 kg and 20 kg per tree were available respectively (Fig. 2).

The intake experiment was carried out over two days, during which the flock grazed pods for 1.45 hours. On average 140 head or 68% of the flock participated in the grazing at any one time. During that time-span 126 kg of pods were eaten, which constituted 63% of the total available on the ground. If it is assumed tht each of the 206 animals had an equal opportunity to participate in pod grazing, pod consumption was 250 g on day one and 360 g/head on day two; these total quantities are somewhat below those consumed by the confined animals (Fig 1).

Grazing Behaviour

Over the 5-day recording period, smallstock flocks spend between 9 and 11 hours in the field (Table 1). Actural grazing and browsing time was rather low at 4 hours per day compared to an average of 6.3 hours recorded during the dry season for flocks resident in Mbirikani (Peacock, 1984). A large proportion of the actual grazing time was spent on pod grazing: 40% in 1982 and almost 70% in 1983.

In 1982, shaking down pods with long hooked poles was allowed by the group ranch management whereas in 1983 this practice was forbidden. As a consequence, in 1982 actual pod grazing time was low because flocks had to wait for pods to be shaken down before they were allowed to graze. However, large number of trees were available as 1982 was considered a good pod year with high yields/tree. As smallstock spent 1.7 hours to consume pods from 31 trees (or 5 minutes/tree), their pod intake could be upto 1 kg if their intake rate was equal to 10 g of pod/head/minute. Even at half the recorded rate, a daily intake of 0.5 kg of pods would amount to 1.7% of the weight of 30 kg animal; thus little additional grazing time would be required to reach a satisfactory daily intake.

In 1983 pod productivity was reported to be much lower than in 1982. Also, in 1983, flock had to rely on pods that fell from trees by natural causes. Consequently, the number of available trees was much smaller and

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[1]Pod weight was variable and ranged from 1.4 g for mature ripe pods to 0.6 g for unripe green pods at harves.

yield per tree much lower. Hence average pod grazing time in 1983 was much longer and took a larger proportion of the total grazing time (Table 1).

Nutritive Value of Pods

Pods contained between 2.0 and 2.8% of Nitrogen with a mean of 2.5% or 15.6% crude protein which is similar to values reported from West Africa (Lehouerou, 1980) and from East Africa (Dougal and Bogdan, 1958). Lehouerou (1980) reported a protein digestibility of 75% giving a DCP content of 11.7%. In vitro digestibility averaged 64%, but given the fairly high tannin content actual digestibility may be somewhat lower (Table 2). Peacock (1984) estimated the metabolizable energy (ME) content to be 13.8 MJ/kg whereas Lehouerou (1980) listed the net energy content as 6.0 MJ. The analysis for oestrogens gave inconclusive results. No classical oestrogens were found but according to Peacock (1984, p. 258) "this does not preclude pods having oestrogenic activity."

Stock Performance

The main reason that Maasai producers endeavour to send their smallstock to Kimana Acacia tortillis woodlands is to enhance reproductive rates during the breeding season. In 1983 Peacock visited 18 flocks, comprising 1170 sheep and 1260 goats. These flocks belonged to 35 owners, 60% of which had come south of Mbirikani group ranch and the remeainder came from Kimana and neighbouring ranches. Most herders also brought upto 20 cattle with them, three quarters of which were lactating to provide milk while in Kimana.

While in the Kimana area, most stockowners removed the aprons off their rams and bucks to allow them free and constant access to the breeding females. Mating in July-August is preferred in order to have the youg drop in November-December towards the end of the short rains.

To study the effect of pod feeding, weight changes and reproductive performance was compared on four flocks that remained in Mbirikani and two that went to Kimana. The effect of pod feeding on weight changes of entire flocks was +6 kg in goats and +4.5 kg in sheep (Table 3). A similar effect was recorded on the weight changes of breeding females. While in the Kimana area female goats usually gained weight whereas sheep did not (Table 4). Differential weight changes between goats and sheep during the dry season is a common finding. Comparison of mature sheep and goats in 4 flocks during the 1982 dry season showed that goats within the same flock always grew better than sheep (Figure 3). However, it appeared that mating and conception was related to relative weight changes rather than to actual losses or gains. Those females that were performing better relative to others mated and conceived (Table 5). Thus female goats that gained most and sheep that lost less got bred. Birth rates in goats were 600% higher, while in sheep they were only 20% higher as compared to flocks that remained in Mbirikani (Table 5).

Discussion

The hypothesis that Maasai producers take their smallstock to Acacia tortilis areas so that their nutritive status is improved by pod consumption, which increased the libido of males and the conception rates of females, can be accepted. Pod grazing is equivalent to "flushing" or putting ewes on a high plain of nutrition before joining. Both Morley et al (1978) and Ducker and Boyd (1977) indicated that higher lambing rates result from flushing but only when breeding females are in poor condition at the start. This situation is generally true in Mbirikani for breeding females. As the peak in giving birth extends from November to February, and the young are weaned 5 months or so later, females enter the long dry season generally in poor condition.

The pod feeding results in a high plain of nutrition can be clearly demonstrated. Peacock (1984) calculated that a 30 kg goat walking 15 km per day would require an energy intake of 5.8 MJ for maintenance, foraging and walking. If the ME content of pods is equal to 13.8 MJ, some 400 g/day would be sufficient to satisfy maintenance requirements. It has also been shown that stock have enough appetite to eat this amount of pods and therefore potentially such intakes are feasible given the pod yields per tree recorded and the time required for pod consumption.

The beneficial effect of the high plane of nutrition on reproductive performance was quite evident (Table 5) and explains why Maasai producers make the effort to take their smallstock to the *Acacia tortilis* area. The necessity of such management is quite obvious since poor reproductive performance seems to be the major limitation to increased productivity in this ranch in particular during the dry periods. A comparison with similar productivity data from Maasai flock in Northern Kaputiei and Elangata Wuas showed that birth rates in smallstock flocks in Mbirikani were very low (Wilson et al, 1984; Peacock, 1984). This was due to a long parturition interval; during 1981-83 only 17% of the goats and 24% of the sheep gave birth twice and of those that re-conceived the parturition interval was 13.6 and 12.3 months for goats and sheep respectively. The low reproductive performance was mainly due to females failing to be bred in 1983, conception rates being only half as high as in 1982. This coincided with the poor yields of *Acacia tortilis* pods and indicates that the "flushing" on Acacia pods is an essential component of the overall management strategy to maintain the productivity.

Acknowledgements

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Table 1. Grazing Activities of Flocks Grazing in the Kimana Pod-bearing Area During 1982 and 1983.

	1982	1983
Total herding day, hrs	9.2	10.0
Grazing and browsing, hrs	4.1	4.1
Pod consumption, hrs	1.7	2.8
No trees/day	3	14

Adapted from Peacock, 1984 Table 5.4.7, p. 254

Table 2. Nutrient Content of *Acacia tortilis* pods

	N%	IVDMD	NDF
Green	2.8	65.8	33.0
Dry	2.0	54.8	34.6
Mean	2.5	63.8	33.4

Peacock, 1984, Table 5.4.8, p. 255

Table 3. The Effect of Movement to a Pod Feeding Area on Average Weight Changes in Four Flocks from 1 June to 1 September 1983 (kg).

Pod Feeding	No Pod Feeding
Goats +3.5	-2.5
Sheep +2.2	-2.3

Adapted from Peacock 1984, Fig. 5.4.1., p. 250

Table 4. The Effect of Pod Feeding on Weights and Weight Changes(1) in Breeding Females (kg).

Pod Feeding

	Goats		Sheep	
Conceiving	Wt	Wt Change	Wt	Wt Change
Yes	31.5	+2.5	35.7	-1.2
No	32.2	+2.0	33.6	-3.8

No Pod Feeding

	Goats		Sheep	
Mating	Wt	Wt Change	Wt	Wt Change
Yes	31.4	+1.3	31.6	-1.7
No	31.1	-2.2	31.6	-2.6

Adapted from Peacock 1984, Table 5.4.3., p. 251.

(1) Weight change 1 July - 1 September 1983

Table 5. Effect of Pod Feeding in 1983 on the Reproductive Performance of Goats and Sheep (in % of Total Breeding Females).

	Pod Feeding		No Pod Feeding	
	Goats	Sheep	Goats	Sheep
% mated	97	73	20	47
% conceived	80	54	20	47
% birth	79	54	13	44
% abortion	1	0	7	3

Adapted from Peacock 1984, Table 5.4.2., p. 245

FEEDING BEHAVIOUR AND DIETARY SELECTION OF GOATS IN EAST AFRICA

By

Peter Njenga Kamau[1]

Introduction

The savannahs of South Central Kenya exhibit a wide array of bush conditions which have been in part due to overgrazing by large herbivores and the suppression of fire (Kamau 1985). However knowledge of the browsing behaviour of goats in semi-arid region would be a useful criterion in assessing their complementary role in livestock production. Presently, very little information exists as to the role bush plays in the diets of goats during the most stressful period stretching from June through September. Preconceived ideas and lack of observations about goats prevent a better understanding of the role they play in land use and in many situations use of goats is viewed harmful to the environment (Lopes and Stuth 1984).

Goats will feed readily on most plants and plant parts including leaves, stems, fruits, inflorenscence of grasses, bark and roots when forced by circumstances to do so (French 1970). Goats have a prehensive upper lip which allows them to be very discrete in the selection of plant parts (Maher 1945, Rector 1982). Studies have indicated that goats have a unique preference for shrubs and tree leaves whether deciduous or ever green (Cory 1927, Edwards 1948, Wilson 1957). Goats have a tendency to change their diets with changing seasons and appear to be highly selective in taking plant parts palatable to them.

There is limited information on the nutritive value of goats' diets grazing range plants. Browse and forbs generally contain higher levels of crude protein during the growing season than do grasses or graminoids (Rector and Huston 1976). Generally, browse is a source of crude protein, while grasses are a source of energy in the diets of goats grazing range plants.

A study was conducted at Kiboko National Range Research Station in Machakos District, Kenya to evaluate the effect of bush canopy on the nutritive value, dietary botanical composition and species preference of goat diets during the most stressful period of an average year from June through September, 1982.

Procedure

Materials and Methods

[1]Ministry of Livestock Development, NRRS, P.O. Box 12, Makindu.

The study site was located approximately five km. south of the National Range Research Station headquarters.

Three bush conditions with two replications were identified in the field based on total canopy cover. A method similar to that used by Pratt et al. (1966) was used to categorize these bush conditions. The experimental paddocks were located in a wooded bushed savanna. Bush covers were categorized as less than 15%, 15-35% and greater than 35% as sparse, medium and dense respectively. Each replicated treatment paddock was 2.25 ha in size.

A herd of 7 yearling cattle, 3 mature goats and 3 mature sheep were used to provide grazing pressure on the treatment paddock. The assigned animal unit value of the herd was approximately 7.3. A safe stocking rate of 5 ha/au was selected as the basis for herd and treatment paddock size. Pratt et al. (1966) had recommeded a similar stocking rate for this area. However any single stocking rate for the whole area would be conservative since the area has a large number of range sites with extensive areas covered with lava flows.

Available browse and herbaceous standing crop on each treatment were determined seven days of each grazing, using a modified line intercept belt transect technique. All woody species rooted within the presecribed belt and not exceeding 1.5 m in height were counted and their geometric shapes determined. Canopy volume was determined by describing the appropriate geometrical shape of each individual plant and taking the necessary measurements in order to calculate the volume of the ascribed shape. Standing crop of browse was estimated by the "grazing depth" (GD) technique of Lopes and Stuth (1984). GD is the average depth of canopy surface penetration that can be attained by specific species of grazing animal. Each woody plant species grazing depth was determined by observing animals grazing and estimating a reasonable depth of grazing under different stocking rates.

Herbaceous standing crop was determined randomly by two quadrats (0.5 square metre) in each belt transect prior to each grazing period. Species composition was visually estimated and the combined grass and combined forb component clipped to ground level and weighed to the nearest gram.

All selected field samples (browse and herbaceous) in each treatment paddock were dried at 60 deg.C and all green weights adjusted to oven - dried basis.

One oesophageally fistulated Galla goat with two oesophageally fisitulated small East African goats were allowed to graze each treatment paddock each morning for two consecutive days until enough extrusa was collected. Extrusa was collected in rectangular bags of nylon. which were fitted with two pieces of nylon cords along two opposite hemmed sides. The cords fitted in the bags were then tied around the neck of the animal with the bag over the oesophageal fistula. Dried samples were thoroughly mixed and divided into two sub-samples. One sub-sample was ground and subjected to chemical analysis for crude protein (CP) (micro-Kjeldahl, AOAC 1975), in vitro organic matter digestibility (IVOMD) (Tilley and Terry 1963) and neutral detergent fibre (Van Soest and Wine 1967). Diegestible energy (DE)

(Kcal/Kg) was derived by multiplying % IVOMD by a constant of 4000 Kcal/Kg of IVOMD.

The other subsample was subjected to botanical analysis using a point-fram macrohistological or extrusa fragment analysis technique similar to that described by Lopes and Stuth (1984) and Rector and Huston (1982). Fragments were identified by species and recorded as to whether they were live or dead, leaf, stem, inflorescence or fruit.

Selection ratios

Selection ratios (SR) were determined by the formula of Durham and Kothmann (1977) for different forage species.

$$SR = \frac{\%\text{ in diet - available in field}}{\%\text{ in diet + \% available in field}} \times 10$$

The experimental design of the study was split plot with percent canopy cover and density as the main effects. Analysis of variance (ANOVA) was used to analyze data by treatments and Duncan's multiple range test was used to detect differences between significant treatment means.

Results and Discussions

Composition of available forage

The composition of graminoids in the diets of goats was lowest in November and August, and November and July in light and heavy bush conditions respectively. It seemed the composition of graminoids was lowest at the beginning of the dry season (June/July), the middle of the dry season (August) and at the beginning of the wet season (November). It can be inferred that differential degree of leaf fall (most of the shrubs and trees being deciduous) and limited growth of grasses affected the composition of grass and grasslikes (Table 1). The composition of forbs was highest at the beginning of the dry season, probably because of increased moisture following long rains (March-May). However, forb composition decreased as the dry season progressed until late October following increased moisture (Table 1).

Browse composition was highest at the beginning of the dry season, viz: June-July and at the beginning of wet season in November. However, the composition of browse as a percent of available forage was similar for all months except in July where the heavy bush condition had the highest composition of browse than either light or moderate bush conditions.

Botanical composition of goat diets

Browse dominated goat diets from the moderate and heavy bushed conditions from August through November. Some studies done elsewhere have indicated that goats are more of browsers than grazers. Wilson (1957) made some observations of browsing habits of East African dwarf goats at Serere in the Teso District of Uganda and concluded that goats preferred browse to herbage. Lopes and Stuth (1984) reported that browse was the dominant diet component comprising 76.6% of goat diets on untreated and mechanically treated plots and that the role of browse in diets of goats decreased with gradual reduction of the overstory layer.

Goats have a unique preference for shrub and tree leaves. Compared to other domestic livestock they select from a wider array of plants particularly woody species (Cory 1927, Fraps and Cory 1940, Maher 1945, Edwards 1948, Wilson 1957 and McMahan 1964). Goats are able to meet their nutritional needs by either browsing or grazing and this gives goats considerable advantage over cattle or sheep when there are seasonal variations in the quantity of forage available. During the course of the study it was noted that when there was adequate herbage, goats were selective in their feeding but during the dry season herbage selection was minimal.

The general trends indicated that graminoids were high in the diet of goats in June and July when more grass herbage was available as the woody species were more or less in a dormant stage with their leaves shed. Browse and particularly, Acacia senegal pods and others increased in the diets during the months of August and September when nothing else was available for consumption. Thus, seasonal moisture availability, was the most important factor creating substitutive relationships between graminoids, browse and forbs in the diet composition of goat diets throughout the period of study.

Chemical compositon of goat diets

Crude protein (CP) increased gradually from the beginning of the dry season and reached its peak early in the wet season. This trend of CP has been reported by Wilson (1966). In his review of browse in the nutrition of goats that browse has a more consistent CP content than grasses which are typically high in crude protein at the beginning of the growing season and low in protein when mature. Increased consumption of immature browse leaves and forbs resulted in increased levels of CP in the diets, while increased proportion of dry graminoid reduced CP levels in the diets (Table 1).

Organic matter digestibility (IVOMD) was high in the diets at the beginning of the dry season but decreased by the middle of the dry season, followed by a steady increase until the end of the study period. This trend reflects a decrease in grass and grasslikes in the diets of goats followed by an increase in forb, immature browse and graminoids as the available moisture increased. Presence of graminoids and forbs in goat diets was associated with increased IVOMD.

Digestible energy (DE) was positively correlated with grass and forb in the diet and the level of precipitation.

Selection Order

Variation in species preference by goats was dynamic across months, reflecting the true flexible nature in goats' dietary selection. Preferred species were assumed those with positive selection ratios and confidence intervals. Indifferent species exhibited negative selection ratios and confidence intervals, while avoided species exhibited extreme negative selection ratios of - 10.

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Table 1. Dietary crude protein (%), in vitro organic matter digestibility (%) and energy (kcal/kg) of esophageally fistulated goats grazing an Acacia senegal savannah of varying bush conditions throughout the dry season (June-September) and early wet season (October-November) at Kiboko, Kenya, 1982.

Bush condition	Month						
	June	July	August	September	October	November	Mean
Crude Protein							
Light	11.6 ns	10.3 b	9.3 b	11.0 b	23.7 b	17.6 a	13.9 b
Moderate	12.4	13.7 a	14.0 a	16.3 a	27.9 a	14.2 b	16.4 a
Heavy	12.8	11.4 b	14.7 a	14.8 a	28.3 a	16.8 a	16.5 a
Probability	.20	.01	.01	.01	.01	.01	----
Mean	12.3	11.8	12.7	14.0	26.6	16.2	15.6
Organic matter digestibility							
Light	60.1 b	62.5 a	57.7 a	54.7 ns	70.0 ns	72.3 ns	62.9 ns
Moderate	63.9 a	60.3 b	52.3 b	57.4	68.6	74.1	62.8
Heavy	65.1 a	60.0 b	46.8 c	53.2	69.7	68.7	60.6
Probability	.01	.01	.01	.38	.90	.14	----
Mean	63.0	60.9	52.3	55.1	69.4	71.7	62.1
Digestible energy							
Light	2403.5 ns	2500.7 a	2307.6 a	2189.2 ns	2798.0 ns	2893.5 ns	2515.4 ns
Moderate	2267.8	2410.7 b	2092.1 b	2295.7	2742.8	2962.4	2461.9
Heavy	2603.4	2399.4 b	1873.3 c	2128.0	2787.4	2746.6	2423.0
Probability	.01	.01	.01	.37	.90	.14	-----
Mean	2424.9	2436.9	2091.0	2204.3	2776.1	2867.5	2466.8

abc Means followed by the same letter are not significantly different across bush cover within month and nutritional paddock ($P \leq 0.05$)

LEVELS, CAUSES AND FACTORS AFFECTING MORTALITY IN A HERD OF SMALL EAST AFRICAN GOATS ON A SEMI-ARID THORNBUSH SAVANNAH

By

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

Introduction

Kenya comprises vast arid and semi-arid areas and at the present level of technology and economic infrastructure in the country, the only feasible way to produce food for human consumption from these areas is through domestic ruminants.

Small stock production has played a major role in th economy of range areas in the past 10 years. Sheep and goats have contributed significantly more than cattle in terms of livestock products in these areas (Semenye, 1977).

The goat population has recently been estimated at 7.7 million with 40% of these being kept by pastoralists (Stotz, 1983).

An increasing proportion of goats is observed in the pastoralists flocks with increasing aridity of the environment, leading to the assumption that goats are better adapted to the conditions of the arid rangeland of Northern Kenya.

High mortality rates, especially preweaning, has been cited as a major constraint on improving productivity. Wilson et al. (1985) reported a preweaning mortality of 28.6% for goats in a Maasai ranch. Carles et al. (1982), working in a pastoral area in Northern Kenya, reported mortalities of 6-12% for breeding females, rising as high as 66% during the first year of life.

An opportunity arose to study in more detail, the causes, levels and factors affecting mortality in a typical pastoral system with the establishment, by the Department of Animal Production in cooperation with the Ministry of Livestock Development, the European Economic Community, the German Research Foundation and the German Agency for Technical cooperation, of a research station in a pastoral area near Isiolo.

Materials and Methods

Environment:

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

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[1]Department of Animal Production University of Nairobi, P.O. Box 29053, NAIROBI.

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

Experimental animals:

These comprised a herd of small East African goats. The original stock of 60 mature and immature females was provided by the research division of the Ministry of Livestock Development. By culling and further local purchases, 90 mature and 50 immature females were present at the start of the recording. Except for 56 of the mature does, which were tooth aged, the rest of the animals had age and previous birth records.

Herd management:

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

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

Data collection:

All events such as abortions, births and deaths were recorded continuously, liveweights and milk yields were measured regularly every two weeks.

Whenever possible dead animals were subjected to a post mortem examination to attempt to establish the cause of death. Due to the distance from the Department and the unavailability of a veterinarian at all times to perform the post-mortem when a carcass was fresh, standard post mortem sheets were designea to enable trained field assistants to carry out a systematic examination and description of the carcass.

Pasture condition was judged every two weeks using a simple classification with four categories incorporating forage availability and quality.

The following factors were then analysed to determine whether they affected kid survival:-

1. Type of birth
2. Sex

3. Forage condition
4. Birth weight
5. Dam weight at kidding
6. Dam age at kidding
7. Milk consumption
8. weight gain

Data analysis was done using the least squares methods for multiple classifications of non-orthogonal data, as described by Harvey (1966) and applied by Seebeck (1975) in his computer programme SYSNOVA (Version 7.1).

Due to the binomial nature of the kid data, the problem of unequal error variance arose and was overcome by using weighted least squares analysis (Neter and Wasserman, 1974).

Results and Discussion

Levels:

Mortality levels for different age groups are shown in Table 1.

Table 1: Age specific mortality rates

Class	Age (days)	Mortality rate
Young kids	1-13	16%
Older kids	14-160	18%
Weaners	161-365	4%
Adults	>365	12%

Mortality rates are higher for kids than adults and weaners. This was expected and has been reported by Carles et al. (1982) working in a similar area in Northern Kenya. This higher mortality in kids could be attributed to the young being less resistant to environmental factors and infectious diseases. The weaners had the least mortality. Almost all adult deaths occured in animals which were lactating or pregnant during a dry season and this could explain the lower mortality of the weaners. The difference between the two kid groups was very small and could be attributed to chance.

Causes:

The causes of death for adults and immatures are given in Table 2. The original classification of causes of death which included; unexplained loss, predation, doubtful diagnosis, miscellaneus causes, pneumonia, emaciation, cestodes and strongyles had to be modified for analysis due to the small numbers observed in some classes.

Table 2: Causes of death for 40 adults and immatures

Causes	Proportion (%)
Unexplained loss	17.5
Emaciation	30
Miscellaneous	20
Predator	15
Pneumonia	17.5

The major cause of death was emaciation and this was attributed to a prolonged drought in 1984 when most deaths in this class occured. Miscellaneous causes included animals which were sick, a postmortem was done, but the causes of death were too diverse to be classified separately. Unexplained loss were those animals which died and for some reason a post-mortem examination was not done. Animals dying from pneumonia had lesions typical of CCPP. Most of the predation occured during the drought when some animals were very weak and were separated from the herd during grazing.

For kids the causes of death were not analysed as the gross pathological findings of the carcass were inadequate for specific diagnosis to be made.

Factors affecting mortality in kids:

Young kids (1-13 days)

Of the factors analysed only sex ($P<0.05$), birth weight ($P>0.001$) and milk intake ($P<0.001$) were significant. Forage condition, type of birth (single or multiple), dam weight at kidding and age of dam at kidding were non-significant ($P>0.05$).

The female kids had a 3.7% higher probability of survival than the male. Although this is a little surprising it is consistent with the findings of Wahome (1986) (from the same data) that does with male kids produced less milk than those with female kids.

For every extra 100g in birthweight the probability of survival increased by 2.6%. There was a 34% difference in probability of survival between kids born with the lowest birth weight and those with highest over the expected range covering 90% of the observations (Figure 1). The high rates of survival for heavier kids could be attributed to the fact that these are more mature at birth, their physiological systems are more developed therefore more resistant to environmental stress.

Milk intake is critical for the survival of kids. The results indicate that for every extra 100 ml/day of milk taken, the probability of survival increased by 0.03%. There was a 21% difference in probability of survival between kids with lowest milk intake and those with highest intake during the first two weeks of life over the 90% expected range of observations (Figure 2).

Figure 3 shows that dams whose kids died before weaning were generally lower yielders.

Older kids (14-160 days):

Only average daily weight gain upto 42 days was significant ($P<0.001$). Birth weight, dam weight at kidding, dam age at kidding and sex were not significant ($P>0.05$).

The weight gain was highly significant. For every 1 g advantage daily weight gain, the probability of survival increased by 1.05% over the expected 90% range of observations (Figure 4). Weight gain is a reflection of the general fitness and level of nutrition. Fast growing kids are relatively mor mature and thus more resistant to environmental stress.

The major nutritional component at this age is milk. Milk intake was analysed separately and its effect was highly significant.

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Fig. 1. Partial relationship between survival and birth weight.

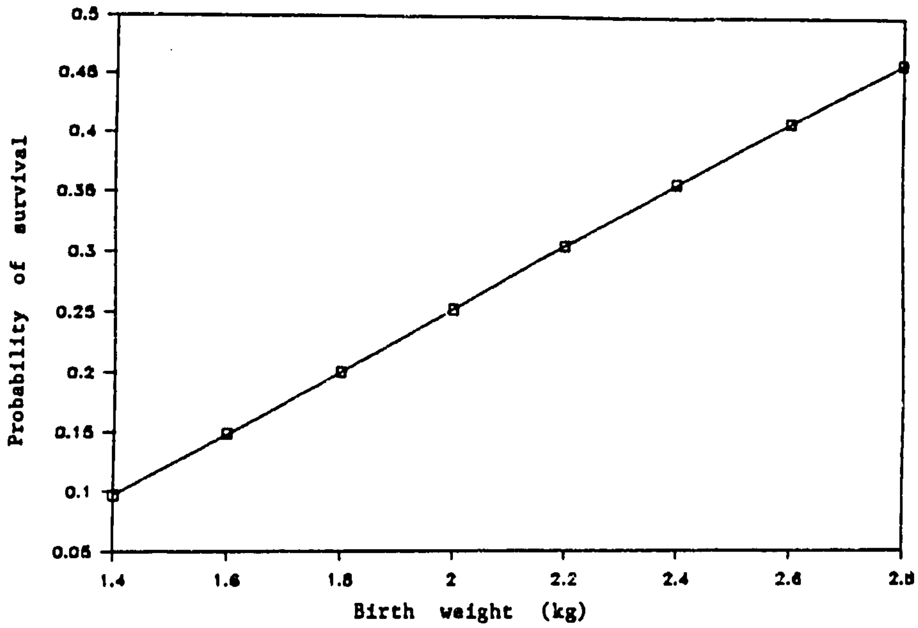


Fig. 2. Partial relationship between survival and milk intake

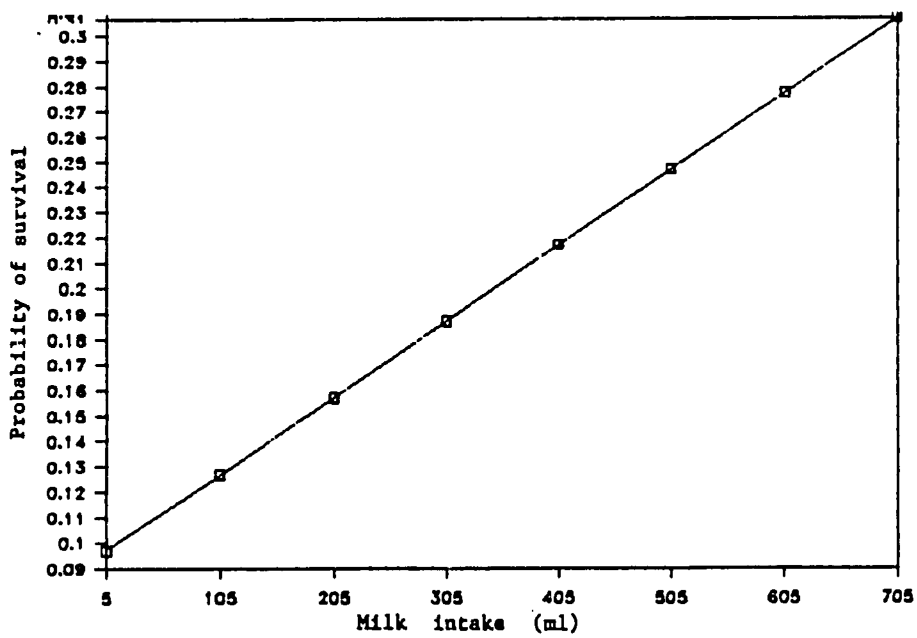


Fig. 3. Effect of milk yield on kid survival

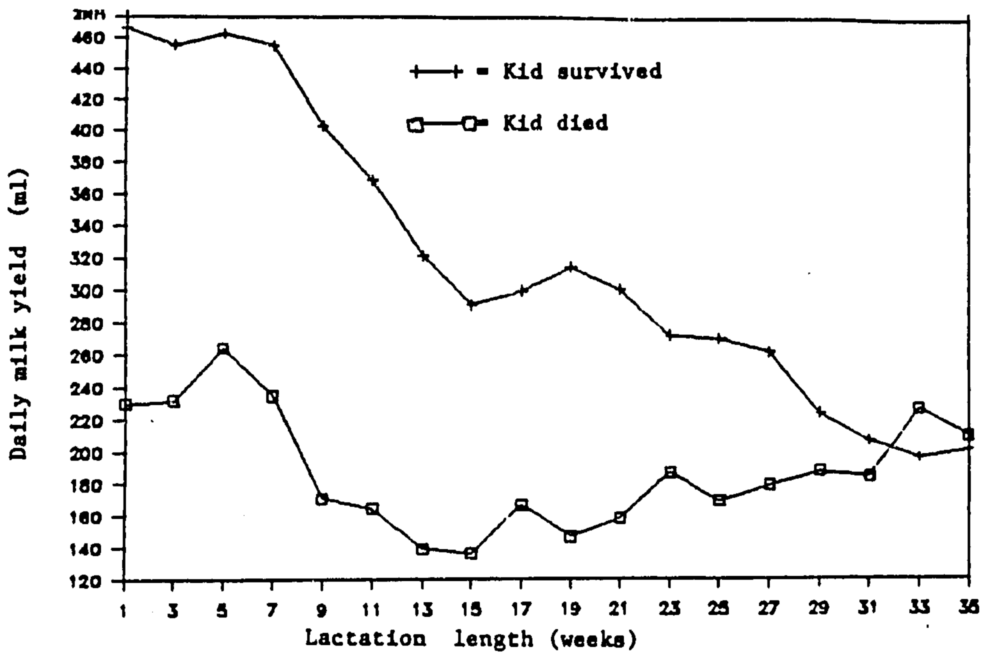
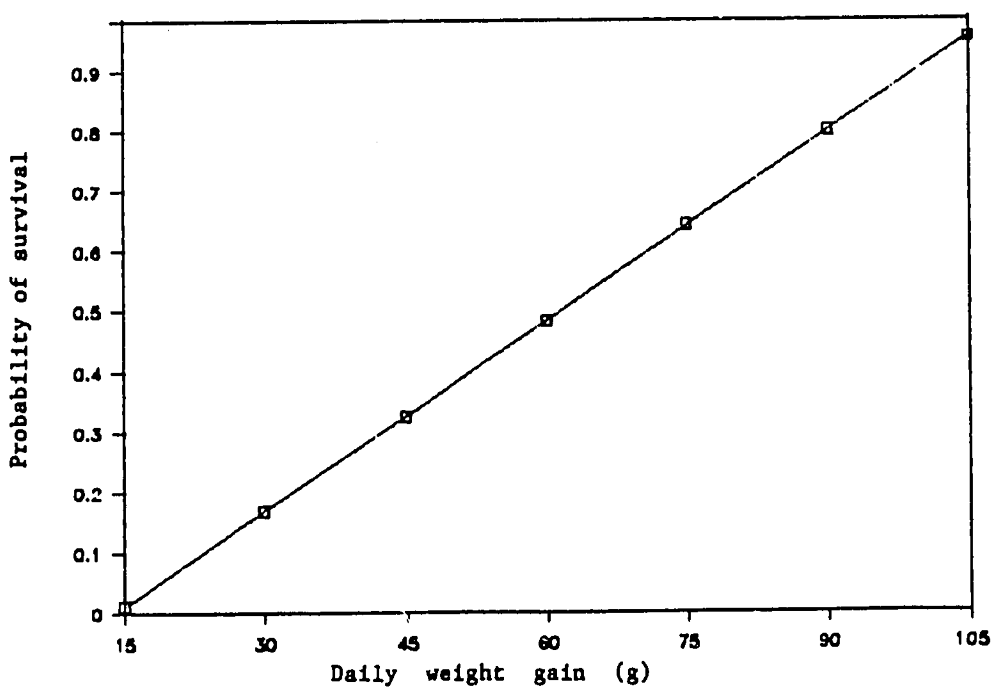


Fig. 4. Partial relationship between survival and daily weight gain.



MILK YIELD AND THE LACTATION CURVE IN A HERD OF EAST AFRICAN OATS ON SEMI-ARID THORNBUSH SAVANNAH

By

R.G. Wahome, A.B. Carles, and H.J. Schwartz

Department of Animal Production
P.O. Box 29053, Nairobi, Kenya.

Introduction

Kenya's goat population was estimated at 7,700,000 by Stotz (1983). They are widely distributed in the country, and the most abundant breed is the Small East African goat (Schoen, 1968).

Goat milk has a high acceptance to Kenya's peoples. It is especially important to pastoralists who live in the drier areas. The goats are milked together with camels and cattle (Khainga et al., 1984).

Studies on the milk production capacity of the Small East African goat have shown that they are low yielders (Field, 1978; Carles, 1980; Field, 1982). But these studies are generalised, giving only the ranges of lactation length and yield. The variation of daily milk yield and the causes of such variation have been largely unstudied. The lactation curve also has not been adequately described.

The purpose of this paper is an attempt to give description of some of the areas that have not been covered.

Materials and Methods

The data for this study was obtained from on going research at Isiolo Animal Production Department Station at Isiolo Livestock Marketing Division holding ground. The milk yield, body weight and vegetation assessment data were collected periodically every two weeks. Other data such as births and deaths were collected continously. Milk yield were recorded on 2 consecutive days. On the first day, the right half of the udder was milked in the evening and next morning. The left half of the udder was milked on the second day, again in the evening and the next morning. Thus in those 2 days the whole udder was milked. The milk records from both halves of the udder were totalled to give the daily milk yield. The average daily milk yield for a two week period was calculated at the beginning and end of the period. When the yield was less than 5 mls then the lactation was terminated. In this study all the lactations were included.

The factors that were studied as causes of variation in daily milk yield were litter size, kid sex, kid survival, vegetation condition score, year effect, litter weight (kg), doe weight (kg), doe age (days), weight changes (kg) and lactation length (weeks).

Such factors as were significant in the above analysis were used to obtain adjusted estimates of daily milk yield and these were used in fitting the mathematical function proposed by Wood (1967) for the description of a lactation curve.

The log transformed data was fitted to the function using the least square multiple regression techniques.

Results and Discussions

Levels of Milk yield and related variables

Normal distributions statistics for the daily milk yield and related variables are shown in Table 1.

Frequency Histograms (Figure 1) show that majority of does are low yielders regardless of the period of lactation. The variation in the daily milk yield was high and the upper limits were comparable to other tropical dairy goats such as Jamnapari, Malabar and Barbari (Devendra, 1982).

Lactation curve

A plot of the observed yields and predicted yields for each period of lactation is shown in Figure 2. The standard lactation curve is characterised by an initial rise in daily milk yield and then a gradual decrease in yield to the time of drying off. The characteristic rise to a peak was lacking. The yield was maintained at a high level for the first seven weeks of lactation and then was followed by a sharp decline in yield in the next 7 weeks. From the 15th week of lactation, the rate of decline was reduced and a gradual decrease in yield was noted to the time of drying off.

After fitting the mathematical function the least square estimates of a, b and c were .92, -0.0098, and 0.00238 respectively. The variance accounted for (R^2) was 99.2 % before adjusting for the intercept and 46.28 after adjusting for the intercept. Wood (1969) reported an R^2 of 83% while Goodall (1983) reported an R^2 of 92%. It is assumed that they had adjusted for the intercept. But they were dealing with highly selected dairy cattle in a high level of management which is totally different from dealing with unselected goats in a semi-arid environment. The lack of fit calculated on the the log-transformed data was not significant. The predicted values from the function, however were consistently lower than the observed (Figure 2). The consistent difference suggests that a small modification of the function is indicated for this data to adjust for the difference in the intercepts.

Factors affecting the lactation curve

The results of this analysis are shown in Table 2. All the factors were significant except the age and the weight change variables. Kid survival, vegetation, condition and the time period produced the expected effects. It is not clear whether the does who lost their kids produced lower yields because of that loss or whether they lost their kids because of the lower yields. Suckling stimulation is required to maintain the lactation in goats (Gall, 1975), and therefore this could be the cause of the lower yields (Figure 3). Figure 4 shows the effect of vegetation on the lactation. This follows the expected pattern with the yields being higher in better vegetation conditions. The yield was much higher for the year 1985 than the drought year 1984 (Figure 5). Yields were higher for the heavier does and also for litters that were heavier and as expected yields decreased with time of lactation. The age factor was not significant and this could be explained by the fact that most does had attained a reasonably mature age by the first kidding.

The effect of litter size on the lactation surve was surprising (Figure 6). The does having single kids had higher yields than those with twins. Other workers have reported higher yields for the does with twins (Ehoche and Buvanendran, 1983). These results possibly were due to greater stress in the goat during pregnancy for the does with twins in these range conditions, which led to depletion of body reserves in contrast to the does that had single kids. The effect of suckling stress in the rangeland may also have been greater for the does who had twins where they had to move about in search of suitable forage. The effect of sex was equally puzzling since the does having female kids yield more milk than those with male kids (Figure 7). This was against the expectation that does having male kids would probably have higher yields due to the greater size of the males.

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Table 1. Normal distribution statistics of some milk related variables.

Variable	Daily Milk Yield (ml)	Complete lactation Length (wks)	Complete lactation Yield (l)
Observations	1302	56	56
Range from	17.5	4	2.8
to	1200	52	161.6
Mean	287.86	31.41	55.41
s.d.	195.5	11.25	38.2

Table 2. Analysis of the variance and covariance of daily milk yield.

Source	Df	Mean square x 10^{-3}	F
Litter size	1	1028.85	44.73 ***
Litter weight	1	557.85	24.25 ***
Kid sex	1	183.38	7.97 ***
Kid survival	1	94.08	4.09 *
Vegetation score	1	2253.39	97.9 ***
Year effect	1	1650.35	71.76 ***
Dam weight	1	1182.97	51.43 ***
Dam weight change in 4 weeks	1	.79	0 04
Dam age	1	22.79	0.99
Lactation length	1	8241.07	358.33 ***
Residual	1287	23.00	

* (P < 0.05)
*** (P < 0.001)

THE OPERATION OF THE ONGATA RONGAI SMALLSTOCK MARKET

By

F.N. Chabari and S. Bekure
Agricultural Economists
ILCA/Kenya
P.O. Box 46847
Nairobi

Introduction

The major suppliers of meat to the city of Nairobi are private abattoirs located in the outskirts of the city. The town of Ongata Rongai, located 15 km south-west of Nairobi has two abattoirs, one individually owned and the other owned by a co-operative society. In addition, the centre has designated market sites for livestock trade and supervised by the county council of Olkejuado.

Studies of the Emali market, (Bekure et al., 1982), reported that Ongata Rongai was indicated as a destination for 32% of the slaughter cattle sold by pastoral Maasai producers and livestock traders in eastern Kajiado. ILCA's decision to study the Ongata Rongai livestock market was based on the need to follow stock from the regional market (Emali) to Ongata Rongai, a major terminal market. The Ongata Rongai studies revealed that, in addition to the cattle, substantial numbers of smallstock pass through the live market and the abattoirs to the Nairobi meat market. Two other market centres in northern Kajiado supplying meat to the Nairobi butcheries are Kiserian and Ngong. Livestock kill data from the three market centres show that Ongata Rongai handled 65% of the cattle, 55% of the sheep and 51% of the goats during the first half of 1985.

This paper describes the market component taken up by smallstock at Ongata Rongai. The sources of supply of live animals, the characteristics of the smallstock traded and how these charcteristics influence prices paid. Finally, the paper examines the marketing efficinecy by comparing costs and returns from sources of supply through the live market transaction and wholesale meat supply to Nairobi.

Materials and Methods

Enumerators trained in identification and classification of market livestock were employed. The enumerators were also trained in the techniques of interviewing sellers and buyers at the market.

Data collection started in January 1982. Initially, data were collected twice weekly and after May 1983, once weekly using questionnaires included as appendix 1. Information about individual animal characteristics included the species, breed, sex and body condition visually assessed and scored on a scale of 1 to 4. A score of 1 was given to emaciated animals in poor body condition, a score of 2 to those in fair condition, a score of 3 to those in good condition and a score of 4 to those in excellent condition. Sellers were also identified either as producers or traders and the prices they realised at Ongata Rongai. In case of traders, the sources of supply and the prices they had paid for them were asked. The buyers were also asked to state the destination of the stock bought, purpose of purchase and the mode of transportation from Ongata Rongai to destination. A total of 1613 transactions during 1982 to 1984 were recorded in this manner. Of these, 965 smallstock bought and taken to a private abattoir at Ongata Rongai for immediate slaughter were physically identified to the abattoir manager who supplied killingout weights of the same.

Killing-out rate of 47% (KMC long term average) was used to estimate liveweights of these animals. Ordinary least squares regression technique has been used in estimating equations for relating market price to body weight as an independent variable. Analysis of varience has been used in testing for differences in market price between classes of smallstock.

Results and Discussion

Type of Sellers and Sources of Supply

About 61% of the sheep (N=701) and 57% of the goats (N=619) sold at the market originated from trading centres within Kajiado. Including all sources, Kajiado district supplied 86% of the sheep and 88% of the goats traded at Ongata Rongai. The two Maasai districts (Kajiado and Narok) supplied 96% of the sheep and 96% of the goats sold here. The rest came mainly from Machakos district and other non-specified sources.

Sellers at the market were identified either as producers themselves or traders. It was found that traders were the major sellers supplying 94% of the sheep and 98% of the goats. The producers and traders selling sheep received mean prices of Ksh 193.90 and Ksh 209.20 per head respectively, which were not significantly different at $P<0.05$ level of confidence. However, the producers and traders selling goats received mean prices of Ksh. 281.30 and Ksh. 211.00 per head respectively, which were significantly different at $P<0.01$ level of confidence.

A major factor affecting supply of livestock to Ongata Rongai is the frequent outbreak of notifiable diseases in the vicinity of the market and the areas of supply. In the event of a disease outbreak, the market is closed and the traders, especially meat wholesalers, have to shift buying sites to closer terminal markets like Kiserian, Ngong and Dagoretti and also utilize abattoirs in these market centres.

Destinations of Small Stock Traded

Of the 995 sheep and goats for which the purpose of purchase were indicated, 187 (19%) were for resale at a later date, 800 (80%) for immediate slaughter and only 8 (1%) for rearing. It can be safely assumed however, that those destined for resale were also slaughter stock. Studies conducted within Maasailand (ILCA 1986) show that Maasai pastoral producers rarely dispose of or purchase productive breeding stock at the markets. It is evident from Table 1 that most of the stock sold at Ongata Rongai were also slaughtered or resold here. Dagoretti, a major destination for cattle sold at Ongata Rongai (ILCA, unpublished) received only 11% of the small ruminants traded.

Quality, Weight and Breed Influences of Market Price

The mean body condition score for 965 sheep and goats was 2.8 (mid-score is 2.5). For this number, a one-way Analysis of varience test showed that significantly different prices, at P<0.01 level of confidence, were paid for the four body condition classes. It is clear that body condition of the animal significantly determined the price the trader was willing to pay.

Between body condition groups, the highest range of prices was observed between male sheep, those in excellent body condition (score 4) averaging Ksh. 417.70 (N=57) and those in poor condition (score 1) averaging Ksh. 164.00 (N=44). The mean prices by species body condition and sex are presented in
Table 2.

The mean weights for sheep and goats (N=965) were 29.3 ± 7.2 kg. By species, the mean weights for goats was 28.5 ± 6.4 kg and 29.9 ± 7.7 kg for sheep. Body weight as a regressional prediction variable for market price was highly significant. The correlation coefficient for price and body weights was r = +0.75 and a regression highly significant at P<0.01 level of confidence.

This strongly suggests that traders pay a lot of attention to expected killing-out weights especially when buying slaughter stock. Often, traders were seen hand lifting some of the animals they wished to buy in order to acquire an estimate of the body weights. A simple regression equation was estimated as:

$$Y = 12.0 + 6.3\ X$$

$$SE_B = 0.182$$

Where: Y = Price in Kenya shillings

X = Body weight in kilogrammes

SE_B = Standard error of B-coefficient

Summarises of the weights and prices by species are presented in Table 3 the results show that the mean live weights of sheep in this market were nearly 1 kg heavier than goats traded. There were no differences in body condition. On the basis of prices paid per kg live weight however, the goats were superior at Ksh. 6.90 compared to Ksh. 6.60 for sheep. These results agree with findings of Peacock (1984) that within Maasailand, sheep perform as well or better than goats. Studies from Baringo, Chabari (1986), show that goats outperform sheep in all these measures for similar breeds.

Analysis of varience tests also established that, within species, statistically different prices were paid for the various breeds of sheep and goats at P<0.01 level of confidence. Among the sheep, the Merino had the highest mean price of Ksh. 389.00 per head (N=15 or 2% of the sheep sold). The crosses of the Dorper and the Red Maasai sheep had the second highest mean price at Ksh. 231.00 per head and formed 13% of the sheep sold. The majority of the sheep were, however, the Red Maasai (67%) and received mean prices of Ksh. 214.00 per head. All the other sheep breeds (18%) received lower market prices.

Among the goat breeds, the Small East African (SEA) had the highest mean price at Ksh. 217.00 per head. The SEA was also the major breed, forming almost 93% of the goats sold. As a group, the pure Galla and crosses of the Galla and SEA had a lower mean peice at Ksh. 145.00 per head (N=17 or 2%). A group of nonspecified breeds (N=35 or 5%) had a mean price of Ksh. 173.00 per head.

Marketing Costs and Margins

Small stock to the live market were supplied from several sources. The average prices at these sources was calculated at Ksh. 155.00 per head, (N=796), while the average live selling price at Ongata Rongai was Ksh. 212.00, (N=1613). The average marketing costs up to Ongata Rongai were Ksh. 7.70 per head, giving gross profit margins of Ksh. 49.30. The elements of costs and profit margins are presented in Table 4.

Meat wholesalers frequently purchase live animals at the market and have them custom-slaughtered for their clients in Ongata Rongai or Nairobi. The costs and returns to a meat wholesaler who performs such function and sells to Nairobi consumers are shown on Tables 5 and 6.

The results show that the suppliers of small stock to the Ongata Rongai market achieve a gross profit margin of Ksh. 49.30 as a return to his labour, capital and management. These returns are 30% of the capital outlay or 23% of the selling price.

The meat wholesaler buying from the supplier and supplying the Nairobi butcheries after custom-slaughter at the abattoirs earns a gross profit margin of Ksh. 101.40 or 44% of return to his capital outlay. Chabari (1986) estimated that the meat consumers in Nairobi pay a total of Kshs. 357.00 per head of smallstock to the meat retailer. In addition, Ksh. 10.00 is earned from the sale of a wet skin. On this basis, the producer earns only 42% of the consumer's price per head of small ruminant. This is rather low considering that the total marketing costs per head of small stock are only estimated Ksh. 24.40 or 7% of the consumer's price. About 51% of the consumer's price is gross profit shared by the livestock trader, the meat wholesaler and retailer. Although cost efficient, the marketing system described cannot be regarded as efficient overall since the consumer's price can be lowered by lowering the middlemen's profits.

Conclusions

Ongata Rongai provides an important link in the marketing system of smallstock and supply of meat to Nairobi. Its role as a distribution point for live animals to other markets or direct to the abattoirs is well recognised, more so for cattle than smallstock. These functions can be improved considerably by controlling and minimising incidences of notifiable diseases in northern Kajiado and the supply areas to maintain the flow of market stock.

The trading centres within Maasailand were the major sources of smallstock traded at Ongata Rongai. The traders, rather than the producers, were the main sellers at the market. Most of the stock sold here were slaughtered at the two abattoirs and transported to the Nairobi meat market.

It was established that the body condition of the animal, as a proxy for weight and quality of the carcass, was a major determiant of market price. As a rapid technique for estimating weight and quality, body condition scoring appears best suited for cross-sectional data recording. Effects of season and changes in estimators would, for instance, tend to introduce inconsistencies in the scores. The breed and sex characteristics were also significant in determining market prices. For both sheep and goats, the highest prices were paid for the castrates in good to excellent body condition.

Traders, particularly meat wholesalers, achieved excessively high gross profit margins. This can be an impediment to supply if the information about high profit margins flows back to Maasai producers who are generally reluctant sellers of smallstock. Greater supply could be induced if these margins were reduced in favour of higher prices to the producers.

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Table 1: Destinations of Small Ruminants Traded at Ongata Rongai Market (1982-1984).

Destination	SHEEP (N=865) Percentage to Destination	SHEEP (N=865) Mean Price	GOATS (N=741) Percentage to Destination	GOATS (N=741) Mean Price	Total Percentage to Destination
	(%)	(Ksh)	(%)	(Ksh)	(%)
Ongata Rongai	88.0	216.00	88.0	213.00	88.0
Dagoretti	12.0	180.00	11.0	198.00	11.0
KMC, Athi River	0	0	1.0	234.00	1.0
Total	100.00	212.00	100.00	212.00	100.00

Table 2: Mean Market Price by Species, Body Condition and Sex

Species	Sex		BODY CONDITION 1=V.Poor	2=Fair	3=Good	4=Excellent	All
Sheep	Males	Ksh.	164.00	181.00	154.00	417.00	247.00
	(N)		(44	(38)	(38)	(57)	(177)
	Castrates	Ksh.	-	183.00	333.00	-	261.00
	(N)		(0)	(44)	(48)	(0)	(92)
	Females	Ksh.	157.00	154.00	182.00	-	178.00
	(N)		(11)	(38)	(259)	(0)	(308)
	All Sexes	Ksh.	163.00	173.00	200.00	417.00	212.00
	(N)		(55)	(120)	(345)	(57)	(577)
Goats	Males	Ksh.	202.00	203.00	217.00	275.00	218.00
	(N)		(16)	(54)	(323)	(24)	(417)
	Castrates	Ksh.	85.00	143.00	352.00	-	267.00
	(N)		(1)	(42)	(64)	(0)	(107)
	Females	Ksh.	190.00	162.00	174.00	-	172.00
	(N)		(7)	(46)	(155)	(0)	(208)
	All Sexes	Ksh.	194.00	172.00	221.00	275.00	212.00
	(N)		(24)	(142)	(542)	(24)	(732)
All	All	Ksh.	172.00	172.00	213.00	375.00	212.00
	(N)		(79)	(262)	(887)	(81)	(1309)

Table 3: Summary of mean live weights, Prices and Body Condition by Species

Parameter	Sheep (N=545)	Goats (N=420)	Total (N=965)
Mean body weights (kg)	29.9±7.7	28.50±6.4	29.30±7.2
Mean Price (Ksh)/head	198.10±67.9	196.00±51.9	197.6±61.4[a]
Mean Price/kg (Ksh)	6.60	6.90	6.70
Mean Body Condition Score	2.3	2.8	2.8

[a] For sub-set of data whose weights were available

Table 4: Marketing Costs and Margins per head of Smallstock from Source to Ongata Rongai Market

COST ITEM		AMOUNT (Ksh)
Mean Purchase Price		155.00
Taxes to local Council	1.00	
Transportation costs (trekking)	5.00	
Food and Beverages for trader	0.20	
Transportation costs (trader)	0.70	
		6.90
Subtotal		161.90
Trading losses (0.5%)		0.80
Total costs		162.70
Selling Price at Ongata Rongai		212.00
Gross Profit Margin		49.30

Source: Marketing costs adapted from Chabari, (1986)

Table 5: Marketing Costs per Head of Smallstock to a Meat Wholesaler supplying Nairobi Butcheries

COST ITEM	AMOUNT (KSH)	
Purchase Price at Market		212.00
County Council Cess at Market	1.00	
Flaying, abattoir fees	5.00	
Meat Inspection fees	3.00	9.00
		221.00
Add		
Trading loss at 0.1% condemnation rate	0.20	
County Council cess at Abattoir	2.50	
Meat delivery costs to Nairobi	5.00	7.70
Total Costs		228.70

Source: Marketing costs adapted from Chabari, (1986)

Table 6: Returns per Head of Smallstock to the Meat Wholesaler Supplying Nairobi Butcheries

	ITEM	AMOUNT (KSH)
1.	Wholesale value of carcass (Mean 14.3 kg @ Ksh. 19.00/kg)	271.70
2.	Heart, Lungs, Liver, Kidneys	18.00
3.	Tripes	20.40
4.	Head/Trotters	10.00
5.	Skin	10.00
	Total Revenue	330.10
	Gross Profit	101.40

Source: Chabari, (1986)

A COMPARISON OF THE PERFORMANCE OF SMALL RUMINANT MARKETS IN BARINGO AND MAASAILAND

By

F.N. Chabari and S. Bekure
Agricultural Economists
ILCA/Kenya

Introduction

Various studies indicate that pastoral Maasai producers do not maximise offtake of small ruminants to the commercial markets. White and Meadows (1981) estimated an average annual offtake rate of 6.6% from Maasai flocks in Kajiado. ILCA (1985) estimated an annual offtake rate of 5.8% from Olkarkar group ranch in Eastern Kajiado. Of this, only 2.3% was composed of commercial offtake. In a neighbouring group ranch, Merueshi, a total offtake rate of 8.7% was estimated and only 1.5% composed of commercial offtake. The differences in rates of offtake from Olkarkar and Merueshi were explained by the degree of accessibility and proximity to the consumption centres in which Olkarkar has an advantage over Merueshi. King et al (1982) and Peacock (1984) also found large proportions of unproductive males and females among Maasai flocks. These classes should have been disposed off earlier to give room to younger and more productive stock.

This situation pertains despite the proximity of the Maasai districts (Kajiado and Narok) to the major meat marketing outlets and urban consumption centres like Nairobi where small ruminant meat is in high demand. The districts are also close to large abattoir and meat packing plants [Halal at Ngong and Kenya Meat Commission (KMC) factory at Athi River]. Kajiado district, especially, is connected to the export port of Mombasa by the Nairobi-Mombasa highway.

Despite this comparative advantage that it has over most of the livestock producing districts, commercial offtake of small ruminants from Maasailand remains very low.

To satisfy the demand for small ruminant meat in the urban centres, especially Nairobi, livestock traders bring in live animals from far away districts in northern Kenya and Baringo district in the Rift Valley Province. Airey (1982) states that many livestock traders based in Nairobi, Dagoretti and Limuru towns regularly buy stock from market centres in Baringo for the simple reason that these markets are dependable sources of supply.

The first author of this paper carried out a study in 1985 to investigate the reasons why commercial offtake of small ruminants from Maasailand remains low (Chabari, 1986). This paper is a component of a wider report from the study which compares the market structure, conduct and performance of the Baringo and Kajiado marketing systems.

Methodology

The relative efficiencies of the small ruminant marketing channels employed in Baringo and Kajiado were examined. Marketing efficiency is emphasised as one of the important measures of market performance. In the context of this study, a marketing channel is deemed relatively efficient if it facilitates the marketing operation at the least possible average cost.

Several calculations are performed in assessing the marketing efficiencies. The marketing costs were calculated as the sum of the average costs incurred between buying and reselling of a live animal or selling its carcass. The elements of marketing costs are discussed elsewhere in this paper.

Marketing margins are calculated as the difference between buying and selling prices. The differences between marketing margins and the marketing costs are the gross profit margins. The gross profit margins reflect the returns to the buyers' labour, capital and management. These returns represent the maximum wages the trader would earn in an alternative employment, the highest amount of interest the money invested would earn elsewhere and a payment for the trader's management skills and the risks he would take by being in livestock trade.

The criterion used in measuring efficiency in this study is the ratio of marketing costs to the total cost outlay per head of small ruminant for each channel. Marketing efficiencies for similar market channels in Baringo and Kajiado were then compared on the basis of these ratios. The lower the ratio, the higher the efficiency.

Within each district, marketing operations for livestock originating from one market source but ending up at different destinations and through different modes of transportation are examined. This is done purely to highlight the major elements influencing the marketing costs.

A variety of data sources are used in computing the marketing costs and gross profit margins. These include the livestock transactions data involving 1481 head of small ruminants from the Baringo markets, results of recent studies by ILCA (1985), unpublished ILCA studies of the Ong'ata Rongai livestock market (1982/84) involving 740 sheep and goats and results of buyer interviews conducted during this study. Twenty-four and 32 traders were interviewed at the Baringo and Kajiado markets respectively during the months of March to June, 1985.

Results

Marketing Costs

Mode and Costs of Transporting Livestock

Livestock traders in Baringo preferred trekking stock to their destinations. Only 21% used trucks while 79% trekked their stock. The choice to use trucks or move on hoof was based largely on the distances to the destinations. The longer the distance the more preferrable trucking became. However, livestock moving across districts, especially across Nakuru, had to be trucked to conform to disease control requirements in force at the time. This requirement applied for both cattle and small ruminants. In Kajiado almost all buyers trekked livestock to the markets and slaughter points.

The costs of transporting livestock were highly variable on a per head basis. In March 1985, the cost of trucking cattle and small ruminants from Marigat in Baringo to Limuru in Kiambu district, a distance of approximately 230 km, was respectively estimated at Ksh 120.00 and Ksh. 30.00 per head. Transportation costs within Baringo district depended very much on the mode employed. The average cost per head of trekking small ruminants from Marigat to the abattoirs on the Nakuru-Baringo border (Mogotio) was estimated at Ksh. 5.00 compared to Ksh. 10.00 per head for cattle for the same distance, with a range between Ksh. 2.40 and Ksh. 10.00 for both types. By truck, the costs per head have been estimated at Ksh. 10.00 and Ksh. 20.00 for small ruminants and cattle respectively for the same distance.

The commonest arrangement was, however, to pay the trekkers on the basis of distances trekked irrespective of the type of livestock or exact numbers involved. On this basis, each trekker earned Ksh. 120.00 - 130.00 per trek between Marigat and Mogotio. The livestock numbers trekked comprised approximately 100 head of either cattle or small ruminants and required a minimum of four trekkers. The owners of the animals shared these costs on the basis of the numbers each owned.

In Kajiado, buyers were legally not allowed to trek animals over long distances at the time of the survey because of quarantine restrictions resulting from an outbreak of Foot and Mouth disease. All the animals bought during this period had, therefore, to be moved to the nearest abattoir for slaughter and transported as meat in delivery trucks. For this reason, very little data were acquired with respect to costs of transporting live animals. Traders trucked smallstock from Kisamis (on the Nairobi-Magadi road) to Ong'ata Rongai abattoirs at a cost of Ksh. 10.00 per head.

Other Marketing Costs

In addition to transportation of purchased livestock to destinations, buyers incurred other costs such as transport and room and board in moving between markets. The rusults show that marketing costs per head of small ruminant within Baringo were almost three times the costs incurred within Kajiado, excluding the costs of transporting livestock. Additional costs of marketing cattle in Baringo were 33% higher than Kajiado (Table 1).

Within the district, the ratio of the costs of marketing one head of small ruminant to the cost of marketing one head of cattle in Baringo is 1:3.5. The corresponding ratio within Kajiado is 1:8. This implies that not only are absolute marketing costs for small ruminants lower in Kajiado compared to Baringo but that the relative marketing cost between livestock types makes Kajiado a cheaper area to buy small ruminants from. Therefore high costs of marketing small ruminants are not contributing factors to under-development of ruminant markets in Kajiado.

Relative Marketing Efficiencis

Comparison of Marketing Efficiencies between Noiwet-Nakuru and Ongata Rongai-Nairobi channels.

The level of marketing costs through these channels are expected to be low since no transportation costs are incurred for live animals. The Noiwet-Mogotio markets in Baringo and the Ongata Rongai market in Kajiado are used as examples of sources of livestock and the Nakuru and Nairobi meat retail markets as the respective destinations. In both channels animals were slaughtered at source and carcasses were delivered to the retail butcheries. The marketing costs between Noiwet and Nakuru retail market, 40 km away, averaged 8.7% of total costs and a corresponding 7.5% between Ongata Rongai and Nairobi meat retail market, 15 km away. Transportation costs of the carcasses were Ksh. 10.00 each from Noiwet and Ksh. 5.00 from Ongata Rongai. On the basis of least ratio of marketing costs, therefore, the Ongata Rongai-Nairobi channel is relatively more efficient. The traders selling at the retail meat outlets at Mogotio trading centre, instead of wholeselling at Nakuru made a gross profit margin of 39.0%.

Hinterland Markets - Baringo

Kerio Valley Markets

The marketing costs contributed 12.2% of the total costs for the traders buying from the Kerio Valley and operating meat retail trade in Kabarnet town, a distance of 30 km. The traders from Limuru incurred a corresponding 27.8% of the total costs over a distance approximately 300 km. The difference is largely attributable to the costs of trucking live animals which the Limuru buyers had to undertake while Kabarnet buyers only trekked the stock up the escarpment. The profit margins were consequently in favour of Kabarnet buyers since the meat retail prices in Limuru, although higher than in Kabarnet, were not sufficiently different to offset the increase in marketing costs. Costs of transporting livestock and buyers to and from Limuru, food and accommodation comprised 21.2% of the total marketing costs.

Central Region

The transportation of buyers and assistants and trekking costs per head of small ruminant from Marigat to Mogotio abattoirs formed significant proportions of the marketing costs estimated at 28%. The marketing costs per head were, however, only 15.9% of the total costs and the buyers were able to have a gross profit margin of 32.3% (Table 2).

Kajiado Markets to Mariakani - Mombasa

The transpotation cost of live animals from Simba trading centre on the Nairobi-Mombasa highway to Mariakani was clearly the highest single item of the marketing costs, comprising almost 62% of the marketing costs. Despite the high marketing costs the gross profit margin to the trader were quite attractive at 82.6% based on the mean prices of the markets before Ongata Rongai terminal market and 75.2% based on the mean prices from the group ranches in Eastern Kajiado. The marketing costs formed 18.5% and 16.4% of the total costs of these marketing operations respectively.

Discussion and Conclusions

The analysis of marketing costs and profit margins to small ruminant traders shows that quite favourable returns are realised in both districts. For ease of comparison, a summary of the marketing costs and profit margins are reproduced in Table 2.

The trucking method, as expected, is the most expensive but sometimes indispensable considering the distances invloved between markets and the destinations. It is therefore, not meaningful to compare relative efficiencies between trekking and trucking modes of transportation because, in the analysis, the two are mutually exclusive. Even within similar modes of transportation, comparisons of efficiencies have to be limited to similar marketing stages of the operations.

Within Kajiado district, two distinct marketing channels can be described from the production areas: one originating from Eastern Kajiado to Mombasa wholesale market through Mariakani abattoirs and the second from the Central and Western regions of Kajiado supplying the Nairobi wholesale market through the Ong'ata Rongai/Kiserian abattoirs. Using average producer prices of Ksh. 165.00 in Eastern Kajiado and the wholesale prices of Ksh. 346.00 in Mombasa, the marketing margin would be Ksh. 181.00 per head. The marketing costs have been worked out at Ksh. 32.48 or 16.4% of the total costs.

On the other hand, the Western/Central Kajiado-Ongata Rongai-Nairobi channel had producer prices of Ksh. 157.00 and meat wholesale prices of Ksh. 330 per head in Nairobi. The total marketing costs were Ksh. 20.60 or 11.6% of the total costs. On the basis of this analysis, it can be said that the Western/Central Kajiado-Ongata Rongai-Nairobi channel is relatively more efficient of the two channels within Kajiado.

In Baringo, four main channels can be described. The first channel involves the markets in proximity of the abattoirs. As an example, the Noiwet-Mogotio operation has been analysed. Average marketing costs in this operation per head of small ruminant were 5.6% of total cost outlays. If the channel terminates at Nakuru meat retail market instead of Mogotio retail market, the ratio of marketing costs to cost outlays rises to 8.7% purely due to added transportation costs.

Two of the other three channels involve small ruminant purchases originating from Kerio Valley and ending up at Kabarnet meat retail market and the purchases originating from Kerio Valley and terminating at Limuru meat retail market. Again, mainly due to differences in trasportation costs, the Kerio Valley-Kabarnet channel appears more efficient with a ratio of marketing costs to total cost outlay of 12.2% compared to 27.8% for the Kerio Valley-Limuru channel.

The fourth channel involves the small ruminant purchases from the markets close to Marigat and ending up at Nakuru meat retail through the Nakuru-Baringo border abattoir at Mogotio. Operators in this channel achieve an average marketing costs to total cost outlay ratio of 15.9%. Within Baringo therefore, it can be concluded that marketing operations involving minimum transportation costs perform more efficiently than those involving larger transportation cost elements.

On the basis of least ratio of marketing costs to total costs, the Kajiado-Mariakani-Mombasa channel appears more efficient than the Kerio Valley-Limuru channel. Both channels utilise the trucking method of transportation. The Western/Central Kajiado-Ongata Rongai-Nairobi channel also appears marginally more efficient than the Marigat group of markets - Mogotio-Nakuru channel, the former achieving marketing costs to total cost ratios of 12.4% compared to 15.9% in the latter.

It is concluded from these surveys that small ruminant marketing from the Kajiado system is more cost efficient than from the Baringo system largely on the basis of lower marketing costs within Kajiado. The low market offtake rates from Kajiado are therefore not a result of a high cost marketing system.

The returns measured as the percentage of the traders' profit margin to total costs invested per head of small ruminant, including purchase price, justify the trucking method employed between Simba and Mariakani and between Kerio Valley and Limuru. The buyers in the latter group are also retailers and frequently receive contracts to supply the Nairobi Cold Storage at negotiable wholesale prices. This group also buys most of the sheep from the Kerio Valley markets at mean prices approximately 30% lower than the mean prices for goats. This makes the real profit margins and rates of return much higher than are shown in these calculations because mutton is retailed at the same prices as goat meat.

Generally however, the excessive profit margins achieved in both districts indicate inherent inefficiencies. Conventional marketing theory argues that, barring monopolies, such attractive profit margins ought to attract a large number of traders. It has been reported, however, that the buyer concentration is rather modest (Chabari, 1986). One plausible explanation for the absence of scramble into small ruminant trade in Baringo districts is due to saturated consumer markets within Baringo and Nakuru municipality. It is also very likely that information regarding the excessive profits achieved was not freely disseminated whereas price information at the auction markets was largely public knowledge. This gap in information flow would tend to make the marketing structure less competitive benefiting relatively few traders.

In Kajiado, poor market information flow also seems a plausible explanation for the excessive profits. The market structure is largely responsible for this as most of the transactions are kept secret. At the markets, traders and sellers conduct transactions directly through a one-to-one bargain method. Only local Maasai succeed as primary buyers in the interior, usually buying from bomas along an established market route.. This makes the system less competitive. A partnership of Maasai traders from eastern Kajiado selling into the coastal markets, for instance, is almost a monopoly of small ruminant trade within this production area. The high profits are therefore, partly explained by this monopolistic situation while poor information flow partly explains the lack of challenge from other local buyers.

The retail prices of meat are regulated by the Kenya Government. The results of the analysis, especially the high profit margins, suggest that it is the livestock traders, rather than the producers, who have mostly benefited from rising consumer prices. The trader's gross profit margins make up rather high percentages of the prices the consumers pay.

A major conclusion from these studies is that market offtake of small ruminants from Kajiado remains low because of an underdeveloped marketing system. Although cost efficient in comparison to the Baringo system, the Kajiado markets are characterised by high fluctuations in the numbers presented. The fluctuations are partly explained by the behaviour of the producers in selling small ruminants. Wealthy Maasai keep small ruminants mainly for non-commercial purposes.

The high fluctuations in numbers on offer discourage traders from outside the district from frequenting the Kajiado markets. In addition, the one-to-one bargain method of selling is an impediment to the flow of market information needed for effective marketing.

Recommendations

The main efficiency related recommendation for improving the offtake includes establishment of an auction method of selling to increase competition in buying and selling of small ruminants. Spreading these markets within the production system is essential in order to reduce the number of middlemen. This is expected to lead to a higher price offer to the producers which would be an incentive to increase sales.

The improved price offer to the pastoral producer would in effect be a welcome improvement in his terms of trade. Over the last ten years, the producer price index of middle to low grade beef, the main product of the pastoralist, has risen slower than the price indices of the consumer goods he purchases (ILCA, 1985).

Establishment of abattoirs in the production areas, as has happened along the Baringo-Nakuru border for the Baringo producers, would ensure relatively uninterrupted flow of meat out of the system. Substantial savings in transfer costs can also be made when meat rather than live animals is transported out of the production system, especially when trucking must be done. It is estimated that, on the average, only 45-50% killing out rate is achieved for the small ruminants. This is also the portion (carcass) that contributes 82% of realisable income at wholesale, 18% coming from sale of offals. Comparing the weights and returns, therefore, it is clear that ransporting meat rather than the live animal is a more cost-effective alternative.

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Table 1. Additional Marketing Costs (Mean Ksh/head) from Markets to Abattoirs

Cost Item	BARINGO DISTRICT Small Ruminant	BARINGO DISTRICT Cattle	KAJIADO DISTRICT Small Ruminant	KAJIADO DISTRICT Cattle
	Kshs per head			
Transportation of trader	2.10	7.30	0.20	6.00
Transprotation of assistants	2.50	3.80	0.50	1.10
Board	1.70	11.20	0.20	9.50
Lodging	0.30	3.60	0.00	6.80
Taxes/cess paid	5.00	15.00	3.00	7.00
Total per head	11.60	40.90	3.90	30.40

Source: Chabari, 1986.

Table 2: Summary of Marketing Costs and Profit Margins per Head of Small Ruminants from Baringo and Kajiado Markets

Source (Market)	Transportation Mode (Live animals to abattoir)	Destination (Retail Butcheries)	Total Costs (Ksh.	Marketing Costs (Ksh.)	Percentage of Marketing costs in Total Costs (%)	Percentage Gross Profit in Consumer's price (%)	Total Retail Revenue Ksh.)
Baringo District							
a. Noiwet	H	Mogotio (Baringo)	235.20	13.20	5.6	28.1	326.90
b. Noiwet	H	Nakuru	267.80	23.20	8.7	17.1	323.10
c. Marigat	H	Nakuru	217.50	34.60	15.9	36.6	343.10
d. Kerio Valley	H	Kabarnet (Baringo)	181.30	22.20	12.2	45.8	334.60
e. Kerio Valley	T	Limuru (Kiambu)	214.90	59.70	27.8	34.8	329.50
Kajiado District							
a. Ongata Rongai	H	Ongata Rongai (Kajiado)	218.60	11.70	5.4	39.0	358.30
b. Ongata Rongai	H	Nairobi	223.60	16.70	7.5	39.1	367.00
c. Kajiado hinterland	H	Nairobi	188.40	23.40	12.4	48.7	367.00
d. Kajiado hinterland	T	Mombasa	202.50	37.50	18.5	44.8	367.00

Transportation mode: H = Hoof, T = Truck

Source: Chabari (1986)

THE IMPACT OF THE THERMAL ENVIRONMENT ON THE PRODUCTION OF SHEEP AND GOATS

by

David Robertshaw
Program Director, Small Ruminant CRSP
University of California, Davis, USA

Introduction

In research programs associated with improving the production of small ruminants one topic of debate relates to the question of whether genetic material for high production traits should be imported or indigenous stock upgraded. Attempts to introduce genetic material associated with traits for faster growth rate or higher milk or wool production from temperate countries into tropical and sub-tropical regions have not been universally successful in part due to the inability to meet the full genetic protential caused by the lack of high quality forage in addition to lack of adaptation to adverse environments particularly the thermal environment. In order to examine the question of thermal stress one needs to have an understanding of the nature of the thermal environment and the way in which it supresses production. With this sort of information it is possible to develop management practices that will alleviate heat stress.

Metabolic Heat Production

All energy utilized by a animal eventually appears as heat within the body. The amount of energy consumed, i.e. the metabolic rate, varies between individuals and species. However, most tropical species of animals have a metabolic rate less than that of temperate species. This may be looked upon as an adaptation to the tropical environment since there is less heat to dissipate but it may also be considered an advantage for survival during periods of low food availability. Animals with a low metabolic rate have a low maintenance requirement and this low maintenance requirement may allow them to survive prolonged periods of food deprivation. However, a low metabolic rate carries with it a low growth rate and low production is a common feature of animals indigenous to the hotter parts of the world. A low metabolic rate is part of the array of features associated with adaptation to a hot environment and any intervention therefore can be expected to be associated with certain difficulties. Thus, the high feed requirements of species i.e. from temperate areas, and the lack of adaptation to the thermal environment of high producing species must be accommodated for any breeding program to be sucessful.

Heat Gain From The Environment

The main environmental heat load on a animal is provided by solar radiation but the quantification of heat gain by exposure to the sun is a difficult measurement to make and depends on many variables. Furthermore, the role of the fur in influencing heat gain from the sun must be understood. The direct solar radiation impinging on the fur may either be reflected or absorbed, the amount depending on the color. Thus, white fur will reflect more solar radiation than black fur and brown fur will be somewhere between the two extremes. The heat absorbed at the fur surface may be reradiated back to the atmosphere or dissipated by convection. Any of the absorbed heat not dissipated will be transferred to the skin and will need to be dissipated by the animal together with the heat of metabolism. The significance of coat color is understood from some experiments that were conducted comparing black and white goats. In these experiments it was found that the amount of the solar radiation absorbed by a black coat was 82% and by a white coat 45%, the remaining solar radiation in each case being reflected. At the level of the skin the amount of heat gained by the animal was twice as much for the black goats as it was for the white goats. On the other hand it is obvious that animals which are provided with shade will show no difference between coat color in terms of the amount of heat absorbed. This can be readily observed when examining a group of grazing animals in that the darker animals tend to seek the shade sooner than the lighter colored animals.

Physiological Response To Heat Exposure

As indicated, behavioral responses to a heat load give a clear indication of the degree of heat stress. Animals tend to orient their body so that there is a minmum surface area of exposed to the sun and they will seek shade.

Evaporation is the main mode of increasing heat loss and of the two main options available to sheep and goats i.e. panting and sweating, panting is the main evaporative heat loss mechanism. Most domestic animals when they are not heat stressed breath at a respiration rate of 12 to 15 respirations per minute. At the onset on panting respiration rate usually increases quickly to at least 30 respirations per minute and then progressively increases with the continuation of the heat stress until it reaches a new steady level. Respiratory frequency is an easy parameter to measure and since in most species of sheep and goats it represents the main heat loss mechanism it is an important indicator of the level of heat stress.

Impact of Heat Stress on Production

The growth rate of an animal is genetically determined and even under conditions where high quality food is available growth rate is limited by appetite. Heat stress is known to suppress appetite and it is in this way that an animal not adapted to its thermal environment will not be able to achieve its full genetic potential. If however, animals are allowed to graze freely under tropical conditions they will tend to use the night hours for grazing and rest during the heat of the day. However, if animals are forced to graze during the day appetite and food intake will be reduced and productivity suppressed. One of the effects of reduced grazing time and lower food intake is that the hair cycle whether it be wool or hair is slowed down and the shedding of the hair does not take place in a normal manner. Thus, heat stress animals very often have a long coat which further exacerbates the heat stress.

Alleviation of Heat Stress

Even though animals from temperate regions may have a higher heat production and inferior heat-dissipating mechanisms than tropical species careful management, well designed buildings and adequate water can remove most of the major barriers for sucessful production. Heat stress can be modified by providing a situation that allows minimal heat load and maximal heat loss in the following ways. A) A reduction in heat load. Since most of the heat is in the form of solar radiation provision of adequate shade particularly during the mid day hours is a good management practice. Allowing animals to graze at dawn and at dusk ensures adequate time to satisify appetite. In providing shelters for animals certain guidelines can be followed; for example the materials used in construction should have a high reflectivity. The compass direction of the shelter is also important. Thus, a north-south direction is preferable since animals can follow the movement of the shadow as long as the shadow does not fall outside of the boundaries of the enclosure. For animals confined to a house however in an east-west configuration is preferable and in the northern hemisphere the main slope of the roof should be in a southernly direction leaving part of the roof structure open to the cooler northern sky. The reverse is the case for the southern hemisphere. In addition a double layered roof with adequate ventilation between the layers allows the dissipation of the solar heat absorbed by the outer layer. An opening at the apex of the house will also assist in the ventilation of the space between the layers. B) The use of showers has been tried successfully with cattle. With sheep and goats however, this may not be appropriate particularly with the wool breeds of sheep since wool provides a non-wettable surface.

Summary

It can be seen therefore that the question of poor adaptation to the thermal component of a tropical environment by temperate-adapted species of sheep and goats is a significant part of the lower productivity of these animals when introduced into the tropical countries. However, there are methods available to alleviate, in part, some of the heat stress experienced by these animals.