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ILCA
ANNUAL REPORT
1984

Livestock research and food production in Africa

INTERNATIONAL LIVESTOCK
CENTRE FOR AFRICA

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1984

Livestock research and food production in Africa

INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA
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Foreword

Fifteen years ago Africa was a net exporter of food. Now, the continent is desperately short of food. Crop yields have remained static while the human population has grown more than twice as fast as the increase in the area cultivated. The problem shows no sign of resolution and the famines of 1984/85 seem destined to become common events, despite an extraordinary growth in food imports.

More than any other region of the world, Africa suffers from a declining availability of food and a stagnant productivity of both land and labour. The green revolution of Asia, based on irrigated wheat and rice, has barely touched this continent where irrigation is rare, ecological conditions are frequently difficult, and many soils are fragile.

The cause of this situation is not only lack of investment; much of the money spent on agricultural development in Africa has simply not paid off. Justifiably, donors are unwilling to compound the mistakes of the past, and support for conventional development projects in Africa is declining. A new strategy is essential.

Africa's agriculture is land- and labour-intensive. Expanding production using traditional technology requires more land and more seasonal labour, both of which are increasingly scarce. The basic unit of production is the smallholder subsistence farm, where the main constraints on output include negligible fertilizer use and seasonal labour shortages.

The experiences of the last decade, particularly those in Asia, clearly indicate that the two most powerful forces for reducing poverty are increased food output and declining food prices. We have also learned that the only way in which these two changes can occur simultaneously is through technical advances which increase farm productivity while decreasing the unit costs of production. The major concern at ILCA is to generate the scientific and practical knowledge needed to achieve these objectives in Africa.

Part of the production problem is inappropriate policies and incentives; but 'appropriate policies' are difficult to identify and implement. Price incentives are usually considered a basic component of a wise agricultural policy, yet the increased poverty and malnutrition associated with any rise in food prices cause even the strongest governments to move cautiously in this area. Tempting though it is to believe that the absence of price controls, more realistic exchange rates, free movement of commodities and the encouragement of private traders would stimulate production, if such policy changes alone could easily increase output one must ask why they have not been implemented long before now, since enlightened self-interest is as common in Africa as elsewhere. The answer is that African governments know better than anybody that the increased hunger, poverty and malnutrition associated with price rises in basic foods are threats to the stability of their countries.

Recent evidence from Asia, as well as from Europe, suggests that policy changes that occur in a situation where new technology is available are likely to be more acceptable and more productive. An expanded supply of food resulting from new technology results in reduced food prices, while lower unit costs of production provide greater incentives to farmers. It is the combination of technological innovation with more effective pricing, marketing and training that provides the essential ingredients required to break the production barrier. Under African conditions, however, we know far too little about the interaction of these complex factors. Recognizing this, ILCA has recently developed a unit for livestock policy analysis to assist African policy makers in evaluating the alternatives available in making these most difficult decisions.

In the search for higher output of food grains the role of livestock is critically important; they are the catalyst to low-cost improvements in agricultural output. The more animals subsistence farmers can maintain, the greater is their cash income and capital reserve, the larger is the land area they cultivate and the more fertilizer, better cultivation and improved seeds they use. Animals contribute directly and in large measure to the total production of food crops. Better livestock technology provides a logical starting point for overcoming Africa's food crisis.

At ILCA a first generation of livestock-based improvements is now being tested. Under reasonable management, Africa's trypanotolerant livestock breeds are now known to be more productive than originally thought; good results from chemotherapy programmes for the control of trypanosomiasis have been achieved; improved animal feeding based on strategic supplementation with legumes is immensely beneficial provided specific mineral deficiencies in livestock can also be overcome; crop residues can be better used in a variety of ways; crossbred dairy cows are four times as productive as local breeds; ox-drawn scoops can be used to build small ponds and dams for village water supplies, irrigation and aquaculture; with simple improvements, traditional cultivation implements drawn by oxen can improve drainage, control soil erosion and reduce high seeding rates.

The first generation of improvements is now starting to make an impact on food production, particularly in the ecologically more favoured areas. But in the drier areas, where famine takes its largest toll, current technical advances are still insufficient to produce important changes. More and better research is desperately needed to forge answers to Africa's age-old problems of erosion, declining soil fertility and poor crop yields, and a key research task is to identify and develop new plant varieties and farm management systems that will flourish under dry and difficult conditions.

Africa needs the best that international science can offer: biotechnology, embryo transfer and tissue culture, recombinant DNA technology, genetic mapping, computer analysis and satellite imagery are some of the key techniques that must be used more widely in the future, alongside the more traditional research methods.

ILCA's facilities and skills in these new areas, as well as in research training, documentation, laboratory techniques and policy analysis can provide the support that national research institutions require. It is the money provided by the CGIAR donors to ILCA that makes that support possible. And it is the growth and strength of national institutions that will determine the future of African agriculture. What is now needed is a very much enlarged and sustained commitment to both national and international agricultural research in order to increase the productivity of Africa's agriculture. Otherwise, the landscape, and the people in it, will surely continue to die.

Peter J. Brumby
Director General

ILCA 1984: Highlights

Efforts to improve agricultural output in Africa depend on strong links between national and international research. At ILCA, these links grew in 1984. Uptake of ILCA's research results by national institutes expanded, two new networks were set up, and the Centre provided valuable assistance in the analysis of data from national programmes. Meanwhile, research carried out by ILCA's field programmes and central research units continued to yield results with important implications for the future focus of national programmes.

National programme extension of ILCA research

• The Ethiopian Ministry of Agriculture has ordered the local manufacture of 500 metal scoops for surface pond construction using indigenous oxen in the highlands of the country. The scoops closely follow the model successfully designed and tested by ILCA at its highland research stations. The Ministry has identified sites throughout the highlands suitable for ponds. Two Peasants' Associations in the Debre Berhan area have successfully completed surface ponds using their own oxen.

• The Ministry is also promoting the use of the single-ox plough developed by ILCA. The modified *maresha* is now being used by over 1000 farmers in the highlands, while still more who lost livestock during the 1984 drought will benefit from the technique in 1985.

• The National Livestock Project Unit of the Nigerian Federal Livestock Department extended a pilot project on small ruminant development in southwest Nigeria during 1984. The project, based on research results by ILCA and IITA, is using tissue culture rinderpest vaccine to control *peste des petits ruminants* – the major disease constraining the area's sheep and goat productivity – and is introducing alley farming to provide both food crops and high quality feed for small ruminants. Between April and June 1984, 65 new alley farms were planted.

• The Unit also extended its support for ILCA's fodder bank research. The total number of fodder banks in the country's subhumid zone rose from 24 to 46 during 1984. Of these, about 30 are funded and managed entirely by pastoralists.

New networks for pan-African livestock research

• ILCA launched two new networks during 1984. The Small Ruminant and Camel Network produced the first issue of a newsletter distributed to 300 researchers in 30 countries of Africa. The newsletter of the African Livestock Policy Analysis Network now reaches over 1500 researchers and policy makers in the continent.

Analysis of data from national programmes

• ILCA staff assisted national organisations in the analysis of several important sets of livestock data during 1984.

Zimbabwe: A major comparison between Sanga and *Bos taurus* breeds supported the view that the use of indigenous rather than exotic breeds is more likely to give long-term increases in beef production from African rangelands.

Senegal: Analyses of the performance of the Gobra Zebu breed provided the data required for planning the genetic improvement of this breed under current management schemes.

Rwanda: Analyses of 6 years' data from Songa Station provided valuable information on milk and calf production of Ankole cattle under partial suckling. Further analyses on sheep and goat data were started on behalf of the Institut des Sciences Agronomiques du Rwanda (ISAR).

Malawi: Analysis of stall feeding beef and dairy records from small farms and milk production records from state farms provided bases for strategy decisions.

Tanzania: An extensive analysis of data collected at Mkwaja Ranch over a 10-year period confirmed that Boran cattle can be highly productive under medium to high trypanosomiasis risk if a well managed chemoprophylactic regime is followed. This study was made in collaboration with Amboni Ltd (the owners of Mkwaja Ranch),

ILRAD and May and Baker Ltd (UK). ILCA also assisted the Tanzanian Government in the analysis of data from the Mtwara/Lindi small ruminant project.

Ethiopia: Analyses of various sets of experimental results were made for several staff members of Ethiopia's Institute of Agricultural Research (IAR). Further assistance was given to Ethiopia's Plant Genetic Resources Centre (PGRC) in indexing 27000 accessions collected over the past 10 years.

In the pipeline

• In the Ethiopian highlands vetch (*Vicia villosa* ssp. *dasycarpa*) transferred the equivalent of 45 kg N/ha to a subsequent maize crop. Three native *Trifolium* clovers grown on a Vertisol transferred a minimum of 46 kg N/ha to a subsequent oats crop when supplied with small amounts of P. Some lines of these clovers yielded 8–10 t DM/ha and their seed yields were as high as 1.4 to 1.6 t/ha.

• *Trifolium* yields increased substantially when small or moderate amounts of phosphate (5 to 15 kg P/ha) were added. Egyptian rock phosphate was as effective as superphosphate at low rates of application.

• On Ethiopian Vertisols, the use of broadbeds and furrows to improve surface drainage in research station trials increased the yields of cereals by 40%, potatoes by 160% and horse beans by 380%.

• A low-cost agitator designed by ILCA for use with the traditional earthenware pots used as butter churns in the highlands, increased the amount of fat recovered from soured milk from 67% to 90%.

• In three southwest Nigerian villages, where ILCA's health package for goats has been tested, goat populations doubled (from 114 to 248) after 24 months compared to a maximum increase of 35% in non-treatment villages.

• *Leucaena* trees in their third year grown in alley farms increased maize yields by 40% primarily through mulch, contributed substantially to a total of 2396 sheep grazing days per ha from the alley farming system, and yielded 33 m^3 of wooden poles per ha. Four lines of *Gliricidia sepium* collected from Costa Rica yielded an average of 37% more mulch than local varieties.

• In the subhumid zone of Nigeria, maize crops grown following 2 years of the legume *Stylosanthes hamata* showed yield increases of nearly 3 t/ha over yields on land that had previously been fallow (3600 kg/ha, compared with 850 kg/ha). A study of fields where cattle were kept overnight showed that manure added 41 kg N/ha and 10 kg P/ha to the soil during the 6-month dry season.

• A 1984 study showed that while the share of net livestock output in the total agricultural GDP of 16 African countries averages 27%, the share of expenditure on livestock within agricultural services averages only 11%.

• Studies in Botswana, Kenya and Ethiopia showed that while ranching is more productive than pastoral systems on a per animal basis, the reverse is true on a per hectare basis, despite high rates of animal mortality in the pastoral systems.

• The addition of either molasses with 8% urea or *Trifolium tembense* hay to poor-quality roughage increased DM intake and feed digestibility in sheep. The addition of both simultaneously produced considerable additional benefits.

• The forage legume *Stylosanthes guianensis* cv. Cook shows considerable potential on acid soils in the medium-altitude (1000 m) areas of western Ethiopia. Local seed production has been started and seed is being distributed to peasants' cooperatives and farmers in the densely populated Soddo region where milk production is important.

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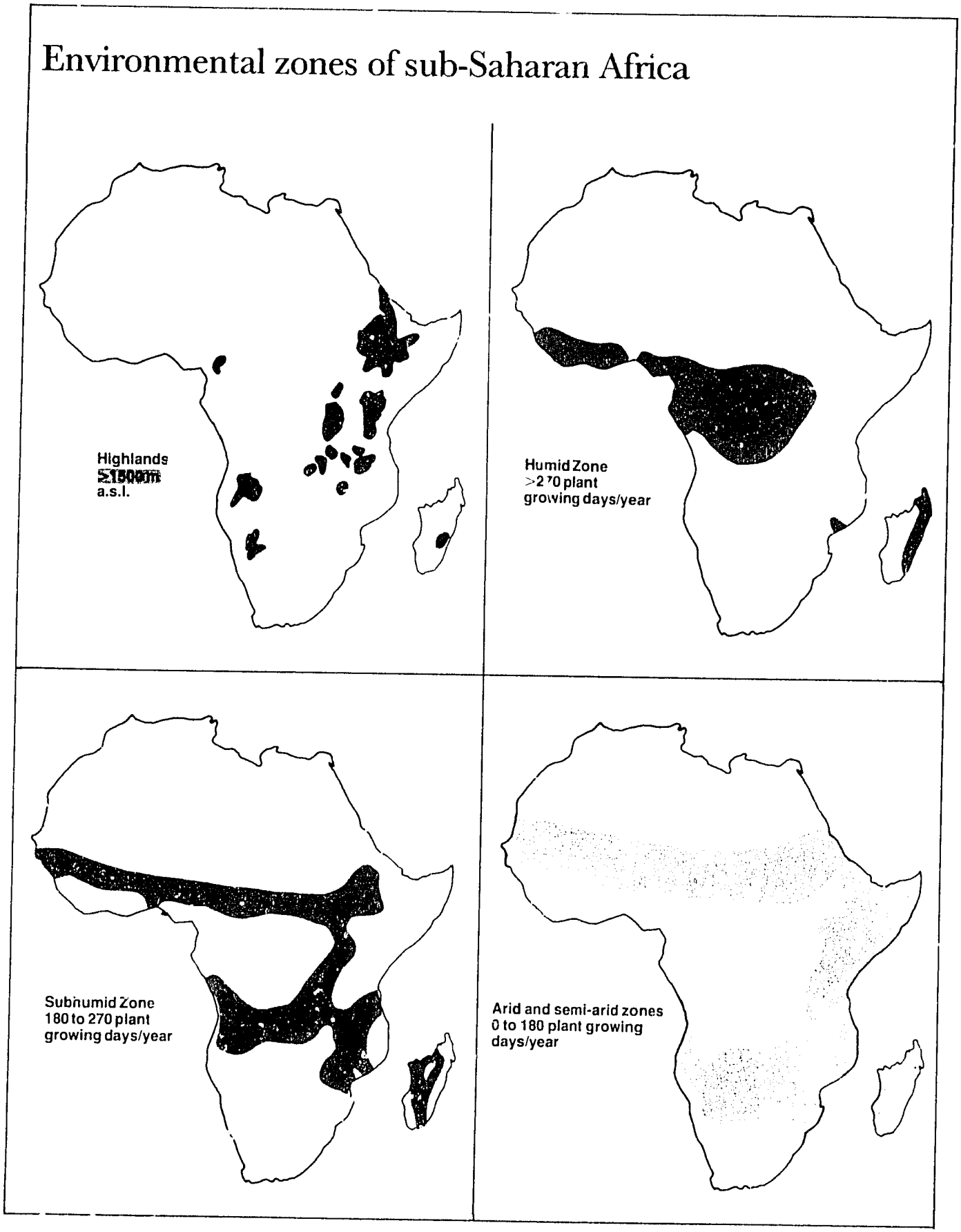
Environmental zones of sub-Saharan Africa



Field programmes

The Highlands Programme

Introduction

Drought in sub-Saharan Africa during 1983 and 1984 has highlighted the urgent need to achieve substantial and sustained increases in food crop production. Livestock support overall farm productivity by supplying cash for farm and household purchases, draught power and manure, and a measure of income security in times of crop failure, when livestock can be sold in exchange for grain. The strength of these and other interactions between crops and livestock on African smallholder farms makes gains in crop production heavily dependent upon increases in livestock production.

ILCA's Highlands Programme is studying the means of raising farm production via livestock enterprises. The research is done mainly in Ethiopia where farmers desperately need to increase farm production and where there are now rural organisations well suited to the adoption of low-cost innovations. Ethiopian smallholders, who keep livestock in small herds and flocks, confront most of the same technical barriers to improved production as do smallholders in other mixed farming areas in sub-Saharan Africa. Research results produced in Ethiopia can therefore be expected to have ready application elsewhere in the continent.

The Programme's major research projects are on legume technology and the management of Vertisol-type soils, efficiency and use of draught animals, milk production and use in smallholder dairy enterprises, and sheep production using indigenous breeds. The effectiveness of the techniques developed at ILCA's headquarters, Debre Berhan and Debre Zeit facilities is appraised in on-farm trials. In these the performance of the innovations is measured against the results achieved by farmers using traditional management methods. Background studies on traditional farms also provide information on the components of the farming systems which most constrain farm production.

Legume technology

Nitrogen (N) deficiency is the major soil-related constraint to increased food and feed production in subsistence-oriented smallholder systems. Inorganic N fertilizer is expensive and often unavailable. Legumes, with their ability to fix atmospheric N, constitute a significant additional source of N under these farming conditions.

The Programme has started an integrated series of trials aimed at:

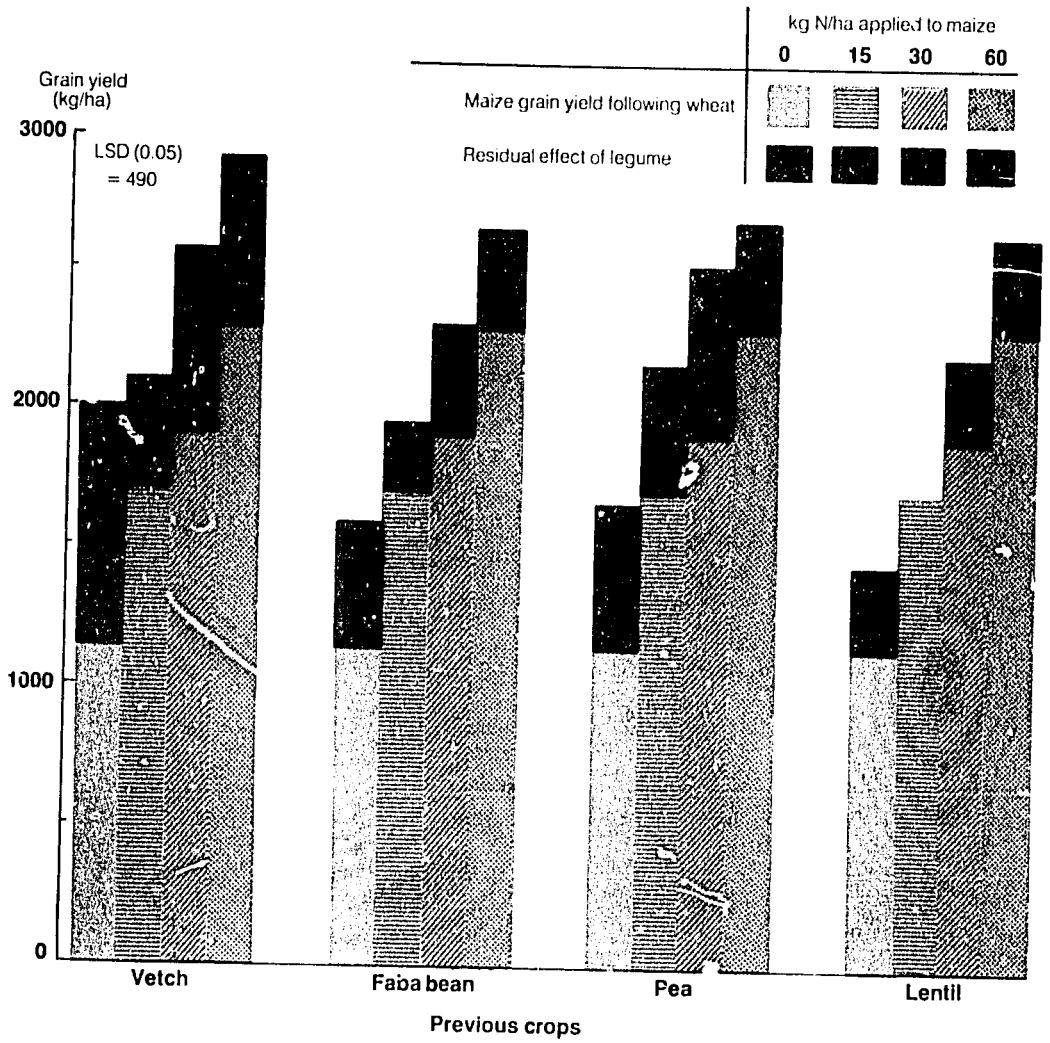
1. Identifying high-yielding leguminous plants with good N fixation rates and with tolerance to low soil fertility; and
2. Designing systems in which legumes can be integrated effectively into food crop production.

Figure 1 shows the effects of N contributed by legumes grown in rotation with maize at Debre Zeit. The amounts of N contributed to the subsequent maize crop were approximately 45, 28, 24 and 17 kg N/ha for vetch, peas, faba beans and lentils respectively.

Phosphorus (P) is also a limiting factor on many highland soils. Figure 2 shows the forage production potential of three African clovers on two different soils with and without P application. *Trifolium tembense* performed best under all conditions, while *T. rueppellianum* appeared to have a limited potential.

The three African clovers *T. tembense*, *T. rueppellianum* and *T. steudneri*, when grown on a Vertisol, transferred at least 46 kg N/ha to

Figure 1. Residual effect of four legume crops on N supply to a following maize crop, Debre Zeit, 1984.



the subsequent oats crop if they were adequately supplied with P. Lucerne (*Medicago sativa*) was shown to have a beneficial effect on companion grasses in the second year after establishment. Lucerne made considerable N available to the two grasses *Chloris gayana* and *Panicum maximum*, and provided about one fifth of the total dry matter yields from the mixture. The grasses grown in pure stands had much lower productivity and showed clear signs of N deficiency.

Forage legume oversowing on native pastures can substantially increase the legume percentage of a mixed sward. But Table 1 clearly shows that the degree to which such gains in pasture quality can be exploited depends on harvest date. Many highland areas are overstocked, and overgrazing has negative effects on the overall pasture yield. The extent of these effects was assessed in an experiment in which overgrazing was simulated. *Andropogon longipes*, the dominant grass on the most severely overgrazed soils of the higher altitudes in Ethiopia, was compared with an exotic grass (*Festuca rubra* cv. Cascade) of similar growth habit and morphology. Table 2 shows that cutting at 2-week intervals (simulating overgrazing) reduced total dry matter (DM) production to about 50% of that achieved from a 4-week cutting regime when no N was applied, while with N the reduction was even greater. Thus if the grasses are too heavily exploited, additional available N cannot be transformed into higher biomass production. Even if the soil N level was sufficiently

Table 1. Effect of harvest date on DM yield, crude protein and P content, DM solubility and botanical composition of a native *Hyparrhenia* pasture[a].

Harvest date	DM yield (t/ha)	Crude protein content (%)	Plant P content (%)	DM solubility (%)	% legumes in DM
30/9/84	1.7	11.8	0.23	58.7	25.8
31/10/84	3.3	11.0	0.19	53.6	38.3
30/11/84	2.6	5.2	0.16	47.3	8.0
LSD (P<0.05)	0.5	1.5	0.03	2.2	9.4

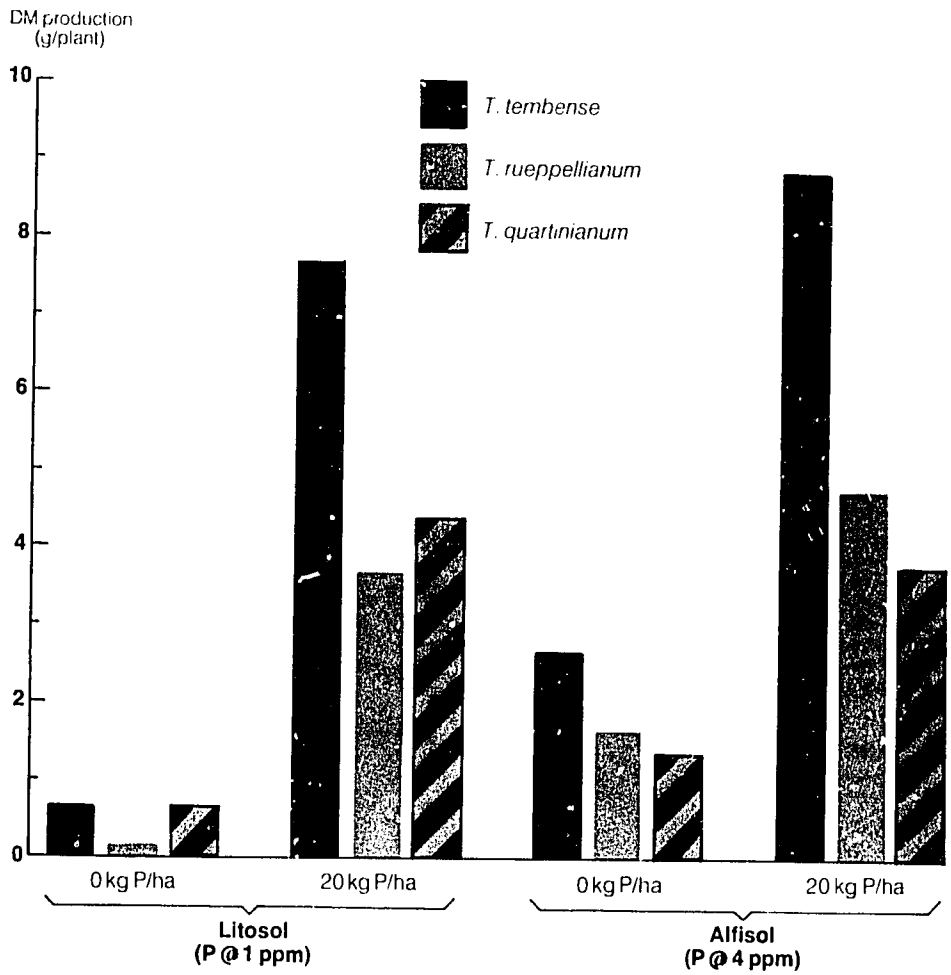
[a] Pasture grown with partial soil ripping, legume overseeding and P fertilization

high, e.g. with a grass–legume mixture, this N could not be effectively used. Table 2 also gives evidence for the better persistence of *Andropogon* under heavy offtake pressure compared with *Festuca rubra*, a species which is also considered to be tolerant to heavy grazing.

Vertisol management

Twenty-four percent of all cropped soils in the Ethiopian highlands are deep black clays classified as Vertisols. Occupying 1.93 million ha, these cropped Vertisols represent 25% of the total Vertisol area in the Ethio-

Figure 2. The effect of soil type and P supply on dry matter production of three African clovers (*Trifolium* spp.), greenhouse pot trial, ILCA headquarters, 1984.



pian highlands, the remainder being uncultivated because of physical problems such as lack of drainage. Vertisols account for about 70% of all Ethiopian highland soils with slopes between 0 and 8%. Most of the cropped Vertisol land is subject to soil erosion during the heaviest rains. Some of the Vertisols are sown to water-tolerant crops such as teff (*Eragrostis tef*). Others are sown to crops such as chickpea only towards the end of the main rains; the crop then matures on residual moisture stored in the soil. This latter practice does not exploit the high productive potential of these soils.

The Programme has recorded large increases in crop yields on these soils if surface water is controlled by the use of broadbeds and furrows or camberbeds and if appropriate cropping practices are used. Using broadbeds and furrows, grain yield increases due to improved drainage alone were about 40% for cereals, 160% for potatoes and 380% for horse beans. Corresponding increases in crop residue yields were recorded.

The main reason for the underutilisation of many deep black soils is the presence of excess water for much of the growing period. Some farmers have taken countermeasures, by preparing ridges and furrows and cropping on ridges, or using drainage furrows across the contour at about 4-m spacings. *Guie*, a local technique in which the soil

Table 2. Effects of simulated overgrazing and N supply on total DM yield of *Andropogon longipes* and *Festuca rubra*, greenhouse pot trial, ILCA headquarters, 1984.

Species	Month of evaluation	Total monthly DM yield (g/pot)				LSD (P<0.05)
		4-week offtake		2-week offtake		
		no N	N[a]	no N	N[a]	
Andropogon longipes	1	0.93	1.83	0.48	0.50	0.20
	2	0.98	1.72	0.59	0.50	0.37
Festuca rubra	1	0.88	1.72	0.42	0.66	0.10
	2	0.84	1.60	0.17	0.26	0.15
LSD (P<0.05)		NS[b]	NS	0.12	0.20	

[a] N fertilizer was applied at a rate of 100 mg/2-litre pot at the start of the experiment and 1 month after the start.

[b] NS = not significant.

on fallowed plots is piled up and burned, is also used by some farmers to improve drainage on Vertisols.

Most soils in the Ethiopian highlands, including Vertisols, are slightly acid and can therefore make good use of rock phosphate, which is cheaper than refined phosphate. Figure 3 demonstrates the effects of triple superphosphate (TSP) and rock phosphate on the growth of *Trifolium steudneri* on a Vertisol deficient in P (available P = ca 1 ppm). The clover grew very poorly at the control level, while TSP and rock phosphate had similarly dramatic effects at 15, 30 and 45 kg P/ha. Triple superphosphate was more effective than rock phosphate only at a high level of P application (60 kg P/ha). Such high rates of application are not relevant to low-income Ethiopian farmers.

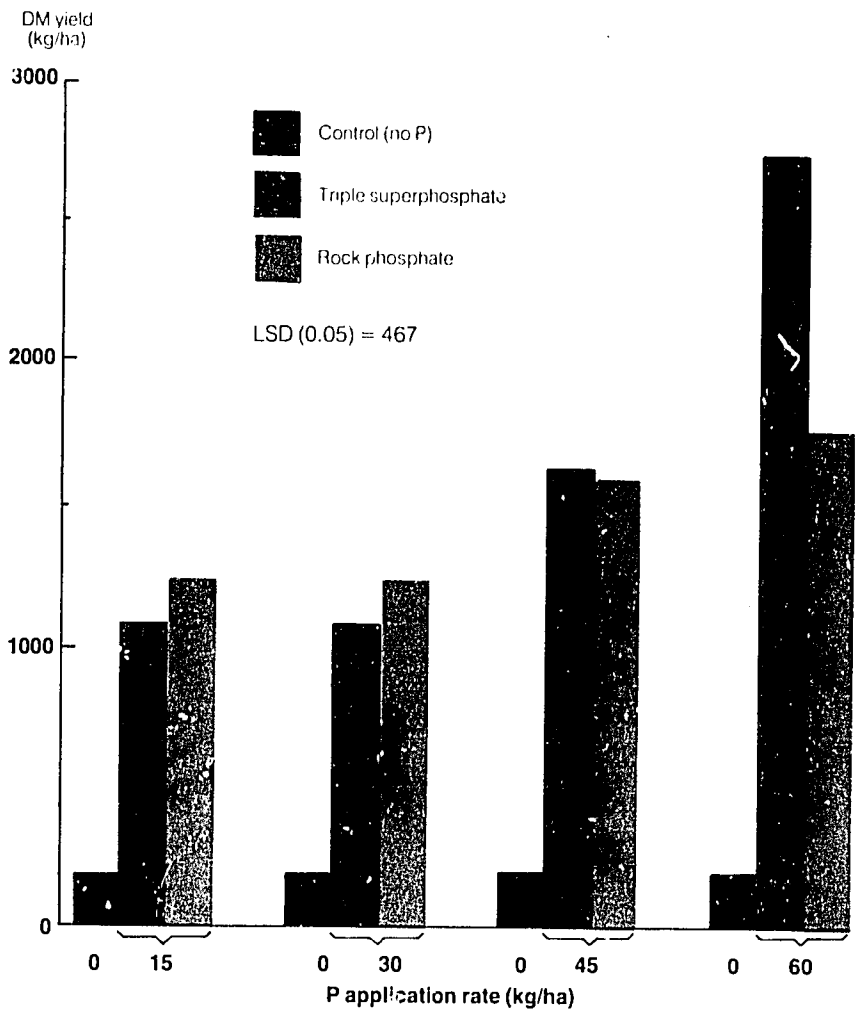
The work to date has shown that the strategic introduction of forage and grain legumes coupled with moderate P applications will form an effective basis for improved cropping in the highlands.

Animal traction

In sub-Saharan Africa, the available feed resources per head of livestock are declining and crop residues are becoming an increasingly important component of livestock diets. This trend highlights the need to develop animal traction methods requiring less power per unit area cultivated and to improve draught animal feeding systems. Both topics are being studied by the Programme. A version of the Ethiopian *maresha*[1], which can be drawn by a single ox rather than a pair as

[1] The *maresha* is a simple, traditional plough used in the Ethiopian highlands.

Figure 3. Relative effects of triple superphosphate and rock phosphate on *Trifolium steudneri*, ILCA headquarters, 1984.



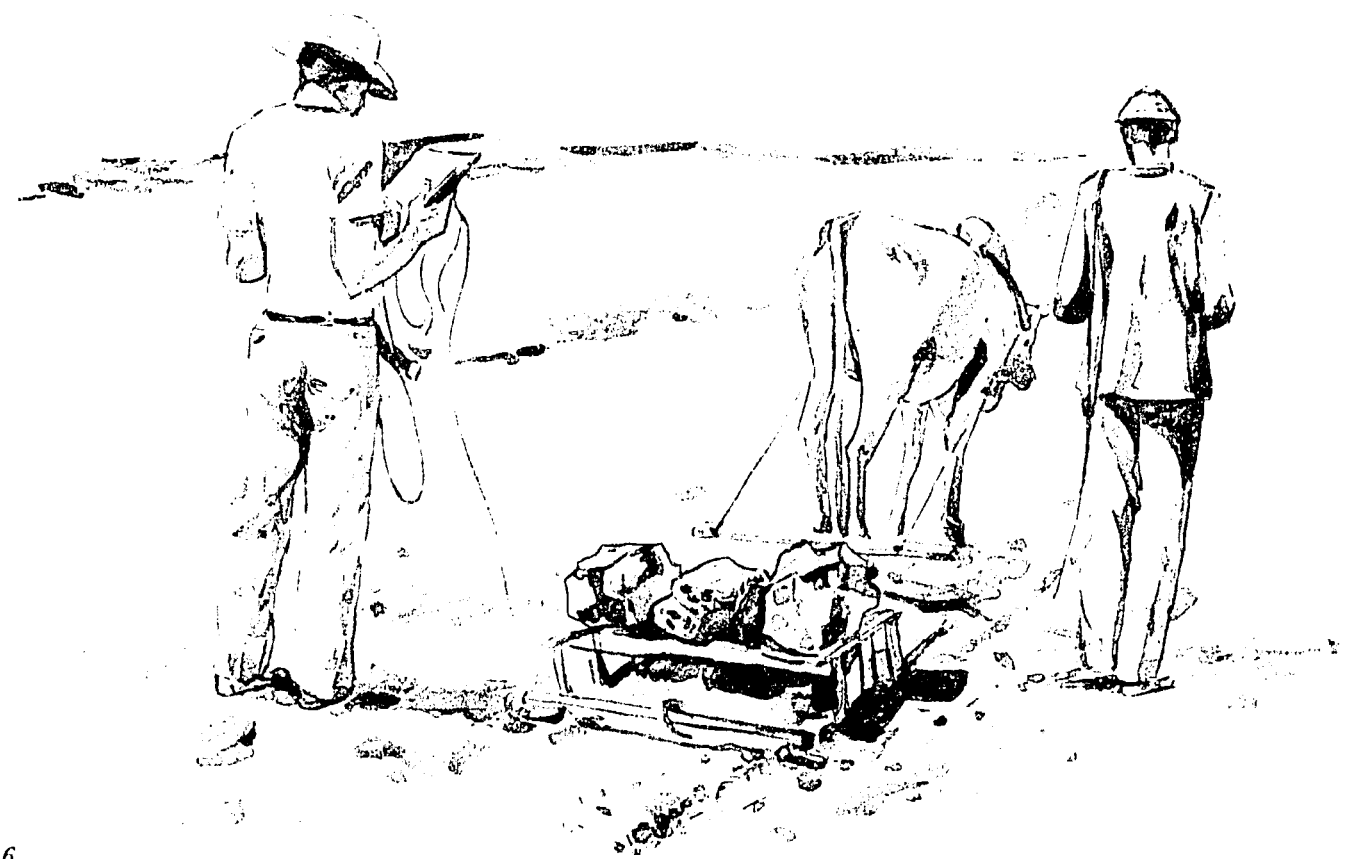
conventionally used, has been developed and tested.

Drawing this modified implement, a single ox can cultivate over 70% of the land tilled in the conventional way. The new implement is now being tested 'on-farm' by over 100 Ethiopian farmers. Their early adoption of this innovation reflects the importance farmers place on having draught power at critical times of the year. The innovation will allow a much higher percentage of farmers than before to have access to cultivation power. This result of research in Ethiopia has direct implications for farming systems in other countries where farmers will be obliged to reduce the numbers of draught animals they can keep because of feed shortages.

A companion study has been undertaken by the Programme in which cows have been used both for milk production and as draught animals. The results show that a pair of crossbred cows can cultivate 2.5 ha per year without significant reductions in milk production and calving frequency. A follow-up study, to be completed early in 1987, has been started in which cows are worked during different phases of their lactation and under different workloads. This study allows the trade-offs between milk production, reproductive performance, work output and nutrition to be elaborated.

Some farmers in ILCA's study areas have sold their oxen and now use cows for all their cultivation needs. This development, and the requests for crossbred cows from other farmers in the area, suggest that cows which can be used for milk, draught power and meat have considerable potential in the more intensive mixed farming areas.

The Programme also aims to improve the overall contribution of draught animals to farm production and thus reduce the effective costs of keeping oxen for only limited periods of work each year. The nutritional status of work oxen is usually lowest when they are most needed for work, i.e. at the end of an extended dry season. The effects of nutritional status on work performance are poorly documented. A major experiment, in which animals on different nutritional regimes are subjected to different workloads, is now in progress. This should enable feed/work standards for working oxen to be established. These results will allow better feeding strategies to be devised for particular work schedules, and will encourage the expansion



of the use of draught animals into periods of the year when they are not presently used.

Following work at the Debre Berhan research station in 1983, when a 7000 m^3 pond was excavated by oxen drawing 0.2 m^3 metal scoops, two groups of farmers began construction of ponds on their own land during the 1984 dry season. The metal scoops used were provided through a grant from Shell (Ethiopia) Ltd. The work was halted by the severe drought which struck the area in 1983/84. It was restarted at the end of 1984, and the ponds will be completed before May 1985, well in advance of the next rainy season.

Rural water supplies for household and domestic livestock needs are deficient for more than 7 months each year in the Ethiopian highlands. A similar situation exists in many parts of sub-Saharan Africa. The Ethiopian Government has started a major pilot programme of pond construction based on the Programme's results.

Other adaptations of traditional implements for use in improved cropping systems on Vertisols are being evaluated by the Programme. These include a mouldboard-type plough able to make and maintain broadbeds and furrows on these soils and a low-cost row planter for sowing on broadbeds. Capital for investment is limited in rural Ethiopia, as is access to short-term credits for farm improvement. These adaptations are intended as low-cost ways of achieving substantial production gains and raising cash incomes, thereby giving farmers greater opportunities to improve their own circumstances.

Dairy development

Dairy production is well known as a powerful means of raising cash incomes on smallholder farms. Dairy development in sub-Saharan Africa has met with mixed success in the past, partly because farm input systems are less well developed than, for example, in Asia, and partly because the marketing of fluid milk is often difficult. In Ethiopia, as in much of sub-Saharan Africa, the more successful smallholder dairy enterprises are within easy reach of major urban centres and/or near to all-weather roads. Smallholder dairy enterprises can also be important sources of increases in farm incomes in more remote areas – but only if relevant technical packages are available.

Poor product markets and communications mean that the successful development of smallholder dairy production will have to be based on a limited use of purchased inputs and on the sale of dairy products other than fluid milk.

A study was made of the efficiency of traditional dairy techniques. Apart from fresh milk, the major dairy products made in the Ethiopian highlands are soured milk, butter and cottage cheese. Soured milk is a popular drink in all highland regions of the country. Butter is always prepared from the soured milk, not from cream, and is churned in a clay pot or in a bottle gourd. Cottage cheese is made from the butter milk remaining after the butter has been skimmed off. The Programme found that the churning techniques used in traditional butter making were inefficient. Much of the fat in the milk was not converted into butter.

The Programme tested a low-cost agitator for use in the earthenware churns commonly used in the highlands. Because of the narrow neck of the traditional churn, the agitator is designed to be assembled inside the churn. Trials showed that 90% of fat in the soured milk could be recovered using the wooden agitator, compared to less than 67% of fat recovered by many traditional producers, and that churning times could be reduced

by more than 50%. The wooden agitator can be made for about US$ 5, and represents a substantial economic improvement for local dairy producers in the highlands.

The Programme has started further investigations of a range of milk products which could be produced by groups of farmers whose individual daily milk production is below 50 litres. Over 20 senior government technicians attended ILCA's first training course on dairy technology in January 1985. These individuals are responsible for promoting such techniques in Ethiopia's provinces. Further courses for nationals from other countries are planned.

Sheep improvement

The Menz is one of the major indigenous sheep breeds of Ethiopia and is of great importance on many mixed smallholder farms. Little research has been done on this breed to quantify its production parameters, to determine its productive adaptability or to assess genetic parameters.

The Programme established flocks of the Menz breed at the Debre Berhan station to develop and evaluate the impact of simple husbandry innovations. Production and survival parameters were collected on these flocks over 3 years. Data analyses showed that age at first lambing was 15.6 months and lambing interval was 8 months. With a twinning rate of 2.4%, the average litter size was 1.02, giving an annual reproduction rate of 1.4 lambs/ewe. Lamb mortality (birth to 12 months) was 12.6%, lamb growth rate was 0.08 kg/day during the first 60 days and lamb yearling weight was 17.5 kg.

The phenotypic variability observed suggests that a number of characters could be improved to raise productivity significantly.

Basic indicators for sub-Saharan Africa

Six indicators for 33 countries of sub-Saharan Africa.

Country	GNP per caput in 1982 (US$)	Population in mid-1982 (millions)	Projected population in 2000[a] (millions)	Daily calorie supply per caput (% of needs[b])	Terms of trade[c] in 1982	Cereal food aid imports in 1982 (kg/caput)
Low-income economies (semi-arid)						
Chad	80	4.6	7	76	99	5.3
Mali	180	7.1	12	72	102	9.4
Burkina Faso	210	6.5	10	95	97	12.7
Somalia	290	4.5	7	100	111	38.7
Niger	310	5.9	11	102	89	12.1
Gambia	360	0.7	1	88	108	34.0
Low-income economies (other)						
Ethiopia	140	32.9	57	76	74	5.5
Guinea-Bissau	170	0.8	1	70	n.av.	32.0
Zaire	190	30.7	55	94	81	3.0
Malawi	210	6.5	12	94	106	0.3
Uganda	230	13.5	25	80	74	3.7
Rwanda	260	5.5	11	88	63	2.3
Burundi	280	4.3	7	95	n.av.	2.1
Tanzania	280	19.8	36	83	86	13.1
Benin	310	3.7	7	101	75	2.2
C.A.R	310	2.4	4	96	90	0.9
Guinea	310	5.7	9	75		7.1
Madagascar	320	9.2	16	109	80	8.5
Togo	340	2.8	5	83	112	1.7
Ghana	360	12.2	24	86	61	3.8
Kenya	390	18.1	40	88	87	6.3
Sierra Leone	390	3.2	5	101	84	7.8
Mozambique	n.av.	12.9	24	70	84	9.8
Middle-income oil importers						
Sudan	440	20.2	34	99	85	9.3
Mauritania	470	1.6	3	97	97	54.0
Liberia	490	2.0	4	114	92	21.0
Senegal	490	6.0	10	101	89	12.8
Lesotho	510	1.4	2	111	n.av.	24.4
Zambia	640	6.0	11	93	72	16.6
Zimbabwe	850	7.5	16	90	105	0.0
Botswana	900	0.9	2	85	n.av.	6.9
Swaziland	940	0.7	1	90	n.av.	0.0
Ivory Coast	950	8.9	17	112	91	0.1
Mauritius	1240	0.9	1	125	91	43.2
Middle-income oil exporters						
Nigeria	860	90.6	169	91	103	0.0
Cameroon	890	9.3	17	102	71	1.2
Congo	1180	1.7	3	94	110	0.2
Gabon	4000	0.7	1	97	111	0.0
Angola	n.av.	8.0	13	83	104	8.4

[a] Projected populations for the year 2000 were made separately for each country by the World Bank (1984). Base year population estimates were made from information from the United Nations, the World Bank, the Population Council and recent national censuses.

[b] The daily calorie supply per caput was calculated by dividing the calorie equivalent of the food supplies in an economy by the population. The daily calorie requirement per caput refers to the calories needed to sustain a person at normal levels of activity and health, taking into account age and sex distributions, average body weights and environmental temperatures.

[c] Terms of trade measure the relative level of export prices compared to import prices. The index is calculated as the ratio of a country's export unit value index to the import unit value index. Base year 1980 = 100.

Source: World Bank 1984 *Toward sustained development in sub-Saharan Africa. A joint program of action.* The World Bank, Washington DC.

The Humid Zone Programme

Introduction

The humid zone of West Africa covers about 2 million km^2 and receives more than 1500 mm annual rainfall. Mean temperatures (27–30°C) and relative humidity (80–90%) are high. The zone is infested with the tsetse fly, which carries and transmits the blood parasites *Trypanosoma* to livestock. Cattle are at present relatively unimportant in the humid zone compared to sheep and goats. ILCA's Humid Zone Programme therefore aims to improve small ruminant production while achieving closer integration of livestock and food crop production

The Programme is based in Ibadan, Nigeria, and has a close working relationship with the International Institute of Tropical Agriculture (IITA). Field work is conducted primarily in southwest and southeast Nigeria. The locations of research sites were shown in *ILCA Annual Report 1983*.

During 1984 the Programme made a major contribution to the planning, initiation and supervision of a goverment-sponsored development project that included small ruminants and alley farming in southwest Nigeria. The pilot project, based on ILCA's research on disease control and browse production, is now well under way.

The Programme also continued research on disease identification and control, browse production and use, and on the socioeconomic factors related to small ruminant development. Results from these long-term activities, together with the experience gained from the pilot project on alley farming, will enable the Programme to make important contributions to other development efforts throughout the humid zone.

Reflecting this wider regional focus, the Programme hosted two major workshops during 1984 on *Small ruminant production systems in humid West Africa* and *Women in agriculture in West Africa*. These workshops, together with the Programme's strong commitment to training, have resulted in a regional network for research on small-scale production systems that include browse and small ruminants.

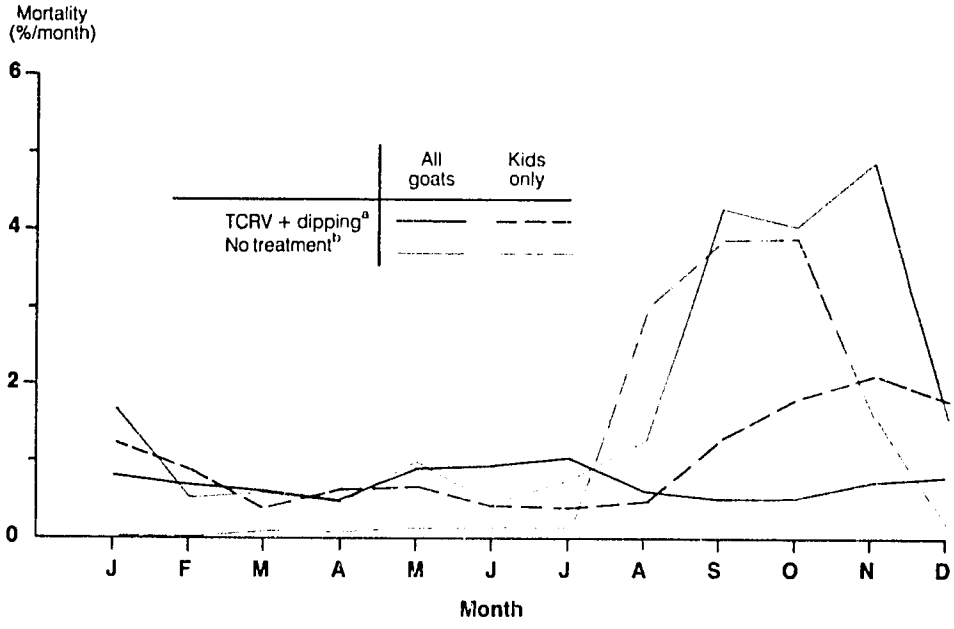
Disease control

In 1982 the Programme started a long-term evaluation of a health package for small ruminants in five villages near Fasola, Oyo State. The package consists of annual vaccination against *peste des petits ruminants* (PPR) with tissue culture rinderpest vaccine (TCRV), and monthly dipping against sarcoptic mange using an acaricide.

Over 27 months, from May 1982 to July 1984, the health package resulted in a 50% reduction in mortality among village goats. Mortality was distinctly seasonal in villages where goats received no treatment (Figure 4); it was highest between July and December, the period that usually coincides with the late rainy season and the early to middle dry season. In villages where animals were vaccinated with TCRV and dipped, overall mortality was generally not seasonal. There was, however, a distinct rise in kid mortality between August and December, suggesting that kids are either not being adequately covered against PPR by the annual vaccination, or that other disease and nutritional factors are involved.

In villages where animals were treated, goat populations doubled after 24 months (rising from 114 in May 1982 to 248 in May 1984) and are still increasing (Figure 5). Goat populations in non-treatment villages fluctuated considerably, but have never increased by more than 35% over the initial populations. These results suggest that under present conditions flock size is constrained primarily by PPR.

Figure 4. Monthly goat mortalities in villages near Fasola, Nigeria, 1982–84.



[a] TCRV = annual vaccination against PPR using TCRV, dipping = monthly dipping against sarcoptic mange using an acaricide, three villages.

[b] Two villages.

Data from the village work support the rationale for intensive work on feed production, even though nutritional stress cannot be demonstrated clearly at present.

Browse production and use

The Programme's research on browse production and use is aimed at documenting how small ruminant production with cultivated fodder trees affects food crops and soil fertility, and at developing production techniques suitable for farmers.

Two long-term trials are being used to evaluate the basic production parameters for alley farming systems. In 2 years of alley cropping and alley grazing, *Leucaena* trees yielded a significant amount of mulch and organic nitrogen during the cropping season. In the first season of 1984 these inputs resulted in a 40% increase in maize yield compared to control plots of food crops which had the same basal fertilizer rate and maize population density (Table 3). The alley grazing plots provided 2396 sheep grazing days per ha per year from browse and natural pasture and yielded 33 m^3 of *Leucaena* poles per ha. This first harvest was made 24 months after the trees were seeded, and 12 months after grazing began.

In the first year of production from a similar trial with *Gliricidia*, the trees yielded 5.9 t of mulch dry matter per ha and 167 kg of nitrogen over two cropping seasons. Alley grazing will be included in this trial during 1985.

The cumulative mulch yield of *Gliricidia* from three harvests in 1984 showed that browse rows with approximately 10 trees per metre (4.1 t DM/ha/year) were significantly more productive than rows with fewer trees per metre (2.2 compared with 3.2 t DM/ha/year). A spacing of 10 trees per metre has been recommended over the last 2 years; however, farmers are often reluctant to plant at this high density.

The evaluation of *Gliricidia sepium* germplasm collected in Costa Rica continued during 1984. The collection contains significant genetic variation, particularly for use as mulch, and several accessions yielded consistently more than the 'Ibadan local' line (Table 4). Four high-yielding accessions have been selected and are being grown in a seed production orchard.

From four harvests in 1984, the four parental lines selected yielded 37% more fresh mulch than the 'Ibadan local'. Two accessions collected on Pacific Ocean beaches in Costa Rica are also being combined for seed

Table 3. Maize yields from maize grown alone, alley farming and maize–cowpea intercropping, Ibadan, 1983–84.

Cropping season	Maize yield[a] (t/ha)			
	Trial 1[b]		Trial 2[c]	
	Maize alone	Alley cropping	Maize alone	Alley cropping
1st season 1983	2.19	2.55	—	—
1st season 1984	2.55	3.59	3.72	4.18
2nd season 1984[d]	1.16 (0.49)	1.36 (0.66)	0.74	0.96
Total (three seasons)	5.90	7.50	4.46	5.14

[a] Yield of whole ears at 13% moisture content, all treatments grown at the same maize plant density and fertilizer rate.

[b] In Trial 1, *Leucaena* trees were established in 1982. 1983 was the first year of production.

[c] In Trial 2, *Gliricidia* trees were established in 1983. 1984 was the first year of production.

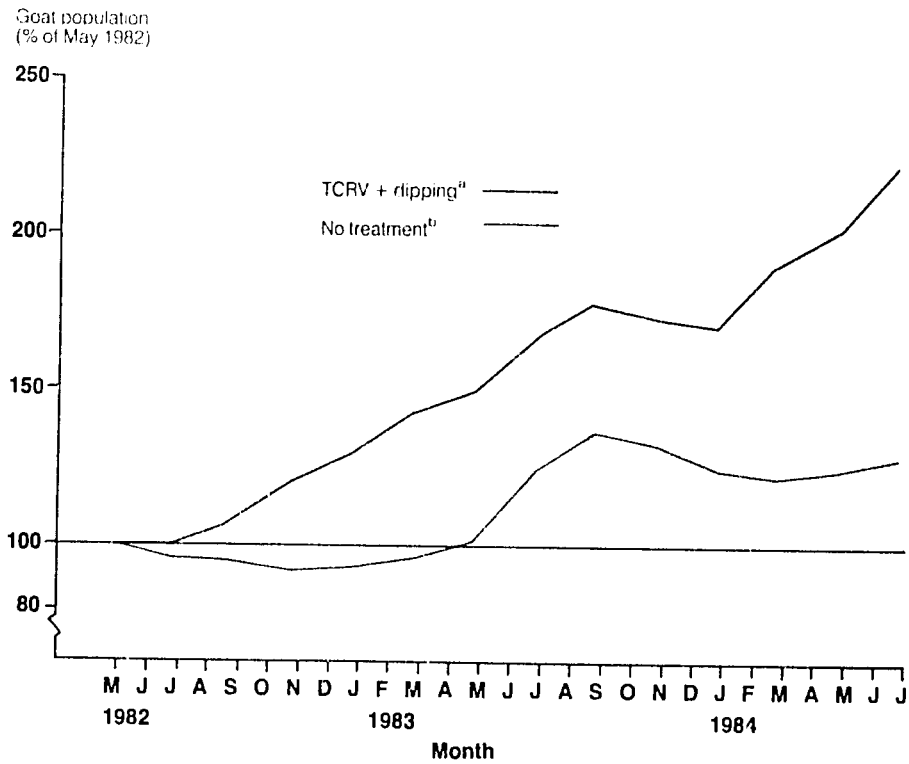
[d] Maize–cowpea intercropping (with cowpea grain yield in parentheses).

production and evaluation under subhumid conditions. Seed of these and other selected populations will be available for wider testing in 1985.

Over half the alley farms planted in 1982 and 1983 are now well established and are being managed by farmers for crop, mulch and feed production. Several alley farms have been abandoned for non-technical reasons unrelated to the presence of the trees e.g. in the Badeku/Ikire area where alley farms were planted by part-time farmers on land that was scheduled to be returned to fallow.

One of the more experienced alley farmers demonstrated the successful use of fire in alley farming. Fire is used traditionally to manage vegetation in the area. At the end of

Figure 5. Average change in goat populations in villages near Fasola, Nigeria, 1982–84.



[a, b] See notes to Figure 4.

the dry season, the farmer piled weeds, residue from recently harvested cassava and some browse branches in a winrow running down the centre of each alley. These winrows were burned without damaging the trees. While the Programme would not necessarily recommend this practice, the farmer has helped confirm the inherent flexibility of alley farming, which can be modified to suit individual needs.

Another farmer has incorporated mulch into the ridges on which his crops are planted. Research at IITA has shown that this practice enables the crop to use the nitrogen from

Table 4. Mulch yields from *Gliricidia* germplasm, Ibadan, 1984.

Accessions/ lines	Mulch yield (kg freshweight/5 m² plot)				
Harvest No.:	1	2	3	4	Total
'Ibadan local'	14.4	12.3	15.2	26.4	68.3
	(100)[a]	(100)	(100)	(100)	(100)
Four accessions of 'high population'	21.4	22.2	18.0	31.8	93.4
	(149)	(180)	(118)	(120)	(137)
Two salt-tolerant accessions	13.9	9.0	13.7	25.9	62.5
	(97)	(73)	(90)	(98)	(92)
Overall mean	16.4	13.2	14.4	26.5	70.5
Range	9.0–22.9	7.7–23.4	9.8–18.4	17.4–34.0	
LSD (P<0.05)	6.3	6.6	3.7	8.8	
CV (%)	19	25	13	15	

[a] Numbers in parentheses are yields relative to 'Ibadan local' (= 100)

the mulch more efficiently. This farmer has demonstrated that cutting trees before ridging permits the incorporation of mulch with little additional labour.

The feeding management trials which were started in 1983 to determine the beneficial effects of browse supplementation on long-term animal productivity, continued in 1984. Results showed that the more browse there was in the diet, the higher was the survivability and growth rate of lambs. This effect continued after weaning when the lambs received the same diet as their dams up to 180 days of age. Lambs on an all-browse diet achieved a 100% higher growth rate between 90 and 180 days than lambs on a basal diet.

Production economics

Studies of production economics have centred on evaluating models for small ruminant production and assessing the market potential for increased output. Using data generated by the Programme over the last 6 years, it is estimated that returns of up to 34% for goats and 55% for sheep are possible under traditional production systems in the zone. Sensitivity analysis has demonstrated the higher risks involved in goat production, reflecting higher mortalities, and has shown that relatively few benefits can be expected from improved marketing without first improving survival, nutrition and management.

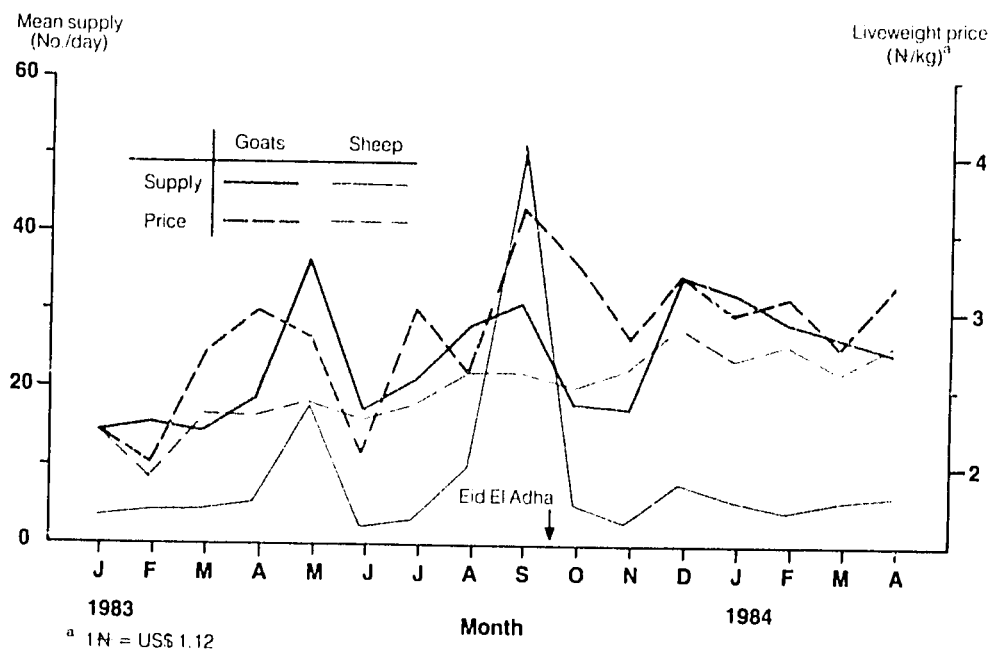
The Programme's market research has also focused on the potential for increased sales of animals in southwest Nigeria. The supply pattern for sheep in this area clearly indicates that the production system is centred around two major Muslim festivals (Figure 6). Corresponding increases in prices suggest that demand is still not met at these times.

LPU/ILCA project

In 1983 a pilot project on small ruminant development was started in southwest Nigeria by the Livestock Project Unit (LPU) of the Nigerian Federal Livestock Department. The project is run jointly by the LPU and ILCA, and is based on PPR control using TCRV, browse planted in alley farms, and meat production from small flocks of sheep and goats. Participants in the project have not received credit, which was deemed unnecessary for the success of the project. ILCA staff act as technical coordinators and use the project to extend their on-farm research over a broad range of cropping and management situations.

Whether or not they participated in the pilot project, interested villagers were given the opportunity to have their sheep and goats

Figure 6. Mean daily supply and average price of dwarf sheep and goats in rural markets, southwest Nigeria, 1983–84.



[a] 1 N = US$ 1.12

vaccinated with TCRV during January and May 1984. The second vaccination was intended to cover new animals and those missed in January. In each month approximately 675 animals from the two villages were vaccinated, there being five times as many goats as sheep. On average three to four animals per owner were vaccinated.

Between April and June 1984, 65 alley farms were planted near Oyo in the adjacent villages of Owu-Ile and Iwo-Ate. The farms ranged in size from 0.05 to 0.50 hectares. *Leucaena* and *Gliricidia* were planted with a variety of food crops, including maize, yam, cassava, pepper and melon. In August, after the first cropping season, all farms were rated for probability of successful establishment. Over 52% of farms were rated good or excellent, and 19% were rated poor. These ratings were largely independent of the particular food crop with which the trees were established, but reflected the level of crop management, especially the amount of weeding.

Leucaena seedlings in some 'savanna' farms were damaged extensively by rodents. Nodulation of the trees has been highly variable: all trees nodulate eventually, but initial growth is often significantly reduced. More inoculation studies are needed to ensure the rapid establishment of future plantings.

Interest in establishing browse trees and alley farms has been generally high. Extra browse seeds have been circulated around villages by farmers with the result that new alley farms are being started regularly.

One of the Programme's aims in monitoring this project is to further define client populations for ILCA's browse interventions and to explain the levels of involvement of different categories of people. Particular emphasis has been placed on detailing the involvement of women. Only 18% of the alley farmers are women, even though women represent 31% of the farming population. Women hesitate to become involved in alley farming partly because they are more concerned with processing and trading than with cultivation. For married women, decision-making is complicated by the need to seek permission from a man.

A second group that is underrepresented consists of farmers belonging to minority ethnic groups. Many such farming families have recently entered the area. In the future, the Programme will emphasise the implications of land tenure for groups of people who plant trees but who lack clearly defined land rights.

Training and workshops

In addition to in-service training of technical staff during 1984, the Programme placed considerable emphasis on other training activities. A cooperative training programme with the Université Nationale du Benin was started, involving five final-year students. After a short course in Ibadan, each student completed a field study in the humid region of southern Benin. The topics of these basic studies were sheep and goat production, cattle production, animal traction and browse production. The studies will be used to develop further research projects aimed at motivating students and faculties alike to consider small-scale sheep and goat production as an important area for research and development.

A workshop entitled *Small ruminant production systems in humid West Africa* was hosted by the Programme from 23 to 26 January 1984. ILCA and the Nigerian Federal Livestock Department co-sponsored the workshop, with additional support from the Ford Foundation and the International Development Research Centre (IDRC) of Canada. Over 50 participants, mostly from West Africa, attended. Nineteen invited papers were presented on animal productivity, disease, feeding, production systems and economics. A selection of papers from the workshop will be published in 1985.

In May the Programme hosted a workshop on *Women in agriculture in West Africa*, which was sponsored by the Ford Foundation. Thirteen papers, covering a wide range of topics concerning women and development, were presented. The workshop was attended by 25 people.

Famine in Africa, 1984

The Centre Spread of the ILCA Annual Report 1983 outlined the food crisis in Africa, and referred to a report of the Ethiopian Relief and Rehabilitation Commission (RRC, 1983) which predicted major food shortages in eight regions of the country. Those predictions were realised during 1984. The international media and television coverage gave great attention to the Ethiopian problem, but other countries in Africa were also badly affected by drought and starvation during the year without receiving such wide-scale press and television coverage.

In 1984, annual rainfall in Chad was only 60% of the already low 1983 level, and crop failures were widely reported throughout the country. About 2000 people starved to death in that country from September to November 1984, and an estimated 1.5 million people face starvation at the time of writing.

Other parts of the Sahel are also faced with famine. Mali in 1984/85 has a 500 000 tonne deficit in cereals alone, with production being only 40% of requirements. Mauritania's cereals deficit is 235 000 tonnes (in a country of only 1.6 million people), and Niger's and Senegal's are in excess of 500 000 tonnes each. Ethiopia and Sudan are in need of large imports – over 1.5 million tonnes each.

In southern Africa food supplies improved with the 1984/85 harvest, but Angola, Botswana, Lesotho, Mozambique and Zambia still need to import about 2 million tonnes of cereals in 1985, compared to 1.4 million tonnes in 1983.

In East Africa, Kenya, Tanzania, Burundi and Rwanda had to import about 1.6 million tonnes of cereals in 1984, compared to 600 000 tonnes in 1983.

Food aid has been generously provided by many countries, so that the worst horrors of famine have been avoided for many people. But sacks of grain can lie at African ports for want of transport to the worst affected areas. Some donor countries have provided air and land transport to distribute grain throughout the countryside. But these generous contributions do not help African countries to achieve food self-sufficiency in the long term. Food aid can only, at best, put off for a short period the problems of low food production, high food imports and shortages of foreign exchange.

The images of famine associated with Africa are depressingly familiar. They give rise to a feeling of futility among many concerned with Africa's problems. But staff at ILCA remain optimistic about the future of food production in Africa, despite the knowledge that famine is present only a short distance up the road.

This optimism is based, in part, on a belief in the impact that the technical improvements being developed at ILCA can have on sustained increases in food production, so that requests for food aid can be steadily reduced.

For that optimism to be justified, agricultural research, development and training organisations, both national and international, need greatly increased support during the 1980s and 1990s. They are the institutes helping to forge the long-term solutions that crisis aid, with all of its immense goodwill, can never provide.

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The Subhumid Zone Programme

Introduction

ILCA's Subhumid Zone Programme is based at Kaduna, Nigeria. The zone receives from 900 to 1500 mm of annual rainfall and has a growing season of 180 to 270 days each year. The productivity of cattle in the zone is low, mainly due to poor dry-season nutrition. The Programme therefore aims to increase livestock productivity through improved feed availability obtained by exploiting the complementarity of legume forage and food crops.

The Programme's field work is done around Kachia in Kaduna State and Ganawuri in Plateau State (Figure 7). The adoption of innovations is also being followed in other states across the subhumid zone of Nigeria. Much of the livestock production in these areas is the responsibility of the Fulani, traditionally a pastoral group who are now settling among farmers and on grazing reserves. The Programme is also working with indigenous farmers and with a few pastoralists who, unlike the majority, have formal land-use rights. This enables the Programme to study the appropriateness of various techniques in the major land ownership and land-use situations of West Africa's subhumid zone.

An important part of the Programme's research during 1984 focused on the use of forage legumes in 'fodder banks' to supplement the quantity and quality of the available grazing and to improve soil fertility. Fodder banks were adopted spontaneously by a further 23 pastoralists during 1984, some in areas far removed from ILCA's case study areas. Problems observed in the adoption of fodder banks by pastoralists have been incorporated into research at the Programme's experimental site at Kurmin Biri.

A new case study area was added during 1984. This area is in Ganawuri District, Plateau State, where crop and livestock enterprises are integrated in the prevailing farming system. The new area affords an opportunity to test fodder improvement techniques in a wider variety of farming systems.

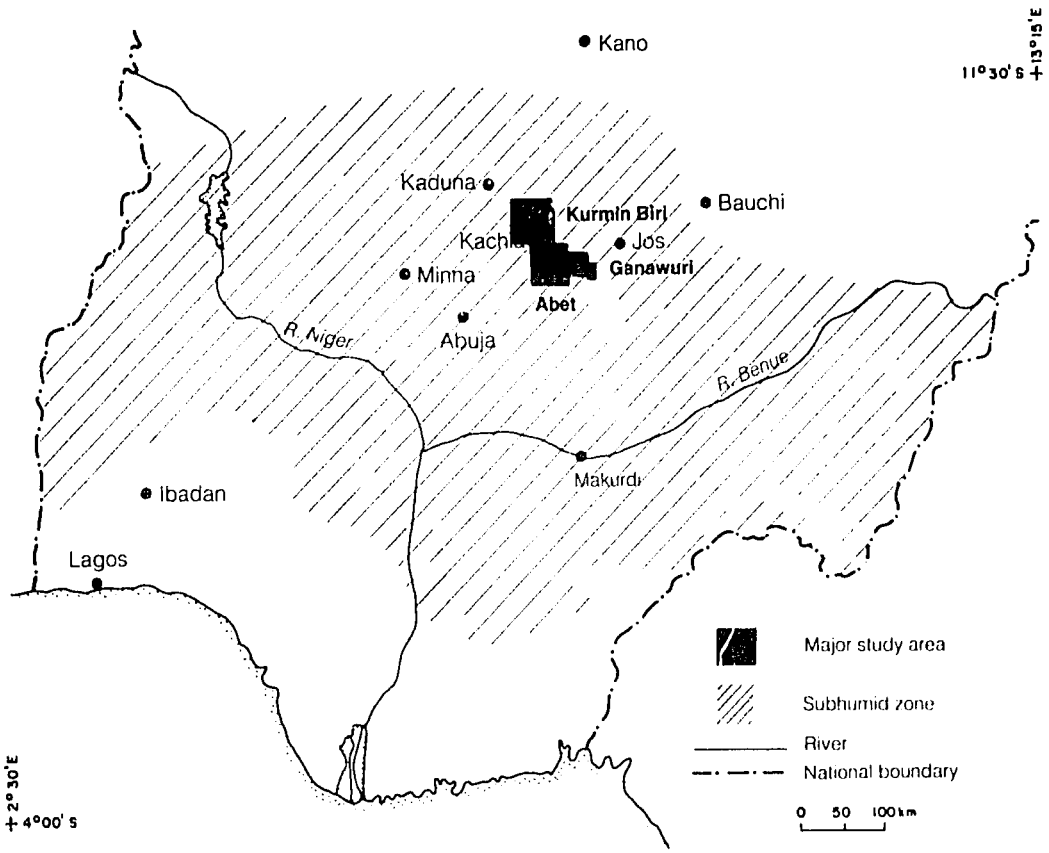
In cooperation with the national Livestock Project Unit (nLPU), the Programme organised a field day attended by farmers and extension agents from Oyo, Niger, Plateau, Benue and Kaduna States. It is now clear that the spread of fodder banks will be limited more by the lack of inputs such as seeds, fencing materials and credit than by lack of farmer interest. The Programme also conducted a workshop sponsored by the UNDP/FAO Cropping Reserve Development Project to brief the staff of the project on fodder bank technology.

Fodder banks

The total number of fodder banks managed by pastoralists in the subhumid zone of Nigeria increased from 23 to 46 during 1984. This development brought to light the following:

1. The use of the herd for land preparation in the dry season and grazing of fodder banks early in the rainy season were unacceptable to some pastoralists;
2. Establishment was poor when the legume was sown early in the season, especially when the frequency of early rains was erratic;
3. *Stylosanthes hamata* cv. Verano produced low dry matter yields even with moderate dressings of superphosphate;
4. There was increased incidence of anthracnose on *Stylosanthes guianensis* cv. Cook; and
5. Grazing periods were longer and stocking rates were higher than recommended.

Figure 7. Map of the subhumid zone of Nigeria, showing the major study areas of ILCA's Subhumid Zone Programme.



Seedbed preparation for fodder banks by night confinement of the herd in the dry season was not favoured by some pastoralists due to their fear of worm infestation and the refusal of animals to graze fouled areas. Research has shown that cattle can readily graze fodder banks 4 weeks after their establishment when the seedbed is prepared by single overnight confinement, with the sites moved daily around the intended fodder bank area. Other land preparation methods, such as heavy grazing immediately following sowing, have been successfully developed to suit varying conditions.

When seeds are broadcast on an uncultivated surface the length of time the soil can supply moisture is critical for germination and establishment. This was clear from an experiment that tested the effect of frequency of wetting to field capacity on the germination of *S. hamata* cv. Verano on a ferruginous soil. Even a break of 2 days in the watering regime was sufficient to reduce seed germination by 52% (Figure 8).

Fodder bank utilisation

The utilisation trial carried out on fodder banks in the 1983/84 dry season included a control group of animals grazing natural vegetation and two groups that grazed fodder banks, one for 2 hours per day and the other for 4. Since one fodder bank could not support all experimental animals, two fodder banks were used (each with a different species of *Stylosanthes*) and the animals were rotated between the two on a daily basis.

The control group of cattle grazing natural vegetation lost 56 kg or 23.5% of initial bodyweight over the 87-day trial period between January and April 1984. The group grazing fodder banks for 4 hours per day lost only 26 kg, and the 2-hour group lost 31 kg. During the course of the experiment, 6 cows and 2 calves out of the 14 animals in the control group died or had to be culled, whereas all animals grazing fodder banks survived the dry season. These results were obtained despite low yields of the fodder banks (2.5 t/ha

at the beginning of the grazing period) caused by an unusually short growing season.

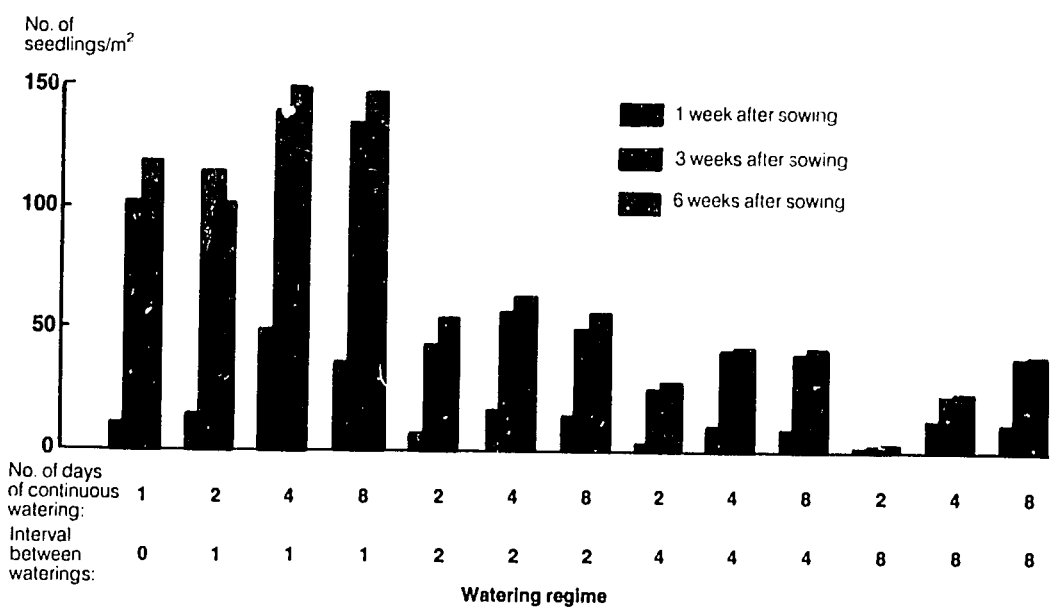
The diet selected by cattle on the two fodder banks differed greatly. On the *S. guianensis*-based fodder bank, the number of bites on stylo never exceeded 20% of the total bites recorded. On the *S. hamata* cv. Verano-based fodder bank, however, stylo accounted for almost 80% of bites recorded. Verano loses most of its leaves in the dry season, but the cattle eagerly licked the fallen leaves from the ground. Until mid-March, licking accounted for approximately 90% of total stylo intake on this fodder bank.

Cattle grazing the fodder banks for 4 hours per day spent about the same time grazing natural vegetation as the control animals. The animals with access to the fodder banks for only 2 hours per day increased their grazing time on natural pasture during the period of fodder bank grazing.

Improved legume varieties

The high incidence of anthracnose in the two *Stylosanthes* cultivars previously used in experiments, namely *S. guianensis* var. Schofield and *S. guianensis* cv. Cook, has necessitated the use of *S. hamata* cv. Verano in all fodder banks until other suitable legume types can

Figure 8. Effect of watering regime on germination of *Stylosanthes hamata* cv. Verano, Kurmin Biri, Nigeria, 1984.



be identified and multiplied. Verano's low productivity compared to *S. guianensis* cultivars was suspected to be due to a soil deficiency problem. An experiment begun in 1983 showed that yields were limited particularly by deficiencies of Cu and P (Figure 9). Further trials to determine the critical levels of these two nutrients were started in 1984 and are ongoing. Initial results indicate an important deficiency of both elements.

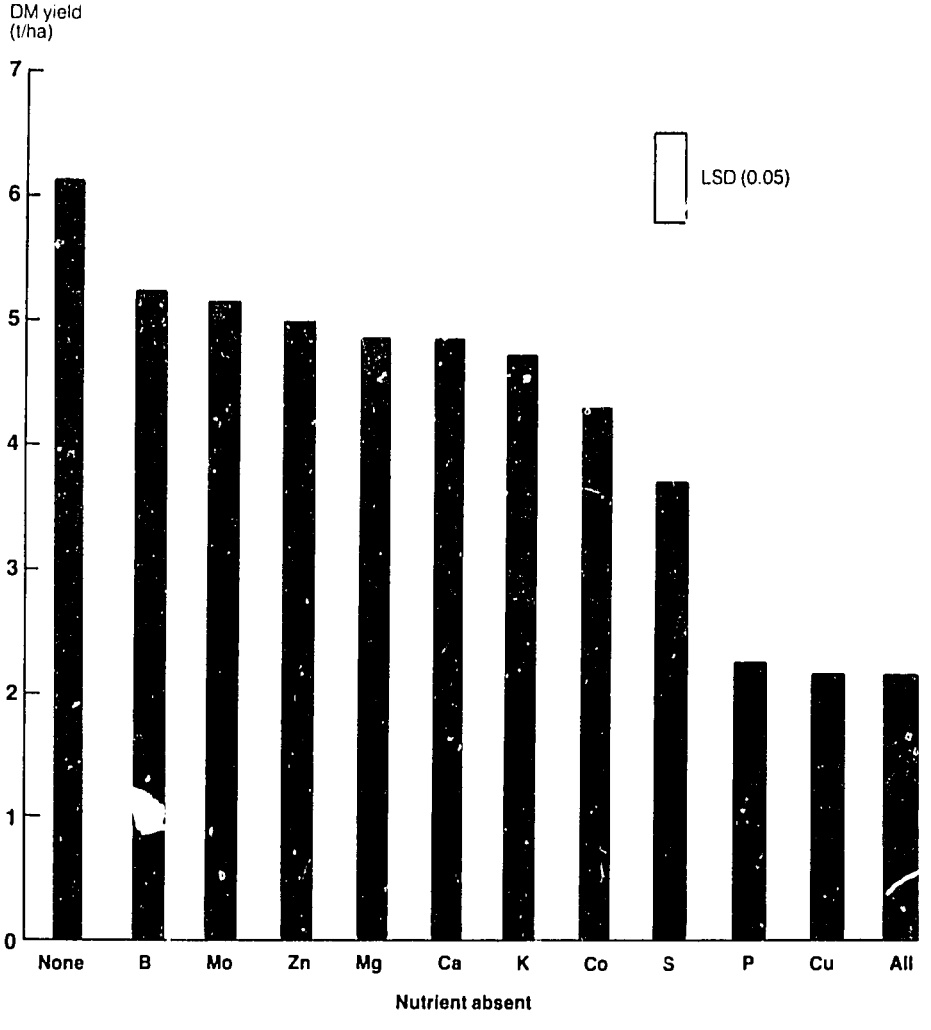
Three species of *Stylosanthes* (*S. capitata*, *S. guianensis* cv. Tardio and *S. macrocephala*) have been screened for resistance to anthracnose. *S. guianensis* accessions CIAT 1283, 1280 and 1523 were found to be highly productive, drought-tolerant and resistant to anthracnose. However, they flowered late in the season and did not set seed in 2 consecutive years.

S. macrocephala lines are low in crude protein content (4.5–4.8%) during the dry season because of their low leaf retention. Among the lines of *S. capitata* evaluated, four entries have been found to meet minimal requirements of disease tolerance, quality, drought tolerance, high DM yields, seed production, and persistence. These have been selected for further field trials. Other legumes such as *Centrosema pascuorum* and *C. brazilianum* also appear promising.

Crop–livestock interactions

An assessment of the feeding value of sorghum and millet stover components showed that the immature panicles and upper leaves had similar digestibilities. Through selective

Figure 9. Dry matter yield of *Stylosanthes hamata* cv. Verano on soils deficient in nutrients, Kurmin Biri, Nigeria, 1984.



grazing, cattle obtained a diet from sorghum and millet residues and weeds that contained two to three times more crude protein (CP) and P than the average CP and P values from natural grazing at the same time of year. Animal responses in increased conception rates are apparent, and it is clear to livestock owners that the integration of pastoral systems with cropping systems enhances land and animal productivity.

The N contribution of manure to cropping was assessed in eight farmers' fields where cattle were kept overnight during the dry season. Maize grain yields were 1 t/ha higher in manured than in non-manured areas. It was estimated that 41 and 10 kg/ha of N and P respectively were applied in the form of cattle dung during the dry season. However, total N uptake in manured areas was 86 kg/ha greater than in non-manured areas. The difference (45 kg) is attributed to N from urine, to the higher cation exchange capacity in manured areas – resulting in a more efficient use of applied N – and to the mineralisation of organic matter incorporated into ridges during land preparation. Other soil benefits associated with manure application were a reduction in pH and increases in organic carbon, P and water holding capacity.

Improvement of food crops and crop residues

Earlier studies of mixed cropping of cereals and stylo showed that the timing of sowing and the spacing of stylo and crop were critical for optimum crop production (*ILCA Annual Reports 1982; 1983*). In a 1984 trial the forage legumes *Centrosema pascuorum*, *Alysicarpus vaginalis* and *Macroptilium lathyroides* sown on the same day with sorghum did not seriously reduce the food crop's grain yield; and, like the stylo, they considerably improved the available protein in the fodder (Table 5).

Regeneration of these legumes following their harvest is being monitored for a period of 5 years to determine their relative effects on the soil. Maize grown on ferruginous soils with different cropping histories at Kurmin Biri produced higher yields following periods of stylo. The soils on these plots were found to contain higher amounts of organic carbon (C) and N following stylo (Table 6).

Table 6. Effect of cropping history on properties of a ferruginous soil, Kurmin Biri, 1981–84.

Soil history	pH	Organic C	Total N
		(%)	
3 years continuous cropping	5.8	0.87	0.058
Uncultivated for many years	5.6	1.09	0.064
2 years *S. hamata*	5.6	1.32	0.091
3 years *S. hamata*	5.3	1.26	0.111
1 year *S. guianensis* cv. Cook	5.5	1.48	0.084
2 years *S. guianensis* cv. Cook	5.5	1.53	0.097

Table 5. Grain and fodder yields of sorghum when sown with forage legumes, Kurmin Biri, 1984.

Crop mixture	Grain yield	Crop residue	Legume DM	Total fodder	Total CP
			(kg/ha)		
Sorghum alone	1296	4467 (2.7)[a]		4467	126
Sorghum + *S. hamata*	313	1685	2778 (11.4)	4463	363
Sorghum + *S. guianensis* cv. Cook	388	1555	2063 (12.8)	3618	326
Sorghum + *M. atropurpureum*	356	2111	1296 (14.2)	3407	241
Sorghum + *C. pascuorum*	1019	2981	1204 (14.9)	4185	259
Sorghum + *A. vaginalis*	1092	2519	926 (10.8)	3445	168
Sorghum + *M. lathyroides*	1297	2761	1481 (16.5)	4222	316

[a] Figures in parentheses are % CP of fodder crop

Soil improvement under short periods of legume is particularly important in areas where prolonged natural fallows cannot be practised due to high land pressure.

Grazing activities of cattle

Grazing activities of cattle herded by agropastoralists were observed over 2 years in a farming area (Abet) and on a grazing reserve (Kurmin Biri). Data analysis was completed in 1984.

Grazing of natural herbaceous vegetation accounted for more than 80% of total annual grazing time in both study areas. Grazing of sorghum and millet residues was, however, twice as important in the farming area as in the grazing reserve. Cattle spent considerably more time browsing in the grazing reserve than in the farming area. Both crop residue grazing time and browsing time showed marked seasonal variation.

Browse

The overall importance of browse in total feed supplies shown by the study of grazing activity noted above led to an investigation of the relative importance of different browse species.

In both Abet and Kurmin Biri pastoralists ranked *Afzelia africana* as the browse species most frequently eaten by cattle, followed by *Khaya senegalensis* in Abet (this plant ranked fourth in Kurmin Biri). Other important browse species were *Adenodolichos paniculatus*, *Mucuna pruriens*, *Daniella oliveri*, *Cussonia barteri* and *Vitex doniana*.

Household studies

A study of milk processing, consumption and sales by 11 agropastoral households in the Zonkwa/Madauchi and ALet areas was started in early 1984.

A preliminary analysis of data collected during the late dry season and most of the wet season showed that 50% of the milk offtake was consumed by household members and visitors, 4% was given to other households – usually Fulani – as gifts, particularly for Islamic or family ceremonies, and 46% was sold.

Of the dairy products consumed at home, almost 75% were taken in the form of

sour milk, over 20% as fresh milk and less than 5% as butter. Fresh milk consumption reached a peak in the early wet season, when almost one third of the milk was consumed fresh, much of this by the men and boys who milk the cows.

Only a small proportion (about 2%) of milk was sold fresh, and this only in the wet season. Of all fluid dairy products, almost 75% were sold as sour milk (*nono*) mixed together with cooked millet balls (*fura*), and 25% as *nono* alone. *Nono* sold with *fura* earns almost 30% more than *nono* sold alone, and accounts for almost 50% of total dairy income.

Land use for grazing and settlement

The settled Fulani have shown themselves to be very flexible in their management of grazing. Livestock movements of up to 20 or 30 km are often made after the first rains in order to graze early grass growth. Some Fulani transfer their cattle to Abet for dry-season graz-

ing, while others who have settled in Abet transfer their herds out of the area for the entire wet season.

Studies during 1984 indicated that some of the Fulani herd owners at Abet have difficulties in grazing their herds due to increased cultivation levels. The expansion of cultivation in 1984 was partly a reaction to the relatively poor harvest of 1983, partly caused by the recent rises in farm produce prices, and partly due to the recent cutback in the numbers of public service staff. The latter has led to an increased availability of farm labour and to an increased need to farm for subsistence.

Animal health

The results of screening of West African plants for anthelmintic activity were analysed during 1984. The major control measure used against helminthiasis in Nigeria is chemotherapy. However, the availability of drugs varies. Fulani herdsmen in Nigeria recognize that the problem of animal helminthiasis is most acute in calves of less than 1 year old, and routine herbal treatment is started within 1 week of birth.

Only a few of the plants traditionally used as anthelmintics in Africa have been previously studied. An initial project was therefore designed to identify and examine traditional anthelmintic herbs used to limit parasitic gastroenteritis in animals.

Eighteen plants used for this purpose by pastoralists in Zonkwa, Kurmin Biri and Abet were screened for anthelmintic activity against *Nippostrongylus braziliensis* in rats. A toxicity trial for each extract was carried out. The maximum tolerated dose was then used for the chemotherapeutic trials.

In the toxicity trial none of the 18 plants tested had a lethal action in rats at the doses tested. Six of them showed significant activity against *N. braziliensis* in rats at non-toxic doses. These were *Aloë barteri* (leaf juice) and extracts of *Terminalia avicennioides* (roots), *Annona senegalensis* (bark), *Cassia occidentalis* (leaf), *Anogeissus leiocarpus* (bark), and *Diospyros mespiliformis* (bark), with deparasitisations of 92, 89, 75, 69, 60 and 58% respectively. Oxfendasole (Systamex R) gave a deparasitisation of 100%.

Arid and Semi-arid Zones Programme

Introduction

In the arid and semi-arid zones of West Africa rainfall is unimodal, varying from 100 to 1000 mm annually over a north-south gradient.

The Arid and Semi-arid Zones Programme is now conducting detailed research in both Mali and Niger. Research in Mali, the country supporting the highest livestock population in the West African zone, began in 1976 at Niono, 350 km northeast of Bamako. In 1983, the Programme started research in Niger in collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), at the Indian-based Centre's Sahelian station at Niamey.

Additional baseline data were collected during 1984, particularly on animal health problems in the agropastoral and pastoral production systems of central Mali. Detailed computer analyses of livestock productivity data collected over the previous 6 years have now been completed. These analyses are currently being incorporated into a series of research reports.

Constraints to improved livestock output in the floodplain pastoral system are associated with marked seasonal fluctuations in the nutritional status of cattle and consequent variations in reproduction, calf growth and calf mortality. Human competition for milk exacerbates low calf growth rates. The lack of an adequate and equitable socio-territorial control system for grazing lands also limits livestock productivity.

Agronomic studies aimed at improving the quality and quantity of livestock feed continued during 1984. The year also saw the continuation of an integrated study of vegetation biomass in the Gourma region of Mali and pastoral areas of central Niger. This study was begun at the request of the Mali and Niger governments and is intended to provide the basis for an early warning system for drought in the Sahel. The study is carried out in collaboration with the Global Inventory Monitoring and Modelling Section (GIMMS) of the National Aeronautics and Space Agency (NASA) of the USA.

In July, the Programme underwent a major review of its previous 5 years' work by a mission of the International Fund for Agricultural Development (IFAD). The review took place during the early stages of another critically low rainfall season in the Sahel.

Animal health

During 1983 and 1984 a series of studies were made to assess the health status of livestock in both rice and millet subsystems in the agropastoral areas of Mali, and among herds and flocks in three further areas of the country.

Among sheep and goats in the agropastoral areas, intestinal parasitism was found to be much more important in the rice subsystem than in the millet subsystem. It was also more marked among sheep than among goats. The principal parasites or diseases found were distomatosis, toxicosis, ticks, mange and coccidiosis.

Studies of cattle herds in the Djenne region showed that morbidity and mortality were low and that there were few diseases. Among adult animals, conjunctivitis was the most important problem, followed by mastitis, lung diseases and mange. Among calves, a number of cases of retarded growth were observed.

Among sheep and goat flocks in the same region a range of diseases were recorded, particularly among goats, although the total

number of individuals affected was low. The predominant diseases observed were ecto-parasitic diseases and foot rot.

Morbidity and mortality rates among cattle in the Mopti and Douentza areas were also low during 1983. The major problems observed were lung diseases and lameness among adults and growth retardation among calves.

Poultry in the Niono area

In the second half of 1984, the rapid survey methods being developed by the Programme were used in a survey of backyard poultry production in the Niono area of Mali. The survey covered 381 households in both urban areas and agropastoral systems, while less detailed information was also obtained from a small sample in the transhumant pastoral system.

The results showed that more households owned poultry in the rice subsystem (89.5%) than in the millet subsystem (81.1%) or in the urban areas (57.1%). Domestic fow were the commonest species in all systems followed by pigeons, guinea fowl and duck (although the latter were absent from th millet subsystem). Most families kept onl one poultry species, but there was more di versification in the rice subsystem. Floc sizes were also largest in the rice subsysten for fowls, guinea fowl and pigeons, whil duck flocks were largest in the urban areas Females predominated in all species excep pigeons, where there were approximately equal numbers of both sexes. Managemen practices with respect to housing, feeding health care, consumption and marketin have been recorded and are being analysed.

Agronomic trials

In spite of the low rainfall during 1984, agro nomic research on the selection and improv ement of legumes for intercropping progresse with trials in Mali being conducted at bot Niono and Banamba. Straw and grain yields of the 20 best cowpea varieties out of 81 tested at the two sites, are shown in Table 7.

As a result of the trial the five best yielding varieties were selected for further study. Their grain yields at Niono ranged from 435 to 517 kg/ha. The five best varieties for hay production yielded from 1517 to 1873 kg DM/ha

The best line of cowpea (CSIRO 45581) yielded 517 kg/ha of grain, ripened early in the season and produced seed at locations where no other grain legume or cereal matured. As a result of the performance of this line, there were many requests from local farmers for seed. This line will be further multiplied during 1985.

Grain yields at Banamba, with twice as much rainfall, were more favourable, ranging from 954 to 1347 kg/ha for the best five varieties. Hay yields were also higher, ranging from 2788 to 4704 kg DM/ha.

Table 7. Straw and grain yields of the best 20 cowpea varieties out of 81 tested at Niono and Banamba, 1984.

Site	1984 rainfall (mm)	Straw yield (kg DM/ha)	Grain yield (kg/ha)
Niono	200	1278	281
Banamba	400	2203	784

At Niono, trials were also carried out on pigeon pea, green gram, black gram and tepary bean. The most productive pigeon pea variety yielded 3 t forage DM/ha. All varieties of green gram and black gram yielded over 100 kg grain/ha, while the best variety produced 600 kg grain/ha. Tepary bean varieties produced about 100 kg grain/ha and 400 kg straw/ha.

Embouche paysanne

In 1984 the Programme started work on crop–livestock production systems associated with a smallholder beef fattening project in Mali, funded by the United States Agency for International Development (USAID). The project is located in two areas, one (the Banamba area) to the west of the Niger river and the other (the Segou area) to the east of the river. The aim of the Programme's work is to assess the economic viability of the fattening project and to develop technical improvements to the system.

The work during 1984 was aimed at understanding the fattening system, and at describing the associated cropping systems, labour availability and constraints to crop and livestock output. Experiments on forage production and livestock feeding were also started.

Preliminary studies of the margins between sale and purchase prices of livestock in the project were made in a survey of 108 farmers. More detailed studies were made of a sample of 12 farmers. Both buying and selling prices of cattle were higher in the Banamba area than in the Segou area during the 1983/84 season. Of the farmers sampled, 38% made losses, 44% made profits of less than US$ 40 per animal and about 18% made profits of more than US$ 40 per animal. Rates of return on investment appeared satisfactory for the Segou area but not for the Banamba area, due to the higher expenditure on non-family labour and fodder in the Banamba area. Marketing of 'finished' animals appears to be one of the project's greatest problems: in 1984, 37% of such animals had not been sold by June and 21% had not been sold by August.

Forage experiments were carried out in order to study the effect of seeding methods on yield, the association of millet and cowpea, and plant population and fertilizer effects on both legumes and millet. The trials were made using 150 lines of legumes at two sites: at Banamba (400 mm rainfall during the season) and at Sotuba (750 mm).

Millet, sorghum and cowpea were seeded on top of ridges, on the side of ridges and in furrows. Seeding on the side of ridges gave yields slightly greater than sowing on the top, but the differences were not significant. Both these treatments produced yields significantly greater than sowing in furrows, although how much this was due to the effect of soil compaction needs further clarification.

A further trial was carried out to determine whether it was possible to maintain the advantages of millet–cowpea crop associations while improving crop management by reducing the degree of intermixture of the component species. The two crops were sown as alternate plants, as alternate lines and as alternate 'double-lines'. However, none of the first-order interactions between treatments were significant. Total forage yield was, however, increased by increased separation of the two crops. The date of harvest of cowpea significantly affected cowpea yield and total forage yield, primarily because of leaf loss due to drying before the later harvests.

Plant populations of legume crops in Mali are low compared to those in other areas of Africa. A study was made of the effects of different seed rates of cowpea and *Lablab purpureus* at two sites. However, due to the low rainfall, *L. purpureus* did not produce seed at either site. Increasing the seed rate of cowpea from 30 000 to 60 000 seeds/ha produced increases in DM yield of over 30% at both sites. Application of 50 kg P/ha also increased yields at both sites, but these increases were not significant.

Integrated surveys

In 1983, the Programme started an integrated study of the Gourma region in Mali. The project is conducted in collaboration with NASA and GIMMS and includes the analysis of data from the advanced very high resolution radiometer (AVHRR) on board the NOAA-7 satellite (of the National Oceanic and Atmospheric Administration) and aerial surveys of the Gourma region.

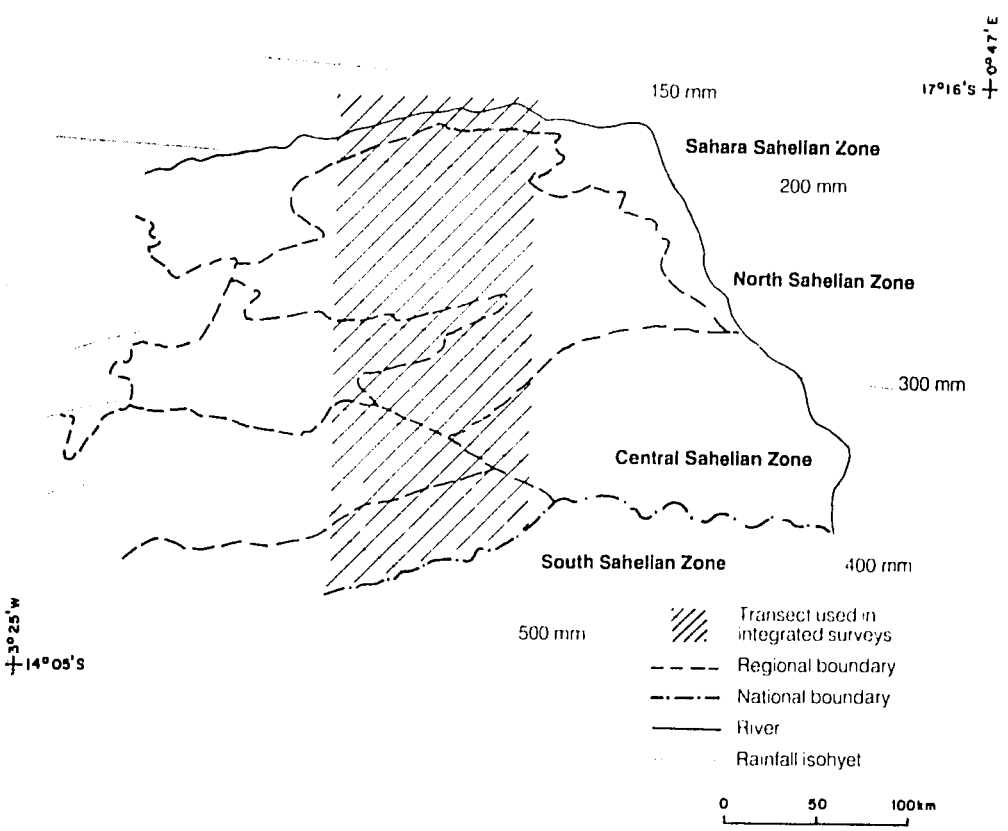
The aim of the project is to test ways of using satellite-derived radiometric data to monitor important variables affecting livestock production, such as vegetation biomass and surface water resources. Routine field records are taken at selected sites and regular aerial surveys are conducted in order to collect information which will facilitate the interpretation of satellite-derived data.

The transect studied covers an area of ca 51 000 km^2 in the centre of the Gourma region (Figure 10). The transect crosses the 200, 300, 400 and 500 mm rainfall isohyets and thus corresponds with a broad range of bioclimatic conditions found in the Sahel.

The results available from the first year of the study were limited because of the extremely low rainfall across the transect, reflecting the situation in the Sahel as a whole. Most grasses and forbs were unable to flower, the exceptions being a few short-cycle varieties or those benefiting from superior soil conditions.

A study was made to determine which vegetation parameter best correlates both with reflectance measurements and with the normalised difference vegetation index (NDVI) (see Centre Spread). The relative

Figure 10. The location of the integrated survey area in the Gourma region of Mali, 1984.



foliage area was positively correlated with radiometric index values. There thus appeared to be a stronger correlation of reflectance measurements with vegetation cover or leaf area index than with above-ground biomass based on chlorophyll activity. However, vegetation cover is more difficult to measure on the ground and is a less useful parameter in determining productivity.

It was also clear that satellite and aerial surveys must take into account the physical and floristic structure of vegetation. In this respect considerable differences exist between ligneous and herbaceous plants. For a given vegetation cover or green biomass value, index values can be modified by different plant orientations and leaf distributions.

Woody plant material (not containing chlorophyll) and soil type also affect index values. Ground truthing and aerial surveys have shown that greater distortion occurs in index measurements when soil moisture levels increase.

Only extreme angles of the sun affect the index – in practice measurements are always taken between 10 a.m. and 2 p.m. and so sun angle is not normally a problem. In general, the index is not affected by atmospheric distortion, but the probability of distortion increases with the altitude from which measurements are taken. Cloud masking can be excluded as a problem for satellite imagery in the Sahel area, but dry fogs and sand screens can produce interference.

The effect of different sources of interference varies greatly between reflectance measurements taken from the ground, the air and from satellites. For example, the foliage structure has a very strong effect on reflectance measurements at ground level, but the effect is not so marked for aerial measurements and is negligible for satellite measurements. Conversely, the effect of atmospheric conditions increases with the altitude from which measurements are taken.

Niger

The Programme began work in Niger in 1983. One senior staff member is now based at ICRISAT's Sahelian Centre in Niamey.

Two research projects were started in Niger in 1984, on the role and productivity of livestock in the semi-arid areas of the country, and on the efficiency of animal traction using cattle and donkeys for the cultivation of millet.

Village studies showed that there was a livestock to human population ratio of 0.3 livestock units (LU)/caput in the area studied. Studies also revealed a typical response of livestock producers to the drought conditions in 1984: many animals were sold and slaughtered, and cattle populations were 17 to 54% lower in December 1984 than in December 1983.

The studies on animal traction showed that the use of cattle and donkeys to cultivate millet fields enabled farmers to reduce the time spent on this activity by 10 to 30% compared with manual cultivation. Tilling the land using a plough drawn by cattle results in higher grain and straw yields of millet. However, the yields from plots ploughed using donkeys did not differ significantly from those on plots tilled by hand.

The Ethiopian Rangelands Programme

Introduction

The rangelands of East Africa are used by ranchers and pastoralists. These two groups of people have widely differing objectives, with pastoralists seeking to optimise the number of people supported per unit area and ranchers seeking to maximise economic returns. The means of increasing the productivity of ranching systems are well established; the means of increasing the productivity of pastoral systems are not.

No more than 10% of the 90 million people of East Africa are pastoralists. Although pastoralists operate systems that produce more food per unit area than equivalent ranching systems, they are not self-sufficient in food production. They must trade small amounts of high-cost meat for large amounts of low-cost cereals and other foods in order to subsist. A reasonable rate of exchange between these items is essential to the stability of pastoral systems, and when this exchange rate changes adversely as in times of drought, so does the pastoral system.

Overstocking is often cited as a major cause of rangeland degradation in East Africa. However, there is no known pastoral system in East Africa in which the number of livestock units (LUs) per person exceeds the minimum required for subsistence. If animals are removed from the system, then people also have to be removed.

Development projects have had disappointing results in the pastoral areas of East Africa, essentially because pastoralists have not been recognized primarily as small-scale dairy producers. Their main problems are similar to those of any smallholder dairyman: improved productive performance of cows and improved growth rates and lower mortality, particularly for calves.

Drought in the southern rangelands

During 1984 the southern rangelands of Ethiopia – an area of about 160 000 km^2 – suffered a severe drought. Rainfall over the period 1980 to 1984 was highly variable; a poor year in 1983 was followed by a failure of the main rains in April and May 1984 (Table 8).

In years of average rainfall most Borana families meet their food energy requirements by selling the surplus 10% of their cattle produced in a normal year and using the proceeds to buy grains to supplement their milk. In such years milk provides about 50% of their annual food energy requirements, meat about 16% and purchased cereals and other foods about 34%.

The viability of the Borana system depends on the production of sufficient milk, and reasonable terms of trade for converting surplus livestock into grain. Neither of these conditions prevailed in 1984.

Calving rates, which are commonly 45 to 55% during the main rainy season, were about 25% during 1984. This was due to poor conception rates and stress-induced abortions following the low rainfall in 1983. With little or no feed available during 1984, milk production and offtake fell rapidly, and human milk consumption dropped to less than 10% of food energy requirements. Herd mortalities more than doubled: 50 to 70% of the breeding herd died or were sold for grain, and almost all calves died.

Drought feeding of breeding stock

Heavy losses of key breeding stock during severe droughts make recovery of herd numbers a slow process. The strategic feeding of

a supplement such as molasses/urea during drought periods can reduce animal losses and facilitate the recovery process.

At the end of 1984, a molasses–urea supplementation trial was started in which 2400 cows of breeding age are being fed a daily ration of about 1 kg of 4% molasses/urea mix, but are otherwise managed in a strictly traditional manner. Every 3 days 12 kg of supplement is issued to each family head to feed four cows of breeding age per family.

Three main parameters are being measured: mortality, conception rate and condition. The data are recorded for 1200 animals fed the molasses/urea mix and 1200 control animals. The fate of each animal is to be followed through to next calving. Records of costs and inputs are also being made. The trial is the first of its kind to be attempted in a traditional East African pastoral system.

Calf survival

Poor calf growth to weaning, combined with high mortality rates, are key constraints to increased productivity in the Borana and other pastoral systems. The start of an experiment to study and measure the effects of forage and mineral supplementation and disease control on calf growth and mortality was reported in the *ILCA Annual Report 1983*. This trial continued in 1984.

Despite the drought, sufficient fodder was grown to feed the calves in the experiment up to 150 days of age. The calves were otherwise managed under traditional conditions.

Results showed a 59% survival rate of supplemented calves up to 120 days of age, compared to a survival rate of 9% for unsupplemented calves (Figure 11). Minerals appeared to confer an advantage up to 60 days of age, when total feed intake became limiting in all treatments as cows ceased lactating. Performance differences between surviving unsupplemented calves and those that had been supplemented were reduced by the

Table 8. Rainfall in the northern and central areas of the southern rangelands, Ethiopia, 1980–84.

Year	Rainfall (mm)			
	Northern		Central	
	Cumulative to August	Annual total	Cumulative to August	Annual total
1980	358	427	161	200
1981	578	704	373	471
1982	291	531	232	507
1983	320	425	181	258
1984	87	360	50	221
Long-term mean		700		500

time the animals reached 210 days of age. Inadequate availability of water appears to have contributed to this reduced difference between the groups as Boran calves are rarely supplemented with water. At low intake levels milk fluids are sufficient, but with forage supplementation water requirements increase appreciably. Without additional water the ability of calves to digest a fodder supplement is severely limited.

Watering frequency and animal productivity

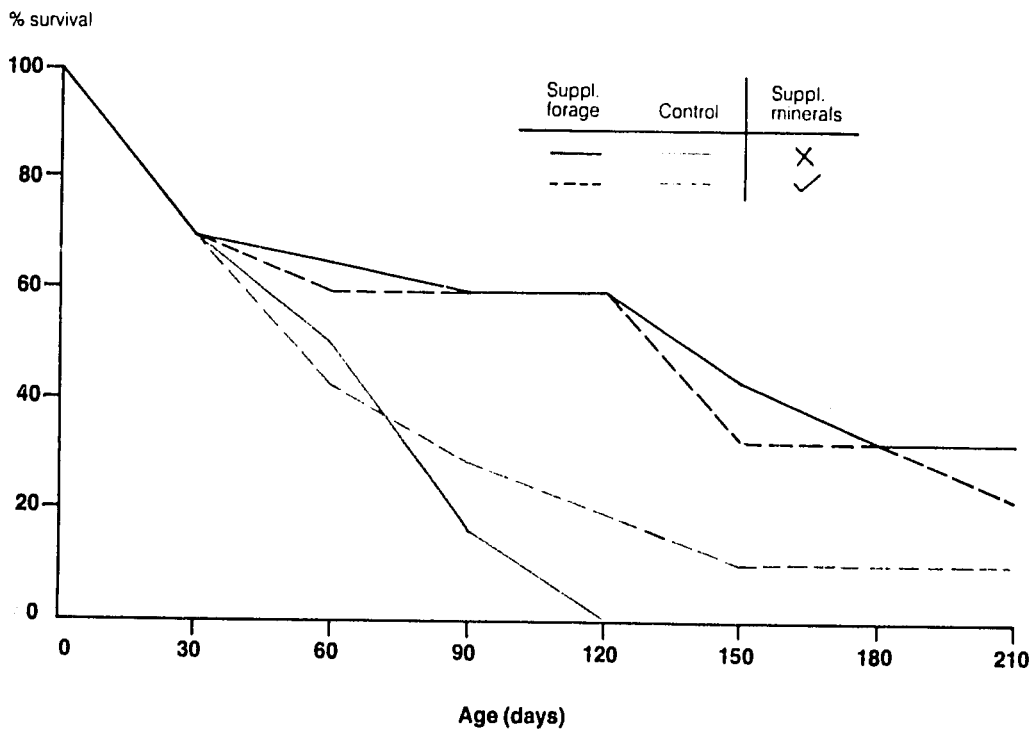
As reported in the *ILCA Annual Report 1983*, a trial was started in August 1983 to assess the effects of 1-, 2- and 3-day watering on the productivity of Boran cattle.

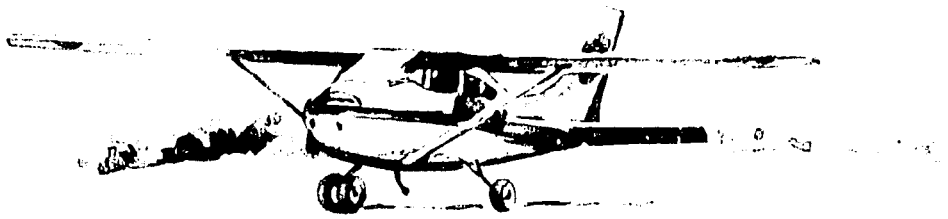
No differences in male calf growth, or in subsequent steer growth, have been observed at weaning or at 20 months of age among the three treatments. During 1984, a second group of calves of both sexes showed no differences in birthweight nor 6-month weight. No differences in calving rate or conception rate were evident. However, there were appreciable differences in weight loss among lactating cows: those watered every 3 days lost 27% of their initial weight between November 1983 and May 1984 compared with 22% for animals watered daily. In the following dry season, from October 1984 to March 1985, lactating cows watered daily lost 15.9% of their initial weight compared with 20.7% among cows watered every 3 days. In contrast, dry cows lost 2.6% and 5.7% of their initial weight on daily and 3-day watering respectively.

As a result of compensatory growth, all cows regained a good breeding condition after the onset of the rains, although cows watered every 3 days did not regain their former very fat condition. Water-restricted cows ate less, rested more and conserved more water by producing drier faeces and more concentrated urine, and by seeking shade to reduce evaporative losses.

At the onset of the dry season, animals watered every 3 days had lower DM intakes, resulting initially in large weight losses followed by weight stabilisation. This has important implications for cattle production in semi-arid areas where critical characteristics are the low availability of dry-season feed and the grazing of animals in orbits around

Figure 11. Effect of supplementary forage and minerals on percentage survival of calves, Sidamo, Ethiopia, 1984–85.





watering points. It appears that 3-day watering would allow more standing fodder to be conserved until later in the dry season as a result of the decrease in DM intake. Three-day watering reduces overall water intake by 30 to 40% compared with drinking *ad libitum*, allows rangeland within 1.5 days' walking distance from water to be effectively used, and probably reduces land degradation around watering points.

Ox-drawn scoops and pond maintenance

Water shortages limit the use of grazing resources in many pastoral areas of East Africa. A common intervention in such areas has been the construction of ponds or dams using heavy earth-moving machinery, but the success rate of these ponds has been low. High annual siltation rates have been the main reason for failure. In the southern Ethiopian rangelands siltation rates were estimated at between 6 and 8% per year, and have been a major reason why the Borana have been unwilling to assume full responsibility for the management of ponds. Digging by hand, they are unable to remove more than 15 to 20 m^3 of silt per pond per year. The initial testing of ox-drawn scoops to desilt ponds was discussed in *ILCA Annual Report 1983*.

In 1984, seven ponds were selected for desilting by ox-drawn scoops. Twenty-four oxen and five metal scoops were used. Ponds were ploughed using the *maresha*, and the average amount of silt excavated per ox-pair per 5-hour day was 13 m^3. A total of 3254 m^3 of silt was excavated.

The main problem encountered was the tendency of ponds on black cotton soil to have a surface crust that was difficult to break. However, the technique has been shown to be feasible and inexpensive (US$ 0.3 per m^3 compared with US$ 3–5 per m^3 using heavy machinery), and the next phase will be the introduction of ox-drawn scoops under control of the pastoralists. The possibility of using camels instead of oxen will also be tested as soon as the current drought breaks.

Systematic reconnaissance flights

Systematic reconnaissance flights (SRF) have been used to provide a rapid evaluation of human and livestock densities and of environmental parameters. Repeated flights are the only practical way to assess trends over large areas of rangeland. However, they are still unsatisfactory in many aspects: the standard sampling procedures result in a lack of precision, and the data give rise to problems of statistical analysis.

A project was started in 1984 to investigate ways in which the effectiveness and accuracy of SRF surveys can be improved. Some of the modified techniques will be used to assess the consequences of the current drought, both in terms of livestock losses and changes in land use.

Bush encroachment

Bush encroachment is the natural response of tropical East African ecosystems to overexploitation: woody plants limit further degradation. Bush encroachment is accompanied by a reduction in grass production and availability. Nutrients are immobilised in trees and shrubs, and the annual turnover of nutrients is reduced so that the natural recovery of the land becomes a slow process. Detailed studies are being made at three sites in the Sidamo area. In a wider study production changes in standing grass biomass are being monitored under various edaphic conditions ranging from arid volcanic plateaux to waterlogged grasslands.

Remote sensing

The measurement of plant biomass and phenology using conventional ground methods is time-consuming and costly, and is often

impossible over large areas of inaccessible rangeland. The use of satellite data from the NOAA-7 AVHRR could be a relatively cheap method of estimating periods of grass growth and total production in rangelands.

A project started in 1983 is comparing radiometric response from vegetation measured by the NOAA-7 satellite, and in-flight or ground measurements of plant radiometric characteristics in the red and near infrared bands of the spectrum.

The main objective of the project is to establish procedures for interpreting AVHRR data of coarse resolution in areas of complex terrain and vegetation. Work on the calibration of AVHRR data includes the production of a detailed topographic map derived from Landsat images and the calibration of normalised difference vegetation index (NDVI) with plant phenology. The correlation of NDVI values with plant biomass is at present not feasible to high levels of accuracy.

Sub-Saharan Africa and industrial market economies: A comparison

Twelve indicators for sub-Saharan Africa and industrial market economies.

Indicator	Sub-Saharan Africa[a]	Industrial market economies[b]
GNP/caput, 1982 (US$)	491	11 070
Energy consumption/caput, 1981 (kg oil equiv.)	111	4 985
Index of food production/caput, 1980–82 (1969–71 = 100)	88	114
Daily calorie supply/caput as % of needs, 1981	90	132
Life expectancy at birth, 1982 (years)	49	75
Crude birth rate/1000, 1982	49	14
Crude death rate/1000, 1982	17	14
Total fertility rate[c], 1982	6.8	1.7
Average annual growth of population (%), 1970–82	2.8	0.7
Urban population as % of total, 1982	22	78
% of GDP accounted for by agriculture, 1982	33	3
% of labour force in agriculture, 1980	72	6

[a] Statistics from 39 sub-Saharan African countries.

[b] Statistics from 19 developed countries.

[c] The total fertility rate represents the number of children that would be born per woman if she were to live to the end of her child bearing years and bear children at each age in accord with prevailing age-specific fertility rates.

Source: World Bank. 1984. *Toward sustained development in sub-Saharan Africa: A joint program of action.* The World Bank, Washington DC

The Kenya Rangelands Programme

Introduction

ILCA's research on the range livestock systems of Kenya is carried out among the Maasai pastoralists. The Kenya Rangelands Programme aims to determine how varying levels of development interventions are modifying the Maasai's traditional methods of production, to identify the constraints to livestock production and to design and test further improvements.

These studies centre on an area of about 1600 km^2 in Kajiado District, southeast of Nairobi. In this area, the Kenya Government has, in collaboration with the Maasai, adopted the group ranch form of territorial organisation as a model for land adjudication for the Maasai and for their social and economic development.

Three group ranches – Olkarkar, Merueshi and Mbirikani – have been studied by ILCA's team since 1986. The locations of the ranches are shown in Figure 12. Inventory surveys of the human and livestock populations of the ranches have been followed by studies on herd structures, reproductive performance, young stock growth, milk production, livestock diseases, livestock offtake and acquisition, household budgets, marketing and human nutrition.

Range resources and cattle nutrition

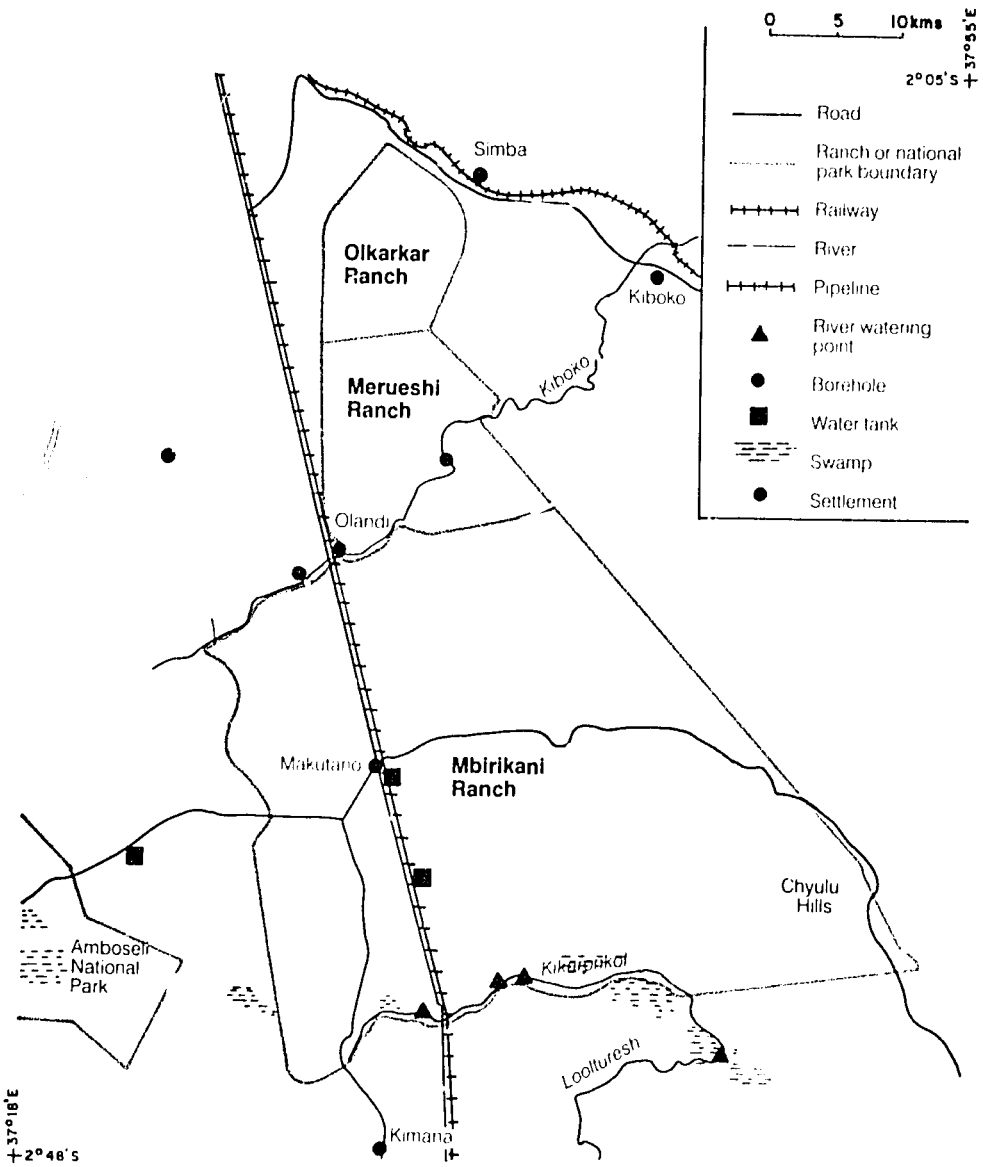
Profiles of the seasonal availability of range resources in different areas were derived from regular surveys over a study period lasting from 1981 to 1984. Data on the quantity and quality of standing biomass were complemented by nutrient analyses of the extrusa of fistulated cows.

Due to the extreme variability of rainfall during the study period, the amount of forage on offer varied greatly between seasons and years as well as between the northern and southern areas studied. These patterns of fluctuation are illustrated in Figure 13 in which standing biomass yield, its CP content and *in vitro* digestibility are given for good and poor year types. In good years, standing biomass normally exceeds 2 t DM/ha/month for 6 months, while over a 7- to 8-month period from mid-October to early June the grazing diet is likely to contain more than 7% CP and over 50% digestible energy. In poor years, the grazeable biomass exceeds 1 t DM/ha/month only during 2 months; due to excessive grazing pressure, peaks of good quality fodder are short.

Most seasons during the 1981–84 period fell between these extremes, the two northern ranches experiencing more favourable conditions than the southern ranch. High rainfall alleviates the shortage of grazing resources during the long dry season; but rapid forage growth is offset by an equally rapid decline in its quality. While early in the season a standing leaf biomass of 0.5 to 1.0 t DM/ha contains 10 to 12% CP, this falls to 4 to 6% CP as standing biomass reaches 2 to 3 t DM/ha. However, due to selective grazing, actual cattle diets showed a much slower decline in CP content of about 1% per month. In the driest month studied (September 1983) cattle still managed to consume forage that contained 4.7 to 4.8% CP and 42 to 46% digestible energy.

Clipped samples and oesophageal extrusa were analysed for P and other important minerals. Phosphorus was always above

Figure 12. Map of the three group ranches studied by the Kenya Rangelands Programme, Kajiado District, Kenya.



the critical level of 0.20% in the dry matter. Even when animals grazed a large percentage of dry standing forage, the minimum P content was 0.35%; even coarse grass tussocks contained 0.25 to 0.27% P.

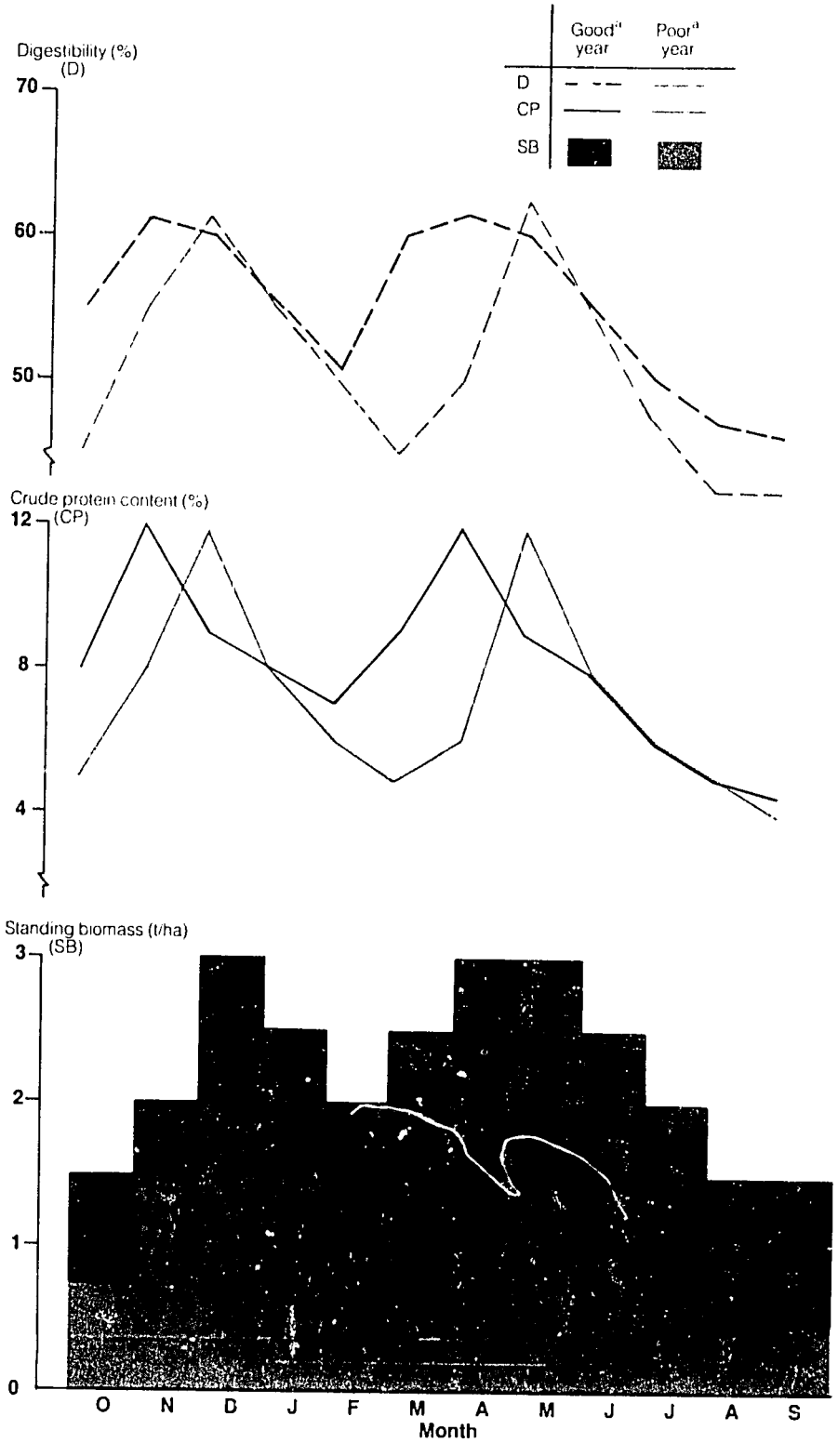
Except for Mg and Cu all other minerals studied (Ca, Na, K, Fe, Zn) were in adequate supply in the animal diet. Levels of Fe were high during the dry season, indicating a high intake of soil and dust.

Due to the relatively high fertility of the predominantly volcanic soils, the mineral nutrient content of the animal diet was comparatively high. Hence, the quantity of forage on offer is more limiting than forage quality. Maasai grazing management leads to high grazing pressures within a 5 to 8 km radius are and homesteads and waterpoints, especially during periods of below-average rainfall.

Integrated evaluation of semi-arid rangelands

The Programme participated in the joint ILCA/NASA research project aimed at developing integrated resource evaluation techniques for pastoral production systems,

Figure 13. Grazing resource profile for 'good' and 'poor' year types, Kajiado District, Kenya.



[a] Good and poor years are based on rainfall and water balance data from the three group ranches and each occurred once every 10 years in the period 1936–1984

combining satellite imagery with aerial and ground surveys.

Remotely sensed or spectral vegetation index data were made available by NASA for eight periods covering the end of the early 1983 rains (May), the long dry season (June to November) and the late 1983 rains and their aftermath (December 1983 to March 1984) for an area of 12 200 km^2 in eastern Kajiado District, Kenya.

The area was subdivided into 16 units, using vegetation physiognomy, the ratio of woody to herbaceous cover, density of the grass cover, landscape geology and location as criteria. A two-way analysis of variance was made using units and months as variables.

During the dry period from June to November 1983 all vegetation types showed mean index values close to zero. Following the rainfall in late December, the vegetation index rose rapidly in early January 1984, the highest values being recorded in wooded vegetation types. In general, mixed vegetation 'greened up' earlier and showed a much slower decline in NDVI than did treeless vegetation. The lowest values occurred in the rangelands of Mbirikani, at the southern end of the rainfall gradient.

Further research is designed to demonstrate to what extent satellite imagery can assist in predicting productivity over the wet and dry cycles in semi-arid rangelands. It is therefore essential that remotely sensed data are recorded over long time-spans so that they can be used in combination with rainfall analyses and with ground or aerial assessments of both primary and secondary productivity.

Smallstock productivity

The overall productivity of sheep and goat flocks in the three ranches studied was low, ranging from just 29 g weaned weight per kg of flock biomass in goat flocks in the southern ranch, to 107 g/kg in sheep flocks in the northern ranches. This poor performance can be attributed to the high mortality of young stock, and to the high proportions of infertile females and old castrate males in most flocks.

The high mortality rates were due largely to predation in sheep and to disease outbreaks in both sheep and goats. Losses were particularly high during an outbreak of Nairobi sheep disease (a tick-borne virus) during early 1983. The rates of predation are par-

ILCA and the NOAA-7 satellite

During the past 2 1/2 years, ILCA has become increasingly involved in the analysis of data derived from the advanced very high resolution radiometer (AVHRR) on board the NOAA-7 satellite. This work is carried out mainly in collaboration with the Global Inventory Monitoring and Modelling Section (GIMMS) of the National Aeronautics and Space Agency (NASA) in the United States. Increasingly, it will also involve UNEP's Global Environmental Monitoring Group (GEMS), the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia, and FAO in Rome.

Background

Over the past 7 years, ILCA teams have carried out detailed analyses of farming and pastoral systems in East and West Africa. It has been extremely difficult to extrapolate from these studies to wider ecological settings. By the late 1970s, however, remotely sensed data from satellites provided a complementary method for investigating ecological phenomena and agricultural potential over large areas.

The AVHRR carried on board the NOAA-7 satellite provides multi-spectral data for measuring the extent of green vegetation. The reflectance from any part of the earth's surface can be measured for 3 consecutive days every 9 days. The nine images available each month can be 'merged' by computer to eliminate interference from cloud cover.

The AVHRR records five wavebands, two of which - the visible and the near infrared - are highly correlated with green vegetation cover. The reflectance measurements are transmitted periodically to earth receiving stations where the signal is stored on computer as an intensity array of up to 64 figures. The array is usually reduced to 16 figures for visual presentation. The basis of the visual image is provided by the following index of the two wavelength measurements.

$$(IR - R)/(IR + R)$$

where IR = *near infrared reflectance, and*

R = *red reflectance.*

This index is termed the normalised difference vegetation index (NDVI).

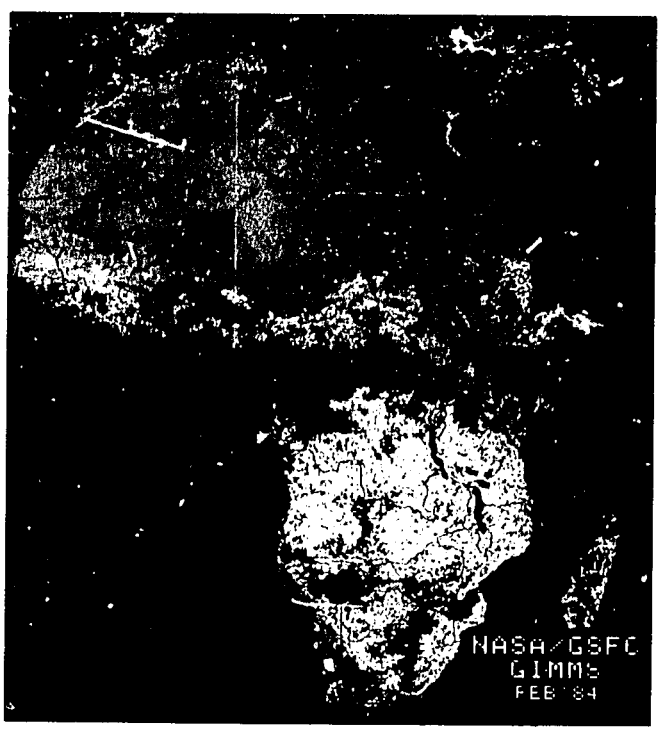


Figure 1. False colour images of continental Africa in a year of drought, where purple represents high green cover and tan represents very low green vegetation cover. These composite monthly images show the dramatic changes in green vegetation cover in Africa in a single year. By February, the December and January rains in central and southern Africa have produced dense green vegetation cover. By July, the mid-year rains in humid West Africa have produced good growth from Senegal across to Zaire – but large areas of East Africa and the Sahel remain devoid of green vegetation.

Figure 2. False colour images of Ethiopia in October and November 1984. These images of two consecutive 2-week periods show how satellite data record rapid changes in green vegetation cover. In just 2 weeks without rain, large areas of Ethiopia have lost what little green vegetation they had. In much of Wello (northeast) and Sidamo (south) provinces, areas of high concentrations of people and livestock, very little vegetation cover is recorded.

Figures 1, 2 and 3 show visual images derived from satellite data and illustrate how satellite imagery can be used at different levels: continental, country and study area.

Potential uses

Few African countries can afford the staff to set up large-scale ecological monitoring networks based on ground recording and aerial survey techniques. Data from the AVHRR on the NOAA-7 satellite can overcome these constraints and provide the following information:

1. *Early warning of famine risk – strong relationships between the spectral response of vegetation and the occurrence of drought in Africa in 1983 and 1984 have been demonstrated;*
2. *Estimation of seasonal herbaceous biomass for different ecological regions – this application is useful in the pastoral areas of sub-Saharan Africa, where feed resources support large numbers of livestock;*
3. *Estimation of the length of plant growing seasons - satellite data can provide time series of spatial vegetation responses. After ground and aerial calibration, these data can be used to assess the duration and distribution of growing seasons in a given year and hence to forecast crop yields.*

Other potential applications include the detection of causal relations between climatic variations and the extent of livestock diseases, the determination of long-term trends in desertification and deforestation, and the refinement of the boundaries of Africa's agroecological zones.

For any of these applications to be successful, multi-spectral data must be calibrated with surface vegetation phenomena. If not, assessments remain approximate and subjective.

Calibration

The calibration of satellite-derived data is complex and requires a well thought-out scientific approach at different spatial levels. ILCA is attempting to provide such an approach for sub-Saharan Africa.

At present, NASA is supplying the basic satellite data and developing 'multi-temporal' analysis techniques. ILCA is collecting data from ground and low-level aerial surveys, and plans to compare different calibration methods in a series of study areas with differing environmental conditions.

1985 research

In Mali, the transect base in the Gourma established in 1984 is being expanded to include 30 ground sites with sampling frequencies ranging from 2 weeks to once a season. In the same country, work in the Niger floodplain seeks to extend the calibration exercise to cover higher biomass production levels, and the potential effects of flood characteristics on the NDVI. The project includes low-level aerial survey measurements with synchronised reflectance and photographic measurements.

In Niger, ILCA is working with the Niger Government, USAID and Tufts University to relate satellite data to resource utilisation and livestock productivity, and to develop an effective early warning system for drought.

These country studies, together with FAO-funded work in Senegal and Sudan, will provide the framework for interpreting multi-temporal AVHRR data across the entire Sahelian zone.

In the East African rangelands, work focuses on the interpretation of AVHRR data in areas of complex terrain and vegetation. Thirteen 400 km² ground truth areas in defined ecological units are being sampled in the southern Ethiopian and northern Kenyan rangelands. At the same time, a multi-stage calibration project is being started in Kenya jointly by GEMS (UNEP) and ILCA. The project consists of low-altitude monitoring of NDVI responses along cross-country transects, backed up by ground and aerial observations in training sites established in the major ecological zones of Kenya.

High priority is being given to developing correction factors for the interference experienced in reflectance measurements due to haze, aerosols and other atmospheric distortion factors. The problem is most serious in West Africa, and a network of transmissiometer-recording stations is planned across the Sahel from Senegal to Sudan.

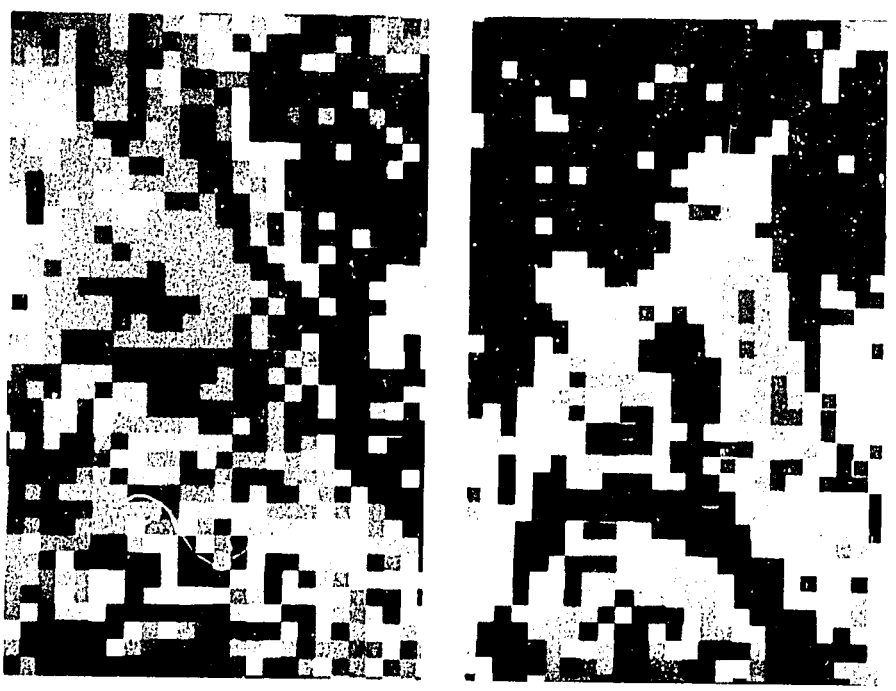
Work has already started in Mali on correlating AVHRR data with biomass data predicted through a water balance model. In East Africa work is focusing on a detailed set of rainfall data derived principally in Ethiopia. This study seeks to integrate AVHRR data on vegetation conditions with a P/PET model of crop status. The work has direct implications for drought early warning and for the integration of standard meteorological ground measurements with satellite data.

An ILCA ground receiving station?

Given adequate funding, ILCA proposes to establish facilities for satellite tracking, data processing and analysis, and information distribution, at its Addis Ababa headquarters.

Remotely sensed spectral data would be received, decoded and calibrated at ILCA. The data would be analysed to monitor droughts, to determine primary productivity in rangeland areas, to estimate the length of plant growing seasons, to identify climatic effects on the distribution of livestock diseases, to observe trends in vegetation patterns and to record short- and long-term shifts in agroecological conditions.

The false colour images in Figures 1, 2 and 3 are reproduced with kind permission of the National Aeronautics and Space Administration (NASA), Goddard Space Flight Center, Maryland 20771, U.S.A.



Approximate area of Kenya covered by the two accompanying satellite images. The three group ranches studied by ILCA are shown in green (see also Figure 12).

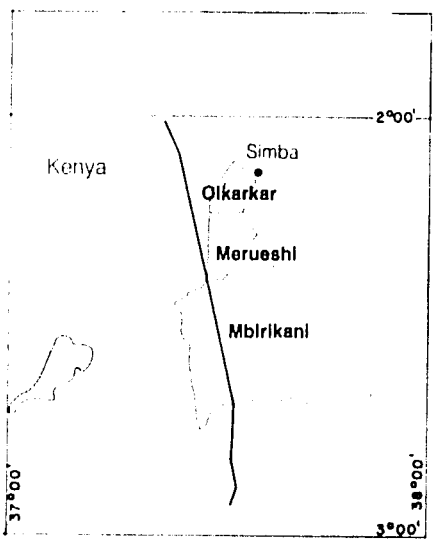


Figure 3. False colour images of the environs of Kajiado District in southeast Kenya for the third week of December 1983 and the second week of January 1984, with accompanying map. The dramatic effect of the December 1983 rains on this study area is apparent. ILCA's work in this area of Kenya in 1985 includes ground and aerial surveys to complement and calibrate the AVHRR data from the NOAA-7 satellite.

tially due to negligent supervision of young suckling stock around the *boma* (homestead) and of young weaned stock during herding.

Sensitivity analyses showed that better management of smallstock, resulting in only small improvements in production parameters, would probably lead to rapid increases in flock output and a large rise in productivity. Current sheep productivity at Mbirikani (60 g weaned weight per kg flock biomass, as shown in Table 9) could be increased to 200 g/kg if mortality was reduced by 10%, mature castrates were replaced by breeding females, and the mean parturition interval was reduced by 20%.

Animal health

An extensive disease survey on the livestock of 39 sample households was conducted. A large number of diseases were diagnosed, but only a few showed important rates of incidence. In cattle, brucellosis and leptospirosis showed 15 and 18% of incidence respectively. High levels of infection of both these and foot-and-mouth disease were confirmed in a few animals which act as the main hosts or reservoirs of infection. Incidence rates of theileriosis (East Coast fever) and anaplasmosis were very low at 4% and 3% respectively. No case of babesiosis was detected.

However, during the dry seasons, herds forced to graze in remote areas where there are no dipping facilities invariably contracted high rates of theileriosis and anaplasmosis.

Other diseases reported to be of major concern to producers were malignant catarrh fever and bovine otitis in cattle, and helminthiasis in sheep and goats. *Strongyloides* and coccidial oocysts were detected by faecal examination in 30% and 20% respectively of the smallstock examined.

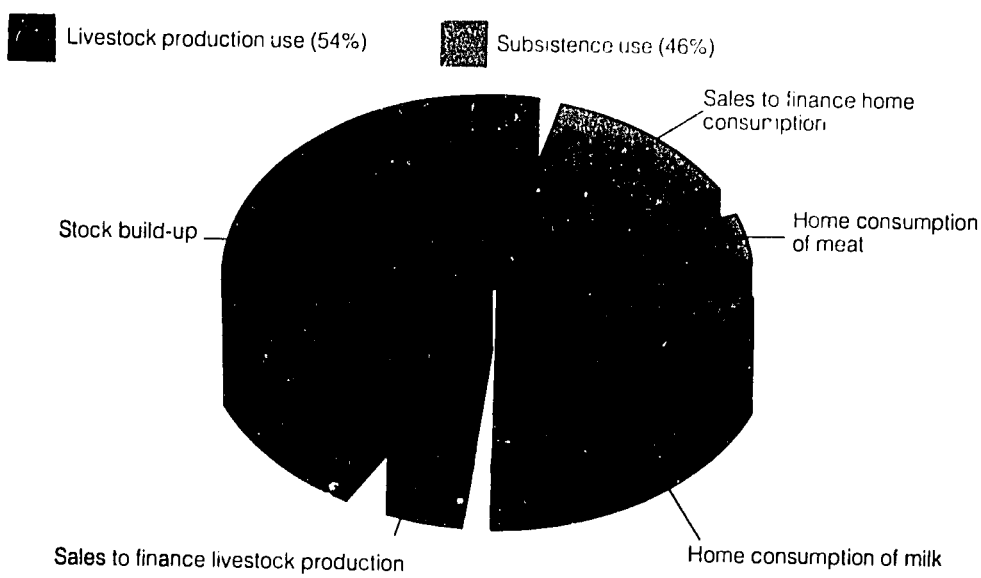
Use of livestock products

Maasai livestock production is essentially a subsistence enterprise. It is geared to provide a year-round supply of milk – a major staple of the diet – and a few animals for sale in order to finance the purchase of subsistence needs (mainly food and clothing) and livestock inputs such as breeding stock, acaricides and veterinary drugs.

Data from Olkarkar Ranch for 1981–83, a period of slightly subnormal rainfall, show that in general 46% of the total value of annual livestock production is devoted to subsistence needs and 9% to financing future livestock production (Figure 14). The remaining 45% is used for building up stock in the form of newborn, purchased and older stock. However, there are important inter-producer differences. For small-scale producers[1], stock build-up represented 33% and consumption 63% of the total value of annual production. The corresponding pro-

[1] Small-scale producers are defined as those having less than 5 livestock units (LU where 1 LU = 250 kg) per active adult male equivalent (AAME); medium-scale producers have from 5 to 12.9 LU/AAME; and large-scale producers have 13 LU/AAME or more.

Figure 14. Utilisation pattern of livestock output, Olkarkar Group Ranch, Kenya, July 1981 to June 1983.



portions for large-scale producers were 53% and 39%.

In terms of types of livestock output, animal offtake and the proportion of milk extracted for human consumption were equal, each representing 28% of the total value of annual production. However, virtually all of this milk (97%) was consumed at home, whereas most of the animal offtake (75%) was sold. Most of the sales were of cattle, while voluntary slaughter was primarily of smallstock. Again there were significant producer differences in milk offtake, which represented 37 and 22% respectively of the value of total annual production for small- and large-scale producers. There was very little difference in animal offtake, which was 29 and 31% respectively for the two classes.

The above indicates that during periods of normal and near normal rainfall Maasai producers 'passively' invest a substantial proportion (44%) of their annual output into future production in the form of stock accumulation. While this strategy is adopted largely to ensure the long-term survival of the pastoral household during periods of severe drought, it also contributes unnecessarily to a high degree of stock loss when severe droughts occur. This suggests that alternative forms of savings and acquisition eventually persuade the large producers, who represent 40% of the human population on Olkarkar Group Ranch but use 70% of the communal range resources, to increase their sale of animals.

Drought monitoring

The complete failure of the April/May rains of 1984, following several seasons of subnormal rainfall, led to serious drought conditions in the study area. Indications to date suggest that the climatic conditions were more serious than any since 1961. The drought conditions, as determined by biomass availability, ended with the onset of rains in November 1984.

In response to these conditions, additional field data were collected from a subsample of 21 households in the three group ranches. The household studies focused on three main areas: 'drought-survival' strategies (primarily mobility and sales), animal mortality and household provisioning. Marketing studies have also been intensified, and

Table 9. Productivity index for sheep and goat flocks in the northern and southern ranches, Kenya, 1981–83.

Parameter	Northern ranches[a]		Southern ranch[b]	
	Sheep	Goats	Sheep	Goats
No. of births/LU/year	0.23	0.26	0.12	0.08
No. of births/LU of breeding female/year	0.39	0.45	0.22	0.14
Litter size	1.01	1.29	1.01	1.29
Survival at weaning	0.90	0.75	0.90	0.68
Survival at 18 months	0.64	0.39	0.55	0.33
Weight at weaning (kg)	13.0	9.7	14.0	10.3
Weight at 18 months (kg)	27.5	19.4	30.6	26.5
Productivity indices				
g/kg biomass of flock[c]				
at weaning	107	98	60	29
at 18 months	159	102	77	34
g/kg biomass of breeding female				
at weaning	194	161	103	49
at 18 months	288	263	132	57

[a] Olkarkar and Merueshi

[b] Mbirikani

[c] Total biomass of all females minus 50% of the young females.

an aerial survey to determine the wider-scale distribution of both domestic and wild animals was carried out in October 1984.

Production in the northern ranches is semi-sedentary, with households and all their animals tending to remain in permanent homesteads in normal years. In the southern, drier site, movement of some animals (e.g. dry cows, steers) to distant grazing areas under the care of young men, is a far more frequent management strategy. In response to the drought conditions prevailing throughout much of 1984, most households in both areas moved livestock into areas not normally exploited. Strategies differed significantly according to many factors, including herd size, labour availability, and the size of producers' social networks (in Maasailand, in the local administration and in neighbouring tribes). The ultimate fall-back areas used included government forest reserves and privately owned farms (with payment for grazing), national parks and research stations (illegal) and areas of Maasailand normally underused because of poor water facilities or the high incidence of East Coast fever (and to a lesser extent trypanosomiasis).

An aerial survey was carried out to complement the household level data collection. It covered an area of 9400 km^2 which included the three study sites and their surroundings. A comparison of this survey with surveys undertaken in 1982 shows interesting changes in the distribution of stock. While the total population in the northern region (900 km^2) covering six group ranches increased only slightly (from 28 700 to 33 000 head), their spatial distribution changed markedly. The relatively even distribution of 1982 changed to concentrations of animals in particular areas in 1984.

Almost 20 000 head were concentrated in one region of 400 km^2 in the northeastern area, which is marked by a range of hills known for high incidence of East Coast fever and trypanosomiasis and which borders a government research station and a national park. The second largest concentration of stock was along the water pipeline which transects the study site. The north-central area, which contained 6200 head in 1982, contained only 1200 during the drought survey.

It is more difficult to make comparisons for the southern area which experienced a minor drought and high mobility during 1982. During that year the cattle population within the ranch boundary (1350 km^2) fell from 43 000 in February to 18 700 in June. Animals had been moved to the southern end of the hills, or to wetter areas along the foothills of Mount Kilimanjaro. In 1984, a similar strategy was employed: in September only 1400 head were found on the ranch, most of them concentrated in the extreme northwestern corner, with access to riverbed wells and distant hill grazing. Approximately 40 000 head were counted in two national parks bordering the area, with a smaller group (2000) near swamps to the southwest. About 28 000 head had moved to areas further east, grazing on farmers' land and in forest reserves. From the ground truthing surveys it is clear that the animals found during the aerial survey represented the resident populations of these areas, with significant influxes of animals from up to 75 km northwest of the aerial survey sites. It appeared that movements of smallstock were of lesser scope; sheep and goats tended to stay within their home ranch territories, although they were often shifted to temporary camps in the southern area.

The expectation of periodic drought influences decisions made throughout a pastoralist's lifetime. Herd accumulation aimed at drought survival and rapid post-drought recovery plays an important role in pastoral systems. The average herd accumulation rate under good conditions in the study area is estimated at 14% per annum, whereas estimated losses over 1984 were up to 50% of cattle. In times of stress, social networks developed during normal years come into play in unique ways as pastoralists strive to gain access to resources they do not normally exploit. Capital and labour availability affect management options with far more dramatic results than are normally observed. The household level studies will provide information on the strategies used by different producers and the causes of herd decreases (starvation, disease, sales).

A complete census, including a determination of herd structure, will be carried out in early 1985 when the pastoralists have returned to their home areas. With this information, a full analysis of the effects of the drought on livestock holdings and the impact of different strategies will be possible. This census will also serve as the baseline for monitoring post-drought recovery.

Central research and support units

The Livestock Productivity and Trypanotolerance Group

Introduction

During 1984 the work of the Livestock Productivity and Trypanotolerance Group continued to focus on the biological and economic aspects of livestock productivity, with a strong emphasis on trypanotolerant livestock. Research was carried out in close collaboration with organisations in 13 countries of Africa. Trypanotolerance research was centred on the collective results of the Trypanotolerance Network at sites in West and central Africa and at associated sites in East Africa. The Group also completed a number of comparative breed studies during 1984. One of these was based on the analysis of a unique collection of matching productivity and health data collected over a 10-year period at Mkwaja Ranch in Tanzania.

Trypanotolerance research

The Trypanotolerance Network

Table 10 shows the management system, animal species and number of animals studied at each site of the West and central African Trypanotolerance Network and at associated sites in Tanzania, Kenya and Ethiopia. At some sites attempts are being made to improve the productivity of trypanotolerant breeds by the use of chemotherapeutic or chemoprophylactic drugs.

Gabon. The ranch of the Office Gabonais de Production de Viande (OGAPROV) at Okouma raises N'Dama and Nguni cattle and their crosses under two levels of trypanosomiasis risk. In 1981 the Gabonese authorities agreed to ILCA's proposals to supply necessary extra materials and to support part of the operating expenses. Data collection according to ILCA's protocol started in September 1981 with four herds and has been extended in 1984 to all herds of the ranch in order to cover a wider range of interactions between breeds, level of tsetse challenge and trypanosomiasis control measures.

Ivory Coast. Work on sheep in the SODEPRA-Nord project (of the Société de Développement des Productions Animales) was extended with support from ILCA during 1981 to cover all recording requirements in a village situation in the subhumid savanna around Korhogo.

The extension of the operations to a higher tsetse challenge area, and to cover both sheep and cattle (Zebu, Baoule and N'Dama breeds), is now being funded by GTZ (Gesellschaft für Technische Zusammenarbeit) as a special project. Agreements were signed in 1983 and the project became fully operational in January 1984. The work is being carried out in collaboration with the Ministry of Animal Production, the Veterinary Laboratory of Korhogo and an FAO project on tsetse control.

Nigeria. ILCA's Humid Zone Programme has collected matching production, health and tsetse data for small ruminants in two contrasting village situations. One is in a low to medium tsetse challenge zone, and the other in a virtually tsetse-free zone.

Initial analyses have amply demonstrated the connection between health and productivity within species, and contrasted the effect of disease on the productivity of different species. The effect of disease has also been compared in two groups of animals of very different age and physiological status.

Goats at Badeku were shown to be more productive than those at Fasola, where disease challenge is higher. The level of packed

Table 10. Summary of data collected in the Trypanotolerance Network, West, central and East Africa, 1984.

Country	Management system (n)[a]	Species	Number of animals[b]
Benin	Villages	Cattle	n.av.[c]
Ethiopia	Villages (3)	Cattle	1200
Gabon	Ranch (1)	Cattle	1100
	Villages (8)	Sheep	700
	Villages (8)	Sheep	500
	Villages (20)	Cattle	500
Kenya	Villages (3)	Cattle	1000
Nigeria	Villages (10)	Sheep/ goats	750
	Ranches (2)	Cattle	450[c]
Senegal/ Gambia	Villages	Cattle	n.av.[c]
Tanzania	Villages (15)	Sheep/ goats	300
Togo	Station (1)	Cattle	250
	Villages (10)	Cattle	380
	Villages (12)	Sheep/ goats	420
Zaire	Ranches (2)	Cattle	1000
	Villages	Cattle	n.av.

[a] n = number of locations.

[b] Number of breeding females recorded for health and productivity.

[c] Data collection to start in 1985.

red cell volume (PCV), used as an indicator of health, was higher at Badeku than at Fasola. Lactating does had lower PCV levels and higher infection rates of trypanosomiasis, babesiosis and gastrointestinal parasites than did post-weaning kids.

Sheep had higher levels of gastrointestinal parasites than goats at Badeku, negligible levels of anaplasmosis and trypanosomiasis, and approximately the same PCV levels as goats. They appeared to have a higher tolerance to infection, since their productivity was greater than that of goats. Peaks in infection levels did not occur at the same time in goats and sheep. Possibly this is due to different grazing habits, resulting in ingestion of nutrients and parasites at different times. Dipping and vaccination reduced mortality rates in both sheep and goats.

Togo. The Government of Togo and GTZ proposed an extension of the activities of the Centre de Recherche et d'Elevage at Avetonou (CREAT) to carry out comprehensive work on the cattle and *métayage* operations at the Avetonou station. Data are also being collected on small ruminants raised in two different ecological zones of Togo. Field operations started in December 1983.

Senegal/Gambia. In Gambia the African Development Bank has agreed to finance an 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 the International Laboratory for Research on Animal Diseases (ILRAD), financed 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 degrees of tsetse challenge. This proposal has been linked with a request to EDF to fund the Gambian operation. The two projects will constitute a single, integrated operation.

Zaire. All activities in Zaire focus on the N'Dama breed of cattle raised under various levels of trypanosomiasis risk and under different management systems.

Operations on ranches owned by Compagnie J. van Lancker started in November 1982 at Kolo Ranch and in May 1983 at Mushie. The first intermediate evaluation was performed at the end of 1984.

Associated network sites in East Africa

Ethiopia. In August 1984 ILCA opened new network sites in southwestern Ethiopia in areas of low, medium and high trypanosomiasis risk. The productivity and health of the East African Zebu and Sheko breeds (a taurine breed said to be trypanotolerant) are being studied. ILCA is cooperating with Ethiopian Veterinary Services and Addis Ababa University in this project.

Kenya. The associated work in Kenya comprises a veterinary project carried out by the Kenya Ministry of Agriculture, May and Baker Ltd, ILCA and ILRAD. Initial results analysed in 1984 covered matching animal health and performance data collected at monthly intervals from October 1982 to September 1983. These involved approximately

700 East African Zebu cattle in 17 village herds in the Muhaka area of Coast Province. Daily liveweight gain of pre-weaners, post-weaners and adults averaged 154 g, 81 g and 29 g respectively over the year and closely followed the rainfall pattern. Trypanosome detection rates averaged 2.3, 2.6 and 3.7% monthly for pre-weaners, post-weaners and adults respectively. Low PCV measurements in November 1982 and August 1983 were consistent with the higher trypanosome detection rates in these months. In all age groups there was a highly significant positive relationship between PCV and daily liveweight change.

Tanzania. Collaboration has been established with the Overseas Development Administration (ODA) of the UK and the Tanzania Veterinary Department to evaluate the productivity of small ruminants raised under different levels of tsetse–trypanosomiasis risk. Starting in 1981, approximately 300 sheep and goats in 15 villages in Mtwara and Newala Districts were monitored for growth and reproductive performance in relation to different health treatment schemes. The statistical data analysis is currently being carried out at ILCA.

Data flow

A micro-computer unit has been established in Nairobi to allow for rapid capture, checking and filing of field information from various sites. The unit consists of three HP125s, one HP150, two dual floppy discs, two fixed discs, three printers and one plotter.

Field sites are supplied with simple preprinted recording forms that are easily completed by field staff each month. After verifying the accuracy of the data, the forms are sent to the unit in Nairobi. Upon receipt of the data recording sheets in Nairobi the data set is first checked for completeness and data quality. In the case of major omissions or inaccuracies, the field site is informed accordingly.

Data of acceptable quality are entered at a computer terminal using a database software package. After the correctness of the information in the computer file has been verified, the file is stored on mini floppy discs, which at the same time provide the data link between the micro-computer unit in Nairobi and the main-frame computer at ILCA headquarters.

As micro-statistical software only allows simple monthly statistics to be calculated, all large-scale analyses of unbalanced designs have to be carried out on the main-frame computer at ILCA headquarters, where a scientist from Nairobi is present each time a major data set is analysed.

Coordination of network operations

All network activities are coordinated by the Livestock Productivity and Trypanotolerance Group in Nairobi. Technical supervision of field work and training of network field staff are carried out in close cooperation with ILRAD. Six scientists from ILCA and ILRAD are involved in the network activities. Frequent field visits are necessary for supervising ongoing network field activities and to maintain a high quality of data collected. Technical support and supervision missions have increased as the network has expanded.

Training

Figure 15 shows the participation of staff from network countries in training courses organised by ILCA and ILRAD. Overall, 25 technical staff spent a total of 128 weeks on the training courses. Additionally, during missions to network countries, visiting scientists organise training courses for technicians involved in data collection.

Livestock productivity research

During 1984, ILCA was involved in a considerable number of comparative breed studies in cooperation with national organisations. The aim is to build up comparative production information on important livestock groups in Africa, so that decisions can more easily be made when a breed has been shown to be a constraint in a particular production system. In this way the many questions directed to ILCA on the value of alternative genotypes for specific production systems in various ecological zones, can be answered more clearly.

In 1984 major studies were completed on grade Boran cattle maintained by chemoprophylaxis in Tanzania (see Box, p. 49), Gobra Zebu cattle at the Centre de Recherches Zootechniques de Dahra, Senegal, and crossbreeding of range beef cattle at the Matopos Research Station, Zimbabwe. Considerable

work was also carried out on Ankole cattle and their crosses at Songa Station, Rwanda.

Beef cattle crossbreeding in Zimbabwe

The Zimbabwe study represented a major comparison between four Sanga breeds (Africander, Mashona, Ankole and Tuli), one Zebu breed (Brahman) and two *Bos taurus* breeds (Sussex and Charolais). Terminal sire breeds also included Tuli, Aberdeen Angus, Hereford, Simmental and Friesland. Considerable data on reproductive performance, viability, calf growth and cow weight were analysed and interpreted. The results support the view that the use of indigenous instead of exotic breeds is likely to bring about lasting improvements in beef production from range. The performance of the Brahman, which has been introduced to Zimbabwe only recently, is encouraging, but further evaluation of this breed is required.

It was also recommended to continue to evaluate the use of other exotic breeds not considered in this study. Exploitation of maternal heterosis from F_1 cows will not be achieved on many ranches because of the managerial limitations of the terminal crossbreeding system. As rotational crossing systems appear more feasible, the evaluation of maternal heterosis retained in such systems is necessary.

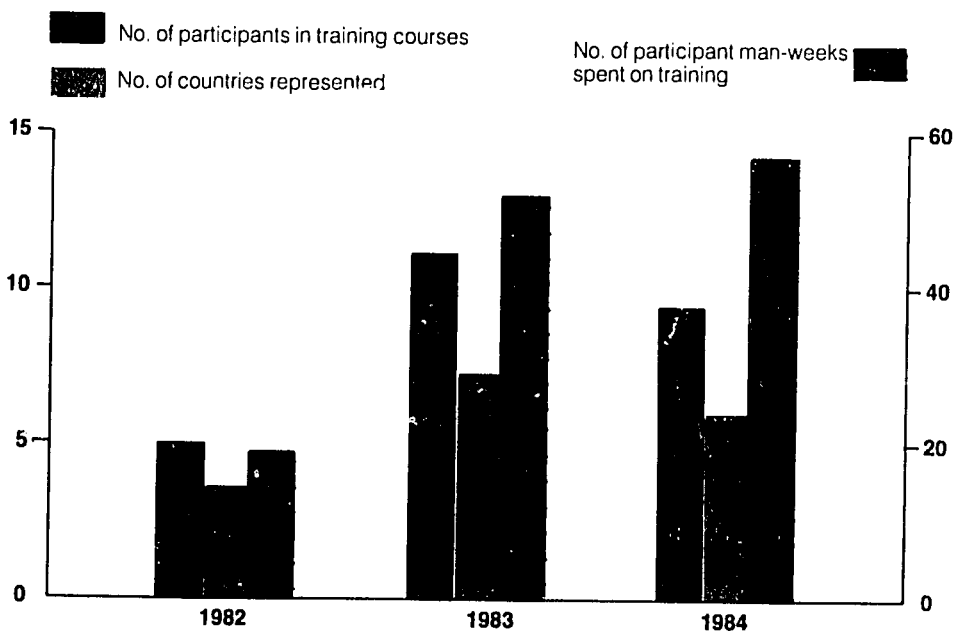
Genetic analysis of Gobra Zebu in Senegal

In contrast, the Senegal study represented a detailed genetic analysis of performance aspects of the Gobra Zebu breed, indicating the genetic progress possible through selection under the current management scheme. Possible approaches for increasing the rate of genetic improvement were explored.

Ankole cattle crossbreeding in Rwanda

In Rwanda, initial analyses of data from Songa Station are providing valuable information on the milk production of Ankole cattle under partial suckling. The data enable a comparison to be made of complete milking out of Jersey x Ankole and Sahiwal x Ankole, and of pure Jersey and pure Sahiwal breeds.

Figure 15. Summary of training for the Trypanotolerance Network, held at ILRAD and ILCA, 1982–84.



Drug treatment successful against trypanosomiasis

Detailed analysis of the performance of Boran cattle has shown that prophylactic drugs can be used successfully for profitable cattle production in an area of high tsetse challenge. Twenty thousand calving records collected over a 10-year period at Mkwaja Ranch in Tanzania – one of the biggest data sets ever recorded in Africa – were analysed by ILCA in collaboration with ILRAD and May and Baker Ltd. The results of the analysis, published as ILCA Research Report No. 9, offer renewed hope that tsetse-infested areas can be used to a greater degree than before through the controlled use of prophylactic drugs.

Trypanosomiasis at present precludes domestic livestock production in almost 50% of Africa. Since the 1950s, tsetse infestation has expanded to cover new areas in countries such as Nigeria, Cameroon and Zambia, thus increasing the grazing pressure in tsetse-free areas. It is increasingly important to make greater use of tsetse-infested areas in order to reduce this pressure on tsetse-free regions.

The development of livestock production in infested areas has been largely based on the introduction of trypanotolerant livestock. This recent ILCA study offers hope that breeds not considered trypanotolerant may be productive in spite of a high tsetse challenge under a well managed prophylactic regime.

Analysis of the Mkwaja data was successful only because of the excellent data recording carried out by employees of Amboni Ltd, the leaseholders of Mkwaja Ranch. The ranch has been used by Amboni Ltd since 1954 to supply beef to the labour force on the company's sisal estates.

The level of tsetse challenge at Mkwaja Ranch is such that cattle can survive there only with the use of trypanocidal drugs. A chemoprophylactic regime using isometamidium chloride (Samorin, May and Baker Ltd, England) was started in 1964. From 1973 all animals from weaning onwards were maintained under Samorin prophylaxis. Treatment with Samorin was supported by treatment of pre-weaning calves with diminazene aceturate (Berenil, Hoechst, West Germany).

Using an average of 4.6 Samorin and 0.7 Berenil treatments per animal per year, a high level of productivity was achieved. Pre-weaning viability was 92%, annual cow viability was 94%, average weaning weight at 8 months was 133.5 kg and herd productivity as weight of 8-month-old calf per 100 kg$^{0.73}$ of cow per year was 137.8 kg.

In spite of the extensive use of trypanocidal drugs, there was no evidence of drug resistance having developed. Only 1% of all calf deaths were due to trypanosomiasis, showing the regime to be highly effective.

The effectiveness of Samorin was highlighted by an experiment conducted at Mkwaja from 1975 to 1977. Ninety-five calves treated monthly with Berenil prior to weaning were split into three groups at 9 months of age. Over the next 30 months these groups were treated as follows:

Group 1: 37 calves were treated with Samorin (0.5 mg/kg) every 2 to 3 months;

Group 2: 40 calves were treated with Berenil (3.5 mg/kg) every 2 to 3 months;

Group 3: 18 calves were untreated.

After 30 months of tsetse challenge 33 of the 37 cattle treated with Samorin were alive and productive, 19 of the 40 animals treated with Berenil had survived, but all of the 18 untreated cattle had died

The importance of the Mkwaja results is emphasised when the performance of Mkwaja Boran cattle is compared with that of West African N'Dama cattle under medium to high risk of trypanosomiasis and with Boran cattle in Kenya under no trypanosomiasis risk. Non-trypanotolerant Boran cattle are shown to be 35% more productive under the Mkwaja regime than are the trypanotolerant N'Dama under medium to high trypanosomiasis risk in West and central Africa. Herd productivity at Mkwaja was approximately 80% that of Kenya Boran cattle reared on trypanosomiasis-free ranches in Kenya, under management conditions considered to be amongst the best in Africa.

The Livestock Policy Unit

Introduction

Both technical and financial constraints have hindered the progress of livestock development in sub-Saharan Africa. In addition, government policies affecting the livestock sector have sometimes been inappropriate. Nevertheless, while it is easy to identify particular policies which have caused harm, it is less easy to predict in advance which policies will do good. ILCA's Livestock Policy Unit was established in 1983 to do research on policy issues and to bring the results of this and other research to the attention of policy analysts and policy makers in organisations concerned with African livestock development.

In 1984 the Unit worked on four main research issues related to livestock development in sub-Saharan Africa:

- The financing of livestock services;
- The effects of imports of dairy commodities on domestic production, consumption and welfare;
- Dairy marketing systems; and
- Pricing policies.

In September, the Unit convened and organised a major conference of those who make or affect policies for livestock development.

The conference was funded by the Club du Sahel, the Ford Foundation, ILCA and USAID, and was attended by about 60 senior officials and academics. Major donor organisations were represented as well as both anglophone and francophone countries accounting for over 70% of sub-Saharan Africa's livestock population. The conference demonstrated the importance of appropriate policies, and enabled the key people involved in African livestock policy issues to share their experiences and to identify ways in which policy-oriented research can improve policy making.

Financing livestock services

Work continued on the analysis of factors that affect both the level of recurrent government expenditure on livestock services and their quality and viability. By the end of 1984, fairly complete data had been assembled on 16 countries (Table 11). While the share of net livestock output in the total agricultural GDP in these countries averages about 27%, the share of expenditure by government on livestock services in recurrent expenditure on all agricultural services is only 11%. This finding clearly reveals the tendency of governments to neglect their livestock sectors.

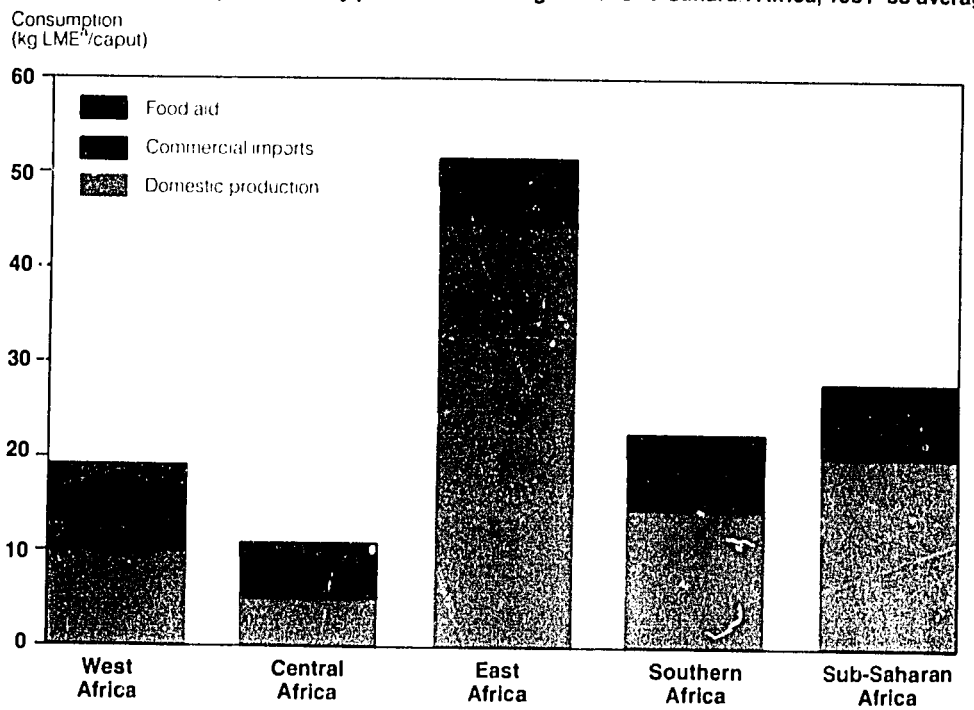
Among individual countries there is no correlation between the importance of the livestock sector in agricultural GDP and the share it receives of the government's agricultural budget. Nor do the richer countries allocate a bigger share of their agricultural budget to livestock in recognition of the higher share of livestock products in food consumption as wealth increases. However, in terms of absolute expenditure per head of livestock, richer countries do spend more on their livestock services, and in most of the countries reviewed expenditure per head of livestock during the 1970s did increase in constant US$ terms, although in about one third of these countries this increase was caused as much by a decline in the livestock population as by an increase in aggregate expenditure.

This apparent increase in governments' expenditures on livestock needs to be viewed alongside a possible decline in the quality of services provided. One indication of quality is the relationship between staff and non-staff costs in total expenditure. A rough rule-of-thumb is that when staff costs take up more than half the total budget, there are then inadequate funds left for the supply of vaccines, drugs, transport and other materials needed for the staff to be really effective. In over half of the countries reviewed, the proportion of the total budget spent on staff costs rose significantly in the 1970s. There is no evidence to show that a rise in the proportion of staff costs reflects better qualified staff and so a higher quality of service.

Imports of dairy products

About 1 in every 4 litres of milk (or its equivalent in other dairy products) currently consumed in sub-Saharan Africa has been imported (Figure 16). In West and central Africa the proportion is about one in two, and in some countries, such as Ivory Coast and Nigeria, it rises to two or even more in every three.

Figure 16. Consumption of dairy products in the regions of sub-Saharan Africa, 1981–83 average.



[a] LME = whole liquid milk equivalent

Table 11. Financing and staffing of livestock services in sub-Saharan Africa.

Country	Government recurrent expenditure on livestock services		Staffing ratios in animal health services			Livestock GDP as % of agricultural GDP in 1982[d]	1982 GNP per caput
	US$[a]/LU[b]	As % of all agricultural services	Staff costs as % of all costs	'000 LU per high-level staff[c]	No. of low- and medium-level staff per high-level staff[c]		(US$)
Benin	0.9	n.av.	81	41	8	12	310
Botswana	1.6	51	21	5[illegible]	10	n.av.	900
Burkina Faso	0.2	16	91	21[illegible]	15	29	210
Chad	0.3	4	81	141	13	37	80
Ethiopia	0.1	11	66	355	17	29	140
Gambia	n.av.	3	70	n.av.	n.av.	21	360
Ivory Coast	8.4	n.av.	74	18	9	3	950
Kenya	2.0	27	69	66	16	40	390
Malawi	3.7	23	34	40	26	6	210
Mauritania	3.1	9	63	289	15	95	470
Niger	n.av.	8	61	120	13	29	310
Senegal	1.4	n.av.	85	13	4	29	490
Sierra Leone	1.8	5	29	18	3	7	390
Togo	0.8	2	92	10	3	11	340
Zambia	3.4	4	45	81	3	37	640
Zimbabwe	n.av.	19	48	73	7	33	850

The most recent available data are shown for each country.

Most of the undated data in the above table are for the year 1978/79, but a few data are from 1974/75.

[a] In 1970 constant prices

[b] LU = livestock unit (250 kg liveweight)

[c] High-level staff are veterinary doctors and their equivalents.

[d] Assumes that the ratio between the value of inputs and the value of outputs in the livestock sector is the same in 1982 as in 1975.

Imports on such a scale clearly have a significant effect on aggregate consumption and consumer welfare, and probably have some effect on domestic production. Such production effects may be negative – where cheap imports depress domestic price levels making domestic production uneconomic. But they may also be positive – where the supplementation of domestic liquid milk supply by milk reconstituted from imported skim milk powder and butter oil allows economies of scale in processing and marketing which permit better prices and facilities for domestic producers; or where profits made by government on food aid are reinvested in domestic dairy production.

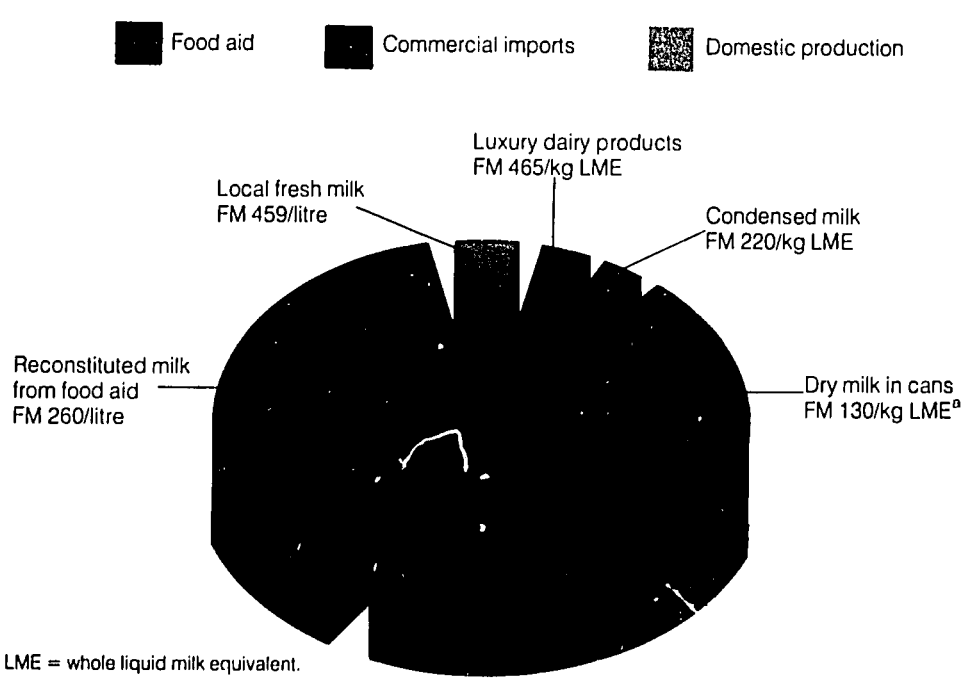
During 1984 a study was carried out on dairy imports into sub-Saharan Africa. The results indicate that the scale of imports into individual countries cannot be adequately explained by exogenous factors such as growth in human population, per caput incomes or domestic dairy production (to the extent that this is exogenous). Other factors, of which those affected by trade policy are likely to be crucial, have played an important role.

In addition to this study on sub-Saharan Africa, two case studies on dairy imports into individual countries were carried out in 1984. A study on Nigeria was done by a Nigerian academic working in collaboration with the Unit. The other, by Unit staff, was on Mali. Some results from the latter are already available.

Dairy imports – one third of them food aid – contribute about 20% to total milk consumption in Mali. An estimated 65% of these imports are consumed in Bamako, Mali's capital. Imports account for 90 to 95% of the supply of milk and dairy products to Bamako (Figure 17). The government aims to provide consumers in Bamako with dairy products at 'reasonable prices', and at the same time to stimulate local milk production by spending the revenues from sales of dairy food aid on dairy development.

However, the strategy appears not to be effective: consumer welfare, in comparison to a situation without government interference, has not increased, and the measures to stimulate milk production have not had significant effects. Retail prices for dairy products in Bamako are distorted by government policy, which favours the consumption of dry milk (Figure 17). As a result, dry milk is the most prominent of all dairy imports. The results of this research have been discussed with the authorities in Mali.

Figure 17. Proportion of total consumption and retail prices of dairy products in Bamako, Mali, 1983.



[a] LME = whole liquid milk equivalent.

Pricing policies

In 1984 a study was carried out on government pricing policy towards the beef sector in Zimbabwe. It found that, in the period 1965–82, the government's consumer subsidy was of more benefit to producers than to consumers. The price elasticity of demand among consumers was in the range −0.35 to −0.72, and short-run price elasticities of supply were in the range −0.6 to −1.4 in the case of commercial beef producers, and around −0.34 in the case of producers in Zimbabwe's communal areas. Since the Government of Zimbabwe does not insulate the domestic from the international market, these results imply that periods of high international prices, unless prolonged, are likely to lead to lower volumes of beef exports from Zimbabwe.

Dairy marketing systems

A brief survey was carried out of the literature on dairy marketing systems in sub-Saharan Africa. This revealed a substantial record of government interventions in dairy marketing, but extremely little analysis of their consequences. A case study of dairy marketing in and around Addis Ababa was started. Analysis of the results of the study's pilot phase revealed very low average levels of milk consumption, and that only a small proportion (10 to 15%) of those households with less than average incomes buy milk as often as once a week. The majority of liquid milk purchases appear to take the form of direct transactions between consumers and producers whose herds are kept within the confines of Addis Ababa.

The Systems Research Unit

In mid-1984 the Systems Research Unit was established at headquarters with the appointment of a senior staff member. The Unit's functions and activities are:

- To provide a support and advisory service to ILCA's field programmes and to ILCA management in the social sciences and especially in microeconomics; and
- To develop analytical techniques, especially systems modelling, and to analyse field data not analysed by other ILCA units.

In the second half of 1984 the Unit concentrated on providing a support service to ILCA's Arid and Semi-arid, Subhumid and Humid Zones Programmes in West Africa. In addition, an analysis was made of the allocation by ILCA of its overall research resources.

Bird resistance versus digestibility in sorghum

Many of ILCA's research projects are intended to benefit both food crop and livestock production. One such project is reported here.

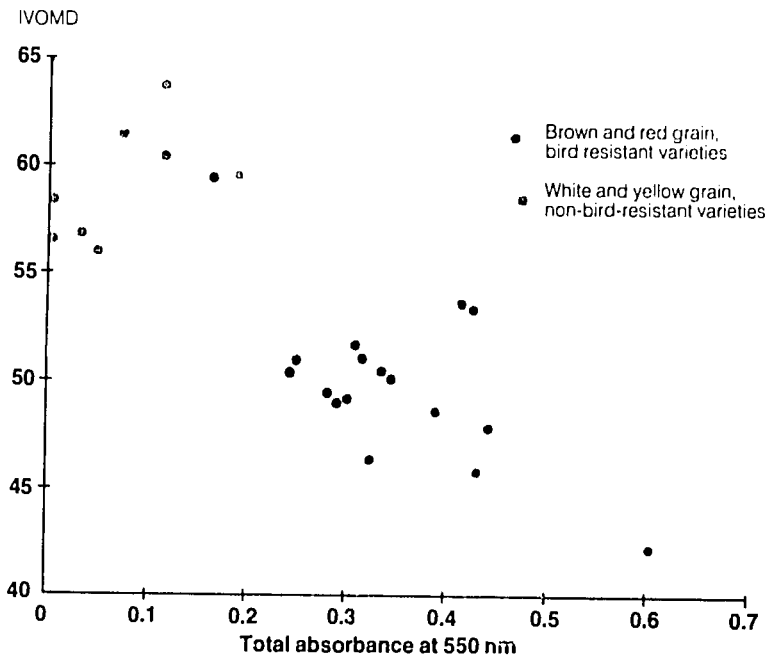
Bird damage limits grain production from sorghum in the semi-arid zones of Africa. However, the presence of proanthocyanidins (condensed tannins) in sorghum grain affords resistance to bird damage. Proanthocyanidins are also responsible for variations in grain colour.

A system to quantify proanthocyanidins and red pigments in sorghum leaves was developed by ILCA's Nutrition Unit. Aqueous ethanol (7:3, v:v, ethanol:water) was used to extract soluble compounds. Absorbance of the resulting solution was measured at 550 nm, the approximate wavelength of peak absorbance for red pigments. The residue after extraction still contained insoluble proanthocyanidins. Their content was measured by heating the residue in n-butanol containing 5% HCl. The absorbance of the resulting red solution was also measured at 550 nm. The sum of the two absorbance measurements was used as an index for the content of proanthocyanidins.

Soluble and insoluble proanthocyanidins and in vitro organic matter digestibility (IVOMD) were measured in the leaves (blade plus sheath) of 24 sorghum varieties. The varieties were divided into two groups by grain pigmentation: Group 1 had red or brown grain (bird-resistant varieties, n = 17); and Group 2 had white or yellow grain (non-bird-resistant varieties, n = 7). Group 2 had a lower proanthocyanidin index for leaves than Group 1 (mean difference was 0.296, $P < 0.001$). Group 2 also averaged 9 units higher in IVOMD of leaves (59.3% for Group 2 and 50.0% for Group 1, $P < 0.001$). The figure below shows that there was a significant negative correlation between the index for proanthocyanidins and IVOMD ($r = -0.82$, $P < 0.001$).

These results indicate that selection for bird resistance by increasing the proanthocyanidin content of grain would decrease the nutritive value of stover. However, some varieties may have enough proanthocyanidins in the grain to prevent bird damage while the content in the leaves may be low, having little effect on digestibility. The figure shows one bird-resistant variety whose leaves had a high IVOMD and a low proanthocyanidin index. Such varieties could improve both sorghum grain yields and the quality of livestock feed.

Relationship between *in vitro* organic matter digestibility (IVOMD) and the proanthocyanidin index (total absorbance) in leaves of 24 sorghum varieties, ILCA headquarters, 1984.



[a] A bird-resistant variety with high IVOMD

The Nutrition Unit

Introduction

The Nutrition Unit is based at ILCA's headquarters and runs laboratory facilities for both animal and plant experimentation and analysis. The Unit provides service facilities for the analysis of samples from ILCA's field programmes. However, in 1984 increased emphasis was given to original research on the problems of animal nutrition and improved feed resources for livestock in sub-Saharan Africa.

Nutrition of draught animals

Debre Zeit trials

The nutritional requirements of work animals are poorly understood. In on-farm work conducted in 1983, no differences in work output could be detected between draught oxen fed 100% or 50% of their calculated requirements (*ILCA Annual Report 1983*). Further trials under rigorously controlled conditions have been started at ILCA's Debre Zeit station. An experiment in which oxen are subjected to different workloads is being used to study the effect of work output on feed intake and digestibility in highland Zebu and crossbred Holstein oxen. Eight animals of each breed group are subjected to different workloads equivalent to 1.0 or 1.1 Newtons per kg bodyweight by adjusting weights placed on metal sleds which are pulled for a total of 5 hours each day. Periods when work is performed are compared with recovery periods. Rations are based on *ad libitum* teff straw with limited quantities of hay supplemented with urea. Measurements are made of intake of feed and water, digestibility and rate of passage of digesta through the intestinal tract. Results indicate differences in both intake and digestibility between breed groups (Table 12).

Donkeys versus oxen

Sub-Saharan Africa contains more than 7 million donkeys. The species is particularly important for transport of farm produce and other goods. However, little is known about the quantity of feed consumed by donkeys, or its efficiency of use. The digestion of poor quality hay by donkeys was compared with its digestion by oxen. The digestibility of all components measured was less in donkeys than in oxen. Thus fermentation in the caecum of donkeys may be less efficient than that in the rumen of oxen.

Fattening culled work oxen

The sale of fattened and culled work oxen can be an important source of income for farmers in the Ethiopian highlands. Culled oxen were fed on poor quality grass hay alone or poor quality hay plus *Trifolium tembense* hay at the rate of 27 g per kg $BW^{0.75}$ for a period of 63 days. Oxen fed hay alone gained 163 g/day, while those supplemented with legume hay gained 362 g/day. Over a second period of 70 days, culled oxen were allocated to four groups. Poor quality grass hay was fed *ad libitum* while supplements were given to three of the groups as follows: *Trifolium* hay as before; *nueg* meal calculated to provide the same amount of protein as the *Trifolium* hay; and an equivalent amount of protein from both *nueg* meal and *Trifolium*. The fourth group received no supplement. Each animal was also given 1 kg of molasses per day. Daily gains were 114 g with *Trifolium* supplement, 314 g with *nueg* supplement,

Table 12. Digestibility and intake of hay and straw when fed alone to oxen of different breeds, Debre Zeit, Ethiopia, 1984.

Breed	Digestibility of DM (%)		Daily intake (% LW)	
	Hay	Straw	Hay	Straw
Friesian x highland Zebu	47.0a	46.1a	1.67a	1.69a
Highland Zebu	51.0b	52.5b	1.48b	1.45b

Values in a column pair with different letters differ significantly ($P<0.05$)

357 g with *Trifolium* and *nueg* supplement and −214 g with no supplement. Culled oxen can therefore be fattened successfully with by-products commonly available in Ethiopia.

Supplementation of cereal crop residues with legumes

Supplementation of cereal crop residues with legume hay improves both digestibility and intake compared with crop residues fed alone (*ILCA Annual Report 1983*).

However, crop residue/legume hay mixtures can be marginally deficient in both P and S. A trial was conducted using male castrate sheep to investigate the effects of P and S supplementation of teff straw fed alone or with *Trifolium tembense* hay (30 g/kg $LW^{0.75}$). Digestibility of cell wall components was significantly improved by the addition of P. The addition of either P or S improved N utilisation when straw was fed with *Trifolium*. In a second experiment, the straw was sprayed with a solution of 4% urea, and supplements of P, S and *Trifolium* hay were given. The complete treatment (i.e. teff straw + urea + *Trifolium* + P + S) was markedly superior to other treatments in DM intake and digestibility of DM, organic matter, acid detergent fibre and cellulose.

A further trial was conducted to determine the effects of feeding *Trifolium* and molasses/urea as supplements to wheat straw. Male castrate sheep were fed wheat straw alone, wheat straw + *Trifolium*, wheat straw + molasses/urea mixture, and wheat straw + *Trifolium* + molasses/urea. Total intake of DM was significantly increased by the addition of *Trifolium*, but intake of wheat straw was decreased. The addition of molasses/urea significantly increased total DM consumption without a corresponding decrease in wheat straw intake. The addition of both *Trifolium* and molasses/urea gave the highest total DM intake and digestibility. All supplements significantly increased digestibility. The intake of digestible nutrients was increased by more than 200% when both *Trifolium* and molasses/urea were added.

Laboratory studies of nutritive value of feeds

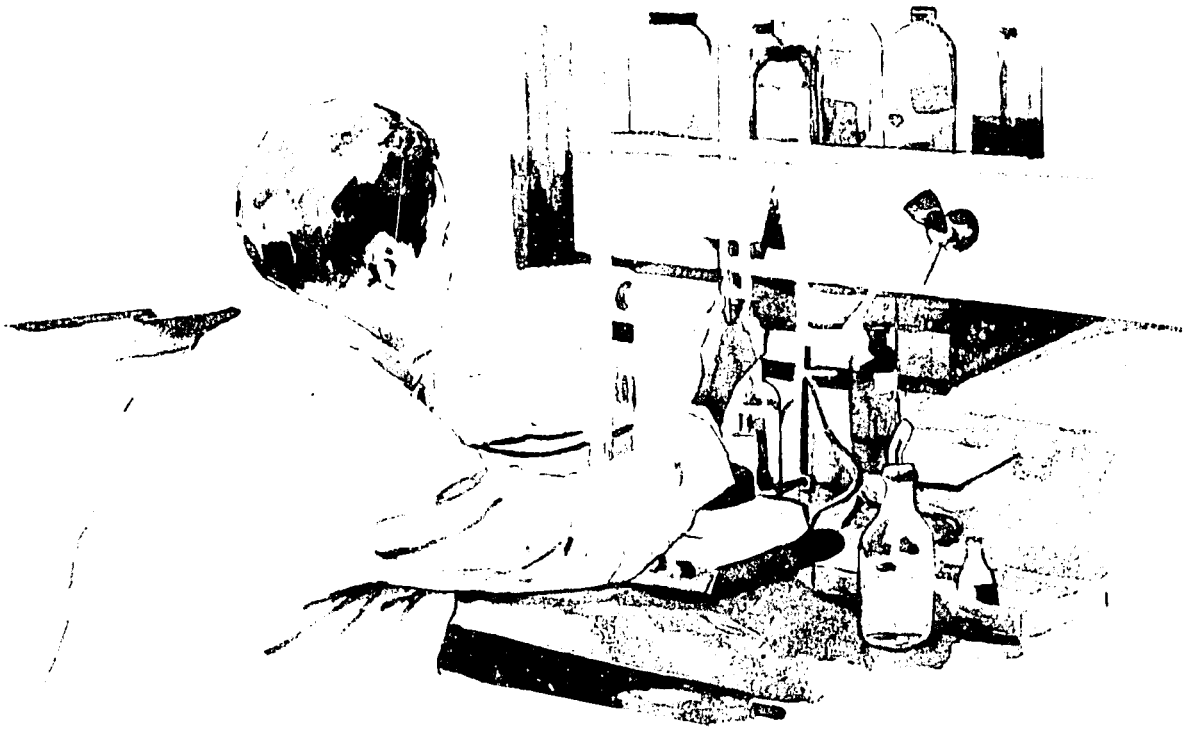
Fibre digestibility estimated by cellulase

Incubation of forages with commercially available cellulases to estimate digestibility has been proposed as an alternative to *in vitro* rumen liquor techniques. Two methods for determining fibre digestibility in tropical forages were compared:

Method 1: Pretreatment with pepsin-HCl for 48 hours followed by incubation with cellulase for 48 hours (this method being widely used to estimate digestibility); and

Method 2: Incubation of the neutral detergent fibre fraction of the forage with cellulase for 48 hours.

Fibre digestibilities by these methods were then compared to *in vitro* fibre digestibility by rumen micro-organisms. Two sets of samples were used: 27 straw samples from farmers' stacks used to feed draught oxen; and the leaves of 10 plant species browsed by camels.



In the straw samples, the mean *in vitro* fibre digestibility was 36.9 units greater than the estimate from Method 1 and 22.3 units greater than that from Method 2. Cellulase methods are thus less effective than rumen micro-organisms in digesting fibre from cereal crop residues.

In the browse samples, the mean *in vitro* fibre digestibility was 46.6 units higher than for Method 1, but was not significantly different (P = 0.48) from Method 2. In 7 of the 10 browse species, Method 1 gave a negative fibre digestibility because the residues after incubation with both enzymes were greater than the total fibre. These browse species contain tannins which inhibit and precipitate the enzymes. Pretreatment with neutral detergent removed the soluble tannins, so that in Method 2 inhibition and precipitation did not occur.

Microfibre apparatus

The amount of total fibre in forages, crop residues and byproducts is important in determining nutritive value. In cereal crop residues fibre is the most important substrate for rumen micro-organisms and is therefore the major source of energy for ruminants. Estimation of fibre by the crude fibre method is not recommended in most developed countries because it underestimates total fibre. Lignin and hemicellulose are not recovered in the crude fibre method, but are important components in the cell wall of forages. In cereal crop residues these two fractions account for over 50% of the total fibre.

However, research groups in developing countries have been slow to adopt newer methods of forage fibre analysis such as the detergent system, partly due to high costs of reagents and apparatus. The Unit has developed a microfibre apparatus that costs a fraction of the amount of conventional apparatus and which uses one tenth of the amount of reagent. Results indicate that the micro method is as accurate as conventional methods (Table 13).

Table 13. Comparison of ILCA's microfibre apparatus and a conventional method in determination of neutral detergent fibre, ILCA headquarters, 1984.

Crop/component	Neutral detergent fibre as % of DM	
	ILCA microfibre method	Conventional method
Maize stover	66.9	64.6
Teff straw	70.1	70.7
Wheat straw	68.9	68.0
Sorghum leaves	51.1	52.6
Sorghum stems	58.8	60.4
Trifolium tembense leaves	27.2	27.9
Trifolium tembense stems	43.0	42.5

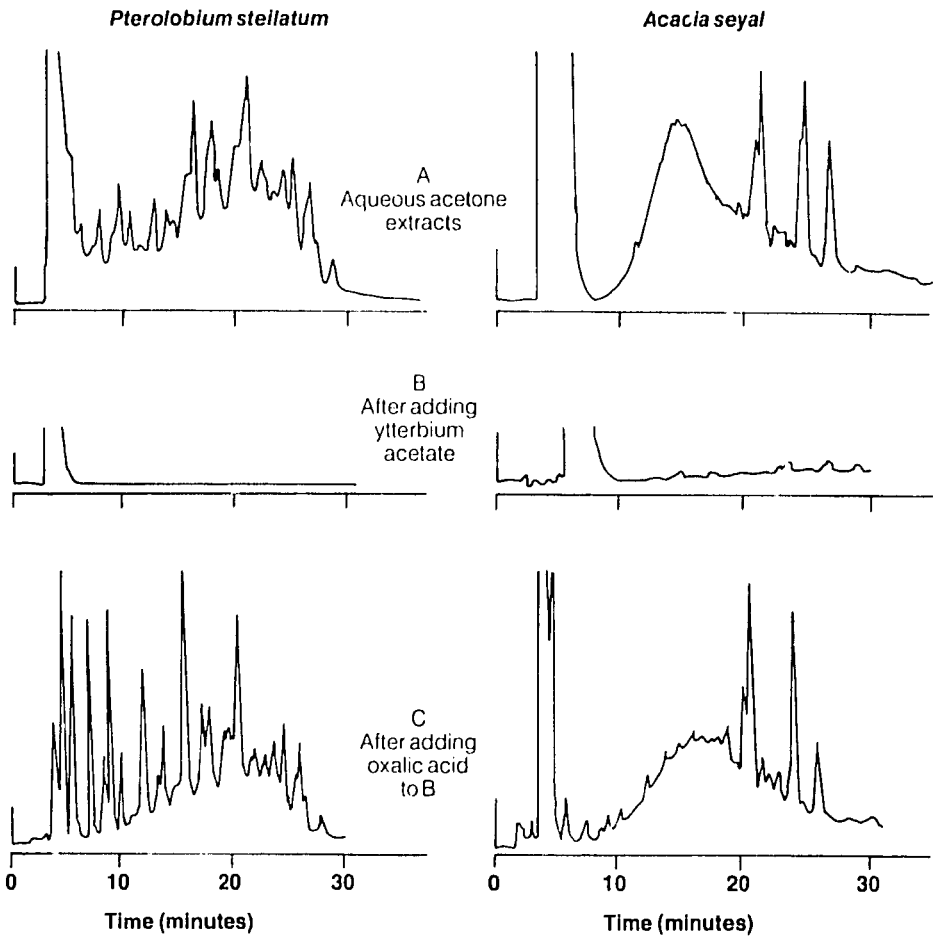
High performance liquid chromatography

Phenolic compounds such as tannins lower the nutritive value of browse, forage legumes, crop residues and agro-industrial byproducts. In collaboration with the Grassland Research Institute (UK), high performance liquid chromatography (HPLC) methods were developed to determine and study phenolic compounds in tropical forages. An HPLC method was also used to determine the effectiveness of quantifying and isolating phenolic compounds by precipitation with ytterbium acetate (see *ILCA Annual Report 1983*). Chromatographs show that almost all phenolic compounds are precipitated by Yb (Figure 18). Solutions of isolated phenolic compounds can be prepared by adding an oxalic acid solution to the precipitate. Chromatographs of solutions from browse plants containing hydrolysable tannins (e.g. *Pterolobium stellatum*) indicated that the recovery of isolated phenolic compounds was higher than for browse plants containing condensed tannins (e.g. *Acacia seyal*).

Nutritive value of *nueg* meal

Nueg meal can be fed to milking cows as the sole supplement when other ingredients are difficult to obtain. A trial was conducted to determine the effects of high levels of *nueg* meal on milk production or butterfat composition. Cows were fed over 3 kg of *nueg* meal per head per day for a period of more than 150 days without affecting milk production. Work carried out by the National Institute of Dairying in the UK showed that there were marked differences between the composition of butterfat in butter made from *nueg*-fed cows and that in butter made from cows fed conventional concentrates. Both oleic acid and linoleic acid were higher in *nueg*-fed cows (35% and 2.8% respectively) than in cows

Figure 18. High performance liquid chromatograms of extracts from *Pterolobium stellatum* and *Acacia seyal*, ILCA headquarters, 1984.



fed conventional concentrates (21% and 1.9% respectively). *Nueg* oil contains large amounts of linoleic acid (73%), which is reduced to oleic acid in the rumen.

Nutrition of animals exposed to trypanosomiasis

In collaboration with ILRAD and ILCA's Livestock Productivity and Trypanotolerance Group, the nutritional status of livestock which are trypanotolerant or exposed to trypanosomiasis stress is being studied. A field team and laboratory have been established at Muhaka in southern Kenya in cooperation with the Kenya Veterinary Department. A major objective is to identify nutritional constraints to productivity and to study their influence on trypanosomiasis. One year's data on animal behaviour, condition scoring and vegetation as well as the chemical analyses of forage, blood, faeces and water are now available. Results indicate significant differences between herds in the time spent grazing from month to month, and a wide variation in the preferred grasses eaten. Differences in grazing time are related to the amount of forage available, but the results also reflect differences between herds in trypanosomiasis and tsetse challenge.

Appropriate feed supplementation and the genetic improvement of livestock

Most crop residues and dry season grazing resources in tropical areas are low in digestibility and in N content. They also constitute the major source of feed for ruminant livestock in Africa.

When these resources are the sole feed available they are barely sufficient for maintenance, and weight loss under these conditions is normal. But if these materials are supplemented with an N source such as green forage or urea, microbial activity and fibre digestion in the rumen are enhanced and feed utilisation is increased. Further supplementation with a forage legume or an oilseed cake rich in protein frequently increases the voluntary intake of the basic feed and improves the protein to energy ratio in the absorbed products of digestion, thus supporting higher levels of animal productivity.

In the case of milk production, the classical approach to coping with poor-quality basic feed is to supplement it with 'balanced' concentrates based on a cereal-rich mixture supplemented with a protein source. About 2 kg/day of this mixture is usually provided to assist in meeting maintenance needs, and a further 0.5 kg is added for each litre of milk produced. Such mixtures are usually expensive, in short supply, and deplete local cereal reserves that might be used more efficiently in other ways.

An alternative approach is to use feed supplements that maximise microbial activity in the rumen and enhance the utilisation of poor-quality but widely available roughage feeds. Leguminous forage and oilseed cakes, possibly supplemented by non-protein N in the form of urea, offer considerable opportunities for reducing feed costs, increasing animal performance and making available cereal-rich concentrates, such as wheat bran, for pig and poultry feeding. The alkali treatment of roughage using ammoniation in closed stacks, or the mixing of residues with strong alkali, are also technically feasible but usually impractical under African smallholder conditions.

ILCA studies in the major ecological zones of Africa clearly indicate major differences among breeds in their resistance to nutritional stress, and in their relative performance in the absence of nutritional stress. As Vercoe and Frisch (1982) noted, there is a negative genetic relationship between these two traits. Where nutritional stress can be mitigated by improving microbial activity in ruminant livestock using strategic supplements, breed improvement as well as better performance is possible. In brief, improvement in the genetic potential of livestock can only proceed at the pace determined by the improvements achieved in increasing the energy utilisation of the roughages that make up the diets of Africa's ruminants.

Source

Vercoe J E and Frisch J E. 1982. Animal breeding for improved productivity. In: *Nutritional limits to animal production from pastures*. CAB.

The Forage Legume Agronomy Group

Introduction

The Forage Legume Agronomy Group aims to investigate, evaluate and promote the introduction of more productive plants, particularly legumes, into African livestock production systems.

To date the Group has identified, acquired and screened suitable legume lines at a range of sites. This work provides seeds and technical advice for ILCA's field programmes, and national research and development organisations throughout sub-Saharan Africa. The Group is now also concerned with legume establishment and ecology, productivity in pastures and cropping systems, N fixation, soil fertility and improvements in food crop yields.

The Group plays a key role in training and communication among forage research workers in Africa through the publication of germplasm and forage information newsletters and the coordination of a network on forage systems.

Germplasm collection

An important aspect of the Group's work is the acquisition, collection, maintenance and multiplication of forage germplasm. These activities are intended to make forage germplasm of high potential freely available to research and development workers in sub-Saharan Africa. ILCA has been designated by IBPGR as the centre to hold base collections of certain African forage species of high economic value. These include members of the genera *Neonotonia*, African *Trifolium*, *Cenchrus*, *Digitaria* and *Chloris*.

Over 1300 lines of leguminous germplasm were acquired in 1984 from organisations such as the International Center for Tropical Agriculture (CIAT), the University of Florida, the Commonwealth Scientific and Industrial Research Organization (CSIRO) and the United States Department of Agriculture (USDA).

Eleven collection trips were made in Ethiopia in 1984. Four of these were made to collect native legume species used as browse by local farmers. *Erythrina* species were found to be the most widely planted, particularly *Erythrina brucei*. Twenty-six species and 98 lines of browse germplasm were collected. Five of the collection trips were done in collaboration with CIAT whose staff were collecting *Brachiaria* and *Andropogon* germplasm. These trips yielded 375 lines of 30 grass and legume species. *Rhizobium* strains associated with highland *Trifolium* species were also collected. Nodules have been sent to a number of laboratories for isolation of effective *Rhizobium* strains for promising *Trifolium* lines.

Another ILCA–CIAT collection trip was undertaken in the eastern and southern areas of Kenya. This yielded 42 species and 173 lines of grasses, and 40 species and 255 lines of legumes. ILCA staff also participated in a 2-month collection trip made by the International Board for Plant Genetic Resources (IBPGR) in Niger. This trip was intended to save forage germplasm threatened with genetic erosion; 108 forage lines were collected. Most of the Group's collection activities have been supported financially by IBPGR.

A germplasm catalogue listing details of all lines held by ILCA was prepared during 1984.

Multiplication of germplasm for storage and distribution to national programmes increased during the year. A 2-ha irrigated area at ILCA headquarters is now being intensively used for seed multiplication.

Field activities

The Group's field activities are undertaken at ILCA's headquarters at Shola, Addis Ababa, under highland, subhumid conditions, and at medium altitudes in the Rift Valley at Abernosa Ranch, a semi-arid site on alkaline soils, and at Soddo, a subhumid site on acid soils.

The highland site is used for the agronomic description and initial yield assessment of temperate forage species, mainly highland African *Trifolium* lines. The two medium altitude sites have relevance not only for areas of Ethiopia but also for other areas of Africa. They are being used as demonstration and training sites as well as for the identification of promising forage lines for comparable environments. During 1984, particular emphasis was placed on the screening of species with browse potential.

Trial results

Twenty-seven lines of annual *Trifolium* species (native to the African highlands) were planted in a replicated yield trial receiving 10 kg P/ha on a Vertisol at Shola (2400 m altitude, 900 mm rainfall). The results showed that lines of *T. steudneri* and *T. quartinianum* generally gave the highest seed yields, while those of *T. decorum* required more than 130 days to achieve 50% flowering (Table 14). Some lines of *T. rueppellianum*, *T. decorum* and *T. quartinianum* produced more than 8 t DM/ha. The highest yielding line was ILCA 6301 (*T. quartinianum*), which produced 10 t/ha of DM and 0.9 t/ha of seed at maturity.

The failure of the small rains in 1984 limited growth in trials at Addis Ababa and at Abernosa Ranch. At Abernosa the 7-month dry season which preceded the 1984 rains caused the death of most of the perennial *Stylosanthes* lines being tested. Lines of *Neonotonia*, *Lablab* and *Zornia* were among the most vigorous survivors. *S. hamata* cv. Verano was particularly vigorous in regrowing from seed, but some of the regrowth plants did not produce seed before again drying off. Two new trials, the oversowing of native pasture with forage legumes and a browse screening trial, were both severely affected by the short growing season.

Despite the below normal rainfall at Soddo (900 instead of 1300 mm) there was excellent growth of adapted legumes, particularly *Stylosanthes* species. *S. guianensis* cv. Cook is the most vigorous legume identified to date, producing 3 t DM/ha under 10 kg P/ha in the first growing season. It has survived well in farmers' fields for 2 years when interplanted with maize and cut for animal feed. No serious anthracnose infection has been observed. *Desmodium intortum* cv. Greenleaf has also shown itself to be well adapted, growing under coffee and *ensete* (false banana), and has survived cutting for animal feed.

In agronomic evaluations during irrigated seed production at Zwai, the Group has identified three vigorous lines of *S. guianensis* and one of *S. hamata* which are apparently resistant to local strains of anthracnose.

Table 14. Agronomic characteristics of selected lines of highland *Trifolium* species, ILCA headquarters, 1984.

Species	No. of lines	Days to 50% flowering	Yield (t/ha)	
			DM	Seed
T. decorum	5	>130	5.1–8.7	0.03–0.3
T. quartinianum	5	90–109	2.6–10.0	0.8–1.6
T. rueppellianum	5	79–95	5.7–8.2	0.2–0.6
T. simense	1	113	2.8	0.02
T. steudneri	6	73–104	5.1–7.2	0.4–1.5
T. tembense	4	93–129	5.1–7.4	0.1–0.8
Other *Trifolium* sp.	1	130	7.0	0.2

Cooperative activities

The Group has provided experimental quantities of seeds to cooperators in 15 African and 13 other countries. In order to publicise its germplasm holdings and to improve communications, the Group publishes a Germplasm Newsletter in collaboration with the Plant Genetic Resources Centre (PGRC) in Ethiopia. The Newsletter is distributed to over 2000 scientists both in Africa and elsewhere.

Network activities are an important part of the Group's work. The Forage Network in Ethiopia has regular meetings and field trips, and publishes a Newsletter which is distributed to about 200 scientists. Multi-location trials within Ethiopia are an important aspect of the network's activities and includes strip trials and replicated yield trials.

The Small Ruminant and Camel Group

Introduction

The Small Ruminant and Camel Group assists ILCA's field programmes with the design and execution of field surveys and experiments, and also helps with data analysis. In addition it provides advisory and analytical services to national and regional research organisations.

During 1984, the Group worked closely with the Computer Unit in data analysis and with the Livestock Policy Unit in the design of a research programme in Somalia and of farming systems research in Zimbabwe.

Collaborative research

Analysis of data on small ruminants from ILCA's field programmes showed that high levels of pre-weaning mortality are probably the major constraint to increased productivity (Table 15). Poor growth rates are also

Table 15. Pre-weaning mortality (%) of kids for different variables at five African sites, 1978–83.

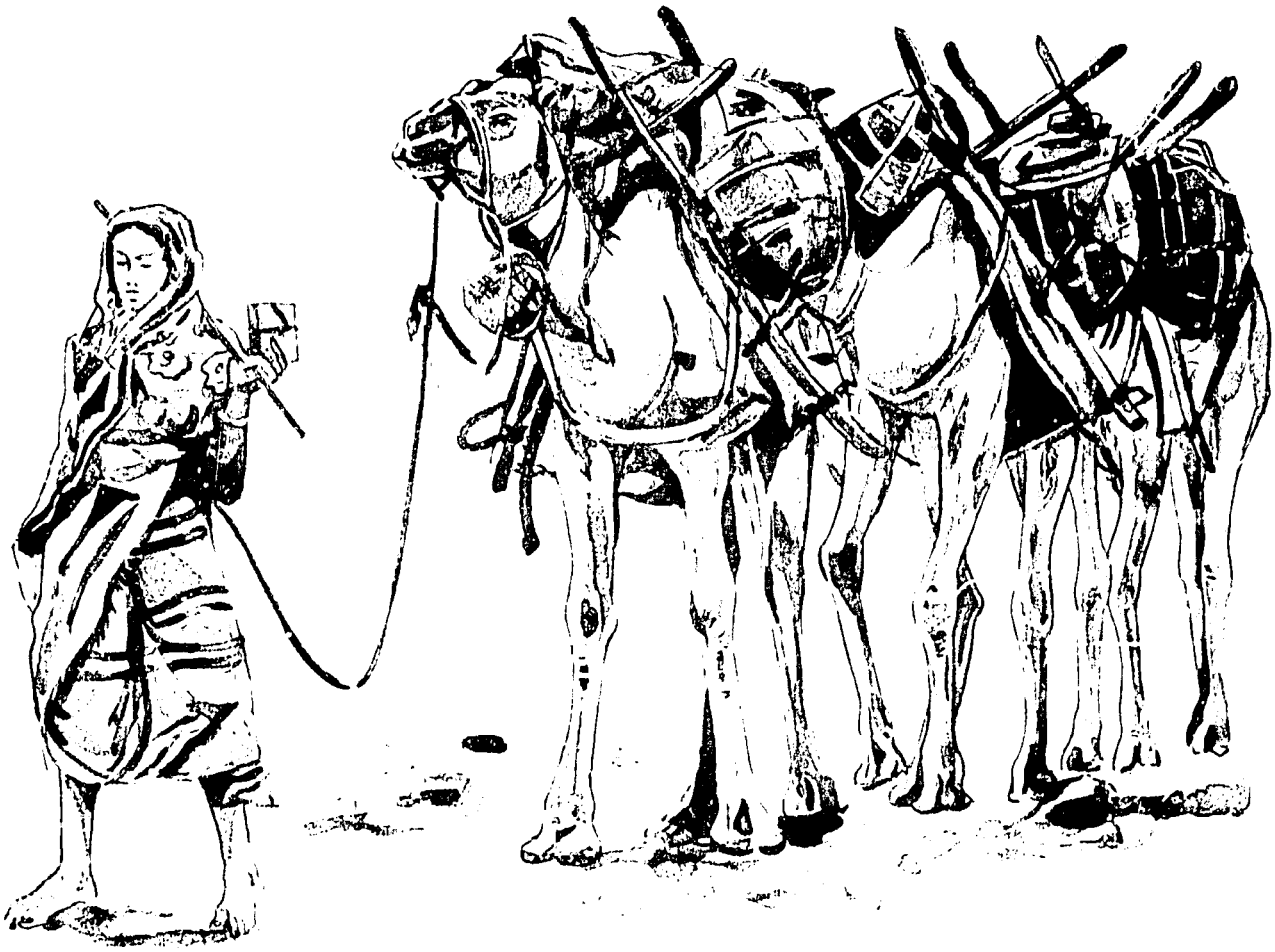
Variable	Sudan	Mali	Kenya 1[a]	Kenya 2	Nigeria
LS means	24.8	35.0	22.3	31.3	23.0
System A[b]	24.1	38.6a	–	25.1	25.0
B	25.5	31.3b	–	35.1	22.0
Sex: male	27.7	37.0a	21.7	33.2	23.0
female	21.9	32.9b	23.0	29.4	24.0
Birth type: single	22.1	33.3	18.8a	22.6a	20.0
twin	26.0	36.6	25.8b	40.0b	22.0
triplet	26.3		–	–	28.0
Birth season: A[c]	21.3a	39.5a	23.8a	25.9	–
B	34.0	36.9ab	14.6	–	–
C	16.9c	32.5bc	31.4c	31.4	–
D	27.0a	30.9c	19.3a	36.6	–
Parity: 1	43.7a	47.9a	23.6	–	23.0
2	21.6b	38.8b	20.0	–	–
3	12.3c	31.4bc	13.0	–	–
4–9	19.1b	26.1c	20.2	–	20.0
Flock: best	16.7a	21.5a	12.4a	–	–
worst	41.0b	54.8b	40.0b	–	–

[a] Kenya 1 = Elangata Wuas Group Ranch, 1978–81. Kenya 2 = three Kaputei Section group ranches, 1981–1983.

[b] Sudan A = sedentary, B = migratory, Mali A = rainfed millet, B = irrigated rice, Kenya 2A = small flocks, B = large flocks; Nigeria A = forest, B = savanna

[c] Sudan, Mali A = cold dry, B = hot dry, C = rains, D = post rains, Kenya A = short dry, B = long rains, C = long dry, D = short rains.

For each variable, means in same column with different letters differ significantly.



limiting, indicating nutritional stress associated with a disease burden. Reproductive performance appears to be satisfactory. The Group is collaborating with ILCA's field programmes to identify the causes of mortality and to overcome disease problems

In Burkina Faso, research on the productivity of sheep and goats in the Sahel area in the north of the country is funded jointly by ILCA and GTZ. Initial results suggest that high mortality is again the major constraint to productivity.

The Group has assisted national research organisations in both Rwanda and Sudan with the preparation of long-term data for analysis, and is currently analysing data from Rwanda on sheep and goats. Assistance has also been given to the Institut de Recherches Agronomiques et Zootechniques de la Communauté Economique des Pays des Grands Lacs and to the Research and Specialist Services Department of the Zimbabwe Ministry of Agriculture in the formulation of research programmes.

In Kenya, the Group has collaborated with commercial ranches that include camels. A preliminary analysis of data has shown that breeding is not seasonal in this area close to the equator. However, it is probable that this is due to the highly nutritious feed available throughout the year on commercial ranches where browse has not previously been used.

The first issue of the Group's Newsletter was distributed during October 1984 to scientists working on small ruminant and camel problems in 30 African countries. Copies were also sent to a number of other countries where these species are of economic and social importance.

The Range Science Unit

Introduction

The Range Science Unit was established at ILCA headquarters during 1984. At present the Unit consists of two senior staff members qualified in animal production and plant production.

The aims of the Unit are:

- To conduct literature reviews and to give guidelines for ILCA's rangeland research;
- To develop data collection techniques to facilitate ground truthing for satellite imagery and aerial surveys; and
- To test and develop mathematical simulation models to analyse large sets of data from rangeland areas.

Initial results

Literature surveys in 1984 included a comparison of traditional livestock systems and ranching in Botswana. In terms of total output from each system, the study showed that ranching is more productive on a per animal basis, while traditional systems are more productive on a per hectare basis, despite high rates of animal mortality in the traditional systems (Table 16).

Table 16. Cattle productivity in traditional and ranching systems in Botswana.

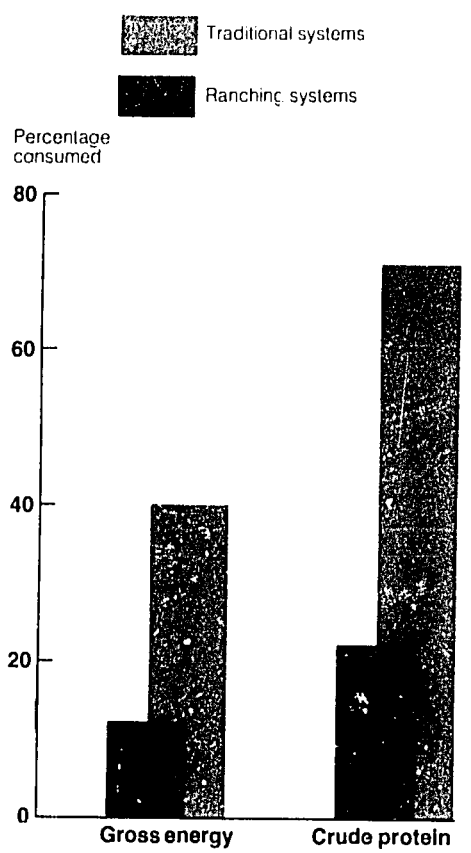
Component	Productivity[a] (kg/ha/year)	
	Traditional systems	Ranching
Heifers	2.55	1.44
Bullocks	3.31	2.32
Young bulls	0.52	0.15
Total	+6.38	+3.90
Effect of mortality	-5.65	-0.83
Net total	0.73	3.07
Calves	6.53	5.01
Milk offtake	2.22	–
Draught power	0.65	–
Productivity per ha (kg/year)	10.13	8.08
Stocking rate (LU/ha)	0.17	0.08
Production per LU[b] (kg/year)	60.65	101.00

[a] Productivity figures are liveweight equivalents.

[b] LU = livestock unit (250 kg)

Food chain efficiency, defined as the consumption of plant gross energy (GE) and crude protein (CP) by cattle divided by the production of GE and CP by the pasture, appears to be higher in traditional than in ranching systems (Figure 19). The differences between the two systems, expressed as

Figure 19. Percentage of available plant energy and crude protein consumed by cattle, traditional and ranching systems, Botswana.



production per animal and per hectare, are fully explained by higher stocking rates in traditional systems. Thus in traditional systems there may be a higher risk of pasture degradation and a greater frequency of food shortages in dry years.

However, lower stocking rates and changes in product allocation in these systems would probably lead to lower productivity per hectare. Nationally, this would result in lower total food production and higher unemployment. Thus a socio-economic

analysis at the national level is urgently needed in Botswana in order to assess the effects of developing ranching at the cost of traditional systems.

During 1984 research on remote sensing was started, and work began on the use of mathematical simulation models. An ILCA model has been evaluated for its use in pastoral systems. Results of this preliminary evaluation were presented at a workshop held in Israel in February 1985. The Unit was responsible for the organisation of the workshop and the publication of the proceedings.

The Computer Unit

Expansion

During 1984, the computer hardware available at ILCA expanded rapidly. Following the 100% increase in computer use during 1983, it was decided that a second mini-computer was needed at ILCA headquarters. The new HP3000/48 mini-computer was installed in June 1984.

The two HP3000 mini-computers are 'hardwired linked' and connected to 36 terminals. The new system can be expanded to include 128 terminals.

In addition to the mini-computer, there has been an expansion of micro-computer facilities both at headquarters and within field programmes. This expansion has been based on HP150 micro-computers

A number of additional micro-computer software packages were purchased during 1984. The software packages currently available for use with HP150 micro-computers at ILCA are listed in Table 17.

The Unit's staffing was augmented by two Ethiopian graduates who joined the Unit as trainee programmers in 1984. The

Table 17. Software packages available for use with HP150 micro-computers at ILCA, 1984.

P.A.M. List and Start Application Programme	Word processing:
SYS–MASTER	Memomaker
M.S. DOS	Wordstar
Format	Spellbinder
Device Configuration	Miniword
Application Master	Programming languages:
Copy	Basic
Install	Fortran
Editor	Pascal
DSN–LINK	Cobol
Visicalc	Microstat
Personal Card File	Mstat
dBASE	Minimax
Lotus 1–2–3	Graphics:
Print Graph	Graphics 150
Utility	Picture Perfect
	Diagraph
	Graphwriter

Unit now includes four senior programmers, two trainee programmers, a biometrician, five data entry personnel and a secretary.

Computer use

Computer use during 1984 is summarised in Figure 20. There was an increase in use by African researchers through ILCA's training fellowships, and by external users within Ethiopia.

Within ILCA's research activities, the analysis of data from the Livestock Productivity and Trypanotolerance Group accounts for 40% of computer use. The Highlands Programme and the Ethiopian Rangelands Programme together accounted for 25% of research computer use during 1984.

Computer use by the Administration and Finance Department increased by 100% during 1984, with the introduction of a new accounting system and increased computerisation of administrative procedures.

Figure 20. Use of ILCA's HP3000 mini-computers, 1984.

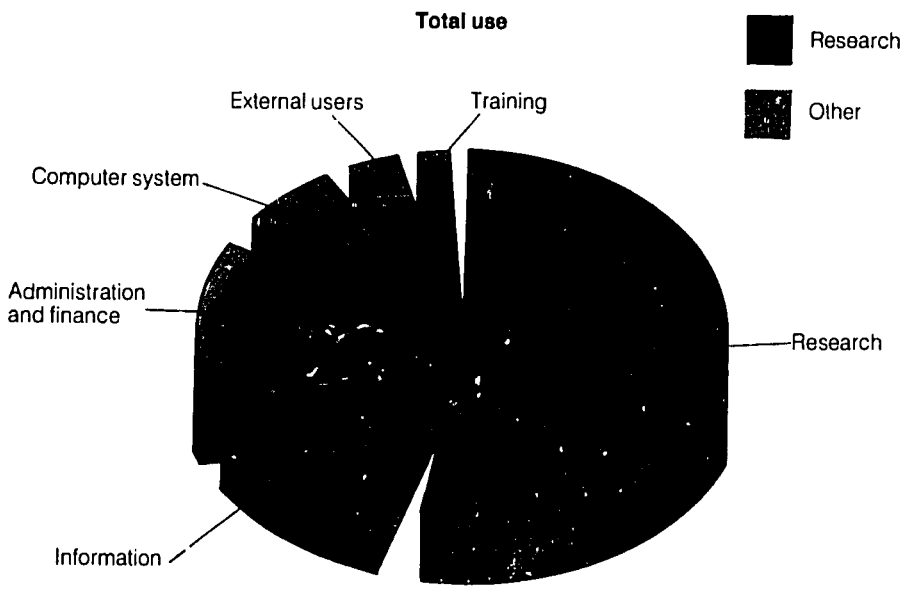
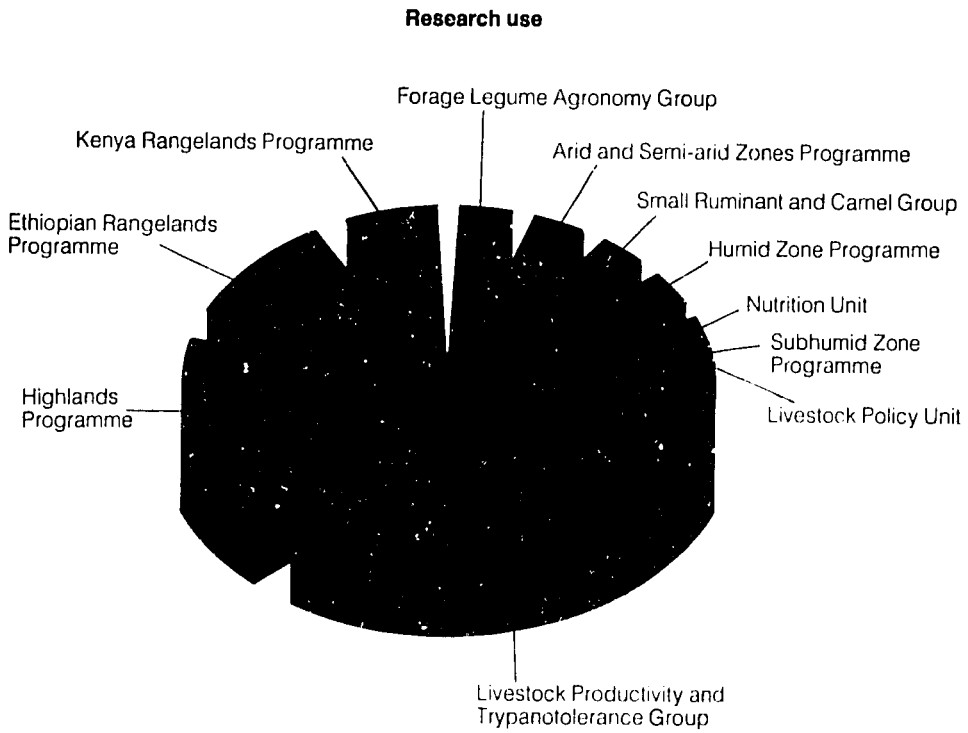


Figure 20. (cont.)



The Training Department

Introduction

An assessment of ILCA's training priorities was concluded during 1984, and changes were made to strengthen and expand ILCA's involvement in livestock agricultural training in Africa. Training was separated from International Liaison during the year, and a new Director of Training started work in August. Plans for increased group and individual training in 1985 were approved.

Group training

A total of nine group training activities were held during 1984. These were attended by 257 people and are listed in Table 18. Some activities were held at ILCA's field programme sites in East and West Africa. In addition to participants in ILCA training courses, workshops and seminars, the conference and hostel facilities at headquarters were used by 376 participants in a further 10 meetings.

Individual training

During 1984, 35 awards were made for individual training at ILCA. About a third of these awards were supported by non-ILCA funds. Increasing emphasis is being placed on the use of ILCA's laboratory and field research facilities for training young African research scientists. Long-term associations with ILCA scientists in the fields of nutrition, forage agronomy, data analysis, agricultural economics and animal husbandry are made possible through networks. Young scientists can be introduced early to the practical problems of African livestock production. Rather than doing their graduate research in the developed world, with technologies that may not be appropriate to Africa, through ILCA they can learn how to use methods that can be applied in their home countries.

Various levels of individual training have been developed. Senior African scientists are often in residence at ILCA as visit-

ing scientists, where they can share their knowledge of Africa's problems with ILCA staff and trainees. There are now eight postdoctoral associates working for 1- to 2-year periods on scientific projects at ILCA. A similar number of graduate associates doing thesis research for postgraduate degrees, and undergraduate associates forming their first impressions of the applied scientific

also studying at ILCA. Techni- ational laboratories visit ILCA ds of 1 to 4 months to learn computer methods for data analysis, and nutrition and forage research techniques.

These training schemes are being expanded to help a larger number of young Africans become more capable research workers.

Table 18. Group training courses and workshops organised by ILCA during 1984.

Title of course/workshop	Sponsor(s)[a]	No. of participants	Dates and location
Workshops			
Small ruminant production in the subhumid zone	ILCA/FLD	26	23–26 January Ibadan
Livestock production systems research: The Maasai	ILCA/MALD	75	7–8 February Nairobi
Incorporating nutritional goals into international agricultural research	IFPRI/ILCA	37	29 February–3 March Addis Ababa
Guidelines for research on crop residues	FAO/ILCA	34	5–9 March Addis Ababa
Women in agriculture in West Africa	ILCA/Ford Foundation	23	7–9 May Ibadan
Production systems in the subhumid zone of West Africa	ILCA/NAPRI	26	29 October–2 November Kaduna
Courses			
Economics of animal health and disease control	ILCA	13	30 July–11 August Addis Ababa
Animal nutrition and forage evaluation techniques	ILCA	13	27 August–14 September Addis Ababa
Farm analysis computer training	FAO/ILCA	10	17 September–11 October Addis Ababa
TOTAL		257	

[a] FLD = Federal Livestock Department, Nigeria, MALD = Ministry of Agriculture Livestock Department, Kenya IFPRI = International Food Policy Research Institute, USA, NAPRI = National Animal Production Research Institute, Nigeria

The Library and Documentation Section

Introduction

The Library and Documentation Section continued to provide information support for research workers in Africa during 1984. The following major activities of the Section were expanded:

- The provision of computerised literature search and current awareness services;
- The collection and dissemination of non-conventional literature on microfiche;
- Library services giving access to an up-to-date collection of books and journals; and
- Photocopying services.

A new service of 'current contents' was introduced in 1984, with the first experimental issue being distributed to 100 agricultural research libraries in Africa. This quarterly service groups together the contents pages of journals in five major sets of disciplines: animal nutrition, animal science, agronomy and soil science, agricultural economics and rural sociology, and animal health and veterinary medicine. The unit also trained 13 librarians and documentalists from national institutes of different African countries during the year.

Computerised information services

The selective dissemination of information (SDI) service that was started in 1983 has generated great interest among African scientists. The service provides individualised current information to researchers, and is based on the monthly tapes of the Commonwealth Agricultural Bureaux (CAB) in UK and of AGRIS, FAO's agricultural information system. The number of users at the end of 1984 was almost twice as great as in 1983 (Figure 21). Retrospective literature searches were made for ILCA staff and outside users, on both the in-house database, which now contains over 30 000 records, and external databases.

The Section assisted ILCA's Forage Legume Agronomy Group, the Ethiopian Plant Genetic Resources Centre and the Ministry of Agriculture in managing computerised data banks for plant genetic re-

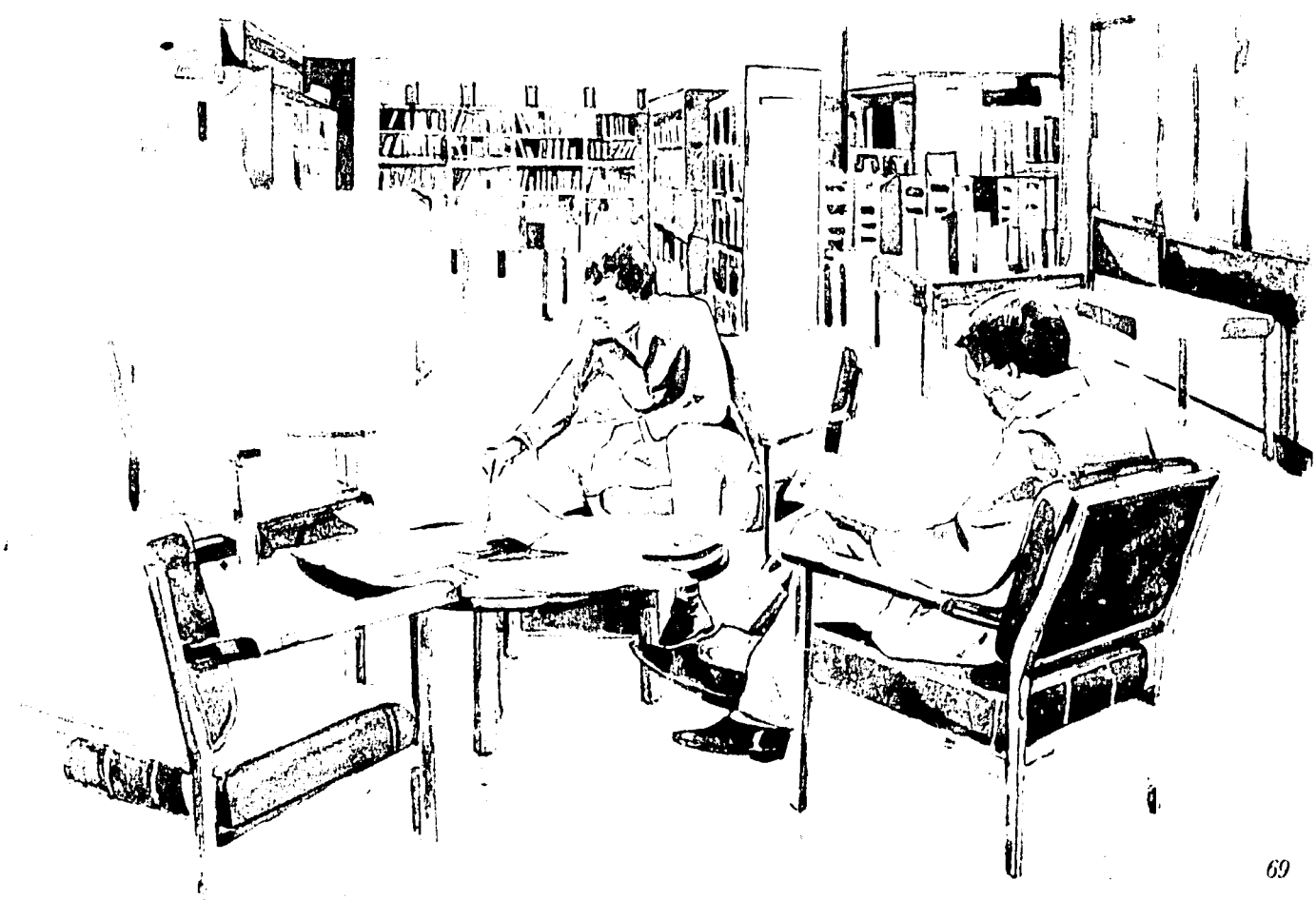
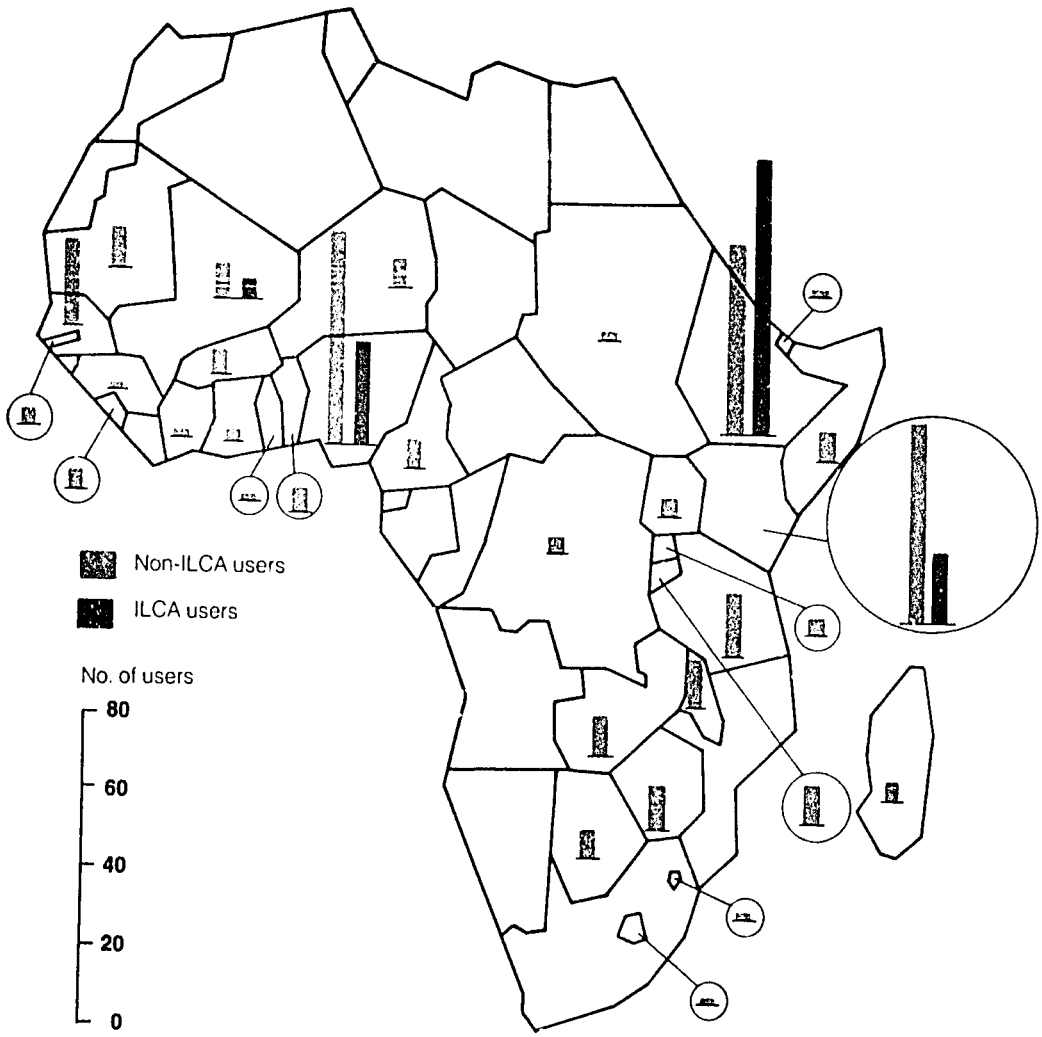


Figure 21. Distribution and numbers of users of ILCA's SDI services in sub-Saharan Africa, 1984.



resources. The United Nations High Commission for Refugees (UNHCR) and the International Red Cross also used the Section's expertise in developing databases based on the MINISIS software package.

Microfiche project

The second phase of the microfiche project, supported by IDRC, was launched in 1984. The project is designed to identify and microfilm non-conventional literature relevant to livestock production in sub-Saharan Africa and to make this literature readily accessible to national research workers. In 1984 microfilming missions were conducted in Benin, Kenya (for the second time), Mauritania, Niger and Togo. Catalogues listing microfiches collected from Burkina Faso, Ivory Coast and Malawi were printed and distributed in 1984. Fourteen microfiche readers and duplicate sets of microfiches were distributed to libraries of national agricultural research centres throughout sub-Saharan Africa.

Library

ILCA's library provides loans, photocopies and microfiches as services to users. The book collection grew to 18 300 volumes in 1984 and the periodicals collection increased to 986 titles. During the year, the library distributed more than 110 000 photocopy sheets to internal and external users on request. Over 26 000 microfiches were also distributed to individuals and research institutes throughout Africa.

Agricultural research publications from sub-Saharan Africa, 1972–84

Summary

The data presented in this box are taken from computer searches of the database of the Commonwealth Agricultural Bureaux (CAB) in UK.

CAB's entire database of agricultural research publications from 1972 to 1984 was scanned for references relating to the countries and regions of sub-Saharan Africa. The total number of research publications on the continent during this period was 52 569. About 40% of these were from West Africa.

Just over 16% of sub-Saharan Africa's agricultural research publications were based on research in Nigeria, and about 10% were from Kenya. As 1% of the total is equivalent to 525 publications, work in 12 of the 47 countries studied accounted for less than 250 publications per country in the 12-year period.

The second table reveals that while most of the subject categories of African research publications are represented in similar proportions as in the world's publications, three categories are markedly different: dairy science, nutrition and agricultural economics/social science.

Finally, agricultural research publications on sub-Saharan Africa account for only 2.9% of the world total.

Percentage shares of agricultural research publications listed by CAB, by country and region, 1972–84.

Key word	% share of SSA total
West Africa	3.2
Benin	0.4
Burkina Faso	1.9
Cape Verde	0.2
Gambia	0.8
Ghana	3.5
Guinea	2.7
Guinea-Bissau	0.3
Ivory Coast	4.2
Liberia	0.6
Mauritania	0.4
Nigeria	16.4
Sao Tome	0.1
Senegal	3.5
Sierra Leone	1.1
St Helena	0.1
Togo	0.7
(West Africa total	40.1)
Central Africa	0.5
Angola	0.5
Cameroon	2.3
C.A.R.	0.4
Congo	0.8
Gabon	0.4
Zaire	1.5
Zambia	2.4
(Central Africa total	8.8)
Sahel	1.1
Chad	0.9
Mali	2.0
Niger	1.5
Sudan	6.2
(Sahel total	11.7)

Percentage shares (cont.)

East Africa	1.9
Burundi	0.3
Comores	0.0
Djibouti	0.0
Ethiopia	2.7
Kenya	10.1
Rwanda	0.5
Seychelles	0.2
Somalia	0.7
Tanzania	5.5
Uganda	2.6
(East Africa total	24.5)
Botswana	2.0
Lesotho	0.5
Madagascar	1.4
Malawi	2.1
Mauritius	1.1
Mozambique	0.8
Namibia	0.4
Reunion	0.7
Swaziland	0.7
Zimbabwe	5.2
(Southern Africa total	14.9)

Distribution of SSA research publications by subject area.

Subject area	% of SSA total	% of world total
General agriculture	15.2	18.2
Agricultural economics, social science	25.6	7.3
Veterinary science	23.8	26.1
Nutrition	3.7	8.3
Breeding	8.9	13.1
Dairy science	1.4	5.0
Herbage	3.9	3.3
Field crops	6.7	5.9
Weeds and pests	6.3	7.2
Soils and fertilizers	4.5	5.6
TOTAL	100.0	100.0

The Publications Section

Production increase

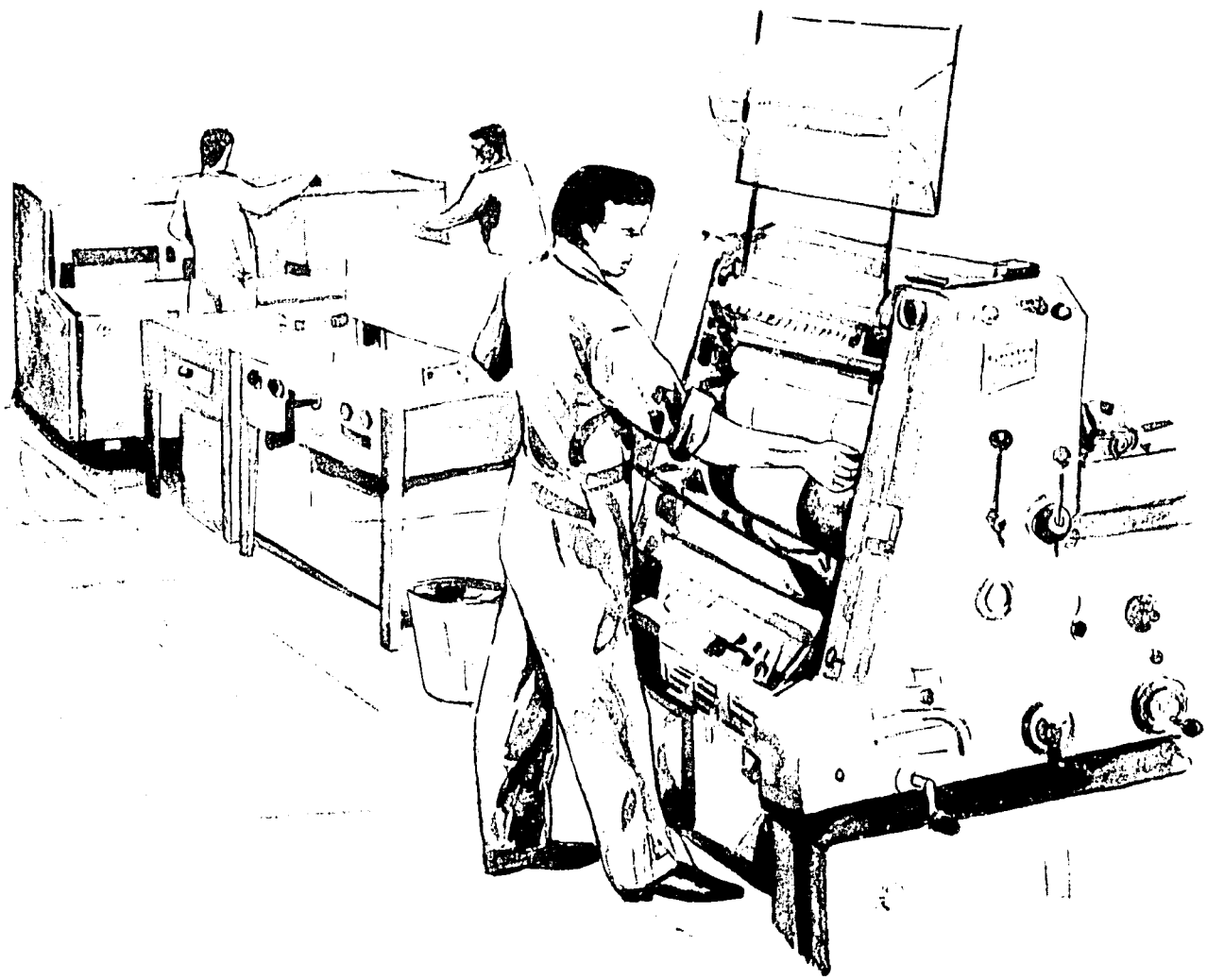
For the second year running, the Publications Section at ILCA headquarters achieved an increase in production over the previous year. In terms of the number of pages printed, the output of publications grew by 26% in 1984, following a rise of 79% in 1983. The 1984 increase was again accompanied by a decline in the proportion of administrative printing, from 29% of total passes on the press in 1983 to 24% in 1984. The new titles appearing during the year are listed in the Annex to this report.

New staff and equipment accounted for some of the gain in output: two translators and a consultant science writer joined the team in the second half of the year, and a new (Kord) Heidelberg press was installed in June. There were also gains in the productivity of existing staff and equipment. Mailing list growth leading to longer print runs, was a further factor. New publishing ventures included two new network newsletters.

The growth in output was accompanied by continued emphasis on quality. The scope and appeal of the *ILCA Bulletin* were broadened by including a wider variety of articles in each issue and by redesigning the cover and text layout. ILCA's 1982 *Annual Report* won a prize for excellence under the Critique and Awards Program of the Agricultural Communicators in Education, a professional association of the USA. The 1983 *Annual Report* was also widely acclaimed for both its content and design.

Wider audience

In 1984 the work of ILCA and the Consultative Group on International Agricultural Research (CGIAR) was brought to the atten-



tion of a wider audience in both the developed and the developing world. A representative from the BBC's Farming World programme visited ILCA during the Technical Advisory Committee (TAC) and CGIAR Centre Directors' meeting held at headquarters in June, enabling leading staff from throughout the CGIAR to give interviews describing their work or discussing issues in international agricultural research. Several other journalists visited ILCA during the year, and ILCA staff members were interviewed by Ethiopian national broadcasting services and by 'Voice of America'. About 25 news items and articles about ILCA appeared in newspapers and the popular scientific press. The number of reviews of ILCA publications also rose, bringing awareness of their availability to more people. Two commercial distribution schemes for ILCA's publications were launched, one through the International Agricultural Development Service (IADS) covering the North American market, and one through Josef Margraf covering Italy and West Germany. ISBN and ISSN numbers were allocated to ILCA publications for the first time during 1984.

ILCA's mailing list grew rapidly during the year, from 3234 names in January to 4714 in December. However, unchecked growth in a mailing list quickly leads to wastage, and efforts were made to prune the list by means of a simple questionnaire sent out during the last quarter of the year.

Staff training

Five local staff members from the publications team received overseas training during 1984 – two in publications design and production management at the London College of Printing, and three in typesetting and pressmanship at Linotype and Heidelberg in West Germany.

The Audio-Visuals and Mapping Section

The Audio-Visuals Section was formed in August 1984; it became the Audio-Visuals and Mapping Section at the end of the year. The Section brings together photographic and cartographic staff who were previously working in different ILCA units; two additional staff have been recruited locally.

The major aims of the Section are to produce tape/slide presentations on ILCA's work for a variety of audiences, to produce visual aids for ILCA staff giving conference presentations and to provide audio-visual support to ILCA's training courses.

In 1984, the Section produced copies of tape/slide presentations on ILCA's work in general. Two English and one French version(s) of the ILCA Slide Show are now available. All three presentations are mounted in one set of projector carousels and are accessed by the choice of cassette. Copies of the ILCA Slide Show have been distributed to field programmes, Board members and selected visitors.

The Section has developed expertise in the production of computer graphics using an HP150 micro-computer and plotter. Graphics are produced as overhead transparencies, 35 mm slides or as camera-ready figures for publication. The number of requests for visual aids from ILCA staff has risen rapidly.

The Section also provides photographic services for the Centre. A number of displays were mounted in 1984, while the Section's artist produced original artwork for a range of ILCA publications.

Abbreviations used in the text

AAME	active adult male equivalent
ADF	acid detergent fraction
AVHRR	advanced very high resolution radiometer
Berenil	diminazene aceturate
BW	birthweight
C	carbon
Ca	calcium
CAB	Commonwealth Agricultural Bureaux, UK
C.A.R.	Central African Republic
CGIAR	Consultative Group on International Agricultural Research, Washington DC
CIAT	Centro Internacional de Agricultura Tropical, Colombia
CP	crude protein
CREAT	Centre de Recherche et d'Elevage, Avetonou, Togo
CSIRO	Commonwealth Scientific and Industrial Research Organisation, Australia
Cu	copper
D	digestibility
DM	dry matter
EDF	European Development Fund, Belgium
FAO	Food and Agriculture Organization of the United Nations
Fe	iron
FLD	Federal Livestock Department, Nigeria
GEMS	Global Environmental Monitoring Service of the United Nations Environment Programme
GIMMS	Global Inventory Monitoring and Modelling Section, NASA, USA
GNP	gross national product
GTZ	Gesellschaft für Technische Zusammenarbeit, Germany, F.R.
ha	hectare
HP	Hewlett Packard
HPLC	high performance liquid chromatography
IADS	International Agricultural Development Service, USA
IBPGR	International Board for Plant Genetic Resources, Italy
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics, India
IDRC	International Development Research Centre, Canada
IFAD	International Fund for Agricultural Development, Italy
IFPRI	International Food Policy Research Institute, Washington DC
IITA	International Institute for Tropical Agriculture, Nigeria
ILCA	International Livestock Centre for Africa, Ethiopia
ILRAD	International Laboratory for Research on Animal Diseases, Kenya
IR	infrared reflectance
IVOMD	*in vitro* organic matter digestibility
kg	kilogram
km	kilometre
LME	whole liquid milk equivalent
LPU	Livestock Project Unit of the Nigerian Federal Livestock Department
LSD	least significant difference
LU	livestock unit (250 kg LW)
LW	liveweight
MALD	Ministry of Agriculture Livestock Department, Kenya
N	nitrogen
Na	sodium
NASA	National Aeronautics and Space Agency, USA
NAPRI	National Animal Production Research Institute, Nigeria
NDVI	normalised difference vegetation index

NOAA	National Oceanic and Atmospheric Administration, USA
ODA	Overseas Development Administration, UK
OGAPROV	Office Gabonais de Production de Viande, Gabon
OM	organic matter
P	phosphorus
PCV	packed red cell volume
PGRC	Plant Genetic Resources Centre, Ethiopia
PPR	*peste des petits ruminants*
R	red reflectance
Samorin	isometamidium chloride
SB	standing biomass
SDI	selective dissemination of information
SODEPRA	Société de Développement des Productions Animales, Ivory Coast
SSA	sub-Saharan Africa
t	metric tonne
TCRV	tissue culture rinderpest vaccine
TSP	triple superphosphate
UNEP	United Nations Environment Programme, Italy
UNHCR	United Nations High Commission for Refugees, Switzerland
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
Yb	ytterbium
Zn	zinc

Annexes

Staff List

(Supervisory and professional staff, as at 1 January 1985)

CENTRAL UNITS

Director General's Office

P J Brumby, *Director General*
G Gryseels, *Assistant to the Director General*
Zewdnesh Abegaz, *Executive Secretary*

Other Directors

L J Lambourne, *Director of Research and Operations*
M Sall, *Director of International Liaison*
S G Sandford, *Director of Information*
R G Scholtens, *Director of Training*
M H Butterworth, *Deputy Director of Research*

Livestock Policy Unit

S G Sandford, *Economist and Head of Unit*
Addis Antenehe, *Economist*
Valentin von Massow, *Post-doctoral Fellow*
S Mbogoh, *Post-doctoral Fellow*
G Rodriguez, *Economist*

Systems Research Unit

J McIntire, *Economist*

Livestock Productivity and Trypanotolerance Group

J C M Trail, *Animal Geneticist and Head of Group*
G D'Ieteren, *Animal Scientist*
H Maehl, *Animal Scientist*
R Westell, *Post-doctoral Fellow*

Forage Legume Agronomy Group

J Tothill, *Head of Group*
J R Lazier, *Forage Agronomist*
J M Kahurananga, *Plant Ecologist*
M Nuwanyakpa, *Post-doctoral Fellow*
A Russell-Smith, *Forage Agronomist*

Nutrition Unit

M H Butterworth, *Head of Unit*
Aklilu Askabe, *Research Farm Supervisor*
J Greiling, *Post-doctoral Fellow*
A K Mosi, *Senior Animal Nutritionist*
J D Reed, *Animal Nutritionist*
H Soller, *Post-doctoral Fellow*
Tekalegn Tadesse, *Analytical Chemist*

Small Ruminant and Camel Group

R T Wilson, *Animal Scientist and Head of Group*

Range Science Unit

N de Ridder, *Range Management Expert*
K T Wagenaar, *Animal Scientist*

Aerial Survey Unit

J Meunier, *Pilot*
Tassew G. Medhin, *Pilot*

Computer Unit

J Durkin, *Computer Manager*
E Kontrohr, *Scientific Programmer*
D Light, *Senior Programmer*
G Roscoe, *Administration Programmer*
A R Sayers, *Biometrician*

Library and Documentation

Michael Hailu, *Head of Section*
Azeb Abraham, *Librarian*
Marcos Sahlu, *Head of Information Processing*

Publications

S D Chater, *Head of Section*
I Alipui, *Assistant Editor*
A Gillard, *Designer*
A Leymarie, *Editor/Translator*
D Niang, *Revisor/Editor (French)*
R A Stewart, *Science Writer*
C de Stoop, *Administrative Assistant*

Audio-Visual and Mapping

R A Stewart, *Head of Section*
Admassu Wondafrash, *Draftsman*

Training Department

R G Scholtens, *Director of Training*
E Mukassa-Mugerwa, *Training Officer*

Liaison Office

Amde Wondafrash, *Liaison Officer*
Alemayehou W. Giorgis, *Travel Officer*
Bekele Teferi, *Liaison Assistant*
Membere Shitaye, *Liaison Assistant*
Tafesse Akale, *Protocol Officer*
Werqu Mekasha, *Extension Officer*

Administration

K F M Geerts, *Head of Administration*
E Albers, *General Services Officer*
A M Conti, *Personnel Officer*
F Leone, *Maintenance Engineer*
Pietro Monaia, *Senior Maintenance Assistant*
Sahle Kebede, *Catering Officer*
Shiferaw Kebede, *Registry Supervisor*
Tekeste B Habtu, *Procurement Officer*
J A T Thersby, *Warden*

Finance

A H Thabit, *Financial Controller*
Ahmed Osman, *Accounts Supervisor*
Belayhun Wondimu, *Chief Accountant*
Emmanuel Tesfamariam, *Budget Officer/ Internal Auditor*
Negussie Abraham, *Disbursement and Collection Supervisor*

FIELD PROGRAMMES

Highlands Programme

F M Anderson, *Agricultural Economist and Team Leader*
Abate Tedla, *Forage Agronomist*
Abiye Astatke, *Senior Technical Assistant*
K Agyemang, *Post-doctoral Fellow*
Ephraim Bekele, *Dairy Technical Advisor/ Animal Scientist*
Getachew Assamenew, *Agricultural Economist*
I Haque, *Soil Scientist*
S Jutzi, *Forage Agronomist*
F O'Mahony, *Dairy Technologist*
Tadesse Tessema, *Debre Zeit Station Coordinator*
I Whalen, *Post-doctoral Fellow (Rockefeller Foundation)*
S Weise, *Post-doctoral Fellow*
Woldeab Wolde Mariam, *Debre Berhan Station Coordinator*

Humid Zone Programme

C Okali, *Socio-economist and Team Leader*
A Atta-Krah, *Post-doctoral Fellow*
B Opasina, *Veterinarian*
J E Sumberg, *Forage Agronomist*

Subhumid Zone Programme

R von Kaufmann, *Agricultural Economist and Team Leader*
J A Maina, *Veterinarian*
E O Otchere, *Animal Nutritionist*
J M Powell, *Crop Agronomist*
M A M Saleem, *Forage Agronomist*
H Suleiman, *Ecologist/Administration Officer*

Arid and Semi-arid Zones Programme (West Africa)

P Bartholemew, *Forage Agronomist*
H Baur, *Agricultural Economist*
M I Cissé, *Sociologist*
S Cissé, *Sociologist*
M Dicko, *Animal Nutritionist (Niger)*
L Diarra, *Ecologist*
P Hiernaux, *Ecologist*
H Hulet, *Agronomist*
S Maiga, *Veterinarian*
S Soumare, *Sociologist*
A Tall, *Administrative Officer*
A Traore, *Veterinarian*

Ethiopian Rangelands Programme

N J Cossins, *Socio-economist and Team Leader*
Assefa Eshete, *Ecologist/Photo-interpreter*
Beiete Déssalegne, *Animal Scientist*
J C Bille, *Ecologist*
Michel Corra, *Ecologist*
M J Nicholson, *Animal Scientist*

Kenyan Rangelands Programme

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

ILCA publications in 1984

Annual Reports

ILCA Annual Report 1983

CIPEA Rapport annuel 1982

Rapport annuel du CIPEA, 1983

ILCA research highlights (E and F)*

Research Reports

Montgolfier-Kouévi C et Vlavonou A. 1983. *Tendances et perspectives de l'élevage en Afrique subsahariennne.* ILCA Research Report 1, Addis Ababa.

Konandreas P A and Anderson F M. 1983. *Dynamique du troupeau de bovins: un modèle entier et stochastique pour l'évaluation des options de production.* ILCA Research Report 2, Addis Ababa.

Gryseels G and Anderson F M. 1983. *Research on farm and livestock productivity in the central Ethiopian highlands: Initial results, 1977–1980.* ILCA Research Report 4, Addis Ababa.

Systems Studies

La production animale dans la zone subhumide de l'Afrique de l'ouest: une étude régionale. ILCA Systems Study 2, Addis Ababa.

Bulletins

ILCA Bulletin Nos. 17, 18, 19, 20.

Bulletin du CIPEA N° 17

Newsletters

ILCA Newsletter Vol. 3 (Nos. 1–4) (E and F)

ARNAB Newsletter Vol. 3 (No. 4)
Vol. 4 (Nos. 1, 2 and 3)

Forage Network in Ethiopia Newsletter Nos. 4, 5 and 6

PGRC/E – ILCA Germplasm Newsletter Nos. 4, 5, 6 and 7

Bulletin sur les ressources génétiques, PGRC/E–CIPEA Nos. 5, 6 and 7

The Small Ruminant and Camel Group Newsletter No. 1

* E = English; F = French.

Indexes

Service de la documentation. 1984. *Index des documents microfichés par l'équipe CIPEA/CRDI en Cote d'Ivoire.* Addis Ababa.

Service de la documentation. 1984. *Index des documents microfichés par l'équipe CIPEA/CRDI au Rwanda.* Addis Ababa.

Documentation Services. 1984. *Index to livestock literature microfiched by the ILCA/IDRC team in Malawi.* Addis Ababa.

Library and Documentation Services. 1984. *Accessions Bulletin* (March 1984). Addis Ababa.

Library and Documentation Services. 1984. *Accessions Bulletin* (June 1984). Addis Ababa.

Library and Documentation Services. 1984. Catalogue of maps and atlases. (June 1984). Addis Ababa.

Library and Documentation Services. 1984. *Catalogue of audio-visual documents* (June 1984). Addis Ababa.

Library and Documentation Services. 1984. *Accessions Bulletin* (September 1984). Addis Ababa.

Brochures/Leaflets

ILCA training and international liaison activities in 1984. Addis Ababa. An overview of ILCA's individual and group activities as well as meetings scheduled for 1984. (E and F)

Village sheep and goat production in Africa's humid zone. 1984. Addis Ababa. Gives background information on ILCA's research programme in Ibadan, Nigeria.

ILCA and Ethiopia. 1984. Addis Ababa. Commemorates the visit of the Ethiopian Head of State to ILCA's headquarters.

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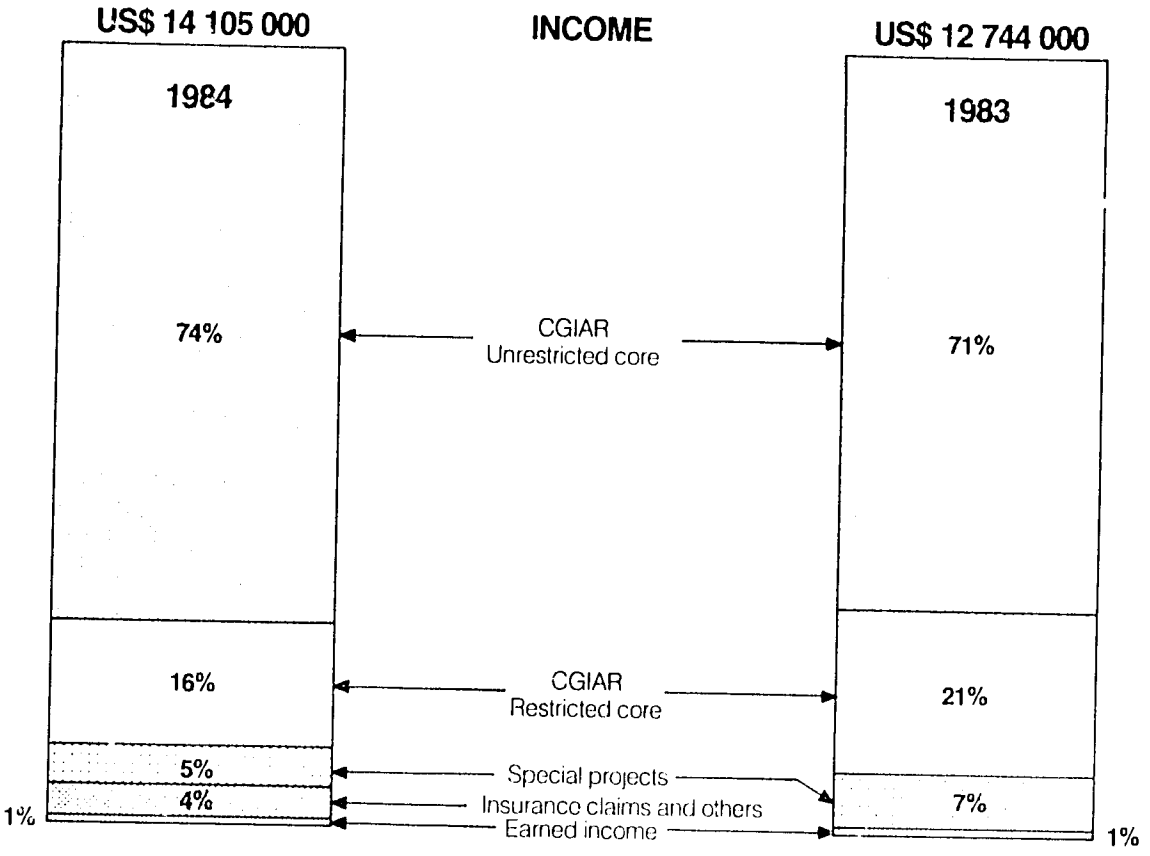
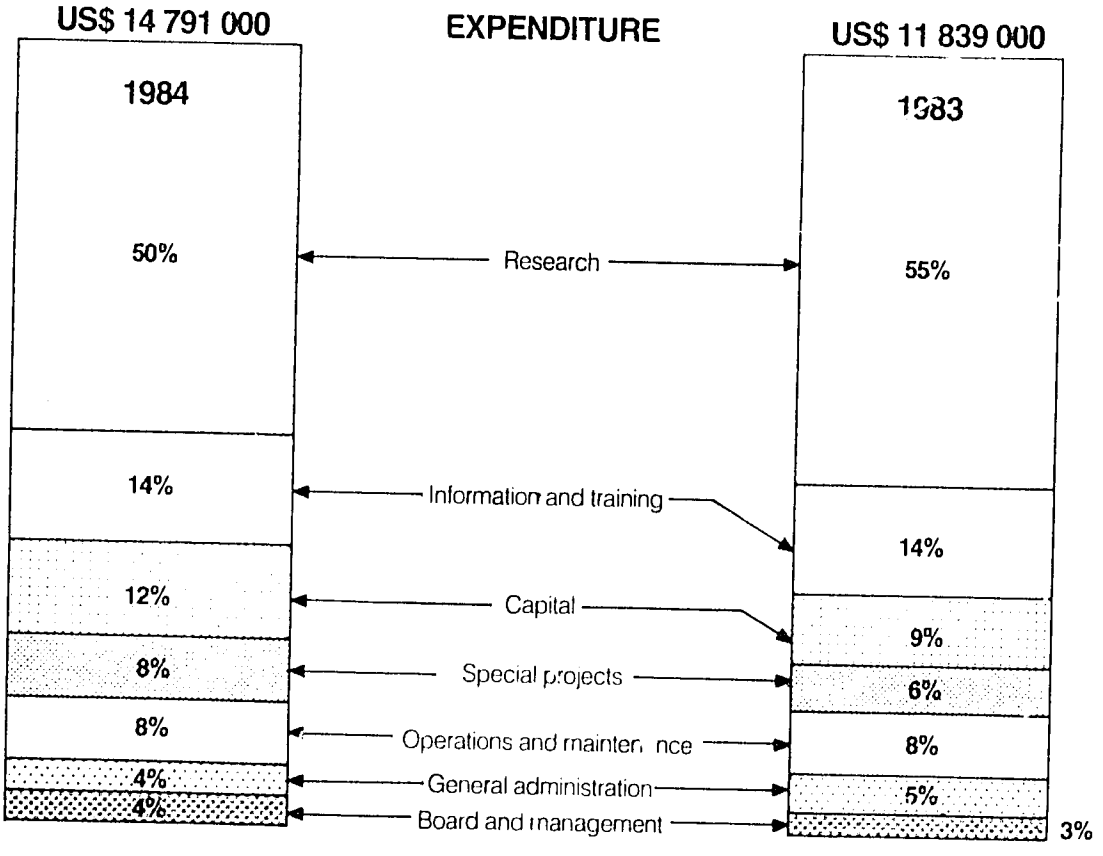
INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA STATEMENT OF REVENUE, EXPENDITURE AND FUND BALANCES for the year ended December 31, 1984

(US$ '000)

Revenue	1984	1983
CGIAR contributions	$ 12 641	$ 11 783
Special project grants	775	824
Earned income	127	137
Insurance claim and others	562	–
Total revenue	14 105	12 744
Operating expenditure		
Research	7 472	6 592
Information services	1 085	956
Training and conferences	921	663
General administration	592	584
HQ operations and maintenance	1 171	911
Board and management	569	392
Total operating expenditure	11 810	10 098
Capital expenditure	1 803	1 063
Special projects	1 178	678
Total expenditure	14 791	11 839
Excess of expenditure over revenue (1983 excess of revenue over expenditure)	$ (686)	$ 905
FUND BALANCES		
Opening balances		
Core	$ 1 332	$ 578
Special projects	252	101
Total opening balances	1 584	679
Less excess of expenditure over revenue (1983 excess of revenue over expenditure)	(686)	905
Closing balances		
Working capital	487	1 013
Restricted capital grant	–	319
Special projects	(151)	252
Capital development fund	562	–
Total closing balances	$ 898	$ 1 584

Source and application of funds, 1984 and 1983