PN-AAY-741

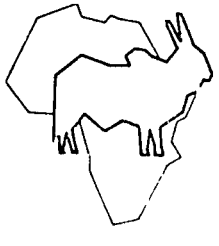
ILCA
ANNUAL REPORT
1986/87

A year of progress and change

INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA

ILCA
ANNUAL REPORT
1986/87

A year of progress and change



INTERNATIONAL LIVESTOCK
CENTRE FOR AFRICA
P.O.Box 5689, Addis Ababa, Ethiopia

This report was written, edited, designed and produced at ILCA

Drawings by Jill Lasi

ISSN 0255–0040

Correct citation: ILCA (International Livestock Centre for Africa). 1987. ILCA Annual Report 1986/87. Addis Ababa, Ethiopia.

Contents

Foreword, *vi*
1986/87 Highlights, *viii*
ILCA's addresses, *xi*
Board of Trustees, *xii*
ILCA's donors in 1986, *xiii*
Field Programmes
- Highlands Programme, *1*
- Humid Zone Programme, *5*
- Subhumid Zone Programme, *11*
- Sahel Programme, *17*
- East African Rangelands Programme, *22*

Central research and support units
- Livestock Productivity and Trypanotolerance Group, *29*
- Animal Nutrition Unit, *39*
- Animal Reproduction and Health Unit, *43*
- Dairy Technology Unit, *45*
- Small Ruminant and Camel Group, *46*
- Forage Agronomy Section, *49*
- Soils and Plant Nutrition Section, *53*
- Livestock Economics Division, *55*
- Computer Unit, *59*

Training and Information Department
- Training Division, *61*
- Library and Documentation Division, *64*
- Publications Division, *65*

Centre spread
- ILCA's strategy and long-term plan, *34*

Abbreviations, *66*

Annexes
- Staff list, *69*
- Publications, *71*
- Meetings attended, *77*
- Financial summary, *79*
- Source and application of funds, 1985 and 1986, *82*

List of Tables

Table 1. Impact of number of oxen owned on area planted to cereals per farm at Debre Zeit and Debre Berhan. *2*

Table 2. Economic performance of improved Vertisol management at Inewari, 1986. *3*

Table 3. Drainage effects on grain and straw yields of wheat and faba bean at Were Ilu, Wello: on-farm trial results, 1986, individual farmers. *4*

Table 4. Effect of land preparation method on grain and straw yields of finger millet and noug at Wereta, Gonder: on-farm results, 1986, producers' cooperative. *4*

Table 5. Effects of browse supplementation to West African Dwarf sheep offered *Panicum maximum ad libitum* on growth rates of lambs. *6*

Table 6. Mortality rate of West African Dwarf sheep offered two planes of nutrition and inoculated with *Trypanosoma vivax*. *7*

Table 7. Dry-matter yields of *S. hamata* cv Verano as influenced by nutrient additions on a ferric luvisol. *13*

Table 8. Mean (SE) maize grain yield with repeated application of N following 3 years of either *S. hamata* or natural fallow (n = 3 for each mean. The LSDs apply to differences between any pair of means within an area). *15*

Table 9. Performance of herds with and without fodder banks in Kurmin Biri. *16*

Table 10. Trends in rainfall in the Gourma. *18*

Table 11. Effect of diet on average daily weight gain over 11 weeks in castrated adult zebus. *21*

Table 12. General structure of the ecological studies in the Ethiopian rangelands, illustrating relationships among satellite (NOAA), systematic aerial reconnaissance survey (SRF) and ground survey methodologies. *24*

Table 13. Pre-drought (1983), drought (1985) and post-drought (1986) livestock populations in the southern Sidamo rangelands. *25*

Table 14. Simulated impact of increased sales offtake on annual herd productivity, Olkarkar Group Ranch. *27*

Table 15. Tsetse and livestock populations at the network sites, 1986. *30*

Table 16. Percentage depression of PCV traits in cows following trypanosome infection at three network sites with medium or high trypanosomiasis risk. *37*

Table 17. The effect of sorghum variety on intake of crop residue by highland zebu oxen. *41*

Table 18. Composition of cheese made from milk of different fat contents. *46*

Table 19. Reproductive components of some African small ruminant types under various environmental conditions. *47*

Table 20. Dry-matter yields from elite lines of six African *Trifolium* species, 1983–86. *50*

Table 21. Effect of previous cropping on grain yield of cereals on a soil with "vertic" properties, Debre Zeit. *54*

Table 22. Dairy product sale patterns by different producers, Ethiopian highlands, 1986. *56*

Table 23. Net present value (NPV) of investment in a biogas digestor in highland Ethiopia under different assumptions. *58*

Table 24. The internal rate of return (IRR) to investments in a zero-grazing dairy system in Kenya under different assumptions. *58*

Table 25. Group training courses at ILCA, 1986. *62*

Table 26. Individual training by country, 1986. *63*

List of Figures

Figure 1. Least squares means of cereal area per farm for three levels of oxen ownership at Debre Berhan, 1979–84. *2*

Figure 2. Effect of mulching and nitrogen fertilizer on maize grain yield, Ibadan, 1986. *8*

Figure 3. Effect of cutting frequency and inter-row spacing on fodder dry-matter yield of leucaena under intensive cultivation, Ibadan, 1986. *9*

Figure 4. Sites at which forage germplasm was tested in 1986. *13*

Figure 5. Dry-matter yield and total soil N as affected by grass–stylo mixtures, Kachia, wet season 1985. *14*

Figure 6. Trends in maximum annual standing biomass of three pasture types in the Inner Niger Delta in relation to the water level of the Niger river. *18*

Figure 7. Evolution of above-ground vegetation biomass, rainfall and radiometric indices, central Gourma, 1985. *19*

Figure 8. Simulated relative changes in herd size and permissible stocking rate on a Maasai group ranch over a 30-year period. *26*

Figure 9. Infections by trypanosome species in cattle and sheep, Boundiali, Côte d'Ivoire, 1984/85. *32*

Figure 10. Distribution of PCV values (%) for N'Dama cows and N'Dama calves, with and without trypanosome infection, Mushie Ranch, Zaire, 1984/85. *38*

Figure 11. Fitted mean liveweights of sheep fed leucaena. *40*

Figure 12. Effect of restricted suckling on (a) calf liveweight and (b) milk yield/offtake, ILCA headquarters, 1986. *42*

Figure 13. Relationships between parity number and (a) litter size, (b) parturition interval and (c) annual reproductive rate in Mali goats, 1978–84. *48*

Figure 14. Dry-matter yields of four stylosanthes cultivars cut every 6 weeks, Soddo, 1984–86. *51*

Figure 15. Proportions of fresh milk sold to different purchasers by different classes of producers, Ethiopia, 1986. *57*

Figure 16. Percentage of total minicomputer resources used by ILCA and NARS research, 1985 and 1986. *59*

Figure 17. Number of HP150 and IBM-PC-compatible microcomputers in research departments, 1985 and 1986. *60*

Foreword

In 1986, ILCA underwent External Programme and Management Reviews: the routine assessments of its research activities and management, commissioned every 5 years by the Technical Advisory Committee (TAC) of the CGIAR.

Both reviews praised ILCA's progress since its last reviews in 1981, but stressed the need for the Centre to focus its research activities more sharply. The Centre's mandate – "...to assist national efforts which aim to ... increase the sustained yield and output of livestock products and improve the quality of life of the people in [sub-Saharan Africa]" – is very broad. Unless ILCA focuses its efforts more sharply, the reviews suggested, it risks spreading its limited resources too thinly over a broad spectrum of activities.

ILCA's success will be measured in terms of improvement in the sustainable economic output of livestock products.

Work started in the second half of 1986 on preparing a clearly defined strategy for ILCA's work. This effort involved discussions between the Centre's staff and its Board of Trustees, and incorporated many of the insights gained from the biennial meetings between ILCA and the leaders of African livestock research. The resultant strategy, which has now been reviewed by TAC, is described in the centre spread of this report.

A central feature of the strategy is greater emphasis on partnership with national agricultural research systems (NARSs) and with specialist institutes overseas. In a continent of the size and environmental diversity of Africa, a small research centre with limited resources cannot hope to address all the problems facing livestock development. Neither can it conduct the location-specific adaptive work needed to fit innovations into all existing production systems. It is in this work that ILCA seeks to strengthen its collaboration with NARSs.

Shortage of trained staff is a major constraint in African NARSs. Without trained personnel there can be little hope of innovations being effectively tested and extended to our ultimate target group, the smallholder farmer. Also, without research support facilities, such as computing and well-equipped laboratories, the NARSs will be constrained in the work they can perform.

Much of ILCA's collaborative efforts will concentrate on strengthening the staff of NARSs through training and information. The Centre's research support facilities will assist NARSs in the analysis and publication of their research results. Networking will bring together scientists working on similar problems, allowing experiences to be shared and better coordination of widely spread research activities.

The effort involved in developing our strategy for the future was worthwhile and timely. The concentration of our efforts on assessing the livestock research needs of Africa and in identifying those areas in which ILCA's intervention can have the greatest impact has given our staff a more urgent awareness of the task facing us, and redoubled our commitment to achieving the aims set out in the Centre's mandate.

ILCA's broad mandate is now complemented by an operational mandate, naming the animal species, commodities, target groups and zones on which we will concen-

trate, and by clearly defined research thrusts encompassing the crucial areas of research that ILCA can effectively address.

While the work on ILCA's strategy represented a major effort in 1986, our research also made some significant advances during the year. Work in the highlands of Ethiopia showed the benefits of using improved animal-drawn implements to cultivate heavy clay soils prone to waterlogging, with both large increases in crop yields and substantial labour savings.

In the humid zone of Nigeria, the number of alley farms again increased and work began on finding browse species suited to acid soils, which will further extend the applicability of this intervention. The impact of fodder banks also continued to expand, with farmers seeking to establish them for feeding small ruminants as well as cattle. The Centre is also seeking to extend the alley farming and fodder bank technology into subhumid and semi-arid areas of Mali.

In Kenya, simulation modelling showed that the productivity of large herds in the rangelands could be increased markedly through increased offtake – but that this is only likely if policies change to encourage it. The influence of policies on the livestock subsector was the subject of a training course on livestock policy analysis, the first of its kind to be offered by ILCA.

These and other activities are reported in detail in the body of this report.

John Walsh
Director General

1986/87 Highlights

Highlands

● An ILCA-developed technology for constructing surface ponds is now being disseminated through most of Ethiopia's provinces by the Ministry of Agriculture. The technology employs metal scoops drawn by pairs of local oxen to build up surface soil into dam walls. More than 3000 scoops have been made locally in Ethiopia. ILCA has produced a technical manual for use in choosing pond sites and in applying the technology. Surface ponds constructed in this way make use of draught animals during the "off-season", provide water for rural settlements throughout the dry season, can be used to irrigate small areas of high-return crops and can be stocked with fish to provide an additional protein source.

● A collaborative project involving ILCA, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the Government of Ethiopia has shown that Vertisols — deep black clay soils — can be made more productive than at present through better management. The project has developed a low-cost, ox-drawn plough for making broadbeds and furrows (BBFs). The BBFs reduce waterlogging and facilitate faster, earlier planting of crops. In 1986 grain yield increases of 25 to 63% for breadwheat, 144% for durum wheat, 297% for faba beans and 84% for finger millet were recorded on farmers' fields.

Humid Zone

● Collaborative studies between ILCA and national institutions increased in 1986. Joint studies into leguminous multipurpose tree species are underway in Senegal, Côte d'Ivoire, Ghana, Sierra Leone, Benin, Nigeria, Cameroon and Zaire. In southeastern Nigeria a joint study involving five national institutions is underway to identify widely used indigenous browse species, to investigate techniques for tree establishment on the different soil types found in the region and to determine levels of production for those successfully established. Productivity will be compared to that of leucaena and gliricidia, followed by feeding trials for the most promising species.

● Nutrition was shown to have a strong effect on the severity of *Trypanosoma vivax* infection in adult West African Dwarf sheep. Eighty per cent of infected, undernourished males died, whereas all those on a maintenance diet survived. Ewes infected in pregnancy aborted or produced premature lambs. All the lambs of undernourished ewes died, while 33% of those of maintenance-fed ewes survived. When ewes were infected in early lactation, low milk production from the undernourished animals reduced lamb survival: only 12% of lambs from undernourished ewes survived, compared with 83% from maintenance-fed dams.

● Studies of household organisation and the adoption and use of browse trees in Nigeria have shown that the marked differences which exist between the farming systems of the southwest and the southeast of the country are associated with different patterns of decision-making within the household. While household members in the southwest tend to be responsible for separate enterprises, in the southeast, farms are managed jointly. Many women in the southwest have independently established viable alley farms. However, in the southeast, although most of the agricultural labour is provided by women, men make decisions about land allocation and use, including the decision to plant trees. Extension strategies need to be designed to reach both male and female farmers.

● In the fourth year of cropping, maize grown under continuous alley cropping yielded 60% more grain than under continuous cropping without trees. When a fallow period was included in the alley farming system, maize yield in the following year was double that under continuous cropping. However, as more tree foliage was removed for animal feed, the yield advantage of alley cropping was reduced.

● Intensive feed gardens of leguminous trees and grasses can produce more than 20 t DM/ha per year to supplement feed available from alley farms. Plots of leucaena planted with spacings of 25 x 50 cm and pruned every 12 weeks yielded 38 t of fodder DM/ha in 1986.

Subhumid Zone

- By the end of 1986, more than 80 stylosanthes fodder banks were under the control of agropastoralists and farmers in Nigeria's subhumid zone. The stylo is used mainly as cattle feed, but more than 20 farmers sought to establish fodder banks exclusively for feeding small ruminants.

Sahel

- Reducing the amount of cottonseed residue in cattle fattening diets (from 4 to 2 kg/day) reduced weight gains from 0.81 kg/day to 0.72 kg/day, but increased profitability. The national extension agency is now recommending this practice to smallholders.

East African Rangelands

- In the southern rangelands of Ethiopia, calves supplemented with legume hay and additional water had similar weights at 40 weeks to calves that received all their dams milk. Animals from the best hay/water treatment were valued at US$ 73.00, 57% more than unsupplemented animals.

- Aerial surveys in 1985 showed that the cattle population of the southern rangelands had fallen by 47% compared with 1983 pre-drought levels. Small ruminant and camel populations were also lower, but were less affected than the cattle population. However, repeat surveys in 1986 showed livestock populations to have recovered to pre-drought levels, indicating that the pastoralists had moved the animals to more favourable environments during the drought and then brought them back once the rains began again.

- In Kenya, a simulation model was used to estimate the long-term productivity of the Maasai system. Results suggest that the productivity of large herds (those with more than 300 head of cattle) can be increased substantially by increased exploitation of production, but that the productivity of small herds (30 head or fewer) is only likely to be increased by intensifying production using forage conservation, feed gardens, improved calf rearing practices and better animal health care. The analysis suggests that encouraging increased offtake through better pricing policies will increase the productivity of large herds more quickly and cost-effectively than will technical interventions.

Livestock Productivity and Trypanotolerance

- A 3-year baseline study was completed at the end of 1986 at two network sites, Boundiali and Tengrela, in northern Côte d'Ivoire. Funded by GTZ, and carried out jointly with the Ministry of Livestock, SODEPRA NORD, this study quantified various factors affecting trypanosomiasis and provided an estimate of the effect of trypanosome infection and other blood and internal parasites on PCV level and liveweight in cattle and sheep. ILCA is now cooperating with a GTZ tsetse control project to study the effects on livestock health and performance of controlling tsetse through the use of insecticide-impregnated traps and screens in village areas at Boundiali. The data on tsetse challenge, animal health and productivity obtained during the baseline study will enable more precise evaluation of the benefits of this tsetse control than has previously been possible.

- The Kenya Veterinary Department, in collaboration with May & Baker Ltd., ILCA and ILRAD, has been testing chemoprophylactic drugs on East African Zebu cattle in village herds at Muhaka, where trypanosomiasis affects livestock performance. The study was completed at the end of 1986 and data analysis will be completed by mid-1987. These results will complement recent research findings on the successful use of chemoprophylactic drugs in zebu cattle under ranch management at Mkwaja, Tanzania. Initial results from the first 24 months at Muhaka show that trypanocidal drug use significantly reduced detectable parasitaemia and increased daily liveweight gain. Analysis of information on viability and reproductive performance will allow clear assessment of the economic viability of chemoprophylaxis under village conditions.

Animal Nutrition Section

- Rumen bacteria that detoxify mimosine and DHP from leucaena have been successfully transferred into sheep and goats at ILCA headquarters and other sites. When leucaena comprised more than 50% of the diet dry matter, sheep inoculated with the bacteria grew about 50% faster than non-inoculated sheep.

- Restricted suckling of calves resulted in greater weight gains (20 kg more at weaning) without reducing milk offtake to weaning.

Animal Reproduction and Health Unit

- Serodiagnostic studies in 1986 indicated a high prevalence (67%) of infectious bovine rhinotracheitis/infectious pustulo vulvovaginitis in Ethiopian zebu cattle. Brucellosis was less common (4%), and both trichomoniasis and campylobacteriosis were uncommon.

- Among sheep sent for slaughter at the Addis Ababa abattoir, 74% of ewes were pregnant, 24% of them with twins. These are much higher than lambing percentages in the field, and studies are underway to determine the cause of the disparity.

Dairy Technology Unit

- The Dairy Technology Unit provided the teaching expertise and laboratory facilities for three training courses on rural dairy technology during 1986. One course was arranged for 19 participants from six African countries, while the other two were for a total of 30 Ethiopian participants.

- Preliminary results of a study of the economics of using a milk separator in dairy cooperatives in Ethiopia showed a net increase in income of about US$ 1200 over 12 months.

- On-farm studies of the use of an ILCA-developed internal agitator fitted to the traditional clay pot milk churn showed that it halved churning time and increased butterfat recovery from an average of 75% to 92%.

Small Ruminant and Camel Group

- Comparison of data from 10 countries showed that reproductive performance of small ruminants tends to be better in traditional systems in which no breeding control is imposed. Data from Mali showed that manipulating the average age of breeding females in flocks can further improve reproductive performance.

Forage Agronomy Section

- The Forage Agronomy Section, in collaboration with the Ethiopian Ministry of Agriculture, has successfully introduced *Desmodium intortum* to the local farming system near Soddo, a densely populated coffee-growing area in southern Ethiopia. When sown under coffee plants, desmodium forms a dense vigorous sward that persists under lenient cutting. The foliage is highly palatable to dairy cattle and increases their milk and butterfat yields.

- The ILCA gene bank provided almost twice as much seed to researchers in 1986 as in 1985. Seeds were sent to national researchers in 41 countries, of which 27 were in Africa. African researchers submitted a total of 166 of the 201 seed requests received and received 4287 of the 4866 accessions dispatched. In 1986 the Section installed controlled environment storage facilities to enhance conservation of this germplasm and ensure a continued and improved service to users.

- The Forage Agronomy Section initiated both formal and informal training of national research staff at its gene bank, research and seed multiplication sites in Ethiopia. The training covered such areas as germplasm collection, seed storage and management techniques for germplasm and simple forage germplasm evaluation techniques. Training on these and other topics related to forage agronomy will be a regular part of the Section's programme. In 1986, six small-group, hands-on training courses were held at Soddo and 23 participants attended two formal regional training courses.

Livestock Economics Division

- The Livestock Economics Division held its first training course on livestock policy analysis in September 1986. The course, held in English, was attended by 20 policy analysts and officials responsible for formulating policies affecting the livestock sector in 9 countries. The course will be repeated in 1987 for participants from francophone countries in sub-Saharan Africa.

- In 1986, the Division developed and tested a herd projection and livestock model that can be used to evaluate the long-term effects of technical innovations on herd productivity and structure. Given technical parameters (e.g. calving rate, mortality, nutrition or health), economic parameters (e.g. input and output prices, interest rate) and the herd structure at the beginning of an investment period, the model provides a detailed projection of herd composition, productivity, costs and benefits over 10 years, and calculates the net present value and the internal rate of return that the investment will give. The model was initially used to estimate the economic and technical implications of adopting fodder banks for cow supplementation in the subhumid zone of Nigeria, and was subsequently used to evaluate the effects of changes in input and output prices and in technology profitability in three dairy production schemes in Kenya.

- A major policy research project in 1986 examined the effects of dairy imports on national production and consumption of milk in a number of sub-Saharan African countries. The study showed that the disincentive effect of imports on local production was not a direct retail price effect, but was due to the availability of cheap imports reducing the desire of managers of milk factories to build up effective infrastructure and services to collect milk from local producers. The study has a number of policy implications. Countries that have no comparative advantage in milk production should take advantage of cheap imports. If more local production is needed, factory managers should be given incentives to collect and use local milk rather than imported raw materials.

Computer Unit

- Computing assistance to NARSs more than doubled from 1985 to 1986. In 1986, 21% of ILCA's total minicomputer resources were used to support NARSs research analysis.

- IDEAS, ILCA's data entry and analysis system, was installed at 11 sites in both East and West Africa. The Unit trained staff from both national and international research organisations in Gambia, Kenya, Mali, Nigeria and Senegal in the use of the package and in the interpretation of results.

Training and Information Department

Training Division

Eleven courses were staged on nine topics in 1986. Instruction on range ecology research techniques, evaluation of forage legumes and methods for analysing national livestock policies was given for the first time. Course participants came from 38 African countries, including, for the first time, trainees from Angola and Guinea-Bissau.

- The number of participants in training courses increased from 152 in 1985 to 201 in 1986. The number of individual trainees also increased, from 38 in 1985 to 60 in 1986.

Library and Documentation Division

- The number of people receiving the selective dissemination of information (SDI) service rose to 652, a 36% increase over 1985. The number of retrospective searches on all databases also increased by 20% to 480; 93% of these were conducted on ILCA's in-house database. The number of entries on ILCA's database increased by 7000 to 44 000.

ILCA's addresses

Headquarters/Central Research/Training and Information
P.O. Box 5689, Addis Ababa, Ethiopia.
Telex: 21207 ET Tel: 183215–25, 181128, 182455, 187047

Highlands Programme
P.O. Box 5689, Addis Ababa, Ethiopia.
Telex: 21207 ET Tel: 183215–25, 181128, 182455, 187047

Humid Zone Programme
P.O. Box 5320, Ibadan, Nigeria.
Telex: 31417 Tel: 413440

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

Sahel Programme
P.O. Box 60, Bamako, Mali.
Telex: 459 Tel: 222177

East African Rangelands Programme

Ethiopian rangelands
P.O. Box 5689, Addis Ababa, Ethiopia.
Telex: 21207 ET Tel: 183215–25, 181128, 182455, 187047

Kenya rangelands
P.O. Box 46847, Nairobi, Kenya.
Telex: 22040 Tel: 592066

Livestock Productivity and Trypanotolerance Group
P.O. Box 46847, Nairobi, Kenya.
Telex: 22040 Tel: 592066

ILCA/ICRISAT
P.O. Box 12404, Niamey, Niger.
Telex: 5406 Tel: 722509

Board of Trustees

(at 1 May 1987)

B. Nestel (UK), Chairman

R. W. Cummings (USA), Chairman-elect

Aklilu Afework (Ethiopia)

P. Chigaru (Zimbabwe)

K.B. David-West (Nigeria)

Gizaw Negussie (Ethiopia)

M. Kyomo (Tanzania)

G. Rognoni (Italy)

G.M. Sørbø (Norway)

H.A. Steppler (Canada)

P. Thiongane (Senegal)

J.S. Tye (Switzerland)

J. Walsh (Ireland)

Executive Committee

Chairman: B. Nestel

Programme Committee

Chairman: K.B. David-West

Audit Committee

Chairman: R.W. Cummings

Nomination Committee

Chairman: P. Chigaru

ILCA's donors in 1986

CGIAR contributions

African Development Bank

Australia

Austria

Belgium

Canada

Denmark

Federal Republic of Germany

Finland

France

India

International Development Association (IDA, World Bank)

International Development Research Centre (IDRC)

Ireland

Italy

Nigeria

Norway

Organization of Petroleum Exporting Countries (OPEC)

Sweden

Switzerland

The Netherlands

United Kingdom

United States of America (USAID)

Special project grants

Commonwealth Scientific and Industrial Research Organisation (Australia)

Belgium

CARE-Ethiopia

Caritas (Switzerland)

Christian Relief Development Agency (CRDA)

City of Beursel

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)

European Economic Commission (EEC)

Ford Foundation

International Board for Plant Genetic Resources (IBPGR)

International Development Research Centre (IDRC)

Ireland

Medios

Nigeria

Norway

Oxfam America

Royal Shakespeare Company

United Nations Environmental Programme (UNEP)

United Nations Sahelian Office (UNSO)

United States of America

Field programmes

Highlands Programme

Introduction

The work of ILCA's Highlands Programme is aimed at increasing livestock and food production in highland areas of Africa. Although highlands (defined as land lying more than 1500 m above sea level) comprise only 4% of Africa's land area, about 20% of the continent's cattle and sheep and 10% of its goats are found in this zone. Smallholder mixed farming systems predominate, with livestock production and cropping closely integrated.

Much of the Programme's work concerns improved soil management using animal traction. Research on draught animal nutrition is done in collaboration with the Animal Nutrition Section, and on smallholder dairying with the Dairy Technology Unit. The Programme also conducts research at Debre Berhan on increasing the productivity of indigenous sheep.

Due to the increasing needs of ILCA's central research units for field research, the Debre Zeit experiment station was transferred to the Research Directorate in 1986.

Analysis of input and production data

Whole farm input and production data have been collected on sample farms in Debre Zeit since 1978 and in Debre Berhan since 1979. These data were analysed in 1986 with particular reference to the impact of oxen ownership on grain production. Debre Zeit is an intensively farmed area with virtually no arable land left fallow. It is representative of the country's large middle altitude cereal-pulse cropping zone. Teff (*Eragrostis tef*) is the main cereal grown. Average farm size at Debre Zeit is around 2 ha. The Debre Berhan area is higher (around 2800 m vs 1800 m at Debre Zeit), with lower ambient temperatures, less fertile and shallower soils and with a large proportion of each farm under fallow. On average, farmers in Debre Berhan cultivate about 2.3 ha of their 3-hectare farms each year. Farmers in both areas plant more cereals than legumes.

Animal feed shortages are more acute at Debre Zeit than at Debre Berhan and a larger proportion of farmers' livestock holdings in Debre Zeit are oxen, reflecting the greater dependence of the Debre Zeit farming system on oxen raised in other areas of the country.

Oxen ownership and cereal cultivation

In the Debre Berhan area farmers with two oxen plant an average of 32% more land to

cereals each year than farmers with no oxen. The corresponding difference at Debre Zeit was greater; farmers owning two oxen plant 60% more land to cereals than farmers with fewer than two oxen (Table 1). In both areas year of cultivation had a significant effect on yield per hectare. Only at Debre Berhan was there a significant effect of number of oxen owned on yields per hectare. However, the combined effect of number of oxen owned on area cultivated and yields per hectare showed that farmers with two oxen produced an average of 63% more cereal grain each year than farmers in the same area with no oxen. The corresponding margin over farmers owning one ox was only 19%. Cropping patterns were also strongly influenced by number of oxen owned. Farmers owning fewer oxen allocated more land to pulses; land preparation for pulses requires fewer oxen-pair hours than for cereals. Thus, farmers with fewer than two oxen have significantly lower net incomes than those with two or more oxen.

Table 1. Impact of number of oxen owned on area planted to cereals per farm at Debre Zeit and Debre Berhan.

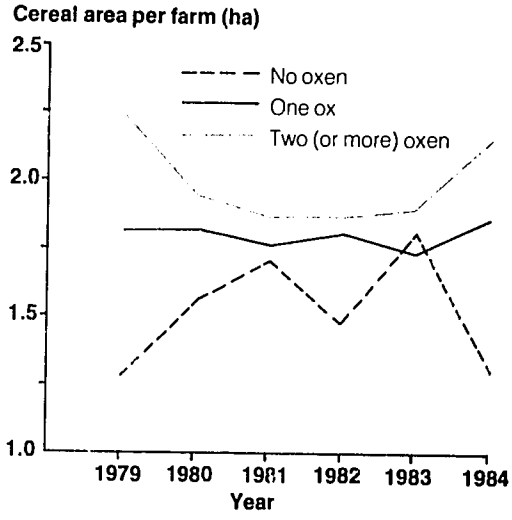
No. of oxen owned	Area planted to cereals (ha/farm)[1]	
	Debre Berhan (1979–1984)	Debre Zeit (1978–1980)
0	1.50	1.09[a]
1	1.79	
2	1.98	1.74

1. Statistical estimate.

a. Grouping necessitated by data limitations.

The area planted to cereals varied each year, and was affected by oxen ownership (Figure 1). Debre Berhan has a weakly bimodal rainfall pattern. If a poor main-season harvest is not followed immediately by effective rains in the short growing season, farmers with no oxen are unable to cultivate as much land as in years with short rains. Yields in the 1978 and 1983 main cropping seasons were well below average and the short rains of early 1979 and 1984 failed. As a consequence, farmers with two or more oxen cultivated 77% more land to cereals than farmers with no oxen in the 1979 main cropping season, and 65% more in 1984.

Figure 1. Least squares means of cereal area per farm for three levels of oxen ownership at Debre Berhan, 1979–84.



Animal power and Vertisol cropping

Vertisols, or deep black clay soils, cover about 100 million ha in sub-Saharan Africa, including about 8 million ha in the Ethiopian highlands. They are among the most fertile of Africa's soils, but are prone to waterlogging and difficult to plough.

A collaborative project, started in 1986, is studying ways to increase the contribution of Vertisols to food and feed production in the Ethiopian highlands. The project involves ILCA, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India, and the Institute of Agricultural Research, Ministry of Agriculture, Alemaya University of Agriculture and the Addis Ababa University in Ethiopia. It is funded by the Swiss, Norwegian and Finnish governments, Caritas Switzerland and Oxfam America.

Testing broadbed and furrow technology

Broadbeds and furrows (BBFs) are raised beds with shallow drainage ditches between them. Research in India by ICRISAT showed that BBF cultivation of Vertisols prone to waterlogging increased both grain and straw yields of traditional crops dramatically, and also allowed higher-yielding crops to be grown. In 1986 the Highlands Programme tested a broadbed maker, modified from the local *maresha* plough, at four sites ranging in altitude from 1900 to 2600 m,

representative of the main smallholder farming zones in Ethiopia.

BBFs and labour requirements

On the Inewari Vertisol plateau in central Ethiopia at 2600 m above sea level, farmers traditionally make broadbeds and furrows by hand. Using the broadbed maker, forming BBFs required 30 hours/ha, compared with 60 hours of hand labour to form the BBFs. The total labour requirement for land preparation, seeding and drainage in the traditional system is about 90 hours for faba bean and 120 hours for wheat, compared with 60 and 90 hours respectively using the broadbed maker – an increase of 25 to 33% in labour productivity assuming yields to be constant. However, faba bean yielded 14% more grain and wheat 63% more grain on plots prepared using the broadbed maker than on plots prepared traditionally. Using the broadbed maker increased returns to labour by 43% for wheat and by 140% for faba bean, compared with preparing the broadbeds by hand (Table 2).

An on-station experiment at Debre Zeit showed that 40% less labour was needed for weeding teff and maize on broadbeds than on traditionally managed plots.

BBFs and crop yields

On the Were Ilu Vertisol plateau in the Wello region, also at 2600 m above sea level, no efficient surface drainage practice is traditionally used. Crop yields are generally extremely low in high-rainfall years. The 1986 crop season was extremely wet; 31 rainy days were recorded in August. The resultant heavy waterlogging depressed yields throughout the plateau (Table 3). Yields of faba bean and wheat grown on BBFs, however, were comparable to those achieved in good years.

In Debre Zeit, at 1900 m above sea level, the performance of teff and wheat was monitored on the fields of 34 farmers. Although total rainfall during the 1986 growing season was one third below average, wheat yields were 1680 kg/ha on the BBFs, compared with 1340 kg/ha on traditionally managed plots. White teff yields increased from 1868 to 2108 kg/ha on BBFs.

At Wereta in Gonder province, at 1800 m above sea level, trials were conducted with finger millet and noug (*Guizotia abyssinica*), which are traditional crops in this high-rainfall area (1500 mm). Yields of both crops were significantly ($P<0.001$) higher on broadbeds than on traditionally managed plots (Table 4).

Soil fertility management on clay soils

Many Ethiopian highland Vertisols are low in plant-available phosphorus. Since they are all in the acid range they can make good use of slow-releasing rock phosphates. Triple superphosphate and Egyptian phosphate rock were applied to a range of *Trifolium* species in Addis Ababa in 1984. Over the 3 years following phosphate application, triple superphosphate gave significantly higher yields than phosphate rock at higher levels of application (45 and 60 kg P/ha) only. Since there is generally a direct positive relationship between above-ground yield of legumes

Table 2. Economic performance of improved Vertisol management at Inewari, 1986.

Technology and crop	Average yield (kg/ha)	Gross return (US$/ha)[1]	Operational cost (US$/ha)[2]	Return to labour (US$/hr)[3]	Change over traditional (%)
Animal-powered					
BBF construction					
Faba bean	810	238	105	0.5	+140
Wheat	617	268	110	0.6	+43
Traditional					
BBF construction					
Faba bean	709	218	126	0.35	
Wheat	402	170	133	0.25	

1. Includes value of grain and straw.
2. Costs of all material, human and animal labour and annual cost of implement.
3. After deducting all costs (operational and fixed) except labour.

Table 3. Drainage effects on grain and straw yields of wheat and faba bean at Were Ilu, Wello: on-farm trial results, 1986, individual farmers.

Crop	Land preparation method	N	Grain yield (kg/ha)	Straw yield (kg/ha)
Durum wheat	BBF[1]	163	759***	1140***
	Traditional[2]	167	311	449
Faba bean	BBF	170	683***	572***
	Traditional	166	172	162

1. BBF: broadbeds and furrows, 120 cm width.
2. Traditional: ridges and furrows, ridge 30 cm width.

*** Difference between land preparation significant at P<0.001.

Table 4. Effect of land preparation method on grain and straw yields of finger millet and noug at Wereta, Gonder: on-farm results, 1986, producers' cooperative.

Crop	Land preparation method	N	Grain yield (kg/ha)	Straw yield (kg/ha)
Finger millet	BBF[1]	36	731***	1636***
	Traditional[2]	24	398	1024
Noug	BBF	47	164***	1609
	Traditional	40	90	1207

1. BBF: broadbeds and furrows, 120 cm width.
2. Traditional: ridges and furrows, ridge 30 cm width.

*** Difference between land preparation significant at P<0.001.

and their N fixation, phosphorus fertilization increases the legume's contribution to the N economy of the soil.

Extension of ILCA pond technology

A second pond of 17 000 m^3 capacity was excavated on the Debre Berhan station by oxen drawing the ILCA-developed metal scoop. Water supplies for all research stock on the station are now assured. This same technology is now being disseminated through most of Ethiopia's provinces by the Ministry of Agriculture. Some 3000 scoops have been made in the country. The ILCA site at Debre Berhan was used in the Ministry's training programme for officers who will be involved in the national pond construction programme.

Humid Zone Programme

Introduction

The humid zone of Africa covers 4.1 million km^2, including coastal West Africa, much of central Africa, eastern Madagascar and part of Mozambique. These areas receive over 1500 mm annual rainfall and have a growing season in excess of 270 days. The zone contains 6% of the cattle, 9% of the small ruminants and 9% of the human population of tropical Africa. Livestock production in 90% of the zone is restricted by trypanosomiasis, a blood parasitic disease carried by tsetse flies, hence trypanotolerant livestock breeds predominate. In the Nigerian humid zone the typical farm family comprises six to eight people cultivating 2 to 4 ha and owning three to five small ruminants. Small ruminant production is generally a minor farm enterprise. Cattle are found in larger herds than small ruminants, usually in the care of Fulani herdsmen.

The lowland forest zone contains farmland under cultivation and bush fallow. Adjacent to the forest zone, regular fires have destroyed tall trees, leaving low trees, shrubs and bushes to form a derived savannah belt.

The Humid Zone Programme, based at Ibadan, Nigeria, near the boundary between the forest and derived savannah zones, has focused on developing low-cost interventions to improve animal health and nutrition as a means to increase animal productivity. Measures to control *Peste des petits ruminants* have been described in earlier *ILCA Annual Reports*. Efforts to improve small-ruminant nutrition have concentrated on providing cut-and-carry fodder from the leguminous trees *Leucaena leucocephala* and *Gliricidia sepium* as supplementary feed. Tree foliage can also be used as mulch to improve soil fertility and raise crop yields.

Increasing human population, and the resultant demands for cropland, have shortened fallow periods in the traditional cropping cycle. Soil degradation has increased as a result and crop yields are falling. Alley farming is seen as a sustainable and productive alternative to the traditional system of land use.

Small ruminants in the humid zone are generally free-roaming and receive few inputs. However, increasing human population and demand for land in some areas has led to restrictions on animal movement to prevent crop damage. In the derived savannah, increased human population and greater land-use intensity are believed to be the cause of a decrease in the population of tsetse flies, allowing cattle owners more op-

portunity to benefit from available natural forage.

Animal health and productivity

Browse supplementation trials

Browse supplementation trials with leucaena and gliricidia, offered on a cut-and-carry basis to individually penned sheep, showed that lamb survival and growth rates increased with the level of supplementation (Table 5). Ewes consuming 371 g of mixed browse dry matter daily as a supplement to *ad libitum Panicum maximum* produced lambs that grew at almost twice the rate of those from unsupplemented ewes. Eighty-nine percent of the lambs of supplemented ewes survived to weaning, compared with only 50% of lambs from unsupplemented ewes.

ductivity are in progress with the University of Ife.

Nutrition and trypanotolerance

The interaction between nutrition and trypanotolerance was studied in groups of West African Dwarf sheep offered either a sub-maintenance or maintenance diet, and infected by intravenously administering *Trypanosoma vivax* (Table 6). Animals were treated with Berenil and removed from the trial if their packed cell volume (PCV) fell to 10% and, for females, if their lamb had died. These conditions were only met in females that had been infected in late pregnancy. The mortality rate among underfed males in the 7 weeks post-inoculation was 80%, while all the males on the maintenance diet survived.

Table 5. Effects of browse supplementation to West African Dwarf sheep offered *Panicum maximum ad libitum* on growth rates of lambs.

Browse intake (g DM/day)		Growth rate (g/day)		
Dam[1]	Lamb[2]	Birth–12 weeks	12–24 weeks	Birth–24 weeks
0	0	39.0[a]	11.9[a]	25.5[a]
103	27	43.5[a]	17.9[ab]	33.2[ab]
199	71	58.7[b]	21.4[bc]	38.3[bc]
371	111	57.9[a]	25.5[c]	44.3[c]

1. Before weaning at 90 days.
2. After weaning.

Within a column, values followed by the same letter are not significantly different ($P<0.05$).

Leucaena toxicity

No signs of toxicity from mimosine or its metabolite, DHP, were observed with individually fed sheep, in contrast to a previous trial with group-fed sheep receiving the same levels of supplementation, in which some animals were observed to consume more leucaena than average. During early 1986, toxicity was observed in sheep grazing leucaena alleys, and two animals died. The rumens of the remaining grazing animals were inoculated with bacteria that detoxify mimosine and DHP, and no further signs of toxicity were observed. Healthy lambs were born to this group in September. Collaborative studies into the effects of detoxifying bacteria on feed utilisation and animal pro-

When pregnant ewes were infected at 4 months post-conception, abortions and premature births occurred. All lambs from the underfed group died, but one third of the lambs of maintenance-fed ewes survived. Inoculating ewes 3 days after parturition resulted in lamb mortality of 88% in the underfed group and 17% in the maintenance group.

Poor milk production was suspected to be the major contributing factor to lamb mortality when ewes were infected in early lactation, but premature birth of weak lambs was the major factor when ewes were infected in late pregnancy. Parasitaemia developed faster and was more severe in underfed animals of both sexes. Trypanosome infection depressed feed intake at both planes

Table 6. Mortality rate of West African Dwarf sheep offered two planes of nutrition and inoculated with *Trypanosoma vivax*.

	Mortality (%)	
	Submaintenance	Maintenance
Males		
Infected adults	80	0
Females		
Infected pregnant[1]	17	17
Infected lactating	50	0
Lambs		
From infected pregnant dams	100	67
From infected lactating dams	88	17

1. After the death of a lamb, dams were treated with Berenil when packed cell volume fell below 10%.

of nutrition. Thus, undernutrition, which affects the majority of domestic ruminants in the dry season, depresses trypanotolerance and the effects are more severe when undernourished animals are infected during late pregnancy.

Survey of herds in southwest Nigeria

A survey of cattle in the derived savannah in five states in southwest Nigeria was started in the rainy season. The average herd comprised 66 animals under the control of settled Fulani families. The herd owners generally also had arable fields, and had lived at their present site for more than 10 years. The incidence of trypanosomiasis in the herds varied from zero up to 47% in one herd. Omitting this exceptionally high value, the overall infection rate in a sample of 640 animals was 12%. The survey will be repeated during the dry season.

Incidence of trypanosomiasis in slaughter cattle

In a 12-month survey of blood parasites in slaughter cattle at the main abattoir in Ibadan, *Trypanosoma vivax* occurred most frequently (7.5%), with a peak incidence of 19% in November. Low packed cell volumes and trypanosome infection rates occurred simultaneously, suggesting that trypanosomiasis was not the major cause of anaemia in the cattle sampled. Almost all the slaughter cattle originated in the north of Nigeria and were brought to Ibadan by lorry.

Browse and forage agronomy

The Programme's agronomy research focuses on integrating fodder trees in traditional farming systems and the development of fodder production strategies using alley farming – the integration of fodder trees with arable crops – and intensive feed gardens – specialised fodder production from trees and grasses.

Alley farming

A comparison of maize production from continuous cropping without trees, continuous alley cropping and alley farming[1] after a 2-year grazed fallow confirmed the results of 1985. Maize grain yield under continuous alley cropping and alley farming after fallow was 60 and 100% higher respectively than under continuous cropping without trees. Tree foliage production was greater after the fallow period, possibly due to increased root development while pruning was less frequent. Soils under alley farming and grazing systems were richer in organic carbon and major nutrients such as N, Ca and Mg. The

1. In an alley cropping scheme, as defined by IITA and ILCA, annual crops are grown between rows of leguminous trees, and the tree trimmings are used for mulch. In alley farming, the tree foliage is either fed to small ruminants or used for both feed and mulch.

N content of maize leaves was highest in alley farming after fallow, improving the feed quality of crop residues after grain harvest.

The effects on maize yield of removing various proportions of tree foliage from alley farms as cut-and-carry feed was investigated under three fertilizer regimes, 0, 40 and 80 kg N/ha (Figure 2). Maize yields increased at all three levels of fertilizer application as the proportion of tree foliage used for mulch increased. Offtake of tree foliage for cut-and-carry feed must therefore be justified by higher livestock productivity to compensate for any loss of crop yield.

International testing of gliricidia

The evaluation of gliricidia germplasm at nine sites in West and central African countries continued in 1986. The high-yielding composite line that was the most productive at Ibadan grew well at some sites, but grew poorly where soils were acidic or rainfall was low. Additional low rainfall sites will be included in 1987.

Intensive feed gardens

Different designs of intensive feed garden (IFG) were tested to identify the most productive configuration of fodder trees, leucaena and gliricidia, and grasses, panicum and pennisetum. Tree rows spaced 2.5 m apart with 2 rows of grass within the alley, and tree rows 4.0 m apart with 4 rows of grass, both yielded over 20 t DM/ha. The former design, with more trees per hectare, produced the higher protein yield.

A second trial assessed the effect of inter-row spacing and cutting frequency on biomass production and tree survival under intensive management (Figure 3). Inter-row spacings for leucaena of 0.5 to 2.0 m and cutting intervals of 6 to 12 weeks were investigated. Frequently-cut trees had smaller stump diameters and higher mortalities. Individual plant vigour and productivity declined with decreasing inter-row spacing. The highest yield per hectare (38 t DM/ha) was obtained with a 0.5 m inter-row spacing and a 12-week cutting cycle.

Impact of alley farming

The Programme tests the acceptability and viability of alley farming under farmer management and collects data on productivity and profitability on alley farms managed jointly by farmers and researchers. The increase in the number of alley farms under farmer management from 4 in 1982 to

Figure 2. Effect of mulching and nitrogen fertilizer on maize grain yield, Ibadan, 1986.

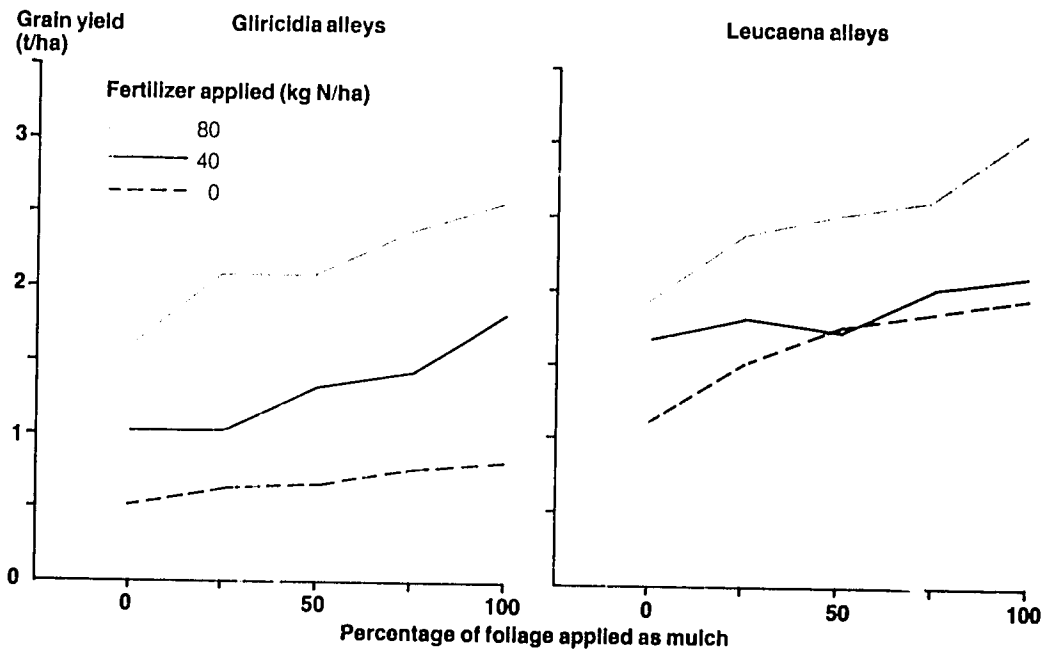
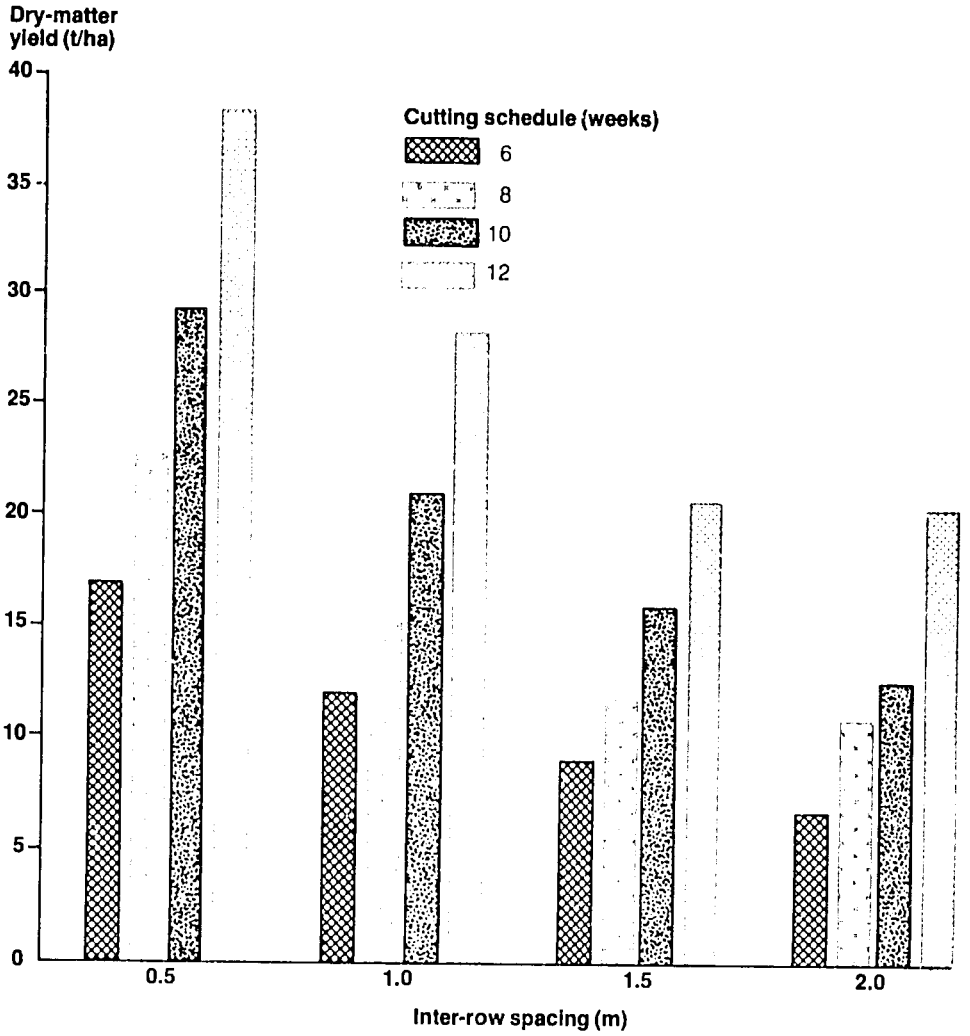


Figure 3. Effect of cutting frequency and inter-row spacing on fodder dry-matter yield of leucaena under intensive cultivation, Ibadan, 1986.



around 250 in 1986 indicates the acceptability of the technology. Quantitative data from established farms in southwest Nigeria showed that tree productivity varied widely from 1.3 to 5.3 t/ha over an 8-month harvesting period. The effects on crop yield are being studied on newly planted farms that include control plots.

In southeast Nigeria the productivity of 19 different fodder tree species and accessions are being compared to find lines that are more tolerant of acid soil conditions. The trees were planted in mid-1986 and pruning will start in 1987. Early height measurements have indicated differences in growth patterns among the lines.

Feed consumption by confined smallstock is being recorded on established alley farms and intensive feed gardens. From the limited data set now available, household wastes appear to be a more important dietary component for confined animals than indicated by a previous survey of free-roaming animals in southwest Nigeria. Cassava peel is one of the most-frequently offered household wastes, at a level of 220 g DM/animal per day.

Socio-economic studies

The role of women

A number of related projects have examined the relationship between small ruminant production, fodder tree cultivation and household dynamics. In southwest Nigeria, the proportion of women engaged in agriculture was higher than usually assumed, and the successful management and continued viability of alley farms established by women

has suggested that the potential of the technology for women is high. The main constraint to the expansion of women's enterprises was identified as access to capital, both for purchase of animals and for hiring labour.

In southeast Nigeria, food processing was an important off-farm activity for rural women, often conflicting with fodder tree cultivation. Palm oil and cassava processing were the two main food processing activities. While the former is the more profitable, the byproducts of cassava processing are an important feed for small ruminants.

Regional differences between systems

Marked differences exist between farming and livestock systems in southwest and southeast Nigeria. In the southeast, where human population densities are much higher than in the southwest, land-use is considerably more intensive, animals are confined and cut-and-carry feeding is practised, whereas in the southwest the animals roam freely and forage for themselves. These differences are associated with contrasts in household organisation: in the southwest household members tend to be responsible for separate enterprises, while in the southeast, farms tend to be managed jointly. The division of labour and decision-making within households in these two areas has implications for the distribution of the costs and benefits of the new technologies.

Southeast Nigeria survey

A survey of livestock and farming systems in four states of southeastern Nigeria showed that 92% of sampled households owned goats and 28% owned sheep (20% kept both species). The mean flock sizes for owners of each species were 7.4 goats and 11.1 sheep, with an average of 6.8 goats and 3.1 sheep across all households. However, ownership of both species, especially of sheep, was highly skewed. The median values for the sample were 2 goats and no sheep. Farmers considered feed, disease and housing the main problems in livestock management.

Land tenure and alley farming

Alley farming requires access to land and the right to plant, own and utilise trees. Further research on the implications of land-tenure systems for fodder tree cultivation has shown that alley farms and feed gardens may be planted readily on land where rights are individual and secure, as they generally are around the compound. Where tenure is communal, as it often is in the outlying fields in southeast Nigeria, there is no guarantee of continuous use of the land, and farmers may be discouraged from planting fodder trees because they might not receive the long-term benefits from their efforts.

Bush-fallow studies

Research on the bush-fallow system at two sites in southwest Nigeria indicated that land management strategies differ according to ecology, with both cropping and fallow periods longer on savannah than on forest land, and the use of fertilizer being more common on savannah land. The analysis also indicates that even in the relatively under-populated areas around Owu-Ile and Iwo-Ate (northern Oyo State), about half of all farmers appear to be utilising their land at its limit of sustainability, with short fallows and maximum use of their total land base.

Alley farming workshop

During March a workshop on alley farming, attended by over 100 participants from 19 countries, was held at Ibadan to discuss the 'state of the art', research and training requirements and methods of collaboration. Participants recommended that an alley farming network be established to further improve and test the technology across diverse environments in tropical Africa, and to encourage inter- and intra-country cooperation.

Cooperation with national institutes

Cooperation with national institutions is an important facet of the Humid Zone Programme. In 1986 collaborative projects were undertaken with 11 institutions in Nigeria and with 8 other West and central African countries. A training course in alley farming jointly organised by ILCA and IITA in May attracted 40 participants from 20 countries.

Subhumid Zone Programme

Introduction

The subhumid zone occupies 21% of tropical Africa, some 4.8 million km^2. Unlike much of the remainder of the continent, it is sparsely populated and underproductive relative to its potential.

It was formerly assumed that the tsetse-borne disease, trypanosomiasis, was the main cause of the low population densities in the subhumid zone. However, increased cultivation following human migration into the zone has eliminated much of the habitat of the tsetse fly, thus reducing tsetse challenge, and it is apparent that irregular rainfall and poor soils are the main constraints to crop and livestock productivity. Other constraints to livestock productivity include the rights of use and access to land, which limit the quantity and quality of livestock feed.

Livestock in the zone depend increasingly on crop residues for feed during much of the year. In recent decades, livestock owners have suffered as cropping has encroached on grazing land and crops that offer little residue for livestock feed, such as maize and yams, have expanded. Farmers also use chemical fertilizers rather than manure for their crops. If livestock production in the zone is to increase, livestock must become more integrated with cropping. Thus, only interventions that benefit crop farmers as well as livestock owners are likely to succeed.

Development trends in mixed farming systems

Survey of mixed farming

Information about the circumstances of mixed farmers will be increased by a Ph.D. study, begun in 1986, of livestock holdings, land ownership and decision-making among the Aten people, mixed farmers of Ganawuri district, Nigeria. This work is supported by Bergen University, Norway. Early results indicate that 9% of all households own cattle, with herds ranging from 1 to 80 animals. Comparison of recent survey data with a census of livestock ownership in the early 1960s shows that goat and pig populations have increased substantially, while other species have declined slightly. Unlike the semi-arid zone, cattle in Ganawuri are only marginally integrated with the farming system: they are not used for traction and are often pastured in remote hill areas where their manure cannot be used for fertilizer. The land tenure system is changing: pressure on land has resulted in the collapse of the principle of inalienability of land use.

This has led to land sales and pressure on non-Aten cattle owners, in particular the FulBe, to leave the district.

Adoption of fodder banks

The involvement of the National Livestock Projects Department in the extension of fodder banks has led to their adoption by livestock owners outside both the original target group and the subhumid zone, in particular in the highland and semi-arid zones. However, observations of the pattern of uptake indicated that the experience and availability of extension officers is important. Research is needed to maximise the effectiveness of available support systems and staff, particularly where extension officers from non-pastoral communities need to establish a rapport with pastoralists.

Forage production research

Screening stylo for anthracnose resistance

In 1986, 131 stylo lines (63 *S. hamata* and 68 *S. guinanensis*) were screened for anthracnose resistance. Many failed to germinate. The hamata lines that germinated were either susceptible to anthracnose or did not perform as well as the Verano stylo that is used currently. Although *S. guianensis* cv Pauciflora did not show signs of anthracnose, its productivity was less than that of earlier acquisitions of *S. guianensis* cv "Tardio" (CIAT 1280, 1283, 1583).

Evaluation of browse

In 1986, 23 browse lines of the genera *Acacia*, *Albizia*, *Cajanus*, *Erythrina*, *Gmelina*, *Khaya* and *Leucaena* were evaluated for herbage production and drought tolerance. Some were also tested for use as fence posts to replace the expensive metal posts currently used to fence fodder banks. Preliminary observations indicated that *Gmelina* has a good potential for live fencing. It grows very rapidly but the foliage is less palatable than that of other fodder trees and therefore is hardly browsed during the wet season. It can thus be established to a height of 1.5 to 2 metres without protection from herbivores during the wet season.

Regional evaluation trials

Regional evaluation trials were initiated in 1986 in collaboration with the Forage Agronomy Section at headquarters. Forty-seven lines within the genera *Stylosanthes*, *Centrosema*, *Cassia*, *Desmanthus*, *Macroptilium*, *Cajanus*, *Lablab*, *Neonotonia*, *Macrotyloma*, *Leucaena*, *Zoernia* and *Desmodium* were planted in 1-m^2 plots at six environmentally diverse sites (Figure 4). Lablab (I 11609) gave consistently higher biomass yields than all other lines at all sites.

Effect of fertilizer on stylo yields

Soil without protective cover is degraded by the combined effects of direct insolation and impact of rain drops. As organic matter decomposes and soil is eroded, the remaining topsoil will be able neither to meet the nutrient demands of growing plants nor to retain applied nutrients. This is a serious problem on a large proportion of soils in the subhumid zone because they have a shallow petroferric hard pan.

An experiment, started in 1983, examined the effect of applying fertilizer in alternate years on the dry-matter yield of *Stylosanthes hamata* cv Verano. The trial was established on land that had previously been under natural fallow.

In the first year, the fertilized plots yielded an average of 190% more than the non-fertilized plots (Table 7). This yield differential was maintained in the second year, in which no fertilizer was applied. However, yields on all plots were only half those in the first year, despite similar amount and distribution of rainfall.

When fertilizer was again applied in the third year (1985), yields on fertilized plots were about 10 times those on non-fertilized plots. Yields in the fourth year were similar to those in 1985, although no fertilizer was applied.

These effects may be attributed to the greater ability of the soil to retain nutrients in the third year than in the first year. It is likely that some of the nutrients applied in the first year were washed off the plots. When the legumes were established, the soil was bare and its cation exchange capacity (CEC) was low. The higher biomass yields on fertilized plots increased soil organic-matter content and CEC much faster than a natural fallow and this could have aided better nutrient retention in the third year. Erosion was also probably reduced by the stubble on the legume plots after the establishment year.

Figure 4. Sites at which forage germplasm was tested in 1986.

Legume leys may therefore be useful in maintaining soil fertility in the wake of shortening fallow periods in the subhumid zone.

Fodder banks and maize yields

A major constraint to the adoption of fodder banks by pastoralists is that they have limited access to land on which to establish them. Thus, if fodder banks are to be widely adopted they must appeal to the farmers who control the land. Trials started in 1984 demonstrated that maize grown within fodder banks yielded 1.5 to 2.5 t more grain per hectare than maize grown on adjacent continuously cropped land (*ILCA Annual Report 1985/86*), sufficient to encourage farmers to establish fodder banks. This testing was expanded in 1986 to six sites at which farmers carried out most of the cultural operations: results were similar to those obtained in the previous 2 years. Yield increases were equivalent to those obtained by applying 60 to 120 kg N/ha.

The increase in maize yield due to growing the crop in a fodder bank depends on the productivity and duration of stylo grown previously. Since the proportion of

Table 7. Dry-matter yields of *S. hamata* cv Verano as influenced by nutrient additions on a ferric luvisol.

	DM yields (kg/ha)			
Treatment	1983	1984	1985	1986
With nutrients[1]	4920	2380	7383	7420
Without nutrients	1704	816	702	850
LSD (0.05)	621	116	1407	1372

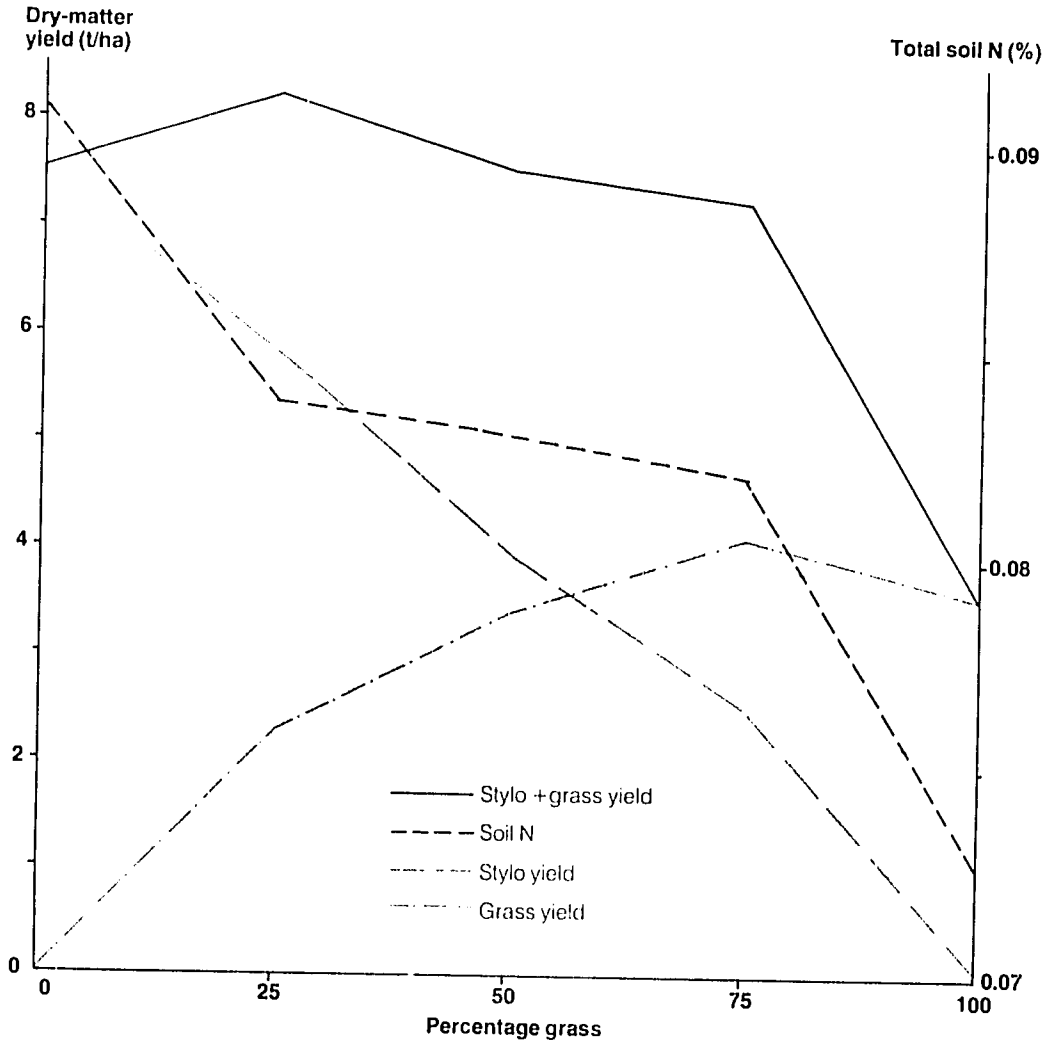
1. Nutrients applied in 1983 and 1985 (kg/ha) – 135P, 50K, 60S, 200Ca, 25Mg, 6B, 6Cu, 0.5Mo, 0.5Co.

stylo in fodder banks managed by pastoralists can vary from 10 to 80%, an experiment was started in 1986 to study the effects of various proportions of grass and stylo on fodder bank productivity and subsequent crop yields. Initial results are presented in Figure 5. The DM yield of grass alone was much lower than that of stylo alone, possibly due to low soil N. The grass yield did not increase linearly with increasing proportion of grass in the pasture, but was higher at each level of incorporation than would be expected from the yield of the grass in pure stand. This suggests some beneficial effect of the stylo/grass association, possibly transfer of N from the legume to the grass. Total soil N at the end of the year was higher when the legume was planted in the pasture (Figure 5). Next year, the effect of the varying proportions of legume in the pasture on a subsequent cereal crop will be determine ' by bioassay.

Effect of stylo alone on maize yields

Clearing virgin or fallow land is arduous and time consuming, so farmers tend to cultivate cleared land continuously. An experiment begun in 1984 at Funa Funa examined the residual effects of growing stylo (*S. hamata*) on the N response and yield of subsequent maize crops. Maize was grown on land that had been either under stylo for 3 years or fallowed. Nitrogen was applied annually at 0, 40, 80 or 120 kg/ha on both areas. Maize grain yield per kilogram of N applied de-

Figure 5. Dry-matter yield and total soil N as affected by grass–stylo mixtures, Kachia, wet season 1985.



clined after the first year on the "stylo soil", while the response of maize to N on the fallowed soil remained constant. By the third year of the experiment (1986) yields on both stylo soil and fallowed soil were similar (Table 8).

Ridging stylo soil that had been cultivated previously required only half as much labour as the initial cultivation (7 vs 14 man days/ha). This should, however, be taken as indicative, because these labour averages are from a few single-year observations at one experiment site. The labour advantage from repeated cultivation must be offset against the higher yield obtained from a new area. Also, repeated cultivation of the same area will deplete the stylo seed reserve in the soil, necessitating replanting.

banks showed considerable variation in the proportion of legume in their vegetation. However, continuous monitoring of an *S. hamata* fodder bank grazed at 2.5, 3.5 and 5.0 AU/ha did not show significant changes in the productivity of the stylo or its proportion in the fodder bank in 1986 as compared to 1985 (*ILCA Annual Report 1985/86*). In 1986, 20 farmers in Abet requested fodder banks for small ruminants.

Effect of fodder banks on herd offtake

Offtake of animals from herds with and without access to fodder banks was studied at Kurmin Biri in 1986. This site was chosen because it has the longest-established fodder banks.

Table 8. Mean (SE) maize grain yield with repeated application of N following 3 years of either *S. hamata* or natural fallow (n = 3 for each mean. The LSDs apply to differences between any pair of means within an area).

N application (kg/ha/year)	Maize grain yield (kg/ha)					
	Stylo area			Fallow area		
	1984	1985	1986	1984	1985	1986
0	2839	1050	839	961	750	578
	(56)	(70)	(97)	(90)	(51)	(48)
40	4706	2533	2269	1722	1956	2278
	(304)	(77)	(176)	(115)	(270)	(15)
80	5792	3133	3069	2800	2756	3097
	(309)	(214)	(73)	(161)	(160)	(147)
120	6114	3622	3528	3225	3422	3531
	(114)	(190)	(137)	(308)	(247)	(209)
LSD (0.05)		476			487	

Livestock studies

Effect of grazing pressure on legume proportion

A major objective in fodder bank management is to maintain a high proportion of legume in the vegetation. Pastoralists seem to be unable to adjust grazing pressures to achieve this, and most fodder banks under pastoralist management are either over- or undergrazed. A rapid survey of all fodder

Herds with access to fodder banks can maintain their size from births alone, whereas those without access to fodder banks would decline in size (Table 9). Herd owners who did not have fodder banks depended on purchases and transfers in to maintain their herd size. They also made more "salvage" sales, often associated with nutritional distress. The greater productivity of herds with access to fodder banks was translated into increased transfers out to herds of relatives rather than sales.

Table 9. Performance of herds with and without fodder banks in Kurmin Biri.

Herd	No.	Births	Purchases	Transfers in	Deaths	Transfers out	Sales	Births as % of exits excluding transfers out
		(% of total entries)			(% of total exits)			
With fodder bank	11	83	5	11	24	19	58	114
No fodder bank	5	52	16	31	23	9	65	63

Source: Calculated from von Kaufmann and Blench (1986).

Sahel Programme

Introduction

Shortage of feed is the main constraint to livestock productivity in the arid and semi-arid zones. The Sahel Programme, based in Mali, focuses its research on increasing the availability and quality of livestock feed. Scientists study regeneration and management of natural grazing in the pastoral system and the introduction of forage crops and agroforestry in the agropastoral system.

Pastoral system

Effect of drought on natural resources

The recent drought in the Sahel, beginning with the low rainfall period starting in 1984 (Table 10), significantly reduced vegetation ground cover, density and biomass (Figure 6). The composition of the flora has also changed: in many grassy savannas of the Niger Delta, the hitherto predominant perennial grasses have been replaced by annuals.

In the Gourma the number of browse trees on the hills and slopes has declined. Most of the herbaceous plants are short-cycle species adapted to the stresses of pasture land or poor soil conditions, including *Cenchrus biflorus*, *Tragus hertheronianns*, *Tribulus terrestris* and *Zornia glochidiata*. In 1983 plant production ranged between 25 and 75 kg DM/ha per day; by 1986 this had fallen to an average of 18 kg DM/ha per day. Over the same period, the seed stock in the top layer of sandy soils in the northern Gourma fell from several thousand viable seeds per square meter to less than 100. The combination of low seed stocks and low yields severely limits rangeland productivity.

A study of regional forage resources centred on testing or ground truthing normalised difference vegetation indices (NDVIs), derived from the red and infrared reflectances sensed by both the NOAA satellite's advanced very high resolution radiometer (AVHRR) and a hand-held radiometer.

Analysis of data obtained in 1985 showed an indirect relationship between NDVI and vegetation biomass (Figure 7). The relationship between biomass and the integrated value of increments of NDVI over time was closer: linear regression gave significant correlation coefficients of $r = 0.62$ for 25 sites and $r = 0.80$ for 13 sandy sites. Atmospheric effects on NDVI were reduced by taking into account cloud cover, haze and other factors, calculating values for seven stations in the region, and selecting compo-

Table 10. Trends in rainfall in the Gourma.

Site (latitude N)	Annual rainfall (mm) 1984	1985	1986	Average rainfall (mm) before 1980
Gourma Rharous (16°35')	47.0	23.3	26.8	158 (48 yrs)
Hambouri (15°17')	154.0	218.9	204.6	411 (42 yrs)
Douentza (14°55')	205.0	317.0	369.4	485 (48 yrs)
Mopti (14°41')	274.8	437.7	400.6	528 (58 yrs)

sited values of NDVI. Interference linked to the nature of the background soil has been avoided by considering separately the results from different substrata.

Structure and productivity of livestock herds

A study aimed at elucidating the effects of drought on the structure and productivity of herds and flocks in the Gourma region of Mali was started in 1986. Data were collected from more than 100 herds and flocks, with a total population of 7500 animals, owned by the main ethnic groups of the region.

Preliminary results indicate that the proportion of small herds of cattle, comprising fewer than 30 head, increased from 4.8% in 1983 to 38.5% in 1986. The proportion of animals in the herds less than 1 year old had fallen by about 50% from their 1983 levels of

Figure 6. Trends in maximum annual standing biomass of three pasture types in the Inner Niger Delta in relation to the water level of the Niger river.

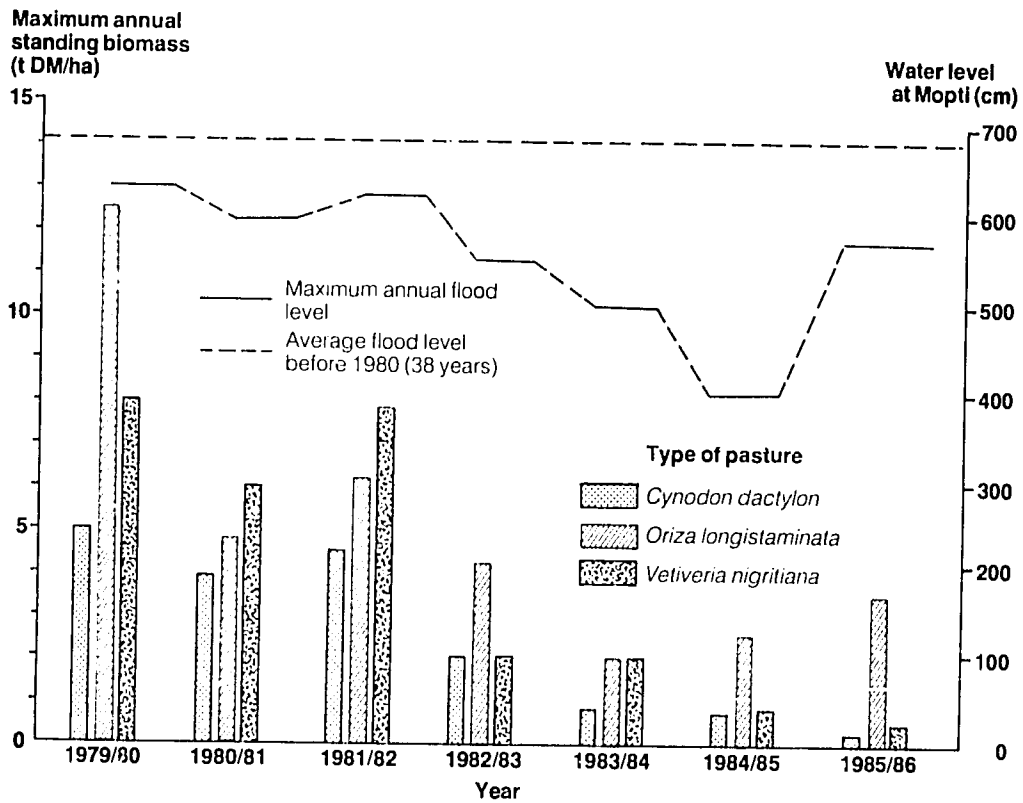
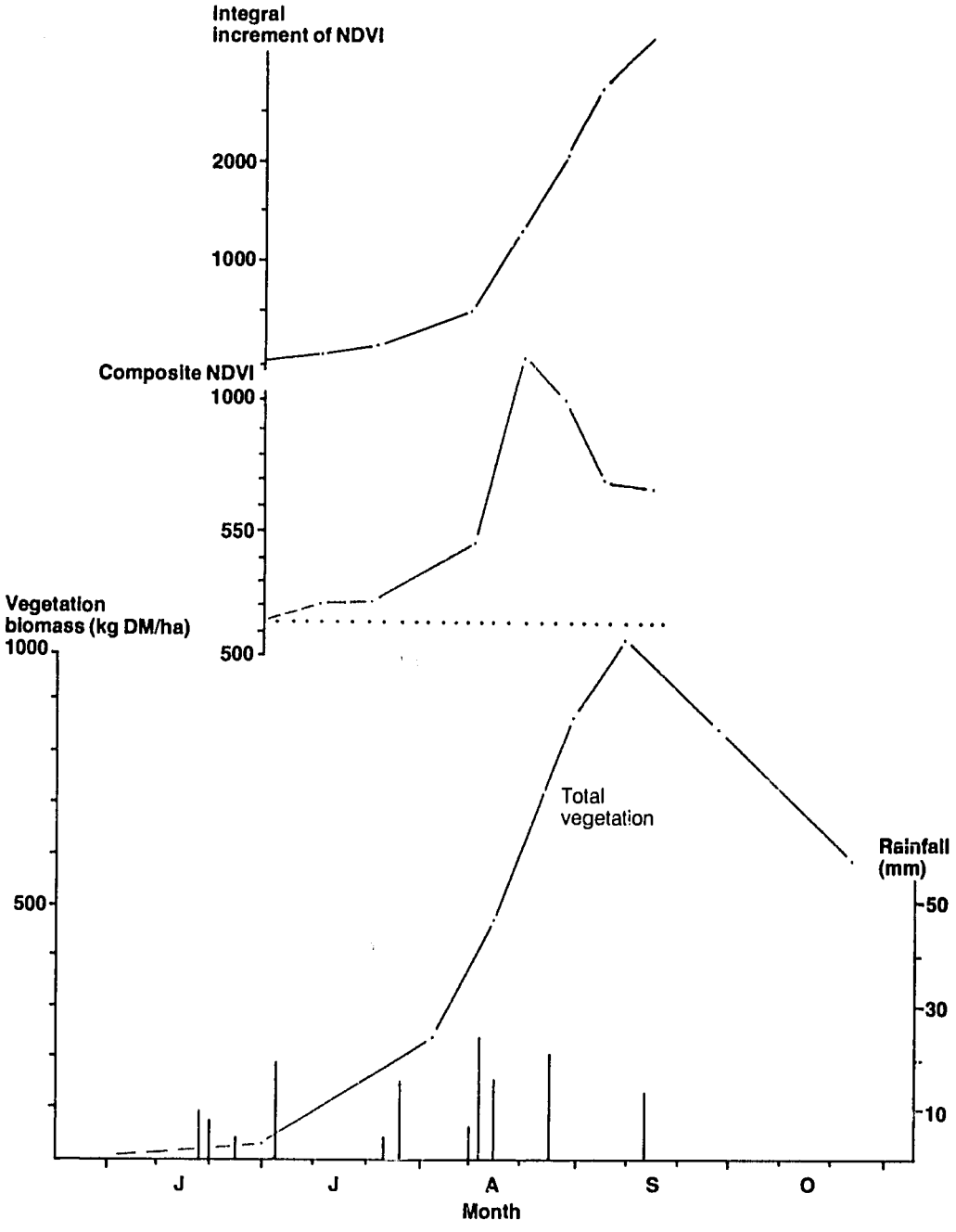


Figure 7. Evolution of above-ground vegetation biomass, rainfall and radiometric indices, central Gourma, 1985.



13.9% for males and 10.5% for females. Reproductive parameters varied very little.

Epidemiology of pneumopathy in small ruminants

Pneumopathic diseases are among the principal causes of the high mortality observed in small ruminants. Treatment is made difficult by the fact that little is known of their etiology. The Programme is attempting to identify the causal agents of these diseases in pastoral herds in the Delta and Gourma regions, in collaboration with the Central Veterinary Laboratory in Bamako, Mali, and ISRA in Senegal. Between February and May 1986, 1700 serum samples were taken from a random sample of animals, some of which showed signs of pneumopathy.

Preliminary results showed pasteurella

antibodies in 214 vaccinated and 171 non-vaccinated animals. *Pasteurella multocida* types A and D were isolated. Some 204 non-vaccinated animals had not been in contact with pasteurella. The serum from 35 cattle reacted positively to Blue Tongue.

The importance of salt licks in the Gourma

During the second half of the year a field study identified 115 salt licks, seven of which were used frequently, and recorded users' perceptions of their value. Of the seven, all were used "medicinally", six to increase fecundity, three for their purgative effects, four to increase lactation and four to increase weight gains of cattle. The use made of these sites by smallholders is also dependent on the size of the herd, the need for certain minerals, the breeding system, and the amount of available vegetation and surface water.

Agropastoral system

Husbandry and herd productivity

Because previous studies have shown differences in productivity between herds within the same production system in the Niono area, a study was started in 1986 to identify the causes of these differences. About 20 cattle herds and a similar number of small ruminant flocks have been identified in each of the millet and rice subsystems. The extent of the grazing orbits of these herds and flocks has been determined and the extent to which the natural pastures affect the feeding of the animals will be determined in 1987.

Small ruminant reproduction

Data collected at the Niono abattoir have shown that, despite the lack of absolute seasonal anoestrus, fertility in small ruminants is lowest between January and April, when there is a shortage of feed. During this period, 47.5% of female sheep and 33.8% of female goats had inactive ovaries. The incidence of early embryonic mortality was low (6.7% in the case of multiple pregnancy), and the period of maximum ovarian activity occurred between July and October, when most twins are conceived.

Intensification of crop/livestock interaction

More feed is needed in the agropastoral system to supplement draught oxen and to fatten animals in the dry season.

The Programme is testing alley farming and fodder bank techniques in the subhumid and semi-arid regions of Mali. Three hundred accessions belonging to the genera *Vigna*, *Stylosanthes*, *Centrosema*, *Desmodium*, *Lablab*, *Clitoria*, *Macroptilium* and *Alysicarpus* are being screened under subhumid conditions. Exotic browse species (17 cultivars of *Gliricidia sepium*, 1 of *Leucaena leucocephala* and 1 of *Prosopis*) and indigenous species (*Acacia*, *Pterocarpus*) are being screened in the semi-arid and subhumid zones, and establishment techniques for 16 indigenous browse species are being studied in the semi-arid zone. An alley farming trial has been established in the subhumid zone, involving maize, gliricidia and leucaena.

The "Embouche paysanne" Project

The *Embouche paysanne* Project, financed jointly by the Mali Government and USAID, is being carried out in conjunction with the Institut national de recherche zootechnique forestière et hydrobiologique (INRZFH) in the semi-arid zone of Mali. This smallholder beef fattening scheme represents an intensification of the traditional agropastoral system.

Dry-season fattening of cattle

As in 1985, data were collected on 125 animals belonging to 31 farmers. The sample comprised 58% Peul Zebu and 39% Maure Zebu; 81% of the animals were castrates. In a 3-month fattening period, the animals gained an average of 0.81 kg/day, compared with 0.58 kg/day over the same period in 1985. The average total weight gain was 73 kg, from a purchase weight of 302 kg to a sale weight of 375 kg.

After deducting production costs, the average net profit per animal, including the value of unsold animals, was 17 400 CFA francs. This average figure masks considerable variations among smallholders: 27% of smallholders made no profit or lost money, while 23% made a profit of 20 000 CFA francs or more per animal.

Studies in 1985 showed that the fattening programme depended largely on cottonseed residues, which have limited long-term availability. An experiment in 1986 studied the effects on production and economic via-

bility of feeding smaller quantities of cottonseed residues to adult castrated zebus, or partly replacing it with other supplements (Table 11).

Although cattle fed a reduced amount of cottonseed residue did not gain as much weight, profitability was increased. Adding molasses/urea or 2 kg of cowpea haulm was not economically justified.

Table 11. Effect of diet on average daily weight gain over 11 weeks in castrated adult zebus.

Coarse fodder (*ad libitum*)	Weight gain (kg/day) when fed cottonseed residue	
	2 kg/day	4 kg/day
Bush hay	0.72	1.01
Bush hay + molasses/urea	1.00	1.12
Bush hay + 2 kg cowpea haulm	0.85	1.04
SE for cottonseed residues	0.0033***	
SE for coarse fodder	0.040*	
SE for interaction	0.057 NS	

Animal traction

The use of animal traction was surveyed in 4 villages comprising 187 smallholders. Although 94% of the smallholders used oxen for soil preparation, 50% of the animals used were either borrowed or hired. Only 46.2% of the smallholders owned two or more oxen, 26.5% owned only one ox and 27.3% did not own any.

Only 21% of the users of draught oxen claimed to have had difficulties in land preparation during the 1986 season, which they attributed to poor nutrition of oxen. Most smallholders (97%) provided supplementary feed for their oxen: the most commonly used supplements were cowpea haulm, bush hay, groundnut haulm and millet bran, used in 85, 65, 60 and 44% of cases respectively.

Forage production

Comparison of different varieties of cowpea and lablab confirmed the results of 1984 and 1985, which showed that these crops have similar dry-matter yields. However, foliage loss in cowpea during the dry season favours the use of lablab if the problems of fodder conservation and labour shortages at harvest time can be overcome.

Poor grain production in lablab remains its principal disadvantage in subsistence agriculture systems. Trials were conducted in 1986 with haricot bean (*Phaseolus vulgaris*) to study the possibility of using this species as a dual purpose crop or as an alternative to cowpea. When sown at four times the density of cowpea (62 000 plants/ha) haricot bean gave haulm and grain yields comparable to those of cowpea.

East African Rangelands Programme

Introduction

The East African Rangelands Programme comprises the former Ethiopian and Kenya Rangelands programmes. The Programme works in the southern rangelands of Ethiopia and among the Maasai pastoralists in Kenya.

Ethiopian rangelands

Poor calf growth has been identified as a major constraint to productivity in the Borana pastoral system, thus calf feeding and forage trials have been established to evaluate the feasibility of interventions. The Programme also collaborated with the ILCA Dairy Technology Unit to investigate possible improvements in traditional milk processing techniques. The Borana studies in Sidamo have been helped greatly by financial assistance from CARE-Ethiopia.

Sidamo rangelands: Productivity interventions

Calf feeding trials

In 1986 a calf feeding facility was constructed to accommodate a research herd of 150 calves and their dams. Traditionally, calves receive about half their dams' milk, are watered every 3 to 10 days and walk up to 10 kilometers while grazing 8 hours per day. A study examined the effects on calf growth of supplementation with lucerne hay (*Medicago sativa*) and provision of extra water superimposed over a simulated regime of traditional management. Six treatments were arranged using two watering levels (traditional and traditional plus 5 litres of water per day) and three levels of hay feeding (0, 400 and 650 g of lucerne offered per day) for about 7 months. Another group received all their dams' milk and no supplements.

Hay and water supplementation had a strong synergistic effect on calf weights at an average age of 40 weeks. Animals that were offered the high level of hay plus extra water weighed 108 kg, 40% more than unsupplemented calves or those receiving supplemental water only (both 77 kg), 32% more than animals that received the high level of hay only (82 kg) and only 5% less than calves that received all their dams' milk (114 kg). The best hay and water treatment also had a large impact on calf price as assessed by six local buyers: animals from the best

treatment were valued at 146 birr (US$ 73.00), 57% more than unsupplemented animals (93 birr or US$ 45.00).

This trial indicates that hay and water supplementation is an adequate alternative to milk consumption, and pastoral families could benefit by higher animal prices without the penalty of reducing milk offtake for human consumption. The data also suggest that strategic water development for young stock must occur if forage improvements are to have a significant impact.

It is encouraging that such effects were observed in a year of excellent rainfall and grass production; larger relative differences are likely in an average rainfall year. The experimental herd will be monitored in 1987/88 to assess the permanency of treatment effects and their influence on time to maturity, and the economics of calf supplementation will be investigated in collaboration with the Livestock Economics Division.

Legume screening and yield trials

Forty-four forage legumes were screened at two sites for productivity under semi-arid conditions, in collaboration with the Forage Agronomy Section. *Stylosanthes hamata* cv Verano yielded 20% more crude protein than *S. scabra* cv Fitzroy or *S. guianensis* cv Graham, despite a slightly lower dry-matter yield. About 10 of the other legumes screened appeared to have good potential, including *Cassia rotundifolia*, *Centrosema* spp., *Macrotyloma africanum*, *Macroptilium* spp., *Vigna heterophylla* and *V. parkeri*.

Milk processing

Data on milk utilisation were collected from 14 Borana families throughout 1986. Over 7 consecutive days in the long rainy season, an average family of five persons with five lactating cows collected about 11 litres of milk per day. About 73% of this was consumed fresh or sold, while the remainder was allowed to sour. Approximately 70% of the soured milk was churned within 5 days to make butter; the rest was fermented for more than 5 days. One litre of whole milk yielded 64 g of butter after 40 minutes of churning with the traditional churn. Milk fat extraction efficiency was reasonably good: the whole milk fat percentage of 4.47% was reduced to 0.75% in the buttermilk at an initial churning temperature of 20°C.

Sidamo rangelands: Resource assessment

Resource assessment in the Sidamo rangelands included inventory of land resources, measurements of seasonal and annual changes in vegetation, livestock populations and land use. A summary of the research is shown in Table 12.

Vegetation trend

Data were collected on twelve 100-m-long transects in 1983 and again in 1986 to assess vegetation change and to evaluate low-cost methods for rapid assessment. The surrounding vegetation was also quantified with an average of 50 observational points at 1-km intervals in the vicinity of each transect. The data are now being analysed.

Ecological mapping

The Programme is preparing an ecological map of southern Sidamo that integrates aspects of climate, soils, landscape and plant community type. The fundamental climatic categorisation includes: Upper and lower subhumid zone (600–800 mm rainfall at 1500–2000 metres above sea level); upper and lower semi-arid (400–600 mm rainfall, 1000–1500 m altitude); and upper arid (300–400 mm rainfall, 900–1000 m altitude). Superimposed over this will be successive classifications of geologic parent material; soil type; landform units; plant community physiognomy; and plant species association within physiognomy types. For each of approximately 30 ultimate vegetation units, research themes and future technical interventions will be prescribed.

Remote sensing to assess primary resources

The Programme has investigated the potential to use data from the NOAA-7 satellite to determine the quantity and distribution of plant biomass and the duration of the growing season. In Ethiopia and Kenya, annual variations in the normalised difference vegetation index (NDVI), derived from satellite data, have a low predictive value for plant biomass. However, NDVI can be used satisfactorily to describe plant phenology and to assist in mapping plant communities. Another potential use of reflectance data is to determine the duration of growing periods. Estimates of the beginning of the growing period

Table 12. General structure of the ecological studies in the Ethiopian rangelands, illustrating relationships among satellite (NOAA), systematic aerial reconnaissance survey (SRF) and ground survey methodologies.

Source of data	Time resolution: Seasonal/annual	Time resolution: Multi-year
NOAA	Plant phenological pattern and length of growing period Spatial distribution of vegetation resources	Regional changes in woody and herbaceous cover
SRF	Correction and calibration of satellite images Distribution and density of human and livestock populations Crop identification, land use	Human and livestock population trends Trends in land use
Ground survey	Site classification, productivity and plant species composition Relation of woody and herbaceous cover to site productivity and utilisation Mechanism of bush encroachment and relation to grazing and soils Relations of bush clearing, cultivation and grazing to site	Local trends in site productivity and plant composition Determination of carrying capacity

based on reflectance data appear to be accurate to within 2 to 3 weeks, while the accuracy falls to 4 to 6 weeks when estimating the end of the growing period.

Animal population and land-use trends

Systematic reconnaissance flights (SRFs) during the pre- and post-drought sequence from 1983 to 1986 revealed the large impact of drought on the Borana cattle population, a 47% drop in 1985, but a lesser impact on camels (−33%) or sheep and goats (−14%) (Table 13). However, the 1986 survey revealed that all populations had recovered to pre-drought levels (Table 13), which suggests that a primary pastoral drought strategy was to move animals out of the southern Sidamo rangelands to more favourable environments, and then return them once the rains began again.

SRF surveys have also revealed that, out of 5000 km^2 of potential arable land and good range in the study area, about 155 km^2 (3%) is now being cropped. There were about 5000 plots scattered throughout the zone, 60% more than observed in pre-drought surveys.

Watering frequency and cattle productivity

The watering frequency trials at Abernosa ranch in the Ethiopian Rift Valley and at Galana ranch in Kenya were modified in 1986 to include walking and night enclosure since these are normal husbandry practices in pastoralist areas. Walking 40 km every third day had little effect on the productivity of breeding and growing cattle, despite being continued throughout the dry season and totalling more than 3000 km. Walking apparently had little effect on milk yield, as indicated by the lack of differences in weaning weights between calves from dams that walked or did not walk. Weaners that walked were 20 kg lighter at 19 months than those that did not walk, although much of this weight difference had disappeared at 24 months of age.

Table 13. Pre-drought (1983), drought (1985) and post-drought (1986) livestock populations in the southern Sidamo rangelands.

Date	Cattle		Sheep and goats		Camels	
	Total (± SE)[1]	No./ha	Total (± SE)	No./ha	Total (± SE)	No./ha
March 1983	241 882 ± 26 607	15.5	80 910 ± 10 518	5.2	5235 ± 994	0.3
March 1985	129 632 ± 16 852	8.3	69 321 ± 9 704	4.5	2411 ± 578	0.2
July 1986	242 944 ± 29 153	15.7	101 722 ± 11 189	6.6	5103 ± 1071	0.3

1. Standard errors calculated using Method 2 in: Jolly G M. 1969. The treatment of errors in aerial counts of wildlife populations. *East Afri. Agric. For J.* 34:50–55.

At Galana ranch no weight differences were observed between steers given water daily and those given water every second day, but after 17 months in the trial steers watered every third day were 20 kg lighter than those in other treatments. The magnitude of the compensatory growth under daily watering is currently being investigated. The combination of night enclosing, a 3-day watering interval and prolonged dry-season trekking had no effect on calving percentage, age at first conception or mature weight of steers when the quantity of dry-season feed was not limiting.

Kenya rangelands

ILCA's research on range livestock systems in Kenya is conducted among the Maasai pastoralists. In 1986, the Programme concentrated its efforts on four projects:

- Use of simulation models to assess the long-term productivity of the Maasai pastoral system;
- Component research in Maasailand on some of the constraints identified by the 1981–84 systems study, in collaboration with the National Range Research Station;
- On-farm research to increase livestock productivity in small-scale mixed farming systems of semi-arid regions, in collaboration with the National Dryland Farming Research Station; and
- Designing and testing calibration methods for remote-sensed data to monitor the distribution of vegetation biomass and phenology.

Modelling the long-term productivity of the Maasai pastoral system

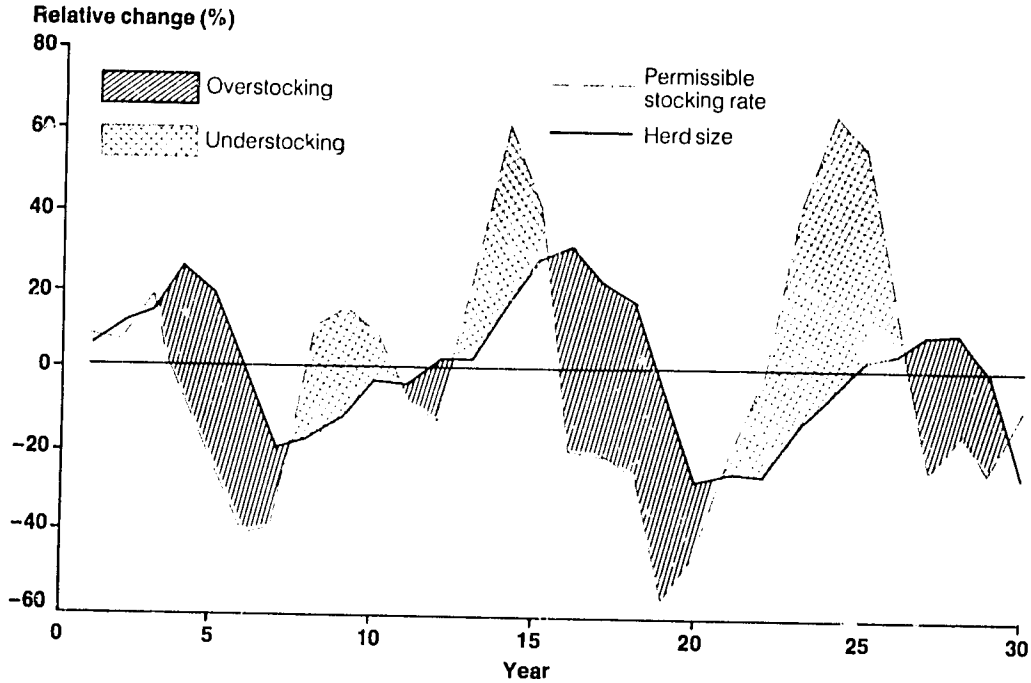
Over the last 100 years the East African rangelands have suffered drought at least once in every 8 to 12 years. This causes enormous fluctuations in the productivity of pastoral livestock systems. Thus, short-term studies, such as that conducted by the Programme between 1981 and 1984, cannot provide a clear picture of the dynamics of pastoral livestock production.

In order to overcome this limitation, the Programme in 1986 used simulation models to estimate the long-term productivity of the Maasai system. A water-balance model was used to estimate primary productivity of the range, using rainfall records for the years 1950 to 1980. These estimates were then used with a simulation model of cattle production to determine secondary production. The area considered was a 10 000-hectare group ranch.

The results indicate that the permissible stocking rate of the range is rarely matched by the size of the herd on the ranch (Figure 8). The ranch is generally overstocked until a major drought causes the livestock population to fall, resulting in a period of understocking and range recovery. The ranch herd increases gradually during this period, soon exceeding the permissible stocking rate. The range remains overstocked until the next major drought.

Estimated animal production ranged from 38 kg liveweight/TLU (33 kg/ha) in years of favourable rainfall to a net loss of 22 kg/TLU (–15 kg/ha) in drought years, with a 28-year mean of 24 kg/TLU (16 kg/ha).

Figure 8. Simulated relative changes in herd size and permissible stocking rate on a Maasai group ranch over a 30-year period.



Annual milk offtake was much less variable, and ranged from 17 kg/ha in good years to 10 kg/ha in drought years, with a mean of 13 kg/ha. The lesser variation was due to large-scale producers extracting as little as 27% of the potential milk yield of their cows during normal and favourable years.

In general, small-scale producers with 30 cattle or less extract as much milk and meat from their herds as possible. The long-term animal offtake of small-scale producers was about 14% of biomass, compared with only 6% for producers with 300 cattle or more. Milk offtake followed a similar pattern: small-scale producers extracted almost 100% of the potential production of their animals, compared with about 70% for large-scale producers. As a result, the average return on capital invested in livestock was 24% for small-scale producers and 9% for large-scale producers. The rate of return realised by large-scale producers is low because they invest as much as 55% of their annual biomass production in stock accumulation, which is lost when major droughts occur.

These results indicate that there is considerable scope to increase the productivity of large herds by increased exploitation of production, while the productivity of small herds can only be increased by intensifying production, using forage conservation, feed gardens and improved calf rearing and animal health care.

A model was also used to simulate the long-term impact on large-scale producers and on the ranch as a whole of increasing sales of animals from the large-scale herds by selling all steers 5 years or older (Table 14). The results imply that annual offtake from each herd could be increased from 17 to 29 head, which would reduce the cattle population on the ranch by 21% and reduce grazing pressure. Liveweight production of the ranch would increase by about 40%/TLU and 70%/ha. The long-term return to capital invested in livestock would increase from 9 to 14% for large-scale producers, and from 11 to 15% for the ranch as a whole.

This analysis suggests that encouraging increased offtake from large herds will increase their productivity more quickly and cost-effectively than will technical improvements.

Component research in Maasailand

In 1986, component research was started in Maasailand to investigate ways to overcome constraints identified in the 1981–84 sys-

Table 14. Simulated impact of increased sales off'ake on annual herd productivity, Olkarkar Group Ranch.

Parameters	Large-scale producers			Ranch		
	Normal	Increased	Change (%)	Normal	Increased	Change (%)
Number of animals sold	17	29	70	399	593	49
Number of animals dead	39	37	−5	729	699	−4
Herd size	392	293	−25	7275	5730	−21
Stocking rate (ha/TLU)	n.a.	n.a.	n.a.	1.5	1.9	27
Liveweight offtake						
kg/TLU	19	30	58	23	33	43
kg/ha	n.a.	n.a	n.a.	16	17	7
Net output						
KSh/caput	2715	3040	12	1945	2090	9
KSh/TLU	80	130	62	103	145	45
KSh/ha	n.a.	n.a.	n.a.	70	89	29
Return to livestock/ capital % p.a.	9	14	56	11	15	36

n.a. = not available.

tems study. Most of the work concentrates on increasing the supply and improving the quality of feed available during the dry season. Other aspects include improving animal health and trials at the National Range Research Station, Kiboko, on the use of Galla goats to increase the availability of milk to poor households.

On-farm component research in semi-arid mixed-farming systems

The Programme is collaborating with the National Dryland Farming Research Station (NDFRS), Katumani, in on-farm testing of livestock-oriented interventions in the Machakos District. Collection of detailed data on labour availability and inputs, forage supply and grazing and feeding management was started on five farms at Matiliku early in 1986.

These data, together with data sets from earlier research by the NDFRS, will be used in linear programming and simulation models to estimate the impact of new technologies. Threshold levels at which new technologies become attractive will be compared with results of on-farm technology trials.

Calibration of remote-sensed data

The ILCA/UNEP AVHRR (advanced very high resolution radiometer) Calibration Project was established in July 1985 to design and test methods of calibrating normalised difference vegetation index (NDVI) data derived from the AVHRR mounted on the NOAA-7 satellite, and to determine the accuracy of these data for use in monitoring the distribution of vegetation biomass and plant phenology.

The areas covered by aerial survey flights comprise two transects, one from Kisumu on Lake Victoria to Malindi on the coast, the second from Nairobi to Lodwar, west of Lake Turkana, and four blocks, one in each of Kajiado, Maasai Mara, Lodwar and Kora. These transects and blocks cover the full range of environmental conditions in Kenya, from moist forest to desert scrub.

Survey flights have been flown over these transects and blocks every 2 months since July 1985. Vertical photographs and radiometer readings ("aircraft NDVI") were taken simultaneously during the surveys and used to determine which vegetation parameters measurable from aerial photographs are most closely correlated with aircraft NDVI.

When the data from the Kisumu-Malindi transect were averaged over 20-km segments, a very high correlation was found between aircraft NDVI and a ground cover/greenness index[1] derived from aerial photographs. A good correlation was also found between satellite NDVI data and aircraft NDVI, indicating that satellite NDVI data give a good indication of plant cover and greenness.

In the large blocks, aircraft NDVI was also significantly correlated with the cover x greenness parameter. Soil type and cloud shadows did not have a significant effect on this relationship, although in areas with no vegetation, dark soil appears to increase the minimum NDVI slightly.

Multiple regression analysis indicated that, in rangeland areas, green woody and green herbaceous vegetation make equal contributions to NDVI.

1. Ground cover/greenness index is calculated as woody cover x woody greenness + herbaceous cover x herbaceous greenness.

Central research and support units

Livestock Productivity and Trypanotolerance Group

Introduction

The work of the Livestock Productivity and Trypanotolerance Group emphasises research on trypanotolerant livestock, with the Group coordinating collaborative research in the African Trypanotolerant Livestock Network at sites in West, central and East Africa. Research on livestock productivity comprises comparative breed studies in cooperation with national organisations, private producers and other international organisations. Training and documentation are vital components of both work areas. In 1986 the Group carried out research in close cooperation with organisations in 11 African countries.

Trypanotolerance research

The African Trypanotolerant Livestock Network

The African Trypanotolerant Livestock Network groups together scientists studying one of the most promising of the possible solutions to the problem of African animal trypanosomiasis, the increased utilisation of trypanotolerant livestock. In collaboration with national research and development institutions and private organisations, an extensive network of research sites has been established in different trypanosomiasis areas throughout tropical Africa in order to study the complex interactions that affect trypanotolerance. Scientists from the different sites receive standardised training and work to a uniform protocol following a single working manual.

Table 15 shows the distribution of the field programmes that contributed to the Network during 1986. It illustrates the wide range of combinations of tsetse populations and livestock systems on which data are being collected. In addition, complementary information was analysed from a completed programme at an associated network site in Tanzania.

Detailed analyses were carried out during 1986 at the eight sites having data covering at least the 2-year period, 1 January 1984 to 31 December 1985 (see Table 15). The following sections summarise the principal results from the Network.

Table 15. Tsetse and livestock populations at the network sites, 1986.

Site	Country	Tsetse group	Relative tsetse challenge	Livestock		
				Species	Type	Management system
Kolo[1]	Zaire	*palpalis*	Zero	Cattle	Trypanotolerant	Ranch
Avetonou[1]	Togo	*palpalis*	Zero/low	Cattle Sheep	Trypanotolerant Non-trypanotolerant	Ranch and village Village
Sokode[1]	Togo	*palpalis*	Low	Sheep and goats	Trypanotolerant	Village
Tengrela[1]	Ivory Coast	*palpalis*	Low	Cattle and sheep	Trypanotolerant and non-trypanotolerant	Village
Boundiali[1]	Ivory Coast	*palpalis*	Medium	Cattle and sheep	Trypanotolerant and non-trypanotolerant	Village
Idiofa	Zaire	*palpalis* and *fusca*	Low	Cattle	Trypanotolerant	Village
OGAPROV[1,2]	Gabon	*palpalis* and *fusca*	Medium	Cattle	Trypanotolerant and non-trypanotolerant	Ranch
Mushie[1]	Zaire	*fusca*	Medium/High	Cattle	Trypanotolerant	Ranch
Muhaka[1]	Kenya	*morsitans* and *fusca*	Low	Cattle	Non-trypanotolerant	Village
Ghibe	Ethiopia	*morsitans* and *palpalis*	Low	Cattle	Non-trypanotolerant	Village
ITC[3]	Gambia	*morsitans* and *palpalis*	Low and medium	Cattle	Trypanotolerant	Village

1. Site contributing to overall analyses of the period 1 January 1984 to 31 December 1985.
2. OGAPROV = Office gabonais d'amélioration et de production viande.
3. ITC = International Trypanotolerance Centre.

Tsetse challenge

Tsetse challenge is measured as the product of tsetse relative density and the trypanosome infection rates in tsetse, modified, where possible, by the proportion of tsetse feeds obtained from livestock. For the eight sites, mean tsetse relative density during 1984 and 1985 ranged from 0.1 to 6.8 flies/trap per day and mean infection rate from 0.0 to 16.3%, giving a range of tsetse challenge from 0.0 (Kolo) to 86.2 (Mushie). At selected sites, tsetse blood-meal analysis was used to estimate the proportion of feeds taken on cattle. For example, at Mushie the proportion of feeds on cattle was 0.43, giving a modified tsetse challenge of 37.1. This modified tsetse challenge will be the index used to quantify relative tsetse challenge at network sites.

Trypanosome prevalence

Trypanosome prevalence (the percentage of animals determined as being parasitaemic at the monthly recording) is the Network's measure of trypanosome infection rate in livestock. Across the eight Network sites there was no clear relationship between mean monthly estimates of tsetse challenge and trypanosome prevalence. The lack of relationship is due, in part, to differences in tsetse species among sites. Local variation in the tsetse challenge to which animals are exposed is also important, as shown by results from the northern Ivory Coast programme in which trypanosome prevalence in cattle and in sheep at the herd/flock level was significantly related to the tsetse challenge measured locally.

Factors influencing trypanosome prevalence included livestock species. N'Dama cattle had about 2 to 3 times more infections than Djallonke sheep when maintained together, while Djallonke sheep and Dwarf West African goats had the same level of infection. Cattle breed also had an important effect on trypanosome prevalence, with major differences shown at OGAPROV (Office gabonais d'amélioration et de production de viande) (N'Dama 8.8%, Nguni 25.9%, N'Dama x Nguni 16.5%) and between trypanotolerant and zebu crossbred populations at Boundiali and Tengrela.

Trypanosome prevalence was consistently lower in the trypanotolerant breeds.

Neither age nor lactational status had any effect on trypanosome prevalence in cattle but age may be important in sheep, as adults had higher prevalences than young stock.

Species and intensity of trypanosome infection

Trypanosome infections are identified by the causal species, *Trypanosoma congolense*, *T. vivax* and *T. brucei*, and the intensity quantified by a parasitaemia score. Important differences were found among livestock species, breeds and age groups for the proportion of infections due to the trypanosome species *T. congolense* and *T. vivax*.

Trypanosoma congolense infections were more frequent in cattle and *T. vivax* infections more frequent in sheep (Figure 9). Sheep and goats had the same species and intensity of infections. Livestock species did not seem to affect the intensity of infection, which was higher in *T. vivax* than in *T. congolense* infections.

In Ivory Coast, zebu cattle had a higher frequency of *T. congolense* infections than the trypanotolerant breeds, while in Gabon the more susceptible Nguni had a lower frequency of *T. congolense* infections than the N'Dama and N'Dama x Nguni. The Nguni had the highest intensity of infection and the N'Dama the lowest.

Results from seven Network sites showed the importance of animal age on the species of infection. The proportion of *T. vivax* infections decreased with age, with calves generally having more *T. vivax* than *T. congolense* infections while the reverse was true in cows. The same effect was observed in sheep.

Trypanosome infection and PCV

A major clinical symptom of trypanosomiasis is anaemia, estimated by blood packed red cell volume (PCV), which is recorded monthly in the network. Results for PCV measured in cows at three network sites are summarised in Table 16. Mean PCV of uninfected cows varied between sites by 2 to 4 percentage points (overall mean 32.8%), but responses to trypanosome infection were similar, a depression of 6.8% on average (2.2 percentage points). Results from Mushie site indicated that there was no difference in pathogenicity between *T. congolense* and *T. vivax* infections. Frequency of infection was more important. PCV was depressed by 1 to 1.5 percentage points (3 to 4%) by one *T. congolense* or *T. vivax* infection, and by 4 percentage points (11%) by two or more infections. The effects of trypanosome infection on ewe PCV were consistent with those for cattle. However, PCV means were lower in sheep than in cattle.

Breed had important effects on PCV. Among cows exposed to trypanosomiasis at the OGAPROV site the N'Dama Okouma strain had the highest PCV (33.3%), the N'Dama Senegal strain an intermediate value (31.3%) and the more susceptible Nguni the lowest PCV (30.5%). N'Dama x Nguni cows had a PCV of 31.6%.

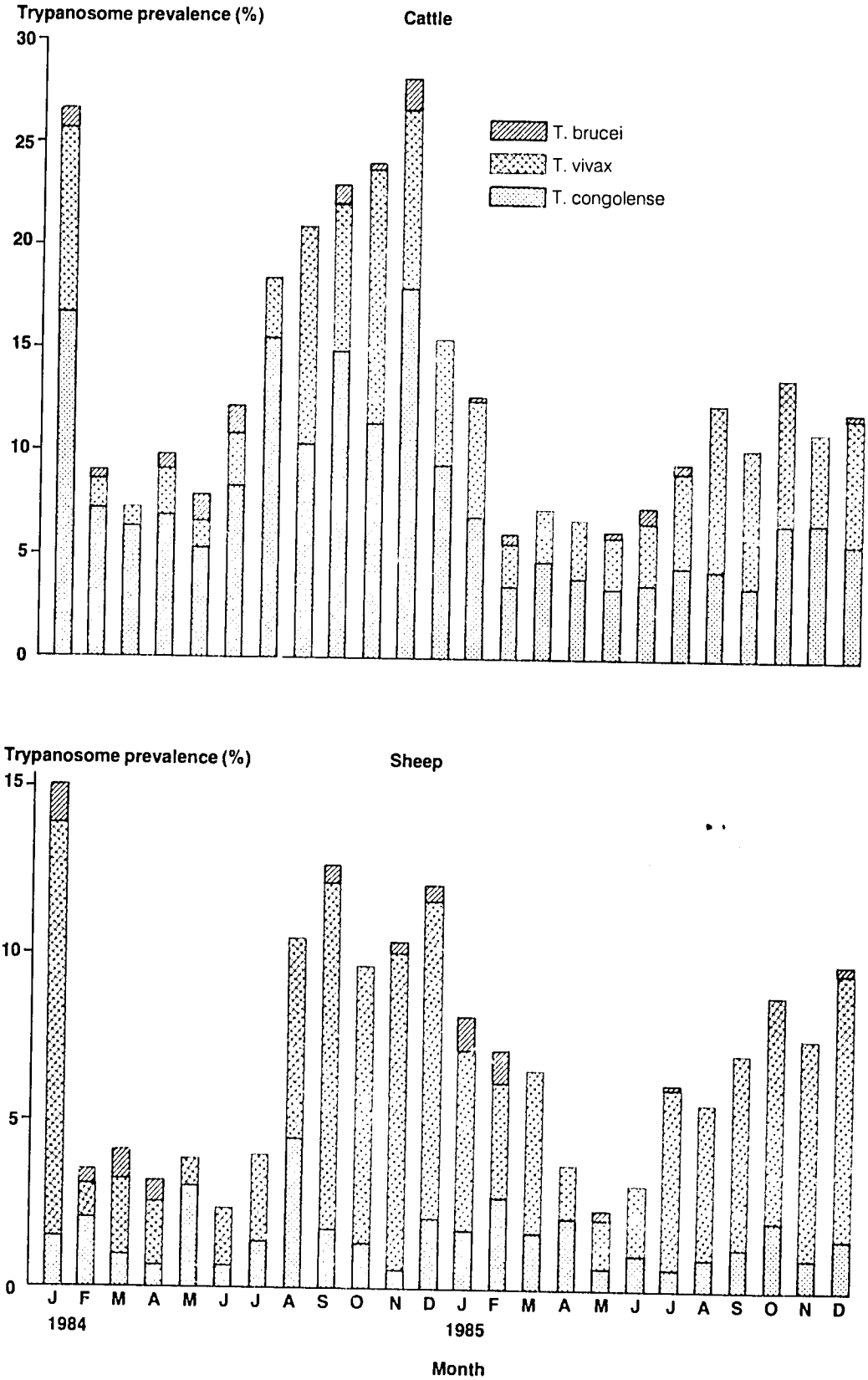
Lactation, calf sex and animal age also had important effects on PCV: Lactation depressed PCV by about 2 percentage points; the PCV of female calves was about 1 percentage point higher than that of males; and cows had higher PCV than calves when not exposed to trypanosomiasis (Kolo), but calves had marginally higher PCV than cows when exposed to trypanosomiasis (Mushie) (Figure 10). This age x trypanosomiasis risk interaction for PCV indicates the persistence of PCV depression resulting from trypanosome infection. Some internal and blood parasites other than trypanosomes had major effects on PCV levels in cattle and sheep. Nutritional status may also have been important.

The repeatability of the monthly PCV measured in cattle in contrasting situations ranged from 0.26 to 0.36, indicating the possibility of a heritability estimate adequate for a selection programme for trypanotolerance. The most appropriate selection criterion based on PCV must now be identified. Repeatability of trypanosome infection was low with no possibility of selecting directly against susceptibility to trypanosome infection.

Trypanosome infection and livestock productivity

Viability of trypanotolerant cattle exposed to trypanosomiasis was at least as good as that in comparable management systems in tsetse-free areas, including that of N'Dama

Figure 9. Infections by trypanosome species in cattle and sheep, Boundiali, Ivory Coast, 1984–85.



(Cont. on page 37)

ILCA's strategy and long-term plan

The mandate

ILCA's formal mandate is ... *to assist national efforts which aim to effect a change in the production and marketing systems of tropical Africa so as to increase the sustained yield and output of livestock products and improve the quality of life of the people of this region.*

"Tropical Africa" is a big place and "livestock products" covers a multitude of possibilities. The continent's livestock sector is beset by a complex of technical, social, economic and institutional constraints.

ILCA is a relatively small organisation, with limited manpower and funds. It cannot simultaneously address all the livestock-related problems in a region of the size and diversity of tropical Africa.

Obviously, ILCA's ultimate goal is to fulfil the Centre's formal mandate, but as the wording of the mandate suggests, ILCA is not intended to achieve its aims by working in isolation, but rather to pursue them in collaboration with Africa's national efforts. A number of intermediate goals have been identified in areas that ILCA can be expected to influence directly. These intermediate, or operational, goals are:

- to strengthen the ability of NARSs to conduct technical and policy research in livestock-related fields and thus to develop their own technical solutions to production problems and to promote livestock and rural development.
- to develop, through ILCA's research and that of other organisations, technical packages to increase livestock production and the contribution of livestock to agricultural production and income.
- to contribute to scientific knowledge in a way conducive to solutions to livestock production problems; such knowledge may relate to the understanding of production constraints and opportunities, or to research methods and techniques.

These operational goals form the basis against which ILCA's success will be measured.

The concept of success measurement constitutes another focus: in the absence of a single measurement of success, any focussing of the research activities will be tend to be illusory. The Centre has selected a single concept of success that will be used to evaluate all activities: an increase in the sustainable economic output of livestock products.

Strategy statement

Recognising the Centre's limited financial resources and the number and complexity of factors affecting livestock production in Africa, ILCA's strategy is to choose a limited number of activities that will achieve measurable and sustainable increases in livestock output in sub-Saharan Africa.

Fundamental choices

To complement these operational goals, focussing the Centre's activities has required that ILCA makes a series of fundamental choices of those species, target groups, zones and commodities/functions on which ILCA's scientists will concentrate their efforts. The choices made are outlined in Figure 1.

Figure 1. ILCA's research priorities.

Species	**Cattle, Sheep, Goats** Camels, Equines, Pigs, Poultry, Unconventional Species, Fish
Target Groups	**Smallholders, Agropastoralists** *Pastoralists* Ranchers
Zones	**Semi-arid, Subhumid, Humid, Highland** Arid
Products	**Meat, Milk, Traction, Manure** Transport, Hides, Skins, Fibres, Eggs

Bold = High priority; *Italics* = Medium priority; Light = Low/no

Project selection

This operational mandate forms the framework within which ILCA will work, but still leaves considerable room for flexibility in choosing specific projects. Even with this narrower operational mandate, criteria are needed with which to select individual projects.

The criteria that we have developed are:

- Is the problem a researchable one? If so, where does it lie in the research spectrum, and how widely applicable will the research results be?
- In the light of its past experience and current resources, does ILCA have an advantage over other institutes that might work on a given topic?
- Can we find organisations, within or outside ILCA's mandate region, that are both able and willing to work with us so as to increase the scope of our research on a given topic and to broaden its impact?

- Can ILCA command the scientific staff and facilities needed to tackle a given research problem?
- Is the research likely to have a sizeable impact commensurate with one or more of ILCA's operational goals?
- Will the research contribute to an improved production system that is at once sustainable ecologically and stable in terms of economic return?

Using these criteria, ILCA has formulated its work programme for the next 5 to 10 years, based on six "thrusts".

Six thrusts

ILCA's work in the coming years will focus on six thrusts:

- Cattle milk and meat
- Small ruminant meat and milk
- Animal traction
- Animal feed resources
- Trypanotolerance
- Livestock policy and resource use

The first three are "commodity thrusts", in that they aim at increasing the output of the three products, milk, meat and traction. The other three are "strategic thrusts", which will support the commodity thrusts by providing inputs of information and/or technology.

Cattle milk and meat

ILCA's research under this thrust will concentrate on the subhumid, humid and highland zones of Africa. Each of these offers major opportunities for large increases in cattle milk and meat production, although in different respects and over different time-scales. The subhumid zone offers the best possibilities for increases in the short to medium term, because it has reasonable potential for feed production, low trypanosomiasis pressure, relatively sparse population and a relatively large existing cattle herd. The potential for increased cattle production in the humid zone is vast, but is unlikely to be realised immediately: the main constraint at present is diseases, primarily trypanosomiasis and dermatophilosis. Before the potential of this zone can be realised, disease must be overcome, the most obvious solution at present being increased use of trypanotolerant cattle breeds. The opportunities to increase meat production in the highlands of East Africa are limited, because these areas are already well supplied with meat, but there are major possibilities to increase milk production if forages can be incorporated in cropping patterns.

The major topics that will be addressed in this thrust are:

- evaluation of the genetic potential of cattle breeds and their crosses for milk and meat production;
- use of forage legumes to support both crop production and a dairy enterprise;
- development of feeding systems for dairy cows and fattening cattle;
- reduction of reproductive wastage and young-stock losses;
- development of simple milk processing techniques to promote the marketability of dairy produce;
- use of trypanotolerant stock to launch pilot smallholder milk production projects in the humid zone;
- policy and institutional factors determining successful smallholder milk and meat production and marketing;
- investigation of social and economic obstacles to increased milk production and consumption.

Small ruminant meat and milk

Meat and milk from small ruminants are important both for subsistence and as potential sources of additional income for resource-poor smallholders. The small body size, high reproductive rate and rapid growth of sheep and goats makes it easy to integrate these animals into production systems. There are three major zones on which research will concentrate: the semi-arid zone, where most small ruminants are now raised and where there is a large potential for exporting live animals to other zones; the highlands, which offer considerable scope for producing and marketing sheep; and the humid zone, which has both markets and high potential for forage production.

The major topics to be addressed by this thrust are:

- evaluation of small ruminant genetic resources in order to identify appropriate breeding strategies;
- identification and testing of suitable browse and forage legumes for smallholder production systems;
- use of improved management and feeding practices to reduce disease risk and increase productivity;
- investigation of the extent and causes of reproductive wastage and testing of possible solutions;
- impact of improved production systems on farm income and producer welfare;
- analysis of social and economic factors affecting technology uptake.

Animal traction

Althought estimated to account for nearly one third of the total value of livestock outputs in sub-Saharan Africa, only 10 to 15% of Africa's farmers are thought to use animal traction at present. Most draught animals are in the semi-arid and highland zones, where they are used primarily for ploughing and threshing, but little else.

Previous attempts to introduce or increase the use of animal traction have given poor results, mainly due to lack of inputs, inappropriate technologies and inadequate nutrition of the draught animals. If the use of draught animals is to persist once introduced, a number of conditions must be met. First, investment costs for both animals and implements must be low. Second, there must be opportunities for intensifying and diversifying the applications of animal traction. Third, farmers will have to learn animal management skills in addition to cultivation techniques, and, if extension staff are to provide useful advice, they too will have to be trained. Fourth, the problem of animal nutrition will have to be addressed through low-cost inputs to increase the efficiency of draught animals, and appropriate animal health packages will be needed to protect them against disease.

The research under this thrust falls into two categories:

- intensifying and diversifying the use of animal traction in the highland and semi-arid zones; and
- examining the constraints to the adoption of animal traction in those zones where it is not used at present, primarily the subhumid zone, and the introduction of packages that combine all the inputs needed to overcome the constraints identified.

The major topics to be addressed are:

- adaptation and testing of low-cost implements to improve farm operations and benefit soil/water management;
- assessment of working efficiency at low feeding levels and testing of strategic supplementary feeding;
- impact of improved animal traction technology on food production and farm income;
- development of efficient triple-purpose (draught, milk and meat) animal production enterprises;
- integration of crop and livestock production through improved use of manure;
- diagnosis of technical, social and economic constraints to the use of draught animals in the subhumid zone;
- creation of complete packages (including credit, veterinary services, etc) for introducing animal traction to new areas.

Animal feed resources

Feed shortage in the dry season, and even in the wet season, is a major constraint to animal production in all zones except the humid. Even where feed is plentiful, it may not provide a balanced diet, or may be inefficiently converted into animal products. To increase the availability and quality of feed, packages are needed that combine a variety of feed resources, including forage legumes, fodder trees, crop residues and agro-industrial byproducts, as well as other existing feed resources. The aim of this thrust is to develop and evaluate suitable forages and other feeds, as well as to increase the efficiency with which existing and new feed resources are utilised.

The research activities of this thrust will be:

- acquisition, storage, screening and evaluation of forage germplasm of potential value to smallholder production systems;
- identification of entry points for forage legumes and multi-purpose fodder trees in traditional farming systems;
- investigation of soil-plant-water-nutrient relationships in order to increase forage and food crop yields;
- response of legumes to rock phosphate or other low-cost fertilizers;
- determination and improvement of the nutritive value of new and existing feed resources in order to develop improved feed packages;
- ability of selected feed combinations to increase animal production through improved rumen function and feed conversion;
- development of grain crop varieties with increased feed value of the residue as well as higher grain yield;
- investigation of economic and institutional factors inhibiting the optimum use of feed resources.

Trypanotolerance

Trypanosomiasis, transmitted by the tsetse fly, inhibits animal production an area of humid and subhumid Africa larger that the USA. Small populations of cattle, sheep and goats tolerant of the disease are found in this area. If these trypanotolerant animals are to play their part in meeting West and central Africa's large and growing demand for meat and milk, more needs to be known about the conditions determining their successful use. Information is needed on genetic and acquired resistance, environmental factors affecting susceptibility and the efficacy of control measures, as well as further studies on the productivity of the trypanotolerant breeds themselves.

The research in this thrust will thus be concentrated in the humid and subhumid zones, and will address the following topics:

- collection and analysis of data on the productivity of trypanotolerant breeds under varying levels of trypanosomiasis risk;
- identification of more reliable indicators of trypanosomiasis risk;
- definition of a selection criterion for trypanotolerance, in order to devise optimum breeding programmes;
- evaluation of the costs and benefits of selected tsetse control measures and their interaction with prophylactic drugs;

- testing of nutritional interventions to improve livestock productivity in tsetse-infested areas;
- study of the effects of trypanocidal drugs in order to determine appropriate interventions in areas of medium to high trypanosomiasis risk.

Livestock policy and resource use

Better policies and resource management are crucial to livestock development in Africa. Policy problems are ubiquitous and broadly similar in kind throughout the continent. However, there is a need to compare the experiences of different countries in their search for solutions, since these will often vary according to the natural and socio-economic environment. Problems of resource use, on the other hand, are at their most acute in the semi-arid and arid lands, where the long-term future of agriculture appears to be threatened. Here there is a need to develop better methods to assess both resources and long-term productivity trends, and to improve the role of livestock in stabilising and sustaining farm income and crop production in marginal areas.

Research activities in this thrust will therefore concentrate on cross-country comparison of the critical policy issues affecting technology uptake, and on the sustainability of crop and livestock production, especially in marginal areas. The major research topics to be covered include:

- ways in which government policies influence the use of inputs and the adoption of technology by producers;
- effects of government policies on the stability and sustainability of mixed farming in marginal areas;
- the role of livestock in stabilising and sustaining farming systems in the semi-arid zone;
- development of low-cost methods to assess long-term productivity trends in the semi-arid and arid rangelands;
- the role of credit in technology adoption by livestock producers;
- relationships between land tenure and other factors affecting technology adoption;
- social and economic factors affecting the demand for livestock products;
- financing of livestock services;
- effects of meat and milk pricing policies on production by smallholders and pastoralists.

Training and information

The four major concepts that govern ILCA's training and information activities are that:

- they should be based on needs expressed by NARSs;
- in most cases they should be closely related to our chosen thrust areas;
- ILCA has a role to fulfil in bringing skills and information to Africa from other parts of the world; and
- there must be a two-way flow of information between ILCA and NARSs.

Training

The focus of ILCA's new strategy is on collaborative research and a network approach. For this to be successful, NARS staff must be adequately trained to make them effective partners in the work. In the short term we will therefore concentrate on training young African scientists in research techniques.

As ILCA's research programme generates more technology, the emphasis will shift towards training technicians in adapting and transferring technologies. It is hoped to achieve this primarily through "training the trainers".

Most training will be closely tied to ILCA's research thrusts. However, in collaboration with other institutes, ILCA will continue to offer courses on some additional subjects which are believed to be vital for the development of livestock production in Africa.

Publishing

ILCA's publishing activities were set up primarily to disseminate its research results to NARSs. They also serve, however, as a means by which NARSs can communicate with ILCA.

The main emphasis in the future will fall on supporting our research thrusts by publishing research results and providing training materials. To promote the two-way flow of information, we will encourage national scientists to contribute to ILCA publications, such as the ILCA Newsletter and the ILCA Bulletin, in addition to the network newsletters.

Documentation

African NARSs often lack adequate access to information on livestock production. ILCA provides a comprehensive range of services, including selective dissemination of information, current titles and the provision of microfiches/photocopies, to disseminate relevant information throughout the continent. Through ILCA, African scientists can consult international data bases such as CABI and AGRIS, as well as gaining access to relevant scholarly and non-conventional African literature.

These services will be continued, and expanded, as resources allow. While the emphasis will be on provision of information related to ILCA's thrusts, the service to scientists interested in other fields of livestock production and those not directly collaborating with ILCA will be continued.

Table 16. Percentage depression of PCV traits in cows following trypanosome infection at three network sites with medium or high trypanosomiasis risk.

Site	Trypanosome prevalence (%)	Average PCV in gestation (%)		PCV at parturition (%)		Average PCV in the lactation (%)		PCV at weaning (%)		Overall	
		Mean[1]	Per cent depression	Mean	Per cent depression	Mean	Per cent depression	Mean	Per cent depression	Mean[1]	Per cent depression
Boundiali	13.1	33.0	7.6	31.4	9.2	30.8	4.5	30.6	5.9	31.5	6.8
Mushie	8.8	35.2	6.0	34.1	6.5	35.2	7.1	35.0	6.0	34.9	6.4
Avetonou	7.2	33.5	5.7	30.6	3.9	32.0	6.3	32.2	12.4	32.1	7.1
Overall: Mean[1]		33.9		32.0		32.7		32.6		32.8	
Per cent depression			6.4		6.5		6.0		8.1		6.8

1. Mean of uninfected cows.

cattle at no trypanosomiasis risk at the Kolo site. At the OGAPROV site the more susceptible Nguni cattle had higher trypanosome prevalence and lower viability than N'Dama and N'Dama x Nguni cattle. The viability of sheep and goats, when exposed to trypanosomiasis risk, was lower than that of cattle, although it is likely that factors other than trypanosomiasis were the causes.

Reproductive performance of trypanotolerant cows and ewes that had been infected with trypanosomes postpartum was consistently lower than that of females that had not been infected. The poorer performance was not associated with any important liveweight loss.

In trypanotolerant cattle and sheep, trypanosome infections during gestation and/or lactation did not have a large effect on liveweights at parturition and weaning nor on liveweight change during the lactating/suckling period. Performance was depressed by 3 to 5% by infections suffered by the animal itself, while infection in the cow during the last 6 months of gestation significantly depressed calf birthweight. Studies of possible cumulative effects of trypanosome infections on liveweights are now required.

Possible relationships between PCV and livestock performance were examined. Postpartum PCV level was related to reproductive performance, low PCV being associated with lower performance and high PCV with higher performance. However, there was no consistent relationship between PCV and liveweight traits in cattle and sheep, although in general low PCV was associated with poorer performance and high PCV with better performance. The strongest relationships, between PCV and weaning traits in cattle, were also shown at Kolo where there is no trypanosomiasis risk.

The limited effect of trypanosome infection on the performance of these populations confirms their trypanotolerant status.

Use of trypanocidal drugs

In Kenya, chemoprophylactic drug programmes have been tested on East African Zebu cattle in village herds at Muhaka (Table 15). Initial results from the first 24 months of the comparison showed that treatment with the trypanocidal drug reduced detectable parasitaemia by 39% and increased PCV and daily liveweight gain (DLG) of non-parasitaemic animals. For example, DLG of post-weaners increased from 42 to to 82 g/day. The beneficial effect of trypanocidal drugs appeared to decline gradually during the 3 months following treatment. The study period ended in December 1986 when reproductive status was assessed. Biological and economic productivity will be analysed during 1987.

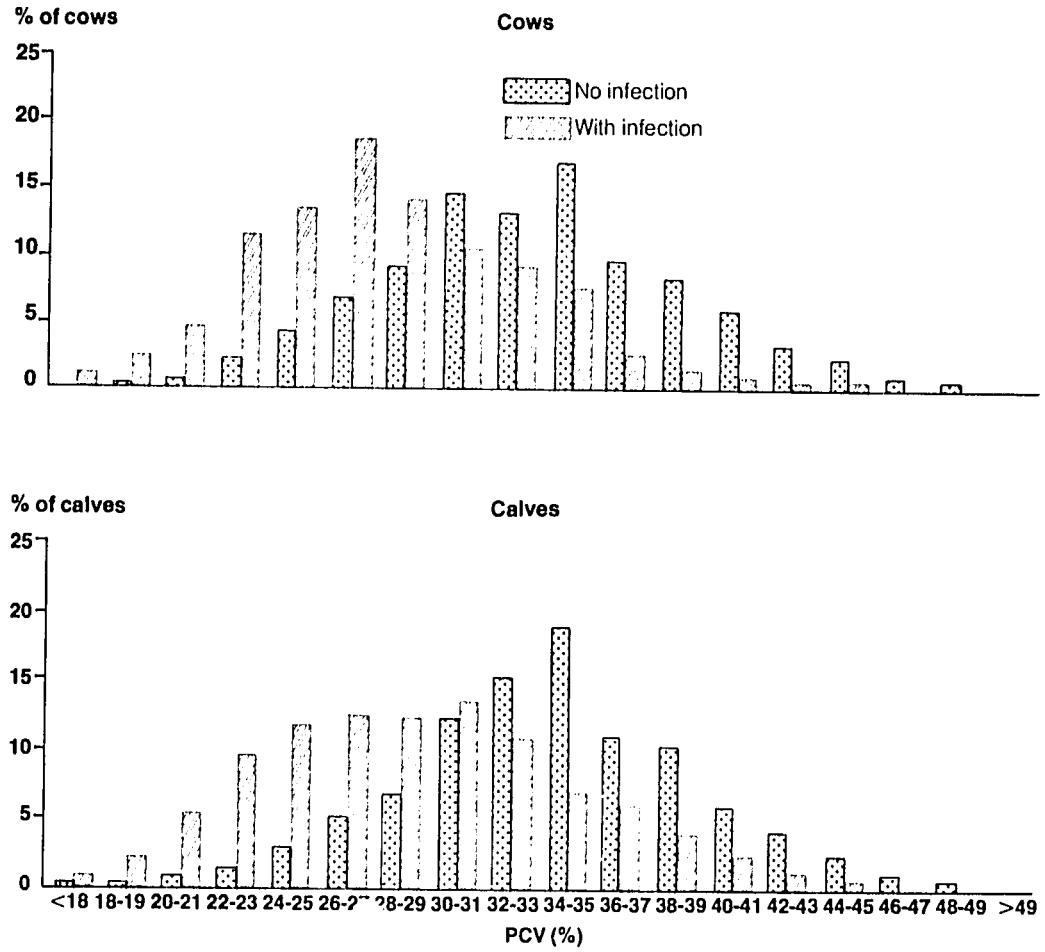
Livestock productivity studies

Work in collaboration with national researchers focused on the preparation of four research reports which approached completion.

- *Evaluation de la productivité du Zébu Gobra au Centre de recherches zootechniques de Dahra-Sénégal*

Analyses of 13 years' data covering reproduction, growth and viability allowed esti-

Figure 10. Distribution of PCV values (%) for N'Dama cows and N'Dama calves, with and without trypanosome infection, Mushie Ranch, Zaire, 1984–85.



mation of genetic parameters. The improvement possible through selection programmes under the ongoing management system was calculated, and possible ways to increase this improvement are indicated.

– *Evaluation of beef breeds for rangeland weaner production in Zimbabwe*

The indigenous Mashona, Nkone and Tuli breeds, and the introduced Africander, Brahman, Sussex and Charolais were evaluated as purebreds and as crosses. Productivity estimates combining calving rate, cow weight, calf weaning weight and pre-weaning viability demonstrated the superiority of indigenous breeds and the Brahman over Africander and *Bos taurus* breeds. Overall estimates of heterosis were positive for all performance traits, but no crosses were significantly superior to the pure Mashona in terms of productivity per unit metabolic weight of cow per year.

– *Evaluation de la productivité de la race bovine Ankolé au Rwanda*

This study will be of particular interest to ILCA's programmes in the area of milk production, as it ranged from pure beef production through partial milking, to complete milking-out. It evaluated an indigenous breed, the Ankole Longhorn, crosses with an introduced *Bos indicus*, the Sahiwal, crosses with a *Bos taurus*, the Jersey, and the pure Jersey.

– *Breed and heterosis effects of exotic Bos taurus and indigenous Bos indicus cattle on beef production characters in a tropical environment*

The purpose of this report is to provide in a single document a comprehensive summary

of results from cattle breeding investigations conducted over 8 years in the tropics. These results provide life-cycle characterisation for biological traits of economic value for exotic *Bos taurus* and indigenous *Bos indicus* breeds for potential use in beef production systems in the tropics. Also, estimates of heterosis from a *Bos taurus-Bos indicus* breed cross and from crosses among *Bos indicus* breeds of cattle are provided.

Animal Nutrition Section

Introduction

The Animal Nutrition Section conducts research at both headquarters and Debre Zeit, and its laboratories also provide analytical services for other ILCA programmes. More emphasis was placed on collaborative research in 1986, and contact at various levels has been expanded with all of ILCA's other research programmes and with national agricultural research services. Collaboration with national groups has centred around the African Research Network for Agricultural Byproducts (ARNAB).

The Section's research relates closely to crop–livestock interactions, focusing on improved utilisation of crop residues as animal feed by using supplements of resources currently or potentially available locally. The basis of this work has been that the major limiting components are likely to be protein and digestible energy; however, probable widespread deficiencies of essential minerals prompted the Section to start mineral nutrition research in 1986.

Legume evaluation

Leucaena feeding trials

The tree legume leucaena is a valuable source of dietary protein for ruminants in the tropics; however, it contains an amino acid, mimosine, that is metabolised in the rumen to dihydroxy pyridine (DHP). Both mimosine and DHP are toxic and can restrict the benefits to be gained from including leucaena in the diet. Bacteria that degrade these compounds in the rumen were introduced successfully to ILCA from CSIRO, Australia, and an experiment was conducted to determine their effect on sheep fed leucaena.

Four groups of 12 young Ethiopian highland rams were offered poor-quality hay *ad libitum* and 100, 200, 400 or 600 g of dried leucaena leaves daily for 13 weeks; half the animals in each group were inoculated with the bacteria intraruminally. A control group fed only hay lost weight during the trial at the rate of 9 g/day. Supplementing the diet with leucaena resulted in mean daily weight gains of 15, 37, 53 and 65 g in animals fed 100, 200, 400 and 600 g of leucaena respectively. Although inoculation with the DHP-degrading bacteria had no effect on weight gains at the 100, 200 and 400 g levels of

leucaena offered, the organisms exerted a highly significant beneficial effect at the 600 g level: inoculated animals gained 79 g/day compared with 50 g/day for uninoculated animals ($P<0.001$) (Figure 11).

The proportions of leucaena in the diets averaged 15, 27, 45 and 59% respectively, and evidence of a toxic effect in the absence of the DHP-degrading bacteria appeared at the highest level of incorporation.

Nitrogen utilisation by sheep and goats fed leguminous browse

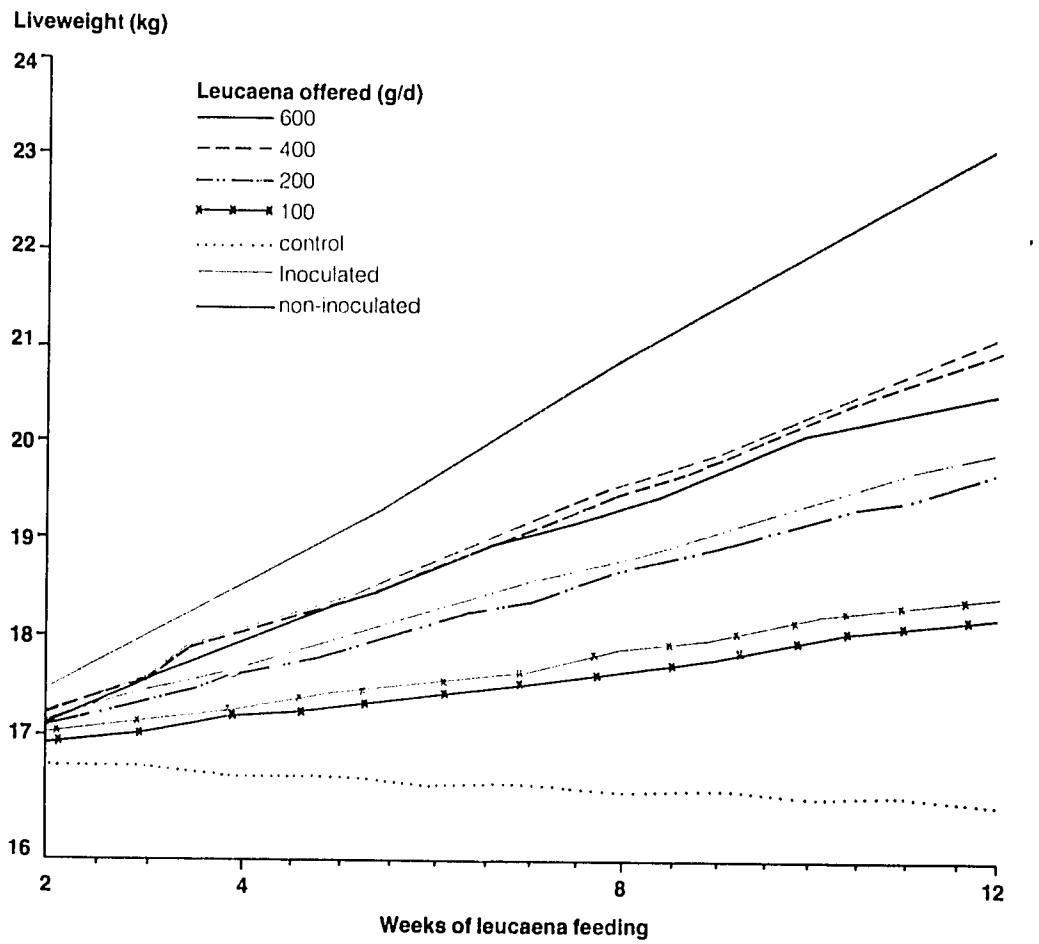
Two leguminous browse species, *Acacia brevispica* and *Sesbania sesban*, and a forage legume hay (*Vicia dasycarpa*) were compared as protein supplements to straw-based diets for sheep and goats. *Acacia brevispica* is an important browse in many semi-arid areas of East Africa and contains moderate amounts of condensed tannins. *Sesbania sesban* is being used in alley cropping systems on Vertisols; neither this nor vetch contains tannins. Isonitrogenous levels of the legumes were fed to sheep and goats, and urinary N loss, blood urea N (BUN) and rumen NH_3 were used as parameters to determine the efficiency of N utilisation in the rumen.

There was little difference between sheep and goats in parameters of N utilisation, but there were large differences among legumes. Animals given *S. sesban* had the highest urinary N loss, BUN and rumen NH_3, which indicates inefficient utilisation of N in the rumen. These parameters were lowest in animals fed *A. brevispica*.

Influence of strategic supplementation on milk production

The basic feed resource available to crossbred dairy cows is low quality roughage, in

Figure 11. Fitted mean liveweights of sheep fed leucaena.



the form of crop residues or native grasses, either grazed or conserved as hay. Several experiments were conducted in which grass hay was supplemented with molasses, with the emphasis on its use as a vehicle for urea, and noug cake, as a representative of oilseed residue widely available in Ethiopia.

Cows averaging 150 days into lactation were fed grass hay *ad libitum* and 1 kg of noug/day, and were given 1 kg of molasses containing 0, 2.5, 5 or 10% urea. Milk yield during the week before the experiment averaged 5.1 litres/day and did not differ among treatments. In the 5 weeks of the experiment, mean daily milk yields were 4.3, 4.4 and 4.5 litres/day for the 0, 2.5 and 5% urea treatments respectively, which did not differ significantly. Cows in the 10% urea treatment, however, yielded 4.8 litres/day, significantly more than all other treatments ($P<0.01$).

Subsequently, cows were given 100 g of urea/day with either 900 or 1400 g of molasses. The milk yield of cows receiving the larger amount of molasses was slightly, but not significantly, higher. Adding 50 g of a commercial mixture of branched-chain fatty acids had no effect on milk yield. In another experiment the addition of the fatty-acid mixture slightly, but not significantly, increased persistency of milk yield in cows in late lactation (200 to 240 days), but had no effect on cows in early lactation (40 to 80 days).

When cows were fed grass hay and molasses/urea blocks (10% urea) *ad libitum*, feeding a supplement of 1 kg of noug/day increased milk production by almost 40% ($P<0.001$), but a further 1 kg of noug had no significant effect.

Nutritive value of sorghum crop residue

Varietal differences

Two sorghum variety trials replicated across two sites were conducted in collaboration with the sorghum improvement team of the Ethiopian Institute of Agricultural Research. The crop residue from each plot was subsampled and separated into leaf blade, leaf sheath and stem. Nitrogen content and *in vitro* digestibilities of organic matter and neutral-detergent fibre (NDF) for each fraction differed significantly ($P<0.01$) among varieties. The mean and range of digestibilities of NDF in leaf blade, leaf sheath and stems were 60% (55–68%), 51% (43–58%) and 55% (49–63%) respectively.

Intake and digestibility

A trial was conducted to determine the effect of variety on intake and digestibility of sorghum crop residue in mature highland zebu oxen. Five sorghum varieties were selected based on yield criteria. After grain harvest, the crop residue from each variety was chopped coarsely and fed to oxen in a latin square design: 12 kg of crop residue dry matter were offered per day, supplemented with 60 g of urea/day added to the drinking water.

Daily dry-matter intake varied by more than 1 kg among varieties (Table 17). The variety with the lowest intake (MW5020) is a dwarf, bird-resistant variety which gives high grain yield but little residue. The intake of digestible energy from MW5020 would be adequate for maintenance requirements only, whereas the intake from Melkamash (high yielding and non-bird-resistant) and 5DX160 would allow weight gains of over 200 g/day.

Differences among varieties were further illustrated in an experiment in which the brans from MW5020 and Melkamash were fed as supplements to sheep and goats at 150 or 300 g/day for 3 months. The sheep grew at approximately 30 g/day and the goats at 15 g/day when given 150 g of Melkamash bran and 150 or 300 g of MW5020 bran. However, 300 g of Melkamash bran allowed for significantly greater gains of 54 g/day in sheep and 39 g/day in goats.

Table 17. The effect of sorghum variety on intake of crop residue by highland zebu oxen.

		Intake (kg/day)	
Variety	n	Mean	SE
Buraihi	5	4.43ac	0.13
5DX-160	5	5.18b	0.13
2KX 17/6/1	2	4.89bc	0.24
MW5020	5	4.11a	0.13
Melkamash	5	5.96b	0.13

Means followed by the same letter are not significantly different ($P>0.05$).

Coffee pulp in sheep diets

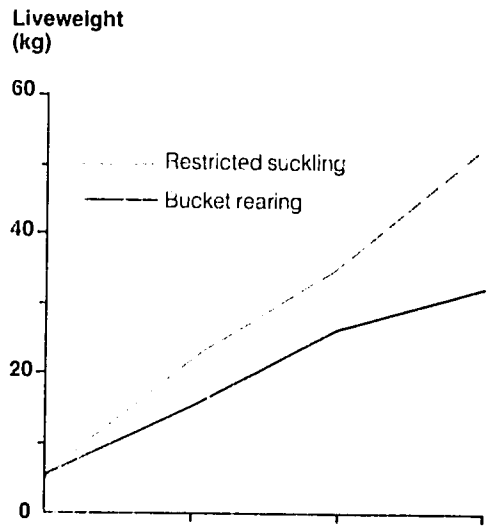
The effect of supplementation with dry, processed coffee pulp (0, 60, 120 and 150 g/day) on intake, digestibility and N retention in sheep fed hay was determined in a collaborative project with Alemaya University of Agriculture, Ethiopia. There was no effect of supplementation level on feed intake or digestibility, but N balance was significantly depressed at the 120 and 150 g levels, at which both urinary and faecal N losses and total urine excretion increased. Faecal N loss may have increased because coffee pulp contains condensed tannins which form indigestible protein complexes. Urine excretion and N loss may have increased due to effects of caffeine on renal function. The presence of these compounds in coffee pulp appear therefore to limit its nutritive value.

Calf rearing

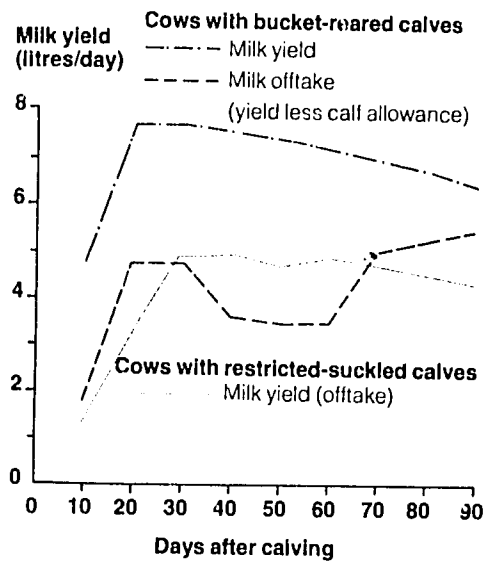
Work on restricted suckling of calves started in 1986 in collaboration with the Highlands Programme. Initial results show that calves subjected to a restricted suckling regime gained weight much more rapidly than those reared traditionally using bucket feeding, and were 20 kg heavier than bucket-fed calves when weaned at 90 days, with no penalty in milk offtake (Figure 12).

Figure 12. Effect of restricted suckling on (a) calf liveweight and (b) milk yield/offtake, ILCA headquarters, 1986.

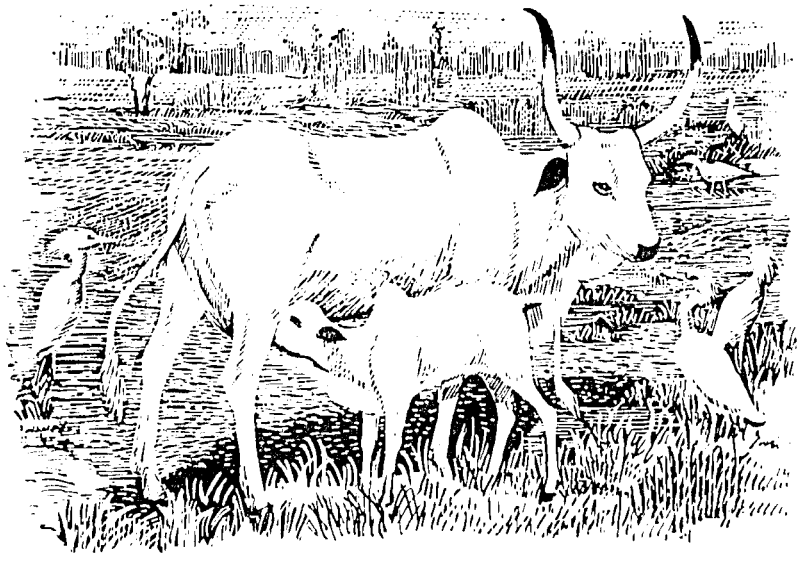
a) Calf liveweight



(b) Milk yield/offtake (means over 10-day periods)



Animal Reproduction and Health Unit



Introduction

In 1986 the Animal Reproduction and Health Unit assembled a herd of 30 Small East African Zebu cattle and a flock of 100 indigenous sheep at the ILCA Debre Berhan station. These form the core of the Unit's experimental animals for in-depth studies. More extensive studies are carried out in collaboration with the Ministry of Agriculture at the cattle breeding ranches at Abernosa and Gobe, and at government slaughterhouses in Addis Ababa, Melge Wondo and Dire Dawa.

Cattle reproduction and health

Disease and reproduction

Several diseases, both venereal and systemic, affect cattle fertility. Serodiagnostic studies were started in June 1986 to determine the prevalence of five such diseases, bovine brucellosis, leptospirosis, infectious bovine rhinotracheitis (IBR), campylobacteriosis and trichomoniasis, using a sample of about 1600 cattle. Initial results indicate that 4.1% of the animals were infected with brucellosis and 66.6% with IBR. Of the 60 samples tested for campylobacteriosis and trichomoniasis, all were negative.

Efforts are being made to determine whether enzyme-linked immunosorbent assay (ELISA) methods could be adapted to diagnose some of these, and other, diseases under African conditions.

Nutrition and reproduction

Nutrition has a large effect on cattle fertility, and trials are being conducted at Abernosa and Gobe to elucidate the interactions between reproduction and nutrition under Ethiopian ranch conditions. Aspects under study include the effect of dietary supplementation on the growth and reproductive development (histological and endocrinological) of young Boran and Boran-cross bulls and heifers; the influence of season on testicular function in Boran and Boran-cross bulls; and the effects of dietary supplementation, body weight and condition on the fertility of the postpartum cow.

Oestrus behaviour of zebu cows

The pattern of oestrus behaviour of East African Zebu cows is being studied in order to understand the events that characterise the phases of oestrus in zebu cows. Zebu cattle form the bulk of the African cattle population and will continue to be the basis for improved productivity. This study is part of a broader effort to understand the reproductive physiology of these cows, in order to provide practical answers to such questions as: What are the most obvious signs of oestrus? How long does the oestrus period last? At what time of the day is oestrus most likely to occur? When does ovulation occur? The answers to these questions will provide information useful for the rational exploitation of these cattle breeds using either artificial insemination or hand mating.

Sheep reproduction and health

Reproductive function in Ethiopian sheep

The reproductive function of Ethiopian indigenous sheep was studied among ewes slaughtered at the main Addis Ababa abattoir. Six hundred specimens of the reproductive organs, primarily from sheep raised

traditionally, were collected over a 12-month period in 1985/86. Over the study period, 70.1% of the animals were pregnant, 24.4% with twins. This is higher than actual twinning rates of 4 to 10% reported under field conditions. Although pregnant sheep were encountered throughout the year, there was an increase in the proportion of pregnant ewes during the long rains. Conception rates were highest during the short rains with a secondary peak during the post-harvest period, coinciding with the periods of greatest feed availability. The observed differences between pregnancy and parturition rates suggest high prenatal wastage. Work is underway to verify the seasonality of ovarian function by examining changes in the number and size of follicles and corpora lutea. The same study will assess the relationship between the level of plasma progesterone and the number and size of corpora lutea.

Transmission of gastrointestinal helminths

A study of seasonality of transmission of gastrointestinal helminths in Ethiopian sheep was completed in 1986. A slaughterhouse survey in Addis Ababa showed peak infestation in August 1985 and March 1986, coinciding with the two rainy seasons. This suggests that strategic treatment of sheep with anthelmintics in June and January is likely to reduce the shedding of ova at critical periods and minimise transmission levels during the rainy seasons. This hypothesis is being tested in trials with farmers' animals in the Gobe (Arsi) area.

Prevalence of zoonoses in sheep

A number of sheep diseases are zoonoses, i.e., they can also infect humans, and are thus of public health importance. Among these, cysticercosis and hydatidosis have been found in 37.1% and 16.4%, respectively, of the 560 sheep examined at the Addis Ababa abattoir.

Laboratory activities

The laboratory continued to serve as a back-up facility for the Unit's field work, other departments and the ILCA staff clinic. The laboratory has four sections: biochemistry, clinical chemistry, parasitology and histology.

The biochemistry section performed 2000 analyses for progesterone using the ELISA method. The laboratory is attempting to develop a technique that would promote local use of this method to diagnose fascioliasis and brucellosis. It is also studying ways to preserve plasma and serum in the field for subsequent hormonal determination, which is important in assessing reproductive function. Studies are being conducted to determine the best way to collect and handle specimens for laboratory analysis under tropical conditions.

Dairy Technology Unit

Introduction

The Dairy Technology Unit, formerly part of the Highlands Programme, was formed in 1986. The Unit's objective is to develop improved milk processing techniques for African smallholders. Much of the Unit's work is aimed at increasing the efficiency and yield of traditional milk processing techniques and introducing simple alternative products.

Improved dairy technology in producers' cooperatives in Ethiopia

The Unit collected monthly milk production and disposal data from 15 producers' cooperatives in Arsi, Sidamo, Wellega, Ilubabor, Jimma and Gojam Administrative Regions in Ethiopia. These data, covering a 2-year period, will be used to evaluate the impact of improved dairy technology, such as milk separators and butter churns, on the profitability of dairy producers' cooperatives.

Preliminary results from four cooperatives in Arsi showed that by using a cream separator, their net income increased by an average of more than 2500 birr (US$ 1200) over 12 months.

Churning with an internal agitator

The effect of using an internal agitator fitted to the traditional clay pot churn was studied on five farms in the Debre Berhan area, and in eight households near Debre Zeit. Data were collected on churning time and fat recovery, as well as on physical factors that affect churning time and fat recovery.

At Debre Berhan, use of the internal agitator increased the percentage of fat recovered as butter from an average of 75% to 92%, and reduced churning time from an average of 128 minutes to 62 minutes. At Debre Zeit, however, although the internal agitator reduced churning times, it did not increase fat recovery. This was attributed to the higher ambient, and hence churning, temperature at Debre Zeit.

Making cottage cheese

Ayib, a soft, cottage-type cheese, is made in Ethiopia by heating soured skim- or buttermilk to about 50°C to precipitate casein and some of the remaining fat. An experiment in 1986 examined the effect of temperature on the yield and quality of *ayib*.

Over a temperature range from 30 to more than 80°C, there was little difference in yield. Heating buttermilk to 70°C for 30 minutes gave the best-textured *ayib*; higher temperatures gave a cooked flavour. Temperature also had a marked effect on storage stability. *Ayib* made by heating to 70°C could be stored for up to 5 months, compared with less than 2 months for that made at lower temperatures.

Making Queso blanco cheese from separated milk

In many producer cooperatives in Africa, milk is separated and butter or ghee is made from the cream. The separated milk is usually fed to calves. In 1986 the Unit investigated making cheese from low-fat separated milk as an alternative to feeding it to calves.

Cheese was made from a range of milks containing different fat percentages (Table 18). Queso blanco was chosen because it is simple to make and does not require rennet. The physical appearance of the cheese did not differ markedly, despite the wide range in fat content.

Table 18. Composition of cheese made from milk of different fat contents.

Fat in milk (%)	Fat in cheese (%)	Moisture (%)	Ash (%)	Protein (%)
0.5	4.00	58.44	3.25	25.94
1.0	10.00	58.48	3.37	23.83
2.0	12.50	56.10	3.20	20.86
3.0	20.00	49.83	3.38	24.85

Training

The Unit conducted three training courses in 1986. The first, from 20 January to 7 February, was attended by 19 participants from six African countries, and covered both theory and practical aspects of rural dairy technology. The second, from 17 April to 6 May, was conducted jointly by ILCA and the Ethiopian Relief and Rehabilitation Commission (RRC) for 12 participants from RRC who will extend the technologies to rural dairy producers throughout Ethiopia. In November, the Unit conducted a training course at the request of the South-Eastern Agricultural Development Zone (SEADZ) office in Ethiopia. The course was attended by 18 dairy technologists working in southern Ethiopia.

Small Ruminant and Camel Group

Introduction

The main objective of the Small Ruminant and Camel Group (SRCG) is to assist national research programmes in their efforts to increase the productivity of these species. The Group assists national programmes in planning, executing, analysing and publishing research, and coordinates an information network.

Reproductive performance

Concern is frequently voiced at the poor reproductive performance of African domestic livestock. Recent results obtained by the Group, however, indicate that most problems related to reproduction in small ruminants and camels can be overcome in the medium term through adequate research and by improved management.

Research on small ruminants in Africa has ignored the non-seasonality of breeding in indigenous breeds and has artificially low-

ered reproductive output by limiting animals to lambing or kidding once a year. Reproductive performance tends to be better in traditional systems where little breeding control is imposed. In African small ruminants, the annual reproductive rate should be governed not only by litter size, but also by manipulation of parturition intervals so that they are optimal (Table 19). Some African breeds of goats and sheep are potentially highly fertile. These could be used to improve less prolific types without the loss of adaptation to the stressful African environment often associated with the introduction of non-African genotypes. Overall reproductive performance could also be increased by manipulating the average age of breeding females in the flocks so that maximum performance can be achieved and sustained (Figure 13).

Research on camels has also shown the potential for increased reproductive performance. Under traditional management in Niger the interval between births is about 26 months, while in Kenya under improved management and better nutrition the interval is about 18 months.

Network activities

Three issues of the Group's newsletter (in both French and English) were issued during 1986. There are now almost 1000 network members receiving the newsletter, the majority of whom are in 45 African countries. An encouraging feature of the Newsletter in 1986 has been the increased number of contributions from national scientists. Eighteen such articles and notes were published on all three species in which the Group has a major interest.

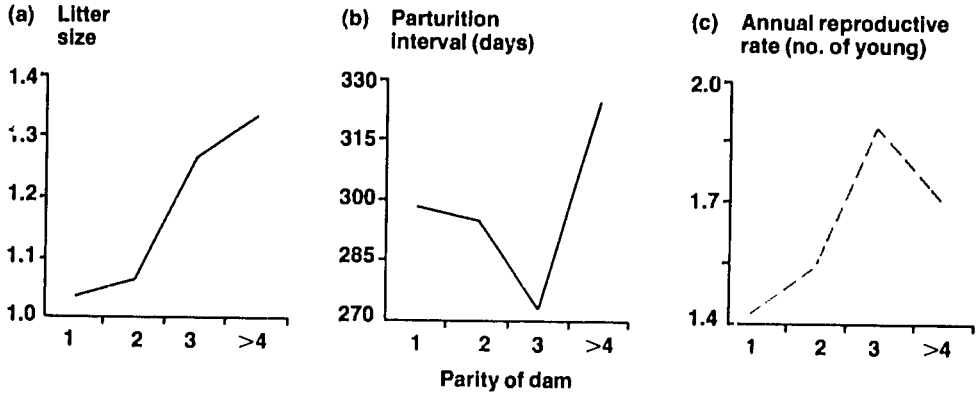
Group staff visited 17 African countries in connection with Network activities and research collaboration and also assisted 13 countries on the United Nations Sahelian Office (UNSO) collaborative project on camel research. As a result of these visits, Cameroon, Congo and Djibouti were assisted in the preparation of research protocols and cooperative research has started in Congo

Table 19. Reproductive components of some African small ruminant types under various environmental conditions.

			Goats			Sheep			
Country	Zone	Management	Litter size (No.)	Parturition interval (days)	Annual reproductive rate (young/year)	Litter size (No.)	Parturition interval (days)	Annual reproductive rate (young/year)	Source of data
Burkina Faso	Semi-arid	Traditional	1.21	285	1.51	1.02	268	1.36	ILCA/GTZ[3]
Ethiopia	Highlands	Station[1]	–	–	–	1.08	262	1.66	ILCA
Ivory Coast	Humid	Traditional	–	–	–	1.23	230	1.95	SODEPRA[4]/ GTZ
Kenya	Semi-arid	Traditional[2]	1.23	306	1.47	1.05	312	1.23	ILCA
Mali	Semi-arid	Traditional	1.16	297	1.58	1.03	275	1.58	ILCA
Mozambique	Subhumid	Station	1.62	391	1.51	1.36	360	1.37	IREMA[5]/ ILCA
Nigeria	Humid	Traditional	1.49	259	2.10	1.26	322	1.43	ILCA
Rwanda	Highlands	Station	1.75	343	1.86	1.43	406	1.24	ISAR[6]/ILCA
Senegal	Semi-arid	Station	–	–	–	1.12	307	1.33	ISRA[7]/ILCA
Sudan	Semi-arid	Traditional	1.57	238	2.41	1.14	275	1.56	HTS[8]

1. No control of breeding.
2. Control of breeding practised.
3. GTZ = Gesellschaft für Technische Zusammenarbeit.
4. SODEPRA = Sociéte de développement des productions animales.
5. IREMA = Instituto de reproduccao et de mejoramiento animale.
6. ISAR = Institut des sciences agronomiques du Rwanda.
7. ISRA = Institut sénégalais des recherches agricoles.
8. HTS = Hunting Technical Services.

Figure 13. Relationships between parity number and (a) litter size, (b) parturition interval and (c) annual reproductive rate in Mali goats, 1978–84.



Source: Adapted from R T Wilson. 1986. *Livestock production in central Mali: Long-term studies on cattle and small ruminants in the agro-pastoral system.* ILCA Research Report 14. ILCA, Addis Ababa.

between the Group and the national Science and Technology Research Organisation. The Group has also assisted the Livestock Research and Improvement Institute of Mozambique and the Animal Production Research Administration of Sudan with analysis and publication of data that these two organisations have been collecting over many years.

The joint Group/UNSO study has resulted in a proposal "Towards Collaborative Research on the One-humped Camel in Africa" which will be submitted to donors for possible financing during 1987. The Group also assisted the Camel Research Unit of the University of Khartoum in editing and publishing their research results (Group Document No. 12).

Forage Agronomy Section

Introduction

The Forage Agronomy Section is responsible for the acquisition, initial evaluation and increase of germplasm for dissemination to researchers for further testing. Research is conducted on germplasm quality control, environmentally related genetic adaptation and distribution of genetic resources, agronomic characterisation of germplasm and rhizobial relationships with soils and plant genotypes. The Section also coordinates and publishes newsletters for three networks: the Pasture Network for Eastern and Southern Africa (PANESA), the Forage Network in Ethiopia (FNE) and an informal germplasm network in conjuction with the Plant Genetic Resources Centre in Ethiopia. These networks are an important part of improving forage research in the region.

Germplasm resources

Genebank

The controlled environment seed store, drying facility and ancillary laboratories for the genebank were completed in 1986. The genebank contains some 9000 accessions held at several levels of storage. The working collection in the medium-term store contains seed stocks that are readily available for use by ILCA and its clients. Seed is held at 5°C and 30% relative humidity. Seed in the reference collection in the long-term store is dried to 5% moisture content and held at −20°C in hermetically sealed packs.

Germplasm collection

A collection mission was carried out in Burundi, Rwanda and Zaire in collaboration with the Institut de recherche agronomique et zootechnique de la Communauté économique des pays des Grand Lacs (IRAZ), the International Board for Plant Genetic Resources (IBPGR) and the Royal Botanical Gardens, UK. The genera collected included *Trifolium*, *Stylosanthes*, *Vigna*, *Neonotonia*, *Sesbania*, *Macrotyloma*, *Brachiaria*, *Pennisetum*, *Panicum*, *Chloris* and *Cenchrus*. Collection missions in Ethiopia centred on *Sesbania* and *Acacia* species. *Sesbania* accessions were also acquired from Hawaii and Australia and *Chamaecytisus* accessions from New Zealand.

Germplasm distribution

Following the publication of germplasm catalogues in 1985, the number of requests for seed increased sharply in 1986. Participants in 1986 training courses also requested seed. Demand for seed from members of the Forage Network in Ethiopia also increased considerably. Some 4870 samples of grass, legume and browse seed were distributed to 201 requesters in 1986.

Seed multiplication

Seed multiplication and initial characterisation of forage germplasm is on-going, with over 2100 lines being planted in 1986: 186 accessions of highland materials at ILCA headquarters, almost 1500 in middle altitude basic soils and 488 accessions on middle altitude acid soils at Soddo.

Screening and evaluation

Germplasm is screened and evaluated under three agro-ecological conditions: highland (temperate) in Ethiopia, mid-altitude (subtropical) in Ethiopia and lowland (tropical) in Nigeria.

Highland temperate zone

Testing is carried out mainly at the headquarters farm at 2300 m above sea level and in the Debre Berhan area at 2600 to 2800 m. Most germplasm adapted to highland conditions is African *Trifolium* species, of which the Section now holds 1750 accessions in 25 species. Some 70% of the species are annuals and 30% are perennials.

Annual *Trifolium* species accessions that performed well in trials in 1983 to 1985 were screened in 1986 in a consolidated trial together with new accessions from Tanzania.

Trifolium quartinianum has been consistently high yielding, but *T. bilineatum*, a species collected recently from red acid soils in western Ethiopia, performed equally well in 1986 (Table 20). This illustrates the value of continued exploration.

Forage yields vary considerably among years, and are highest in years of low rainfall. This pattern has also been observed in crop yields, and is attributed to less severe waterlogging in low rainfall years.

Work on perennial *Trifolium* species shows them to be much slower to establish, with *T. cryptopodium*, and *T. burchellianum* var. *Johnsonii* yielding somewhat higher than *T. semipilosum* var. *pilosum*.

Mid-altitude, sub-tropical zone

Seed increase, initial evaluation and agronomic description of accessions continued at medium and lower altitudes at Zwai Horticulture State Farm (under irrigation), and at two Ministry of Agriculture sites, Abernosa Ranch (rainfed) and Welayita Region Station, Soddo (rainfed). The Zwai site was moved during the year, and thus little selection could be made during 1986. Work at the Abernosa site was discontinued at the end of 1986 because it was found to be an atypical environment, albeit a rigorous testing site for dryland materials.

The Soddo area is representative of much of the middle-altitude (1400 to 2000 m), medium-rainfall (1100 mm), acid-soil regions of eastern Africa. In trials started in 1984, *Stylosanthes guianensis* cv Cook has shown excellent growth and persistence in native pastures under cutting and under grazing when oversown, or when sown into cultivated strips. Other accessions that have performed well in grazed strips include *S. scabra*, *S. fruticosa* and other *S. guianensis* lines.

In a replicated yield trial, *S. guianensis* cv Cook yielded highest in the first 2 years of the experiment (1984 and 1985), but yielded much less than *S. scabra* cvs Seca and Fitzroy in 1986 (Figure 14).

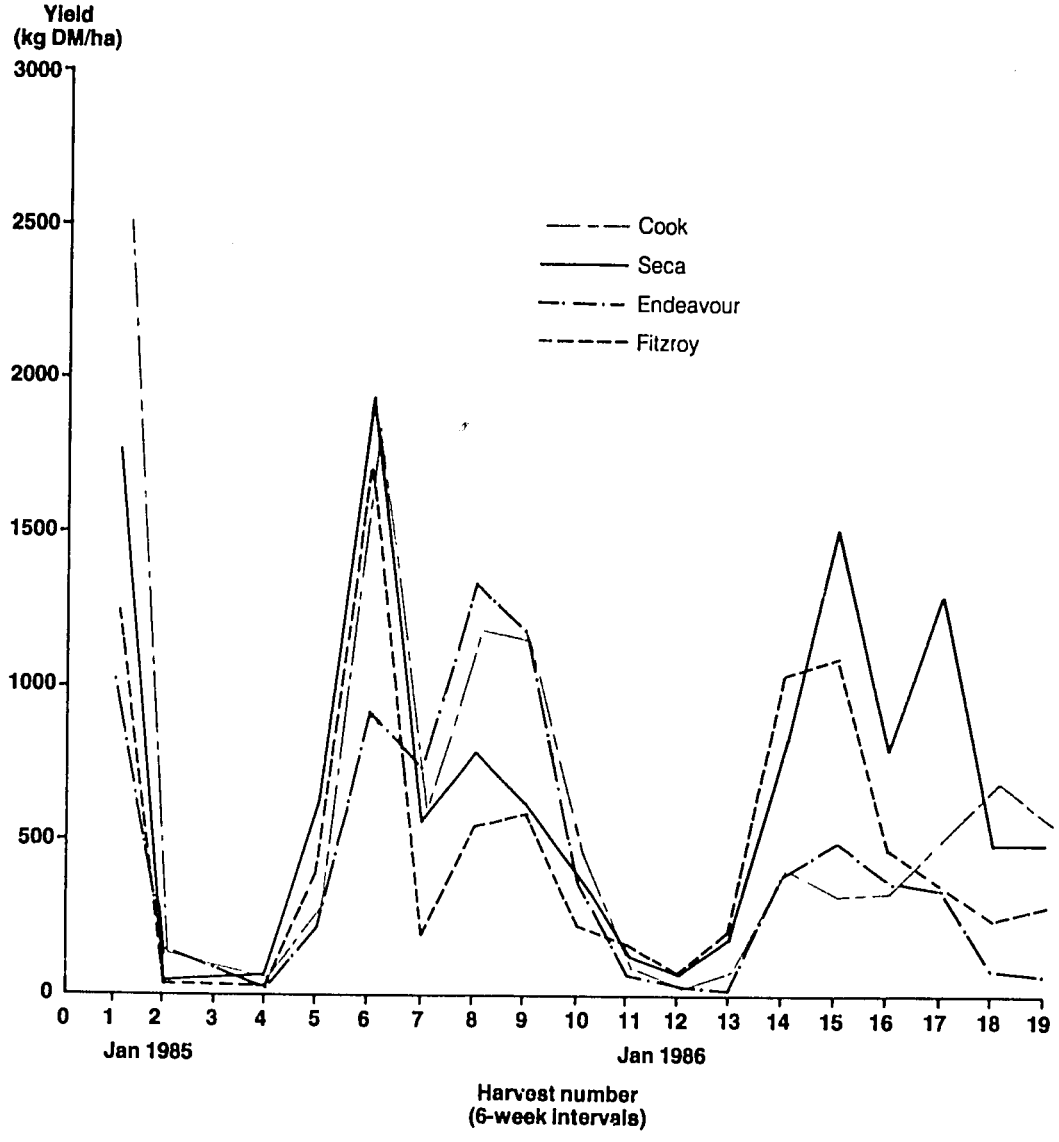
In observational, unreplicated strip trials of legumes and grasses on two seasonally waterlogged sites in the Soddo area, the legumes Cook stylo, *Desmodium uncinatum* cv Silverleaf, *Aeschynomene histrix*, and grasses *Melinis minutiflora*, *Setaria anceps* cv Narok, *Chloris gayana* (various cultivars) and *Panicum maximum* were apparently much more productive than native legumes and grasses.

The Section has had considerable success in the introduction of legumes to farming systems in the Welayita region. Testing began in 1983 with the introduction of potentially adapted commercial lines to peasant farms. After four grazing seasons three forages have proved to be productive, persistent and highly acceptable to farmers: *D. intortum* cv Greenleaf under coffee and false banana (*Ensete ventricosum*); Cook stylo and *Macrotyloma axillare* cv Archer, planted in pure sward or established as an intercrop with maize. Farmers appear to like their ease

Table 20. Dry-matter yields from elite lines of six African *Trifolium* species, 1983–86.

Species	DM yield (t/ha)			
	1986	1985	1984	1983
T. bilineatum	2.3	–	–	–
T. quartinianum	2.3	4.1	6.5	5.7
T. decorum	2.2	3.5	5.3	5.9
T. tembense	1.6	2.5	5.6	6.3
T. rueppellianum	1.4	3.5	5.3	3.8
T. steudneri	1.3	2.6	5.3	5.3

Figure 14. Dry-matter yields of four stylosanthes cultivars cut every 6 weeks, Soddo, 1984–86.



of establishment, high productivity and positive effects on milk yields and quality.

Lowland tropical zone

Trials in the lowland tropical zone are carried out in conjunction with the Humid Zone Programme. Results are reported under the Humid Zone Programme section of this report.

Adaptation to agro-ecological zones

A series of five trials was established during 1986 at three sites in Ethiopia with contrasting climates and soils. Information from the trials will be used to develop yield and phenology models for a range of forage legumes, with the ultimate aim of predicting their adaptation to different agro-ecological zones. Preliminary results indicate that water-balance models will be a useful tool for predictive modelling of yield responses once lines are established, but that soil pH and physical and chemical characteristics have a large effect on initial establishment.

A study was completed on the use of taxonomic composition of natural grass floras to define agro-ecological zones in Africa. The tribal composition of grass floras is closely correlated with annual rainfall and length of growing period, and can be used for agro-ecological classification of sites. However, the homogeneity (and thus usefulness)

of the classificatory units depends to some extent on the diversity of regional grass flora. In East Africa, which has a rich grass flora and much endemism, classification was less successful than in West Africa which has a relatively limited grass flora. The extent to which data quality, rainfall variability and distribution and soil fertility affect the classifications has yet to be fully determined.

Rhizobiology

Collaborative work with the University of British Columbia began on a project to monitor the viability of rhizobium inoculants and detect inoculation problems in the field during the early stages of screening native perennial *Trifolium* species. Initial collections of germplasm, nodules and soil samples were made in 1986, with funding from the International Development Research Centre (IDRC), Canada.

Tissue culture

Work on shoot-tip culture of *Brachiaria* grasses continued in 1986. The goal of this work is to provide a means of distribution of disease-free germplasm to the Centro Internacional de Agricultura Tropical (CIAT), with whom the collections were made. A proposal for the development of a tissue culture facility to maintain tropical grass germplasm *in vitro* was accepted by IBPGR, who will be funding a postdoctoral fellowship for 1987.

Training

The Section began more formal training activities in 1986. A PANESA course on "Forage plant introduction and initial evaluation", funded by IDRC, was offered in cooperation with the Ethiopian Ministry of Agriculture, and a course in "Genebank techniques", funded by IBPGR, was given in cooperation with the Ethiopian national genebank. In addition, a 3-week, hands-on course in simple forage evaluation techniques was given on five occasions for up to four African forage workers. Informal training of forage workers continued.

Two technicians from Gambia and Tanzania received 6 weeks on-the-job training, an undergraduate associate from the University of Wageningen assisted in an evaluation project of *Brachiaria* grasses at Zwai for 3 months and an IBPGR Intern was attached to the Genetic Resources Section for 12 months of on-the-job training in forage genetic resources.

Other institutions, including the Veterinary School and the Ministry of Agriculture, used the Section's sites for training.

Soils and Plant Nutrition Section

Introduction

The Soils and Plant Nutrition Section was established at ILCA headquarters in early 1986. The Section's objectives are to:

- conduct literature searches as a basis for logical development of research strategies;
- evaluate the constraints from and efficiency of use of nutrients and water in legume-based feed production systems; and
- provide advisory and support services to ILCA's field programmes and forage networks on soils and plant nutrition research.

Characterisation of soil types with respect to nutrients

Production of high-quality feed is dependent on optimum soil nutrient conditions. Of the soil elements essential for normal forage growth, phosphorus (P) is the most vital and yet the most deficient in the majority of soils. In order to have better data on the P status of some Ethiopian soils, studies were conducted in the laboratory and greenhouse and attempts were made to characterise the soils in terms of P fixation capacity and organic, inorganic and available P forms. The results provide information on the ability of the soils to provide P to plants and the extent to which they fix applied P.

Among 32 Ethiopian soils, total P content ranged from 185 to 1981 ppm, with an average of 864 ppm. About 41% of the mean total P content was in the form of organic P. Calcium-phosphorus compounds were the most abundant forms of P in most soils. Phosphorus fixation varied considerably among soils. Soil factors including pH, organic matter, Fe and Al oxide contents were significantly correlated with P fixation.

Available P in the soils was estimated using 12 chemical methods, with *Macroptilium lathyroides* as an indicator plant. Results from Olsen's bicarbonate extraction, Truog's sulphuric acid and Warren and Cook's 0.3 NHCl methods correlated best with plant yield data and available P forms. The critical soil P level, as given by the Olsen method, below which response to P fertilization would be expected on these soils was 8.5: 97% of the predictions were correct.

Nutrient management and water use in legume-based feed production systems

Forages

Shortage of P is the main constraint to forage growth on most soils in sub-Saharan Africa. Pot trials and P sorption studies were conducted to determine the critical external P requirements of seven Ethiopian clovers. External P requirements ranged from 0.003 to 0.025 mg P/litre on a soil with low fixation capacity and from 0.0004 to 0.0019 mg P/litre on a soil with high fixation capacity.

Rotations

Research on the residual effects of forage legumes on cereal yields continued. Table 21

Table 21. Effect of previous cropping on grain yield of cereals on a soil with "vertic" properties, Debre Zeit.

1984 crop	Grain yield (kg/ha)	
	Sorghum 1985	Maize 1986
Trifolium steudneri	2632.0a	2730.7ab
Vicia dasycarpa	2130.3ab	3273.7a
Lablab purpureus	1549.7b	2461.7b
Trifolium tembense	1842.0ab	2170.7b
Avena sativa	1386.0b	1571.3c

Means followed by the same letter do not differ significantly ($P<0.05$).

shows the effect of four legumes on maize yields in the second year of cereal cropping. Maize on plots that had been planted to legumes in 1984 gave significantly higher grain yield than maize on plots that had been planted to oats. *Vicia dasycarpa* plots gave the highest maize grain yield.

Intercropping

Previous studies at Debre Zeit showed that intercropping forage legumes with cereals can produce higher biomass and protein yields than legumes or cereals grown in pure stand. Maize (cv Katumani) and three forage-type cowpeas (cvs TVU 1977 OD, CIT-White Wonder Trailing and CIT-Black-Eyed EXD) were grown in pure stand and intercropped at Debre Zeit. The combined dry-matter yields were generally equal to or greater than those from sole maize or cowpeas. The highest combined dry-matter yield from CIT-White Wonder Trailing and maize was 15 t DM/ha, 24% higher than pure maize and 38% higher than pure cowpea.

Soils laboratory

The soils laboratory provides a soil analysis service to ILCA's field programmes and forage networks. The laboratory received 1978 samples for which 5640 determinations were requested and 4837 samples were analysed during the year. A soil physics laboratory was built and equipped during the year: this will be used to measure the impact of legumes on soil physical properties.

Livestock Economics Division

Introduction

The work of the Livestock Economics Division is organised into two subprogrammes, policy and micro-economics. During 1986, the major projects in the policy subprogramme were a multi-country study on financing livestock services, a case study of dairy marketing systems in Ethiopia and two case studies on effects of milk prices in Kenya and Zimbabwe. All these projects were continuations of work started in previous years. In addition, work proceeded on a minor study of changes in the relative importance in production and consumption of different kinds of meat, e.g. beef, mutton, poultry, in sub-Saharan Africa. Two sets of papers were issued through the African Livestock Policy Analysis Network, and in September 1986 the first training course in livestock policy analysis took place. The 4-week course, which was attended by 20 English-speaking officials from nine African countries, stemmed from one of the main recommendations of the 1984 Livestock Policy Conference. Work was virtually complete by the end of 1986 on the preparation of a handbook of African livestock statistics.

In the micro-economics subprogramme the main project was one carried out jointly with the World Bank on crop–livestock interactions. In addition a herd projection model was developed and a minor study was carried out on the economics of a biogas digestor in Ethiopia.

Dairy marketing systems in Ethiopia

The *ILCA Annual Report 1985/86* gave data on milk purchases by consumers in Addis Ababa. In 1986 a survey was carried out on the sales pattern of milk producers. Three major groups were investigated: intra-urban producers, peri-urban large-scale producers west of Addis Ababa, and peasant producers to the north of Addis Ababa. This last group was classified according to whether producers were near (ca. 20 km) or far (ca. 85 km) from Addis Ababa and further sub-classified according to whether they were near (<3 km) or far (3–10 km) from the main road on which the parastatal Dairy Development Enterprise (DDE) operates milk collection stations to which peasant producers can sell fresh milk daily.

Table 22 presents some data on production and sales. Intra-urban producers, peri-urban large-scale producers and those peasant producers living near Addis Ababa with easy access to a collection centre all operate rather monetised dairy enterprises, selling about 70% of total (including that taken by the calf) milk production. Peasants further from collection centres or from Addis Ababa have a more subsistence-oriented system, selling about 50% or less of milk produced. The proportion of total milk sold which is sold fresh, rather than in the form of butter and cheese, appears to be sensitive to the ease with which milk can be sold, as indicated by the distance between the producer and the Addis Ababa market or to a DDE milk collection centre. Table 22 indicates, however, that this proportion is less sensitive to the relative prices of fresh milk and the alternative forms, i.e. butter and cheese, in which milk can be sold. The proportion of milk sold through different outlets (e.g. direct to consuming households, coffee houses, etc.) also varies in accordance with ease of access (see Figure 15). Intra-urban producers

Table 22. Dairy product sale patterns by different producers, Ethiopian highlands, 1986.

	Intra-urban producers	Peri-urban (large) producers	Peasant producers: Near Addis Ababa, Near a CS[1]	Peasant producers: Near Addis Ababa, Far from a CS	Peasant producers: Far from Addis Ababa, Near a CS	Peasant producers: Far from Addis Ababa, Far from a CS
Lactating cow holdings/producer (cows)						
Mean (S.D.)	5(8)	15(19)	3(2)	3(1)	2(1)	2(1)
Milk production and sales						
Mean production/producer/day (litres)	15	114	12	11	6	7
Mean sales/producer/day (litres)	10	77	5	0.5	3	0.12
Butter and cottage cheese sales						
Mean butter sales/producer/day (g)	0	59	172	183	7	91
Mean cheese sales/producer/day (g)	0	181	198	513	0	11
Milk equivalent sales of butter and cheese[2] (litres)	0	1.4	4.1	4.4	0.2	2.2
Ratios						
Sales of fresh milk and of milk equivalents to total milk production	0.67	0.69	0.76	0.45	0.53	0.33
Sales of fresh milk to sales of milk equivalents	–[3]	55.0	1.2	0.1	17.0	0.5
Producer price of fresh milk to producer price of milk used for butter and cheese	0.95[4]	1.04	0.96	1.04	1.09	1.09
Dairy product incomes						
Income from milk, butter and cheese/producer/day (EB)[5]	8.00	56.00	4.00	2.09	1.75	0.68

1. CS = Dairy Development Enterprise (DDE) collection station.
2. 24 litres of milk yield 1 kg of cooking butter in addition to 4 kg of cheese
3. Not computed because divisor is zero.
4. Although did not sell butter and cheese, could sell at EB11/kg and EB2.50/kg respectively.
5. EB = Ethiopian birr

sell mostly to consuming households, while peri-urban producers sell to coffee houses, hotels and restaurants. DDE is the major purchaser of peasant producers' milk, although small amounts are sold to consuming households, itinerant traders etc.

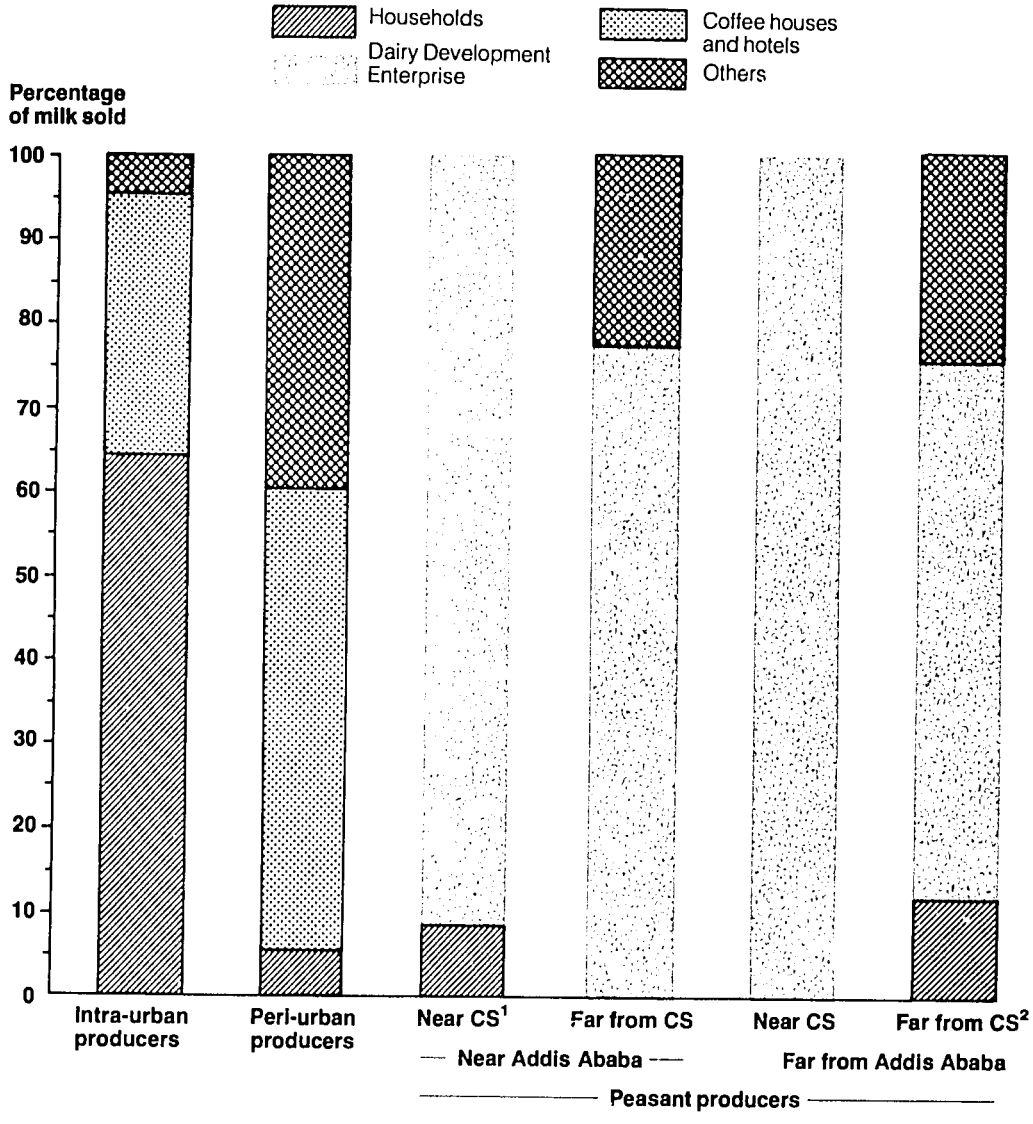
Economics of a biogas digestor

A small study investigated the economics of a biogas digestor, made principally of plastic sheeting, and with an initial capital cost of Ethiopian birr 100 (equivalent to about US$50) and a life of at least 2 years. The digestor yields about 1 m^3 of gas daily, enough for a family's daily needs, and needs about 16 kg of wet manure daily or the collectable output of about 3 mature cattle. In addition to providing household gas, the digestor also has an output of slurry (residual manure and water) which can be used as fertilizer. The study, which was based on synthetic "best guess" data for lack of a sufficient number of digestors in use to provide a representative sample, investigated the economic feasibility of the biogas digestor by the net present value criterion with a 2-year life and a discount rate of 10%.

The economic feasibility depends on the opportunity costs of the digestor's inputs (manure, labour and capital cost) as well as on the economic value of its output. In treeless areas of high population density, dry dung cakes made from cattle manure are marketed as household fuel at a high price. Household labour is required to fetch and load manure and water into the digestor and to remove and spread slurry on the household's fields. These fields and the source of water may be some distance from the digestor, and human labour is the most probable means of transport.

To allow for the wide range of values that inputs and outputs may take under different circumstances, the sensitivity of the net present value (NPV) to alternative assumptions was analysed. A positive NPV indicates that the benefits of the project are greater than its costs, and the project is

Figure 15. Proportions of fresh milk sold to different purchasers by different classes of producers, Ethiopia, 1986.



1. CS = Dairy Development Enterprise milk collection station.
2. This group of producers sold only about 3% of the total volume of milk sold by all producers.

therefore potentially worth undertaking. According to the analysis, the biogas digestor is a good investment for households with enough cattle, except in areas where firewood is cheap, water is scarce and holdings are fragmented (Table 23). Water scarcity and fragmentation of holdings inflate the labour costs of operating the digestor.

Herd projection and livestock model

Many technical innovations in livestock production have effects spread over different classes of animals (e.g. cows, calves) and several years. Evaluation of such innovations requires numerous and interlocking calculations. In 1986 the Division and the Subhumid Zone Programme jointly developed a microcomputer spreadsheet model to facilitate such work.

The model was initially designed to estimate the economic and technical implications of adopting fodder banks for cow supplementation in the subhumid zone of Nigeria. The model, however, is not subject-specific and is highly flexible, e.g. it can also be used to determine the impact of veteri-

Table 23. Net present value (NPV) of investment in a biogas digestor in highland Ethiopia under different assumptions.

Output assumptions		Input assumptions:	Net present value (EB)[1] with manure valued at			
			Market price as domestic fuel[2] with labour valued at (EB/day)[4]		Price of equivalent amount of fertilizer[3] with labour valued at (EB/day)	
Biogas[5] substitutes for	Slurry fertilizer valued at[3]		1.50	0	1.50	0
Dung cake valued at market price	Official price		664	855	Incompatible assumptions	
	Half official price		560	741		
Firewood valued at market price	Official price		Incompatible assumptions		269	459
	Half official price				165	355
half market price	Offical price				5	184
	Half official price				-99	80

1. EB = Ethiopian birr.
2. 16 kg of wet cattle manure make 6.4 kg of dung cake. The market price of dung cake is EB 0.20/kg.
3. The fertilizer considered for comparison was diammonium phosphate, at an offical price of EB 0.81/kg of compound fertilizer.
4. The daily rural wage is EB 3/day. Family labour, valued alternatively at half the rural wage or at zero cost, is used to operate the digestor, i.e. to fetch and load wet dung and water and to remove and spread slurry on adjacent fields; 1.5 hours/day were budgeted, of which 30% was for fetching water, 55% for carrying slurry to the field and 15% for spreading the slurry on the field.
5. 1 m^3 of biogas substitutes as fuel for 12.3 kg of dung cake or 3.5 kg of firewood.

nary intervention on the productivity of a herd and net income to be generated from such investment.

The model is deterministic and dynamic. Given technical parameters (e.g. calving rate, mortality, nutrition or health), economic parameters (e.g. input and output prices, interest rate) and the herd structure at the beginning of an investment period, the model provides a detailed projection of herd composition, productivity, costs and benefits over 10 years, and calculates the net present value (NPV) and the internal rate of return (IRR) which the investment will give. It also allows users to make various sensitivity analyses.

The model was subsequently used to evaluate the effects of changes in input and output prices and in technology on profitability in three dairy production systems in Kenya. The systems can be classified as common grazing with crossbred cows, and semi-zero grazing and zero grazing with grade cattle. The results from the numerous runs and sensitivity analyses revealed:

- Lower calf mortality and increased calving rates are the key factors to substantially increased benefits.
- The IRR is affected more by milk price changes at higher milk yields.
- Zero-grazing technology can only realise its full potential where wages and fertilizer prices are low.
- The effects on profitability of an adjustment in the price of commercial feeds are similar to those of an increase in milk price.

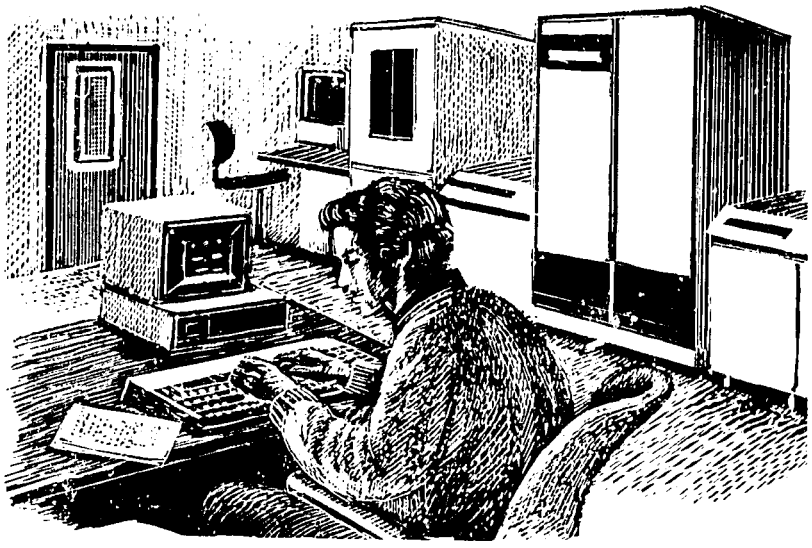
Table 24 illustrates the sort of sensitivity analysis which the model makes possible.

Table 24. The internal rate of return (IRR) to investments in a zero-grazing dairy system in Kenya under different assumptions.

Assumed daily milk yield (litres)	Assumed cost of fertilizer (KSh/kg)[1]	IRR (%) Assumed milk price of (KSh/litre) 4.5	5.5
8	3.5	10.9	22.1
	2.5	12.7	24.1
	1.5	14.6	26.2
9	3.5	17.4	29.1
	2.5	19.3	31.3
	1.5	21.3	33.6

1. KSh = Kenyan shillings.

Computer Unit



Introduction

The Computer Unit maintains and manages the Centre's minicomputer, services the needs of microcomputer users, provides programming, statistical and biometric support for research and programming support for administration.

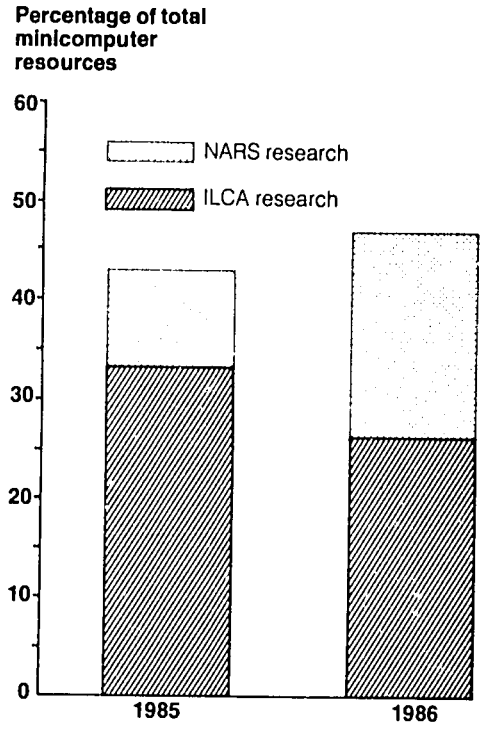
Minicomputers

Overall research use of the minicomputers was 47% of total use in 1986. Use by ILCA research units declined by about 7%, but assistance to national agricultural research services (NARSs) more than doubled from almost 10% in 1985 to 21% in 1986 (Figure 16). Use of the minicomputers by administration and library/documentation remained at 1985 levels.

Microcomputers

More powerful statistical software was released for use with the IBM PC/ATs installed in the West African field programmes and the HP Vectras in the East African programmes. A substantial amount of data analysis can now be carried out within these programmes. The slight decline in ILCA's research use of the minicomputer was due mainly to the installation of additional microcomputers for ILCA researchers (Figure 17). At headquarters, microcomputers are now used more widely by Administration to support payroll and personnel procedures.

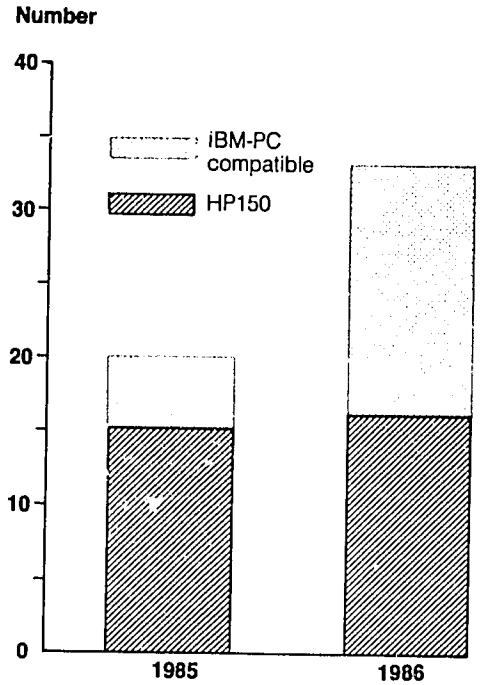
Figure 16. Percentage of total minicomputer resources used by ILCA and NARS research, 1985 and 1986.



IDEAS

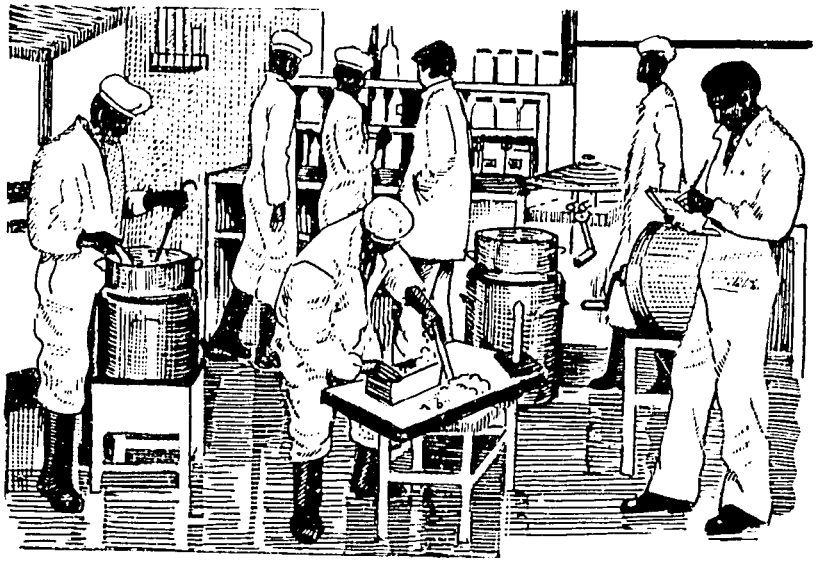
IDEAS (ILCA data entry and analysis system) is a microcomputer-based animal recording system developed by ILCA to facilitate recording and analysis of performance data for different livestock species (see centre spread, *ILCA Annual Report 1985/86*). The system was installed at 11 research sites in both West and East Africa during 1986. The Unit trained staff of national and international agricultural research agencies from Gambia, Kenya, Mali, Nigeria and Senegal in the use of the package and the interpretation of its output.

Figure 17. Number of HP150 and IBM-PC-compatible microcomputers in research departments, 1985 and 1986.



Training and Information Department

Training Division



Introduction

Although often well educated, many African livestock scientists lack practical experience in the research techniques and methodologies of their disciplines. Because they are few and widely dispersed, this inexperience is difficult to overcome through peer contact. The isolation and inexperience of individuals can be overcome by suitable training; the value of this training is greatly enhanced if it brings together like-minded colleagues and provides a basis for continuing professional contact.

ILCA has developed programmes for training African scientists in the techniques used by ILCA scientists in their own research projects. The objectives of this training are to expand research project efforts over larger parts of the continent and introduce standardised procedures that produce comparable data. The training has also aided the development of specialised information and research networks to link participants with their peers, stimulate their individual efforts and increase the quality and impact of their research.

Research methods, ranging from adaptation testing of forage legumes to the economic evaluation of animal disease control programmes, are now the subject of most of ILCA's training. During 1986 techniques for field and laboratory research were taught to 201 participants in courses and individual instruction was given to an additional 261 young scientists.

Training courses

Eleven courses were given on nine topics (Table 25). Instruction on range ecology research techniques, how to evaluate the potential of forage legumes and methods for analysing national livestock policies were offered for the first time. Two popular, regular courses, on animal nutrition and the economics of animal health, were taught for the sixth and fourth time respectively. Four major courses were given in French. The course participants in 1986 represented 38 African countries, including, for the first time, trainees from Angola and Guinea-Bissau.

Individual training

The greatest expansion during 1986 in ILCA's training activities, however, was in special programmes for individuals; the number of individual trainees increased from 38 in 1985 to 60 in 1986 (Table 26).

Table 25. Group training courses at ILCA, 1986.

Name	Attendance	
	No. of participants	No. of countries
Dairy technology	19	6
ILCA/RRC/OXFAM dairy technology	12	1
Standardisation of livestock data (French)	20	10
Range ecology (French)	21	11
Economics of animal health (French)	22	14
Agricultural information (French)	18	10
Livestock policy	20	9
Animal nutrition	16	9
IDRC/PANESA/ILCA forage evaluation	16	10
ILCA/SEADZ dairy technology	18	1
CIMMYT/ILCA data collection and analytical techniques	19	10
Total	201	

These 60 participants worked for varying periods in 15 different ILCA research units located in 4 African countries. Most of this increase occurred in two training categories: graduate associate positions to enable university students to do their thesis research in Africa, and undergraduate associate positions to enable younger university students to work on special projects in foreign countries.

Most graduate associates at ILCA are Africans studying at universities overseas. By doing their research at ILCA they are able to study the livestock problems of their home continent. Because their university supervisors visit them to monitor their progress, links between ILCA and universities are also strengthened.

Undergraduate associates come mostly from donor countries in the developed world. These are usually highly motivated young people contemplating careers in international agriculture. They must fund their travel to Africa, but their board and project costs are paid by ILCA.

The 60 individual trainees in 1986 came from 25 countries: 16 in Africa and 9 in Europe or North America. Seventeen were graduate associates on programmes lasting from 6 to 24 months; 15 were technician associates—junior scientists from African research institutes who come to ILCA for 4 to 16 weeks to learn special techniques; 12 were post-doctoral associates on 2-year assignments to work with ILCA staff; 9 were undergraduate associates; 4 were visiting scientists from African universities; and 3 were research fellows completing projects with the aid of ILCA information, computer or laboratory facilities. Of the 60 individual trainees, 37 completed their studies during the year and 23 were resident into 1987.

Table 26. Individual training by country, 1986.

Category	Country	Number	Total
Post-doctoral Associate	Ghana	4	
	Liberia	1	
	Sierra Leone	1	
	Kenya	1	
	Ethiopia	1	12
	Tanzania	1	
	Uganda	1	
	Mali	1	
	Canada	1	
Visiting Scientist	Nigeria	2	
	Kenya	1	4
	Sierra Leone	1	
Graduate Associate	Ethiopia	7	
	Tanzania	1	
	Uganda	1	
	Switzerland	1	17
	USA	2	
	FRG	1	
	Italy	2	
	Norway	1	
	Ireland	1	
Undergraduate Associate	Nigeria	2	
	Holland	2	
	Switzerland	1	9
	UK	1	
	Canada	2	
	FRG	1	
Technician Associate	Niger	1	
	Togo	1	
	Gambia	2	
	Malawi	1	
	Nigeria	2	15
	Tanzania	2	
	Ethiopia	4	
	Zimbabwe	1	
	UK	1	
Research Fellow	Mali	1	
	Sudan	1	3
	Zaire	1	
	Grand total	60	60

Library and Documentation Division

Introduction

ILCA's Library and Documentation Division provides literature and information on livestock research and development to ILCA scientists, researchers working in national agricultural research institutions and others involved in livestock development in Africa. During 1986, the Division strengthened its activities by introducing new services and by improving the quality of existing ones.

ILCA/IDRC information projects

The ILCA/IDRC microfiche project, launched in 1978, ended in June 1986. Twenty-five countries in sub-Saharan Africa were covered under the project and over 20 000 "grey literature" documents microfiched. These unpublished documents are made available to collaborating institutes and can be accessed through a series of published indexes or through the Division's computerised database.

A new three-pronged project for an integrated livestock information service, again funded by IDRC, started in 1986. The project provides for detailed evaluation of the microfiche project, preparation of a series of specialised bibliographies on subjects central to ILCA's research and expansion of the selective dissemination of information service.

Computerised information services

In 1986 ILCA's selective dissemination of information (SDI) service provided 550 researchers in 42 sub-Saharan African countries with monthly updates of relevant world literature according to individual research interests. This service is based on the monthly supply of information from the Commonwealth Agricultural Bureaux International (CABI) and from FAO's agricultural information service, AGRIS. Under the new project, this service will be extended to a total of 1000 scientists.

Five hundred retrospective searches were also made for ILCA staff and external users on ILCA's internal database and external databases. ILCA's database now contains 44 000 entries.

Library

In 1986 the Library purchased 1072 books and acquired 1134 through donations, bringing the total book collection to 20 000. The collection of periodicals and monograph series now comprises 1623 titles. The computerisation of the entire book collection catalogue was completed during 1986: the catalogue is now available on-line for bibliographic searches. In addition to books, the database, with over 45 000 entries, also contains the microfiche catalogue, the list of serials in the library collection and some non-conventional literature.

A total of 182 000 photocopy sheets, 14 000 microfiches and 8000 ILCA publications were distributed upon request to both internal and external users. The "current titles" service, which groups the contents pages of journals according to five major disciplines, was sent to 100 agricultural libraries in sub-Saharan Africa.

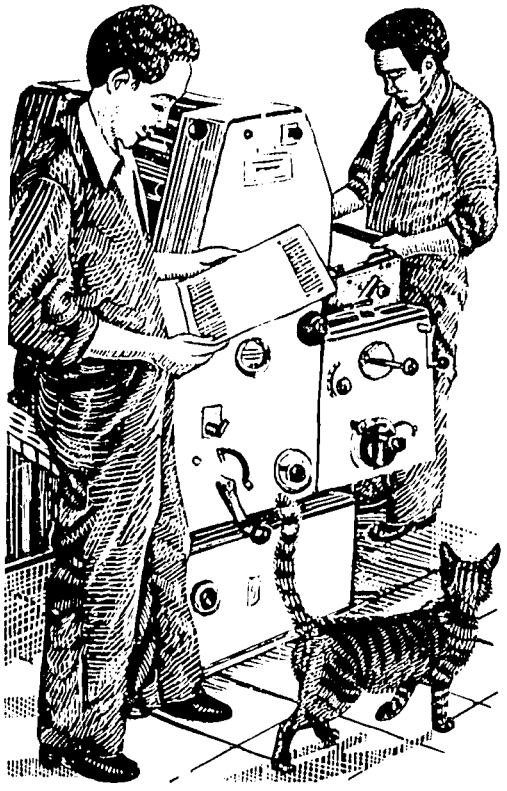
Training

A formal 2-week training course on handling and dissemination of agricultural information offered by the Division was attended by 25 participants from francophone African countries. The Division also gave 2 months in-service training on microfiche technology to two staff members from libraries of national agricultural research organisations in Nigeria and Togo.

Mailing and distribution

ILCA's computerised mailing list now contains over 7000 addresses of institutions and individuals, 63% of which are in Africa. Efforts have been made to increase the number of recipients in those countries that receive few ILCA publications relative to their contribution to ILCA's budget or, for African countries, relative to their livestock and human populations.

Publications Division



In August 1986 the Publications Section and the Audio-Visuals and Mapping Section were merged to form the Publications Division.

The Division produced a range of official ILCA publications during 1986 — these are listed in the Annexes of this report. The Division also met the Centre's internal and administrative printing requirements and provided a number of services to ILCA staff and their departments.

Compared with 1985, there were increases in the number of official ILCA publications in the following series: *ILCA Research Report*, conference proceedings and microfiche indexes. Significantly, the Division also increased its support for ILCA's training activities by assisting in the preparation of draft training manuals and educational tape/slide presentations.

During 1986 the Division handled increasing numbers of internal requests for various services, including photography and processing, provision of visual aids, translation and printing. The total number of pages printed by the Division increased by 29% compared with 1985, due to both the requirements of the External Programme and Management Reviews of May 1986 and recent additions to ILCA's mailing lists.

The Division's infrastructure was further improved during the year by the installation of a new camera, a film dryer and a heavy-duty photocopier in the Print Unit, and by upgrading of the phototypesetting equipment in the Pre-Print Unit.

List of Abbreviations

AGRIS	Agricultural Information Service of FAO
Al	aluminium
ARNAB	African Research Network for Agricultural Byproducts
AU	animal units
AVHRR	advanced very high resolution radiometer
B	boron
BBF	broadbed and furrow
Ca	calcium
CABI	Commonwealth Agricultural Bureaux International
CFA	Communauté financière africaine
CIAT	Centro Internacional de Agricultura Tropical
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
Co	cobalt
CS	DDE milk collection station
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
Cu	copper
DDE	Dairy Development Enterprise (Ethiopia)
DHP	dihydroxy pyridine
DLG	daily liveweight gain
DM	dry matter
EB	Ethiopian birr
ELISA	enzyme-linked immunosorbent assay
Fe	iron
FNE	Forage Network in Ethiopia
FRG	Federal Republic of Germany
GTZ	Gesellschaft für Technische Zusammenarbeit (Agency for Technical Cooperation, Fed. Rep. of Germany)
ha	hectare
HP	Hewlett-Packard
HTS	Hunting Technical Services
NDVI	normalised difference vegetation index
IBM	International Business Machines
IBPGR	International Board for Plant Genetic Resources
IBR	infectious bovine rhinotracheitis
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDEAS	ILCA data entry and analysis system
IDRC	International Development Research Centre (Canada)
IFG	intensive feed garden
IITA	International Institute of Tropical Agriculture
INRZFH	Institut national de recherche zootechnique forestière et hydrobiologique (Mali)
IRAZ	Institut de recherche agronomique et zootechnique de la Communauté économique des pays des Grand Lacs
IREMA	Instituto de reproduccao et de mejoramiento animale
IRR	internal rate of return
ISAR	Institut des sciences agronomiques du Rwanda
ISRA	Institut sénégalais des recherches agricoles
ITC	International Trypano-tolerance Centre (Gambia)
K	potassium
KSh	Kenyan shilling
LSD	least significant difference
Mg	magnesium
Mo	molybdenum

N	nitrogen
n.a.	not available
NARS	national agricultural research service
NDF	neutral-detergent fibre
NDFRS	National Dryland Farming Research Station (Kenya)
SDI	selective dissemination of information
NOAA	National Oceanic and Atmospheric Administration (USA)
NPV	net present value
NS	not significant
OGAPROV	Office gabonais d'amélioration et de production de viande
P	phosphorus
p.a.	per annum
PANESA	Pasture Network for Eastern and Southern Africa
PCV	packed cell volume
RRC	Relief and Rehabilitation Commission
S	sulphur
SE	standard error
SEADZ	South-Eastern Agricultural Development Zone (Ethiopia)
SODEPRA	Société de développement des productions animale
SRF	systematic reconnaissance flights
t	tonne
TLU	tropical livestock unit
UNEP	United Nations Environment Programme (Kenya)
UNSO	United Nations Sahelian Office
USAID	United States Agency for International Development

Annexes

Staff list

(Supervisory and professional staff, at 1 May 1987)

DIRECTOR GENERAL'S OFFICE

J Walsh, *Director General*
R A Stewart, *Assistant to the Director General and Director of Donor and Board Secretariat*
Tehout Workalemahu, *Executive Secretary*

RESEARCH DEPARTMENT

K J Peters, *Director of Research*

Zonal Research Division

Highlands Programme

S Jutzi, *Forage Agronomist and Team Leader*
Abate Tedla, *Forage Agronomist*
Abiye Astatke, *Agricultural Engineer*
Getachew Asamenew, *Agricultural Economist*
M Goe, *Animal Scientist*
E Ikavalko, *Agronomist (Associate Scientist)*
Tadesse Tessema, *Debre Zeit Station Coordinator*
S Weise, *Forage Agronomist (Research Associate)*
Woldeab Wolde Mariam, *Debre Berhan Station Coordinator*

Humid Zone Programme

L Reynolds, *Animal Scientist and Team Leader*
A Atta-Krah, *Agronomist*
J Cobbina, *Forage Agronomist (Post-doctoral Associate)*
P Francis, *Agro-economist*

Subhumid Zone Programme

R von Kaufmann, *Agricultural Economist and Team Leader*
M A Mohamed-Saleem, *Forage Agronomist*
G Tarawali, *Forage Agronomist*

Sahel Programme

A K Diallo, *Animal Scientist and Team Leader*
P Bartholomew, *Forage Agronomist*
M I Cissé, *Ecologist*
M Diagayete, *Animal Scientist (Post-doctoral Associate)*
L Diarra, *Ecologist*
M Dicko, *Animal Nutritionist (Niger)*
K Fofana, *Chief Accountant*
P Hiernaux, *Ecologist*
H Hulet, *Agronomist*
S Maiga, *Veterinarian*
S Soumare, *Sociologist*
A Tall, *Administrative Officer*
A Traoré, *Veterinarian*

East African Rangelands Programme

Ethiopian rangelands

L Coppock, *Animal Scientist/Ecologist and Team Leader*
Assefa Eshete, *Ecologist/Photo-interpreter*
Belete Dessalegne, *Animal Scientist*
Michel Corra, *Ecologist*
M J Nicholson, *Animal Production Scientist*
Tassew G/Medhin, *Pilot*

Kenya rangelands

Solomon Bekure, *Agricultural Economist and Team Leader*
F Chabari, *Agricultural Economist*
P N de Leeuw, *Ecologist*
A Okuome, *Administrative and Financial Officer*
I ole Pasha, *Sociologist*

Animal Science Division

J C M Trail, *Deputy Director of Research (Animal Science)*

Animal Nutrition Section

D Little, *Head of Section*
Aklilu Askabe, *Farm and Grounds Manager*
E Kabaija, *Animal Scientist (Post-doctoral Associate)*
J D Reed, *Animal Nutritionist*
Tekalegn Tadesse, *Analytical Chemist*
A M Said, *Animal Nutritionist/ARNAB Coordinator*

Animal Reproduction and Health Unit

O Kasali, *Head of Unit*
G Cecchini, *Biochemist (Research Associate)*
M Mattoni, *Veterinarian*
E Mukassa-Mugerwa, *Animal Scientist*

B Njau, *Veterinarian (Post-doctoral Associate)*
S Sovani, *Veterinarian (Research Associate)*
Teklye Bekele, *Veterinarian*

Livestock Productivity and Trypanotolerance Group

J C M Trail, *Animal Geneticist and Head of Group*
K Agyemang, *Animal Production Scientist (ITC, Gambia)*
G d'Ieteren, *Veterinarian and Network Coordinator*
P Itty, *FAO Associate Specialist*
H Maehl, *Animal Production Specialist*
S Nagda, *Senior Biological Data Analyst*
A Ouattara, *Bilingual Assistant to Network Coordinator*
J M Rarieya, *Biological Data Assistant*
W Thorpe, *Animal Scientist*
Woudyalew Mulate, *Project Supervisor (Ethiopia)*

Small Ruminant and Camel Group

R T Wilson, *Animal Scientist and Head of Group*
D Bourzat, *Animal Scientist*
K Gautsch, *Animal Scientist (Post-doctoral Associate)*

Plant Science Division

J Tothill, *Deputy Director of Research (Plant Science)*

Forage Agronomy Section

J R Lazier, *Forage Agronomist and Head of Section*
B Dzowela, *PANESA Coordinator (Kenya)*
J Hanson, *Gene Bank Manager*
J M Kahurananga, *Plant Ecologist*
A Russell-Smith, *Forage Agronomist*

Soils and Plant Nutrition Section

I Haque, *Soil Scientist*
C S Kamara, *Visiting Scientist*
Tekalign Mamo, Soil Scientist (Post-doctoral Associate)

Livestock Economics Division

S G Sandford, *Deputy Director of Research (Economics)*

Livestock Economics Unit

S G Sandford, *Head of Unit*
Addis Anteneh, *Economist*
S Debra, *Economist (Post-doctoral Associate)*
J McIntire, *Economist*
Senait Seyoum, *Senior Economic Assistant*

Computer Unit

J Durkin, *Computer Operations and Systems Manager*
T Metz, *Scientific Programmer*
E Richardson, *Biometrician*
G Roscoe, *Administrative Programmer*
A R Sayers, *Biometrician*

TRAINING AND INFORMATION DEPARTMENT

R G Scholtens, *Director of Training and Information*

Training

L Padolina, *Administrative Assistant*
Werqu Mekasha, *Training and Conference Officer*

Information

Library and Documentation

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

Publications Division

Admassu Wondafresh, *Head of Audio-Visual and Mapping Section*
I Alipui, *Assistant Editor*
S R Beckerman, *Head of English Copy Unit*
A Leymarie, *Editor/Translator*
Manyahlishal Kebede, *Production Manager*
P J H Neate, *Science Writer*
D Niang, *Head of French Copy Unit*
C de Stoop, *French Proofreader*

OUTREACH DEPARTMENT

M Sall, *Director of Outreach*
Amde Wondafrash, *National Liaison Officer*
Ephraim Bekele, *Liaison Service Officer*
Alemayehu W Giorgis, *Travel Officer*
Tafesse Akale, *Protocol Officer*

ADMINISTRATION

K F M Geerts, *Head of Administration*
B Johri, *Personnel Manager*
A M Conti, *Personnel Officer*
Ahmed Osman, *Assistant Personnel Officer*
F Leone, *Physical Plant Manager*
Pietro Monaia, *Senior Maintenance Assistant*
Sahle Kebede, *Catering Officer*
Shiferaw Kebede, *Registry Supervisor*
Tekeste B Habtu, *Procurement Officer*
J A T Thersby, *Warden*

FINANCE

Antonio Silla, *Assistant Auditor*
Belayhun Wondimu, *Chief Accountant*
Emmanuel Tesfamariam, *Budget Officer/Internal Auditor*
Negussie Abraham, *Disbursement and Collection Supervisor*

Publications

Annual Reports

ILCA Annual Report 1985/86

CIPEA Rapport annuel 1984/85

Research Reports

Trail J C M, Sones K, Jibbo J M C, Durkin J, Light D E and Murray, Max. 1985. *Productivity of Boran cattle maintained by chemoprophylaxis under trypanosomiasis risk.* ILCA Research Report 9, Addis Ababa.

Trail J C M, Sones K, Jibbo J M C, Durkin J, Light D E and Murray, Max. 1986. *Productivité de bovins Boran protégés par chimioprophylaxie contre la trypanosomiase.* ILCA Research Report 9, Addis Ababa.

Kiwuwa G H, Trail J C M, Kurtu M Y, Getachew Worku, Anderson F M and Durkin J. 1986. *Productivité de bovins laitiers métis dans la région d'Arsi en Ethiopie.* ILCA Research Report 11, Addis Ababa.

Agyemang K and Nkhonjera L P. 1986. *Evaluation of the productivity of crossbred dairy cattle on smallholder and Government farms in the Republic of Malawi.* ILCA Research Report 12, Addis Ababa.

Wagenaar K T, Diallo A and Sayers A R. 1986. *Productivity of transhumant Fulani cattle in the inner Niger delta of Mali.* ILCA Research Report 13, Addis Ababa.

Wilson R T. 1986. *Livestock production in central Mali: Long-term studies on cattle and small ruminants in the agropastoral system.* ILCA Research Report 14, Addis Ababa.

Monograph

CIPEA/Ministère Kenyen de l'Environnement et des Resources Naturelles/Programme des Nations Unies pour l'Environnement. 1986. *Enquêtes à basse altitude.* CIPEA Monographie 4, Addis Ababa.

Bulletins

ILCA Bulletin Nos 23, 24 and 25
Bulletin du CIPEA Nos 22 and 23

Newsletters

ILCA Newsletter Vol. 5 (Nos 1, 2, 3 and 4) (E and F)*

ALPAN Newsletter Nos 3 and 4 (E and F)

ALPAN Newsletter Supplements 3 and 4 (E and F)

ALPAN Network Papers 7, 8, 9, 10, 11 and 12

PGRC/E-ILCA Germplasm Newsletter Nos 10, 11 and 12

Forage Network in Ethiopia Newsletter Nos 10, 11 and 12

PANESA Newsletter Nos 2 and 3

The Small Ruminant and Camel Group Newsletter Nos 5, 6 and 7 (E and F)

Manual

Abiye Astatke, Bunning S and Anderson F M. 1986. *Building ponds with animal power in the Ethiopian highlands.* ILCA Manual 2, Addis Ababa.

Indexes/Bibliographies

Sumberg J E. 1986. *Gliricidia sepium (Jacq.) Steud: A selected bibliography.* Addis Ababa.

Documentation Services. 1986. *Index to livestock literature microfiched in Zimbabwe.* Addis Ababa.

Documentation Services. 1986. *Index des documents microfichés par l'équipe CIPEA/CDRI au Bénin.* Addis Ababa.

Conference reports

Haque I, Jutzi S and Neate P J H (eds). 1986. *Potentials of forage legumes in farming systems of sub-Saharan Africa.* Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 16–19 September 1985. ILCA, Addis Ababa.

---

* E = English; F = French.

ARNAB (Agricultural Research Network for Agricultural Byproducts). 1986. *Towards optimal feeding of agricultural byproducts to livestock in Africa.* Proceedings of a workshop held at Alexandria University, Alexandria, Egypt, October 1985. ILCA, Addis Ababa.

von Kaufmann R, Chater S and Blench R. 1986. *Livestock systems research in Nigeria's subhumid zone.* Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Papers, books and chapters of books

Aken'Ova M E. 1986. *In vitro* germination of *Gliricidia sepium* pollen. *Nitrogen Fixing Tree Research Reports* 4:25–26.

Aken'Ova M E and Atta-Krah A N. 1986. Control of spear grass (*Imperata cylindrica* (L.) Beauv) in an alley cropping fallow. *Nitrogen Fixing Tree Research Reports* 4:27–28.

Aken'Ova M E and Sumberg J E. 1986. Observations of the pollination system of *Gliricidia sepium. Nitrogen Fixing Tree Research Reports* 4:29–30.

Bourzat D. 1986. Enquetes et analyses multidimensionnelles: application à un cas concret de recherche-développement. *Rev. Elev. Méd. Vét. Pays Trop.* 39:13–20.

Coppock D L and Detling J K. 1986. Alteration of bison and black-tailed prairie dog grazing interaction by prescribed burning. *J Wildl. Manage.* 50(3):452–455.

Coppock D L, Ellis J E and Swift D M. 1986. Livestock feeding ecology and resource utilization in a nomadic pastoral ecosystem. *J. Appl. Ecol.* 23(2):573–584.

Coppock D L, Swift D M and Ellis J E. 1986. Seasonal nutritional characteristics of livestock diets in a nomadic pastoral ecosystem. *J. Appl. Ecol.* 23(2):585–596.

Coppock D L, Swift D M, Ellis J E and Galvin K. 1986. Seasonal patterns of energy allocation to basal metabolism, activity and production for livestock in a nomadic pastoral ecosystem. *J. Agric. Sci. (Camb.)* 107:357–365.

Henricksen B L. 1986. Reflections on drought: Ethiopia 1983–1984. *Int. J. Remote Sensing* 7(11):1447–1451.

Henricksen B L and Durkin J W. 1986. Growing period and drought early warning in Africa using satellite data. *Int. J. Remote Sensing* 7(11):1583–1608.

Hiernaux P H Y and Justice C O. 1986. Suivi du développement végétal au cours de l'été 1984 dans le Sahel malien. *Int. J. Remote Sensing* 7(11):1515–1531.

Justice C O and Hiernaux P H Y. 1986. Monitoring the grasslands of the Sahel using NOAA AVHRR data: Niger 1983. *Int. J. Remote Sensing* 7(11):1475–1497.

Kuit H G, Traoré A and Wilson R T. 1986. Livestock production in central Mali: Ownership, management and productivity of poultry in the traditional sector. *Trop. Anim. Health Prod.* 18:222–231.

Mohamed-Saleem M A and von Kaufmann R. 1986. Effect of phosphorus application on the productivity and quality of three *Stylosanthes* cultivars. *Trop. Agric. (Trinidad)* 63(3):212–216.

McIntire J. 1986. Constraints to fertilizer use in sub-Saharan Africa. In: Uzo Mokwunye and Paul L G Vlek (eds), *Management of nitrogen and phosphorus fertilizers in sub-Saharan Africa.* Elsevier, Amsterdam, The Netherlands.

Mohamed-Saleem M A and Otsyina R M. 1986. Grain yields of maize and the nitrogen contribution following *Stylosanthes* pasture in the Nigerian subhumid zone. *Exp. Agric.* 22:207–214.

Mohamed-Saleem M A, Otsyina R M and Butterworth M H. 1986. Performance of *Stylosanthes hamata* cv Verano as influenced by nutrient changes. *Trop. Agric. (Trinidad)* 63(3):217–220.

Mohamed-Saleem M A and Suleiman H. 1986. Fodder banks: Dry-season feed supplementation for traditionally managed cattle in the subhumid zone. *World Anim. Rev.* 59:11–17.

Nicholson M J. 1986. The effect of drinking frequency on some aspects of the productivity of zebu cattle. *J. Agric. Sci. (Camb.)* 108:111–117.

Powell J M. 1986. Manure for cropping: A case study from central Nigeria. *Exp. Agric.* 22:15–24.

Reed J D. 1986. Relationships among soluble phenolics, insoluble proanthocyanidins and fiber in East African browse species. *J. Range Manage.* 39:5–7.

Stewart R. 1986. Prospects for livestock production in tsetse-infested Africa. *Impact of Science on Society* 142:117–125. (Also available as "Perspectives d'élevage dans les régions d'Afrique infestées par la mouche tsé-tsé". *Impact: Science et Société* 142:139–148.)

Sumberg J E. 1986. Alley farming with *Gliricidia sepium*: Germplasm evaluation and planting density trial. *Trop. Agric. (Trinidad)* 63(3):170–172.

Tewe O and Kasali O B. 1986. Effect of cassava peel processing on the performance, nutrient

utilisation and physiopathology of African giant rat (*Cricetomys gambianus* Waterhouse). *Trop. Agric. (Trinidad)* 63 (2): 125–128

Traoré A and Bako G. 1984. Etude du cycle sexuel chez les vaches et génisses N'Dama élevées au Centre de Recherches Zootechniques de Sotuba (Mali). I. Incidence de l'utilisation d'un taureau boute-en-train sur les taux de détection des chaleurs. *Rev. Elev. Méd. Vét. Pays Trop.* 1984.

Traoré A and Bako G. 1984. Etude du cycle sexuel chez les vaches et génisses N'Dama élevées au Centre de Recherches Zootechniques de Sotudba (Mali). II.Caractéristiques du cycle oestral et de l'oestrus. *Rev. Elev. Méd. Vet. Pays Trop.* 1984.

Wilson R T. 1986. Central Mali: Cattle husbandry in the agro-pastoral system. *World Anim. Rev.* 58: 23–30.

Wilson R T. 1986. Reproductive performance and survival of young one-humped camels on Kenya commercial ranches. *Anim. Prod.* 42: 375–380.

Wilson R T. 1986. Poultry production in sub-Saharan Africa. *Outlook on Agriculture* 15: 121–127.

Wilson R T. 1986. Chapter 2: Management. In: R M Gatenby, *Sheep production in the tropics and sub-tropics*. Longman, London. pp. 17–39.

Wilson R T. 1986. Strategies to increase sheep production in East Africa. In: V M Timon and J P Hanrahan (eds), *Small ruminant production in the developing countries*. FAO Anim. Prod. Health Paper 58. FAO, Rome. pp. 118–123.

Wilson R T and Light D. 1986. Livestock production in central Mali: Economic characters and productivity indices for traditionally managed goats and sheep. *J. Anim. Sci.* 62: 567–575.

Papers published in proceedings

Agishi E and de Leeuw P N. 1986. The performance of stylosanthes species in different production systems in Nigeria. In: I Haque, S Jutzi and P J H Neate (eds), *Potentials of forage legumes in farming systems of sub-Saharan Africa*. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 16–19 September 1985. ILCA, Addis Ababa.

Akyeampong E. 1986. Some responses of cowpea to drought stress. In: I Haque, S Jutzi and P J H Neate (eds), *Potentials of forage legumes in farming systems of sub-Saharan Africa*. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 16–19 September 1985. ILCA, Addis Ababa.

Anderson F M, Gryseels G and Durkin J W. 1986. Factors affecting smallholder grain production in the Ethiopian highlands. Proceedings of the OAU/SAFGRAD international symposium on food grain production in the semi-arid regions of Africa. Nairobi, May 1986.

Atta-Krah A N, Sumberg J E and Reynolds L. 1986. Leguminous fodder trees in the farming system – an overview of research at the Humid Zone Programme of ILCA in south-western Nigeria. In: I Haque, S Jutzi and P J H Neate (eds), *Potentials of forage legumes in farming systems of sub-Saharan Africa*. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 16–19 September 1985. ILCA, Addis Ababa.

Bayer W. 1986. Traditional small ruminant production in the subhumid zone of Nigeria. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Bayer W. 1986. Utilization of fodder banks. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Bayer W. 1986. Agropastoral herding practices and the grazing behaviour of cattle. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Bourzat D. 1986. Recherche et développement sur les petits ruminants systèmes de production, constraintes et priorités dans les zones arides et semi-arides sud-Sahariennes. In: *Coordination de la recherche pour le développement des petits ruminants en Afrique*. Proceedings of a seminar held in Montpellier, France, 13–17 October 1986. Centre Technique de Coopération Agricole et Rurale, Wageningen, The Netherlands. pp. 91–117.

Bourzat D. 1986. The role of small ruminants in the agro-pastoral farming systems in Yatenga Province (Burkina Faso). In: *Small ruminant production in Nigeria*. Proceedings of a National Conference on Small Ruminant Production held at Zaria, Nigeria, 6–10 October 1985.

The National Animal Production Research Institute, Shika-Zaria, Nigeria. pp. 186–194.

Detling J K, Painter E L and Coppock D L. 1986. Ecotypic differentiation resulting from grazing pressure: Evidence for a likely phenomenon. In: P J Joss, P W Lynch and O B Williams (eds), *Proceedings of the Second International Rangeland Congress, Adelaide, Australia*. Australian Academy of Science, Canberra.

Dzowela B H. 1986. Value of a forage legume component in summer beef fattening systems in Malawi. In: I Haque, S Jutzi and P J H Neate (eds), *Potentials of forage legumes in farming systems of sub-Saharan Africa*. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 16–19 September 1985. ILCA, Addis Ababa.

Haque I, Nnadi L A and Mohamed-Saleem M A. 1986. Phosphorus management with special reference to forage legumes. In: I Haque, S Jutzi and P J H Neate (eds), *Potentials of forage legumes in farming systems of sub-Saharan Africa*. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 16–19 September 1985. ILCA, Addis Ababa.

Hulet H and Gosseye P. 1986. Effect of intercropping cowpea on dry-matter and grain yield of millet in the semi-arid zone of Mali In: I Haque, S Jutzi and P J H Neate (eds), *Potentials of forage legumes in farming systems of sub-Saharan Africa*. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 16–19 September 1985. ILCA, Addis Ababa.

Jibbo J M C, Trail J C M, Sones K, Durkin J, Light D and Murray, M. 1986. Productivity of Boran cattle maintained with chemoprophylaxis under high tsetse challenge at Mkwaja Ranch in Tanzania. 1. Ranch organisation and animal health management. ISCTRC 18th meeting, Harare, Zimbabwe, 1985. No. 113:230–231.

Jutzi S. 1986. Herbage seed production in sub-Saharan Africa, its integration in national pasture research and seed industry development and prospects for regional supporting activities. In: I Haque, S Jutzi and P J H Neate (eds), *Potentials of forage legumes in farming systems of sub-Saharan Africa*. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 16–19 September 1985. ILCA, Addis Ababa

von Kaufmann R. 1986. An introduction to the subhumid zone of West Africa and the ILCA Subhumid Zone Programme. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

von Kaufmann R. 1986. The expected impact and future of the ILCA Subhumid Zone Programme. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

von Kaufmann R. 1986. Matching the impositions of the farming and research systems as a prelude to farming systems research. *ILCA and Farming Systems Support Project Network* 2:137–162. University of Florida, USA, and ILCA, Addis Ababa.

von Kaufmann R R, Wilson R T and Reynolds L. 1986. The economic role of small ruminants in agricultural communities and land use systems in Africa. In: *Coordination de la recherche pour le développement des petits ruminants en Afrique*. Proceedings of a seminar held in Montpellier, France, 13–17 October 1986. Centre Technique de Coopération Agricole et Rurale, Wageningen, The Netherlands.

Lamprey R and de Leeuw P N. 1986. The use of NOAA-AVHRR imagery for rangeland and cropland monitoring. In: R M Henson, B M Woie and R D Child (eds), *Proceedings of a Conference on Range Development and Research in Kenya*. Winrock International, USA. pp. 441–454.

Lazier J R. 1986. Forage networks. In: I Haque, S Jutzi and P J H Neate (eds), *Potentials of forage legumes in farming systems of sub-Saharan Africa*. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 16–19 September 1985. ILCA, Addis Ababa.

Leak S G A, Paling R W, Moloo S K, Machl J H H, Jeannin P, Yangari G and Zang-mve J P. 1986. The trypanotolerance network. 2. A study on health and productivity of N'Dama, Nguni and their crosses under quantified levels of tsetse challenge in Gabon. 2.1. Tsetse survey. ISCTRC 18th meeting, Harare, Zimbabwe, 1985. No. 113:253–258.

Maina J A. 1986. Animal health in subhumid Nigeria. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Maloo S H, Chema S, Koskey S, Kimotho P G, Trail J C M and Murray M. 1986. Health and productivity of East African Zebu under village management in a tsetse-infested area on the coast of Kenya. ISCTRC 18th meeting, Harare, Zimbabwe, 1985. No. 113:182–186.

McIntire J. 1986. On the alleged difficulties of on-farm research with livestock. *ILCA and Farming Systems Support Project Network* 2:117–136. University of Florida, USA and ILCA, Addis Ababa.

Mohamed-Saleem M A. 1986. The ecology, vegetation and land use of subhumid Nigeria. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Mohamed-Saleem M A. 1986. Integration of forage legumes into the cropping systems of Nigeria's subhumid zone. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Mohamed-Saleem M A. 1986. The establishment and management of fodder banks. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Mohamed-Saleem M A and Suleiman H. 1986. Use and issues in on-farm research to improve fodder for livestock of agropastoralists in the Nigerian subhumid zone. *ILCA and Farming Systems Support Project Network* 2:117–136. University of Florida, USA and ILCA, Addis Ababa.

Mohamed-Saleem M A, Otsyina R and von Kaufmann R. 1986. Some methods for improving fodder by incorporating forage legumes in cereal cropping systems in the Nigerian subhumid zone. In: I Haque, S Jutzi and P J H Neate (eds), *Potentials of forage legumes in farming systems of sub-Saharan Africa*. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 16–19 September 1985. ILCA, Addis Ababa.

Mohamed-Saleem M A, Suleiman H and Otsyina R M. 1986. Fodder banks: For pastoralists or farmers. In: I Haque, S Jutzi and P J H Neate (eds), *Potentials of forage legumes in farming systems of sub-Saharan Africa*. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 16–19 September 1985. ILCA, Addis Ababa.

Mohamed-Saleem M A, von Kaufmann R, Otsyina R M and Suleiman H. 1986. Potential role for stylo in traditional crop and livestock production systems in the Nigerian subhumid zone. In: *Proceedings of the XV International Grassland Congress*, Kyoto, Japan, 24–31 August 1985.

Murray, Max and Trail J C M. 1986. Comparative epidemiology and control of trypanosomes. In: M J Howell (ed.), *Parasitology – Quo vadit?* Proceedings of the sixth international congress of parasitology. Australian Academy of Science, Canberra. pp. 621–627.

Murray, Max, Trail J C M and Black S J. 1986. Genetic resistance to parasitic diseases: African trypanosomiasis. *Proceedings of the 3rd World Congress on Genetics applied to Livestock Production*. Lincoln, Nebraska, USA. Vol. XI, pp. 551–562.

Nnadi L A and Haque I. 1986. Forage legume–cereal systems: Improvement of soil fertility and agricultural productivity with special reference to sub-Saharan Africa. In: I Haque, S Jutzi and P J H Neate (eds), *Potentials of forage legumes in farming systems of sub-Saharan Africa*. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 16–19 September 1985. ILCA, Addis Ababa.

Nuwanyakpa M Y, Preston T R and Sayers A R. 1986. Effects of watering frequency on the response of sheep to supplementation with molasses/urea and noug cake (*Guizotia abyssinica*). In: ARNAB (African Research Network for Agricultural Byproducts), *Towards optimal feeding of agricultural byproducts to livestock in Africa*. Proceedings of a workshop held at Alexandria University, Alexandria, Egypt, October 1985. ILCA, Addis Ababa. pp. 93–101.

ole Pasha I K. 1986. Evolution of individuation of group ranches in Maasailand. In: R M Henson, B M Wole and R D Child (eds), *Proceedings of a Conference on Range Development and Research in Kenya*. Winrock International, USA. pp. 303–318.

Otchere E O. 1986. Traditional cattle production in the subhumid zone of Nigeria. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Otchere E O. 1986. The effects of supplementary feeding of traditionally managed Bunaji cows. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Paling R W, Leak S G A, Machl J H H, Jeannin P and Yangari G. 1986. The trypanotolerance network. 2. A study on health and productivity of N'Dama, Nguni and their crosses under quantified levels of tsetse challenge in Gabon. 2.2. The influence of trypanosomiasis on the health status and performance. ISCTRC 18th meeting, Harare, Zimbabwe, 1985. No. 113:259–260.

Powell J M. 1986. Cropping systems in the subhumid zone. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Powell J M. 1986. Crop–livestock interactions in the subhumid zone of Nigeria. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Preston T R. 1986. Strategies for optimising the utilisation of crop residues and agro-industrial byproducts for livestock feeding in the tropics. In: ARNAB (African Research Network for Agricultural Byproducts), *Towards optimal feeding of agricultural byproducts to livestock in Africa*. Proceedings of a workshop held at Alexandria University, Alexandria, Egypt, October 1985. ILCA, Addis Ababa. pp. 145–166.

Preston T R. 1986. Strategic supplementation to optimise rumen function and the balance of absorbed nutrients in ruminants fed largely on crop residues. In: ARNAB (African Research Network for Agricultural Byproducts), *Towards optimal feeding of agricultural byproducts to livestock in Africa*. Proceedings of a workshop held at Alexandria University, Alexandria, Egypt, October 1985. ILCA, Addis Ababa. pp. 167–180.

Solomon Bekure and Chabari F N. 1986. Livestock marketing in Kajiado district, Kenya. In: R M Henson, B M Woie and R D Child (eds), *Proceedings of a Conference on Range Development and Research in Kenya*. Winrock International, USA. pp. 351–364.

Taylor-Powell E and Ingawa S A. 1986. Beneficiary reactions to the fodder bank trials. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Taylor-Powell E and Suleiman H. 1986. Extension implementation of ILCA interventions: Dry-season cow supplementation and fodder banks. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Tothill J C. 1986. The role of legumes in farming systems of sub-Saharan Africa. In: I Haque, S Jutzi and P J H Neate (eds), *Potentials of forage legumes in farming systems of sub-Saharan Africa*. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 16–19 September 1985. ILCA, Addis Ababa.

Trail J C M. 1986. Animal breeding in developing country situations in Africa. *Proceedings of the 3rd World Congress on Genetics applied to Livestock Production*. Lincoln, Nebraska, USA. Vol. XI, pp. 474–485.

Trail J C M, Murray M, Sones K, Jibbo J M C, Durkin J and Light D. 1986. Productivity of Boran cattle maintained with chemoprophylaxis under high tsetse challenge at Mkwaja Ranch in Tanzania. 2. Productivity. ISCTRC 18th meeting, Harare, Zimbabwe, 1985. No. 113:232–236

Trail J C M, Wissocq Y J, D'Ieteren G, Maehl J H H, Murray, Max, Paling R W, Leak S G A and Moloo S K. 1986. The Trypanotolerance Network. 1. Objectives, organisation and current activities. ISCTRC 18th meeting, Harare, Zimbabwe, 1985. No. 113:247–252.

Waters-Bayer A. 1986. Dairy subsector of the agropastoral household economy. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Waters-Bayer A and Taylor-Powell E. 1986. Population and land use in the subhumid zone of Nigeria. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Waters-Bayer A and Taylor-Powell E. 1986. Settlement and land use by Fulani pastoralists in case study areas. In: R von Kaufmann, S Chater and R Blench (eds), *Livestock systems research in Nigeria's subhumid zone*. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November 1984. ILCA, Addis Ababa.

Wilson R T. 1986. The Small Ruminant and Camel Group and research network of the International Livestock Centre for Africa. In: *Coordination de la recherche pour le développement des petits ruminants en Afrique*. Proceedings of a seminar held in Montpellier, France, 13–17 October 1986. Centre Technique de Coopération Agricole et Rurale, Wageningen, The Netherlands. pp. 155–161.

Meetings attended

Africa Mountains Workshop, sponsored by the Commission on Mountain Geoecology, International Geographical Union, Addis Ababa, October 1986.

Annual Meeting of the Kenya Veterinary Association, March 1986.

ARNAB Workshop on Agricultural Byproducts using Technologies Appropriate for Small-scale Farmers, Blantyre, Malawi, August–September 1986.

ASA-CSSA-SSSA 1986 Annual Meeting, New Orleans, November–December 1986.

Atelier sur la Méthodologie des Etudes Systémiques en Afrique Intertropicale, ISRA, Senegal, February 1986.

CGIAR Farming Systems Workshop, ICRISAT, Hyderabad, India, February 1986.

Conference on Agro-Technological Systems Towards 2000: A European Perspective, Bologna, Italy, September 1986.

Conference on the Application of Micro-computers in Information, Documentation and Libraries, Baden-Baden, Federal Republic of Germany, March 1986.

Consultation on Plant Genetic Resources in SADCC Countries, Lusaka, Zambia, September 1986.

Coordination de la Recherche pour le Développement des Petits Ruminants en Afrique, CTA/EEC/GTZ/IEMVT, France, October 1986.

Crop–Livestock Systems Research Workshop, Khon Kaen, Thailand, July 1986.

EEC-Convened Meeting on the Systran System of Machine Translation, Luxembourg, February 1986.

Eleventh Meeting of the Nigerian Society of Animal Production, Ahmadu Bello University, Zaria, March 1986.

FAO Commission on African Animal Trypanosomiasis, Fourth Session, Ouagadougou, November 1986.

FAO Expert Consultation on Biotechnology for Livestock Production and Health, Rome, Italy, October 1986.

FAO Middle and Near East Animal Production Development Project Conference on Camels, FAO/Ministry of Livestock, Kuwait, October 1986.

Fifth International Conference of Institutions of Tropical Veterinary Medicine, Malaysia, August 1986.

Fifth SR-CRSP Annual Workshop, Nairobi, Kenya, November 1986.

Fifth Technical Consultation of AGRIS Participating Centres, Rome, Italy, June 1986.

First Australian AVHRR Conference, Perth, Australia, September 1986.

First IBSRAM Networkshop in Africa on Improved Vertisol Management, Nairobi, Kenya, December 1986.

First Somalian Veterinary Conference, Mogadishu, Somalia, October 1986.

Fourth Tanzanian Veterinary Association Scientific Conference, Arusha, Tanzania, December 1986.

HP3000 International Users' Meeting, Madrid, Spain, March 1986.

Inter-Centre Workshop on Agroforestry, ICRAF, Nairobi, Kenya, September 1986.

Inter-Centre Workshop on Agro-ecological Characterisation, Classification and Mapping, Rome, Italy, April 1986.

International Conference on Drought, Desertification and Food Deficits, African Academy of Science Inaugural Meeting, Nairobi, Kenya, June 1986.

International Symposium on Drought Prediction, Detection, Impact Assessment and Response, University of Nebraska, September 1986.

International Symposium on the Conservation and Utilisation of Ethiopian Germplasm, Addis Ababa, Ethiopia, October 1986.

International Trypanotolerance Centre, Council Meeting, Banjul, Gambia, October 1986.

MINISIS Advanced Training Course and MINISIS Users' Group Meeting, Singapore, October 1986.

Nairobi Cluster/Kenya Veterinary Association Joint Meeting, Nairobi, Kenya, October 1986.

Nairobi Cluster Meetings, February/June/October 1986.

National Crop Improvement Conference, Institute of Agricultural Research, Nazret, Ethiopia, April 1986.

National Workshop on Food Strategies for Ethiopia, Alemaya University of Agriculture, Dire Dawa, Ethiopia, December 1986.

Ninth Session of the Commission of Agrometeorology, World Meteorological Organisation, Madrid, Spain, November 1986.

OAU/SAFGRAD International Drought Symposium on Food Grain Production in the Semi-arid Regions of Africa, Nairobi, Kenya, May 1986.

Post Conference International AVHRR Workshop, Melbourne, Australia, September 1986.

Second Conference of the African Association for Biological Nitrogen Fixation, Cairo, Egypt, December 1986.

Second International Symposium on the Flora of Ethiopia and Plants of Eastern and North-Eastern Africa and Southern Arabia, Addis Ababa University, October 1986.

Second West African Integrated Livestock Systems Networkshop on "The Introduction, Intensification and Diversification of the Use of Animal Power in West African Farming Systems: Implications at the Farm Level", held jointly by the Farming Systems Support Project, University of Florida, USA, and the Sierra Leone Work Oxen Project, Freetown, Sierra Leone, September 1986.

Sixth Annual Farming Systems Research and Extension Symposium, Kansas State University, Manhattan, Kansas, October 1986.

Special Program for African Agricultural Research (SPAAR), Network Task Force Meeting, Brussels, Belgium, January 1986.

State Farm Managers' Workshop, Ambo, Ethiopia, April 1986.

Stratégies de Développement de l'Elevage Pastoral au Niger, Ministère de Développement Rural, Niger, February 1986.

Symposium on Plains Indian Cultures: Past and Present Meanings, Center for Great Plains Studies, University of Nebraska, March 1986.

The Potential of Small Ruminants in Eastern and Southern Africa, IBAR/OAU, Kenya, August 1986.

Third International DLG Symposium, Goslar, Federal Republic of Germany, May 1986.

Third Meeting of the Comité Scientifique et Technique of INRZFH, Mali, May 1986.

Third World Congress on Genetics Applied to Livestock Production, University of Nebraska, July 1986.

Twentieth International Symposium of Remote Sensing of the Environment, Nairobi, Kenya, December 1986.

Twenty-first International Seed Testing Association Congress, Brisbane, Australia, July 1986.

37ème Conférence Annuelle de la Fédération Européenne de la Zootechnie, FEZ, Hungary, September 1986.

Workshop on Biological and Genetic Control of *Leucaena psyllid*, NFTA, Hawaii, November 1986.

Workshop on Research on Smallholder Dairy, Small Ruminants and Pig and Poultry Production in SADCC Countries, SACCAR, Lesotho, November 1986.

Workshop on Review of Soil Science Research in Ethiopia, Addis Ababa, February 1986.

Financial summary

International Livestock Centre for Africa
Balance Sheet at December 31, 1986

(US$ '000)

ASSETS

Current assets	1986	1985
Cash	4 252	7 237
Receivable from - donors	1 681	938
- employees	26	34
- others	350	501
Inventories	697	540
Deposits and prepayments	250	117
Total current assets	7 256	9 367
Fixed assets		
Buildings	9 284	8 820
Research and laboratory equipment	2 406	1 972
Computer	1 282	978
Furnishings and office equipment	2 512	2 345
Vehicles and aircraft	2 266	1 831
Other	142	127
Total fixed assets	17 892	16 073
Total assets	25 148	25 440

LIABILITIES AND FUND BALANCES

Current liabilities		
Accounts payable employees	329	362
Other payables and accruals	3 816	3 702
Contributions received in advance	839	4 040
Total current liabilities	4 984	8 104
Fund balances		
Invested in fixed assets	17 892	16 073
Working capital	1 972	1 063
Capiital development fund	300	200
Total fund balances	20 164	17 336
Total liabilities and fund balances	25 148	25 440

International Livestock Centre for Africa
Statement of Revenue, Expenditure and Fund Balances
for the year ended December 31, 1986

(US$ '000)

	1986	1985
Revenue		
CGIAR contributions	15 176	13 803
Special project grants	2 077	1 675
Earned income	115	193
Capital development fund	439	470
Total revenue	17 807	16 141
Operating expenditure		
Research	8 638	8 362
Information services	1 291	1 133
Training and conferences	1 142	1 070
General administration & operations	1 068	1 549
Board and management	764	506
Total operating expenditure	12,903	12 620
Capital expenditure	1 818	1 765
Special projects	2 077	1 391
Total expenditure	16 798	15 776
Excess of revenue over expenditure	1 009	365
FUND BALANCES		
Opening balances		
Core	1 063	487
Special projects	–	(151)
Capital development fund	200	562
Total opening balances	1 263	898
Excess of revenue over expenditure	1 009	365
Closing balances		
Working capital	1 972	1 063
Capital development fund	300	200
Total closing balances	2 272	1 263

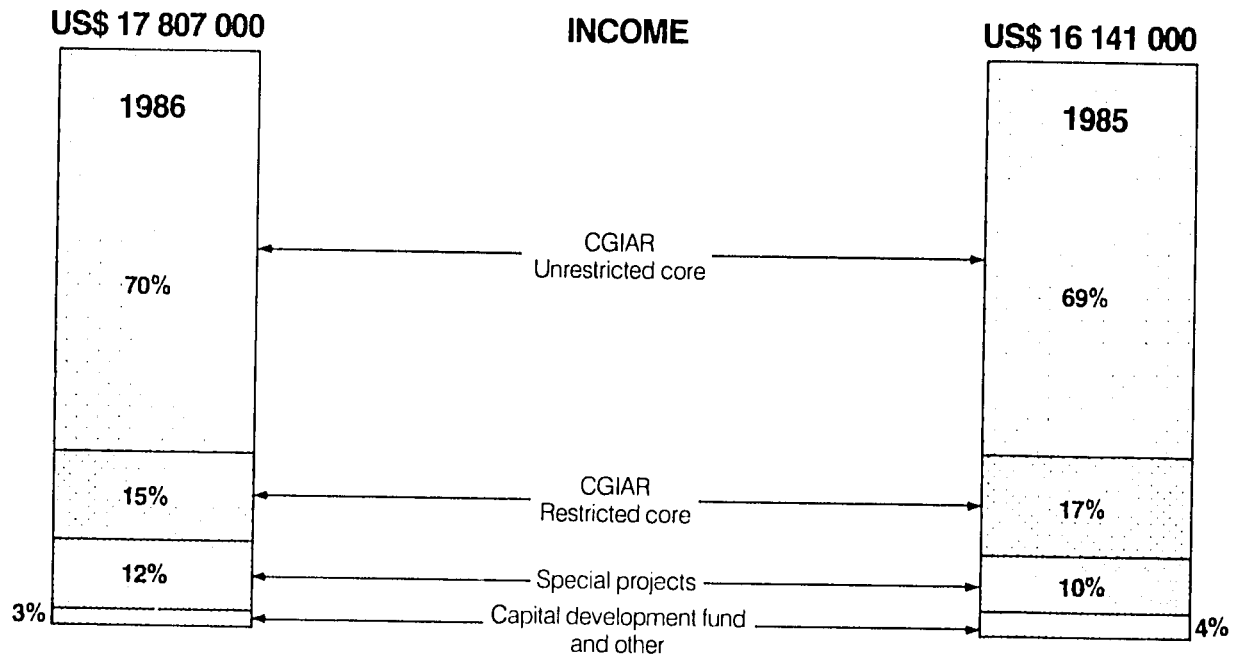
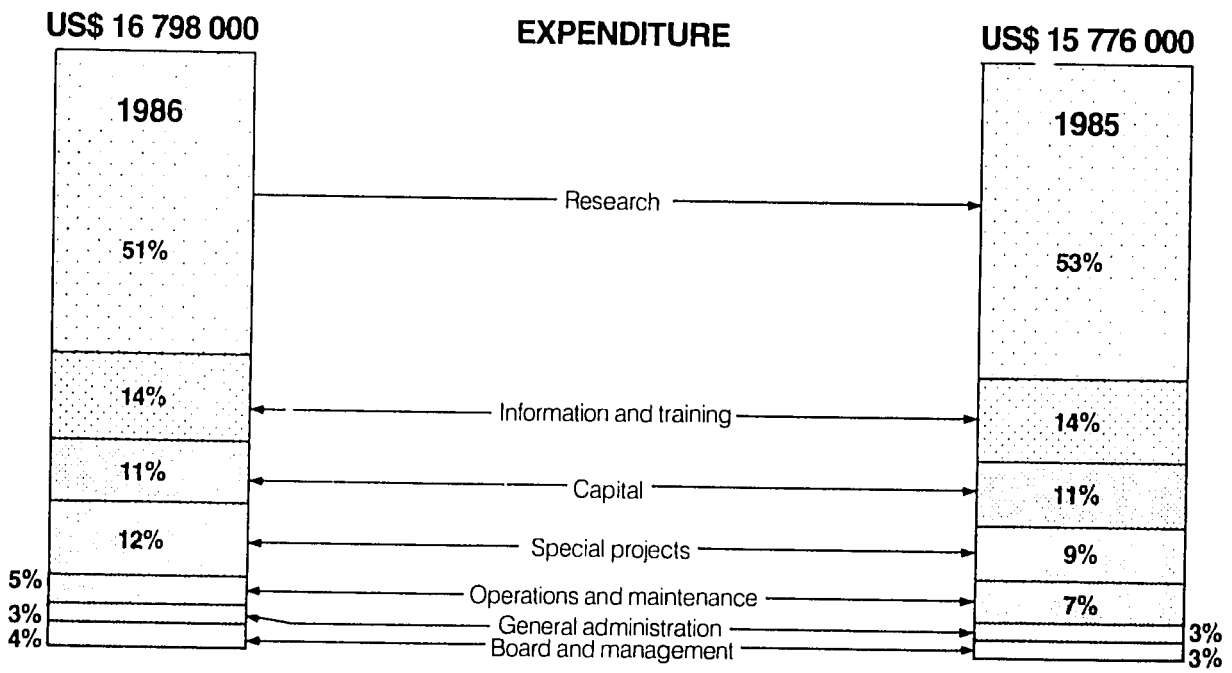
International Livestock Centre for Africa
Schedule of CGIAR Contributions and Special Project Grants
for the year ended December 31, 1986

(US$ '000)

CGIAR Contributions	1986	1985
African Development Bank	200	–
Australia	295	281
Austria	175	–
Belgium	672	481
Canada	718	549
China	–	33
Denmark	254	184
Finland	391	250
France	200	117
Germany - Federal Republic	746	626
India	25	–
International Development Association (World Bank)	3 200	3 450
International Development Research Centre (IDRC)	268	143
International Fund for Agricultural Development (IFAD)	–	500
Ireland	343	172
Italy	1 487	1 681
Netherlands	324	244
Nigeria	45	167
Norway	414	283
Organization of Petroleum Exporting Countries (OPEC)	63	–
Sweden	359	251
Switzerland	1 091	612
United Kingdom	431	302
United States of America (USAID)	3 475	3 175
Stabilization Fund	–	302
Total CGIAR contributions	15 176	13 803
Special project grants		
Australia (ACIAR)	–	7
Australia (CSIRO)	8	–
Belgium	63	–
Canada	–	25
CARE – Ethiopia	69	40
Caritas (Switzerland)	63	–
Christian Relief Development Agency (CRDA)	11	–
City of Beursel	1	–
Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)	422	130
Egyptian Technical Cooperation Fund for Africa	–	17
European Economic Commission (EEC)	622	423
Ford Foundation	34	56
International Board for Plant Genetic Resources (IBPGR)	22	47
International Development Research Centre (IDRC)	143	186
Ireland	3	..
Medios	10	–
Nigeria (FLD)	11	304
Norway	150	–
Oxfam America	132	–
Total C/F	1 764	1 235

CGIAR Contributions and Special Project Grants (Cont'd)

(US$ '000)

	1986	1985
Total B/F	1 764	1 235
Royal Shakespeare Company	31	–
Tufts University/USAID	–	256
United Nations Environmental Programme (UNEP)	25	15
United Nations Sahelian Office (UNSO)	30	–
United States of America (USAID)	227	91
World Vision	–	78
Total special project grants	2 077	1 675

Source and application of funds, 1986 and 1985