ILCA ANNUAL REPORT 1982

A year in the service of African livestock improvement

INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA

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INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA
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Foreword

Food production in Africa is inadequate. In 1970 cereal production in sub-Saharan Africa was 37.8 million tonnes; in 1980 it was 42.4 million tonnes. This corresponds to an annual increase of little over 1% in a continent where population is increasing by 3% per annum. In the livestock sector, trends are a little more encouraging: a 1% annual increase in cattle numbers has been accompanied by a slight increase in milk and meat production per animal.

Some countries, however, have performed much better than this. The top five have recorded average increases in foodgrain output of 5% a year. Significantly, these countries also recorded the largest increases in cattle numbers and in meat and milk production.

The decline in food production per caput has been accompanied by a marked rise in cereal and livestock imports. In 1970 cereal imports to sub-Saharan Africa amounted to 3.2 million tonnes; by 1980 they had reached 8.6 million tonnes. Meat imports in 1970 were 26 000 tonnes; by 1980 the figure was 123 000 tonnes. As a result of these large increases in imports, the average food supply remained level at about 2170 calories and 55 grams of protein per person per day, about 25% of which was of animal origin.

This increasing reliance on imported food exposes Africa to the harsh trends and fluctuations of international trade. Only 10 years ago grain prices escalated far beyond the reach of many developing countries. If bad weather were again to cause low harvests in several parts of the world, then a similar crisis could recur with the same disastrous consequences. Self-sufficiency in food is of vital importance to Africa, and the current trend towards greater food imports must be reversed.

The immediate task is therefore to increase cereal supplies. This being so, Africa's policy makers must ask the crucial question: does livestock development complement or compete with cereal production?

An analysis of the production figures for sub-Saharan Africa since 1960 provides the answer. A significant correlation of changes in livestock numbers and in cereal output is apparent across all countries. Each extra animal in the cattle population is associated with an extra 0.25 ha of cropland and about 200 kg of additional grain, as well as 13 kg more meat and 38 litres of milk.

This correlation of increases in crop and livestock production is by no means unique to Africa. In India's northwestern states, where substantial increases in wheat and rice output have occurred, milk production has also greatly increased. In other Asian countries where rice production has expanded, large increases in meat and milk production are also reported.

Five separate factors account for the close association between increases in foodgrain output and livestock production.

The first factor is the availability of money. On subsistence farms cash income is extremely low because almost all produce is consumed at home. Consequently there is no money available to buy the inputs needed to increase crop production - fertiliser, improved seed, pesticides or irrigation water. If credit is not available on reasonable terms, money must be obtained from other sources. A common and convenient source is livestock whose production is normally associated with a very large value-added cash component. An upward production spiral is initiated by increasing the sale of livestock products, thereby generating the cash to purchase crop inputs. The catalyst for improvement is livestock.

The second factor is the provision of draught power by oxen. Working oxen are the pivot point of farm production in many countries, and the type and numbers of livestock kept by farmers are frequently determined by their need for draught power. In general, a pair of oxen can cultivate 2 to 4 ha of land per year. A recent ILCA study shows that, as households own more work oxen, so their cropped area increases.

The third factor is market demand. As populations increase and people become richer, the demand

for more and better food rises rapidly. Meat and milk are most people's idea of better food: more and better livestock provide them.

The fourth factor is that livestock provide the manure vital for maintaining soil fertility and structure. Many African soils are very old and subject to intense heat, violent rain storms and powerful winds. When livestock numbers increase, more manure becomes available to improve soils and enhance crop yields.

The fifth and last factor is that crop residues play a crucial role in livestock nutrition throughout Africa. As cereal area increases, more residues become available to feed greater numbers of livestock.

These five factors, coupled with the development experience of Europe, North America and Australia, highlight the strong complementarity of livestock and crop production. The aim of ILCA is to build upon this relationship by developing cost-effective means to increase livestock output.

Throughout Africa livestock output is constrained by the overall lack of improved technology as well as by a difficult economic environment. High performing drought- and disease-resistant forage plants are not available. Rangeland management techniques remain traditional. Trypanosomiasis limits livestock production to roughly half the available land area. This lack of improved technology must be overcome, and at the same time producers must be offered greater incentives to increase output.

ILCA, together with the other 12 institutes of the CGIAR system, was created by a group of far-sighted individuals who recognised the urgent need for well-planned and location-specific research to provide improved technology. Their judgement is now supported by the 17 international donors that are generously funding ILCA's research, documentation and training programmes. In the pages that follow the precise goals of these programmes are described and the progress that ILCA has achieved in providing improved technology for livestock owners is presented.

Peter J. Brumby
Director General

1982 Highlights

1 In the Ethiopian highlands it is customary for oxen to plough the land in pairs. As many households do not own two oxen, animals must be shared, borrowed or hired. Thus land cultivation is often late and inadequate. During 1982 ILCA introduced a modified traditional harness and yoke which allows the local plough to be drawn by a single ox, an innovation which is proving highly popular with farmers.

2 In the subhumid zone of West Africa the protein intake of cattle is insufficient for maintenance requirements during five months of the dry season, resulting in a weight loss of 15%. During 1982 ILCA showed that forage legumes for dry-season feed supplementation can be introduced by methods that do not demand excessive labour. Fodder banks – plots of *Stylosanthes* reserved for dry-season grazing by lactating and in-calf cows - have yielded almost 7 t DM/ha with 11% protein content at the start and 6% at the end of the dry season. This technology seems likely to solve one of the most serious constraints to increasing livestock production throughout the 1 300 000 km^2 of the subhumid zone.

3 At Ibadan, Nigeria, disease is the major constraint to improved productivity in small ruminants. A veterinary package was introduced in April 1980, consisting of Tissue Culture Rinderpest Vaccine to control *peste des petits ruminants* and a dipping programme to check mange. Results reported at the Seminar on Small Ruminant Breed Productivity held by ILCA during 1982 show that kid survival subsequently increased from 67% to 86%, reproductive efficiency of does improved by 25% and mortality fell from 30-40% to about 13%.

4 The Niger delta in central Mali provides dry-season grazing for about 1 million cattle and 1.5 million small ruminants. The traditional code of control over the use of pastures is threatened by an influx of arable farmers and a rapidly increasing livestock population. During 1982 ILCA completed a 3-year study for the Organisation pour le Développement de l'Elevage dans la Région de Mopti (ODEM). Analysis of the ownership and management of herds, combined with a detailed assessment of vegetation resources, has allowed new grazing regimes to be devised and tested at the Niono Ranch of the Institut du Sahel. These grazing regimes permit better utilisation of the delta without concomitant ecological damage.

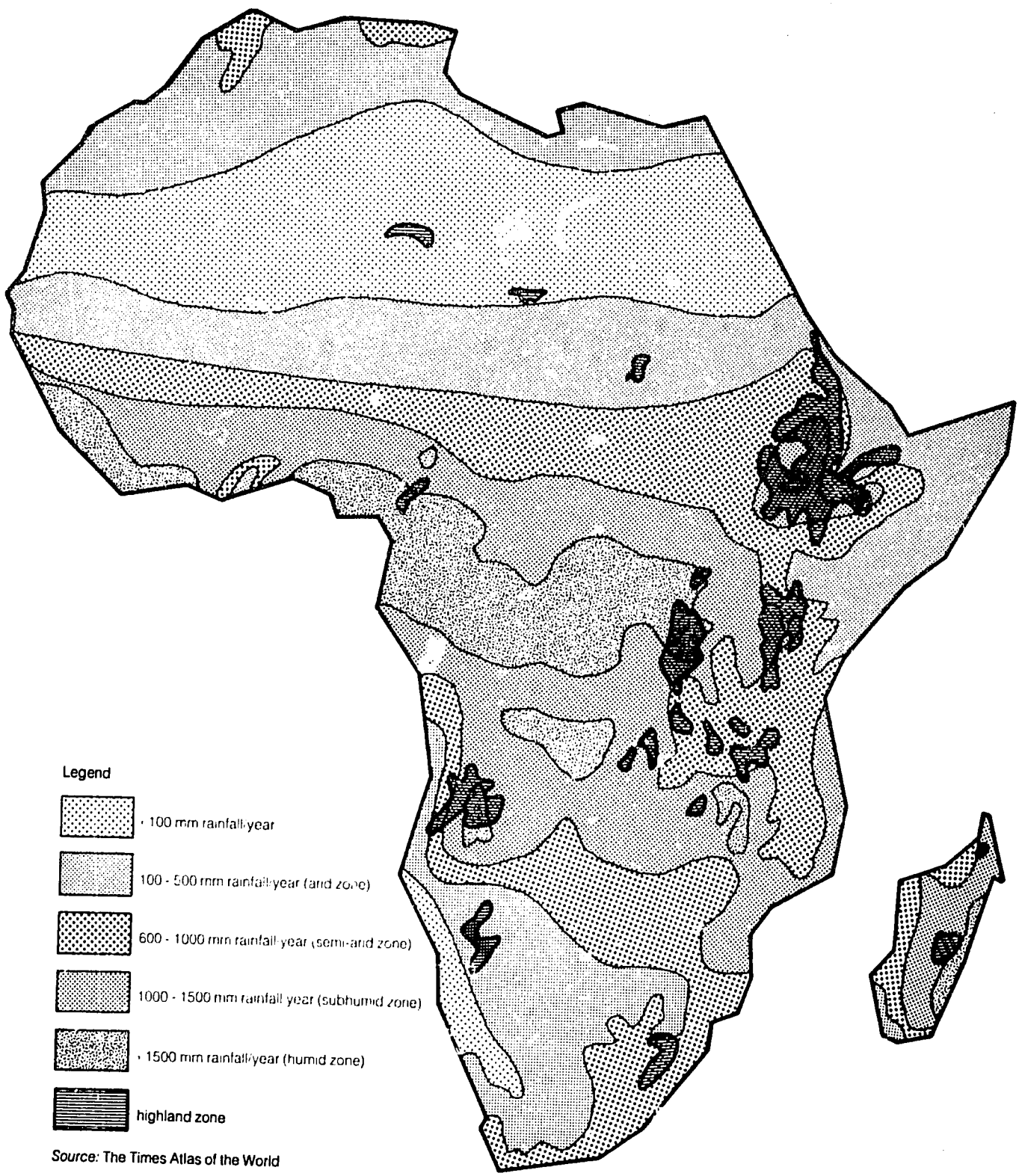
5 A Forage Legume Agronomy Group was established at ILCA headquarters during 1982. By the end of the year its germplasm collection contained 1793 "best bet" accessions, mainly from overseas, although some have been collected within Ethiopia by the group's Plant Exploration Section. A computerised indexing system based on 120 descriptors has been devised which allows the rapid identification of those accessions believed to be best suited to the climatic, edaphic and livestock production conditions of various African countries.

6 In the semi-arid zone of Mali, millet is the staple cereal of sedentary agropastoralists. During 1982 ILCA showed that the intercropping of forage legumes with millet can provide increased dry-season fodder for livestock without decreasing millet yields. So far 242 legume accessions have been screened. Cowpea lines appear the most promising - cowpea grain yields of 724 kg/ha and haulm yields of 6.5 t DM/ha have been recorded.

7 A Selective Dissemination of Information (SDI) service was launched during 1982. Using CAB and AGRIS tapes, ILCA's Documentation Service scans the international agricultural literature each month to identify publications relevant to individual scientists according to their research "profiles". Select bibliographies are disseminated free of charge to research workers and decision makers throughout Africa.

8 During 1982 14 trainees received instruction in refresher courses on forage analysis and animal nutrition, while 16 individuals received tuition in their own specialist discipline or were supported in doctoral research of direct interest to ILCA, and two specialists were received as post-doctoral or sabbatical fellows. In addition, 185 research workers and decision makers participated in training courses and workshops held by ILCA on pasture production and evaluation (Kaduna), small ruminant breed productivity (Addis Ababa), and arid zones research for West Africa (Bamako).

Figure 1. The ecological zones of Africa



Source: The Times Atlas of the World

Field programmes

The Highlands Programme in Ethiopia

Introduction

Highland areas, defined as land above 1500 metres, are found in many African countries but are concentrated mainly in the east of the continent, as Figure 1 shows. The highland zone covers some 1 million km^2 - approximately 4% of the continent's surface area - and is thus the smallest zone under study by an ILCA team. The modest size of the zone belies its importance in terms of livestock production, since it is here that the highest concentration of domestic ruminants occurs, 20% of Africa's cattle and sheep and 10% of its goats being kept in this zone.

ILCA's Highlands Programme started in 1977 and conducts field research in two study areas in the Ethiopian highlands: Debre Zeit and Debre Berhan. The former is 50 km south of Addis Ababa at 1800 m and receives a mean annual rainfall of 850 mm. Debre Berhan is 1000 m higher, with a rainfall of 1100 mm and is 120 km northeast of Addis Ababa.

The principal crops in the Debre Zeit area are teff (a small grain cereal), wheat, chickpeas and faba beans. Most households own livestock - cattle, sheep, goats and donkeys - the latter being used for transport of farm products. Cattle provide milk, draught power and manure. The latter is used as household fuel, since wood is generally scarce in the Ethiopian highlands.

At Debre Berhan, because of the lower mean temperatures, barley rather than teff is the staple cereal. Since valley bottoms suffer from frosts at harvest time, cultivation is restricted to hillsides, which have become badly eroded and low in fertility as a result of centuries of cultivation. Sheep are more important at Debre Berhan than at Debre Zeit, and flocks may number up to 40 head.

Descriptive studies

Livestock ownership

During 1982 120 households at Debre Berhan were interviewed every 3 months to record changes in livestock ownership. This survey will help to explain how smallholders manage their investment in livestock to counter the impact of poor crop years, such as 1982. This study will continue during 1983 in order to identify any medium-term effects on subsequent crop production.

Dairy technology

The marketing of fresh milk in the Ethiopian highlands is restricted by long distances to market and the observance of extended fasting periods when the consumption of animal products is prohibited. However, small-scale milk processing is widely practised, the products contributing substantially to the cash incomes of smallholders. It was not known whether improvements could be made to the local processing methods through gains in efficiency and the production of a wider range of products. The team therefore conducted a survey of local processing methods in July and August 1982 which covered farmers in 8 of the 14 administrative regions of Ethiopia. Butter was the principal product, but traditional methods were inefficient: up to 40% of the available butterfat was not converted to butter. There is thus considerable scope to improve the efficiency and increase the range of products to include, for example, ghee and hard cheeses.

Fallow land productivity

In the Debre Berhan area, fallow periods may be as long as 15 years. A study began in

1982 on fallows of four different ages. Both fixed and mobile exclosures were used and pasture was harvested at 6-week intervals. In all instances total production to the end of the main wet season was less than 1 t DM/ha. While several useful *Trifolium* species were present in these fallows, they constituted only a low proportion of the sward, reflecting the low fertility of this land. If economic methods of increasing fertility can be found it should be possible to reduce the fallow periods so that more land can be cultivated. The study will be expanded and continued during the 1983 crop year.

Animal traction

In 1982 a PhD candidate began research on the power output and feed requirements of work oxen near Debre Berhan research station. Data were collected from 24 farms over two major and minor rainy seasons. The oxen were weighed monthly and heartgirth measurements were taken. Force measurements were recorded using a strain gauge located between the beam and the yoke. Other variables recorded were depth of ploughing, speed of travel, volume of soil moved, oxen respiration rates and soil moisture. At the end of each working day the tilled area was measured. These data were augmented by information on feed intake on working and rest days, feed samples being analysed at ILCA headquarters. The knowledge gained from this study, which will be completed during 1982, will help ILCA staff to develop improved traction technology within the farmer's resources.

Designing improvements

Pasture production in valley bottoms

Permanent pastures in valley bottoms are a major source of grazing and hay during the dry season. Most valley bottoms are waterlogged through much of the wet season, rendering crop production impossible unless water management is practised on a comparatively large scale. Because of the contribution of these bottomlands to animal nutrition, an investigation into low-cost methods of increasing production was begun. A method which showed particular promise was ripping the pastures with a winged tine to a depth of around 15 cm at row spacings of 25 cm. An increase of at least 50% in yield over the present production of about 4 t DM/ha was achieved on three test plots. The tine was drawn by a pair of oxen. If applicable on a large scale, this low-cost technique will contribute directly to the overall productivity of the farming system, especially through reducing the dependence of livestock on fallow lands for dry-season grazing. During 1983, formal trials will be carried out at three sites, two of which will be on farmers' pastures.

Single-ox ploughing

Throughout the Ethiopian highlands, ploughing is performed by pairs of work oxen drawing the traditional *maresha* - an implement which has remained unchanged for many centuries. However, many households do not own two work oxen and are obliged to borrow or hire animals each year, causing

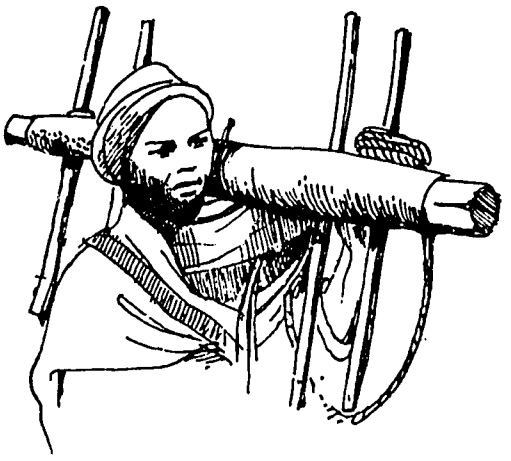
late and inadequate land preparation. The team therefore undertook research on the use of oxen working individually rather than in pairs. The designs of the traditional yoke, harness and *maresha* were modified. Initial trials were successful and it was found that a single ox could provide some 70% of the power output of a pair. At field days in both the Debre Berhan and Debre Zeit areas, farmers showed great interest in this low-cost technique. In 1983 some 60 farmers will be testing single-ox ploughing on their own farms and at their own risk.

Provision of dry-season water

During the dry season, considerable time is spent carrying water to households and in walking livestock to water. There is thus a great potential for small-scale catchment ponds to retain surface water that would otherwise be lost. However, the digging of such ponds is a heavy manual task, particularly if they are to be completed within one dry season. During 1982 a site on the Debre Berhan station was selected for a 9000 m^3 pond which is now being excavated by pairs of oxen drawing metal scoops of 0.15 m^3 capacity. Detailed records are being kept during construction so that the feasibility of this technology can be estimated before it is offered to farmers, a move planned for the 1984 dry season. This research is being undertaken in close collaboration with the Soil and Water Conservation Department of the Ministry of Agriculture.

Cultivation trials

In 1982 a 3-year trial was completed which assessed the performance of three cultivation implements: the traditional *maresha,* a mouldboard plough and a spring tine. Each implement was used to prepare three different soil types, and measurements were taken of power requirements, crop yields, weed growth, soil fertility and other factors. Ploughing all soil types with the two modern implements took only half the time that was required with the *maresha.* On a clay loam soil where wheat and teff were sown, yields were highest when a mouldboard plough was used, although ploughing by *maresha* resulted in higher yields than those obtained with a spring tine. An economic appraisal of the 3 years' data will be undertaken during 1983.



The use of cows for traction

The reproductive performance of local cattle breeds in the highland zone is low and calf mortality is high. A large number of breeding stock are therefore required to provide replacement work oxen. If cows could substitute for work oxen, then a much smaller herd would be required, releasing resources for food and cash-crop production. This is particularly true in areas which are intensively cultivated and where feed resources are scarce. The team is examining the work output, milk yield and feed requirements of a group of 16 Friesian x Boran cows in a trial at Debre Berhan. The performance of these cows is being compared with that of a control group of the same size which is being milked but not worked. Both groups are fed high-quality fodder. This experiment will continue for 4 years, ending in 1984.

Crossbred dairy cows

From 1969 to 1975, 124 crossbred cows were issued by the Chilalo Agricultural Development Unit (CADU) to farmers in the Arsi region. The crosses included Friesian x Zebu, Friesian x Arsi and Jersey x Arsi. The Arsi breed is a small zebu type, indigenous to Ethiopia. Management and output data were collected on these cows but had not been fully analysed. With Ford Foundation support, a Ugandan scientist on sabbatical leave at ILCA undertook a full analysis of the production records as a joint ILCA/ARDU[1] project.

Breed groups differed significantly in lactation yield and length, as well as in milk yield per day. Year of calving influenced lactation length and daily milk yield, while par-

[1] ARDU, the Arsi Rural Development Unit, is a larger scale successor to CADU.

ity was found to influence both lactation yield and daily milk yield. No significant effects of dry period or calving interval were detected, but breed group and parturition number were shown to influence annual milk yield. The 1/2-Friesian x 1/2-Zebu and 3/4-Friesian x 1/4-Zebu crosses had significantly higher annual milk yields than crosses of the two other breed groups in the study, 1/2-Friesian x 1/2-Arsi and 1/2-Jersey x 1/2-Arsi. In terms of annual milk yield under smallholder management the crosses were ranked as shown in Table 1.

Table 1. Productivity indices of four exotic x local crosses in Arsi region, Ethiopia.

The study also showed that there was a clear superiority of all crossbreds over indigenous breed groups (105%), that the former had the major advantage of calving during the wet season from June to September and that performance of the indigenous Arsi and Zebu breeds was very similar. Parallel studies of similar data sets from other African countries are planned.

Improved pastures

The team tested the productivity and persistence of 12 experimental lines of perennial grasses sown with *Trifolium repens* at the Ministry of Agriculture's sheep breeding station at Debre Berhan. The main species used in this trial were *Lolium perenne, Dactylis glomerata* and *Festuca arundinacea.* In a second trial, the performance of various legumes when sown with *Dactylis glomerata* was examined. In addition, 12 lines of *Trifolium,* generally *T. pratense,* were planted for observation. In both trials germination and establishment were poor. This may have been due to low soil fertility, late sowing, waterlogging, frost damage or a combination of these factors.

As part of the newly formed Ethiopian Forage Research Network, the team participated in a multilocation trial to evaluate promising annual and perennial forage species. Ten species were tested in 14 sites around Ethiopia, of which ILCA provided three. At ILCA headquarters, DM yields of up to 5.4 t/ha were obtained from *Lolium multiflorum.* Other groups participating in the network are the Institute of Agricultural Research (IAR) and ARDU.

Evaluating interventions

Studies on the traditional system

Careful monitoring of all interventions is an integral part of the programme's research strategy. During 1982 the team continued to collect data from 42 farmers in both Debre Zeit and Debre Berhan who have not recently adopted or tested any technical innovations. Data from this control group provide standards against which the effects of new technology can be compared.

These surveys, which began in 1977 at Debre Zeit and in 1979 at Debre Berhan, cover farm input/output patterns, household consumption, cash sales, off-farm income, farm inventories, livestock productivity and market prices. The survey results are also used by the team to improve its understanding of the farming systems in the zone and to focus its component research on the most important constraints.

Dairy crossbreds

An early improvement introduced by ILCA was that of small-scale dairying. The package comprised a crossbred Boran x Friesian cow fed on oats/vetch forage, and the use of fertiliser and improved seed for cereal cropping. Crop yields increased and allowed a reduction in the food crop area, thus releasing land for growing forage. The package was first introduced to 18 farmers at Debre Zeit in 1978. Results to date indicate average yields of oats/vetch mixtures of 4 t DM/ha, and average milk yields of 2500 kg/year. Crop yields for these test farmers were 40% above those of control farmers, and net cash income rose from US$ 200/year to US$ 800/year.

During 1982 the team extended this package to another 16 farmers at Debre Zeit and to 20 farmers at Debre Berhan. Some of these farmers have better access to a liquid milk market than others; thus the team will be

New frontiers in livestock technology

Biotechnology is making rapid advances in many areas of agricultural science. In animal breeding, embryo transfer is now almost a routine procedure, while the manipulation of embryos to create genetically modified animals is being attempted, as is the cloning of embryos to produce a series of animals of identical genotype. Although the genetic engineering of animal tissue is a highly exacting technique, notable advances are currently being made, mainly in laboratories in the developed countries. ILCA is following these activities with keen interest in relation to their potential use in improving livestock production in Africa.

Monoclonal antibody production now makes it possible to identify genetic markers associated with key animal production traits. ILCA is particularly interested in identifying genetic characters that may be associated with trypanotolerance. The techniques involved are complex and expensive, and at this stage ILCA's role is merely that of onlooker, keeping a watchful eye on the pioneering work of laboratories with an established capability in this field, such as the International Laboratory for Research on Animal Diseases (ILRAD), Nairobi. The use of monoclonal antibodies to improve diagnostic procedures in animal health investigations is also a most important advance, of great potential value to ILCA's work.

In animal nutrition ILCA is particularly concerned with the role of legumes as a critical source of supplementary protein for African livestock during the dry season. Genetic engineering to adapt key legume species to difficult environments, together with genetic modification of the microbial rhizobia species associated with these legumes, are new research fields of considerable interest to ILCA.

Assessing intake in free-grazing animals, measuring nutritional balance in livestock under various management conditions, diagnosing the reasons for low reproductive performance and clarifying the interactions among the different causes of young stock mortality – all these are fields in which ILCA is working and where further technological advances would help resolve the constraints on increased livestock output in Africa.

able to examine the importance of market access in the adoption of dairying.

Future activities

A dairy technology study will begin in 1983 which will examine the techniques for processing milk into products such as hard cheese and ghee, which are more marketable than liquid milk in areas far from towns. A small dairy unit, using low-cost technology, will be operated at Debre Berhan where this study will be centred. The project is supported by the Irish Government and construction of the unit began in 1982. This research will be closely linked with the programme's forage production studies on smallholder farms keeping crossbred dairy cows.

In 1983 the team will begin to assess the production potential of indigenous sheep grazing improved pastures at Debre Berhan. The productivity of local flocks in this area is comparatively low. The team is therefore planning a set of trials with some 1000 ewes to investigate the performance of flocks under a variety of management regimes.

A 2-year cooperative trial on animal traction with the IAR and ARDU will start in 1983. A common design has been developed for this trial on the three major soil types found in Ethiopia. The trial will provide detailed information on the benefits of improved implements and different ox breeds throughout the highland zone.

The Subhumid Zone Programme in Nigeria

Introduction

The subhumid zone of West Africa, shown in Figure 1, covers 1.3 million km^2 of savanna. With its low population density (20 persons/km^2), a mean annual rainfall of 1000-1500 mm and a growing season of 180-270 days, this region is attracting migrants from both the congested humid zone to the south and the arid pastoral grounds to the north. Only small parts of the zone are currently under cultivation, but if heavy in-migration persists at its present rate then all the available arable land will be cropped by the end of the century.

Throughout this zone livestock output is seriously constrained by the poor quality of fodder available during the dry season. This prime constraint has been the focus of ILCA's Subhumid Zone Programme since it was established in northern Nigeria in 1978. Seven scientists, backed by two part-time consultants, are investigating methods of increasing the supply of high-quality fodder during the dry season in two areas south of Kaduna: Abet and Kurmin Biri.

The two study areas are the same size (2500 km^2) and both contain arable farmers and Fulani agropastoralists. The sedentary arable farmers cultivate sorghum, millet, maize and a wide range of other crops, for both consumption and sale, and generally rear a small herd of goats. The central activity of the agropastoralists on the other hand is livestock production, cropping being of lesser importance. Their herds of Bunaji (White Fulani) cattle averaging 50 head in size, together with smaller flocks of sheep, graze natural pastures throughout the year and crop residues after harvest. In the dry season the arable farmers pay the Fulani to corral their animals overnight on individual farm plots where they drop their manure, a practice which helps to maintain soil structure and fertility. The Fulani prefer to sell sheep rather than cattle, sales of the latter occurring only when animals are incurably diseased or in order to finance a major expense.

The human population density at Kurmin Biri is 12/km^2, while at Abet it is 70/km^2, resulting in considerable interaction between the two ethnic groups in the latter study area. One mode of interaction is the exchange of goods and services, the Fulani selling milk and manure to the arable farmers or bartering them for grain and the right to graze crop residues. A second mode is the control of land rights, these being temporarily granted by the arable farmers to the Fulani. The result of these two separate interactions is an interdependency between the two groups. ILCA's studies of land tenure and traditional authority structures have revealed no rising trend in conflicts over land allocation or crop damage by livestock, and it appears that the two groups are co-existing peacefully.

In the sparsely populated area of Kurmin Biri the state government has established a 30 000-ha grazing reserve where Fulani may settle, graze their herds and cultivate subsistence crops without the prior consent of arable farmers. Land security is therefore greater, and technical change may proceed more smoothly here than in Abet. But because the role of grazing reserves in national terms will always be relatively small, the research at Abet, although more complex, stands to yield greater dividends.

A diagnostic survey, started in 1978, revealed the effect of poor-quality fodder on cattle production. For 5 months of the

year protein intake was insufficient to meet even maintenance requirements, and cattle liveweight fell by some 15% during the dry season. From the start the programme has therefore had one central aim - to find a way of producing forage legumes appropriate to the agropastoralist in terms of his resources and objectives. This would enable agropastoralists to establish and maintain plots of forage legumes to feed to in-calf and lactating cows after crop residues have been exhausted. It is this target group within the herd whose protein deficit is most debilitating and where improved nutrition will generate the greatest benefits: increased milk offtake for human consumption, higher calving rates, improved calf survival and faster calf growth.

The team set out to show agropastoralists the benefit of rationing scarce feed resources to selected animals. They were encouraged to feed cottonseed cake to in-calf and lactating cows only, instead of feeding it sporadically and unsystematically to the whole herd, which was the general practice.

Milk yield and other production parameters improved when rationing was practised, and this encouraged some agropastoralists to adopt the concept. This first phase of the programme is continuing under the aegis of the National Smallholder Dairy Scheme and is currently being monitored by the ILCA team. The acceptance of rationing is crucial, since it is essential for the efficient utilisation of forage legumes, the introduction of which forms the second phase of the team's research. This two-phase approach to the successful introduction and utilisation of forage legumes has been accepted by the extension services and has formed the basis of an extension film made by the Livestock Project Unit of the Federal Livestock Department.

Descriptive studies

Herd monitoring

Since 1979 45 local herds, comprising some 1600 cattle, have been closely monitored to determine herd structure and productivity as a baseline for the evaluation of interventions. Initial analyses have revealed a low level of productivity in traditional systems: a calving rate of 49%, a mean milk yield of 0.7 litres/day and a mean calf weight at one year of 86 kg. A bimodal pattern of calving was evident, reflecting higher conception rates in the early wet season, and also directly after harvest when crop residues are most readily available. This survey will continue during 1983 but at a reduced level of data collection.

Small ruminant studies

In both Abet and Kurmin Biri small ruminants are common, with Fulani households owning up to 10 sheep and arable farmers generally keeping a few goats. In January 1982 the team started to record the productivity of approximately 200 sheep and goats to identify the main constraints on output - currently thought to be either a high level of disease or inadequate nutrition.

Health surveys

Tick-borne diseases. The seasonality of tick infestation in Kurmin Biri has been studied since January 1982. From December to April tick numbers were low, but they increased sharply in June with the onset of the rains. Numbers of all species except *Amblyona* spp declined rapidly after only 2 weeks of the rainy season and studies revealed that children were removing ticks from cattle by hand. If these children begin to attend school, an acaricide spraying programme may be necessary as an alternative form of control.

Brucellosis. With the assistance of the National Veterinary Research Institute at Vom, the team started brucellosis testing in 1982. Sixteen herds have so far been examined using the milk ring test; positive responses were observed in two herds, five were inconclusive

while nine were negative. Serological tests to identify infected individuals are now in progress.

Sociological studies

Earlier work at Abet on land tenure and authority structures had suggested that the fencing of plots - essential for the management of forage legumes but hitherto unknown in the area - was not likely to arouse the hostility of the arable farmers, provided that local authorities had been consulted beforehand. During 1982 four plots were fenced in Abet for the cultivation of *Stylosanthes* in fodder banks without opposition from arable farmers. However, the reaction of arable farmers may well change with increasing numbers of such fodder banks in any one district. The recording of farmers' opinions over time and with increasing numbers of fodder banks is essential for assessing the potential uptake of this innovation in different situations.

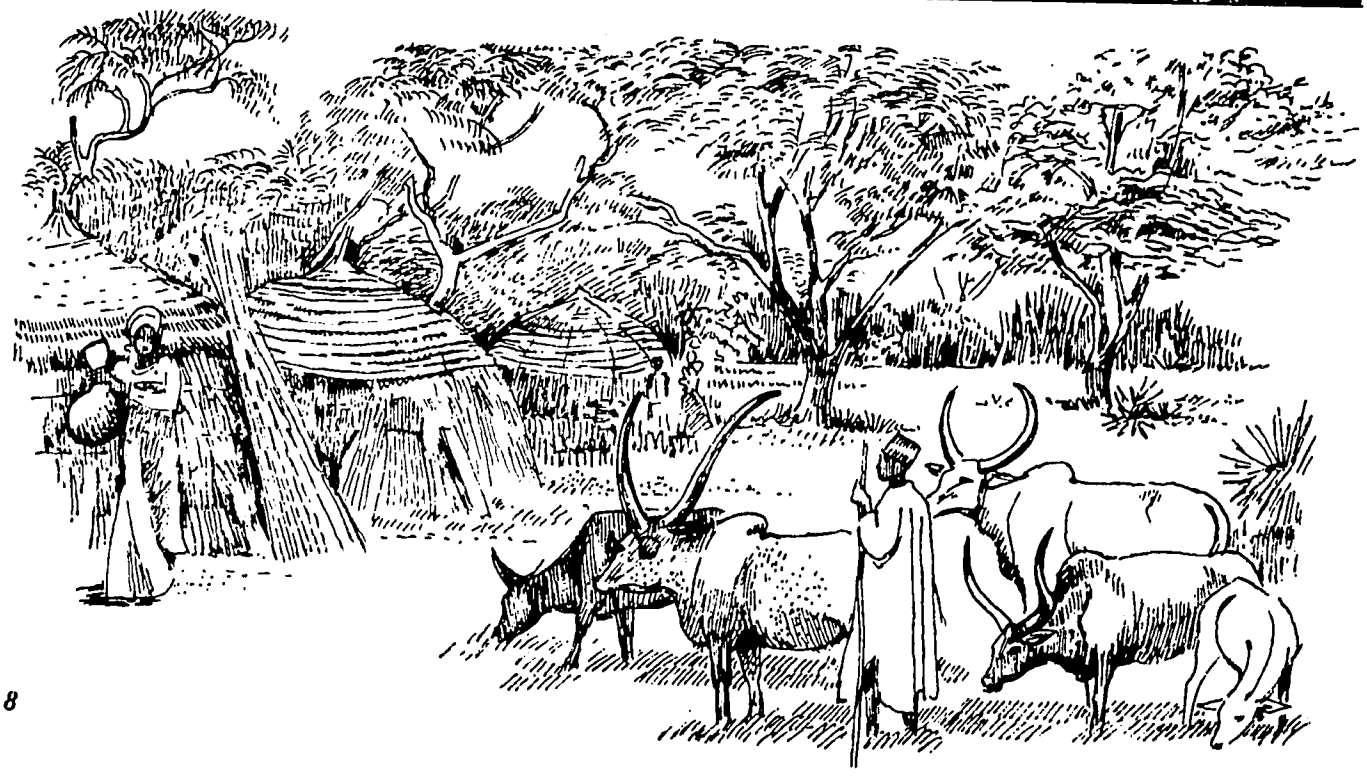
In 1982 a survey was conducted to find out how resources and income were controlled within households, since it is important to direct interventions towards those responsible for the relevant decisions. The study showed that Fulani women often own some animals or hold them in trust for their children. Extension efforts should therefore be directed towards women as well as towards men.

A further study - on the spatial settlement of pastoralists in Abet - was started in 1982 to find out why the Fulani settled in particular places and how their grazing rights were defined.

Assessment of crop residues

Earlier studies on grazing behaviour had indicated the important role played by crop residues in livestock nutrition. During 1982 the team measured crop yields and the nutritive value of residues from 64 fields. Mean grain yields of sorghum and millet were 950 and 770 kg/ha respectively. Table 2 gives residue yields and their nutritive value for these two important cereals.

Table 2. Yield (t/ha) and nutritive value (% DM) of sorghum and millet residues near Kaduna, northern Nigeria.



Although the stems comprised the greater part of the DM, their crude protein and mineral contents were inferior to those of the leaves. A fruitful avenue for research would be the assessment of leaf to stem ratios in other sorghum and millet cultivars, with the selection and field testing of those lines with the greatest proportion of leaf and the highest nutritional value of the residue.

The team is studying the nutritional importance of the immature grain remaining in heads left in the fields after harvest, together with simple storage methods that will allow residues to be fed to livestock later in the dry season.

Study of mineral status in soil, plants and animals

Yields of *Stylosanthes* spp were occasionally low, even with the application of fertiliser. A 12-month study to determine nutrient status throughout the production chain therefore began in October 1981. A final report will be issued in early 1983 which will identify any mineral deficiencies that are likely to affect plant and/or animal output.

Designing improvements

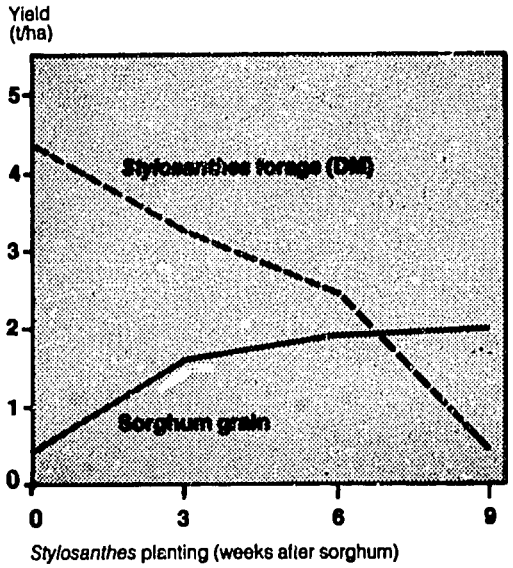
Dry-season fodder

Studies at both Abet and Kurmin Biri have shown that during the growing season very little surplus labour is available. If agropastoralists are to be able to grow forages, either labour must be saved within the present system or low-labour methods of forage management must be found.

For dry-season forage the team has focused on *Stylosanthes* spp, as this genus performs well in the subhumid zone. In 1982 the team continued to examine ways of producing *Stylosanthes* on both cropped and fallow land with minimal labour requirements.

1. *Production on cropped land.* Sorghum is the first crop to be sown by agropastoralists and the team examined the practicality of undersowing *Stylosanthes* into a sorghum stand. The date of undersowing was found to be critical for the yield of both crops. High yields of *Stylosanthes* with little reduction in sorghum yields were obtained when the former was undersown 3 to 6 weeks after sorghum establishment. Results from these trials are shown in Figure 2. Sorghum yields in the trial were substantially higher than those recorded on farmers' plots because improved cultivars and fertiliser were used.

Figure 2. Effect of time of sowing on yields of sorghum grain and *Stylosanthes* DM near Kaduna, northern Nigoria.



The undersowing of *Stylosanthes* into a stand of sorghum is technically attractive, but the desired date of undersowing coincides with a period of high labour demand for weeding This technique may thus prove unattractive for agropastoralists.

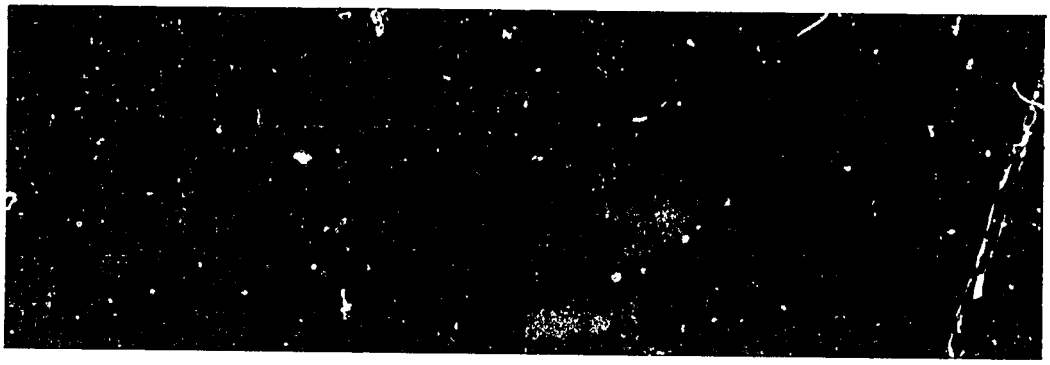
2. *Production on fallow land.* Of greater promise is a low-labour method for establishing *Stylosanthes* on fallow land. Seed is sown on fenced land that has been trampled by cattle at the start of the rains, thus avoiding the need to cultivate by hand. Later the herd returns to graze the fast growing native grasses which compete with the legume seedlings.

Five such fodder banks were established in 1981. The subsequent response from agropastoralists was gratifying and an additional 16 were set up during 1982. Two of these were sown without inducement or technical assistance from ILCA.

The performance of these fodder banks has been very encouraging: yields and nutritional value of three of the earlier banks during their first dry season are given in Table 3.

The CP content, which fell to a minimum of 6% DM, was consistently superior to that of the native pasture at comparable times during the dry season. The team is currently monitoring the performance of some 200 cows that agropastoralists are rationing on fodder banks.

Table 3. Yield and composition of forage available in three fodder banks during the dry season (1981/82) near Kaduna, northern Nigeria.



To derive the probable benefit of the nitrogen fixed by *Stylosanthes* and to avoid the premature ploughing-in of *Stylosanthes* by farmers anxious to reclaim their land for growing their own crops, research has been conducted on the transplanting of sorghum and millet seedlings into swards of *Stylosanthes*. The transplanting of cereal seedlings from a nursery is already practised in the existing farming system as a technical adaptation to the shortage of labour: seedlings are transplanted throughout the growing season as land is cultivated. The team found that yields of sorghum transplanted into *Stylosanthes* stands were some 20 to 30% lower than those obtained in pure stands, but that labour input was only two thirds the requirement for conventional ridge planting. Returns to labour were therefore higher.

A second method of incorporating forage legumes into the cropping system lies in the rotation of cropped plots within the forage stand. However, this method is in its earliest stages of research and, like the transplanting of cereals, requires further investigation.

Legume screening

Some *Stylosanthes* cultivars have been slightly damaged by the plant fungal disease anthracnose, and there is a danger in relying entirely on one legume genus alone. A screening house was constructed during the year and 68 accessions of seven different legume genera were received. These lines are currently being multiplied and screening will start in 1983.

Crossbred cattle

The use of exotic x native cattle by traditional pastoralists may become feasible if forage legumes are available to improve their nutrition during the dry season. In 1981 a small number of Friesian x Bunaji cows were introduced into local herds for observation during 1982. Initially, tick-borne diseases were a problem as the cows were unused to deticking by hand and had little natural immunity. However, these diseases have now been brought under control through a combination of chemo-immunisation and acaricide spraying. The virus disease dermatophilosis (*Dermatophilus congolense*) is now the major disease problem and has so far caused two cows to be culled. Assessment of the performance of crossbreds will continue through 1983, using Bunaji cows under identical conditions as controls.

Calf helminthiasis

As is to be expected in sedentary herds, helminth infection is high: 40% of 94 calves sampled had faecal egg counts in excess of 400/g of faeces during August and October 1981. A trial on the strategic control of helminths in 30 local herds began in April 1982. Two groups, each of 60 calves, were treated with anthelminthics either twice or five times annually and their growth rates compared with a control group. The trial will continue until January 1983.

Technical cooperation

The team maintained close contact with the National Animal Production Research Institute (NAPRI) at Zaria and with the regional agencies of the Federal Livestock Department (FLD). The study of mineral status in soil, plants and animals was conducted by a visiting scientist from Ahmadu Bello University, Zaria, where the chemical analyses

were conducted. A veterinary pharmacologist from the same university, studying traditional anthelmintics, assisted the team in its helminthiasis trials. Land and staff were made available to the team by the Kaduna State Ministry of Forestry and Natural Resources. The National Veterinary Research Institute at Vom conducted brucellosis testing and made post-mortem results available. With support from the Livestock Project Unit (the development agency of FLD) and staff from NAPRI, the team ran a course on fodder production and pasture evaluation for extension staff and took part in a workshop on pastoral development. During 1983 the team will assist in the training of staff for a livestock systems study project at NAPRI.

Future activities

The multidisciplinary research programme, with its central objective of overcoming the shortage of high-quality dry-season forage, will concentrate on the management of fodder banks, with some component research on specific aspects of forage production. It will also study the production, storage and utilisation of crop residues.

The Humid Zone Programme in Nigeria

Introduction

Much of the low-lying coastal belt of West Africa lies within the humid zone. The high annual rainfall (more than 1500 mm) and high mean temperatures (27-32°C) of this region combine to raise the relative humidity to 80-90%. The zone covers some 2 million km^2 and is shown in Figure 1.

The vegetation of the humid zone is mostly tropical rain forest, with derived savanna in the less humid areas in the north. In the forest area tree crops such as cocoa, coconut, palm oil and rubber are important sources of cash for the farmer, and in those countries with a high rate of urbanisation, crops which were traditionally grown only for subsistence, for instance yam and cassava, are now important cash crops also. A similar trend has occurred in the derived savanna areas, with maize now rivalling cotton and groundnuts as a source of cash for the farmer. Since the entire zone is infested with tsetse fly, livestock production is limited to those breeds that are trypanotolerant. The size of sheep and goat flocks varies markedly, modal size being about three although flocks of up to 200 are kept in some areas. Cattle keeping is of minor importance because of the low tolerance to trypanosomiasis of most breeds; despite this, African livestock research in this zone has historically concentrated on cattle to the virtual exclusion of sheep and goats. Thus when ILCA established its small ruminant research team in the humid zone in 1979, few base studies existed.

The humid zone team of five scientists is based at Ibadan in the forest zone of southwest Nigeria. The Oyo State Government has made 40 ha of land available at Fashola, in the derived savanna 60 km north of Ibadan, where smallstock are bred for experimental trials. Village work is conducted in the vicinity of Ibadan, in southeastern Nigeria and also in Ghana. Laboratory and computer analyses are performed at the International Institute of Tropical Agriculture (IITA, Ibadan), where the team has a 16-ha experimental plot and office facilities.

During 1982 the team completed a number of surveys and started several new ones in order to understand the traditional systems of livestock production in greater depth. The team also started a series of agronomic and animal nutrition trials and continued to evaluate the small ruminant health package that it had earlier introduced into several villages near Ibadan.

Descriptive studies

Prevalence of tsetse fly

A study to assess tsetse fly challenge was started in October 1982. Fly traps were set up to determine the number and species of tsetse fly at four locations near Ibadan. By the end of the year no flies had been detected at the Badeku village site in the forest zone. Trapping will continue at monthly intervals in order to assess the seasonality of tsetse infestation.

Occurrence of internal parasites

A continuing veterinary survey is examining the occurrence of endoparasites in 850 goats and 150 sheep in two villages near Ibadan. Few small ruminants were found to be infected with trypanosomes, but in those that were, blood counts of *Trypanosoma vivax* were high. The consequences of such high blood counts are now being studied, particularly the possible depressive effects on productivity of trypanotolerant stock.

Three major types of worm egg were identified in the samples: *Strongylus, Strongyloides* and *Moniezia.* A few *Coccidia* ova were also seen. Of these *Strongylus, Moniezia* and *Coccidia* are the most important in terms of potential effects on productivity. However, clinical coccidiosis was not common. *Strongyloides* counts were considerably higher in the forest zone among sheep in the late wet season, whereas the incidence of *Strongylus* fluctuated considerably and showed no clear trend. *Moniezia* counts were also higher in sheep and appeared to reach their highest levels in the late dry season.

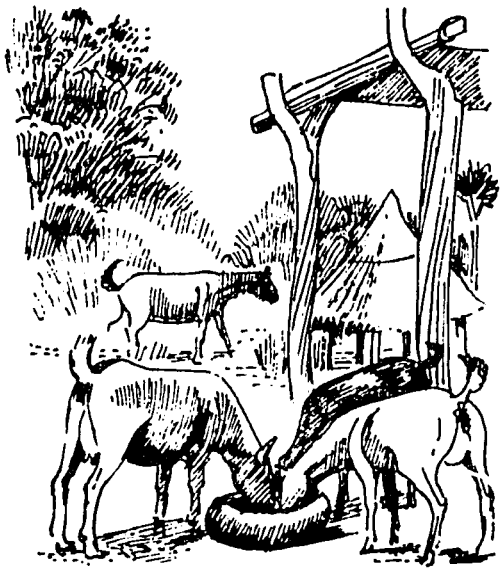
Occurrence of viral diseases

A second veterinary survey, using the same village animals as above, was started in 1982 to study viral diseases in small ruminants. Blood samples were analysed serologically for the presence of viral antibodies. Results have shown infrequent occurrence of antibodies to bovine virus diarrhoea, foot-and-mouth disease and adenoviruses, but many reactors to *peste des petits ruminants* (PPR) and bluetongue. Although no clinical signs of the latter disease were observed, antibodies were detected in 69% of the blood samples. Outbreaks of PPR are common throughout the zone and mortality is high.

This survey of the major diseases is in its preliminary stages, but together with the other disease studies described above, it will provide the team with a complete disease picture by the end of 1983.

Diseases in goats

To assess the incidence of goat diseases the team is monitoring village flocks in the derived savanna. The results from the first 5 months of monitoring were consistent with those from Eruwa, another site in the derived savanna previously studied by ILCA: a high incidence of ectoparasitic infestations accounting for 39% of recorded morbidity. Trypanosomiasis (*T. vivax*) and helminthiasis were the most important single problems, accounting for 17 and 13% respectively of all diseases recorded. It is already clear that trypanosomiasis appears most frequently in adults under stress. PPR was observed in only one area, where it was the major disease. This study will be completed in early 1984.



Studies of intensive livestock husbandry

During 1982 the team received a grant from the Nigerian Federal Government which allowed research to be extended to southeastern Nigeria. In this densely populated area, sheep and goats are commonly housed and handfed on natural forages - a practice that contrasts strongly with the more usual free-range form of husbandry. This monitoring programme will identify any disease and nutritional problems occurring in this more intensive livestock production system.

Livestock marketing

Since July 1981, retail meat prices have been monitored in one urban and three rural markets near Ibadan. Prices varied throughout the year but were highest from August to September, reflecting an increased demand for the Muslim festivals of Id-El Fitri and Id-El Kabri. Rural prices were generally slightly higher than those in the urban market, northern animals were higher priced than southern, and sheep higher priced than goats. The latter were generally available throughout the year.

Mineral content of forage and browse

During 1982 the chemical analysis of 343 samples of forage and browse commonly eaten by village sheep and goats was completed. The mean nitrogen content (2.91% DM) and that of magnesium (0.45% DM) were adequate for all classes of stock. Phos-

Weight of young (g) produced per kg metabolic weight of dam per year.

phorus content averaged 0.23%, which may be insufficient for pregnant and lactating animals, and was only 0.18% in dry-season grasses. The high potassium content (3.16%) may affect the efficient utilisation of sodium, the concentration of which was only 631 ppm. The generally high iron content (over 800 ppm) may depress the uptake of copper and manganese. There were no important differences between zones or seasons. Based on these results, a supplementary feeding study is proposed in order to confirm the plant mineral concentrations at which dwarf sheep and goats respond to supplementation.

Animal productivity studies

A further year's data (March 1981- March 1982) has been added to the original baseline data set, giving a total of 3.5 years' data on animal productivity. Over 3300 animals have been included in the survey, which covered sheep and goats in forest and derived savanna villages.

Overall productivity was estimated using an index of total weight of weaned offspring per year per kg of dam metabolic weight. Zone had relatively little effect on the major components of the index. A zonal effect was apparent only in kid daily liveweight gains to 90 days, with forest and derived savanna kids gaining 38 and 33 g/day respectively.

Analysis showed no clear seasonal pattern for lambing and kidding. Likewise, no clear pattern was observed in the monthly variation in dam weights at parturition. Goats had an annual reproductive rate of 2.2 kids/year/doe compared with 1.5 lambs/year/ewe. However, sheep were significantly more productive than goats, with indices of 1036 and 742 respectively[1]. The difference in productivity between species is attributable to the superior liveweight gains recorded for sheep compared with goats, 74 and 35 g/day respectively.

Designing improvements

Browse as fodder

The potential value of browse as high-quality fodder during the dry season is well recognised and the team has concentrated on ways of integrating browse species into existing farming systems. Thus in 1981 the team began a series of studies on the feasibility of alley cropping, an experimental system in which crops are sown between rows of leguminous browse (*Leucaena leucocephala* and *Gliricidia sepium*), to be grazed by sheep or cut and fed to goats. Some of the trials currently in progress are short-term, while those investigating the effects of such systems on soil fertility are planned for a longer time scale, in some cases up to 10 years.

In one of the short-term trials started in 1981, first maize and then cassava was planted between rows consisting of both *Leucaena* and *Gliricidia*. During 1982 sheep grazed the

natural fallow and the leguminous browse. While the *Leucaena* trees withstood heavy grazing, those of Gliricidia suffered severe damage. The *Leucaena* had been established from seed, whereas the *Gliricidia* had been grown from stakes. Subsequent studies have shown that *Gliricidia* established from seed has a deep tap root, in contrast to the shallow rooting system of *Gliricidia* grown from stakes.

Feeding value of Gliricidia and Leucaena

Twelve ewes maintained good condition when fed on a ration consisting of two thirds *Gliricidia* over 4 months during the dry season. *Leucaena* was fed to sheep and goats in various proportions of the diet. Signs of mimosine toxicity appeared within 6 weeks in sheep fed a diet containing more than 60% *Leucaena*. No signs of toxicity were observed in goats, but they needed up to 10 weeks to adapt to these diets. It is evident that these browse species are most suitable for use as a supplement to a basic pasture diet rather than as the major feed source.

Forage screening studies

A collection of *Gliricidia* lines was made in the Ibadan-Oyo-Ife area and a nursery containing 40 accessions established at IITA. These accessions will be evaluated for variation in gross morphology, flowering and seed characters, and used as a guide for further collections of this species.

The present browse work needs to be supplemented in order to provide other options in situations where alley cropping is less appropriate and where the two species presently used are unsuitable. The browse evaluation nursery established in 1981 was expanded with the addition of 30 new accessions in 1982. Entries established in 1981 have been managed in a variety of ways in an attempt to ascertain their potential use as intensively managed browse species. To date, no entry has appeared as productive or manageable as *Leucaena* and *Gliricidia*.

Living fence

The team has successfully developed a living fence utilising *Leucaena*. When small ruminants are fitted with neck yokes this fence is impenetrable, providing smallholders with a fence that is both cheap and easy to maintain.

Evaluating interventions

The monitoring of some 3300 small ruminants over different periods between late 1978 and mid-1982 has enabled the team to assess the productivity of flocks under village conditions. In April 1980 a veterinary package consisting of Tissue Culture Rinderpest Vaccine (TCRV) against PPR and mange control through dipping was introduced by the team into the survey area. Data analysed so far suggest that the package improved kid survival rate from 67% to 86%, while the weight of young surviving to 90 days per kg of doe metabolic weight increased from 665 g per year to 819 g per year. It is still not clear whether these treatments are profitable, and the team is therefore undertaking village trials to compare the performance of treated animals with that of control groups.

Future activities

The main research themes will be continued so that the full potential of alley cropping can be appraised. The team will also undertake alley cropping research on acid soils and in the intensive systems of southeastern Nigeria. In addition to their role as a source of dry-season fodder, browse species may also have potential as mulch in the cultivation of crops. The team will therefore investigate the agronomy and economics of these alternative uses for leaves of browse trees. Four different rates of mulch application to maize and cassava plots will be compared for their effects on crop yield, soil fertility and soil structure.

It is proposed in 1983 to start a limited herbaceous legume and grass screening project. Only a small number of "best bet" species will be evaluated for use in particular environments and management systems. Much of the team's germplasm has been shared with the Forage Legume Agronomy Group at ILCA headquarters as part of the centre's strategy to provide a strong core of legume germplasm.

Technical cooperation

During 1982 links were established with the University of Ibadan to undertake joint studies on the control of PPR through vaccination. The team worked closely on alley cropping research with IITA, and maintained the cooperative agreement with this institute whereby ILCA has access to labor-

ILCA's approach to livestock systems research

A Workshop on Pastoral Systems Research in Sub-Saharan Africa was held at ILCA headquarters from March 21 to 24 1983. The workshop was attended by participants from many national programmes and universities in Africa, and focused on ILCA's approach to livestock systems research in pastoral regions.

Livestock systems research at ILCA is based on a farming systems research philosophy and seeks to:

- *understand all components of a given farming system;*
- *identify the constraints to agricultural production within that system;*
- *design and carry out research aimed at removing those constraints;*
- *test potential improvements through on-farm (or on-range) trials;*
- *monitor the adoption of the improvements.*

The process is iterative, and there is overlap between its different stages. For example, information from the testing and extension stages is fed back into the design of improvements to the system.

Livestock systems research at ILCA is carried out by multidisciplinary teams of scientists in which generalists are backed up by specialists in all fields of livestock research. The identification, testing and assessment of improvements is a team effort.

ILCA's systems approach to research has evolved from programmes which began in 1976 in Mali, Kenya and the Ethiopian rangelands, in 1977 in Botswana and the Ethiopian highlands, in 1978 in the subhumid zone of Nigeria and in 1979 in the humid zone of Nigeria. It embraces the following stages:

1. The diagnostic stage

The diagnostic stage includes the description of the existing livestock system in order to determine the environmental, technical, economic and social context in which improvements are to be sought. This descriptive process, coupled with continuous analysis of data, leads to the identification of constraints to improved livestock production in the system.

2. The design stage

Potential improvements are then designed, and their likely impact on the natural environment and on the welfare of different social groups is assessed. How quickly an improvement will be adopted is also determined, through the more detailed study of social and economic constraints. Research sites are selected as representative of the target area for improvement. Research on the different components of the system is then carried out, taking into account the other features of the overall system. At this stage trials which are both managed and carried out by the researcher may be made on the research station.

3. The testing stage

The improvements designed in stage two are then tested in trials carried out by producers in the target area. Initially these trials are managed by the researcher, but subsequently by the producer himself. Comparisons are made between enterprises testing the improvements and those using traditional methods in order to evaluate the improvements and assess producers' acceptance of them. There is continuous feedback between the different stages of testing so that adjustments can be made where appropriate.

4. The extension stage

Improvements which have proved successful in trials which were both managed and carried out by the farmer can then be presented for adoption through national extension services. Adoption is closely monitored so that changes in the system can be taken into account in subsequent diagnostic stages to ensure the relevance of subsequent research.

atory and computing facilities and experimental plots.

Financial support

During the year the team received special funding from three sources: the International Development Research Centre (IDRC) for the alley cropping research, the Ford Foundation for technical training and economic studies, and the Federal Government of Nigeria for the studies of pneumonia and PPR, the surveys in southeast Nigeria, the serological analyses and the establishment of ILCA's veterinary laboratory at Ibadan.

The Arid and Semi-arid Zones Programme in Mali

In West Africa the arid zone is delineated by the 100 mm and 600 mm isohyets, while the semi-arid zone, lying directly to the south, extends to the 1000 mm isohyet. In both these zones rainfall is unimodal, falling mostly during August in the northern limits of the arid zone, while at the southern boundary of the semi-arid zone the rainy season lasts 4 months from July to early October. Figure 1 shows the location of these two zones together with that of the Sahel, which receives 200-600 mm rainfall and therefore constitutes the southern belt of the arid zone.

Of the five countries covered by the arid and semi-arid zones in West Africa, Mali supports the highest livestock population. In 1976 ILCA signed a cooperative agreement with the Institut d'Economie Rurale at Bamako and began to study various livestock systems in Mali representing the two main types existing in the two zones, namely pastoralism and agropastoralism.

The example of the pastoral type of livestock system chosen for study by ILCA is that of the Fulani transhumants, who migrate from the floodplains of the inner Niger delta to Sahelian pastures in northern Mali and Mauritania. It is representative of transhumant systems that exploit alluvial floodplains or lakeshores and their surrounding Sahelian pastures, which are found in Senegal, Mauritania, Niger, Chad and Sudan. The Niger delta consists of two separate components: one which is flooded each year is known as the "live" delta, while the other, which is no longer subject to annual flooding, is known as the "dead" delta.

Two variants of agropastoralism are distinguished according to the source of fodder available during the dry season: one is based on millet residues, the other on rice residues. The former predominates throughout the semi-arid zone of Africa, while livestock production using rice residues occurs in irrigated areas and where the water table is high. The agropastoral team is studying examples of the millet subsystem at three different locations near Niono, while research on the rice subsystem is conducted in a rice scheme run by the Office du Niger, the national authority responsible for the development of the river basin.

Research on pastoralism

Introduction

The 54 000 km^2 Niger delta constitutes an invaluable source of dry-season fodder, not only for the livestock population permanently within or around it but also for transhumant herds migrating to it from the north, east and southwest. From late July to early December much of the delta is flooded. Transhumant groups, however, begin to arrive on the banks of the delta as early as October to await permission to cross, and in this transition zone fodder is particularly scarce. Once herds have crossed the Diaka river (a bifurcate of the Niger lying to its west), their subsequent transhumance within the delta as the flood waters recede is, in theory, strictly controlled under the juridical code estab-

lished by Sheik Amadou, the founder of the Fulani theocratic empire of the 19th century. It is estimated that, at the height of the dry season, nearly 1 million cattle and 1.5 million small ruminants graze the pastures of the delta.

Since 1976 ILCA has conducted research not only into aspects of the delta itself but also into the complex system of which the delta is the major component. Research has covered the ecology of both the delta and the surrounding upland Sahel, as well as the management and productivity of a group of Fulani-owned herds that exploit both these sources of fodder. Within the delta itself the highly complex juridical code governing access to pasture has been studied in great detail. The ecological, juridical and livestock research was conducted in cooperation with the Office du Développement de l'Elevage dans la Région de Mopti (ODEM), to which ILCA was under contract from November 1980 until November 1982.

Descriptive studies

Ecological studies

The team's research has furnished a thorough understanding of the ecology and productivity of both deltaic and upland pastures. In the delta, ouput varies with pasture type but lies between 2 and 25 t DM/ha. Much of this standing biomass consists of mature herbage with a low leaf to stem ratio and is consequently of poor nutritional value. High-quality herbage containing more than 60% digestible energy comprises only 10-30% of the grazed biomass, and the supply of fodder containing over 7.4% crude protein rarely exceeds 400 kg DM/ha/year, although at certain times of the year some pastures yield more than 3000 kg DM/ha/year. Growth periods in the delta extend over much of the year, in contrast to the seasonal development of the Sahelian pastures, the production of which rises to a peak and then falls away sharply.

The majority of the species found in the upland Sahelian pastures are annual grasses such as *Schoenefeldia gracilis* and *Cenchrus biflorus*, and tree species, in particular *Acacia seyal* and *Pterocarpus lucens*. Herbage growth begins in late June to early July and provides from 300 to 1200 kg DM/ha. Leaf production of most browse species starts well before the rains and continues into the dry season, when the grass component has dried out.

Cartography

As a sequel to its earlier cartographic studies of comparative land use and zonal ecology, in 1980 the team began the detailed mapping of the entire live delta. This was completed in 1982. The aim was to provide ODEM with a detailed analysis of the delta's resources so that a management plan for cropping and grazing could be formulated. Thirty map sheets were drawn at a scale of 1:50 000, each of which depicted existing vegetation ecotypes and potential carrying capacities. The former were determined from ground truthing, in conjunction with aerial photointerpretation. Corresponding to each ecological map is an equivalent juridical map indicating access to pastures as established by the traditional code of control. The team is currently engaged in mapping the dead delta and, with the completion of this phase in March 1983, the ecological resources of the entire study area will have been mapped. Figure 3 shows these areas, while Table 4 gives details of the maps produced.

Table 4. Maps produced of the pastoral study area in central Mali.

Livestock studies

ILCA began research on livestock production in January 1979 by studying a group of Fulani transhumants based at Diafarabe in the delta and herding some 1400 cattle. Research has revealed the complexity of cattle ownership: while the herder himself possesses some cattle he is by no means the sole owner, additional cattle in his charge being owned by farmers, traders, fishermen, civil servants and other members of his ethnic group. In addition, herd management is especially complex, cattle being continuously re-allocated to groups and subgroups, each of which receives separate treatment. The two main groups are the *garti* and the *bendi*. The *garti* comprises the majority of dry and in-calf cows, young bulls and heifers, some older steers, a few breeding bulls and some lactating cows to furnish the herders with milk for consumption and barter while en route to the dry-season pastures. The *bendi* group consists of most of the lactating cows and a few heifers, steers and breeding bulls. This group remains in the village during the annual flooding of the Niger delta before going on a short transhumant trek of about 100 km into the upland pastures of the Sahel. There it joins the returning *garti*, and the two groups cross back into the delta together at the beginning of December.

The age structure of herds has been determined, and a rapid reduction in the proportion of males in the herd has been observed with age: only 16% of animals are males

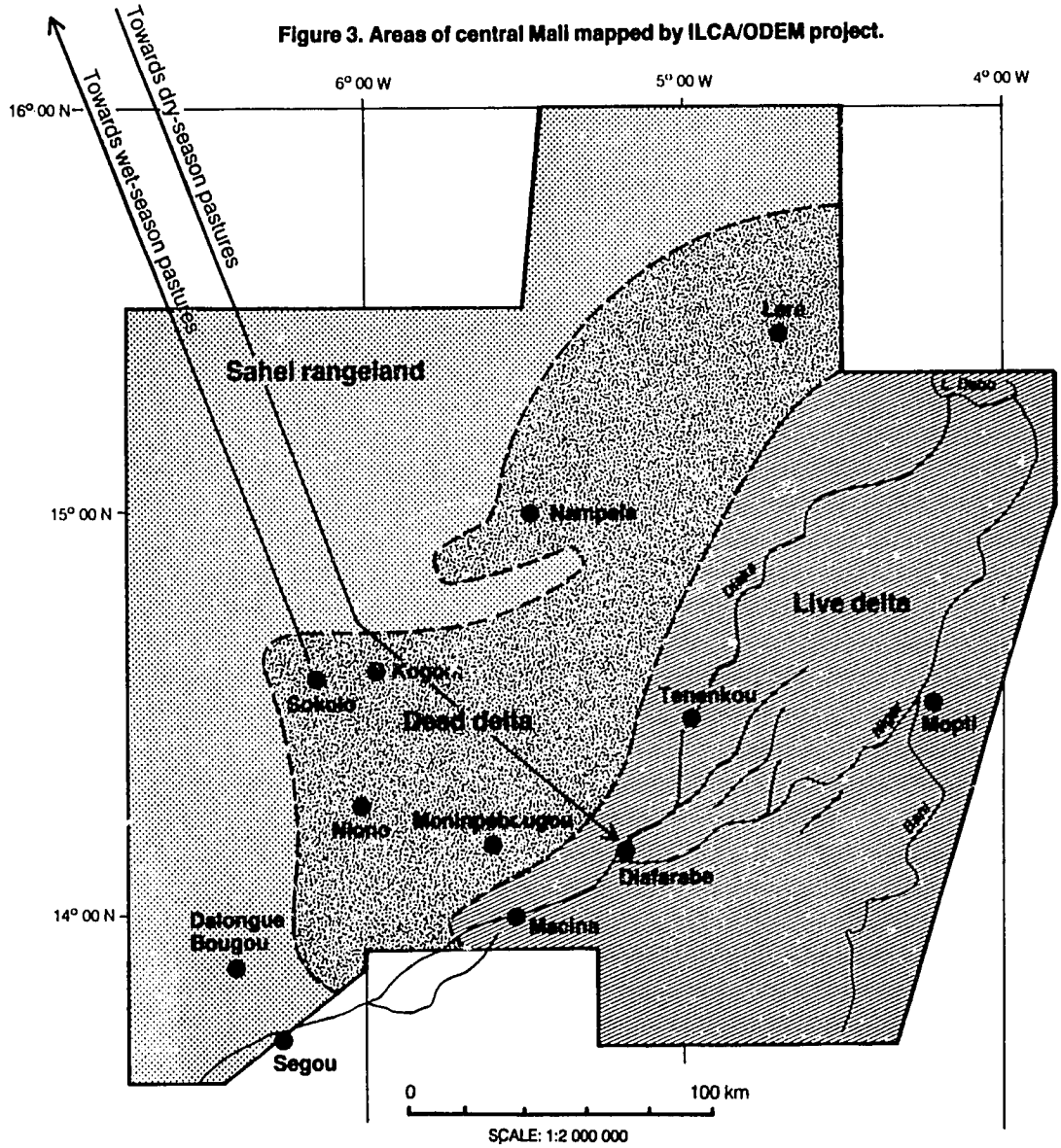
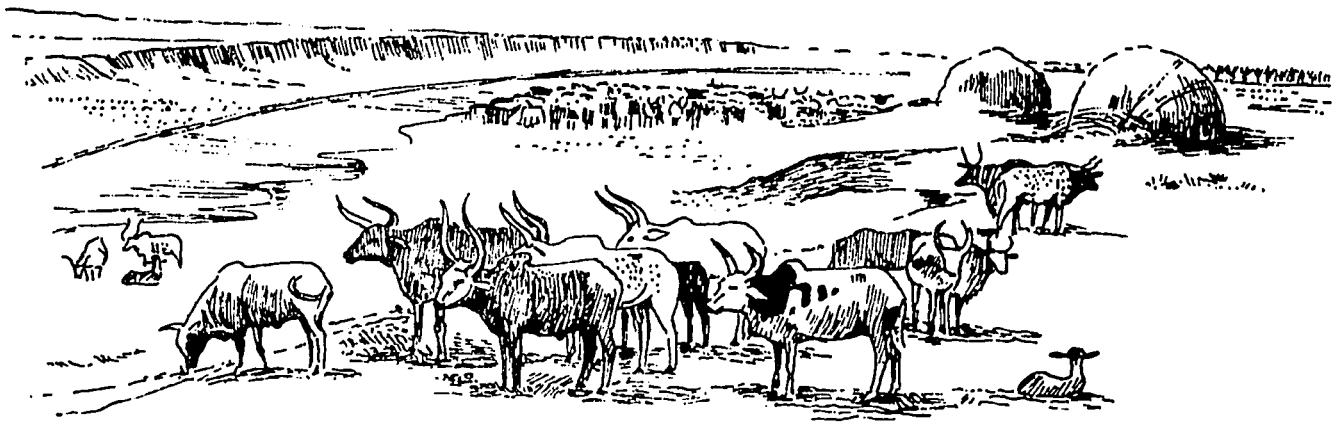


Figure 3. Areas of central Mali mapped by ILCA/ODEM project.



over 3 years old, most of these being used for traction. This feature is consistent with the herders' objective of high milk output. Average milk yield over an 11-month lactation was calculated at 235 kg. A severe weight loss was recorded towards the end of the delta transhumant period. Further investigations led to the tentative conclusion that some of the delta pastures were overgrazed while surrounding areas were stocked below their optimal carrying capacity. A more definite conclusion can be drawn only after compilation of the vegetation map and a more accurate assessment of fodder resources.

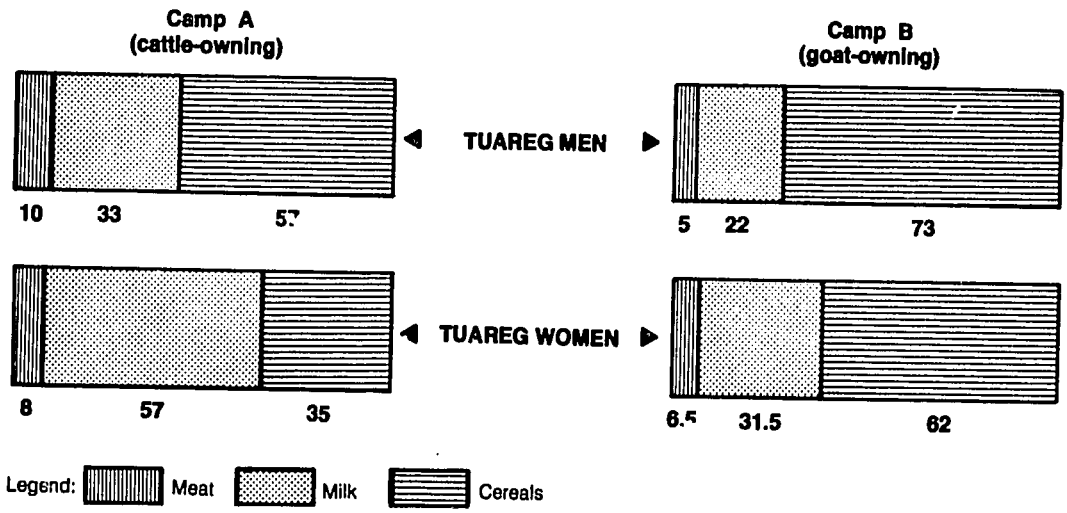
Human nutrition studies

Since June 1981 a survey of food intake and anthropometry has been conducted on two groups in the delta – one Tuareg and the other Fulani. During 1982, one year's data from the Tuareg group were analysed. This group comprised two camps: members of one camp (A) tended to own cattle while in the other (B) goats were more common. Grain, milk and meat were the main food items for both camps. Figure 4 shows the proportion of energy intake derived from these items over 12 months according to sex and camp. Of particular interest was the finding that women in the richer, cattle-owning camp derived more than half their energy intake from milk alone. Cereals appeared to play a more important role in the goat-owning than in the cattle-owning camp. In the latter, no grain was consumed during July and August due to high prices, the inability of cattle owners to sell stock in poor condition, and the long distance to urban markets from seasonal grazing areas.

The survey found that the stress period starts at the end of the dry season and continues until the second half of the rainy season. This coincides with the period of highest disease incidence.

Weight changes in the cattle-owning camp were correlated to food intake, but this was not found to be the case for the poorer

Figure 4. Nutritional energy sources (%) for two Tuareg camps in the inner Niger delta, central Mali.



goat-owning camp. In both camps only a few cases of malnutrition (defined as body weight less than 80% of standard weight for a given height) were observed. Indeed, some of the women were overweight, a tendency which appeared to set in during childhood.

Designing improvements

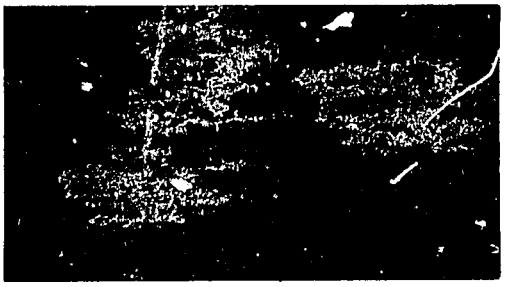
Deltaic pastures

In 1982 10 sites, representing the different vegetation types in the delta, were subjected to various treatments. Five of these sites were in their third continuous year of study, under treatments including early and late burning, early and late cutting, repeated cutting at varying intervals, and irrigation with and without fertilisation.

Around these experimental sites, measurements were taken of herbage removed through grazing and of the biomass remaining, both of which were then related to the observed grazing pressure. The most important conclusions from these trials were:

1. The optimal cutting interval varies with species: for instance, that of *Echinochloa stagnina* was 10-15 days while that for *Andropogon gayanus* was 30 days, as shown in Table 5.

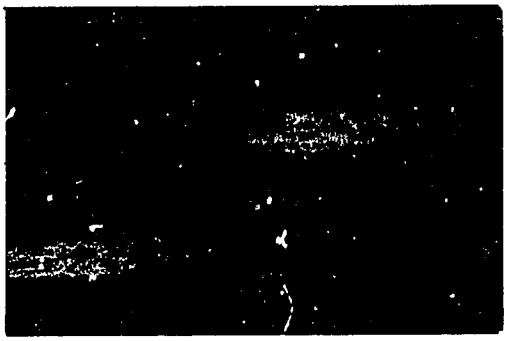
Table 5. Optimal cutting interval of two pasture species in the Inner Niger delta, central Mali.



2. The irrigation treatments demonstrated that substantial yield increases were technically possible, as shown in Table 6.

3. The combined effects of irrigation and fertiliser (50 kg/ha of P plus 25 kg/ha of N/month) gave a threefold increase in yield for *Oryza longistaminata*, from 1124 to 3783 kg DM/ha.

Table 6. Effect of irrigation on yield of four pasture species of the Inner Niger delta, central Mali.



Upland pastures

During the dry season of 1981/82 observations continued on the botanical composition and yield of Sahelian pastures under a variety of grazing regimes and on two different soils. These trials, started in 1979, have shown that dry-season grazing had the effect of enlarging bare areas under trees by less than 5% per year on loamy clay soils, while the tendency on sandy soils is towards denser tussocks and fewer species. Wet-season grazing, if it extends throughout the entire growing season, can be very damaging to vegetation particularly on heavy soils. Experiments have been conducted on 12 browse species to assess production and population dynamics. The results of this study will be available in 1983.

Future activities

The team completed much of its research on the pastoral system in October 1982, when fieldwork for the ODEM contract was finished. However, component research will continue during 1983, focusing on young-stock mortality, epidemiology, and the evaluation of future management schemes for the delta.

In January 1983 an experimental reconnaissance survey of the Gourma region in eastern Mali was launched, and the team may conduct research on nomadic forms of livestock production in this region in the near future.

Research on agropastoralism

Introduction

ILCA's research on agropastoralism has concentrated mainly on the millet-based subsystem, since this is more common in the arid and semi-arid zones than subsystems based on irrigated rice. Research results from both subsystems are presented together here, since direct comparison is useful.

The villages where millet-based agropastoralism is predominant are populated mainly by Bambara families. The Bambara are traditionally arable farmers, but they now own on average some 20 cattle and 30 small ruminants. Fulani households constitute a minority group, being transhumants (and therefore temporary residents), and/or contract herders for the Bambara. Although arable farming and livestock production are generally undertaken by different ethnic groups they are by no means functionally independent: cropping provides valuable dry-season residues for livestock, which in turn supply manure and traction for cultivating the crops. For both groups livestock represent an insurance policy against the vagaries of climate, drought in particular being a constant threat throughout the arid and semi-arid zones.

Descriptive studies

Socio-economic studies

The results of a 2-year study on a cluster of villages growing millet were reported in September 1982. The study examined many features of the local economy and society and tested various hypotheses concerning crop yields.

As part of these studies the effect of manuring was examined by comparing millet yields on fields with and without manure. These yields are shown in Table 7.

Table 7. Effect of manure on millet yields from village fields near Niono, central Mali.

These yields are significantly different within years at the 95% level. Arable farmers with access to manure achieved considerably higher yields than those without.

Livestock productivity studies

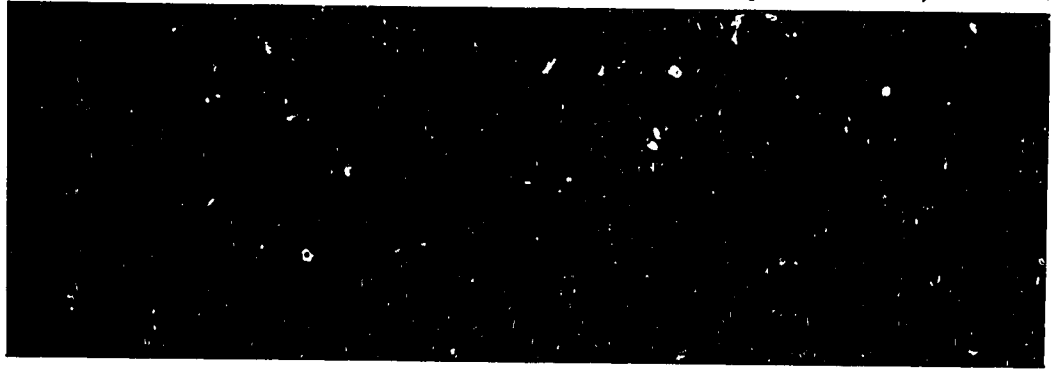
Since 1978, livestock productivity data have been collected for small ruminants and cattle in both the millet and rice subsystems. Analysis has revealed a severe weight loss (18%) in cattle during the dry season due to the lack of sufficient fodder. For sheep and goats productivity parameters have been calculated as shown in Table 8.

These surveys will continue until mid-1983, after which full analysis of this unusually long time-series of data will be undertaken.

Livestock nutrition research

Studies on livestock nutrition continued until November 1982 and concentrated on cattle and small ruminants in both the rice and millet subsystems

Table 8. Productivity parameters for small ruminants in the agropastoral system near Niono, central Mali.



[a] Values for these parameters were not significantly different at the 95% level and were therefore calculated as a mean for the two subsystems.

The following aspects were investigated:

1. Patterns of grazing and fodder availability during the year.
2. The amount of time spent grazing and walking.
3. Fodder intake, quality and digestibility over the year.
4. Feed intake in terms of crude protein and metabolisable energy.

The proportion of time spent by ruminants grazing different types of forage in the two subsystems is shown in Figure 5.

The 3 years' data are currently being analysed.

Designing improvements

Forage legume research

Early studies identified low soil nitrogen as a fundamental constraint on output throughout the millet subsystem. The team is therefore developing methods of introducing forage legumes into the existing cropping system. Since labour is in short supply during the growing season (a feature also apparent from ILCA's research in the subhumid zone), the team is concentrating on the intercropping of legumes with millet. During 1982 242 legume accessions were screened at Niono, the majority of these being varieties of *Vigna sinensis* (cowpea). Cowpea grain yields of up to 724 kg/ha and haulm production of up to 6.5 t/ha were attained, but the yield of one component was generally at the expense of the other. *Phaseolus acutifolius* and *Vigna radiata* gave good grain but poor haulm yields, while the converse was found for *Lablab niger*.

Animal traction studies

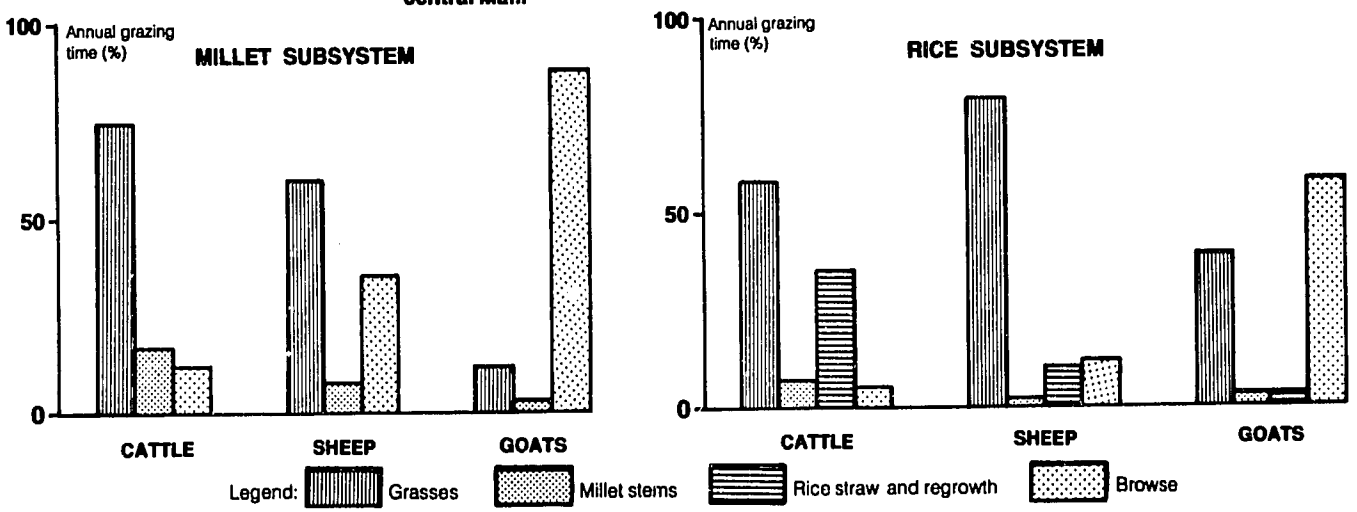
The serious deterioration in the condition of work oxen during the dry season has led the team to examine the feasibility of feeding cowpea hay as a high-protein supplement. During the last 3 months of the dry season of 1981/82, eight pairs of work oxen were fed between 2.5 and 3 kg cowpea hay per day and their performance was monitored in terms of power output and work rate over the ploughing season. A control group receiving no supplementation was observed over the same period. The results of these trials are currently being analysed.

Future activities

The three research topics described above will continue during 1983 and are to be augmented by a veterinary programme that will examine mortality in small ruminants, the mineral status of animals and the epidemiology of livestock diseases. These studies will be conducted in collaboration with the Laboratoire Vétérinaire Central in Bamako.

ILCA will also cooperate in a joint research project with the Institut National de Recherche Zootechnique, Forestière et Hydrobiologique. This project, financed by USAID, will focus on the introduction of forage legumes for smallholder fattening schemes, for milk production and for feeding work oxen. The project will be based at the Centre National de Recherches Zootechniques at Sotuba, with fieldwork also being conducted at the ICRISAT site near Segou and in the Banamba region.

Figure 5. Proportion of time spent by ruminants grazing various types of feed in the agropastoral system, central Mali.



The Rangelands Programme in Ethiopia

The Ethiopian Rangelands Programme is jointly financed by ILCA and the Ethiopian Government through the Rangelands Development Project (RDP), which is supported by the World Bank. Research covers two pastoral societies: the Borana in the south and the Afar in the northeast of the country.

The Borana system

Introduction

The Borana plateau covers 95 000 km^2 of southern Ethiopia and is one of the best preserved pastoral areas of Africa. It slopes gently from an altitude of 1500 m in the foothills of the Bale - Sidamo massif in the north to 1000 m near the Kenyan border in the south. Mean annual rainfall decreases from over 700 mm in the northeast to 400 mm in the southeastern parts of the plateau. The main rains, accounting for 60% of total rainfall, fall from March to May, while the small rains fall from September to November. The timing, frequency, quantity and intensity of rainfall are highly variable during both seasons.

The Borana system is based on a group of permanent wells and a grazing area defined by water availability. During the dry season the Borana can graze their cattle only in a limited area around groups of permanent wells, being excluded through lack of water from the more extensive areas grazed during the wet season.

The Borana divide their cattle into lactating and dry herds. The former remain close to a semi-permanent encampment while the latter graze more distant areas. The lack of surface water during the early dry season means that animals must retreat from wet-season grazing areas before all the available pasture has been grazed. Initial research indicates that as much as 50% of available fodder remains unused. The inability to exploit such fodder resources is a problem common to many pastoral systems.

Research concentrates on approximately 16 000 km^2 of the Borana plateau, an area containing 90 000 people, 325 000 cattle, 125 000 smallstock and an estimated 60 000 camels. A reconnaissance survey preceded the formal research programme, which started in 1981. The team has now completed most of the descriptive studies and has begun to design interventions that may increase livestock output.

Descriptive studies

Water use studies

Water is a critical resource for the Borana. In the wet season the availability of surface water defines grazing limits; in the dry season the output of wells and the availability of forage in their neighbourhood set the limit to livestock numbers. Research on the utilisation of water therefore represents an effective method of studying the whole livestock system.

During 1982 studies were conducted on the utilisation of wells and ponds. Initially, 30 groups of wells were examined during the main dry season, from November to March, while eight of the more representative and important groups were the subject of a more detailed subsequent survey during the short dry season from July to September. Data were collected on a wide range of parameters including the age, sex and origin of the majority of livestock, the size and ownership of

herds and flocks, water intake and quality, grazing orbits, and labour requirements for the watering of livestock. These surveys formed part of a longer study, planned to last 2 years, and have led to a number of supplementary studies, for example on the effect of watering frequency and intake on cattle productivity, and the long-term effects of different grazing pressures on pasture production. Similar studies were conducted on the utilisation of ponds. Most of these studies will be completed in early 1983 and will appear as a series of programme documents.

Ecology studies

After stratifying the study area by field survey in conjunction with satellite imagery, the team selected 12 ecological study areas, each of 400 km^2. The studies in these areas examine plant communities, grass cover, tree density and population, grazing pressure and vegetation dynamics. Field data are augmented by information derived from aerial survey, and range condition is monitored. In two areas a separate study examines cattle condition, while two further areas are currently being developed as ranches by the RDP. Some of these study areas include wells or ponds, while others do not.

Interpretation of ecological data began in 1982 and enabled the team to describe the ecology of Borana in general terms. These studies will continue during 1983.

In addition to these studies, during 1982 the team maintained and upgraded a network of 10 meteorological stations in Borana as part of its long-term ecological research.

Animal production

Studies were conducted on the relationship between milk offtake and calf growth, water intake, herd demography and animal mortality.

Water intake at intervals of 3 days equalled 25% of cattle body weight without any apparent detrimental effects. Further studies will be conducted on the possible physiological adaptation of Boran cattle to such a regime, which has important implications for rangeland development.

Mean calf weaning weight at 120 days was 45 kg, compared with the known genetic potential of 180 kg. Whether factors other than the high level of milk offtake for human consumption influenced this low weaning weight will be a subject for further research. It was also found that the effect of nutritional status on milk yield overrode that of lactation stage, as shown in Figure 6.

Studies on households and pastoral strategy

Since mid-1981 data have been collected from 50 pastoral families on livestock management and household economics. Production parameters such as milk offtake and weaning weight were determined in 1982, and further analysis of the data will be completed during 1983. An extensive demographic study of the network of households

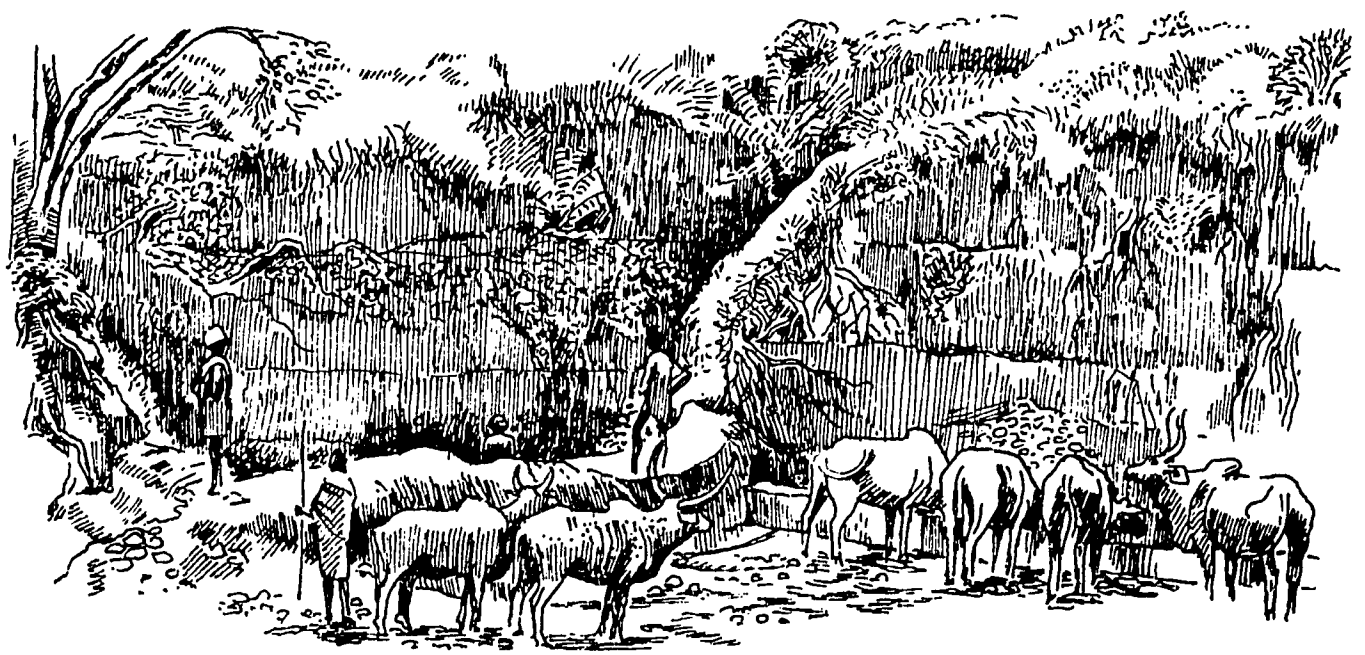
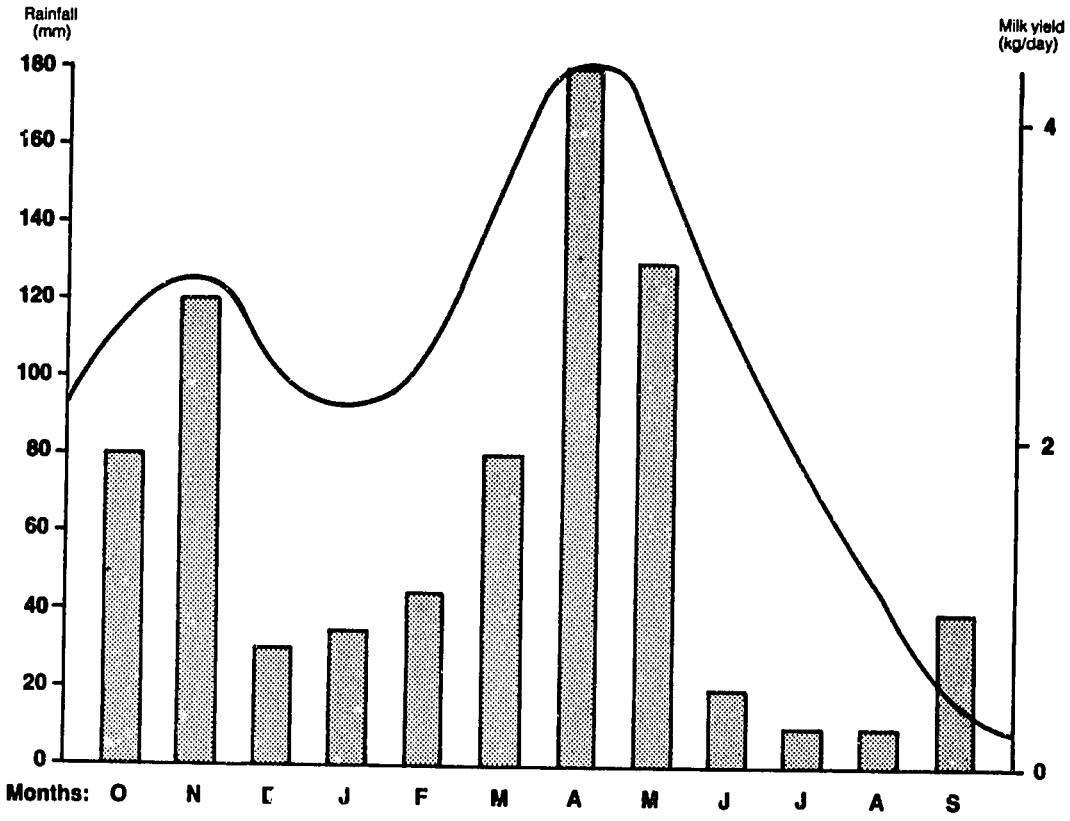


Figure 6. Effect of season on lactation yield for a Boran cow in the southern Ethiopian rangelands.



Calf born: October 1981; Lactation length: 12 months; Total yield: 716 kg

was started during 1982 and will also be completed in 1983.

In June 1982 a low-level aerial survey covered all areas where ground studies are now being conducted and where security was not a limiting factor. The survey indicated marked gaps in livestock distribution, particularly in the western and extreme south-eastern regions. Some areas in the west had high cattle densities, adjacent to other areas with virtually no cattle. These western areas contrast with other areas in the east of the plateau, where stocking densities are more uniform. Contrary to expectations, the highest densities were associated with medium tree cover rather than with open rangeland, and this feature is now being studied.

During the wet season, the occurrence of surface water appeared to be the major determinant of livestock distribution. While further water development may result in a greater use of range resources through more even livestock distribution, this will depend on the future pond construction programme of the RDP.

Historical and archaeological studies

Placing pastoral societies in their historical perspective is important, since present practices, structures and populations can often be explained by past events and are generally part of an historical trend. Thus in 1981 the team collaborated with the History Department of the University of Addis Ababa in pioneering research to discover what changes in ecology and economy have affected the Borana system in the past, and what conclusions can be drawn from them for eastern African pastoralism in general. In particular this work is elucidating ecological events and trends over the last 1000 years, and changes in trading patterns and technology and climatic variation over the previous half millenia. A report on this fundamental research will be prepared during 1983.

Market studies

During 1982 the team continued detailed studies on five major markets. Cattle offtake from the Borana system was found to be

Sub-Saharan Africa in figures

Changes in agricultural output and productivity, 1960-1980[a]

	Output			Growth rates (% p.a.)	
	1960	1970	1980	1960-70	1970-80
Human population (million)	200.9	263.7	350.4	2.8	2.9
Cereal production (million t)	24.5	37.8	42.4	4.4	1.2
Cattle population (million)	96.9	131.6	148.9	3.1	1.2
Small ruminant population (million)	160.8	209.3	238.8	2.7	1.3
Meat production (all types) (million t)	1.6	2.7	3.2	5.1	1.8
Milk production (cows only) (million t)[b]	–	5.0	5.6	–	1.3
Cereal yield (kg/ha)	723.7	793.8	765.0	0.9	0.4
Beef yield (kg/head)	12.8	13.3	13.9	0.4	0.4
Milk yield (kg/head)[b]	–	37.7	37.8	–	0.02
Milk production per caput (kg)[b]	–	19.0	18.0	–	–1.7
Meat production (all types) per caput (kg)	8.0	10.2	9.1	2.5	–1.1
Cereal production per caput (kg)	122.0	143.4	121.0	1.6	–1.7

[a] All estimates derived from *FAO production yearbooks*, with the exception of the 1960 human population estimate for Nigeria, which is adjusted from the 1963 Nigerian census result.

[b] Data on milk production in the 1960s are thought to be particularly inaccurate, and have therefore been omitted.

The table above shows the major trends for agricultural output and productivity in sub-Saharan Africa over the last 20 years. During this period considerable progress has been made in data collection throughout the continent, and data quality has improved substantially. However, the costs of establishing and maintaining statistical services able to cover the entire area of some of the larger African countries are enormous. Hence some individual country estimates may carry an error of up to ± 10%, and the aggregate production figures cannot therefore be exact. It is nevertheless felt that the major trends in population, output and productivity suggested by the table and discussed below generally reflect reality.

The most important trends are:

1. Human population *is increasing at an alarming rate. If it continues to expand at 2.9% p.a., then by 2005 there will be twice as many mouths to feed as there were in 1980.*

2. Cattle population *continued to increase during the 1970s, but at a substantially lower rate than during the previous decade. One of the causes of this slowdown was the severe drought which decimated herds in the Sahel and Ethiopia during the early 1970s. Subsequent recovery of these herds has been dramatic: by the end of the decade cattle population in these drought-stricken zones was only 8% less than it had been in 1970.*

Of great importance, but relegated to the sidelines by the crisis in the Sahel, is the deceleration of growth in the rest of sub-Saharan Africa. Here cattle population grew at 3.7% during the 1960s, falling to 2.1% for the following decade. Since herd offtake has only increased fractionally (from 10 to 11%), the causes for this slowdown must lie in either or both a decrease in fertility and an increase in mortality. The precise reasons are likely to remain unknown, but increasing war, more frequent outbreaks of disease, and poorer animal nutrition are undoubtedly three important contributory factors. Some diseases occurred with increasing frequency during the 1970s due to a breakdown of control regulations and measures, while poorer nutrition in some areas has been caused by overstocking and the continued encroachment of arable farming.

3. Small ruminant populations *closely paralleled the pattern of change set by the cattle population, with a substantially lower growth rate during the 1970s than during the 1960s. Again, the deceleration was not exclusively due to drought: the non-drought-stricken countries recorded a fall in annual growth rate from 3.3 to 1.8%. The major causes of this slowdown are again likely to have been increasing war, more frequent outbreaks of disease and poorer nutrition levels.*

Significantly, small ruminant populations in the drought-stricken countries have already recovered and surpassed their 1970 level, the 1980 population being 2% larger than at the beginning of the decade. This rapid recovery shows how small ruminants, by virtue of their higher fertility rates, are more adapted to drought-prone areas in demographic terms than are cattle.

4. Yields of meat and milk, *which reflect the efficiency with which plant and animal resources are used, have virtually stagnated, although beef yields have increased marginally. Such increases in total output as have occurred are due more to an expansion of livestock populations than to an increase in the efficiency with which these populations and their feed resources are managed. These trends indicate the limited impact improved techniques have so far made on animal productivity, and are of great concern in view of the decelerating growth rate in the cattle population.*

5. Total meat and milk output *has increased over the last decade, but its growth has been less than that of the human population. In those countries with adequate foreign exchange, the shortfall in domestic supply has been met by importing livestock products. But in view of the deteriorating trade balances of many African countries and the decreasing real per caput incomes of a large proportion of Africa's population, the trend towards lower domestic production per caput is extremely serious. It threatens to deprive large numbers of people of convenient and traditional sources of high-quality protein, and jeopardises the healthy development of many of Africa's present and future children.*

Finally, a comparison between livestock and cereal production. Trends for livestock commodities and cereals are very similar – a rapid growth rate in the 1960s, decreasing sharply in the following decade. But while at least a small proportion of the increase in total meat output is due to higher efficiency (reflected in higher beef yields), this cannot be said of cereal production, where yields have fallen. Cereal yields have decreased because of a combination of factors: too little or too much rain, soil erosion, reduced soil fertility and water holding capacity, increased disease, insect and bird damage, and lower levels of management – sometimes due to the poor nutritional levels of farmers and their families.

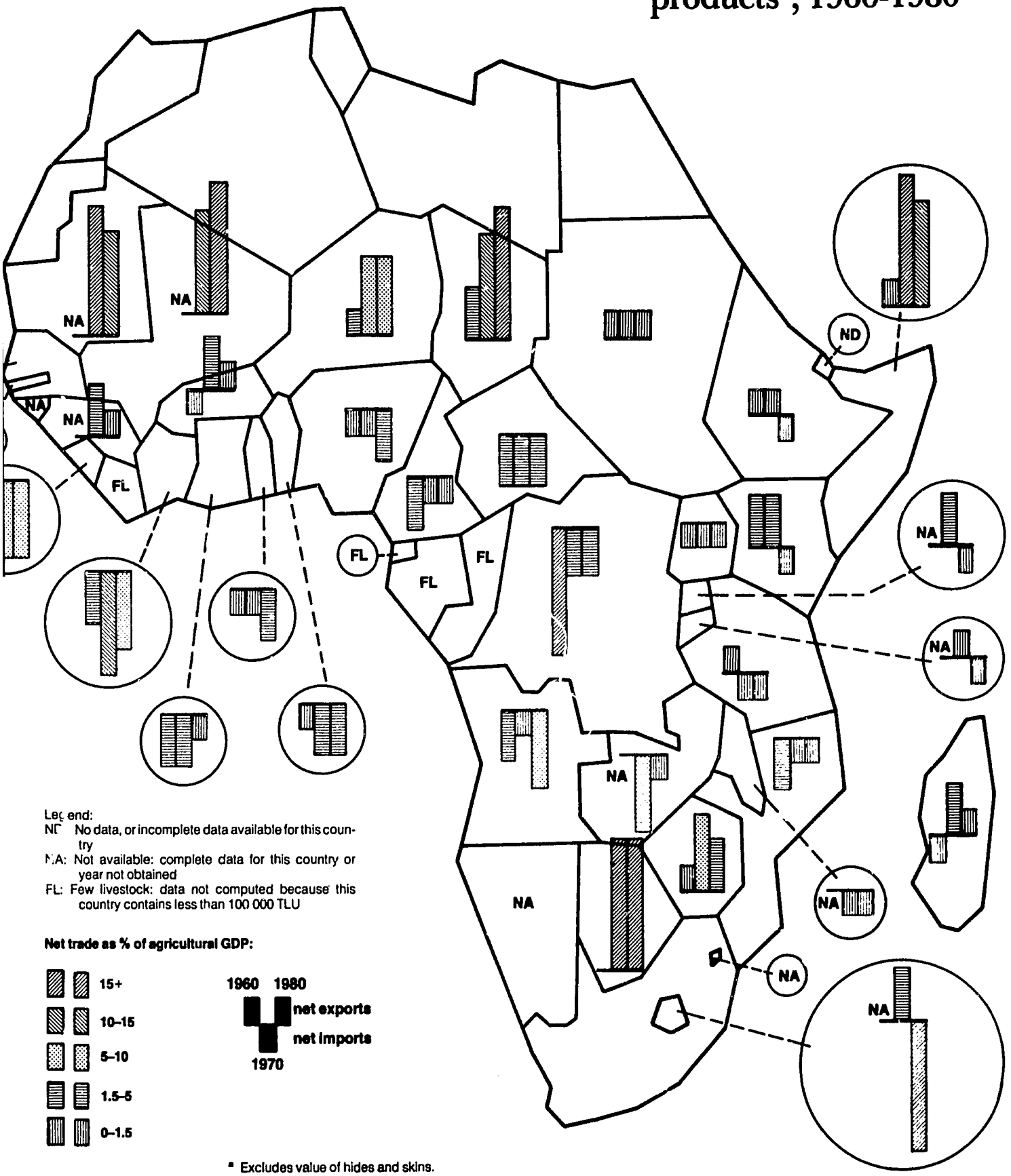
Livestock trade since 1960

In 20 years sub-Saharan Africa's trade deficit in livestock and livestock products[1] has risen nearly tenfold. In 1960 imports were worth about US$ 90 million more than exports; by 1980 the deficit had risen to over US$ 800 million. Only about one third of this enormous rise in net imports can be attributed to rises in prices; the balance represents the extent to which Africa's livestock sector has failed to take advantage of the market opportunities available to it. The map opposite shows which countries are and have been net importers or exporters and how net livestock trade has fared in relation to the agricultural sector generally.

Overall the picture is gloomy, but as the map shows, whether a country is a net importer or exporter is largely determined by its geographical location, and by factors such as climate, population density and infestation by tsetse fly, which are themselves mainly determined by location. Moreover, while the general trend in livestock trade is adverse, there are several countries whose performance has improved since 1960. Furthermore, 65% of the total livestock trade deficit in 1980, and 70% of the deterioration in the deficit since 1960, are due to one country alone – oil-rich Nigeria. On the other hand the apparent improvement in the performance of some other countries is due more to their inability to pay for imports than to an improvement in their domestic livestock production.

[1] *Including eggs but excluding hides and skins.*

Net external trade in livestock, meat, dairy and poultry products[a], 1960-1980



[a] Excludes value of hides and skins.

26C

State of the livestock sector by country, 1980

Country	Population[a] (millions) mid-1980	Area[a] ('000 km²)	GNP per caput[a] US$ 1980	GNP per caput[a] Average annual growth rate (%) 1960-80	Livestock output[b] (annual mean 1979-81) ('000 tonnes) Beef	Sheep and goat meat	Cows' milk	Livestock population[b] (annual mean 1979-81) ('000 head) Cattle	Sheep	Goats
Low-income semi-arid										
Chad	4.5	1 284	120	−1.8	58	21	220	3 900	2 333	2 267
Somalia	3.9	638	–	–	55	85	157	3 883	10 100	16 267
Mali	7.0	1 240	190	1.4	64	50	95	4 953	6 200	6 750
Upper Volta	6.1	274	210	0.1	37	10	44	2 755	1 852	2 794
Gambia[c]	0.6	11	250	2.6	5	73	6	322	158	170
Niger	5.3	1 267	330	−1.6	46	42	95	3 206	2 805	7 023
Mauritania	1.5	1 031	440	1.6	29	19	94	1 195	5 100	2 583
Low-income other										
Ethiopia	31.1	1 222	140	1.4	214	132	617	26 000	23 233	17 177
Guinea-Bissau	0.6	36	170	n.a.	3	n.a.	6	200	50	120
Burundi	4.1	28	200	2.5	14	3	56	846	310	650
Malawi	6.1	118	230	2.9	12	3	34	821	77	645
Rwanda	5.2	26	200	1.5	14	4	26	640	290	875
Benin	3.4	113	310	0.4	10	5	12	766	954	919
Mozambique	12.1	802	230	−0.1	36	2	63	1 400	106	335
Sierra Leone	3.5	72	280	–	3	1	18	343	260	144
Tanzania	18.1	945	280	1.9	130	26	729	12 556	3 782	5 673
Zaire	28.3	2 345	220	0.2	22	9	6	1 183	733	2 751
Guinea	5.4	246	290	0.3	21	2	41	1 753	436	405
Central African Rep.	2.3	623	300	0.9	16	3	4	1 226	84	920
Madagascar	8.7	587	350	−0.5	127	5	36	10 100	590	1 308
Uganda	12.6	236	300	−0.7	82	14	338	4 933	1 072	2 155
Lesotho	1.3	30	420	6.1	8	5	20	595	1 129	777
Togo	2.5	56	410	3.0	4	3	3	230	610	723
Sudan	18.7	2 506	410	−0.2	206	136	939	18 148	17 708	12 532
Middle-income oil importers										
Kenya	15.9	583	420	2.7	198	38	840	10 652	4 333	4 537
Ghana	11.7	239	420	−1.0	13	11	8	943	1 683	2 067
Senegal	5.7	196	450	−0.3	34	8	110	2 344	2 005	1 067
Zimbabwe	7.4	391	630	0.7	113	6	202	5 370	448	1 107
Liberia	1.9	111	530	1.5	1	1	1	39	200	200
Zambia	5.6	753	560	0.2	26	1	47	2 152	49	310
Cameroon	8.4	475	670	2.6	48	15	43	3 195	2 168	2 391
Swaziland[c]	0.5	17	650	7.2	15	3	37	663	45	262
Botswana[c]	0.8	600	720	9.1	40	4	90	2 954	146	625
Mauritius[c]	0.9	2	1 030	2.3	1	n.a.	25	56	4	70
Ivory Coast	8.3	322	1 150	2.5	12	7	9	690	1 200	1 250
Middle-income oil exporters										
Angola	7.1	1 247	470	−2.3	49	3	146	3 117	225	935
Congo	1.6	342	900	0.8	1	n.a.	2	71	8	87
Nigeria	84.7	924	1 010	4.1	204	163	354	12 267	11 683	24 567
Gabon	0.6	268	3 280	6.1	n.a.	1	n.a.	3	100	90

[a] From *World development report 1982*, Oxford University Press (for World Bank), New York, 1982.

[b] From *FAO production yearbook 1981*, FAO, Rome, 1982.

[c] Figures for population, area and GNP from *Accelerated development in sub-Saharan Africa: An agenda for action*, Washington, World Bank, 1981.

n.a. Data not available.

26d

13%, substantially higher than the previous estimate of 6%. This level of offtake represents the maximum that households can sustain - according to estimates derived from earlier studies.

Designing improvements

Food and forage production

In recent years an increasing number of Borana pastoralists have begun to cultivate small plots of food crops near their encampments. If this practice were to become widespread, then a substantial increase in cattle offtake would be possible; it was estimated that 400 kg of maize would substitute for 30% of the milk offtake, which could theoretically release one additional animal per household for sale each year. In this way, 20 000 more cattle could be marketed each year, an increase of 50%.

Since present cultivation techniques are rudimentary, the team will initiate experiments in 1983 with a forage - food crop mixture consisting of legumes and local maize.

Bush control

The ecological studies indicated bush encroachment to be a severe problem. Bush encroachment is a frequent consequence of the prohibition of burning and of changes in livestock population, and is common to large areas of rangeland in eastern Africa. The team therefore undertook a review of previous research on bush control, and started preliminary trials to determine the most cost-effective form of control, accompanied by reseeding trials using grass and grass – legume mixtures.

Feed and water intake, and watering frequency

Most development projects supply water to cattle on a daily basis, although this is expensive. In the Borana system cattle are watered only once every 3 days, yet they appear reasonably productive. The research team is therefore examining the effects of various watering frequencies on productivity, in the hope of identifying more cost-effective methods of overcoming water shortages in arid areas.

Pasture legume trials

The long-term outlook for eastern African pastoralism indicates the need to increase primary production by whatever possible means, including the introduction of improved species of pasture and browse plants. To this end, pasture legume trials were started during the short rains of 1982. Lines of *Lablab, Vigna* and *Stylosanthes* were the most promising of those screened.

Well and pond improvement

The well and water studies found that increases in water output of 7-30% were possible through the sealing and reinforcement of holding ponds and watering troughs. Studies on rates of water lifting from deep wells showed that the size and condition of buckets were major constraints on water output. The prohibition on hunting giraffe and buffalo has meant that new heavy-duty leather is unavailable for the manufacture of replacement well buckets. It was suggested that a trading agreement be established with Kenya for the supply of hides of culled buffalo, 1800 hides being required immediately and 500 per annum subsequently. This would resolve an urgent problem currently confronting the Borana.

Technical cooperation

Throughout 1982 close liaison was maintained between the research team and the RDP. Many of the team's research activities include a service and training component, for example the ecological analysis of project ranch areas, studies on livestock productivity and economics, soil analysis at pond sites, and provision of the results from aerial surveys. When available, RDP staff are trained in techniques and methods of field research. The team also conducted seminars at RDP's headquarters in Sidamo to discuss specific topics and present its research results.

Future activities

In 1983, in addition to continuing the research topics outlined above the team will undertake three further lines of research:

1. Plant biomass assessment

A major problem hindering rangeland research is the lack of a rapid and inexpensive method for assessing and monitoring vegetation and fodder resources over large areas. A technique for estimating plant growth from satellite spectral measurements, developed some years ago at the National Aeronautical

and Space Agency (NASA), is now being tested on Sahel rangeland in Senegal. Initial results are promising, but the higher tree cover of eastern African rangelands requires confirmatory measurement of tree, shrub and grassland vegetation before quantitative interpretation can be made. In association with NASA the team will therefore undertake further testing of this technique, in combination with information derived from low-level aerial survey.

2. Low weaning weights

The team will study the principal causes of low weaning weights other than high milk offtake. This study will be of considerable importance if meat output is to be increased.

3. Nutritional status

Determinations will be made of the content of various nutrients, e.g. nitrogen, phosphorus, calcium and trace elements, in soil, plants and selected animal tissues in order to identify possible imbalances or deficiencies.

In addition to these three further lines of research, during 1983 the team will compile a substantial number of reports covering all the studies so far conducted. These reports will provide the material for a major systems study of the Borana pastoralists.

The Afar system

Introduction

The Afar pastoralists of northern Ethiopia live in an area where the climate is arid to very arid. Severe droughts occur frequently and the viability of the system is in serious doubt. In this pastoral system, camels and smallstock are more important than cattle.

Studies on the Afar system were suspended in March 1982 because of security problems, which had previously disrupted research in the area. Studies during early 1982 covered the following aspects:

Descriptive studies

Marketing

Data were collected and analysed for all markets in the study area, revealing three important aspects of the Afar economy. Firstly the Afar are responsive to smallstock prices, secondly they offer for sale more smallstock than the market system can absorb, and thirdly the demand for grain probably exceeds market supply. The team also established a method for determining the relationship between markets, whereby two "indicator" markets can now be used to represent other markets in the system.

Afar-Oromo relationships and dry-season retreat areas

A particular problem of pastoralism throughout Africa is encroachment on grazing areas by arable farmers. A study of the Tcheffa valley, lying to the west of the Afar lowlands, indicated a conflict over land use, since access to this area is important to the lowland Oromo farmers in most years but crucial to the Afar pastoralists in years of extreme stress. It was proposed that the Oromo plant small plots of forage for both their own and Afar livestock, in order to alleviate the problem of feeding livestock in times of stress.

A second study of the interdependence of the Oromo and Afar showed that while the former may well be able to survive without the latter, the converse is not true. An increasing reliance of pastoralists on arable farmers for access to grazing and provision of grain appears to be a common trend throughout Africa and, as a case study, the Afar situation is of considerable relevance.

Livestock and drought

In regions liable to drought livestock play several roles. In pastoral areas they may provide the main direct forms of subsistence food as well as being the main source of cash income with which other food can be bought. In arable areas not only do livestock provide food and income for their owners, they often also provide critical inputs of draught power and manure to cropping operations. In times of drought, livestock frequently constitute the main capital asset of both pastoralists and crop farmers, which they can sell to buy food for their own survival.

When drought occurs the yields of both crops and livestock fall, as also do the quantities available for domestic consumption or sale. However, whereas the prices of food crops normally rise during drought those of meat and livestock fall, as more animals are sold in poorer and poorer condition in order to buy other food and to avoid their dying on their owners' hands. These price changes are good for crop farmers but can be disastrous for livestock owners.

During drought the marketing of crops in Africa usually presents no problems, the dry weather making transportation easy (except where animals are used) and the rising prices making merchants keen to trade. The marketing of livestock, however, often runs into acute difficulties. With falling prices and deteriorating grazing, traders are reluctant to purchase animals which they may subsequently be able neither to feed nor to sell. Grazing and water supplies along stock routes dry up, making impossible the movement of animals on foot, and in some cases abattoirs do not have the capacity to cope with an increased supply of animals for slaughter

After a drought has ended the recovery rates in the production of livestock and of annual crops also differ. Except where crop production is heavily dependent on livestock inputs of draught power and manure, the areas planted to crops, and their yields, may recover to a normal level within a year of the end of the drought. If the drought has been serious livestock populations may have declined by 50% or even more and, although the calving rates of breeding females are often excellent after a drought, the performance of animals starved at a critical stage in their early development may be permanently impaired. These two factors may cause the level of regional livestock output, particularly from the cattle herd, to be impaired for over a decade after a severe drought. Nevertheless, the decline in livestock populations caused by drought is not wholly deleterious, since it gives some temporary respite for natural vegetation to recuperate.

It is not always sensible, or even possible, to try to stabilise livestock production systems. In regions where rainfall is extremely variable from year to year stability can be achieved only at a lower level of production than that possible if some degree of fluctuation in livestock populations and output is accepted. During drought, particular attention needs to be paid to keeping livestock marketing systems functioning and, after drought, to long-term rehabilitation, if those substantially dependent on livestock for their income and security are not to suffer extreme distress.

Livestock productivity

In 1981 data had been collected from 48 pastoral families, but this activity was disrupted by security problems in the area. Sufficient data had nevertheless been gathered by early 1982 to demonstrate the low productivity of Afar pastoralism and to provide a basis for designing production alternatives.

Future activities

If it is possible to resume research in the area, future studies will include irrigated cropping, small ruminant health and productivity, and improvement of marketing.

The Rangelands Programme in Kenya

Introduction

ILCA's research programme on range livestock systems in Kenya is conducted among the Maasai pastoralists, whose lives are now being affected by the operations of the Kenya Livestock Development Project. The research team aims to find out how, in these semi-arid rangelands, varying levels of development interventions are modifying traditional patterns of production; to identify the continuing constraints on production and the opportunities for increased output; and to clarify causal relations within the production system.

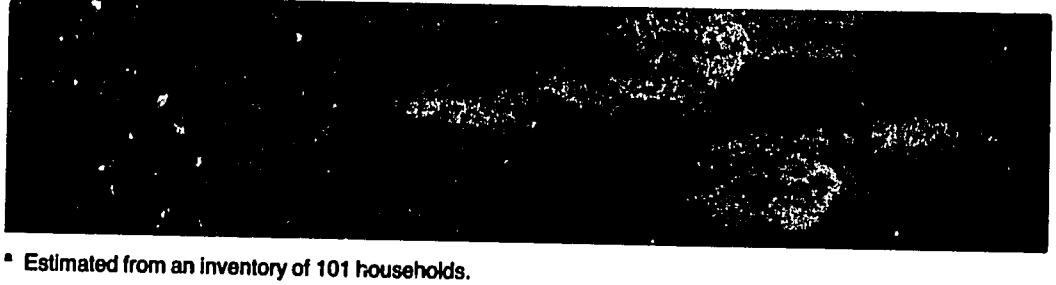
The programme is based on a systems approach whereby the impact on total output of changes in individual components of the production system is studied. Pastoral systems are complex in organisation, a feature that reflects their adaptation to highly variable and risky environments. If development is to increase output, then it must be based on an understanding of the many interactions between the social, economic and technical factors that make up the production process.

The research programme covers an area of roughly 1700 km^2 in Kajiado District, southeast of Nairobi. The site was chosen to include a part of the Kaputiei section of the Maasai grazing lands developed under phase 1 of Kenya's Livestock Development Project, as well as part of the Kisongo section, subject to more recent development under phase 2. This area was selected for study because the Government of Kenya, in consultation with the Maasai, had adopted the group ranch form of territorial organisation as a model for land adjudication for the Maasai people and their socio-economic development. Environmental factors further influenced site selection.

After an initial aerial survey and discussions with officers of the Ministry of Livestock Development, in the second half of 1980 three group ranches were selected for study: Olkarkar, Merueshi and Mbirikani. Inventory surveys of their human and livestock populations were conducted in the same year; the results are shown in Table 9.

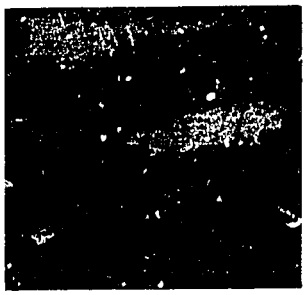
As 1982 was a dry year, there was extensive herd movement from the southern Mbirikani ranch from June onwards to greener areas to the east and south. Much less movement occurred in the northern ranches, where rainfall was higher and better distributed, resulting in much longer availability of green herbage. These movements have been

Table 9. Characteristics of Maasai group ranches in southeast Kenya.



[a] Estimated from an inventory of 101 households.

Table 10. Herd structure (%) on Maasai group ranches in south-east Kenya, 1969 and 1981/82.



analysed in terms of producers' decisions and their effects on herd and flock productivity.

Although land is communally owned, exclusive grazing rights are recognised on calf pastures. The effects of different management strategies for these reserved pastures on species composition and productivity are being measured.

Livestock production

A survey of herd structure showed that, while there were differences between wealth levels and ranches, all Maasai households in the sample were managing their herds for milk rather than for beef production. Indeed, a comparison of results from the UNDP/FAO survey in 1969 with those obtained by the ILCA team in 1981/82 reveals little change in herd structure, as shown in Table 10.

The ILCA survey also revealed a substantial increase in the small ruminant population since 1970. All households owned smallstock, although numbers differed across wealth strata. The cattle to small ruminant ratio for the rich stratum was 1.2:1, falling to 1:1 for the poor stratum.

Data analysed so far indicate a bimodal calving pattern with peaks in October and March. Calf mortality to 90 days was low, at 2 - 10%. Mean liveweight at 120 days was 48 kg, giving an average growth rate from birth of 0.24 kg/day. Sahiwal crosses weighed some 5 kg more at 120 days than Zebu calves, but whether their superior performance continues to 210 days will remain unknown until further data have been collected and analysed.

Total milk production increased from 3.2 litres/day at 30 days to 3.6 litres/day at 120 days, of which 20% was taken for human consumption leaving 80% for the calf.

In sheep and goats births occurred all the year round, with a sharp peak during November - January. The mean litter size for goats was 1.34, and for sheep 1.04. The most productive flocks had litter sizes of 2.0 and 1.17 for goats and sheep respectively, compared with 1.0 for both species in the least productive flocks.

Disease was the major factor in the 34% preweaning mortality rate for goats. For sheep the rate was only 13%, caused mainly by predation. Growth rates to 150 days were higher for sheep (74 g/day) than for goats

(51 g/day). Veterinary investigations began in June 1982 and now consist of a programme of disease detection and control in selected households. The objective of these studies is to determine the degree to which disease is a constraint on output and to evaluate the economics of different control measures.

Livestock offtake and acquisition

The Maasai engage in a variety of livestock transactions to acquire and dispose of their animals. Animals are sold, exchanged for other animals, slaughtered for home consumption and given or lent to friends and relatives.

Data were gathered on all livestock transactions in order to deduce producers' strategies in herd manipulation, to interpret changes in the numbers of animals kept and to determine overall productivity.

Preliminary data analysis for Olkarkar and Mbirikani ranches indicates that poor Maasai had higher rates of offtake than richer Maasai, but that all engaged heavily in non-commercial means of offtake and acquisition.

Figure 7 shows the value of various transactions for poor and rich households in Mbirikani. Sales accounted for just over half of total offtake, the balance consisting of gifts, exchanges and slaughter for home consumption, in that order.

The number of livestock sold and their unit value increased with wealth level, the combined effect being that rich households' income from sales was twice that of poor households. For the latter, the mean sale value per animal, for both cattle and smallstock, was 30% less than that obtained by rich households. This suggests that poor

households were obliged to sell their stock at an earlier age to meet immediate cash needs. Seventy-five per cent of all cattle sold were male, and 65% of these were castrates.

Household budget data

The level, structure and seasonal pattern of income and expenditure were examined by monthly interviews with all adult members in the sample. Figure 8 shows that the major source of cash was the sale of cattle.

Expenditure on food (mostly sugar and maize) was some five times that on non-food items. Clothing was the main non-food item, but transport and medicine were also important.

Cash income and expenditure increased in the dry seasons, when the supply of milk was low and livestock sales were high.

Livestock marketing

In September 1981 the team began its first study of a large cattle market at Emali - the only regular market serving the study area. Data were collected weekly on the number of cattle offered for sale and the number of buyers and sellers. For a 30% sample, sex, age, breed and price were recorded and, once a month, a smaller sample of 7% was weighed. The mean weekly supply of cattle was 286 head, with peaks in December - January and June, following the short and long rains respectively. Market prices were highest in September-October and again in April-May because the Maasai offered fewer cattle for sale in anticipation of the rains, when steers have an opportunity to gain weight and condition and when milk yield increases.

Possible constraints on livestock marketing in the study area include:

1. The absence of an organised market for smallstock. Although some smallstock were traded by Maasai, the lack of access to a regular market appears an important limitation to smallstock sales. In Olkarkar, where there was some access to a trading village, smallstock sales contributed 12% to the total per caput revenue from livestock, compared with an equivalent figure of only 3% in Mbirikani. Lack of market access was also inferred

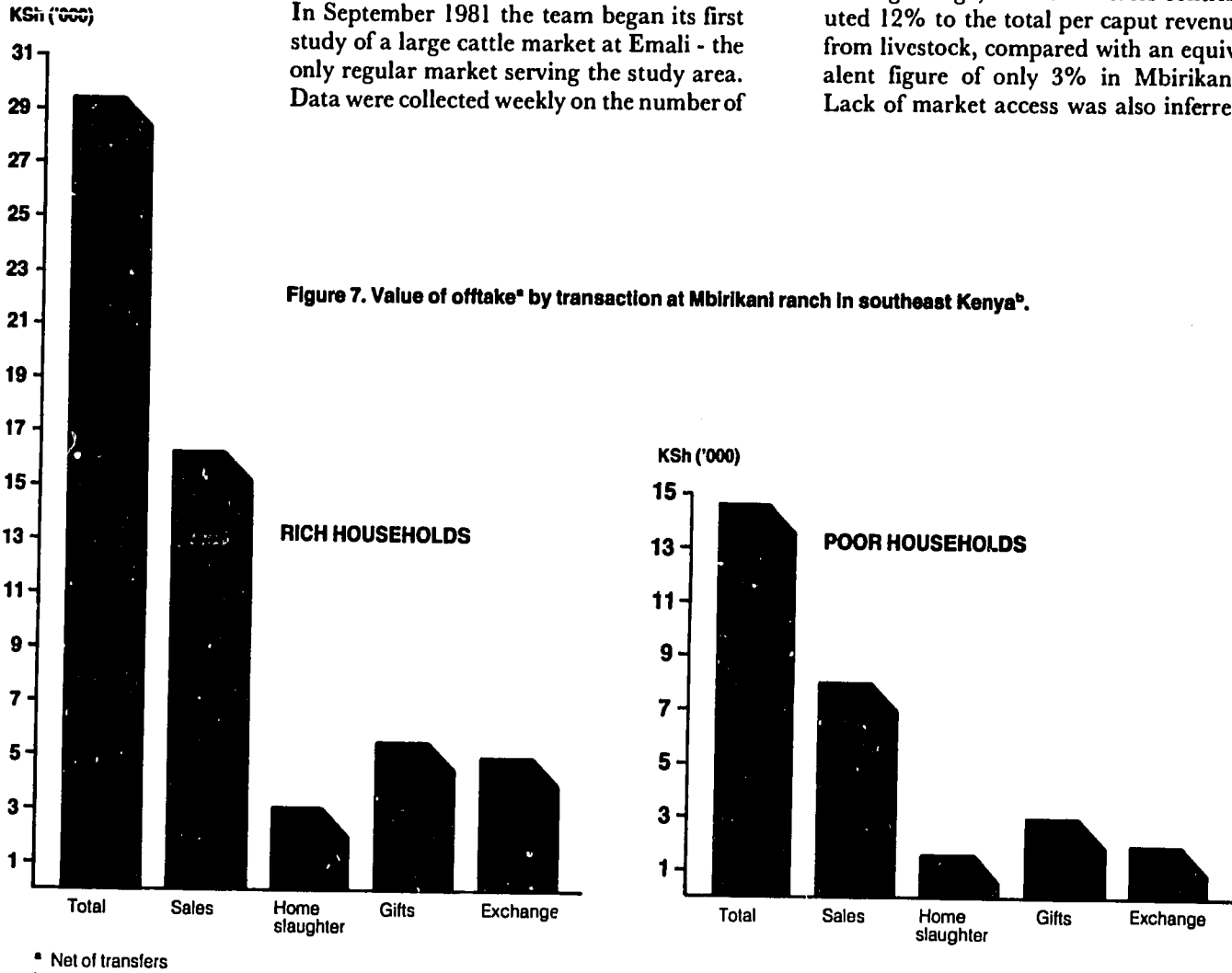
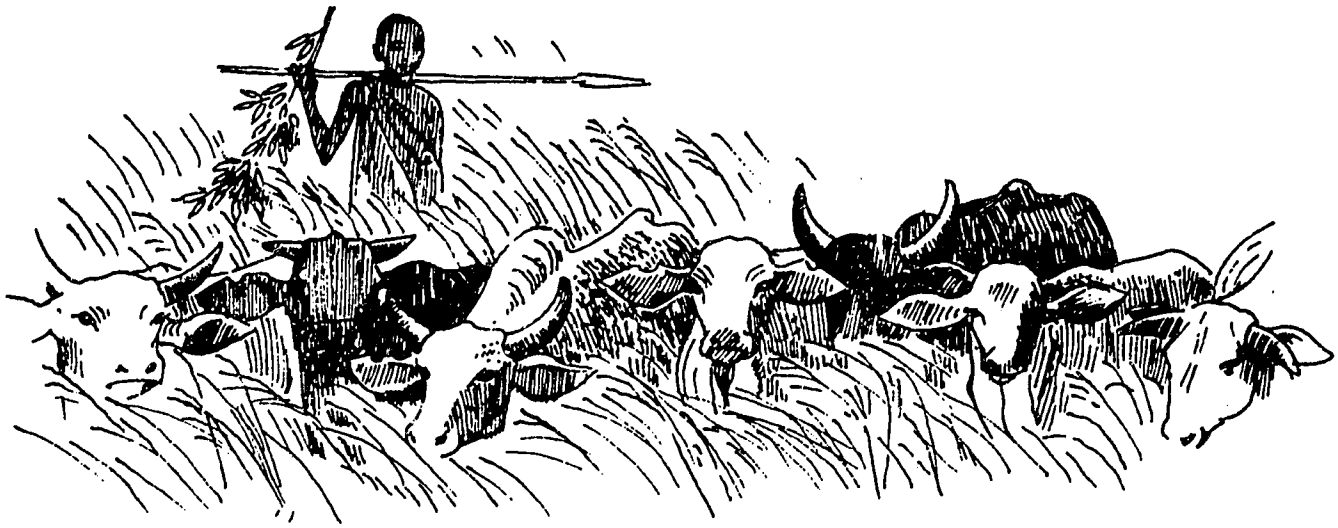


Figure 7. Value of offtake[a] by transaction at Mbirikani ranch in southeast Kenya[b].

[a] Net of transfers
[b] Figures may not add up to 100%, owing to rounding up.



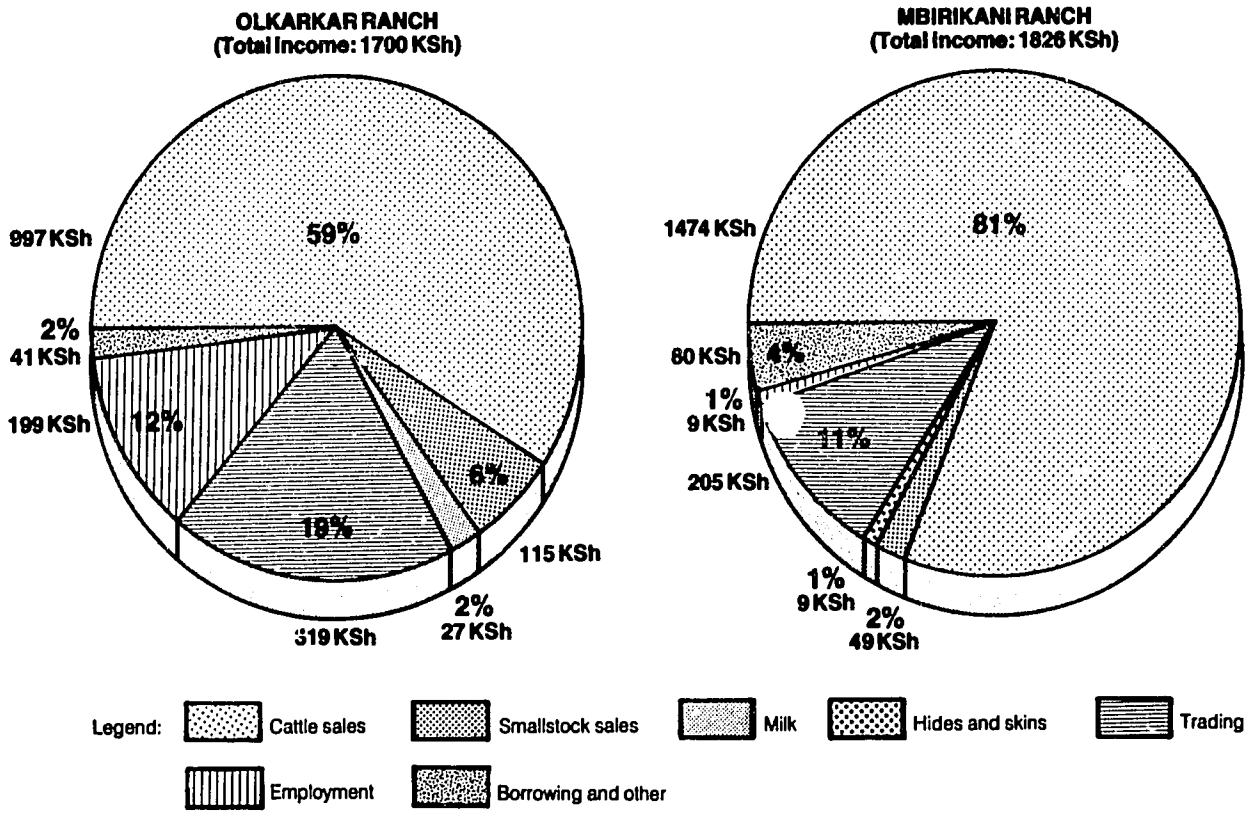
from the larger proportion of old stock in Mbirikani (48% and 42% for goats and sheep respectively) compared with Olkarkar (21% and 20%).

2. The lack of credit for traders. Shortage of funds reduced the turnover of many traders, most of whom were buying and selling no more than five head of cattle per week.
3. Poor body condition. Buyers complained of the poor condition of cattle due to disease and inadequate nutrition during the dry season.

Human nutrition

A grant from the Ford Foundation enabled research on human nutrition to begin during 1982.

Figure 8. Sources of cash income for Maasai households in southeast Kenya, July 1981–June 1982.



Technical cooperation

Cooperative work with Kenyan institutes already forms an important part of the team's research, and will be the basis for all future activities initiated by ILCA in Kenya.

In 1982 ILCA conducted four workshops to train technical assistants in the Range Management Branch of the Kenyan Ministry of Livestock Development in collecting data for monitoring range livestock production. These workshops were held in the districts of Kajiado, Taita-Taveta and Narok, and a total of 44 officers attended.

During the year ILCA was also approached by the Ministry of Livestock Development to contribute to an evaluation of Kenya's experience with livestock development. A paper entitled "Some lessons from the Kenya Livestock Development Project" was submitted. It drew attention to the failure of the group ranch approach to reduce livestock numbers, and to the fact that pastoralists continue to keep cattle for milk rather than changing to commercial beef production.

In 1982 an agreement was reached with the Research Branch of the Ministry of Livestock Development whereby two veterinarians were supplied to the ILCA team to assist in studies on animal disease.

Future activities

The research plans for the Kenya team during 1983 have three interrelated objectives:

1. To complete the system study already under way.
2. To help plan national studies on the key problems constraining output.
3. To examine in retrospect the research methods used and the results obtained by the ILCA team, with the objective of elaborating simplified and low-cost methods for pastoral systems research.

The Rangelands Programme in Botswana

Introduction

ILCA's research in Botswana is designed to help formulate appropriate policies and development projects for the country's Communal Areas, where the government has decided to give high priority to the development of mixed farming systems as well as traditional range livestock production. The Communal Areas of Botswana occupy a large proportion of the 407 000 km^2 of land administered under the country's Tribal Grazing Land Policy. This land lies in the semi-arid zone, receiving a rainfall of 250-600 mm.

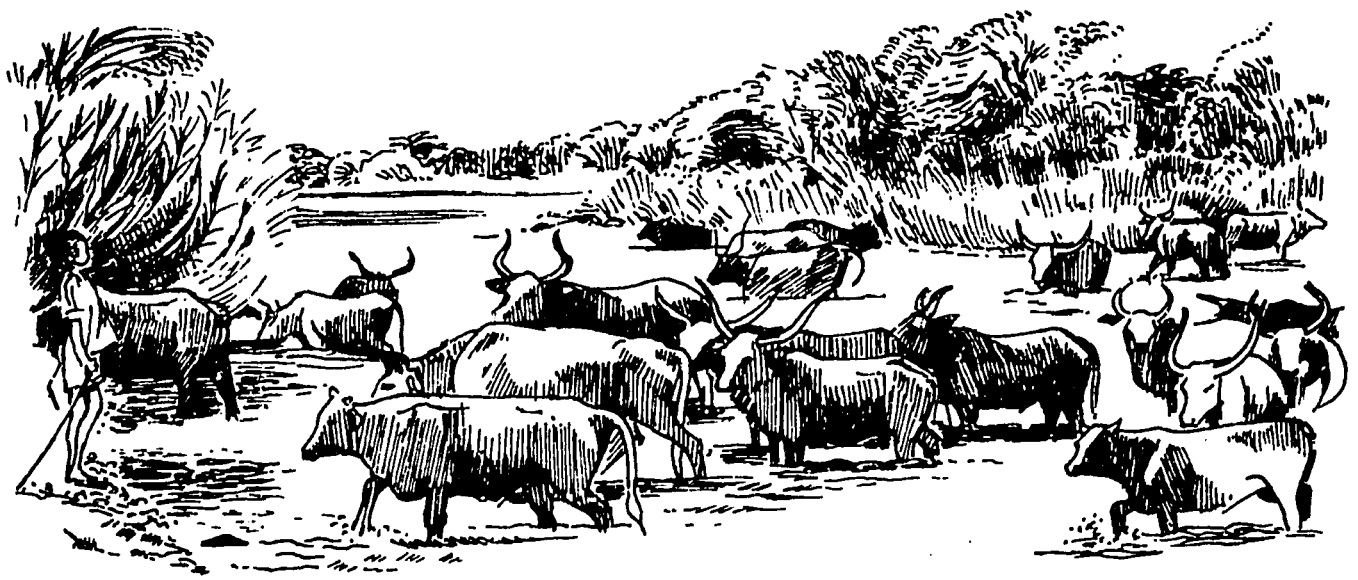
ILCA's research focuses on two Communal Areas in the wetter, eastern part of the country – Shoshong (2400 km^2) and Pelotshetlha (6000 km^2). The research is carried out jointly with the Integrated Farming Pilot Project (IFPP) and the Agricultural Technology Improvement Project (ATIP) of the Ministry of Agriculture. ILCA's participation consists of the provision of a full-time scientist to work with the ministry's Animal Production Research Unit (APRU).

From May to August 1982 the post of ILCA's representative in Botswana remained vacant, but research began again in September with the appointment of a scientist to work with APRU at Sebele.

Descriptive activities

Livestock distribution studies

Research began on the seasonal distribution of livestock in the two study areas, as affected by cordon fences, markets, soils, land-use patterns, the quality and quantity of forage and crop residues, and the availability of surface water. Such information is necessary for the evaluation of fencing policies and for the assessment of fodder crop potential,



range improvement measures and the possible management of forage resources through the controlled use of water points.

Aerial surveys to determine the number and location of livestock were started during 1982. Photographs of forage resources were taken, and were interpreted with the help of ground truthing. Surveys will be repeated at intervals of 2 months to ascertain seasonal changes in livestock population and distribution and the availability and quality of forage resources. Multivariate analyses of this descriptive information should help to explain the distribution patterns observed.

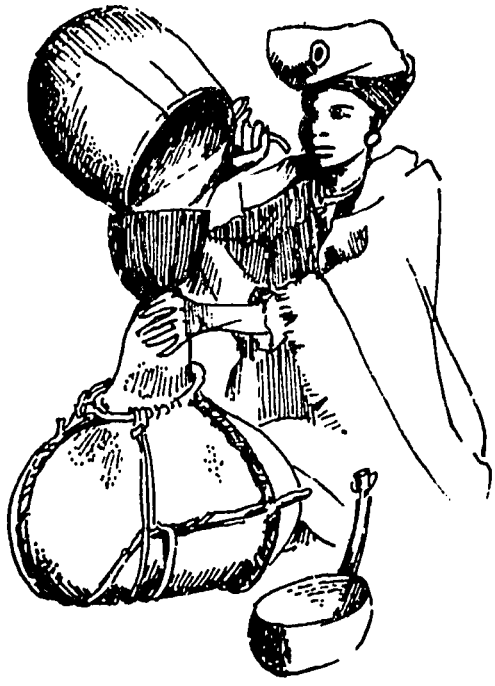
Cattle condition and the quality of feed intake

The relationships between the quality of forage consumed and livestock condition under high stocking densities were examined. In some parts of Botswana livestock densities are very high, and further studies are required to refine existing knowledge about management strategies and herd performance under such conditions.

IFPP and APRU are already collecting data on mortality, growth, purchases, sales and milk production in the Pelotshetlha study area. Similar but less detailed data are being collected in the Shoshong area by the Farm Management Survey and Rural Sociology Units of the Ministry of Agriculture. ILCA is complementing these studies with a visual assessment of cattle condition and an estimate of the quality of forage consumed on different range types.

Technical cooperation

All of ILCA's activities, past and future, in Botswana are carried out in close cooperation with the country's Ministry of Agriculture and its various units. In April 1982 ILCA convened a Workshop on Research Priorities in the Communal Areas. The workshop involved representatives from virtually all the government departments concerned with livestock production in these areas. The following topics were discussed:



1. Livestock production research priorities.
2. Soil research priorities.
3. Priorities of marketing research and economic monitoring.
4. Research into livestock/crop interactions.
5. Priorities for pasture and range research.
6. Future directions for research on Communal Area production systems.

The proceedings of this workshop will be jointly published by ILCA and the Rural Sociology Unit in early 1983.

Future activities

The two studies at Shoshong and Pelotshetlha will continue during 1983. Additional activities will include radio tracking of selected herds in order to interpret small-scale and night-time distribution patterns, and an appraisal of the contribution that data generated by LANDSAT 4 can make towards the mapping of vegetation at a scale useful for livestock management and range monitoring. It is hoped that ILCA's research will lead to the development of rapid and cost-effective methods of data collection and analysis over large tracts of land.

Support units

The Livestock Policy Unit

Origins

It is becoming increasingly clear that the policies of governments and international organisations are as important as appropriate technology, trained staff, adequate funding and well conceived projects in determining the success of African livestock development. ILCA, since its inception, has sought to use the results of research to throw light on policy issues, but it was only in 1982 that this interest was focused by the creation of a Livestock Policy Unit.

The objectives of the unit are to identify the critical policy issues for livestock development in Africa, and to analyse past or present policies of African governments as well as, to a lesser extent, those of international organisations. The unit hopes to clarify the policy options available to governments and the effects of different policies on livestock production and on the quality of life of the human population in Africa.

Staffing and initial work

The unit was formed in 1982 with two members; during 1983 staff numbers will be built up and priorities in the programme of work more sharply defined. It is already clear that the following issues are important: the impact of taxation and pricing policies on consumption, production and equity; the financing of livestock development services; land tenure and administration; methods of organising and managing development efforts; the relationship between livestock and other forms of production; the marketing of livestock and livestock products; and external trade.

The unit will seek to achieve its objectives by carrying out its own research, by encouraging and assisting research by others, and by putting policy makers in touch with each other and with the results of relevant research. In 1982 the unit's main research was in connection with ILCA's modelling activities, from which one ILCA publication emerged during the year and another is in press. Members of the unit also contributed to the work of several other ILCA programmes and to workshops held at the centre. Finally, work was started on devising the programme for a major livestock policy conference to be held in 1983 or 1984.

The Livestock Productivity and Trypanotolerance Group

During 1982 the work of the Livestock Productivity and Trypanotolerance Group focused on the biological and economic aspects of livestock productivity, with a strong emphasis on trypanotolerant livestock. Its research was carried out in close cooperation with national organisations in 12 countries of Africa.

Trypanotolerance research

In 1982 the group coordinated investigations on trypanotolerance at four sites in cooperation with national research organisations and with the help of a number of donor agencies. The objective of these studies was to determine the productivity of different breeds of domestic ruminants exposed to different levels of tsetse-trypanosomiasis risk occurring within various management systems and climatic zones. The results should allow an evaluation of genetic differences in susceptibility to trypanosomiasis between breeds throughout Africa, and possibly provide information on a genetic marker or markers. They should also permit an assessment of the role played by acquired resistance and a between-breed comparison of the rate at which resistance develops.

The four sites at which the programme operated in 1982 were in Gabon, Ivory Coast, Nigeria and Zaire.

In Gabon work centred on the ranch of the Office Gabonais d'Amélioration de la Pro-

duction de Viande at Okouma, where N'Dama and Nguni cattle and their crosses are raised under different levels of trypanosomiasis risk and prophylactic regimes. In addition to the ranch staff assigned to the study, two veterinary assistants were trained, one in Upper Volta and the other in Brazzaville, in the tsetse and animal health fields.

In northern Ivory Coast sheep research being carried out by the Société de Développement des Productions Animales (SODEPRA-Nord) was extended to cover all the recording requirements in a village in the subhumid savanna around Korhogo. The work is being performed in collaboration with SODEPRA-Nord, the Veterinary Laboratory of Korhogo, and an FAO project on tsetse control. The scientist in charge of the operation, who is seconded from the University of Hohenheim, has already begun to analyse the data collected during the first year of the study.

In Nigeria the ILCA humid zone team collected data on trypanosomiasis risk and incidence. A veterinarian from the team spent 4 weeks in Nairobi receiving specialised training. Plans were made for ILCA to monitor Gambian N'Dama cattle imported into Nigeria in cooperation with the Federal Livestock Department. The purchase of these cattle started in November. The animals were eartagged and their precise origin recorded.

In Zaire research focused on N'Dama cattle raised in ranches and in *metayage* operations[1] under various levels of trypanosomiasis risk. One FAO associate expert and a Zairian veterinarian received training in Nairobi for 2 months. Field operations started in early November. It is expected that the programme will be fully operational in the ranches by the end of April 1983 and in the *metayage* operations by the end of June, depending on the recruitment of a second associate expert.

In addition to these country activities, a training manual was produced jointly with the International Laboratory for Research on Animal Diseases (ILRAD) and the International Centre for Insect Physiology and Ecology (ICIPE), describing the parameters and techniques used in the collection of data in the animal health, tsetse-trypanosomiasis risk and animal productivity areas, and indicating how relevant information is extracted, analysed and interpreted.

In 1983, further work will be conducted at new sites in Benin, Congo, Gambia, Senegal and Togo, and the research in Ivory Coast will be expanded in cooperation with the Gesellschaft für Technische Zusammenarbeit (GTZ).

In Benin, in conjunction with FAO/UNDP, ILCA will conduct research on herds at three farms - Samiondji, M'Betecoucou and Okpaha - and in surrounding villages. The Lagunes, Somba and Zebu breeds will be studied. It has been agreed that ILCA will organise training, provide technical supervision and conduct data analysis.

In Congo contacts have already been established with the Dihesse ranch, where N'Dama cattle are raised under low and medium trypanosomiasis risk. Discussions are currently under way for the analysis of production and health data collected on the breeding herds since 1975. This work will begin in 1983.

In Gambia the African Development Bank has agreed to finance a N'Dama production project. The project will have a strong research component aimed at evaluating N'Dama production in villages under various levels of trypanosomiasis risk, and at improving productivity. The productivity and health surveys will be carried out by ILCA and ILRAD, with funds provided by the European Development Fund (EDF).

In 1981, ILCA was requested by the Government of Senegal to organise and support similar research work on Djallonke sheep and N'Dama cattle in Casamance and Senegal Oriental, which encompass different ecological zones and tsetse challenges. This proposal has been linked with the request to EDF to fund the Gambian operation. The two projects will therefore constitute a single, integrated operation.

In Togo GTZ has proposed the extension of the activities of the Centre de Recherche et d'Elevage at Avetonou to carry out a comprehensive trypanotolerance survey of station cattle and *metayage* operations, covering 400 N'Dama females in village herds around the station. The training component required for this project will be provided in 1983.

In Ivory Coast GTZ has agreed to fund the extension of research to cover cattle in addition to sheep, in an area of higher trypanosomiasis risk. This operation is expected to start in July 1983.

[1] The *metayage* system is a contract system used in several central African countries to introduce cattle husbandry at village level in areas where it has not been a traditional activity. Under a 5- to 10-year contract, commercial, governmental or religious organisations provide breeding stock and technical assistance to village individuals or small groups, who in their turn must provide labour and certain basic facilities. At the end of the contract, the organisation must be reimbursed for the breeding stock.

Livestock productivity research

In Botswana ILCA planned a project for the Botswana Government to build up and evaluate a composite beef breed of optimal additive genetic merit and with maximal retention of non-additive contributions.

In Ethiopia results of dairy crossbreeding work at the Arsi Rural Development Unit have been analysed by a visiting scientist in cooperation with ILCA's Highlands Programme. These results are summarised in the section of this report devoted to the Highlands Programme.

In Kenya analyses continued of data on the Boran and its crosses with several different breeds under a range of management systems and ecological zones. These data were combined with those from 10 commercial herds, and interpretation started at the end of 1982.

In Tanzania, in conjunction with Amboni Estates at Tanga, ILRAD, and May and Baker Ltd, an evaluation of the productivity of beef cattle maintained under prophylaxis against trypanosomiasis was initiated. A scientist from May and Baker was seconded to ILCA for 15 months, and started the extraction of data covering cattle productivity and health status over a period of 10 years.

Two Senegalese research scientists completed fellowships of 5 months each. One analysed the productivity of N'Dama cattle and the other the productivity of Djallonke sheep from records collected at the Centre de Recherches Zootechniques, Kolda, Senegal, between 1973 and 1981. The results were published as an ILCA Research Report. Overall N'Dama cattle herd productivity was 67.6 kg of 9-month old calf per cow per year, 28.1 kg of 9-month old calf per 100 kg of cow body weight per year, or 123 kg of 9-month old calf per 100 kg cow metabolic weight per year – figures which are about average and in line with earlier findings for this breed. The overall flock productivity of Djallonke sheep, however, was 8.7 kg of weaned lamb per ewe per year, 362 g of weaned lamb per kg of ewe body weight per year, or 850 g of weaned lamb per kg of ewe metabolic body weight per year – indicating this breed to be fairly productive despite high mortality rates of 33% in lambs and 15% in breeding ewes.

A research scientist from Sierra Leone began a 4-month fellowship on analysis of the productivity of N'Dama and Sahiwal x N'Dama cattle at Teko Station, Sierra Leone. A joint report on this analysis will be produced.

The Forage Legume Agronomy Group

Introduction

The Forage Legume Agronomy Group was established at ILCA headquarters in 1982. Its objectives are to introduce forage legumes into pastures, as pure stands or as intercrops, and to evaluate their productivity under various management methods. The group will acquire and screen suitable legume lines at different research sites. It will provide expertise and germplasm to ILCA's field teams and national research and development institutions. It will also play a key role in training and communication among forage research workers in Africa through ILCA's new germplasm network.

Germplasm acquisition

In Ethiopia, the collection of species of Leguminosae with forage potential was pursued vigorously after the start of the 1982/83 dry season in October. Four collection trips were made in southern and central Ethiopia, resulting in the acquisition of several hundred lines of tropical, subtropical and temperate forage species. Native *Trifolium* species, of which there are about 35, received particular emphasis. *T. tembense* and *T. rueppellianum* lines were among the most important of those collected, and the numbers of native *Trifolium* accessions rose from 108 at the end of 1981 to over 500 at the end of 1982. Besides *Trifolium* the group collected lines of *Neonotonia, Stylosanthes, Zornia* and *Medicago*.

The group received germplasm from existing collections of forage species in different parts of the world, from the Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia), the International Centre for Tropical Agriculture (CIAT, Colombia), the International Centre for Agricultural Research in the Dry Areas

(ICARDA, Syria), the International Maize and Wheat Improvement Centre (CIMMYT, Mexico) and the national collection of Belize.

Germplasm was also received from commercial seed companies outside Africa, which have developed cultivars suited to their own countries that may be productive under some African conditions.

As part of the group's constant effort to secure further sources of germplasm for screening, visits were made to CIAT and CSIRO (for tropical species), and to the Departments of Agriculture in New South Wales (for *Trifolium* spp), in South Australia (for perennial *Medicago* spp) and in Western Australia (for annual *Medicago* and *Trifolium* spp).

The germplasm collection

Work began on the organisation of the germplasm collection, which by the end of 1982 contained over 2000 accessions. The group cooperated closely with the Plant Genetic Resources Centre (PGRC) in Addis Ababa in constructing a primary set of 120 descriptors, which were used to organise the germplasm collections of both institutes. Cooperation in storage facilities was also developed. The status of ILCA's germplasm collection at the end of 1982 is summarised in Table 11.

Table 11. Current status of ILCA's forage germplasm collection.

Germplasm evaluation

During 1982 the group screened a large number of lines at five different locations at varying altitudes and rainfalls in Ethiopia. Table 12 summarises these activities.

The main results were as follows:

1. Some of the *Vicia sativa* lines obtained from ICARDA and tested at Shola (ILCA headquarters) and Debre Zeit showed considerable promise, although the yields of many of the legumes screened at both sites varied markedly.
2. Native species of *Trifolium* screened at Shola and Debre Zeit matured earlier than exotic lines but had much lower yields. On the heavier soils at Shola, *T. alexandrium* and *T. subterraneum* lines were particularly vigorous and persistent.
3. In a trial at Shola comparing the performance of native and exotic (commercial) species of *Trifolium* and their response to

Table 12. Forage lines screened at five locations in Ethiopia.

* Lines obtained from ICARDA and ICRISAT

fertiliser, two native species, *T. rueppellianum* and *T. tembense,* responded well to phosphorus. *T. resupinatum,* an exotic species, was at least as productive, however, and remained green long after the two native species had dried off.

4. Several lines, including *Lablab purpureus, Vigna unguiculata, Stylosanthes* spp and *Centrosema brazilianum* performed well at Abernossa, situated in the Rift Valley at an altitude of 1750 m.
5. Among the *Stylosanthes* species screened at Abernossa, *S. guianensis* cv Graham and *S. humilis* cv Patterson produced the greatest bulk. The latter species was also among the two that produced the most seed, the other being *S. fruticosa,* which is native to the area.

Cooperation and support activities

Within Ethiopia the group gave seed and advice to a number of aid programmes. Close contacts were developed and maintained with Ethiopian government institutions, particularly the Ministry of Agriculture, the Ministry of State Farms and the Institute of Agricultural Research (IAR).

The group also cooperated with several government ministries and institutions in Ethiopia in a continuing series of multilocational yield trials of annual and perennial forage species adapted to particular elevations. These trials took place at 10 locations in 1982, of which two were ILCA research sites.

With the PGRC, the group published the first issue of a joint germplasm newsletter.

Lastly, the group assisted in the forage agronomy work of ILCA's Highlands Programme at Debre Berhan station. This research is described in the Highlands Programme's section of this report.

Germplasm collection and evaluation in 1983

Germplasm collection within Africa will continue, with emphasis on such legume genera as *Stylosanthes, Zornia, Neonotonia* and *Trifolium.*

Screening will be done at the same sites as in 1982, but more broadly in the Rift Valley, by means of strip trials. The selection of screening sites in Ethiopia is being supported by a study which will relate the edaphic and climatic conditions available in Ethiopia to those of the rest of Africa.

A training course on forage production will be run for BSc level agronomists in September - October 1983, while a workshop to initiate an African forage research network is planned for the same period.

The Nutrition Unit

Shola farm

Facilities for nutrition research at Shola farm were improved by the completion of a barn with room for individual feeding of 18 cattle, digestion crates for 20 sheep and storage for feeds.

Livestock kept at Shola for intake and digestibility studies include 24 crossbred Friesian x Zebu cows, 8 local Zebu oxen, a flock of 50 highland ewes and 24 wethers.

In the 1982 wet season 3 ha were used for the initial screening of plant introductions and for a forage trial conducted in cooperation with the Institute of Agricultural Research (IAR). A further area of 3 ha was sown to improved pasture, while 8 ha were used to grow cereals for research on crop residues. The latter area was also used to evaluate the legumes *Trifolium tembense* and *Vicia dasycarpa.*

Forage evaluation

A variety of forages and mixtures which had been found promising in small plots were grown on areas of up to 400 m^2 for feeding trials. Oat varieties and Italian rye grass gave excellent yields and intake by cattle was high. The fat percentage of milk from cows fed on a mixture of oats and forage fell from a norm of 4-4.5% to less than 2.5% after 3 weeks. This effect is common, but is of particular concern in livestock systems in which milk is a major energy food and butter-making is the main form of processing.

An evaluation was made of the local species *Trifolium tembense,* which grows well in seasonally waterlogged soils and in competition with tall-growing grasses. Chemical analyses showed that leaves contained over 25% protein and were 72% digestible. Stems, which formed over 55% of the total

DM, were found to contain nearly 12% protein and were 70% digestible. Feeding trials with sheep showed that stems were more palatable than leaves, an important factor in a species which produces a large proportion of stem.

The effects of feeding *T. tembense* and hay mixtures to Friesian x Zebu cows were investigated. When a grass hay ration of 68% digestibility was replaced by a *T. tembense*/grass hay mixture of 65% digestibility, feed intake increased by 25% and milk yield by 15%. After 2 weeks, milk fat content declined from 5% to 4.2%. On reversion to a ration of grass hay without *T. tembense*, fat content and milk yield returned to their previous levels. *T. tembense* thus appears a useful supplement for dairy cows.

Optimum utilisation of crop residues and forage legumes

Throughout Africa, there is considerable interest in improving the nutritive value of agricultural byproducts and agro-industrial wastes by various chemical, physical and microbiological treatments. Experiments began in 1982 to improve the nutritive value of cereal crop residues (CCRs) by using mild alkaline compounds such as slaked lime and fertiliser grade urea.

In the first experiment, teff straw, wheat straw and a mixture of haricot bean and cowpea haulms were sprayed with 4% urea (1 litre/kg straw). These byproducts were fed to sheep after ensiling for either 3- or 6-week periods, and compared with a control which had been neither sprayed nor ensiled. The results obtained for teff straw are shown in Table 13.

In the second experiment, two further treatments were applied to teff straw: soaking for 72 hours in a 1% solution of slaked lime, and for 24 hours in a 10% solution.

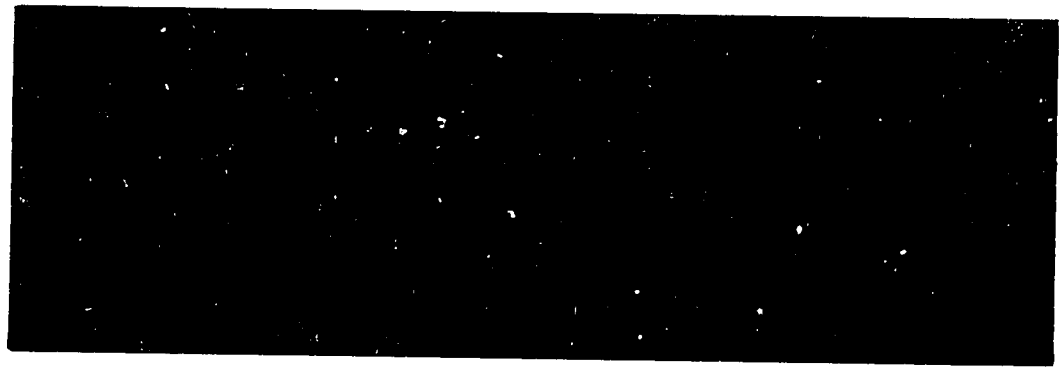
The apparent digestibility of organic matter, DM, neutral detergent fibre and cellulose were not significantly different between the two treatments. Similar observations were made when a mixture of haricot bean and cowpea haulms was treated in the same manner and fed to sheep.

Because the slaked lime treatment did not improve the nutritive value of CCRs, a third experiment was conducted using urea only. The objective of this experiment was to separate the effects of urea as a source of non-protein nitrogen (NPN) and as an alkaline substance decomposing structural carbohydrates. Two treatments were used: firstly oat straw was sprayed with 4% urea solution and fed immediately without ensiling, and secondly oat straw was sprayed with an identical solution but fed after ensiling for 3 weeks.

This experiment showed that ensiling after spraying improved nutritive value by degrading structural carbohydrates. However, NPN was lost as ammonia gas during fermentation.

Further experiments investigated the possible synergistic effects in the utilisation of coarse roughage when graded levels of *T. tembense* were fed with CCRs. Preliminary results indicated that as the proportion of *T. tembense* increased, so there was a progressive and often significant improvement in the intake and digestibility of other chemical components - with the exception of neutral detergent fibre. The digestibility of this component was depressed because of its high level - 44% - in *T. tembense*. There was an indication that when rations contain more than 30% *T. tembense*, urinary nitrogen excretion rises sharply. These experiments will continue during 1983.

Table 13. Nutritional value of teff straw after spraying with urea and ensiling for 3- or 6-week periods.



Improving livestock feed resources: The African Research Network on Agricultural Byproducts

Estimates indicate that of the 140 million cattle in Africa at least 70% depend for part of the year on crop residues. Although these residues are nutritionally low in quality, they may be almost the only feed resources available in the dry season, at which time the natural vegetation is of even lower quality. In Ethiopia, for example, about 80% of the total feed resources are provided by crop residues and stubble grazing.

Over the last 10 years, research workers throughout Africa have tried to improve the nutritive value of cereal straws by using alkalis, or to prepare complete livestock rations with agricultural byproducts such as cocoa husks, groundnut cake and milling byproducts. Research within ILCA focuses on meeting the nitrogen deficiency in coarse roughages by feeding graded quantities of legume hays and haulms, by supplying legumes as fodder banks and alley crops, or as non-protein nitrogen in the form of urea.

Considering the wide diversity of crop residue studies being conducted in Africa, there is a clear need to foster professional contacts and share information.

At a workshop organised by ILCA and the Association for the Advancement of Agricultural Sciences in Africa (AAASA) in Douala in 1980, 52 participants recommended that ILCA form a network of scientists involved in research on the use of crop residues for feeding livestock. Similar requests were tabled at meetings in Arusha (1981) and in Dakar (1981), where over 60 scientists at each workshop met to discuss their work on agricultural byproducts. The network, known as ARNAB, was finally launched in mid-1981. Activities so far have been to identify scientists engaged in relevant research, to encourage information sharing through a newsletter, and to promote interdisciplinary research on availability, seasonality, alternative uses and transport costs of byproducts. Future activities will include assistance to research workers in standardising their experimental procedures, and the development of appropriate technology easily adaptable by farmers.

The network continues to grow in popularity, and the Scientific Secretary broadened his contacts by attending the IDRC Workshop on Byproduct Utilisation in Nairobi in September 1982.

Nutrition laboratory

Expansion of laboratory services continued in 1982 with the installation of an autoanalyser to increase the output of nitrogen and phosphorus analyses. These analyses are important in view of the probabie deficiency of these plant nutrients in many African soils. Other equipment installed and used during 1982 included specific ion electrodes for some mineral analyses. Mineral analyses were carried out on a number of browse samples from pastoral projects. Average contents were 0.07% phosphorus, 0.5 to 2.5% potassium and 0.3 to 8% calcium, while *in vitro* digestibility was 35 to 80%. An adiabatic bomb calorimeter was used to determine the energy content of feeds as part of the animal traction research conducted by the Highlands Programme.

Analyses of groundwater samples from wells in the southern Ethiopian rangelands showed a dissolved mineral content varying from 0.1 to 1.0%. The higher saline wells are used only for camels, sheep and goats. The nature of the solutes is now under study.

During 1982 the nutrition laboratory conducted 11 000 chemical determinations on a total of 4000 soil, water, feed and faecal samples.

For rapid screening purposes and for assessment of animal production potential a modification of the double-enzyme *in vitro* digestion method was developed. The method has been scaled down without serious loss of accuracy or repeatability, thereby economising on reagents and enzymes and permitting the incubation and centrifuging of large numbers of samples in standard-sized labo-

ratory equipment. For a series of 30 forages of known *in vivo* digestibility, the value of the correlation coefficient between *in vitro* and *in vivo* digestibility was 0.94, and the regression equation for estimation of *in vivo* % digestibility (y) from *in vitro* % digestion or % DM solubility (x) was:

$$y = 0.74x + 15.72 \pm 2.83$$

Animal nutrition

Sheep. The occurrence of oestrus in a flock of 50 Ethiopian highland sheep has been studied for nearly a year. Vasectomized rams with mating harnesses and crayons were run with the flock. Ewes began to show oestrus at 16-18 kg liveweight (6-8 months of age), and continued throughout the year with no seasonal anoestrus. Postpartum anoestrus lasted for 90-100 days. Because of the need to keep animals away from growing crops, grazing was restricted during the main wet season (July - September). During this period ewes decreased from 27 to 22 kg in liveweight, and this was associated with a reduction in recorded oestrus cycles from 75% to 45% of the theoretical number. This confirmed that the occurrence of oestrus is influenced by nutritional level.

Cattle. 1. Friesian x Zebu calves were reared on controlled milk intakes ranging from 1.8 to 3.6 litres/day. Because of compensating differences in pasture and hay intake, weight gains were fairly similar for all calves (0.32 to 0.43 kg/day) and the ratio of litres of milk intake to kg liveweight gain ranged from below 5 to over 10, with an overall mean of 8.3. This ratio is an important aspect of the estimation of cow milk production in pastoral systems and merits further study.

2. The feed intake of cows and oxen was estimated by the chromic oxide method over a range of forage quality both in the field and in pens. Some of the results of this work are given in Table 14.

The differences in intake between breeds partly reflect variation in liveweight, but intakes of the Friesian x Zebu dry cows increased far more rapidly with improvements in feed quality than did those of pure Zebus. This finding points to the need for better quality forage to enable Friesian x Zebu cattle to attain their potentially far higher productivity. The digestibility of poor-quality hays was appreciably higher for Zebu cattle than for Friesian x Zebus.

3. Four fistulated cattle were used for training courses prior to their use in pastoral systems to obtain samples of grasses and browse plants eaten by cattle.

Comparison of feed intake with oesophageal fistula extrusa showed that the percentage recovery of ingested herbage ranged from 20% to 65% in different animals, but averaged about 40% for the group of four cattle over all feed types.

Composition of fistula extrusa was greatly affected by the presence of salivary nitrogen and phosphorus, even when excess saliva was allowed to escape from the sample collected. This means that the content of these important nutrients in browse cannot be estimated easily from the samples obtained from oesophageal fistulae.

Table 14. Feed value and intako of grass hays by Zebu and Friesian x Zebu cattle.

* A: Pre-bloom high-quality hay; B: Half-bloom intermediate-quality hay; C: Full-bloom intermediate-quality hay; D: Late-bloom low-quality hay.

The Aerial Survey Unit

ILCA's Aerial Survey Unit maintained a high level of operations throughout 1982. It concentrated on establishing natural resource inventories and seasonal trends over large tracts of land, where accurate data are not obtainable by other means. ILCA owns a twin-engined Partenavia aircraft and maintains a team of trained observers in each country where aerial surveys are regularly conducted. Surveys are flown between 120 and 300 metres above ground, along parallel lines to cover the study area systematically and at a predetermined sampling fraction.

During 1982 nine surveys were conducted in four countries for ILCA's own field teams and for other research groups concerned with livestock development. Details of these surveys are provided in Table 15.

The wet-season survey in the Niger Range and Livestock (NRL) Project area followed two earlier surveys in 1981. The distribution of range resources, livestock and waterpoints was determined for seven herders' associations - the basic unit for development by the project.

The two surveys of Nigeria's subhumid zone were conducted during the wet and dry seasons. The objective of these surveys was to clarify whether the close association of cattle production and arable farming, which had been previously noted by ILCA's subhumid team, was a general feature of the zone. The results from these two surveys will be included in a wider study of the ecology of the subhumid zone of Nigeria. This study will be completed in April 1983.

Data from all these surveys were fully analysed and reports were issued during the year. In 1982 the unit also trained a team of ODEM observers to conduct surveys and analyse data. Finally, the unit supplied a plane and pilot to the UNEP aerial survey programme[1] in Senegal during the year.

[1] Projet Pilote d'Inventaire et de Surveillance Continue des Ecosystèmes Pastoraux Saheliens.

Table 15. Aerial surveys flown by ILCA in 1982.

[a] Office pour le Développement de l'Elevage dans la Région de Mopti.

Computer services

In 1980 ILCA purchased a Hewlett Packard 3000 series III computer system. The system consisted of the computer processor, two 300-line-per-minute printers, two 120-million-character on-line discs, a nine-track magnetic tape unit, a 300-card-per-minute reader and 12 interactive terminals.

The computer is staffed by a computer manager, two computer operators and three data entry operators. Advice and assistance with statistical analysis are provided by a biometrician and two programmers.

Within ILCA there are currently three departments using the computer: Information, Operations and Research.

The Information Department uses the computer for the storage and retrieval of bibliographic material in ILCA's database covering current scientific literature in the ILCA library and documents collected by the ILCA/IDRC microfiche project. These documents are predominantly non-conventional livestock literature collected from African countries.

The Operations Department currently runs a general ledger program for the financial management of ILCA. Further procedures will be computerised as time and resources permit.

Important as these uses are, ILCA's computer system serves mainly for the analysis of data collected by the centre's field programmes.

ILCA cannot afford to develop large software packages and has therefore sought software already written for the HP 3000 III. These are supported and updated by the supplying organisations at minimum cost. ILCA's main software packages are as follows:

1. MINISIS, developed by the International Development Research Centre (IDRC), Canada; used for ILCA's documentation system.
2. SPSS (Statistical Package for the Social Sciences) and BMDP (Biomedical Computer Programs) from McMaster University, Canada; used extensively to tabulate and statistically analyse data quickly and efficiently.
3. LINDO (Linear, Interactive and Discrete Optimizer) from the University of Chicago; used to analyse resource allocations in farming systems.
4. Harvey's Least Squares from Ohio State University; used in the field of animal production to analyse productivity, repeatability and heritability of biological traits.

While the design of such major computer packages is beyond ILCA's resources, the programming staff are constantly writing smaller programs. These programs are used to edit, verify and construct data files for future use by the large software packages. Two programs written by ILCA staff are the general ledger accounting system and ILCA's livestock simulation model.

In the livestock model a herd is simultaneously represented as a biological and an economic unit. The model is described in the following publication: *Cattle herd dynamics: An integer and stochastic model for evaluating production alternatives*, by P.A. Konandreas and F.M. Anderson (ILCA Research Report 2, 1982).

The computer unit performs statistical analyses for all of ILCA's field programmes and has started to expand its services to national research institutes. In the last 12 months work has been completed for the Institute of Agricultural Research in Ethiopia and for Senegal's Centre de Recherches Zootechniques, Kolda. It is hoped that over the next 12 months more research institutes can be assisted in a similar way.

In an effort to streamline data collection, five micro-computers have been installed within ILCA's field programmes. Scientists are thus able to verify their data and obtain initial results before the data are sent to headquarters for complete analysis. A data collection network is to be established throughout ILCA's field programmes using micro-computers, between which data can be transferred on diskettes.

Within the Information and Research Departments, there is a demand for text editing for report preparation. The word processing capabilities of the HP 3000 and the micro-computers enable staff to prepare texts on any one of the terminals connected to the system. Draft material can be modified and edited efficiently, and once in final form can be transferred electronically to the CRTronic Linotype machine in the Publications Section of the Information Department for final typesetting. Alternatively, material can be printed out in multiple copies directly by the computer system itself.

As the need for data entry and analysis increased, an extra four terminals were added in 1982 and a further 10 terminals will be installed in April 1983. This will bring the system to its maximum configuration of 24 terminals. To handle the increased storage requirements of the documentation database and scientific data from research programs, an additional on-line disc of 404 million characters will also be installed in April 1983.

Library and Documentation Services

Library

By the end of 1982 the library's book collection had grown to more than 11 000 titles and included both basic reference works and specialised studies. The microfiche collection contained 20 000 items, ranging from university theses to unpublished reports. The periodicals collection included some 850 general and scientific publications, together with newspapers, abstracts, journals, annual reports, newsletters, bulletins, yearbooks and other material from many institutions and countries. There was also a large collection of pamphlets, maps, photographic prints, colour slides, and atlases.

During 1982 the library provided over 30 000 photocopies and 21 000 microfiches, and lent 7000 titles to users both within and outside ILCA.

Microfiche project

The microfiche project, cosponsored by ILCA and the International Development Research Centre (IDRC), continued to play its important role during 1982. It is designed to locate, conserve and make available documents on livestock production from all parts of sub-Saharan Africa, mainly of a non-conventional nature, that might otherwise be overlooked or lost.

Microfiches had been collected from nine countries by the ILCA microfiche team during the previous year: Burundi, Cameroon, Ghana, Senegal, Sudan, Tanzania, Zaire, Zambia and Zimbabwe. In 1982 600 catalogues each for six of these countries were compiled, printed and distributed, while for Ghana, Senegal and Zimbabwe catalogues were ready for press by the end of the year.

Duplicate sets of microfiches were produced and distributed to 18 institutes in three countries that the ILCA team had visited the previous year – Cameroon, Nigeria and Sudan. In addition to the 20 000 microfiches supplied in this way, ILCA provided further copies of microfiches from its master set to a number of external bodies during 1982.

Besides providing an information service, the project serves to spread the use of microfiches, since at least one institution in each African country involved has now been supplied with its own microfiche reader. For ILCA's own scientists, as well as those in national institutes, the project is providing an invaluable source of research material.

Selective Dissemination of Information (SDI)

During 1982 ILCA started a new service for livestock researchers throughout Africa: the regular screening of tapes from both the FAO Agricultural Information Service (AGRIS) and Commonwealth Agricultural Bureaux (CAB) to provide specialists with abstracts covering their field of interest. A growing number of individual scientists registered their research profiles with ILCA and received monthly print-outs free of charge.

Information Processing Unit

The Information Processing Unit catalogues and indexes all material received and enters it on ILCA's database. During the year the temporary database that had been developed on FAO's system, before ILCA acquired its computer in February 1981, was merged into ILCA's own database, known as BIBLIO. By the end of the year BIBLIO held nearly 20 000 records; from now on it is expected to grow by 5000 items annually.

During the year a number of retrospective searches were conducted for both ILCA staff and outside researchers, using CAB and AGRIS tapes as well as the centre's own database.

The unit also developed a computerised mailing list for the rapid dispatch of ILCA's publications and the efficient updating of addresses.

Future activities

In 1983 a second phase of the IDRC/ILCA microfiche project will start. In this 2-year phase repeat visits will be made to three countries already visited under the first phase – Kenya, Botswana and Zimbabwe. A further 11 countries will be visited for the first time, subject to governmental approval – Chad, Guinea, Ivory Coast, Malawi, Mauritania, Niger, Rwanda, Somalia, Togo, Uganda and Upper Volta.

Specialised bibliographies will be produced on a number of topics in cooperation with ILCA staff. The first of these will cover the field of animal traction, a major topic of ILCA's research.

The documentation facilities offered by ILCA will be publicised throughout Africa and an increasing number of research workers will receive abstracts of papers in their field of interest from ILCA's SDI service.

Training

Group training

During 1982 courses, workshops and seminars were organised by ILCA's field teams as well as by the Training Section at headquarters. Three refresher courses were held to upgrade the technical ability of African researchers in nutritional analysis and laboratory methods.

In addition, three workshops and seminars were convened at which ILCA's research results were presented and discussed with national and international authorities. Table 16 gives details of all the courses, workshops and seminars held during 1982 at headquarters or on the field programmes.

Table 16. Courses, workshops and seminars held by ILCA in 1982.

Individual training

During 1982 18 scientists were registered for individual training. Of these 18, two were visiting scientists on sabbatical leave: one was from Makerere University and analysed animal breeding data with the Highlands Programme, while the other was on leave from Ahmadu Bello University and studied soil/plant/animal/mineral relationships with the Subhumid Zone Programme. A further 11 trainees worked as short- or long-term fellows with ILCA teams in the field or at headquarters. The remaining five were ILCA staff members receiving in-service training at colleges and universities abroad.

Finally, ILCA staff acted at various times during the year as examiners and supervisors at the Alemaya College of Agriculture of the University of Addis Ababa.

Publications

Publishing is one of ILCA's fastest growing activities. As the centre's research matures, so the need to communicate scientific results increases rapidly. As its training and cooperative programmes evolve in scope and complexity, so the need to explain them to a wider audience also grows.

Over the last 2 years ILCA has therefore expanded its publications team and installed a wide range of new equipment at headquarters. The number of staff has grown from 5 to over 20, and the team now includes a Head of Publications, an English-language science writer/editor, a French-language editor/translator, two designers, a photographer, two proofreaders, four typesetters, a printer and seven graphic arts technicians. The new equipment installed includes a CRTronic Linotype electronic typesetter, a full range of filming and plate-making facilities, a Heidelberg GTO single-colour offset printing press and a Minabinda 780 glueing and binding machine. With its new equipment, the team is now independent of commercial printing facilities.

The year 1982 saw the launching of a new range of publications at ILCA. The *ILCA Newsletter* appeared on a quarterly basis, while the centre's first *Annual Report* was published in May. A series of short brochures describing ILCA's research and training activities was initiated, and a new series of *Research Reports* replaced the former *Systems Studies* and *Monographs*. These new publishing ventures reflected the centre's determination to improve the dissemination of its research results as well as to reach a wider audience with a more popular message. Three conference reports and two issues of the *ILCA Bulletin* were also published in 1982. Lastly, six catalogues of literature collected by the ILCA/IDRC microfiche project were produced, the *Programme and Budget* was printed, and the centre met all its own administrative printing requirements. A list of the major titles produced by ILCA Publications in 1982 is given in the Annex to this report.

A publication from ILCA not only has to read well; it has to look good. Another major initiative during 1982 was therefore to improve the design of the centre's publications. New ranges of typefaces and better grades of paper made it possible to produce a wider variety of more attractive publications.

Subject to the availability of resources, activities will expand in two further ways during 1983. Firstly, the team will begin producing tape/slide presentations to promote ILCA's technical innovations. Secondly, a series of technical newsletters will be developed in order to enhance information exchange through ILCA's networks.

The CGIAR: An international network for agricultural research in the Third World

The Consultative Group on International Agricultural Research (CGIAR) was founded in 1971 to finance and coordinate research on the food and agricultural problems confronting the Third World. It consists of governments, international agencies and private foundations. The chairman and secretariat are staff members of the World Bank, while technical guidance and review are provided by a Technical Advisory Committee (TAC) made up of 13 distinguished agricultural and social scientists drawn about equally from developed and developing countries.

The origin of the group lies in the great success of two international research institutes that had been set up by the Ford and Rockefeller Foundations in the 1960s: the International Rice Research Institute (IRRI), established in the Philippines in 1960, and the International Maize and Wheat Improvement Centre (CIMMYT) in Mexico, formally constituted in 1966. Their objective was to breed varieties of rice, maize and wheat that would respond to fertiliser and irrigation. Within 10 years, their breeding programmes had been extremely successful and millions of farmers throughout Latin America and Southeast Asia were adopting the advanced technology of improved varieties and fertiliser. Crop production rose dramatically and the Green Revolution was born.

The impact that high-level scientific research could make on food output in the developing world had been amply proven. But more research was necessary in the light of accelerated population growth. It was to promote such research that the group was set up. Since its establishment a further 11 centres have been created.

The main emphasis continues to be on the improvement of food crops. The International Institute of Tropical Agriculture (IITA), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the International Centre for Agricultural Research in the Dry Areas (ICARDA), the International Centre for Tropical Agriculture (CIAT), the International Potato Centre (CIP) and the West African Rice Development Association (WARDA) all conduct research on the most important cereal, legume, root and tuber crops of the developing world.

However, the group recognised the vital importance of animal production in the Third World, and in the mid-1970s established two centres to conduct research on livestock: the International Livestock Centre for Africa (ILCA) and the International Laboratory for Research on Animal Diseases (ILRAD).

In addition, the International Board for Plant Genetic Resources (IBPGR) was founded to collect and conserve germplasm that might otherwise be lost, while the International Food Policy Research Institute (IFPRI) and the International Service for National Agricultural Research (ISNAR) complete the network.

The impact of this international agricultural research network is not confined to new technology. It provides leadership in multidisciplinary approaches to the analysis and improvement of what are often highly complex food production systems. Such leadership is illustrated by ILCA's systems approach to livestock research. The results of research have demonstrated to policy makers that investment in high-quality agricultural research pays high dividends.

Funding for the 13 centres increased sixfold between 1972 and 1980. However, in the last 2 years donor contributions have grown relatively slowly. In 1982 the group's total core budget amounted to some US$ 140 million, compared with US$ 127 million in 1980. Limited increases in funding, combined with fluctuations in exchange rates and rapid inflation, have caused most centres to cut back their activities at a time when the need and demand for their services are increasing rapidly.

Abbreviations

AAASA:	Association for the Advancement of Agricultural Sciences in Africa
AGRIS:	FAO Agricultural Information Service
APRU:	Animal Production Research Unit (Botswana)
ARDU:	Arsi Rural Development Unit (Ethiopia)
ARNAB:	African Research Network on Agricultural Byproducts (ILCA, Ethiopia)
ATIP:	Agricultural Technology Improvement Project (Botswana)
BIBLIO:	The name of ILCA's bibliographic database
BMDP:	Biomedical Computer Programs
CAB:	Commonwealth Agricultural Bureaux (UK)
CADU:	Chilalo Agricultural Development Unit (Ethiopia)
CCRs:	Cereal crop residues
CGIAR:	Consultative Group on International Agricultural Research (Washington, D.C.)
CIAT:	International Centre for Tropical Agriculture (Colombia)
CYMMIT:	International Maize and Wheat Improvement Centre (Mexico)
CIP:	International Potato Centre (Peru)
CSIRO:	Commonwealth Scientific and Industrial Research Organisation (Australia)
FLD:	Federal Livestock Department (Nigeria)
EEC:	European Economic Community
EDF:	European Development Fund
FAO:	Food and Agriculture Organisation of the United Nations
GTZ:	Gesellschaft für Technische Zusammenarbeit (Agency for Technical Cooperation; Germany – Federal Republic)
IAR:	Institute of Agricultural Research (Ethiopia)
IBPGR:	International Board for Plant Genetic Resources (Italy)
ICARDA:	International Center for Agricultural Research in the Dry Areas (Syria)
ICIPE:	International Centre for Insect Physiology and Ecology (Kenya)
ICRISAT:	International Crops Research Institute for the Semi-Arid Tropics (India)
IDRC:	International Development Research Centre (Canada)
IFAD:	International Fund for Agricultural Development (Italy)
IFPP:	Integrated Farming Pilot Project (Botswana)
IFPRI:	International Food Policy Research Institute (USA)
IITA:	International Institute of Tropical Agriculture (Nigeria)
ILRAD:	International Laboratory for Research on Animal Diseases (Kenya)
IRRI:	International Rice Research Institute (Philippines)
ISNAR:	International Service for National Agricultural Research (Netherlands)
LANDSAT:	Land Resources Satellite
LINDO:	Linear, Interactive and Discrete Optimizer (software package)
MINISIS:	A software package developed by IDRC for handling bibliographic data
NAPRI:	National Animal Production Research Institute (Nigeria)
NASA:	National Aeronautical and Space Agency (USA)
NRL:	Niger Range and Livestock Project
ODEM:	Organisation pour le Développement de l'Elevage dans la Région de Mopti (Mali)
PGRC:	Plant Genetic Resources Centre (Ethiopia)
PPR:	*Peste des petits ruminants*
RDP:	Rangelands Development Project (Ethiopia)
SDI:	Selective Dissemination of Information
SODEPRA:	Société de Développement des Productions Animales (Ivory Coast)
SPSS:	Statistical Package for the Social Sciences
TAC:	Technical Advisory Committee for the CGIAR
TCRV:	Tissue Culture Rinderpest Vaccine
TLU:	Tropical livestock unit (250 kg)
UNDP:	United Nations Development Programme (Italy)
UNEP:	United Nations Environmental Programme (Italy)
USAID:	United States Agency for International Development
WARDA:	West African Rice Development Association (Liberia)

Annexes

Staff List

(Supervisory and professional staff, as at 1 May 1983)

DIRECTORATE

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C. de Haan, *Acting Deputy Director General*

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M.H. Butterworth, *Deputy Director of Research and Head of Nutrition*

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Addis Anteneh, *Economist*

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H. Maehl, *Animal Scientist*
J. Sandford, *Data Analyst*
Y. Wissocq, *Economist*

Forage Legume Agronomy Group

J.R. Lazier, *Forage Agronomist*
J.M. Kahurananga, *Forage Agronomist*

Nutrition Unit

Aklilu Askabe, *Experimental Officer*
A.K. Mosi, *Animal Nutritionist*
M.B. Olayiwole, *Ruminant Nutritionist (Visiting scientist)*
J.D. Reed, *Animal Nutritionist (Post-doctoral fellow)*

Aerial Survey Unit

J. Meunier, *Pilot*

Cartography Unit

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Computer Unit

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D. Light, *Programmer*
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Azeb Abraham, *Librarian*

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D. Niang, *Editor/Translator (French)*
R.A. Stewart, *Science Writer*

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Amde Wondafrash, *Liaison Officer*
E. Mukasa-Mugerwa, *Training Officer*
Tafesse Akale, *Protocol Officer*

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F. Leone, *Maintenance Engineer*
J.A.T. Thersby, *Warden Officer*
J.W. Whalley, *Site Development Manager*

Finance

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Belayhun Wondimu, *Chief Accountant*
Emmanuel Tesfamariam, *Budget Officer*
Tekeste Berhan Habtu, *Procurements Officer*

FIELD PROGRAMMES

Highlands Programme (Ethiopia)

F.M. Anderson, *Team Leader, Agricultural Economist*
Abate Tedla, *Forage Agronomist*
Ephraim Bekele, *Dairy Production Officer*
Getachew Assamenew, *Agricultural Economist*

G. Gryseels, *Agricultural Economist*
I. Haque, *Soil Scientist*
S. Jutzi, *Forage Agronomist*
Tadesse Tessema, *Coordinator, Debre Zeit Field Station*
I. Whalen, *Rural Sociologist (Rockefeller post-doctoral fellow)*
Woldeab Wolde Mariam, *Coordinator, Debre Berhan Field Station*

Arid and Semi-arid Zones Programme (Mali)

R.T. Wilson, *Team Leader, Animal Scientist*
M.S. Dicko, *Animal Nutritionist*
C. Fowler, *Biometrician*
P. Hiernaux, *Ecologist*
H. Hulet, *Agronomist*
S. Maiga, *Veterinarian*
J. Marie, *Geographer*
S. Soumare, *Sociologist*
J.J. Swift, *Economist*
A. Tall, *Administration Officer*
K.T. Wagenaar, *Animal Scientist*
M.C. Wagenaar, *Human Nutritionist*

Subhumid Zone Programme (Nigeria)

R.R. von Kaufmann, *Team Leader, Agricultural Economist*
W. Bayer, *Animal Scientist*
J.A. Maina, *Veterinarian*
E.O. Otchere, *Animal Nutritionist*
J.M. Powell, *Crop Agronomist*
M.A.M. Saleem, *Forage Agronomist*
H. Suleiman, *Field Supervisor*
E. Taylor-Powell, *Sociologist*
A. Waters-Bayer, *Sociologist*

Humid Zone Programme (Nigeria)

C. Okali, *Team Leader, Socio-economist*
B. Carew, *Animal Nutritionist*
S.D. Mack, *Animal Scientist*
E. Onyeka, *Farm Manager*
B. Opasina, *Veterinarian*
J. Sumberg, *Forage Agronomist*

Rangelands Programme (Ethiopia)

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Assefa Eshete, *Photo-interpreter*
Belete Dessalegne, *Animal Scientist*
J-C. Bille, *Ecologist*
M.J. Nicholson, *Animal Scientist*

Rangelands Programme (Kenya)

Solomon Bekure, *Team Leader, Agricultural Economist*
F. Chabari, *Economist*
B.E. Grandin, *Anthropologist*
J. King, *Animal Scientist*
P.N. de Leeuw, *Ecologist*
A. Okuome, *Administration and Finance Officer*
I. ole Pasha, *Sociologist*
P. Semenye, *Animal Scientist*
M. de Souza, *Sociologist*

Rangelands Programme (Botswana)

N. Abel, *Range Scientist*

The ILCA programmes

Headquarters/Central Research/Training/Information
P.O.Box 5689, Addis Ababa, Ethiopia.
Telex: 21207

Highlands Programme
P.O.Box 5689, Addis Ababa, Ethiopia.
Telex: 21207

Humid Zone Programme
P.O.Box 5320, Ibadan, Nigeria.
Telex: 31417

Subhumid Zone Programme
P.O.Box 2248, Kaduna, Nigeria.
Telex: 71384

Arid and Semi-arid Zones Programme
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Telex: 459

Rangelands Programme (Ethiopia)
P.O.Box 5689, Addis Ababa, Ethiopia.
Telex: 21207

Rangelands Programme (Kenya)
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Telex: 22040

Rangelands Programme (Botswana)
P.O.Box 20604, Gaborone, Botswana.
Telex: 2412

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List of 1982 donors

CGIAR contributions

African Development Bank
Australia
Belgium
Denmark
France
Germany - Federal Republic
India
International Development Association (World Bank)
International Fund for Agricultural Development (IFAD)
Ireland
Italy
Netherlands
Nigeria
Norway
Sweden
Switzerland
United Kingdom
United States of America (USAID)

Special project grants

Belgium
Botswana
Ethiopia
Ford Foundation
International Development Research Centre (IDRC)
Kenya
Nigeria
Office de Développement de l'Elevage de la Région de Mopti (ODEM)

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East African range livestock systems research. 1982. Addis Ababa. Describes the sites, research objectives and methods of the ILCA research programme in Kenya.

ILCA 1982. Addis Ababa. Briefly describes ILCA's research and other activities, and the centre's achievements up to 1982.

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AUDITORS' REPORT TO THE BOARD OF TRUSTEES OF THE INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA

Our examination was made in accordance with generally approved auditing standards and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary.

Depreciation has not been provided on fixed assets. This is in accordance with procedures and requirements established by the Secretariat of the Consultative Group on International Agricultural Research.

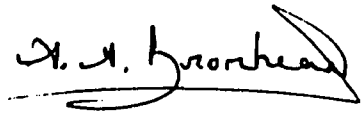
We have not visited sites of country programmes operated by ILCA in Botswana, Kenya, Mali and Nigeria. Returns made from these country programmes of revenue, expenditure and unexpended funds for the year ended December 31 1982 and of assets and liabilities at that date have been incorporated in the annexed accounts. The net assets so incorporated were as follows:

Botswana	$ 60 639
Kenya	198 048
Mali	954 984
Nigeria	920 867
	$ 2 134 538

Since original documents and vouchers in support of expenditure are retained within these countries, the scope of our audit was restricted accordingly.

Included under accounts receivable others, are debts outstanding for periods in excess of one year amounting to $ 166 965 which have not been recovered to date and which in our opinion ought to be provided for.

Subject to the above, in our opinion the attached Balance Sheet, Statement of Revenue, Expenditure and Fund Balances and Statement of Source and Application of Funds, together with the notes thereon forming part of the accounts and exhibits A, B and C which have been prepared under the historical cost convention, present fairly under that convention, the financial position of the International Livestock Centre for Africa at December 31 1982 and the results of its financial operations for the year then ended in conformity with generally accepted accounting principles except as indicated above.



A.A. Bromhead & Co.
Chartered Accountants
March 24 1983

P.O. Box 709
Addis Ababa
Ethiopia

INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA
BALANCE SHEET at December 31 1982
(US$ '000)

ASSETS

	1982	1981
Current assets		
Cash	$ 1 508	$ 544
Receivable from - donors	613	1 175
- employees	34	94
- others	624	412
Inventories	173	234
Prepaid expenses	193	223
Total current assets	3 145	2 682
Fixed assets		
Buildings	6 600	6 401
Research and laboratory equipment	894	533
Computer	518	332
Furnishings and office equipment	1 596	1 653
Vehicles and aircraft	1 524	1 205
Other	310	223
Total fixed assets	11 442	10 347
Total assets	$ 14 587	$ 13 029

LIABILITIES AND FUND BALANCES

Current liabilities		
Bank overdraft	$ 2	$ 829
Accounts payable employees	171	117
Other payables and accruals	1 660	1 447
Contribution received in advance	633	370
Total current liabilities	2 466	2 763
Fund balances		
Invested in fixed assets	11 442	10 347
Working funds (1981 deficit)	578	(115)
Special projects	101	34
Total fund balances	12 121	10 266
Total liabilities and fund balances	$ 14 587	$ 13 029

INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA
STATEMENT OF REVENUE, EXPENDITURE AND FUND BALANCES
for the year ended December 31 1982

(US$ '000)

	1982	1981
Revenue		
CGIAR contributions (Exhibit A)	$ 9 852	$ 9 163
Special project grants (Exhibit A)	1 262	684
Earned income	159	126
Total revenue	11 273	9 973
Operating expenditure		
Research		
Direction	98	209
Central scientific units	558	380
Central support services	889	681
Field programmes	3 772	4 362
Networks	39	93
Total research	5 356	5 725
Information services	693	798
Training and conferences	316	514
General administration	590	663
HQ operations and maintenance	642	704
Board and management	626	614
Total operating expenditure (Exhibit B)	8 223	9 018
Capital expenditure	1 095	811
Special projects (Exhibit C)	1 195	692
Total expenditure	10 513	10 521
Excess (1981 shortage) of revenue over expenditure	$ 760	$ (548)
FUND BALANCES		
Opening balances		
Core	$ (115)	$ 425
Special projects	34	42
Total opening balances	(81)	467
Add excess (1981 shortage) of revenue over expenditure	760	(548)
Closing balances		
Working capital (1981 deficit)	578	(115)
Special projects	101	34
Total closing balances	$ 679	$ (81)

Source and application of funds 1981 and 82