ILCA Annual Report 1988

International Livestock Centre for Africa

ILCA
Annual Report
1988

International Livestock Centre for Africa
P.O.Box 5689, Addis Ababa, Ethiopia

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

ISSN 0255–0040

Cover photo *"Look at my new calf!" Mali.*

Correct citation: ILCA (International Livestock Centre for Africa). 1989. ILCA Annual Report 1988. Addis Ababa, Ethiopia.

Contents

List of Tables

Cattle Milk and Meat Thrust

Small Ruminant Meat and Milk Thrust

Trypanotolerance Thrust

List of Figures

Animal Feed Resources Thrust

Trypanotolerance Thrust

Livestock Policy and Resource Use Thrust

Foreword

The year 1988 was the first full year of implementation of ILCA's revised strategy of 1987. Also during the year we developed our medium-term programme and budget for the period 1989 to 1993. This plan was approved by the CGIAR in October 1988. The programme and budget gives a clear outline for the operational implementation of our strategy, and provides a helpful framework for our annual programme and budget planning. In particular, it helps us to plan activities across many research sites in sub-Saharan Africa and, allied with our project-based accounting system, gives us a powerful but flexible means of planning and developing our research, training and information programmes.

The year was characterised by an intense concentration on the development of ILCA's programmes, both at our research sites and in collaboration with national scientists. A list of collaborative research projects is given in the annexes to this report. This Annual Report provides a comprehensive overview of our programmes and their output, and some of the more important results are presented in our 1988 highlights on page xiv. The year also saw further integration of research across zonal sites, and a full catalogue of research protocols (one for each of ILCA's 180 research subprojects) was produced in 1988.

This report shows the important results obtained in 1988 in our research thrusts, as well as our training and information programmes. In our three commodity thrusts (Cattle Milk and Meat, Small Ruminant Meat and Milk and Animal Traction), we have obtained important results in feeding and supplementation trials; smallholder dairying; alley farming with small ruminants; reproductive diseases; physiology of working animals; and on-farm testing of improved traction techniques. In our three strategic thrusts (Animal Feed Resources, Trypanotolerance and Livestock Policy and Resource Use), 1988 saw significant progress in the development of techniques for in vitro multiplication, storage and dissemination of grass and browse germplasm, and in germplasm screening and intercropping studies; quantification of the relative effects of the components of trypanosome infection and tsetse control techniques; and studies of the impacts of livestock pricing policies on meat and milk output in several countries. Our research activities were complemented by our training and information programmes: we offered 9 major courses during the year, hosted more than 60 individual "trainees", established a new training materials and methods

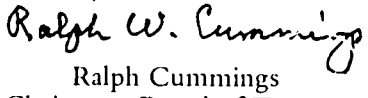
unit and further developed our range of information services for scientists and libraries in the national agricultural research systems (NARS).

As stated in our 1987 strategy documents, our success is measured in terms of improvements in the sustainable economic output of livestock products. The concept of sustainable production pervades all our programme activities. Specific studies on the sustainability of production systems that involve livestock form part of the work of our Livestock Policy and Resource Use Thrust. We look forward to continued involvement in international discussion on this important topic.

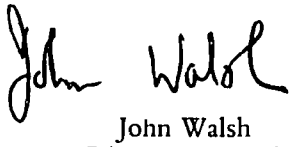
The year saw an accelerated development of a number of collaborative research networks coordinated by ILCA. Networks are being developed in each of our six research thrust areas, and for most of these networks technical steering committees made up of our NARS collaborators have now been formed. Through such groups, the networks facilitate the prioritisation and coordination of national and regional research on livestock and livestock-related topics, as well as training and information activities. We hope that, in future, each network will also provide a focus for ILCA's training and information programmes, as well as for other services that ILCA offers to its NARS partners. We have developed regional facilitation offices, one for West and central Africa and a further office is now being established for East and southern Africa. Through these offices, our different network activities can be coordinated. We are exploring, with several of our donors, methods of funding through the networks both NARS and ILCA/NARS collaborative research.

Ato Aklilu Afework and Ato Gizaw Negussie, Ethiopian members of our Board, left in 1988 and were replaced by Dr Assefa Woldegiorgis and Ato Getachew Teklemedhin. Early in 1989 another two Board members—Dr Howard Steppler and Dr Guissepe Rognoni—retired, each having completed his second 3-year term on the Board. Three new Board members—Mr Paul Egger (Switzerland), Dr Lucile Randria (Madagascar), and Professor Shozo Watanabe (Japan)—were elected in April 1989. We welcome our new Board members, but would especially like to pay tribute to our departing colleagues for their invaluable contributions to the development of ILCA.

Increasingly, ILCA's funding has been allied to collaborative research projects with institutions of donor countries and we welcome this added dimension to the donor–Centre relationship. We present this Annual Report as a record of a year's work and express our gratitude to our donors for the resources, encouragement and assistance that we, and our NARS partners, have received in 1988.



Ralph Cummings
Chairman, Board of Trustees



John Walsh
Director General

Highlights of 1988

Cattle milk and meat thrust

● Studies over three years in southern Ethiopia showed that early supplementation of calves for le s than one year is unlikely to lead to early maturity and calving, as previously thought, and that weaning weights are not reliable indicators of future animal performance in unstable environments.

● Feeding trials in southern Ethiopia showed that locally available feeds (in this case, *Vigna unguiculata* (cowpea) hay, *Acacia tortilis* seed pods, and *Acacia brevispica* leaves) are as good as lucerne *(Medicago sativa)* hay as nitrogen supplements to a basal diet of poor-quality hay for growing livestock. This demonstrates the need for further evaluation of indigenous feeds.

● A survey of households in Bamako, Mali, showed that 38 to 45% of the people preferred locally produced fresh milk to milk powder or reconstituted milk.

● Studies in Ethiopia showed t..at, with minimal supplementation, early weaning increases calf growth to 8 months of age, reduces calf mortality, and results in earlier calving in the mother. Together these effects make early weaning profitable.

● In 1988 the Kenya Agricultural Research Institute (KARI) and ILCA established a collaborative research programme on smallholder dairying in the coastal subhumid zone of Kenya.

Small ruminant meat and milk thrust

● Collaborative studies on small ruminant productivity were conducted in Botswana, Kenya, Mozambique, Nigeria, Somalia, Sudan and Togo. Landim sheep and goats in Mozambique were shown to be highly prolific, suggesting that they could be used to improve other African breeds. Breed characterisation studies, conducted under improved management conditions, demonstrated large breed differences that are usually masked under producer conditions.

● Studies of sheep production in Botswana showed that keeping Karakul sheep for pelt production is more profitable than keeping Karakuls or other breeds for meat production, and would remain so even if prices of pelts fell considerably relative to meat.

● Feeding trials with West African Dwarf sheep and goats in Nigeria showed that supplementing the feed of ewes and does during pregnancy and lactation increased productivity. The main effect of supplementary feeding during lactation was to reduce lamb and kid mortality. Similar observations were made in trials with sheep in the Ethiopian highlands.

● Management of *Leucaena* and *Gliricidia* in alley farms for both livestock feed and mulch was refined in 1988. Trials showed that mulch applied before planting had the greatest effect on crop yields; prunings taken later could be used as animal feed without reducing crop yields. In another trial the overall productivity of both *Leucaena* and *Gliricidia* was greatest from a single harvest at 9 months, leaving 3 months regrowth prior to the next dry-season harvest.

● A study of the causes of morbidity and mortality among more than 1500 sheep in the Debre Birhan area, in the Ethiopian highlands, showed that broncho-pneumonia and gastro-intestinal

parasites were the main causes of morbidity. Broncho-pneumonia also caused 70% of all deaths.

- In on-farm trials in the Ethiopian highlands, supplementing the diet of castrate sheep with locally available feeds significantly increased liveweight gain. However, the rates of gain achieved were lower than those achieved in on-station trials, which suggests that further supplementation is needed.

Animal traction thrust

The Vertisol Management Project in the Ethiopian highlands continued in collaboration with the International Crops Research Institute for the Semi-Arid Tropics, the International Board on Soil Research and Management and five Ethiopian research and development institutions. On-farm testing demonstrated the large benefits from using the improved practices developed by the project (drainage, early planting, improved cultivars and fertilizer). The project is now entering an extension phase.

- Work in Mali indicated that the body weight of work oxen has a greater effect on their work performance than does their body condition, i.e. large animals in moderate condition can do more work than smaller animals in good condition.

Animal feed resources thrust

- ILCA, in collaboration with the International Board for Plant Genetic Resources, developed in vitro techniques for handling grass and browse species that cannot be adequately managed using traditional methods which involve seeds. In vitro techniques were also used to help establish accessions that had few seeds or seed with low vigour.
- At a mid-altitude site in Ethiopia intercropping maize with the legume *Macrotyloma axillare* cv Archer significantly increased dry-matter production and the quality of fodder available as livestock feed without having a significant effect on maize yield.
- Germplasm screening at sites in Ethiopia, Mali and Nigeria identified herbaceous and tree legumes suited to each of the environments covered by the sites.

Trypanotolerance thrust

- The measure of tsetse challenge was refined in 1988 by determining the proportion of feeds tsetse flies took from domestic livestock. This refined measure of tsetse challenge allows more accurate prediction of aspects of animal health and performance from tsetse challenge.
- Further progress was made in quantifying the relative effects of components of trypanosome infection on animal performance. The importance of the animal's ability to control anaemia was highlighted; cattle that can control anaemia continue to be productive even when parasitaemic for considerable periods of time.
- Initial results from a tsetse control programme using cypermethrin-impregnated biconical tsetse traps in northern Côte d'Ivoire indicate that it has dramatically reduced the relative densities of *G. palpalis* and *G. tachinoides* within the first few months.
- Work reported in *ILCA Annual Report 1987* showed that East African Zebu cattle could be maintained under medium trypanosomiasis risk using prophylactic treatments with trypanocidal drugs. Economic analyses in 1988 showed that prophylactic treatment was more profitable than therapeutic treatment.

Livestock policy and resource use thrust

- A study of the impact of livestock pricing policies on meat and milk output in Mali, Nigeria and Zimbabwe indicated that, for most of the period reviewed (1973–86):
  - policies in Mali implicitly taxed producers and subsidised consumers;
  - policies in Nigeria implicitly taxed consumers and subsidised producers; and
  - both producers and consumers were implicitly subsidised in Zimbabwe.

Training and Information

- Nine group training courses were organised during 1988. These short courses each lasted from 2 to 4 weeks, were attended by a total of 177 scientists and technicians from sub-Saharan African countries, dealt with policy analysis, research methods and technology transfer and were given either in French or English.
- Sixteen scientists and 18 technicians completed their individual training associateships with ILCA during the year, and a further 33 individuals started their assignments. Individual trainees spend from 3 weeks to up to 2 years with ILCA.

ILCA's addresses

Headquarters

P.O. Box 5689, Addis Ababa, Ethiopia
Telex: 21207 ILCA ET
Tel: (251-1) 613215
Fax: (251-1) 611892
E-Mail: CGI070 (ILCA)

Thrust coordination

Cattle Milk and Meat/
Small Ruminant Meat and Milk/
Animal Feed Resources/
Livestock Policy and Resource Use

P.O. Box 5689, Addis Ababa, Ethiopia
Telex: 21207 ILCA ET
Tel: (251-1) 613215
Fax: (251-1) 611892
E-Mail: CGI070 (ILCA)

Animal Traction

PMB 2248, Kaduna, Nigeria
Telex: 71384 ILCAKD NG
Tel: (234-62) 211389
E-Mail: CGI154 (ILCA-KADUNA)

Trypanotolerance

P.O. Box 46847, Nairobi, Kenya
Telex: 25747 ILCA KE
Tel: (254-2) 592066, 592122, 592013
Fax: (254-2) 593481
E-Mail: CGU005 (ILRAD)

Zonal research sites

Highlands

P.O. Box 5689, Addis Ababa, Ethiopia
Telex: 21207 ILCA ET
Tel: (251-1) 613215
Fax: (251-1) 611892
E-Mail: CGI070 (ILCA)

Humid zone

PMB 5320, Ibadan, Nigeria
Telex: 31417/31159 TROPIB NG
Tel: (234-22) 413440
E-Mail: CGI072 (IITA57)

Subhumid zone

PMB 2248, Kaduna, Nigeria
Telex: 71384 ILCAKD NG
Tel: (234-62) 211389
E-Mail: CGI154 (ILCA-KADUNA)

P.O. Box 80147, Mombasa, Kenya
Telex: 21465
Tel: 48539/485842

Subhumid/semi-arid zone

BP 60, Bamako, Mali
Telex: 2459 ILCA MJ
Tel: (223) 222177/224279
Fax: (223) 223022

Semi-arid zone

P.O. Box 46847, Nairobi, Kenya
Telex: 25747 ILCA KE
Tel: (254-2) 592066, 592122, 592013
Fax: (254-2) 593481
E-Mail: CGU005 (ILRAD)

ILCA/ICRISAT, BP 12404, Niamey, Niger
Telex: 5560 ICRISAT NI
Tel: (227) 722509
E-Mail: CGU004 (ICRISATSC)

Board of Trustees

(as at 1 May 1989)

R W Cummings (USA), Chairman
J L Dillon (Australia), Vice-Chairman
A A Adegbola (Nigeria)
Assefa Woldegiorgis (Ethiopia)
D F R Bommer (F R Germany)
N Chabeuf (France)
P Egger (Switzerland)
Getachew Teklemedhin (Ethiopia)
M L Kyomo (Tanzania)
L R Randria (Madagascar)
P I Thiongane (Senegal)
J P Walsh (Ireland)
S Watanabe (Japan)

Executive Committee

R W Cummings (Chairman)
D F R Bommer
J L Dillon
Getachew Teklemedhin
P I Thiongane
J P Walsh

Nomination Committee

D F R Bommer (Chairman)
P Egger
M L Kyomo
P I Thiongane

Programme Committee

J L Dillon (Chairman)
A A Adegbola
Assefa Woldegiorgis
D F R Bommer
N Chabeuf
L R Randria
J P Walsh
S Watanabe

Audit Committee

P I Thiongane (Chairman)
N Chabeuf
P Egger

ILCA's donors in 1988

CGIAR contributions

African Development Bank
Austria
Belgium
Canada
Denmark
Federal Republic of Germany
Finland
France
India
International Development Research Centre (IDRC, Canada)
Ireland
Italy
The Netherlands
Nigeria
Norway
Organization of Petroleum Exporting Countries (OPEC)
Sweden
Switzerland
United Kingdom
United States of America
World Bank

Special project grants

Agence de coopération culturelle et technique (ACCT, France)
Australian Centre for International Agricultural Research (ACIAR)
Caritas (Switzerland)
European Economic Commission (EEC)
Federal Republic of Germany
Ford Foundation
Finland
International Board for Plant Genetic Resources (IBPGR)
IDRC
Ireland
Medios (Belgium)
Nigeria
Norway
Organization of African Unity (OAU)
Oxfam America
Rockefeller Foundation
United States of America
University of Hohenheim
West Africa Milk Company

Cattle Milk and Meat Thrust

ILCA has decided to focus on this area of livestock production because, despite a daunting array of technical, policy and institutional problems, there are major opportunities to increase cattle milk and meat production in many parts of Africa. These opportunities take different forms according to ecological zone and region:

- In humid West and central Africa the potential is vast in the long term if trypanosomiasis and dermatophilosis can be controlled and cattle numbers of appropriate breeds increased.
- The subhumid zone of West Africa offers perhaps the best opportunity in the medium term because of its reasonable potential for forage production combined with comparative freedom from tsetse fly, lower cultivation pressure on the land and a relatively large existing cattle herd.

A Borana woman of southern Ethiopia transferring milk to a gorfa, *a container used for storing and processing milk.*

- The highlands of East Africa are well supplied with meat but also offer a major market for milk if forages can be accommodated in cropping systems.
- In southern Africa markets are smaller, but the economic environment appears to be relatively favourable, offering an opportunity for geographical expansion of our efforts in sub-Saharan Africa.

The first three are zones where the need or opportunity to create an impact appears to be greatest; however, ILCA is following up on research in the semi-arid zone that was started before the Centre adopted its current strategy, and the Centre also recognises the need to conduct relevant research in those parts of the semi-arid zone where seasonal milk surpluses are available, indicating a potential for dairy development.

Reproductive wastage and hygiene management

Effects of early supplementation with legume hay and water on cattle growth under simulated pastoral management in semi-arid Ethiopia: impact at weaning and sustainability of intervention

Calves and people compete for milk in many African pastoral and agro-pastoral societies. Up to 50% of all milk produced goes for human consumption. This is thought to limit herd performance by lowering weaning weights, reducing potential cash returns from sales of smaller immatures and particularly by stunting animals and delaying puberty. This research examined the effects of early supplementation of calves with legume hay and water under simulated pastoral management to see:

- if supplementation could compensate the calves fully for milk deprivation in terms of weaning weights; and
- whether increases in growth resulting from supplementation persist or accelerate subsequent performance.

Results will help clarify the economic and development implications of strategic calf supplementation for pastoralists and smallholders in semi-arid Africa.

Trials were conducted on the Borana plateau (1500 m elevation) in southern Sidamo, Ethiopia. Rainfall in Sidamo is bimodal, averaging 600 mm yearly. The area supports a diverse *Acacia* savannah. The experiment consisted of five treatments and two controls replicated over 2 years, with the first group of calves supplemented in 1986–87 and the second in 1987–88. The number of animals in each treatment averaged 17; a total of 250 animals were used over the 2 years. The treatments were superimposed over a background of simulated pastoral management that consisted of restricted milk intake (50 % of dam's milk), confinement in huts at night, local grazing for up to 8 hours a day while walking 10 km, and a variable watering frequency of once every 3 days in the dry season and once every 7 days in the wet season. Animals in one control group were managed traditionally and received no supplements. Animals in the second "positive control" group also received no supplements but had *ad libitum* access to their dams' milk nightly.

The treatments comprised a factorial combination of two levels of water (0 and 5 litres of extra water each day) with three levels of medium-quality (20% crude protein) *Medicago sativa* hay (0, 400 and 650 g offered daily) as a forage standard. Supplements were offered nightly after calves reached 8

weeks of age until weaning at about 8 months, which also took them through their first dry season (December through March) in both years. After the supplementation period, all animals were managed together under pastoral conditions.

Animals were weighed and their frame characteristics measured every 2 weeks up to weaning and monthly after weaning. The effects of these treatments on pubertal development are described elsewhere in this report (see *Effects of calf rearing strategy on subsequent pubertal development under extensive grazing conditions*, page 4).

The first year of the trial, 1986–87, was a year of good rainfall, in that some rain fell throughout the year. The second year, 1987–88, was more typical, with a pronounced long dry season from November 1987 through March 1988.

There were significant interactions between water and hay offered ($P<0.001$) and between treatment and year ($P = 0.03$) on calf weaning weights (Figure 1). Treatment effects were more pronounced in the drier second year. For example, across all treatments, extra water increased weaning weights by an average of 10% in 1986–87, but by 28% in 1987–88. Similarly, the best combination of hay and water resulted in weaning weights 66% higher than that of the control in 1987–88 (78 vs 47 kg), whereas the difference was only 22% in 1986–87 (82 vs 67 kg; Figure 1). In both years weaning weights of animals on the best hay and water treatment averaged 94% to 99% of those of calves given free access to their dams' milk (not illustrated), indicating that legume and water supplementation compensated fully for loss of milk.

Considering only the older animals born in 1986, trends in liveweight suggest that the effects of supplementation before weaning do not persist in

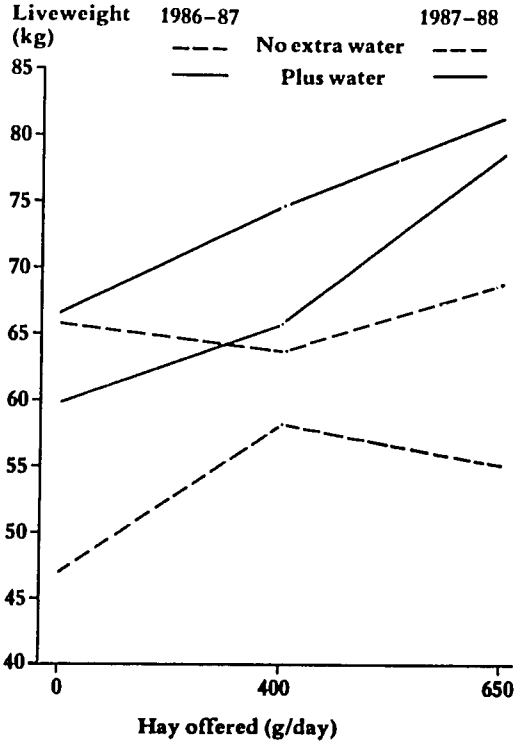


Figure 1.
Effects of supplementation with legume hay, with or without additional water, on calf weaning weights at 8 months during a year of above-average rainfall (1986–87) and a year of normal rainfall (1987–88), southern Ethiopian rangelands.

this environment. Although animals that were on the best hay and water treatment in 1986–87 were nearly 50% heavier than control animals at 10 months of age (110 vs 75 kg), by 31 months this difference had fallen to only 15% (165 vs 141 kg). This convergence appears to be due more to a faster decline in liveweight of the better-conditioned (supplemented) animals during dry periods than to growth compensation by non-supplemented animals during wet periods.

These results appear to invalidate the assumption that giving young cattle supplementary feeding for less than 1 year can result in earlier maturity and first calving. They also indicate that weaning weights are not reliable indicators of future performance in unstable environments. The study highlights the importance of extra water for efficient utilisation of improved forages by calves, indicating the need for development of water resources in regions where water access is limited. The wide annual variation in the effects of supplementation on calf weaning weights shown in this study must be taken into account in analyses of economic costs and benefits.

Effects of calf rearing strategy on subsequent pubertal development under extensive grazing conditions

Zebu *(Bos indicus)* cattle in the tropics tend to achieve sexual maturity late. One of the causes of this is poor nutrition. Early sexual maturity, and hence early first calving, is desirable as it increases the potential lifetime productivity of the animal.

A study was carried out in Sidamo, southern Ethiopia, to assess the effect of providing female calves with additional feed and water on their pubertal development. Sixty-four Boran calves born between March and June 1986 were randomly assigned to one of seven treatment groups:

I: Control (grazing, restricted milk intake (50% of dam's milk) and watering every 3 days)
II: Control + milk *ad libitum*
III: Control + 400 g of lucerne (*Medicago sativa*) hay daily
IV: Control + 650 g of lucerne hay daily
V: Control + watering every day
VI: Control + 400 g of lucerne hay daily + watering every day
VII: Control + 650 g of lucerne hay daily + watering every day

Supplementary feed and water were offered nightly after the calves reached 8 weeks old until they were weaned at about 8 months old. From February 1987 the animals were continuously run with four entire bulls fitted with chin-ball markers to detect oestrus. Blood samples were taken every 10 days and plasma progesterone levels determined. Body weights and body condition scores were recorded at the same time to determine the target weight and body condition at puberty. Regular rectal palpations were performed to assess the development of the heifers' reproductive organs.

The heifers weighed an average of 164.2 ± 26.8 kg at between 29 and 32 months old, with condition scores[1] ranging from M- to M, but they had few palpable ovarian structures and bull mounting activity was scarce. Animals in Group VII weighed an average of 20 kg more than animals in the control group; animals in the other groups were all of similar weight to each other (see *Effects of early supplementation with legume hay and water on cattle growth under simulated pastoral management in semi-arid Ethiopia: Impact at weaning and sustainability of intervention*, page 2).

[1] According to the scoring system given in: Nicholson M J and Butterworth M H. 1986. *A guide to condition scoring of zebu cattle*. ILCA, Addis Ababa. 29 pp.

Only 25 of the 64 heifers (39.1%) had progesterone values higher than 1 ng/ml (this value is one of the criteria for determining attainment of puberty). Even among these, subsequent hormonal patterns have been irregular. This, combined with the lack of pregnancy in heifers that were mounted by the bulls, suggests that none of the heifers has yet attained puberty and sexual maturity.

The results of this study so far suggest that early supplementation of calves with feed and water does not have a large effect on body weight, condition and age at puberty.

Effect of early weaning on calf growth and survival rates

Ideally, cows should produce a live calf every year. However, traditionally raised zebu cattle often have calving intervals longer than 500 days because of their having a long postpartum anoestrus interval. The time at which cows resume reproductive activity postpartum is influenced by several factors, including lactation and suckling intensity. Most cattle in sub- Saharan Africa graze extensively. Cows are accompanied by their calves, which are weaned naturally at 8 months. This study examined the effect of early weaning on subsequent growth and survival rates of Arsi crossbred calves.

The study used 78 calves from multiparous Arsi zebu cows at the Ethiopian Ministry of Agriculture's Gobe ranch. The calves were allocated at random to one of four groups:

I: 20 calves weaned at 5 months
II: 22 calves weaned at 6 months
III: 18 calves weaned at 7 months
IV: 18 calves weaned at 8 months (control)

Weaned calves grazed natural pastures during the day and were housed overnight in sheltered pens. Early-weaned calves were fed 1 kg/head per day of a supplement composed of 50.5% wheat bran, 48.0% noug (*Guizotia abyssinica*) cake, 1.0% limestone and 0.5% common salt. The supplement contained 26.0% crude protein. Supplementation continued until the calves were 8 months old. Water was available *ad libitum*. The dams were observed continuously for oestrus. Animals in heat were inseminated about 12 hours after onset of oestrus.

The trend in mean calf body weight in the 4 months after weaning is shown in Figure 2. Early-weaned calves weighed significantly ($P<0.001$) more at 8 months old than did control calves at that age (mean of 76 kg for the three groups vs 62 kg for the control calves). This advantage was maintained 4 months after weaning (82 vs 64 kg, $P< 0.001$). Over the 4 months after weaning, mortality was significantly higher among control calves than among early-weaned calves (33% vs 10%; $P<0.01$).

These results indicate that early weaning can increase calf growth rate and survival if the calves are given minimal amounts of supplementary feed. The feed supplement provided in this trial cost 0.15 birr/head per day. (US$ 1 = Birr 2.07). The cost of supplementation to weaning for groups I, II and III was 13.50, 9.00 and 4.50 birr respectively, much less than the value of the greater body weights of these calves relative to the controls. In addition, 37% (n = 22) of the dams of early-weaned calves returned to oestrus within 8 months of the birth of their calves (Table 1).

Early weaning thus shows considerable promise as a means of increasing cattle productivity. Studies are continuing to determine the most suitable weaning strategy for multiplication centres raising F_1 heifers for dairy production.

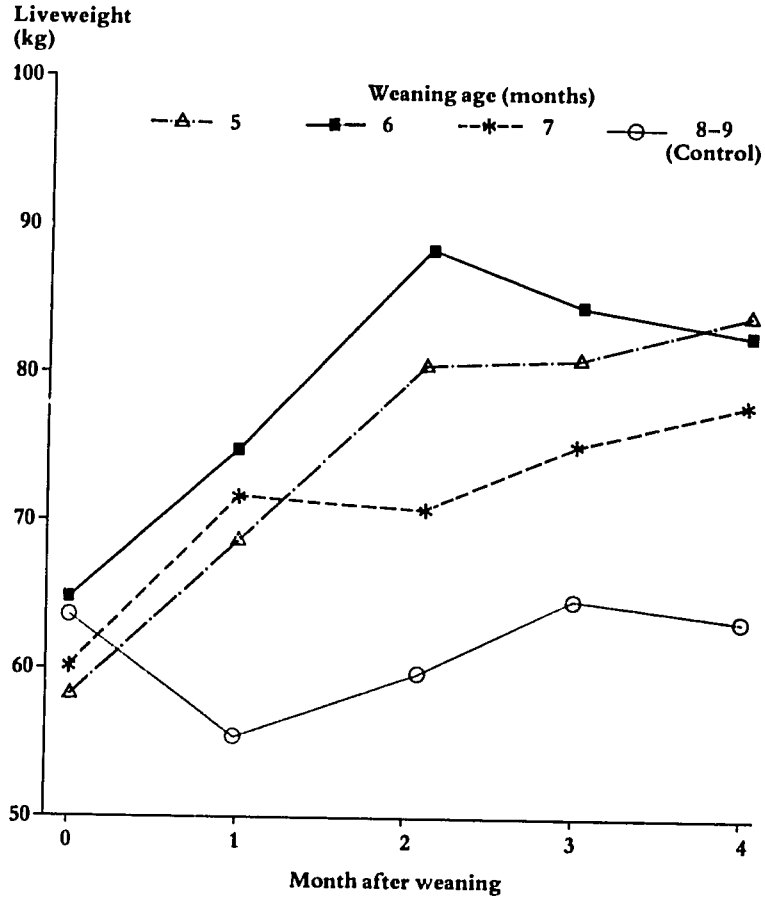


Figure 2.
Liveweights of early-weaned and naturally-weaned calves over the 4 months after weaning, Gobe, Ethiopia, 1988.

Table 1. *Effect of calf weaning age on resumption of oestrus activity by dams.*

Group	Number of cows	Age of calves at weaning (months)	Number of cows cycling by calf age of (months)					
			6	7	8	9	10	11
I	20	5	5	6	7	8	9	10
			(25)	(30)	(35)	(40)	(45)	(50)
II	22	6		5	9	9	11	11
				(23)	(41)	(41)	(50)	(50)
III	18	7			6	7	7	7
					(30)	(39)	(39)	(39)
Control	18	8/9				6	6	6
						(33)	(33)	(33)

Numbers in brackets indicate percentages.

The applicability of heat detection methods to zebu cattle and their crosses

Efficient detection of oestrus is essential in systems using artificial insemination or hand-mating. Oestrus is difficult to detect in zebu cows in the tropics because their cycle is longer and their oestrus shorter than those of *Bos taurus* breeds. In addition, behavioural signs associated with oestrus are often weak in zebu cows. This study examined the effectiveness of various heat detection methods for use with zebu cows. It is a continuation of previous work reported in *ILCA Annual Report 1987* (page 2, *Factors affecting oestrous pattern of zebu cows).*

Nineteen zebu cows were run continuously with two vasectomised bulls at ILCA's Debre Birhan research station between 20 May and 10 October 1988. The animals grazed from 0630 to 1830 hours and were penned at night. In three separate phases, the experiment evaluated the efficiency of a chin-ball marker, the Kamar Heat Mount Detector and tail paint in heat detection. The occurrence of oestrus was monitored by assaying plasma progesterone levels in blood samples taken twice a week.

Daytime mounting activity showed two peaks: from 0600 to 1000 hours (30.1% of mounts) and from 1500 to 1900 hours (32% of mounts). All of the heats were detected when bulls were fitted with the chin-ball marker, compared with a 79.5% detection rate for the tail-paint method and 50% for the Kamar Heat Mount Detector. The rate of false positives was 30.4, 6.6 and 2.0% for the chin-ball marker, tail paint and the Kamar Heat Mount Detector, respectively. When the bulls were fitted with the chin-ball marker, cows in oestrus were marked on average 10.3 ± 5.3 times, compared with 1.8 ± 1.2 times for non-oestrous cows.

Sixty-two per cent of heats could be detected by observing the herd for 2 hours a day, from 0800 to 0900 hours and from 1500 to 1600 hours. The detection rate could be increased to 70% by watching also from 2300 to midnight.

Although the chin-ball marker gave the highest rate of heat detection it was also associated with the highest rate of false positives. Tail painting gave a good rate of heat detection and a low rate of false positives and is thus the method of choice.

Improvement of zebu cattle by embryo transfer

This study is exploring the possibility of using Ethiopian zebu or Boran cows and their crossbreds as either donors or recipients in embryo transfer to help speed up genetic improvement of these breeds.

Thirteen 5-year-old Small East African Zebu cows were used in the study, which was carried out at ILCA's Debre Birhan research station in the Ethiopian highlands. The animals were assigned to five treatment groups as they came into oestrus:

I: 7 animals treated with 2000 International Units (IU) of Pregnant Mare Serum Gonadotropin (PMSG)[1]
II: 2 animals treated with 1500 IU of PMSG
III: 2 animals treated with 1250 IU of PMSG
IV: 2 animals treated with 1000 IU of PMSG
V: 2 animals treated with 14 ampoules each of Human Menopausal Gonadotropin (HMG)[2]

The cows treated with PMSG received the injection on day 11 of their oestrous cycle; they were synchronised using 50 mg of Lutalyse[3] given on day 13 of the oestrous cycle.

[1] PMSG = Folligon®, Intervet, The Netherlands.

[2] HMG = Pergovet®, Serono, Italy.

[3] Lutalyse® (Prostaglandin F_2), Upjohn, Kalamazoo, Michigan, USA.

[4] Estrumate® (Cloprostenol), ICI, Ontario, Canada.

The animals treated with HMG received two injections a day for 5 days, starting from day 9 or 10 of their oestrous cycle. They were synchronised using 2 ml of Estrumate[4] given on the third day of HMG treatment.

Flushing was performed 7 days after the induced oestrus in all animals.

The preliminary results are presented in Table 2. Most of the animals treated with PMSG had ovarian cysts, whereas those treated with HMG did not. Six flushings could not be performed because of metritis (1 case), the cervix could not be passed with the catheter (4 cases) or the superovulatory treatment was not effective (1 case).

Table 2. *Preliminary data on the use of Pregnant Mare Serum Gonadotropin and Human Menopausal Gonadotropin as superovulators in Small East African Zebu cows.*

Treatment group	Animal identification number	Results of:	
		Rectal palpation	Flushing
I	2	7 CL[1], 3 OC[2]	No embryo recovered
	8	9 CL, 1 OC	2 zonae pellucidae recovered
	16	5 CL, 2 OC	*[3]
	18	4 CL, many OC	No embryo recovered
	40	6 CL, 2 OC	No embryo recovered
	41	0 CL, many OC	No flushing, metritis
	49	6 CL, 1 OC	No embryo recovered
II	46	5 CL, 1 OC	*
	44	2 CL, 0 OC	No flushing, no ovarian response
III	43	2 CL, 5 OC	No embryo recovered
	50	7 CL, 2 OC	*
IV	13	4 CL, 2 OC	No embryo recovered
	48	5 CL, 1 OC	*
V	18	4 CL, 0 OC	4 embryos recovered
	40	6 CL, 0 OC	No embryo recovered

Treatments are described in the text.

[1] CL = corpora lutea.

[2] OC = ovarian cysts.

[3] * = cervix could not be passed.

These preliminary results confirm the high degree of variability in the response of zebu cattle to varying doses of different superovulating agents. The Human Menopausal Gonadotropin (HMG) was, in this exploratory study, found to be the more effective of the two superovulatory agents used.

The prevalence of some genital diseases and their impact on bovine reproductive performance

Genital diseases limit the reproductive performance of cattle in many parts of the tropics. The spatial and temporal distributions of these diseases must be known as a basis for efforts aimed at improving the reproductive performance in cattle in these regions.

Since 1986 ILCA has been studying the prevalence of two important genital diseases, brucellosis and infectious bovine rhinotracheitis/infectious pustular vulvovaginitis (IBR/IPV), in central Ethiopia. Serum samples have been collected from 1609 animals near the villages of Ghibe and Gobe. All samples were screened for brucellosis using the Rose Bengal Test (RBT); 1592 samples have been tested for IBR/IPV using the enzyme-linked immunosorbent assay (ELISA) method.

Only 4.2% of the cattle tested for brucellosis were seropositive (Table 3), compared with 67% for those tested for IBR/IPV (Table 4). Investigations are now being conducted to determine the influence of IBR/IPV on reproductive performance and to differentiate the respiratory form of the disease from the genital one.

Table 3. *Prevalence of brucellosis in cattle at Gobe and Ghibe, central Ethiopia, 1986–88.*

Site	Number of samples tested	Samples showing positive reaction	
		Number	%
Gobe	1011	41	4.1
Ghibe	598	26	4.3
Total	1609	67	4.2

Table 4. *Prevalence of infectious bovine rhinotracheitis/infectious pustular vulvovaginitis in cattle at Gobe and Ghibe, central Ethiopia, 1986–88.*

Site	Number of samples tested	Samples showing positive reaction	
		Number	%
Gobe	988	573	58
Ghibe	604	487	81
Total	1592	1060	67

Feeding and management systems

Calf and heifer rearing using crop residues and locally available supplements

Smallholders in the Ethiopian highlands are using Friesian/zebu crossbred cows for milk production. However, their crossbred calves usually grow slowly after weaning. Trials were therefore carried out in 1988 to determine the best combinations of locally available supplements and crop residues as diets for weaned calves and for rearing heifers. Comparisons were made between supplements that farmers can produce (leaves from the multipurpose trees *Sesbania sesban* and *Leucaena leucocephala* and cowpea hay and haulm) and purchased supplements (molasses/urea blocks and cottonseed cake). Poultry litter was also tested as a cheap source of non-protein nitrogen.

Supplementary feeding of calves

Leaves of multipurpose trees as supplements to wheat straw. Two trials were conducted in 1988 to compare leaves of the multipurpose trees *Sesbania sesban* and *Leucaena leucocephala* with molasses/urea blocks and cottonseed cake as supplements to a calf-rearing diet based on *ad libitum* wheat straw. Six animals were allocated to each treatment. Mineral blocks were available to animals that did not have access to molasses/urea blocks. The *Sesbania* trial (I) ran for 35 days. The *Leucaena* trial (II) ran for 102 days. The average initial weights of the calves were 95 kg in Trial I and 121 kg in Trial II.

Calves supplemented with *Sesbania* foliage had daily weight gains significantly higher than those supplemented with molasses/urea blocks and comparable to those supplemented with cottonseed cake (Table 5). At the rates offered in Trial II, *Leucaena* proved to be a less effective supplement, with calves supplemented with *Leucaena* having weight gains not significantly different from those of calves supplemented with molasses/urea blocks (Table 5).

Table 5. *Crossbred calf rearing with leaves of* Sesbania sesban *and* Leucaena leucocephala *as supplements to wheat straw.*

Supplement	Amount fed (kg DM/day)	Wheat straw intake (kg DM/day)	Liveweight change (kg/day)
Trial I[1]			
Molasses/urea block	0.23	2.09	0.03a
Sesbania	0.23	2.45	0.18b
	0.45	2.53	0.25b
Cottonseed cake	0.19	2.37	0.19b
	0.37	2.20	0.26b
Trial II[2]			
Molasses/urea block	0.22	2.49	−0.07a
Leucaena	0.35	2.56	−0.02ab
	0.69	2.93	0.03ab
Cottonseed cake	0.56	2.71	0.10b
	1.11	3.18	0.31c

[1] Animals in Trial I initially weighed an average of 95 kg.

[2] Animals in Trial II initially weighed an average of 121 kg.

Within trials, means followed by the same letter do not differ significantly (P>0.05).

Cowpea haulm as a supplement to wheat straw. A trial was conducted in 1988 to investigate the effect of substituting cowpea haulm for cottonseed cake on the growth of calves fed a basal diet of *ad libitum* wheat straw. Eighteen calves, initially weighing an average of 81 kg, were assigned to one of three groups, each comprising six animals. Each group was allowed *ad libitum* access to wheat straw. Intake of wheat straw and supplements for the 91-day

trial period are shown in Table 6. A mineral block was available at all times. Substituting cowpea haulm for cottonseed cake increased the calves' intake of wheat straw and reduced their daily liveweight gain, but neither trend was significant (Table 6).

Table 6. *Effect of substituting cowpea haulm for cottonseed cake on the liveweight gain of calves fed a basal diet of* ad libitum *wheat straw.*

Feed intake (kg DM/day)			
Cotton-seed cake	Cowpea haulm	Wheat straw	Liveweight gain (kg/day)
0.32	0.41	2.04	0.22
0.19	0.82	2.17	0.18
–	1.32	2.25	0.12

Cowpea hay and haulm as supplements to maize stover. A trial was conducted in 1988 to investigate the effect of substituting cowpea hay and haulm for cottonseed cake on the growth of calves fed a basal diet of *ad libitum* maize stover.

Thirty calves, initially weighing an average of 92 kg, were allocated at random to one of five treatment groups, each comprising six animals. The animals were given *ad libitum* access to maize stover, and were fed supplements of cottonseed cake, alone or combined with cowpea hay and cowpea haulm. The cowpea residues were also fed alone. The trial lasted 70 days.

Calves supplemented with a combination of cottonseed cake and cowpea hay had significantly higher daily weight gains than those supplemented with cowpea hay or haulm alone or cowpea haulm and cottonseed cake (Table 7). Calves consumed most maize stover when supplemented with cottonseed cake alone.

Table 7. *Effect of substituting cowpea hay or cowpea haulm for cottonseed cake on the growth of calves fed a basal diet of* ad libitum *maize stover.*

Feed intake (kg DM/day)				
Cotton-seed cake	Cowpea hay	Cowpea haulm	Maize stover	Liveweight gain (kg/day)
0.68	–	–	1.96	0.48ab
0.34	1.27	–	1.48	0.61b
0.34	–	1.01	1.26	0.42a
–	1.38	–	1.17	0.32a
–	–	1.72	0.98	0.30a

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

Supplementary feeding of heifers

Poultry litter as a supplement to wheat straw. Two trials were conducted in 1988 in which poultry litter was fed, with and without molasses,

as a supplement to heifer diets based on *ad libitum* wheat straw supplemented with *Sesbania sesban*. Five heifers, initially weighing an average of 240 kg, were allocated to each treatment group in the two trials. Trial I lasted 112 days, Trial II ran for 84 days. Feed combinations are shown in Table 8.

Table 8. *Effect of poultry litter and molasses on growth of heifers fed a basal diet of* ad libitum *wheat straw supplemented with* Sesbania sesban.

Feed intake (kg DM/day)				
Sesbania	Poultry litter	Molasses	Wheat straw	Liveweight gain (kg/day)
Trial I				
0.45	–	–	4.50	0.16a
0.45	0.45	–	4.23	0.15a
0.45	0.45	0.40	4.10	0.21ab
0.45	0.45	0.80	4.22	0.27ab
0.45	0.45	1.60	3.43	0.37b
Trial II				
0.68	–	–	4.71	0.06a
0.68	0.45	–	4.60	0.07a
0.68	0.45	0.80	4.60	0.28ab
0.68	0.45	1.60	3.99	0.32a
0.68	0.45	3.20	3.26	0.36b

Within trials, means followed by the same letter do not differ significantly ($P>0.05$).

Poultry litter had no significant effect on daily liveweight gain of heifers except when fed in combination with at least 2 kg of molasses daily (1.6 kg dry matter).

Summary

Improvements in post-weaning growth of calves and heifer rearing depend on increased supply and better balance of nutrients. Across these trials liveweight gains of calves and heifers were more closely related to intake of energy ($r = 0.79$; $P<0.001$), magnesium ($r = 0.76$; $P<0.001$) and phosphorus ($r = 0.60$; $P<0.01$) than to intake of crude protein ($r = 0.46$; $P<0.05$).

Feed evaluation for Africa's semi-arid zone

The main constraints to livestock production in semi-arid Africa are deficits in the amount and quality of forage, especially during the dry seasons. Many young animals die from nutrition-related causes during such times. Strategic supplementation of young stock during dry seasons may thus be of considerable benefit to pastoralists and smallholders in these areas.

Feed interventions in the semi-arid zone probably will have to depend more on locally available feeds because of the difficulties associated with introducing exotic forages into these systems. Trials were thus conducted in 1987 and 1988 to evaluate *Vigna unguiculata* (cowpea) hay, *Acacia tortilis* seed pods and

Acacia brevispica leaves as nitrogen supplements for growing livestock. *Medicago sativa* was used as a comparative standard. Cowpeas are versatile fodder and dual-purpose legumes currently advocated for cropping interventions in semi-arid areas. *Acacia tortilis* is found widely in arid and semi-arid areas. Its pods, produced during dry seasons, are commonly used as animal feed. *Acacia brevispica* is a locally abundant shrub in semi-arid East Africa. It has large leaves, few thorns and is quite palatable. It remains green throughout the year where soil-moisture conditions are favourable.

This research was conducted in two components:

- growth and nutrition trials with stall-fed sheep at ILCA's Debre Zeit station; and
- a growth trial with calves under field conditions at ILCA's site on the Borana Plateau in southern Sidamo.

Comparative performance of Ethiopian sheep on native hay diets supplemented with *Acacia, Vigna* or *Medicago*

Initial results from this trial were reported in *ILCA Annual Report 1987* (pages 6 and 7): the supplements increased growth rate of the sheep by an average of 72%.

The metabolism trial found results similar to those in previous ILCA work on the feeding value of indigenous browses. Supplemented diets increased nitrogen intake by an average of 53% relative to the control diet (12 g/day vs 7.9 g/day). Nitrogen retention was increased by between 71% (*Vigna* diet) and 142% (both *Acacia* diets) in animals receiving supplements, relative to unsupplemented animals. There were no significant differences in nitrogen balance among supplemented animals. However, of the nitrogen excreted, the proportion excreted in the faeces was slightly, but not significantly, higher in animals supplemented with the *Acacias* than in those receiving supplements of *Medicago* or *Vigna* (70% vs 62%). This was related to the higher tannin content of the *Acacias*.

Comparative performance of preweaned calves under simulated pastoral management with *Acacia, Vigna* or *Medicago* as supplements

A group of 125 Boran calves 5 to 6 months old and weighing an average of 37 kg were stratified by weight and randomly allotted to five groups of 25 animals each. All the animals were grazed on *Pennisetum mezianum* rangeland for up to 8 hours a day during the height of the dry season (January to March). Consistent with traditional practice, animals were individually penned at night and allowed restricted access to their dams' milk (approximately 50% of production) in the morning and evening. In addition they were all given daily access to water. The supplements (*Vigna unguiculata* hay, *Acacia tortilis* pods, *A. brevispica* leaves and *Medicago sativa* hay) were fed so as to provide 92 g of crude protein daily. Control group animals received no supplement. The trial lasted 94 days.

Milk intake did not differ significantly ($P > 0.05$) between treatments, indicating that responses to supplementation were unconfounded (Table 9). Refusals of supplements ranged from 29% of that offered for *A. brevispica* and *V. unguiculata* to only 13% for *M. sativa*, suggesting differences in the palatability to calves of these feeds. All the supplements except *V. unguiculata* hay significantly ($P < 0.05$) increased daily liveweight gain and water intake

of calves relative to the control (Table 9). *Medicago sativa* hay gave the highest growth rate. The results suggest that *A. tortilis* pods were comparable to *Medicago sativa* hay as a supplement and that the other local feeds are suitable at least for strategic improvement of animal condition. However, utilisation of these feeds appears to be facilitated by an average increase in water intake of 16%. This implies that water development is also an important intervention.

Table 9. *Intakes of milk, leguminous forage supplements and water by Boran calves and calf growth under a background of simulated pastoral management, southern Ethiopia, 1988.*

Unit	Treatment				
	Control (grazing)	*Medicago sativa* hay	*Vigna unguiculata* hay	*Acacia brevispica* leaves	*Acacia tortilis* pods
Milk intake (ml/kg $LW^{0.73}$)	9.4a	8.9a	8.7a	9.2a	8.5a
Supplement offered (g/day)	0.0	567.0	662.0	473.0	616.0
Supplement intake (g/day)	0.0	494.5a	472.4c	336.6b	525.6d
Growth rate (g/day)	82.0d	158.3a	106.0cd	118.7bc	135.5ab
Water intake (ml/kg $LW^{0.82}$)	110.7c	134.7a	119.4bc	132.9ab	128.3ab

Within rows, means followed by the same letter do not differ significantly ($P>0.05$).

Supplementary feeding of calves in Maasai pastoral herds

Pastoralists put priority on ensuring calf survival, which is essential for continued milk production, rather than on fast growth of calves. The Maasai have developed a calf management system that in years of average rainfall keeps mortality rates at 5 to 10% a year, with calves weighing 90 to 100 kg at one year old. However, herd output falls dramatically in years of below-average rainfall, especially in drought years, due to low milk yield and high mortality of cows and calves.

A feeding trial was conducted to investigate the benefits of supplementing the feed of calves. Treatment groups comprised 120 calves in six households. Another 70 calves in five households were monitored as controls. Calves received supplements of either purchased calf-starter pellets containing 20% crude protein or locally made grass hay containing 8 to 13% crude protein and having an in vitro digestibility of 54 to 61%. The pellets were hand-fed to each calf according to its weight (0.2 kg at 40 kg to 0.4 kg at 60 kg and above). Hay was group-fed *ad libitum*. The feeding trial started in August 1987 and continued until late January 1988. Calves were supplemented from about 3 months old to 6 or 7 months of age and were weighed regularly until they were 10 months old.

Supplementary feeding increased calf growth rate in small herds (52 ± 20 head) but appeared to reduce calf growth in large herds (177 ± 6.7 head) (Table 10). Calves in large herds generally had higher growth rates than those in small herds because cows were milked less intensively and because a larger proportion of the animals in large herds were crossbred (Sahiwal × Boran).

Table 10. *The effect of herd size and supplementation on least-squares means of daily growth rates of calves (g/day).*

Herd size	Treatment	Growth rate (g/day) for period	
		180–300 days	90–300 days
Large	Supplemented	283b	264b
	Unsupplemented	294b	326c
Small	Supplemented	256b	249ab
	Unsupplemented	197a	225a
Mean		258	266

Within columns, means followed by the same letter do not differ significantly ($P>0.05$).

Rainfall was above average and well distributed in 1987/88, and this may have disguised any effects of supplementary feeding in this trial. The value of supplementary feeding will be greatest in years in which the second growing season is short, as has occurred on average every other year over the last 50 years. Low or poorly distributed rainfall during this season lowers the carrying capacity of the rangelands in the 5–7 dry months that follow, leading to feed shortages. These jeopardise the survival of calves, most of which are born during the main calving season from February to April.

Evaluation of grass/legume mixtures for grazing and stall-fed cattle

Fodder production systems acceptable to farmers must be developed if cattle production in the humid and derived savannah zones is to be intensified. Growing grass/legume mixtures is one way to produce large amounts of high-quality feed for intensive cattle production. However, little information is available on the performance of such swards in the West African humid zone.

In 1987 ILCA and the Department of Agronomy, University of Ibadan, Nigeria, started a study of the yield of forage grasses grown either in pure stand or in mixed culture with forage legumes. The trial involved three legumes (*Stylosanthes hamata* cv Verano, *Centrosema pubescens* and *Pueraria phaseoloides*) and three grasses (a local selection (S.9) of *Pennisetum purpureum* (elephant grass), *Cynodon nlemfuensis* var *nlemfuensis* (Ib.8) and *Panicum maximum*). Plots were planted at the University's research farm in south-west Nigeria in June 1987. Plots in which the grasses were grown in pure stand received either no fertilizer or urea at a rate of 200 kg N/ha. No fertilizer was applied to plots in which grass/legume mixtures were planted. A uniform harvest was taken from all the plots at the beginning of the rainy season in March 1988; no data were collected at that time. Yield data were subsequently collected on three harvests taken at 6-week intervals between May and August 1988.

The highest dry-matter yields were produced by *Panicum maximum* while the lowest yield was obtained from *Cynodon* grown in unfertilized pure stand (Table 11). The yield of *Cynodon* in pure stand more than doubled when nitrogen fertilizer was applied; the response of the other two grasses to nitrogen was smaller. Total dry-matter yields of elephant grass and *Panicum* grown in mixtures with the legumes were equivalent to those obtained when the grasses were grown in pure stand and nitrogen fertilizer was applied.

Table 11. *Total dry-matter yields of three grass species grown in pure stand and in mixtures with three forage legumes.*

Species	Total dry-matter yield (t/ha)				
	Pure stand		In mixture with legume		
	No[1]	N1	Stylo	Centro	Pueraria
Cyrodon	4.56	9.20	7.67	6.67	7.33
Pennisetum	7.61	8.43	9.98	9.52	7.63
Panicum	8.44	11.91	10.18	10.78	10.16
LSD (0.05) = 1.92					

[1] No = no nitrogen fertilizer; N1 = urea applied at the rate of 200 kg N/ha.

Yield and nutritive value of *Bajra* and Bana grass in smallholder mixed farms in semi-arid Kenya

ILCA is participating in on-farm research started by the Kenyan National Dryland Farming Research Station and UNDP/FAO in Machakos District, eastern Kenya. The main emphasis of the research is on developing improved feeding systems for crossbred dairy cows to allow higher levels of sustained milk production from smallholder mixed farms.

Bajra (*Pennisetum purpureum* x *P. typhoides* hybrid) and napier grass (*P. purpureum*) cv Bana have been promoted for use as planted forages on smallholder farms in the Machakos District (see *ILCA Annual Report 1987*, pages 11–13). Farmers planted fields, mainly with *Bajra*, in 1984 and 1985. Yields from these fields were assessed over four growing seasons between February 1987 and July 1988. Rainfall over this period averaged 200 to 400 mm per season, with growing periods of 60 to 90 days.

Individual farmers used different harvesting strategies, which made it difficult to assess annual productivity of the planted forage. However, when the grass was not cut during the growing season it yielded 6 to 8 t of dry matter (DM)/ha per season. This equates to a potential annual yield of about 14 t DM/ha, about 6 t of which would be leaf. Cuts taken twice each growing season each yielded 1 to 2 t DM/ha, equivalent to about 6 t DM/ha a year. However, half of this would be available during the growing season when other feeds are relatively abundant.

These yields are low, mainly because plant cover was low (16 to 28%). Increasing the density at which the grass is planted would increase yields.

Farmers in the Machakos District have planted mainly *Bajra* because this is more drought-tolerant than Bana. However, it is early maturing and, if not cut during the growing season, flowers at the end of the rains, resulting in low leaf-to-stem ratios and low nutritional value when farmers most need high-quality feed. Bana gives similar yields to *Bajra* but is easier to manage: it matures later than *Bajra* and does not flower as profusely, thus maintaining its nutritional quality longer than *Bajra*.

Planted grasses accounted for only 10% of farmers' total forage supply, most of which was provided by natural grazing (55%) and maize residues (28%). Feed budgets indicated that shortage of protein was the main feed factor limiting livestock production, particularly during dry seasons. This can be alleviated by feeding a mixed diet comprising high-protein leafy material from planted grasses, fodder from forage and grain legumes and leafy material from maize residues.

Maize residues as a source of feed for livestock in smallholder farms in semi-arid Kenya

Maize residues are an important source of livestock feed on smallholder farms in semi-arid eastern Kenya. In 1987/88, as part of a joint on-farm research project involving the National Dryland Farming Research Station, FAO/UNDP and ILCA, maize yield components were assessed over two rainy seasons on eight farms in the area. The aims of the project are to increase feed production by smallscale farmers, thereby allowing them to replace some of their zebu cattle with crossbred cows and produce more milk for home consumption and sale.

Maize residue yields (cv Katumani composite B) were determined on 44 sample plots of 100 m^2 during the first 1987/88 rains (November 1987 to January 1988) and on 40 plots during the second rains (March to May 1988).

The range of grain yields for the two seasons was similar. In both seasons 60–65% of the plots had grain yields of between 0.5 and 1.5 t/ha. About 25% of the fields sampled had grain yields of less than 0.5 t/ha. Average grain yield in both seasons was close to 1 t/ha (Table 12). Residue yields increased from 1 t/ha where grain yield was less than 0.5 t/ha to more than 5 t/ha in crops with a grain yield of more than 1.5 t/ha.

Table 12. *Total biomass production[1] of maize, according to grain-yield class, over two growing seasons, semi-arid Kenya, 1987/88.*

	Grain-yield class (t/ha)				Weighted mean yield (t/ha)
	<0.5	0.5–0.99	1.00–1.49	>1.50	
	Mean yield (t/ha)				
First season					
Grain	0.25	0.76	1.11	1.86	1.09
Residue	0.74	2.38	2.83	5.92	2.94
Total	0.99	3.14	3.94	7.78	4.03
Second season					
Grain	0.36	0.76	1.19	1.90	0.96
Residue	2.03	2.48	3.13	5.00	2.89
Total	2.39	3.24	4.32	6.90	3.85

[1] Air-dry, dry-matter content approximately 70%.

In the second season maize residues were partitioned into stems, leaves and husks, and cobs to allow their evaluation as livestock feed. Average composition across the four classes of grain yield showed that stem yield increased slowly as grain yield increased, contributing 1.2 to 1.7 t to the total biomass (Figure 3). Leaves and husks increased from 0.8 to 1.7 t/ha, accounting for 40% of the total residue yield in crops with a grain yield of more than 1 t/ha. Cobs accounted for 7 to 20% of residue yield, increasing in proportion with grain yield. When grain yields were below 0.5 t/ha, total residue yield averaged 2.4 t/ha, two-thirds of which came from plants without cobs. The ratio of total residues to grain was 5.6:1 in low-yielding plots with many cobless plants, 3.1 to 3.3:1 where grain yield was between 0.5 and 1.0 t/ha, and 2.7:1 in plots with grain yields of more than 1 t/ha. Although the ratios decreased with increasing grain yield, yield of residue increased with increasing grain yield; this was especially so for the yield of leaf the most nutritious fraction.

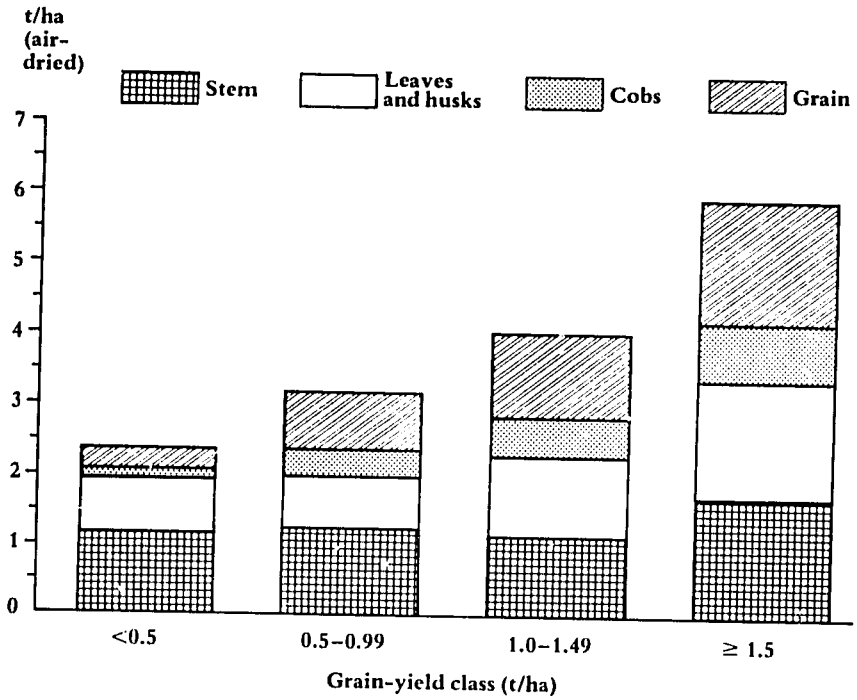


Figure 3.
Composition of maize biomass yield for crops in four grain-yield classes, semi-arid Kenya, 1988.

Assuming that cattle will eat all the leaf and husk fractions and half of the stem and cob fractions, and that the residues had an overall dry-matter (DM) content of 70%, then 1 tonne of residue provides 0.5 t DM of livestock feed. Thus the farms surveyed produced an average of 2.9 t of edible dry matter per hectare of maize over the two rainy seasons.

Nitrogen and phosphorus content and in vitro digestibility were determined for each of the residue components. Nitrogen content ranged from 0.45% in husks and lower stems to 1.64% in green leaves. Phosphorus content was extremely low, ranging from 0.03% in dry husks to 0.08% in green leaves. In contrast, in vitro digestibility of dry matter was high, ranging from 54% in lower stems to 65–67% in husks and leaves. Maize residues are thus relatively high in digestible energy but low in nitrogen and phosphorus and need to be supplemented to provide a balanced diet for livestock.

Cattle in the derived savannah of Nigeria

The most promising area for cattle production in high rainfall areas of Nigeria is the derived savannah. This zone is characterised by a transitional form of vegetation derived from former rain forest by the impact of prolonged human activity and fire. Recent studies have indicated that the incidence of trypanosomiasis in the derived savannah zone is low, possibly because clearing the forest for farming has reduced areas suited to the tsetse fly, *Glossina morsitans*, which transmits the disease. This preliminary investigation in south-east and south-west Nigeria aimed at obtaining baseline data on the distribution and abundance of cattle, cultivation and human habitation from aerial surveys, against which future studies can be compared.

Aerial surveys were carried out in both the wet and the dry season. Flights were made at 1000 feet (300 m) above ground level along north-south

flight lines at longitudinal intervals of half a degree. Each flight line was split into sectors 5 minutes of latitude in length, creating a rectangular sampling grid. Data collected were expressed on a grid cell basis, and multivariate analysis of relationships between cattle distribution and environmental parameters for the zone obtained.

Half a million animals were moved across the Niger and Benue rivers to spend the dry season in the southern part of the subhumid zone or in the derived savannah (Figure 4). The number of cattle in the derived savannah increased from 186 670 in the wet season to 302 450 in the dry season (Table 13). Cattle density in both seasons was twice as high in the south-east as in the south-west. The density of human habitation and the amount of land under cultivation were also higher in the south-east.

Stepwise multivariate regression analysis suggested that the abundance of cattle is best explained in terms of herd distribution. In the dry season the distribution of herds in the zone was positively associated with the presence of cultivated land, the absence of arable dwellings and with the vegetation index. In the wet season the presence of pastoral dwellings, low rainfall, the presence of cultivated land and scrubland were positively correlated with herd distribution. Herd size in the wet season was negatively correlated with the presence of cultivated land.

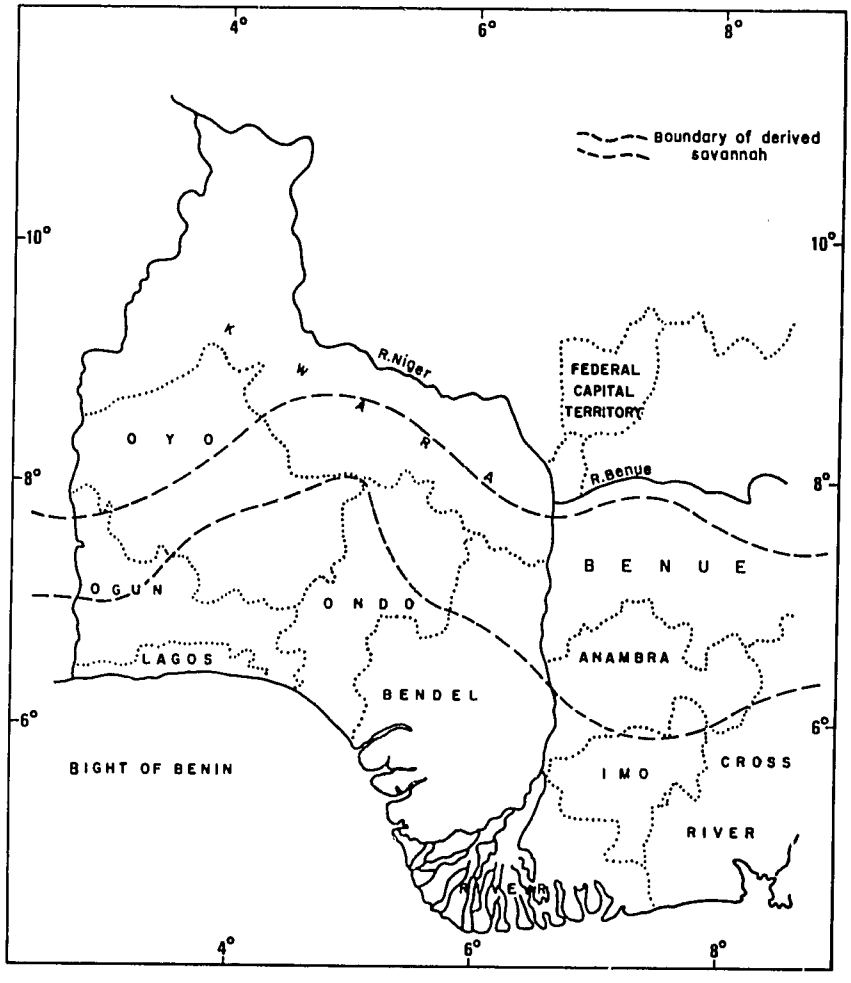


Figure 4.
Southern Nigeria showing the derived savannah zone.

Table 13. *Cattle, cultivation and human settlement in southern Nigeria from aerial survey data.*

		South-west	South-east	Derived savannah
Area surveyed (km^2)		29 160	57 350	42 280
Cultivated land (%)		15.4	27.9	26.4
Dry season				
Arable dwellings	(Total no.)	70 570	374 120	250 780
	($No./km^2$)	2.42	6.52	5.93
Pastoral dwellings	(Total no.)	1660	9450	3210
	($No./km^2$)	0.06	0.16	0.08
Cattle population	(Total no.)	194 020	760 510	302 450
	($No./km^2$)	6.65	13.26	7.15
Herd size (head)		47	71	56
Wet season				
Arable dwellings	(Total no.)	46 440	456 920	310 900
	($No./km^2$)	1.59	7.97	7.35
Pastoral dwellings	(Total no.)	3370	5640	3210
	($No./km^2$)	0.12	0.10	0.08
Cattle population	(Total no.)	88 140	330 410	186 670
	($No./km^2$)	3.02	5.76	4.41
Herd size (head)		38	93	58

In a survey of technology transfer undertaken in Kwara State, using purposive, cluster and random sampling techniques, average family size was found to be 12 people and the average herd comprised 43 animals. Livestock producers thought of extension agents as providers of veterinary care, credit and other livestock inputs. Farmers stated that their main problems were poor animal health and difficulties in providing water. Extension agents thought the farmers' main problems were poor supplies of drugs (and hence poor animal health control), shortage of grazing land, high stock mortality and conflicts between crop and livestock farmers. Livestock owners accepted that animal health interventions, such as vaccination, were beneficial but were less convinced of the benefits of nutritional interventions. Livestock owners and their wives most commonly obtained information on improved livestock practices from radio programmes.

Milk preservation and processing

Calotropis procera extract as a milk coagulating agent

The manufacture of cheese from whole or skimmed milk generally requires the use of a milk-coagulating enzyme, known as rennet. Commercial rennet is expensive and may not be available to smallholders and agropastoralists. ILCA is trying to identify local sources of milk coagulating agents that could be easily obtained and used by African smallholders. The plant *Calotropis procera* is one such source of milk coagulating enzyme. The plant and its extracts are already used in cheese-making in some parts of Africa, e.g. Nigeria.

An initial study was made of the availability of *Calotropis procera* in Ethiopia and the milk-coagulating properties of juice pressed from different parts of the plant, the cheese yields obtained and the fat content of the resulting whey.

About 7.5 kg of the plant were collected near ILCA's Debre Birhan research station in the Ethiopian highlands. The material was separated into leaf, young stem and old stem and finely chopped. Juice was then pressed from each fraction and its pH was measured. The juice was stored at 12°C.

One-litre portions of milk were treated with various amounts of juice from each plant fraction and the time taken for the milk to coagulate was recorded. The curd was then cut and the whey drained from the coagulum. The fat content of the whey was determined and the curd was weighed.

Generally, coagulation time decreased as the amount of juice added was increased. Juice from leaves gave better results than juice from stem fractions (Table 14). Cheese yields ranged from 180 to 194 g per litre of milk, generally decreasing with increasing coagulation time.

Table 14. *Characteristics of juice from leaf and stem fractions of the* Calotropis procera *plant used as a milk coagulating agent.*

Plant part	Juice yield (% w/w)	pH	Coagulation time[1] (minutes)	Whey fat content[1] (%)
Leaf	39	6.23	6	0.47
Young stem	17	5.93	21	0.63
Old stem	18	5.90	32	0.88

[1] For 0.3% rate of juice addition. Average of 10 trials.

These preliminary results indicate that juice from *Calotropis procera* is a useful, readily available and cheap source of a milk coagulating agent. However, more exhaustive studies are needed on several cheese varieties, together with chemical, organoleptic and shelf-life tests on the cheese.

Churning with an internal agitator

In the Ethiopian highlands butter is usually made from soured whole milk using a traditional clay-pot churn. Trials were carried out on eight farms near Debre Birhan, Ethiopia, in 1988 to investigate the effect on churning time and fat recovery of fitting the traditional churn with an internal agitator.

Using the internal agitator reduced churning time to one hour, compared with an average of 3 hours for the traditional churn. Recovery of butterfat increased by about 37%. These results are similar to those found in previous trials on farms in the Debre Birhan area.

Economics of cattle production

Patterns of consumption of dairy products in West Africa

Aggregate statistics for West Africa suggest that dairy consumption in the region, although very low, is increasing. Dairy production has been grow-

ing more slowly than dairy imports. Several factors, operating on both the demand and supply sides, appear to be promoting dairy consumption in the region. Prominent among these are: population growth, urbanisation, changing consumer preferences, plentiful world supplies of dairy products at favourable prices and, in some countries, increasing incomes. A desk study carried out in 1988 investigated the pattern and distribution of dairy consumption in West Africa and looked at some of the factors influencing it.

In the first phase of the study, the literature was reviewed to gather information on dairy consumption in West Africa. This information was categorised on ecological (i.e. moist or dry zone), ethnic, income and urban vs rural bases. The information thus acquired was used, together with population and consumption data, to quantify potential demand for milk and milk products in West Africa in 1988. The resulting demand estimates are disaggregated by product type and origin (local or imported), by ecological zone (dry or moist) and by rural/urban categories.

For West Africa as a whole, total demand for milk and milk products in 1988 was estimated at 3.1 million tonnes of liquid milk equivalent (LME). Although per capita dairy consumption is higher in the dry (arid and semi-arid) than in the moist (humid and subhumid) zone, total demand is almost equally distributed between the dry (51%) and moist (49%) ecological zones.

The zones differ markedly, however, in the proportion of dairy demand met by local production and in the proportion of total dairy demand that occurs in urban areas (Figure 5). In the dry zone, 72% of demand is met by local production, mainly fresh milk and yoghurt, compared with only 38% in the moist zone. This reflects the lower milk production base of the moist zone. Urban demand accounts for only 21% of total demand in the dry zone, compared with 60% in the moist zone. In the dry zone, 22% of urban demand is met by local products, compared with only 5% in the moist zone.

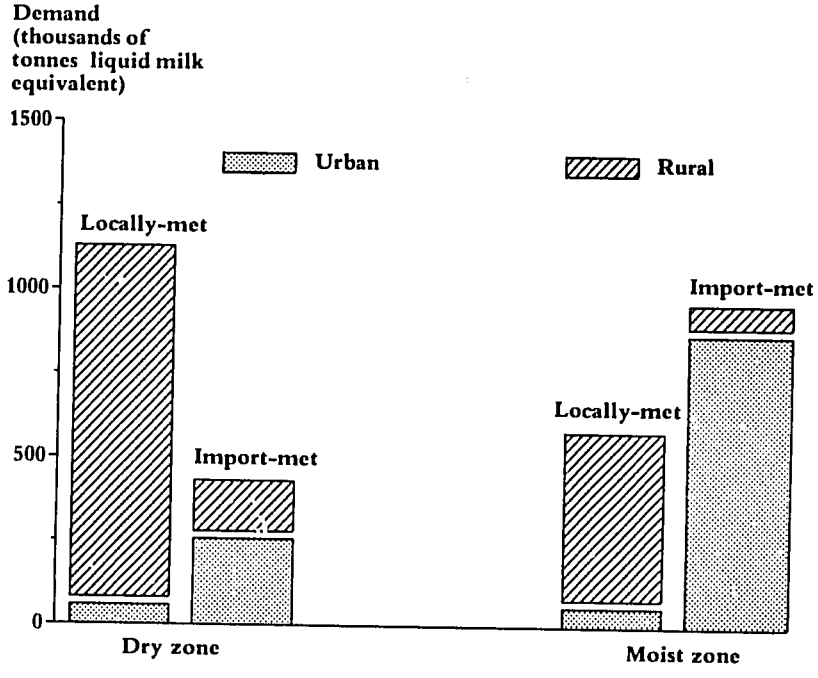


Figure 5.
Demand for milk and milk products, West Africa, 1988.

Milk consumption and marketing in Nigeria

The amount and value of dairy products that Nigeria imported increased rapidly up to September 1986, when the country's Structural Adjustment Programme (SAP) was introduced. The SAP resulted in rapid devaluation of the Naira on the foreign exchange market. This, together with higher prices charged by the European Economic Community (EEC) for its dairy exports, has made import-based dairy products much more expensive. However, little is known about consumption patterns and marketing infrastructure, particularly for locally produced dairy products. A socio-economic survey was started in 1988 to obtain more information on consumption of dairy products at the household level and analyse marketing channels.

Rural and urban areas in Oyo State in south-west Nigeria and Kaduna State in the north were selected for the study. After a preliminary investigation, interviews were conducted in 792 households in Oyo State. Pilot studies were completed in the north; field work there will be concluded in 1989.

Preliminary data analysis shows that marketing and consumption of import-based dairy products do not vary much from one part of the country to another. Consumers of imported dairy products perceive them as luxury items rather than as food staples. Differences in consumption patterns of domestically produced dairy products relate to proximity to Fulani herds or settlements and to ethnic and cultural differences in food tastes and habits.

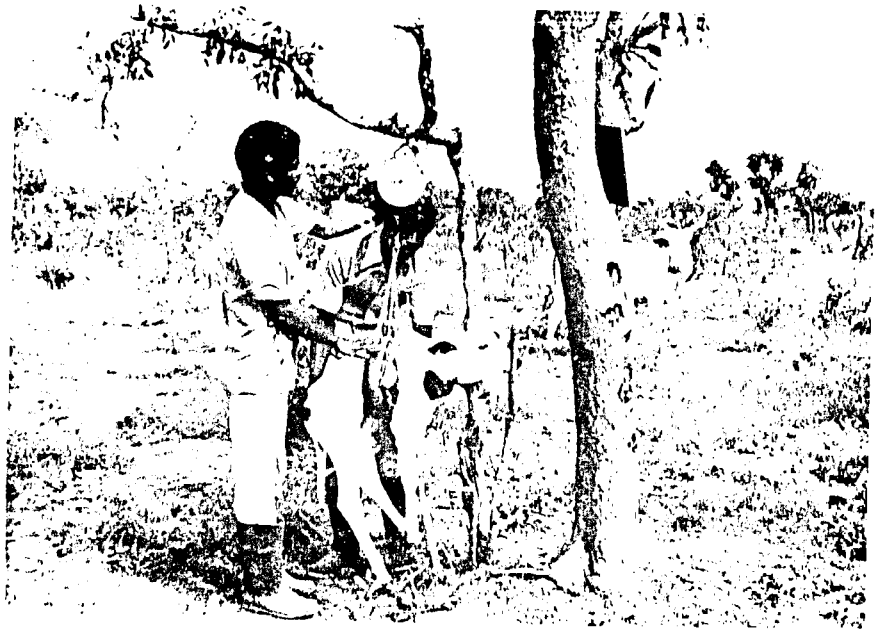
Traditional patterns of consumption differ markedly between northern Nigeria, where most of the Fulani and their cattle are found, and the south, where trypanosomiasis has limited cattle production. However, the increasing interaction of the Fulani with the Yoruba in the south-west has led to processing of surplus milk into cottage cheese (*wara*) for sale by the local Yoruba women. Northerners resident in the south continue to follow traditional habits and consume sour milk (*nono*) and butter (*manshanu*). In the same way the Yoruba in the north show a continued preference for cottage cheese.

Two distinct systems of dairy consumption and marketing appear to operate in Nigeria, the domestic and the import-based systems, with little overlap between them. Almost all domestic milk is produced by the Fulani, who process it in different ways in different parts of the country depending largely on the characteristics and preferences of the ethnic groups with whom they are in contact. The marketing of imported dairy products is mainly in the hands of the Yoruba, who control the marketing system not only in the south-west but also in northern Nigeria.

A diagnostic study of milk production systems around Bamako

ILCA's research has shown that consumption of milk exceeds milk production in subhumid West Africa. The Government of Mali has given high priority to increasing both domestic milk production and milk consumption per person.

In late 1987 and early 1988 ILCA and the Institut national de recherche zootechnique, forestière et hydrobiologique surveyed milk producers within 100 km of Bamako to determine the problems facing the milk producers in this subhumid area. The study was conducted as part of the Mali Livestock Sector Project 618-0218, funded by the United States Agency for International Development and the Government of Mali.



Weighing a White Fulani calf, northern Nigeria.

The survey distinguished three major systems of milk production in the zone:

- traditional village systems at least 25 km from the city;
- communal cattle parks within the city limits; and
- private dairy units within 25 to 30 km of the city.

All were concerned exclusively with milk production from cattle; no milk was produced from small ruminants. The characteristics of the systems are summarised in Table 15. In-depth studies of the systems, covering such aspects as animal health, feeding, management of reproduction and economics, were started in 1988 and will continue in 1989.

Study of socio-economic obstacles to milk production and consumption in Mali

Socio-economic aspects of milk production, marketing and consumption must be understood in order to formulate appropriate dairy policies that encourage domestic production. The objectives of this subproject, based in Bamako, Mali, are to (1) estimate milk production costs in various production systems, (2) determine patterns of acquisition and consumption of milk and milk products in Bamako and (3) identify dairy marketing systems operating within 100 km of Bamako.

Data on acquisition and consumption of dairy products were collected from a sample of 240 households in Bamako. The households were selected at random within low-, medium- and high-income categories. Income categories were defined a priori according to the characteristics of the neighbourhood in which each household was situated. Data were collected weekly over an 8-week period in November and December 1988, during the cool dry season.

Initial analysis of the data indicated dissimilar patterns of income distribution across the sample households (Gini coefficient = 0.47). The sample

Table 15. *Characteristics of milk production systems around Bamako, Mali, 1988.*

	Per cent in each category		
	Traditional system	Communal parks	Private dairies
Producer vocation			
Agriculturalist	93	33	13
Government employee	0	20	34
Trader	0	7	41
Member of cooperative	60	44	91
Herd size[1]			
Households with 80 cattle or more	6	0	27
60 – 79	10	13	14
40 – 59	16	0	26
20 – 39	31	20	26
1 – 19	38	67	7
Herd composition			
Females	65	70	67
Castrates	11	0	10
Entire males	24	30	23
Zebu Peul	16	19	23
Zebu Maure	0	10	37
Zebu Azaouk	0	0	2
Exotic taurine	0	0	2
Exotic taurine×zebu	0	0	7
N'Dama	30	28	6
Mere (N'Dama×zebu)	54	43	23
Productive females in herd	30	24	43
Productive females in milk	60	71	60
Herd productivity[2]			
Proportion of offtake consumed	65	60	17
Proportion of offtake sold	31	36	82

[1] Average number of cattle per household was 34 in the traditional system, 21 in the communal parks and 62 in the private dairies.

[2] Daily milk offtake per cow was 0.52 litres in the traditional system, 0.80 litres in the communal parks and 1.87 litres in the private dairies. Average price received for milk sold was 129 CFA/litre in the traditional system, 250 CFA/litre in the communal parks and 238 CFA/litre in the private dairies.

The survey of the traditional system was conducted between November and January and that of the communal parks and private dairies between May and June.

was thus post-stratified into five income categories. Preliminary results for three of these categories (very-low, medium and very-high income) and the average of the whole sample are presented in Table 16.

Imported dairy products accounted for 56% of the dairy products consumed by the sample households, when products were compared on the basis of liquid milk equivalents. Imported products included whole milk powder (butterfat content of 8.5% or more) and concentrated whole milk. Locally produced milk and milk products accounted for 44% of dairy products

consumed in the very poor households and 37% of consumption in very rich households, but only 24% in medium-income households. Reconstituted milk and milk products produced by the parastatal processing plant accounted for 32% and 9% of total dairy product consumption in very poor and very rich households, respectively. These reconstituted products are made mainly from imported raw materials.

Forty-five per cent of the people in very poor households, 40% of people in middle-income households and 38% of people in very rich households stated that they preferred locally produced fresh milk to milk powder or reconstituted milk. This preference was based both on nutritional grounds and on consumption habits.

The study will be continued in the same households during the hot dry season and the rainy season in 1989.

Table 16. *Patterns of consumption of dairy products in sample households, Bamako, Mali, cool dry season 1988 (preliminary results).*

Item	Income category			
	Very low	Medium	Very high	Whole sample
Number of households	30	121	7	238[a]
Average household income (CFA/month)[1]	13 483	61 762	442 857	85 229
(US$/month)[2]	42.78	190.89	1368.75	263.42
Average expenditure on dairy products (CFA/month)[3]				
Local products	345	239	1485	375
Reconstituted products	112	239	396	264
Imported products	558	2182	8019	3114
Total	1015	2661	9900	3754
Percentage of monthly income spent on dairy products	7	4	2	4
Households regularly consuming dairy products (%)	57	78	95	77
Household composition (number)				
Children (0–5 years)	2.6	2.2	2.7	2.3
Youngsters (5–16 years)	1.9	2.8	3.8	3.0
Adults (over 16)	4.0	4.8	6.7	5.3
Total	8.5	9.8	13.2	10.6
Weekly consumption of dairy products				
(kg LME/household)[4]	0.69	1.6	4.4	2.0
(kg LME/person)	0.08	0.16	0.33	0.18
Dairy products consumed (% of total)				
Local products	44	24	37	28
Reconstituted products	32	24	9	16
Imported products	24	52	54	56

[a] Two households were dropped from the sample during the survey.

[1] Declared income for the whole household.

[2] Based on exchange rate on 24 July 1989.

[3] Rough estimate based on aggregate retail prices of product groups.

[4] LME = liquid milk equivalent.

THRUST STAFF

P Chigaru, *Thrust Coordinator*
A N Atta-Krah, *Agronomist*
P Bartholomew, *Forage Agronomist*
Belete Dessalegn, *Animal Scientist*
R Brokken, *Economist*
B S Capper, *Animal Nutritionist*
D L Coppock, *Animal Scientist/Ecologist*
S Debrah, *Economist*
I V Ezenwa, *Graduate Associate (until September 1988)*
R Franceschini, *Veterinarian (Research Associate)*
P A Francis, *Agro-economist (until May 1988)*
O B Kasali, *Veterinarian/Pathologist*
P N de Leeuw, *Ecologist*
M Mattoni, *Veterinarian*
J McIntire, *Economist*
E Mukasa-Mugerwa, *Animal Scientist*
Mulugeta Assefa, *Graduate Associate (from May 1988)*
C B O'Connor, *Dairy Technologist*
E A Olaloku, *Visiting Scientist*
J D Reed, *Animal Nutritionist*
L Reynolds, *Animal Scientist*
A N Said, *Animal Nutritionist*
Senait Seyoum, *Senior Economic Assistant*
S Soumare, *Sociologist*
S Sovani, *Veterinarian*
Tekelye Bekele, *Veterinarian*
M B Vabi, *Graduate Associate (until September 1988)*
A de Vries Robbe, *Graduate Associate (from September 1988)*

Small Ruminant Meat and Milk Thrust

Meat from sheep and goats accounts for almost 30% of the meat consumed in Africa, and is an especially important marketable commodity for the poorer farmers in sub-Saharan Africa. Consumer demand is particularly high during religious festivals and cultural celebrations.

There are three major zones in which ILCA's research on small ruminants is located:

- the semi-arid zone – perhaps the most important, in terms of both need and potential payoff, and where there is room for considerable growth in 'exports' of live animals to the markets of the more humid zones to the south (or other consumer areas),
- the highlands of East Africa, selected because they provide a major opportunity for increasing the production and marketing of sheep, and
- the humid zone of West Africa, where we seek to raise the productivity of both sheep and goats and where both the markets and the potential for forage production exist.

Genetic resource evaluation and breed improvement

Performance of Ethiopian highland sheep breeds

The potential performance of indigenous African breeds of sheep needs to be known as the basis for rational programmes aimed at improving sheep production. A study was conducted in 1988 of the influence of feed supplementation on the productivity of Arsi, Menz and Wello sheep, three breeds or types found in the Ethiopian highlands.

Seventy-two entire male sheep of each type were kept in low-cost housing at ILCA's Debre Birhan station in the Ethiopian highlands. The animals were about 6 months old at the beginning of the trial. The animals received a basal diet of meadow hay (9.1 MJ metabolisable energy/kg), fed *ad libitum*. Concentrate (18% coarsely ground maize, 50% wheat bran, 30.75% noug *(Guizotia abyssinica)* cake, 1% limestone and 0.25% common salt) was fed either at a rate of 100 g daily or *ad libitum*. All other management conditions were the same for each group. Data were collected on weight gain, feed intake, feed conversion efficiency and carcass characteristics.

Across breeds, animals receiving 100 g of concentrate daily (low-plane diet) ate an average of 707 g of hay daily over the 40 weeks of the trial, compared with 250 g of hay daily for sheep given *ad libitum* access to concentrate (high-plane diet). The latter ate an average of 697 g of concentrate daily. Animals on the high-plane diet generally had significantly ($P<0.05$) higher feed intakes and significantly ($P<0.05$) better feed conversion efficiencies than those on the low-plane diet (Table 17).

Table 17. *Average daily feed intake (hay + concentrate) and feed conversion efficiency of male Arsi, Menz and Wello sheep on low- and high-plane diets, Debre Birhan, Ethiopia, 1988.*

Weeks in trial	Arsi		Menz		Wello		SE
	LP[1]	HP[2]	LP	HP	LP	HP	
Feed intake (g/head per day)							
16	870b	990a	780c	880ab	940ab	950ab	74.0
16 to 24	862bc	1105a	784c	895b	890b	1076a	78.0
24 to 32	739b	898a	691b	714b	775b	807ab	75.0
32 to 40	605d	1023a	639d	929b	785c	1057a	69.0
Feed conversion efficiency[3]							
16	18.1b	8.8c	23.6a	9.0c	18.1b	8.7c	1.74
16 to 24	28.7b	9.1c	34.1a	9.6c	35.6a	10.1c	1.97
24 to 32	35.2b	12.6c	49.3a	13.2c	33.7b	12.8c	2.09
32 to 40	86.4b	26.9d	45.6c	40.4c	157.0a	23.0d	4.75

[1] Low plane = *ad libitum* hay + 100 g of concentrate.

[2] High plane = both hay and concentrate *ad libitum*.

[3] Ratio between feed intake (hay + concentrate) and liveweight gain.

Within rows, means followed by the same letter do not differ significantly ($P>0.05$).

Wello sheep were heavier than Arsi and Menz sheep at the beginning of the trial but, within treatments, were not significantly heavier than Arsi sheep after 16 weeks in the trial (Table 18). Menz sheep were generally lighter than the other two types, significantly so after 32 weeks in the trial.

Table 18. *Mean body weights of male Arsi, Menz and Wello sheep on low- and high-plane diets, Debre Birhan, Ethiopia, 1988.*

Weeks in trial	Liveweight (kg)					
	Arsi		Menz		Wello	
	LP[1]	HP[2]	LP	LP	LP	HP
Initial	14.8ab	14.1b	13.7b	13.3b	15.4a	15.7a
16	20.0c	27.0a	18.8c	24.4b	20.7c	27.9a
24	21.7c	33.8a	20.1c	29.6b	22.1c	33.9a
32	22.9c	37.8a	20.9d	32.6b	23.4c	37.4a
40	23.3c	39.9a	21.7d	33.9b	23.7c	40.0a

[1] Low plane = *ad libitum* hay + 100 g of concentrate.

[2] High plane = both hay and concentrate *ad libitum*.

Within rows, means followed by the same letter do not differ significantly ($P>0.05$).

Among animals slaughtered after 32 weeks in the trial, those on the high-plane diet had a significantly ($P<0.05$) higher dressing percentage than those on the low-plane diet (48.7% vs 35.3%). High-plane animals also had higher proportions of fat and lower proportions of lean, bone and trimmings than those on the low plane of nutrition. Wello sheep tended to have the lowest fat:lean ratio. Arsi sheep on the high-plane diet had the highest proportion of subcutaneous fat.

The larger body size and greater weight gains of Arsi and Wello sheep make them better suited than Menz sheep to intensive mutton production. Arsi sheep would be the best type for markets in which carcass quality is judged on the amount of subcutaneous fat.

Breed characterisation — Mozambique

Small ruminants in Mozambique are nearly all owned by peasant farmers operating in the traditional sector. The traditional system is agropastoral; small, mixed farms in which crop production is the dominant enterprise. Animals are normally managed under a sedentary system and confined to the farm or its immediate area. In some lower rainfall (<400 mm a year) areas some transhumance is practised. An urban system of production, in which animals (mainly goats) scavenge the streets and feed on grassy areas, is developing rapidly.

Sheep and goats fulfil important functions in the life of the small mixed farmer. They provide meat and some milk, generate cash income and play traditional social and religious roles. Research programmes in Mozambique have concentrated on characterising the Landim (Portuguese = local or "land" variety) goats and sheep and evaluating the productivity of the two species.

The Small Ruminant Research Network assisted the Animal Production Institute of Mozambique in analysing its database and interpreting the results with a view to future collaborative research efforts.

Goats had a slightly better overall performance than sheep mainly due to their superior reproductive performance (Table 19) and lower preweaning mortality rate. The differences between the species were not so large as to lead to a recommendation that one species should be preferred to the other. Keeping mixed flocks of sheep and goats may lead to greater overall animal production per unit area than would keeping one species alone.

Table 19. *Comparative reproductive performance of Landim goats and sheep in Mozambique*

Species	Litter size (no.)	Parturition interval (days)	Reproductive rate (young per female per year)
Goat	1.47	408	1.57
Sheep	1.36	416	1.38

In the wider context, Landim sheep and goats, with their large litter sizes (which is the outstanding trait revealed by these analyses), could be used to improve the reproductive performance of other African types of small ruminants in semi-arid environments in southern Africa and perhaps elsewhere on the continent.

Breed characterisation — Sudan

Sudan covers an area of more than 2.5 million km^2, is the largest country in Africa and has one of the continent's largest livestock populations. Sheep

comprise about 36% of the total livestock population of 45 million animals. There are four main Sudanese groups of sheep: Sudan Desert; Sudan Nilotic; Sudan Arid Upland; and Sudan Equatorial Upland. The Sudan Desert accounts for more than 65% of Sudanese sheep and is more productive than other local sheep, which gives it priority in research and development programmes.

The performance of these types must be characterised and evaluated before further progress can be made in increasing sheep productivity in Sudan. The National Sheep Research Station at El Huda has been evaluating the performance of three subtypes of the Sudan Desert sheep since 1975. The Small Ruminant Research Network has helped the Sudanese Animal Production Research Administration plan and execute the analysis of the El Huda database. The aim of the research has been to evaluate the performance of the Shugor, Dubasi and Watish tribal subtypes of Sudan Desert sheep under the same management conditions. Future research will evaluate the pure types and some of their crossbreds and determine the genotypes and management systems best suited to local environments.

The three subtypes differed in primary performance traits (Table 20) but not in overall productivity. Although the Watish subtype was significantly lighter than the other two subtypes, its overall productivity was raised by having a significantly lower lamb mortality rate. There was evidence of heterosis in weights of some of the crossbreds. Development of a synthetic Sudan Desert sheep incorporating the higher viability of the Watish and the heavier weights of the Shugor and Dubasi could increase output from the Sudanese sheep subsector.

Table 20. *Components of productivity and productivity indices of three subtypes of Sudan Desert sheep*

Component and unit	Sheep subtype		
	Shugor	Dubasi	Watish
Litter size (no.)	1.30a	1.18a	1.17b
Parturition interval (days)	449a	425a	403b
Lamb weight at 120 days (kg)	16.9a	16.3a	15.2b
Mortality at 120 days (%)	40.5a	42.6a	29.7b
Ewe postpartum weight (kg)	43.3a	42.2a	37.0b
Productivity indices[1]			
I	17.1	16.4	16.9
II	421	395	443
III	1.15	1.08	1.19

[1] Productivity indices are in:

I: kg of lamb weaned per ewe per year.

II: g of lamb weaned per kg of ewe body weight per year.

III: kg of lamb weaned per kg of ewe metabolic weight ($kg^{0.75}$) per year.

Within rows, values followed by the same letter do not differ significantly ($P>0.05$).

Breed characterisation — Togo, Nigeria and Tanzania

The Network is actively collaborating with the Small Ruminant Project in Togo and the Federal Livestock Department in Nigeria in research. It is hoped that collaborative research will be started with the Tanzanian Livestock Research Organisation during 1989.

Forage production and feeding systems

On-farm verification of sheep fattening systems in the Ethiopian highlands

Farmers in the Ethiopian highlands commonly fatten rams and castrates for sale during major festivals. The feeding system is based largely on grazing and crop residues, supplemented with small amounts of cereal grain. The output and efficiency of the fattening enterprise could be increased by improving the feeding and management of the animals.

In 1988, trials were conducted at Hidi, near Debre Zeit, and at Deneba, about 40 km west of Debre Birhan, to investigate the effects of feed supplementation and control of endoparasites on weight gains of sheep.

The trial at Hidi comprised 60 castrated sheep with an initial average weight of 18 kg. The animals were separated into three groups of 20 animals each. Ten animals in each group were treated for nematodes and trematodes; 10 were not treated. Animals in Group I were kept in pens and received a daily basal ration of 700 g dry matter (DM) of teff straw per head. Groups II and III (the control group) grazed for 7 hours a day on local pastures. Groups I and II received a daily feed supplement of *Seshania sesban* leaves (200 g DM), noug (*Guizotia abyssinica*) cake (50 g), wheat bran (50 g), bone meal (8 g) and salt (5 g). Group III animals were fed 400 g DM of teff straw per head per day to compensate for the poor quality of the grazing. The animals were managed by members of the Hidi Peasant Cooperative; data were collected by ILCA enumerators.

The trial at Hidi began in May 1988 and was completed in December 1988, covering a fattening period of 240 days. The effects of diet on final liveweights and liveweight gains are shown in Table 21. Control of endoparasites had no significant effect on either factor.

Diet had a significant ($P<0.05$) effect on average daily liveweight gain (ADG) and final liveweights of castrates (Table 21). Animals in Group II had the highest ADG and final liveweights. The difference between Groups I and

Table 21. *Effect of diet on final liveweight and average daily gain of castrate sheep over a 240-day fattening period, Hidi, Ethiopian highlands, 1988.*

Feed group[1]	Liveweight (kg ± SE)	Average daily gain (g ± SE)
Group I	28.4 ± 0.54c	38 ± 0.23b
Group II	30.1 ± 0.54a	56 ± 0.23a
Group III	26.0 ± 0.56b	41 ± 0.23b

Within columns, means followed by the same letter do not differ significantly ($P>0.05$).

[1] See text for details of diets.

II indicates that grazing provided a better balanced diet than teff straw. The poor performance of Group III animals reflects the low protein content of the pasture.

The levels of growth achieved in this trial are less than those obtained in on-station trials. This indicates that further supplementation is needed. Molasses/urea blocks could provide the additional energy and nitrogen needed to boost the animals' performance.

Evaluation of sorghum stover as small ruminant feed

Sorghum stover is an important dry-season feed for ruminants throughout sub-Saharan Africa. There are, however, several limitations to its use: low nutrient density, low intake and the presence of anti-nutritional factors such as polyphenolics.

Animals must eat large amounts of sorghum stover to satisfy their daily nutrient requirements but voluntary intake is low. Most methods for increasing voluntary consumption of low-quality roughage (e.g. chemical and physical treatments) are not suitable for use by smallholders. A much simpler alternative is to allow small ruminants to feed selectively on the stover. This was investigated in this project. Two sorghum cultivars were used in the study: MW 5020, a bird-resistant cultivar, and Melkamash, which is not bird resistant.

Forty-eight entire male sheep weighing between 22 and 26 kg were randomly assigned to one of two groups of 24 animals each. These groups corresponded with the two sorghum cultivars. The two main groups were subdivided into three groups of 8 animals each, which were allocated to one of three feeding levels (25, 50 or 75 g of stover dry matter per kg of bodyweight). The animals were confined in individual feeding pens and fed twice a day. Decorticated cottonseed cake was fed as a protein supplement throughout the 10-week experiment. Amounts of feed offered and refused were recorded daily and samples from each were collected and bulked over 2-week periods. Subsamples of the bulked material were partitioned into the four main botanical fractions. The digestibility of the material offered and refused was determined in vitro.

Increasing the amount of stover offered from 25 to 50 g/kg liveweight (LW) significantly ($P<0.05$) increased intake and growth rate for both cultivars (Table 22). Increasing the amount of stover offered from 50 to 75 g/kg LW significantly ($P<0.05$) increased daily weight gain but not intake. The response was larger with Melkamash than with MW 5020, despite the fact that animals ate significantly ($P<0.05$) more MW 5020 stover than Melkamash stover.

The differences between cultivars in the response of animals to increased levels of feeding was related to the chemical and botanical composition of the stover. The composition of the feed refused (Table 23) indicates that the animals ate the leaf and sheath fractions in preference to the stem. Animals fed Melkamash stover were more selective than those fed MW 5020 stover. The degree of differentiation between the fractions was greater in Melkamash than in MW 5020, and this apparently made it easier for the animals to select the leaf and stem fractions.

Results from this experiment show that allowing sheep to feed selectively on sorghum stover increases the animals' feed intake and growth rate. Future work will investigate whether the same phenomenon applies to goats and cattle.

Table 22. *Feed intake and growth rate of sheep fed sorghum stover.*

Variety	Level of offer (g/kg body weight)	Mean[1] stover intake (g/day)	Mean[1] daily gain (g/day)
Melkamash	25	506.36 ± 46.79a	33.45 ± 12.72a
	50	695.67 ± 71.89b	63.37 ± 13.01b
	75	726.95 ± 80.85b	76.65 ± 9.18c
Mean		642.99a	57.82a
MW 5020	25	569.98 ± 49.09a	45.37 ± 12.69a
	50	747.87 ± 55.56b	70.17 ± 8.90b
	75	783.18 ± 100.14b	76.65 ± 14.90c
Mean		690.19b	62.58a

Within columns, means followed by the same letter are not significantly different (P>0.05).
[1] ± standard deviation.

Table 23. *Proportion of botanical fractions and in vitro digestibility of sorghum stover offered to and refused by sheep.*

	Feed offered	Feed refused at (feeding level): 25 g/kg	50 g/kg	75 g/kg
MW 5020				
Feed composition (%)				
Leaf	25.0	-[4]	4.9	10.2
Sheath	22.0	-	12.0	25.4
Stem	42.0	-	76.2	61.2
Head	2.0	-	1.0	0.7
Dust[1]	9.0	-	5.9	2.5
Whole-plant in vitro digestibility (%)	72.6	-	68.2	69.3
Melkamash				
Feed composition (%)				
Leaf	16.7	0.2	2.0	2.9
Sheath	25.2	0.3	4.3	12.8
Stem	49.8	96.0	89.7	80.3
Head	3.8	0.0	0.1	1.1
Dust	4.5	3.5	3.9	2.9
Whole-plant in vitro digestibility (%)	70.7	63.0	67.8	66.6

Proportions are means of 5 subsamples.
[4] No feed refused.
[1] Particles too small for the plant fraction to be identified.

Development of feeding systems for the humid zone

Supplementing the diets of sheep and goats with *Leucaena* and *Gliricidia* during late pregnancy and throughout lactation increases the animals' productivity (*ILCA Annual Report 1987*, pages 22 and 23). However, farmers generally do not have enough browse to supplement their animals continuously and a trial was started in 1988 to investigate the effects of providing supplements at strategic periods in the reproductive cycle.

Leucaena and *Gliricidia* were offered together (400 g total dry matter/day) as a supplement to West African Dwarf goats and sheep in late pregnancy, early lactation, or late lactation.

Supplementary feeding of goats in late pregnancy had no effect on kid birth weight or growth rates to weaning at 16 weeks (Table 24). Supplementing dams in early or late lactation increased kid growth rates while the supplement was being fed but did not significantly increase overall growth rate to weaning. The survival rate to weaning of kids from supplemented does (87%) was higher than that of kids from the control group (58%).

Table 24. *Effect on kid growth rate of supplementing the diet of pregnant and lactating does with* Leucaena *and* Gliricidia.

Period of supplementation	Growth rate (g/day)		
	Birth to 8 weeks	8 to 16 weeks	Birth to 16 weeks
Late pregnancy	34.1a	8.9a	21.5a
Early lactation	43.3b	8.9a	27.1a
Late lactation	34.4a	21.2b	27.8a
Control	31.4a	12.8a	22.1a

Within columns, means followed by the same letter do not differ significantly (P>0.05).

In the sheep trial, feed supplementation significantly increased lamb growth rates only when offered in late lactation (Table 25). None of the treatments significantly affected overall growth rate from birth to weaning at 12 weeks. The survival rate to weaning for lambs from supplemented ewes was 92%, compared with 70% for lambs from the control group.

Table 25. *Effect on lamb growth rate of supplementing the diet of pregnant and lactating ewes with* Leucaena *and* Gliricidia.

Period of supplementation	Growth rate (g/day)		
	Birth to 6 weeks	6 to 12 weeks	Birth to 12 weeks
Late pregnancy	77.2a	32.7a	56.5a
Early lactation	80.2a	23.8a	52.0a
Late lactation	74.6a	37.0b	55.8a
Control	64.8a	18.7a	42.7a

Within columns, means followed by the same letter do not differ significantly (P>0.05).

Alley farming with grazed fallows

A trial was established in 1983 to investigate the long-term effects of continuous alley cropping with *Leucaena leucocephala*, alley cropping in rotation with grazed fallow, and conventional cropping without planted trees. The specific objective was to determine the contribution to soil fertility and sustainability of crop yields of short-term grazed fallows in an alley cropping system. The first phase of the trial ended in 1986 and some of the treatments were modified. The control treatment (continuous cropping without trees) was changed to a rotation of 4 years of cropping followed by 2 years of natural fallow. This treatment was thus under fallow in 1987/88.

Previous results have shown a significant improvement in soil fertility and crop yields following fallow in alleys, compared to continuous alley cropping (*IITA Annual Report 1987*, pages 61 and 62). In 1987, the third year of cropping after the fallow, yields of crops on fallowed plots were still 20% higher than those on continuously cropped alley plots. In 1988 alley plots cropped for the fourth consecutive year after fallow gave yields only slightly higher than alley plots that had been continuously cropped; the differences were not significant (Table 26). This suggests that the gains in soil fertility and crop yield following the 2-year grazed fallow gradually diminish, becoming negligible by the fourth year after the fallow. Cropping for 4 years followed by a 2-year fallow therefore appears to be biologically optimal under these conditions. However, the economic benefits of this crop/fallow sequence also need to be studied over the long term because over a single cropping cycle the higher yields obtained after the fallow period will not compensate for the loss of income from crops during the 2-year fallow.

Table 26. *Dry maize grain yield under continuous* Leucaena *alley cropping and alley cropping after grazed fallow, Nigerian humid zone, 1988.*

Treatment	Maize grain yield (t/ha)
1. Continuous alley cropping	2.90
2. Alley grazing/cropping[1]	3.24
3. Alley grazing/cropping[2]	3.35

[1] Fourth consecutive year of cropping after fallow.

[2] Second year of cropping after fallow.

A similar trial with *Gliricidia sepium* alleys was established on a degraded Alfisol in 1984 to investigate the effects on soil fertility and crop yields of 2-year grazed and ungrazed fallows following 2 years of alley cropping or cropping without trees.

In 1988 maize grain yields were higher from plots that had been fallowed in 1986 and 1987 than from continuously cropped plots (Figure 6). Continuously cropped alley plots yielded 38% more than continuously cropped plots without trees. Under conventional cropping (without trees), yields of maize following grazed fallow were about 20% higher than those following ungrazed fallow, whereas in alley plots there was no difference between the grazing treatments. This lack of response to including animals in the alley plots may have been due to the animals damaging the trees while grazing, as indicated by the lower yields of tree foliage in 1988 from plots that had been grazed in 1986 and 1987 than from ungrazed plots (5.42 vs 6.38 t dry matter/ha).

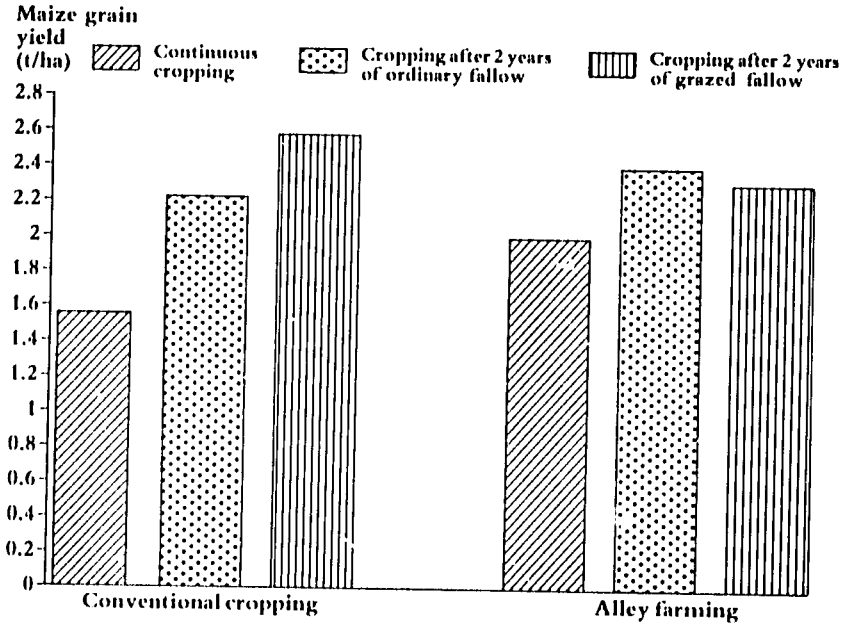


Figure 6.
Effect of a 2-year fallow, grazed or ungrazed, on first season maize yield under conventional (no tree) farming conditions or in Gliricidia alleys, Nigerian humid zone, 1988

Effect on crop yields in alley farming of offtake of fodder at different times

In alley farming, increasing the proportion of tree foliage taken off for animal feed relative to that used for mulch reduces crop yields (*IITA Annual Report 1987*, page 62). This effect is being studied further in a trial started in 1988.

Leucaena and *Gliricidia* trees were pruned on three occasions: the first prunings were taken one week before maize was planted, with the second and third prunings taken at 6-week intervals thereafter. Plots received either no fertilizer or 45 kg of 15:15:15 NPK compound per hectare, 15 kg at planting and 30 kg 6 weeks later. The mulching treatments were:

- No mulching (foliage from all harvests used as animal feed)
- Foliage from only first pruning applied as mulch
- Foliage from first two prunings used as mulch and
- Foliage from all 3 prunings used as mulch (i.e. no offtake as fodder).

Preliminary results indicate that applying inorganic fertilizer reduces the effect of mulching in *Leucaena* alleys (Table 27). In unfertilized plots, applying foliage from the first pruning significantly increased maize yield relative to no mulching. The effects of applying foliage from subsequent prunings as mulch were small and not significant. Treatment differences were less clearly defined in *Gliricidia* plots, partly because some of the plots were infested with armyworms (*Pseudaletia unipuncta*).

These results suggest that, where no fertilizer is used, mulch applied before planting has the greatest effect on crop yields in alley farming. Fodder for livestock should be taken from later prunings to reduce conflict with the need for mulch. If fertilizer is applied, mulching has less effect on crop yields and offtake of foliage for animal feed will have less effect on crop yields.

Table 27. *Effect of mulching with* Leucaena *foliage from different prunings on maize grain yield, Nigerian humid zone, 1988.*

Prunings applied as mulch	Maize grain yield (t/ha)[1]	
	Unfertilized	Fertilized[2]
None	3.10	4.86
First (preplanting)	4.35	4.94
First two	4.68	5.32
All three	4.84	5.31

[1] Total grain yield for first and second cropping seasons.

[2] 45 kg of 15:15:15 compound per hectare, 15 kg at planting and 30 kg 6 weeks later.

Managing alley farming trees for cut-and-carry fodder during fallow periods

A trial was carried out in 1988 to investigate the best cutting schedule to produce dry-season feed from *Leucaena* and *Gliricidia* trees in fallowed alley farming plots.

The trial used two fallowed alley farming plots. All the hedgerows were cut in January 1988, in the middle of the dry season. Five-metre sections were subsequently subjected to one of six pruning regimes:

I: Pruned in January 1989 (12 months regrowth)
II: Pruned in April 1988 (3 months) and January 1989 (9 months)
III: Pruned in July 1988 (6 months) and January 1989 (6 months)
IV: Pruned in April 1988 (3 months), July 1988 (3 months) and January 1989 (6 months)
V: Pruned in October 1988 (9 months) and January 1989 (3 months)
VI: Pruned in April, July and October 1988 and January 1989 (every 3 months).

Foliage from each harvest was sun-dried and preserved in sacks for use as animal feed during the dry season.

Treatment V gave the highest total yield for both *Leucaena* and *Gliricidia* (Figure 7). Yield of *Gliricidia* in Treatment I was very low, reflecting the deciduous nature of this species when unpruned. Yield of *Leucaena* under Treatment I was comparable to yields obtained in Treatments III, IV and VI.

On-farm alley farming research

Testing the acceptability and viability of alley farming with *Leucaena* and *Gliricidia* under farmer management continued in 1988 in the villages of Owu-Ile and Iwo-Ate in south-west Nigeria. More than 250 farmers in the pilot-study area have taken part in this testing programme since it started in 1984 (see *ILCA Annual Report 1985/86* and *ILCA Annual Report 1986/87*). This work is carried out in collaboration with the Nigerian National Livestock Projects Department.

A second phase of on-farm research activity, aimed at assessing the benefit of alley farming under different management conditions, was started in 1987 with two farmers and continued in 1988 with 10 farmers. Two main experiments were conducted in 1988, each with five farmers.

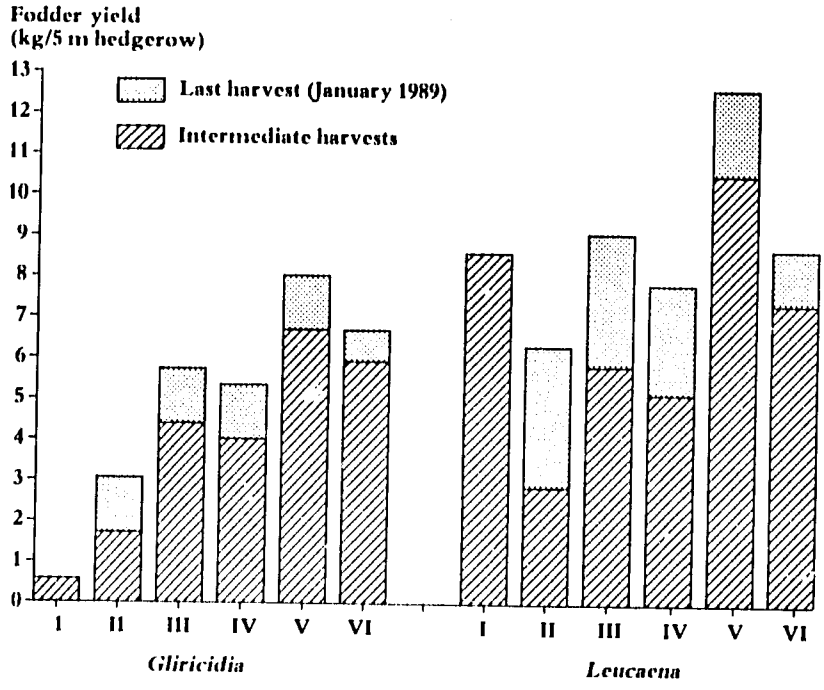


Figure 7.
Effect of pruning management[1] on fodder yield of tree hedgerows in alley farming fallows, Nigerian humid zone, 1988

[1] Treatments are described in the text.

The first experiment investigated the effects of applying various amounts of foliage from leguminous trees to alley plots and "conventional" plots with no trees. Mulch for the conventional plots was obtained from the alley farms. The conventional and alley plots were not directly comparable as most of the conventional plots were established on fallow land adjacent to the alley plots whereas the alleys had been cropped for at least 2 years before the trial. In the first season mulch was applied at rates of approximately 0, 2 and 4 tonnes of dry matter (DM) per hectare. In the second season, mulch rates were modified to reflect actual yields of the trees in the alley farms and foliage was applied at rates of 0, 50 and 100% of foliage yields in each farm. Mean mulch yield across farms in the second season was 1.2 t DM/ha.

Applying tree foliage as mulch increased crop yields both on alleys and conventional plots (Table 28). Increases in crop yields were proportionately greater in on-farm trials than in on-station trials. This was probably due to the fact that farmers ridged their fields and incorporated into the soil mulch that was applied before planting, whereas in on-station trials the mulch remained on the surface of the soil. Actual maize grain yields were, however, lower than those found in on-station trials (3–5 t/ha).

In the second experiment farmers' plots were allocated to one of three treatments:

- Alley farming with tree foliage used as green manure
- Alley farming with tree foliage used only for fodder, and
- Conventional farming without trees.

Using all the tree foliage for livestock feed resulted in the lowest maize yield (Table 29), while using the foliage as green manure gave the highest yield.

Table 28. *Effect of* Leucaena *and* Gliricidia *mulch on maize grain yield in on-farm trials (means of 5 farms), Nigerian humid zone, 1988.*

	Maize grain yield (t/ha)		
First season	Mulch application rate (t/ha)		
	0	2	4
Conventional plots	0.80	1.44	1.94
Alley plots	0.52	1.00	1.27
Second season	Mulch application rate (% foliage yield[1])		
	0	50	100
Conventional plots	0.41	0.78	1.15
Alley plots	0.45	0.73	1.11

[1] Mean foliage yield across farms was 1.2 t DM/ha in the second season.

Table 29. *Effect of* Leucaena *and* Gliricidia *mulch on maize grain yield in on-farm trials (means of 5 farms), Nigerian humid zone, 1988.*

	Maize grain yield (t/ha)		
	No trees, no mulch	Trees, no mulch	Trees, mulch
First season	1.11	0.74	1.44
Second season	0.28	0.22	0.54
Total	1.39	0.96	1.98

These results indicate that farmers should use only part of the tree foliage from alley farms for animal feed and apply the rest as mulch to maintain soil fertility and crop yields. Applying mulch before planting seems to have the largest effect on subsequent crop yields (see *Effect on crop yields in alley farming of offtake of fodder at different times*, p. 38).

Wet season supplementation of goats in the Nigerian subhumid zone

In the Abet case-study area, in the Nigerian subhumid zone, arable farmers keep West African Dwarf goats. They tether their goats on fallow land during the cropping season and confine them in unventilated huts at night to protect them from thieves and rain. The animals receive no feed while confined. After harvest the animals roam freely until the next cropping season.

Tethering individual animals every day during the cropping season is laborious for the owner and limits the animals' ability to select preferred plant species and to mate. Fodder banks (small legume pastures) offer the opportunity of leaving the animals untethered.

A trial started in 1986 continued to investigate the effects on goat productivity of tethering, grazing in enclosed natural pasture and grazing in enclosed forage legume pasture during the second half of the wet season. The trial was carried out under village conditions. General management practices were the same for all flocks; only grazing practice differed between flocks.

The grazing treatment groups were:

- Tethered: 10 herds with a total of 51 goats (2 bucks and 49 does).
- Natural pasture: 4 herds with a total of 13 goats (2 castrates and 11 does).
- Fodder bank: 5 herds with a total of 26 goats (5 bucks and 21 does).

Liveweight changes of adult goats differed significantly ($P<0.05$) between the three treatment groups (Figure 8). Only the goats grazing fodder banks gained weight over the trial period. This was attributed to the greater nutritive value of fodder bank foliage relative to the forage available to tethered goats and those grazing natural pasture.

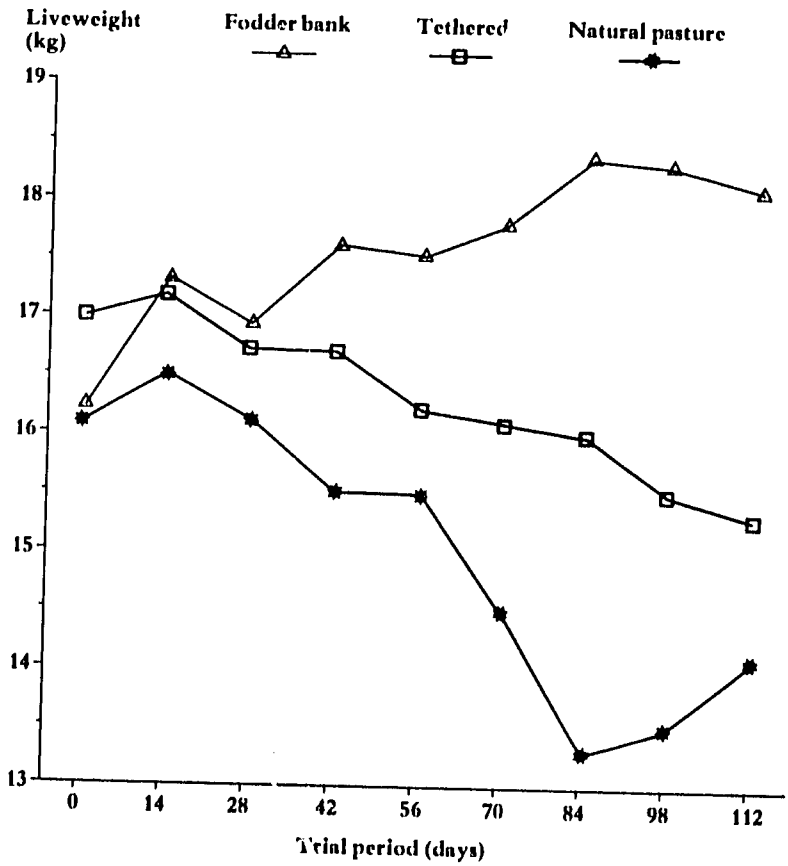


Figure 8.
Effects of tethering on natural pasture and grazing on natural pasture and fodder banks on weight changes in adult goats, Abet, Nigerian subhumid zone, 1988

Average litter sizes (kids ± SD) were 1.3 ± 0.6 for tethered does, 1.5 ± 0.5 for does grazing natural pastures and 1.6 ± 0.5 for does grazing fodder banks. Kid mortality was lower in herds in which the animals were tethered than in those in which goats grazed fodder banks or natural pastures (Figure 9). This may reflect greater attention to animal welfare during individual daily tethering.

Kidding intervals (months ± SD) were 9.5 ± 3.5 for tethered does, 9.8 ± 3.6 for does grazing fodder banks and 10.1 ± 4.5 for does grazing natural pastures. Many of the herds did not have any sexually mature males for long

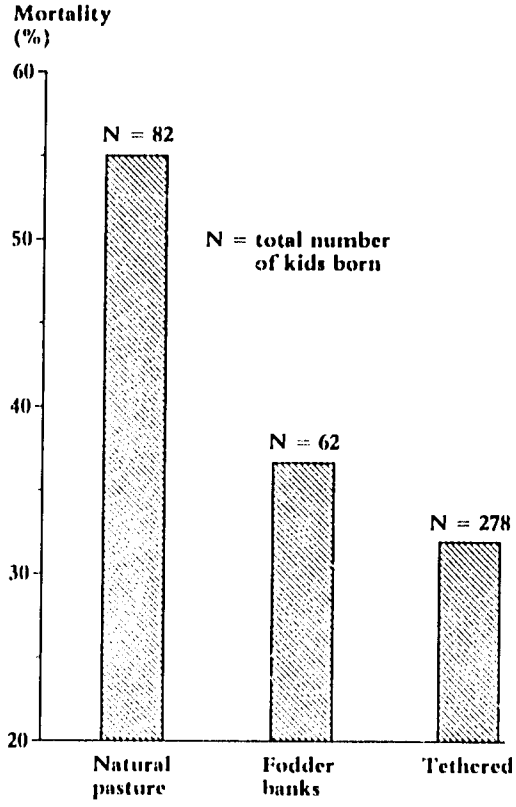


Figure 9.
Percentage mortality of kids in herds in which animals were tethered on natural pasture or grazed on natural pastures or fodder banks, Abet, Nigerian subhumid zone, 1988.

periods during this study. This lack of males may have had a larger effect on kidding intervals than did the feeding regime. Farmers are being encouraged to keep at least one breeding male in their herds for the 1989 trial.

Reproductive wastage in small ruminants

Effect of endoparasites on productivity of Ethiopian highland sheep

Small ruminants are subject to infestation by many gastro-intestinal parasites. The productivity of infested animals is low due to stunted growth, small weight gains, poor feed utilisation and high mortality. The effects of infestation vary according to the parasite concerned, the degree of infestation and several other factors. The temporal and spatial distribution of endoparasites must be understood in order to devise strategies aimed at controlling the parasites and hence increasing livestock productivity.

A study of the effect of endoparasite burden on the productivity of sheep in the Ethiopian highlands was started in June 1988. The study covered five sites in the highlands, in areas where crop production dominates and grazing is limited. Three to four hundred traditionally-managed sheep of the Menz, Horro, Wereilu, and Degen breed types were included in the study at each site. Data were collected monthly on body weight, condition score, pregnancy status, lambing and mortality. Faecal samples were taken; the number

of parasite eggs per gram (EPG) was determined and infective larvae were identified using faecal culture. Blood samples were taken and packed cell volume (PCV) determined. Eight or nine sheep were slaughtered each month at two sites for postmortem examination, estimation of worm load and identification of endoparasites.

Packed cell volume, condition score and body weights of the sheep are presented in Table 30 in relation to the number of parasite eggs per gram of faeces. There were significant ($P < 0.05$) negative correlations between EPG and PCV, and between EPG and condition score.

Table 30. *Mean packed cell volume, condition score and body weight of sheep (± SE) in relation to parasite egg counts, Ethiopian highlands, June–November 1988*

Parasite egg count (eggs/g of faeces)	n	Packed cell volume (%)	Condition score[1]	Body weight (kg)
0	4533	32.41 ± 0.07	1.26 ± 0.014	22.18 ± 0.10
50–500	1968	30.31 ± 0.11	1.20 ± 0.02	24.91 ± 0.13
501–1000	144	28.33 ± 0.41	1.09 ± 0.07	24.55 ± 0.43
1001–5000	77	27.45 ± 0.66	1.08 ± 0.09	24.58 ± 0.60

[1] See: Hossamo H E, Owen J B and Faid M E A 1986. Body condition score and production in fat tailed Awassi sheep under range conditions. *Research and Development in Agriculture* 3 (2): 99–104

Faecal samples indicated that relatively few animals were infested with nematodes and trematodes (Tables 31 and 32), which is in agreement with the low to moderate number of worms found in the abomasa of slaughtered and necropsied sheep (Tables 33 and 34). The main species of nematode found as mature worms were *Trichostrongylus axei*, *T. colubriformis* and *Haemonchus contortus*. Only *T. colubriformis* was found in an immature state. *Haemonchus contortus*, a prolific blood-sucking nematode, was found in 40.8% of sheep necropsied, but there were only three cases in which the number of worms reached 100. This may be attributed to resistance to and/or "self cure" of haemonchosis. The worm counts in the liver and intestine were also very low.

Table 31. *Occurrence of nematode eggs in the faeces of sheep at five sites in the Ethiopian highlands, June–November 1988*

Month	Number of sheep examined	Mean[1] monthly egg count (eggs/g)	Sheep showing nematode eggs in their faeces	
			Number	%
June	1571	169.74 ± 8.84a	800	50.82
July	1409	58.63 ± 4.80b	455	32.29
August	1129	50.66 ± 5.08bc	227	20.08
September	1059	53.37 ± 4.07b	306	28.89
October	959	35.45 ± 3.13cd	269	28.05
November	782	29.60 ± 3.34d	205	26.21

Means followed by the same letter do not differ significantly ($P>0.05$).
[1] ± standard error.

Table 32. *Occurrence of trematode eggs in the faeces of sheep at five sites in the Ethiopian highlands, June–November 1988*

Month	Number examined	Mean[1] monthly egg count (eggs/g)	Sheep with trematode eggs in their faeces	
			Number	%
June	1575	12.21 ± 2.43b	96	6.09
July	1409	0.82 ± 0.11c	19	1.34
August	1130	28.89 ± 5.73a	89	7.87
September	1059	5.38 ± 1.18bc	40	3.77
October	959	0.26 ± 0.11c	5	0.52
November	782	22.89 ± 3.23a	108	13.81

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

[1] ± standard error.

Table 33. *Number of nematodes found in the abomasa of sheep necropsied, Ethiopian highlands, June–November 1988*

Month	Number examined	Mature worms		Immature worms	
		Mean	Range	Mean	Range
June	8	938	0–3300	0	
July	8	450	0–2900	0	
August	9	2444	100–8400	0	
September	8	1475	300–3500	63	0–300
October	8	2200	1100–4700	25	0–200
November	8	2875	200–7400	50	0–200

Table 34. *Frequency with which different species of endoparasites were found in 49 sheep necropsied, Ethiopian highlands, 1988*

Species of endoparasite	Sheep with endoparasite	
	Number	%
Trichostrongylus axei	7	14.3
T. colubriformis	37	75.5
Haemonchus contortus	20	40.8
Oesophagostomum columbianum	2	4.1
Bunostomum trigonocephalum	1	2.0
Trichuris skrjabini	19	38.8
Dictyocaulus filaria	42	85.7
Fasciola hepatica	14	28.6

On-farm surveillance of causes of sheep morbidity and mortality in the Ethiopian highlands

Morbidity and mortality are high among sheep in traditional agropastoral production systems in the Ethiopian highlands. Surveillance studies were started in August 1988 to identify the causes.

Flocks of sheep owned by 10 peasants' associations in and around Debre Birhan, Ethiopian highlands, were monitored for morbidity and mortality twice a week between August and December 1988. The average flock size over this period was 1532 sheep. Morbid sheep were clinically examined and samples were taken for laboratory analyses. Dead sheep were necropsied and samples taken for laboratory diagnosis.

Data indicated 42% (n = 645) morbidity and 15% (n = 233) mortality between August and December 1988. Broncho-pneumonia and gastro-intestinal parasites were the most common causes of morbidity (Table 35). Broncho-pneumonia and neonatal losses, caused by dystocia, colibacillosis and poor milking ability of dams, were the most common causes of death. Neonatal losses are expected to increase with the peak in lambing later in the year. Poor housing predisposed the animals to *Pasteurella* pneumonias. Lamb and dam management was also found to be poor and was responsible for the neonatal losses (of which approximately 90% were perinatal). The high levels of morbidity and mortality account for the slow increase in numbers of sheep in peasant flocks.

Secretory/excretory antigens of adult *Fasciola hepatica* are now being purified to enhance their specificity and sensitivity when used in enzyme-linked immunosorbent assay (ELISA) for diagnosing fascioliasis in sheep. The crude antigen, at a dilution of 1:1000, gave a positive result for 49 (41%)

Table 35. *Causes of morbidity and mortality in sheep in flocks belonging to peasants' associations at Debre Birhan, Ethiopian highlands, August - December 1988*

Cause	Morbidity		Mortality	
	No.	%	No.	%
Broncho-pneumonia	285	18.6	163	10.6
Gastro-intestinal parasitism	158	10.3	2	0.1
Ectoparasitism	54	3.5	0	–
Enzootic ataxia	51	3.3	1	0.06
Neonatal loss	44	2.9	44	2.9
Fascioliasis	22	1.4	1	0.06
Coenurosis	13	0.8	13	0.8
Foot rot	5	0.3	0	–
Malnutrition	4	0.3	0	–
Clostridial infection	4	0.3	4	0.3
Rumenal impaction	2	0.1	2	0.1
Rumenal tympany	2	0.1	2	0.1
Atresia ani	1	0.06	1	0.06
Total	645	42.1	233	15.2

of 120 morbid sheep that showed no sign of *Fasciola* in their faeces. Gel filtration studies identified seven peaks in the crude antigen. In preliminary screening studies of 10 *Fasciola*-infested sheep, 9 were identified as infested by the first antigenic peak, 7 by the second peak and 1 by the third peak. Antigens from *Stilesia hepatica* and *Moniezia* species have been prepared for cross-reaction studies with the above.

Effect of dietary supplementation and control of endoparasites on the reproductive and productive performance of Menz-type sheep

An experiment was started in 1988 to study the effect of dietary supplementation and strategic drenching against endoparasites on the reproductive and productive performance of the Menz-type sheep. The trial is being conducted at ILCA's Debre Birhan research station in the Ethiopian highlands. Two hundred ewes, each between 2 and 4 years old, were allocated at random to one of four treatment groups, each of 50 ewes:

I: Control (no supplement, no drenching)
II: Supplemented, no drenching
III: Drenched, no supplement
IV: Supplemented and drenched

Supplementary feeding started in mid-March 1988. The feed supplement consisted of 300 g of wheat bran and 150 g of noug *(Guizotia abyssinica)* cake and provided the ewes with 8 MJ of digestible energy and about 120 g of crude protein (CP) per head per day. All groups were provided with mineral licks and water *ad libitum*. The four groups grazed together as a single flock. Drenching against endoparasites was done in mid-March, June and September.

Supplementary feeding and endoparasite control, singly and combined, significantly ($P<0.05$) increased mean body weights and condition scores of ewes (Table 36). Supplementary feed and drenching together (Treatment IV) significantly ($P<0.05$) increased lambing rate relative to the control, whereas supplementary feed increased lamb birth weights, whether alone or in combination with drenching (Table 36).

Multiple births accounted for 10.2% of births in Treatment I, 18.6% in Treatment II, 19.4% in Treatment III and 29.5% in Treatment IV. Two sets of triplets were born to ewes in Treatment IV; no other triplets were born.

Ovulation rate was highest in ewes in Treatment IV, but the effect was not significant (Table 36). Neither ewe body weight nor condition score had

Table 36. *Mean ewe body weights, body condition scores, ovulation rates, lambing rates and lamb weights (± SE), Debre Birhan, Ethiopia, 1988.*

Treatment	Body weight (kg)	Condition score	Ovulation rate	Lambing rate (lambs/ewe per year)	Lamb birth weight (kg)
I	25.59 ± 0.10a	2.16 ± 0.01a	1.10 ± 0.11a	1.13 ± 0.03a	2.09 ± 0.05a
II	28.10 ± 0.12b	2.58 ± 0.01b	1.23 ± 0.12a	1.19 ± 0.04a	2.41 ± 0.05b
III	26.37 ± 0.09c	2.21 ± 0.01c	1.23 ± 0.11a	1.16 ± 0.04a	2.25 ± 0.04a
IV	28.57 ± 0.12d	2.69 ± 0.01d	1.38 ± 0.12a	1.31 ± 0.04b	2.31 ± 0.06b

Within columns, means followed by the same letter do not differ significantly ($P>0.05$).

a significant effect on ovulation rate. The difference between ovulation rate estimated using laparoscopy of ewes and actual lambing, which provides a measure of prenatal reproductive wastage, ranged from 0 to 11% among groups between October 1988 and January 1989.

Unsupplemented ewes lost weight and condition between November and January (Figures 10 and 11). Ewe mortality, mainly due to fascioliasis and in some cases complicated by verminous pneumonia and malnutrition, reached 16% in Treatment I and 2% in Treatment II between December and January. There were no deaths in the other groups.

These preliminary findings indicate the benefits of supplementary feeding and strategic drenching both to ewes and to their lambs.

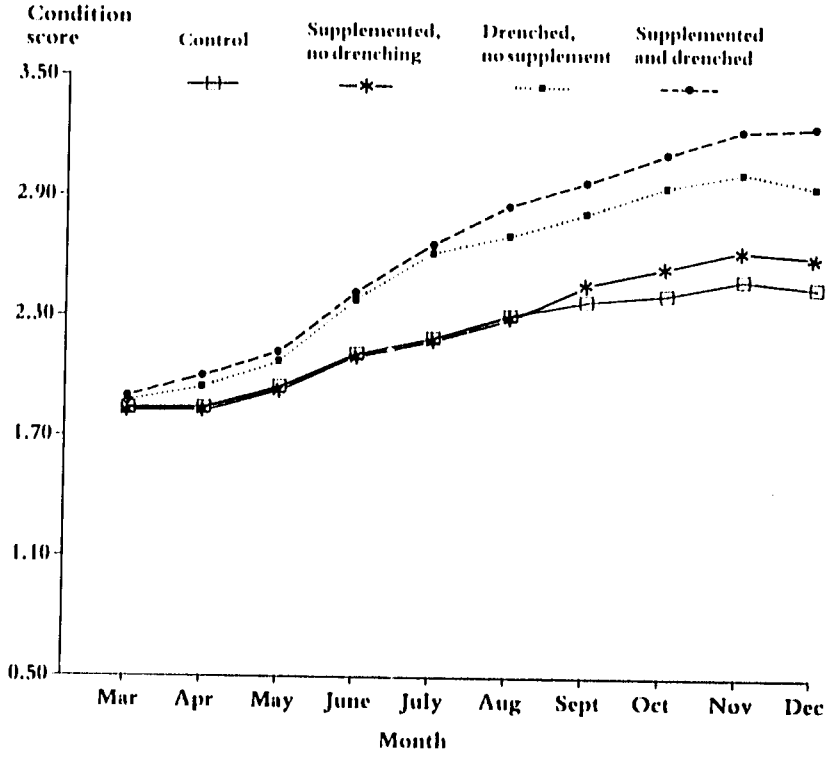


Figure 10.
Effect of dietary supplementation and endoparasite control on condition score of Menz-type ewes, Debre Birhan, 1988

Effect of dietary supplementation and control of endoparasites on Menz ram lambs

The biological and economic efficiencies of sheep production are affected by prenatal reproductive losses in ewes, perinatal and postnatal lamb death and late puberty of lambs. Late puberty reduces the animal's lifetime productivity. The factors that delay puberty must be understood so that management interventions can be designed to overcome them. A study was started in August 1988 at ILCA's Debre Birhan research station to assess the influence of nutrition and control of endoparasites on pubertal development of Ethiopian Menz sheep and to outline a methodology for use in similar studies elsewhere in Africa.

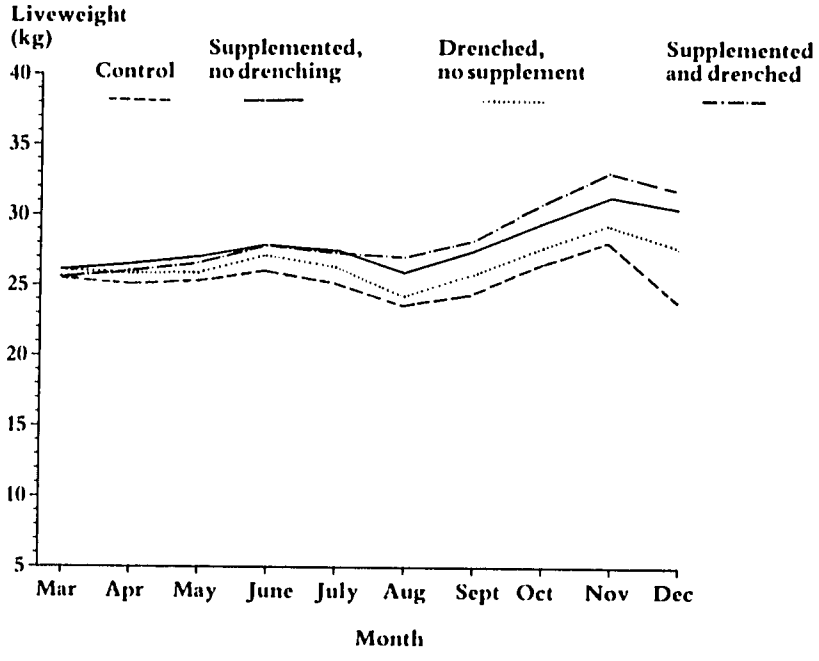


Figure 11.
Effect of dietary supplementation and endoparasite control on liveweight of Menz-type ewes, Debre Birhan, 1988.

A total of 117 Menz-type ram lambs aged 3 to 6 months were allocated at random to four treatment groups:

I: Unsupplemented control (28 lambs)
II: Supplement providing 25% of estimated crude protein (CP) requirement (31 lambs)
III: Supplement providing 50% of estimated CP requirement (27 lambs)
IV: Supplement providing 100% of estimated CP requirement (31 lambs)

Supplementary feed was given until the animals attained puberty. The supplementary feed consisted of maize bran (66%), noug *(Guizotia abyssinica)* cake (33%) and limestone (1%), and contained 22.4% crude protein. Water and mineral licks were available *ad libitum*. Roughly half of the animals in each group were drenched against endoparasites.

The animals were weighed, and their condition score, wither height and scrotal circumference were measured, every 2 weeks. Blood samples were taken at the same time and the packed cell volume (PCV) measured. Faecal samples were taken monthly and the number of parasite eggs counted to provide a measure of endoparasite load. Semen samples were taken monthly and the number of spermatozoa determined. The onset of puberty was defined as the date on which the number of spermatozoa rose above 5 million per ejaculation, with an individual motility of 10%.

By the end of 1988, 46% of the lambs (n = 54) had attained puberty at an average age of 308.3 ± 53.3 days (range 151 to 375 days) and mean body weight of 20.4 ± 3.7 kg (range 15 to 31 kg) (Table 37). Supplementary feeding significantly ($P<0.05$) increased body weight and condition score at puberty (Table 37); drenching against endoparasites had no significant ($P>0.05$) effect on these traits. None of the other traits was affected by either factor.

Table 37. *Effect of feeding regime on mean age, weight, condition score and morphological characteristics of Menz ram lambs at puberty, Ethiopian highlands, 1988.*

Trait	Treatment[1]				
	I	II	III	IV	Mean
Number	8	16	19	11	54
Age	318.0	295.1	315.9	307.3	308.3
	(40.8)	(73.2)	(45.0)	(41.6)	(53.3)
Body weight	16.8a	19.7b	20.9b	23.3c	20.4
	(0.9)	(4.1)	(3.3)	(2.1)	(3.7)
Body condition score	2.0a	2.8b	3.0b	3.2b	2.8
	(0.5)	(0.4)	(0.4)	(1.1)	(0.7)
Heart girth	62.1	64.9	65.2	61.7	63.9
	(2.1)	(4.7)	(3.7)	(20.6)	(9.6)
Wither height	54.2	57.1	57.5	53.2	56.0
	(3.1)	(2.4)	(4.1)	(17.8)	(8.4)
Scrotal circumference	19.8	21.8	22.4	21.7	21.7
	(1.3)	(2.0)	(2.2)	(7.3)	(3.7)

Within rows, means followed by the same letter do not differ significantly ($P>0.05$). Numbers in brackets are standard deviations.

[1] Treatments are described in the text.

Supplementary feeding did not have an apparent effect on semen volume or sperm concentration. The average ejaculate at puberty contained 46 million sperm cells per ml, with mean mass motility and individual motility rates of 2.7 ± 1.2 and 32.2 ± 16.8%.

Four lambs died in Treatment I up to puberty and one lamb died in Treatment II. None have died in the other treatment groups. Three of the four lambs that died in Treatment I had not been treated for endoparasites. The lamb that died in Treatment II died of bloat.

These preliminary results indicate that supplementary feeding does not affect age at puberty of Menz ram lambs, but increases their liveweight and condition score at puberty. It does not, however, appear to affect semen quality. The pattern of mortality observed so far suggests that supplementary feeding and control of endoparasites reduce postweaning mortality in ram lambs. The results will be analysed in more detail when the trial is completed in 1989.

Management systems

Quantification of constraints on highland sheep production

Surveys of traditional production systems in the Ethiopian highlands indicate that the productivity of sheep is low. The reasons for this are not well known. This project is aimed at identifying and quantifying factors that limit the productivity of sheep in these systems as the basis for developing interventions.

Starting in March 1988 more than 2000 Menz-type sheep in 80 flocks in the Debre Birhan area were monitored every 2 weeks. Data were collected on liveweight of the animals, births, purchases, sales, consumption and number and causes of deaths. Preliminary results are presented below.

Males weighed an average of 27.9 kg, compared with 23.0 kg for females. Young sheep weighed an average of 5.3 kg at 30 days old and 12.8 kg at 180 days old. Animals were lightest in August, during the peak of the rainy season; at this time flock owners reduced the amount of time the animals were allowed to graze to avoid losses due to bloat and accidents, e.g. during storms.

Mortality accounted for 38% of all exits of young stock and 43% of exits of adults. Slightly more than one third of the sheep deaths were caused by diseases and drought-related severe malnutrition (Table 38). The largest number of deaths due to disease occurred in September; the main cause was pasteurellosis. The largest number of drought-related deaths occurred in April. Deaths caused by predators and accidents were mainly among young animals.

Table 38. *Causes of sheep deaths, Ethiopian highlands, March–September 1988.*

Cause of death	March		April		May		June		July		Aug		Sept		Overall	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Disease + drought	7	15.9	32	49.2	19	33.3	6	12.5	16	32.6	18	41.9	59	57.3	157	38.4
Predator + accident	28	63.6	19	29.2	17	29.8	22	45.8	22	44.9	9	20.9	9	8.7	126	30.8
Unknown	9	20.5	14	21.5	21	36.8	20	41.7	11	22.5	16	37.2	35	34.0	126	30.8
All	44		65		57		48		49		43		103		409	

Between March and September 1988 a total of 703 animals joined the flocks and 1062 left the flocks. Thus the number of animals in the flocks fell.

Data collection will continue through March 1989 to complete a full year cycle. Other studies are also being conducted on these sheep, and combining the results of these will increase the scope and value of the information obtained.

Causes of differences in productivity between flocks of small ruminants in central Mali

ILCA's studies of traditionally managed small ruminants in central Mali have shown large differences in productivity between flocks within production systems. Studies were conducted in 1988 to identify management and socio-economic factors that cause these differences in productivity. Data were collected on some 1500 small ruminants in 65 flocks at four sites around Niono, central Mali.

Preliminary analyses of the results indicate that differences in productivity between flocks are greater in the millet subsystem than in the rice subsystem. The results for the millet subsystem are summarised in Table 39. Factors that appear to have a large effect on productivity include:

- the use of the children aged between 5 and 15 years to manage goat flocks;
- supplementary feeding; and
- animal housing.

The effects of other factors, such as quality of pastures grazed, use of health care and breed of animal kept, are still being assessed.

Table 39. *Productivity indices[1] of sheep and goats in the millet system of central Mali, 1988.*

Characteristic	Goats		Sheep	
	n	Index	n	Index
Household size (No. of people)				
Small (av = 9)	140	681.2a	50	643.7a
Medium (av = 22)	97	749.1b	81	799.0b
Large (av = 34)	53	522.0c	33	916.1b
Number of children[2]				
Few (av = 5)	214	537.0a	116	790.7a
Many (av = 11)	76	764.0b	48	781.8a
Wealth (TLU)[3]				
Poor (av = 4)	115	633.3ab	47	1151.0a
Average (av = 8)	68	646.5ab	50	876.9b
Rich (av = 24)	69	712.9a	38	722.6b
Very rich (av = 62)	38	610.4b	29	393.8c
Type of anim housing				
Enclosed yard	5	799.3a	35	858.8a
Tethered outdoors	285	632.6b	129	686.5b
Supplementary feed				
Yes	83	799.1a	16	898.9a
No	207	632.8b	148	646.3b

[1] Productivity index = g of lamb per kg of breeding ewe per year.

[2] Children aged between 5 and 15 years.

[3] Wealth was assessed on the number of tropical livestock units (TLU) owned per household. One TLU is equivalent to 250 kg liveweight.

Within parameters and species, indices followed by the same letter do not differ significantly ($P>0.05$, Newman Keuls test).

Investigation on multipurpose use of Karakul sheep in Botswana

A study was completed in 1988 of the productive potential of Botswana Karakul sheep and sheep production in that country. The study was conducted jointly by ILCA, the Ministry of Agriculture and the Animal Production Research Unit in Botswana and the University of Gottingen, Federal Republic of Germany.

Sheep in Botswana are generally raised extensively on communal land by smallholders. Most herds are composed of Karakuls, Namaqua Africanders, Blackhead Persians, Dorpers, and crosses among these breeds. Karakul sheep and their crosses are kept primarily for their pelts. The other breeds are kept mainly for mutton.

From 1986 through 1988 data were collected on reproductive performance, growth and pelt production. An initial survey conducted between May and July 1986 covered 52 smallholder farms that kept a total of more than 13 000 sheep. Thirty-three of these farms keeping a total of 9846 sheep were surveyed monthly for 14 months between July 1986 and September 1987. Pelt production and quality characteristics were estimated from results of

pelt auctions. Data were collected on 15 000 pelts taken from 83 Karakul flocks.

Karakul sheep did not differ in ewe postpartum liveweight or lamb growth to 6 months old from Karakul crosses and mutton breeds (Table 40). Ewes lambed on average 1.4 times a year; lambing frequency did not differ significantly ($P>0.05$) between sheep types. Only 1% of lambings produced twins.

Table 40. *Least-squares means for postpartum ewe weight and liveweight of 4- and 6-month-old lambs of Karakul, Karakul-cross and mutton sheep in Botswana.*

	Postpartum ewe liveweight (kg)			Lamb liveweight at 4 months old			Lamb liveweight at 6 months old		
	n	Mean	SE	n	Mean	SE	n	Mean	SE
Breed									
Karakul	1585	41.0	0.6	680	22.9	0.6	343	28.2	0.8
Karakul crosses	497	40.8	0.6	260	22.9	0.6	132	28.6	0.8
Mutton sheep[1]	470	40.6	0.6	123	22.3	0.7	58	29.1	0.9
Season of birth									
Sept–Nov	605	38.3	0.6	309	23.2	0.6	295	32.2	0.7
Dec–Feb	194	41.4	0.6	125	24.8	0.7	113	28.6	0.7
Mar–May	887	42.0	0.6	542	22.1	0.6	125	25.1	0.8
June–Aug	886	41.5	0.6	87	20.7	0.8	–	–	–

[1] Namaqua Africander, Blackhead Persian, Dorper and crosses.

Season of birth had a significant effect on the weight of lambs at both 4 and 6 months old (Table 40). Lambs born in September through November, before the rainy season, weighed 7.1 kg (28%) more at 6 months old than lambs born in March through June, during the dry season.

Karakul ewes produced an average of 27.7 kg of lamb per year, 0.67 kg of lamb/kg liveweight (LW) per year and 1.71 kg of lamb/kg $LW^{0.75}$ per year.

Forty-three per cent of Karakul lambs were pelted within a day after birth. Farmers produced an average of 74 pelts a year, representing a pelting rate of 35%. Ewes whose lambs were taken for their pelts had shorter subsequent lambing intervals, gained significantly more weight after parturition and had heavier subsequent lambs than ewes whose lambs remained with them.

Pelts from Botswana were inferior to the Swakara average in all important traits; they sold for 12 to 40% less than the Swakara average for their colour categories (Table 41). The prices paid for Botswana pelts were low because the pelts were too small and of poor quality.

At current prices it is more profitable for farmers with Karakul sheep to produce pelts than to produce mutton (Table 42). The price of pelts would have to fall by 40% and at the same time the price of lambs would have to increase by 40% before meat production would become more profitable than pelt production. Pelt production also has other advantages: the nutrient requirement of the flock is lower than that of a flock kept for meat production, the risk of losses is lower, and pelting reduces subsequent lambing intervals, increasing the number of lambs produced each year.

Table 41. *Price and percentage by colour of Swakara and Botswana Karakul pelts offered for sale in auctions in London, UK, between July 1985 and November 1987.*

Pelt colour	Swakara[1]		Botswana[2]	
	Price (£)	Per cent on offer	Price (£)	Per cent on offer
Black	11.40a	69.3	10.00a	73.9
Grey	10.48b	26.2	8.41b	22.6
Brown	7.04cd	1.4	4.25c	1.1
White	8.97c	2.4	5.61d	1.5
Spotted	5.65d	0.2	5.65d	0.9

[1] Total of 2 832 035 pelts.

[2] Total of 15 793 pelts.

Table 42. *Relative advantage of pelt production over meat production (= 1.00) with consideration of prices and ewe stocking rate (100 ewes kept for pelt production = 65 ewes kept for meat production).*

Pelt price[2]	Price for lambs[1]		
	Current (P24.34)[3]	+20% (P32.21)	+40% (P40.08)
−40% (P18.60)	1.48	1.11	0.89
−20% (P24.80)	1.95	1.48	1.18
Current (P31.03)	2.45	1.85	1.49
+20% (P37.20)	2.94	2.21	1.78
+40% (P43.40)	3.43	2.58	2.08

[1] Ex-farm price minus transport charges.

[2] Ex-farm price minus marketing costs.

[3] P = Pula (£1 = P3.02)

Livestock in plantation systems

In Africa there are 31 000 km^2 of oil-palm plantations, 4000 km^2 of coconut plantations and 2000 km^2 of rubber plantations. In several countries there is renewed interest in planting and rehabilitating rubber and oil-palm plantations. ILCA's humid zone research team conducted a preliminary study in 1988 to assess past and present research on livestock in plantation systems and determine the future role, if any, for ILCA in this field.

Literature on livestock in plantation systems was reviewed, and visits were made to Nigeria, Ghana, Côte d'Ivoire and Liberia. These activities showed that animals have commonly been grazed or tethered in plantations

but there has been no planned or systematic integration of livestock and tree crops in the smallholder sector.

Research has shown that grazing must be controlled to ensure sustained forage production, prevent weed encroachment and control internal and external parasites in animals grazing under tree crops. Grasses remain productive for 6 to 8 years under trees planted at spacings conventionally used in plantations; the tree canopy then closes and shades out the grass. However, smallholders generally plant their trees more widely spaced than in plantation systems and grow food crops under them. It seems unlikely that smallholders will plant pastures under their trees, since they give greater priority to crop production than to livestock, but they may find cut-and-carry forage production acceptable.

In the long term, the economics of spacing tree crops more widely to allow more light to reach the understorey and facilitate production of forage for livestock should be investigated. In the medium term, a search should be made for shade-tolerant grasses and legumes for use under existing tree densities, and ways to integrate them into smallholder farming systems should be investigated.

Networks and training

Information exchange — Newsletter

Three issues of the Small Ruminant Network Newsletter were produced in both French and English in 1988. There are now more than 1250 network correspondents, mostly from 48 African countries. Approximately 28% of the correspondents are francophone, which is about the same proportion as that of francophone people in Africa.

The Newsletter continues to be an important and valued means of two-way communication between the Network and its collaborators, as is evident from the constantly increasing mailing list (Figure 12). An extremely encouraging aspect of the Newsletter in 1988 was the contributions of the partners and their willingness to share the results of their research with all participants.

Alley farming network

The participants at a workshop on alley farming, held in Ibadan, Nigeria, in 1986, recommended that a research network be established. A steering committee with members from 8 countries, on which ILCA was represented, was formed and a proposal sent to donors for funding. Funds were committed to the network in 1988 by the Canadian International Development Agency, the International Fund for Agricultural Development and the Danish International Development Agency, and a fulltime coordinator was appointed. The network's steering committee met in September and discussed research proposals prepared by national groups.

Training

A 2-week course entitled "Small Ruminant Production Techniques" is currently held in alternate years in French and English. The second annual course (first in English) was held in Addis Ababa in May 1988.

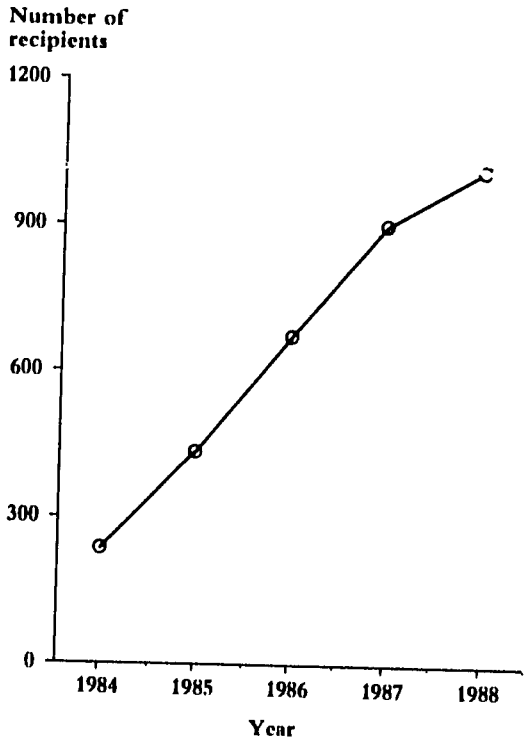


Figure 12.
Number of recipients of the Small Ruminant Network Newsletter, 1984–88.

Ogaden blackhead sheep grazing in the Jerer valley, Ethiopia.

THRUST STAFF

K Peters, *Thrust Coordinator*
A N Atta-Krah, *Agronomist*
C desBordes, *Animal Scientist*
R. Brokken, *Economist*
P A Francis, *Agro-economist (until May 1988)*
K-D Gautsch, *Animal Scientist*
Getachew Asamenew, *Agricultural Economist*
O B Kasali, *Veterinarian/Pathologist*
R von Kaufmann, *Agricultural Economist*
S Maiga, *Veterinarian*
C Martins, *Graduate Associate (until February 1988)*
E Mukasa-Mugerwa, *Animal Scientist*
Negussie Akalework, *Station Coordinator (Debre Birhan)/Project Supervisor*
P Ngategize, *Economist (Post-doctoral Associate) (from July 1988)*
B C Njau, *Veterinarian (Post-doctoral Associate) (until June 1988)*
J D Reed, *Animal Nutritionist*
L Reynolds, *Animal Scientist*
S Soumare, *Sociologist*
G Tarawali, *Agronomist*
Tekelye Bekele, *Veterinarian*
A Traoré, *Veterinarian*
P Viviani, *FAO Associate Expert*
R T Wilson, *Animal Scientist*
Zere Ezaz, *Graduate Associate*

Animal Traction Thrust

Although estimated to be the second most valuable output of livestock in sub-Saharan Africa, only 10 to 15% of farmers use animal traction at present. Most draught animals are found in the semi-arid and highland zones, where they are used primarily for ploughing and threshing. However, in addition to providing energy to power farm operations (primary input function) draught animals also fulfil an important output function by providing meat, milk (in the case of cows), hides, manure and income. They are thus a valuable asset enhancing the productivity and stability of smallholder farming systems.

The outcome of past investments in animal traction has often been disappointing because crucial inputs have been lacking, technologies have been inefficient and animals have been inadequately fed. Given this experience, ILCA has identified research needs for two major areas:

- In the highlands and semi-arid zones, where animal traction is well established, there is a need to intensify and diversify the uses of draught animals in order to increase their contribution to the farm economy. Increasing the quantity and quality of feed for draught animals is a priority need particularly in the semi-arid zone.
- In the subhumid zone, where animal traction is as yet seldom used, there is a need to examine more closely the constraints preventing its adoption and to seek to overcome them by introducing draught animal technologies that combine all the necessary inputs which determine their use.

The main aim in both cases is to develop suitable low-cost technologies that enhance both the profitability and sustainability of African agriculture.

Intensified and diversified use of draught animals

ILCA's work under this theme is carried out under the Vertisol Management Project, a collaborative project that aims at developing and verifying improved Vertisol management techniques in smallholder mixed-farming systems in the Ethiopian highlands. Vertisols cover some 85 million hectares of land in sub-Saharan Africa. Crop production from this land could be increased through expanding the area cultivated annually and by intensifying cropping practices. This can best be achieved through the use of draught animal power for cultivation and land management, combined with improved use of soil nutrients and water.

The Vertisol Management Project's main objectives are to:

- increase production of food crops and crop residues to levels in line with the potential of these soils;
- increase the efficiency with which animal power is used; and
- increase offtake of livestock.

The project involves three international centres (ILCA, the International Crops Research Institute for the Semi-Arid Tropics, India, and the International Board on Soil Research and Management, Thailand), and five Ethiopian Government agencies in the research and development sectors (the Institute of Agricultural Research, Alemaya University of Agriculture, the Ministry of Agriculture, Addis Ababa University and the Relief and Rehabilitation Commission).

Monitoring work oxen

Yearly condition profiles of work animals can indicate periods during which the animals are under stress due to work, poor feeding, disease or combinations of these and other factors. These profiles can thus be used to identify aspects of the system that need to be modified to increase animal performance.

Condition profiles for animals in 1988 at three Vertisol project sites are shown in Figure 13. Changes in the animals' condition followed closely the seasonal pattern of rainfall, and hence feed availability, at the sites. Work stress also contributed to a pronounced decline in animal condition for a brief period at the beginning of the growing season. The animals started to recover body condition when cultivation had been completed and as availability of forage on natural grazing areas increased after the beginning of the rains.

Characterisation, nutrient management and water-use studies in legume-based cropping systems on Vertisols

Waterlogging and shortages of plant-available nitrogen (N) and phosphorus (P) are the main constraints to plant production on Vertisols in the Ethiopian

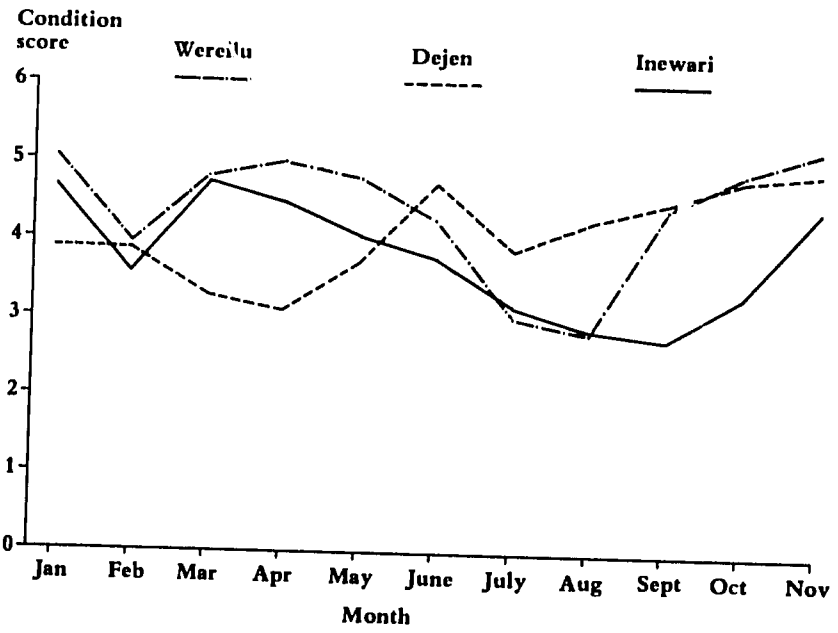


Figure 13.
Condition score of work oxen at three sites in the Ethiopian highlands, 1988.

highlands. Plant production on these soils could be increased by improving surface drainage; growing plant species or cultivars that are tolerant of waterlogging; growing legumes as part of the crop rotation, as intercrops or undersown; and using cheaper sources of nutrients, such as rock phosphate.

Mineral nutrition of legumes

Triple superphosphate (TSP) and Egyptian rock phosphate (ERP) applied to clover at various rates in 1984 significantly ($P<0.05$) increased cumulative dry-matter yield over 5 years. Dry matter production showed a linear increase with increased rates of TSP applied ($y = 3073 + 187\ P$; $R^2 = 0.80$), and a quadratic increase with increased rates of ERP applied ($y = 3191 + 317\ P - 3.3\ P^2$; $R^2 = 0.89$).

The effect of ERP from two sources (ILCA and Ministry of Agriculture) on clover grown on a Vertisol at Shola, Ethiopia, was examined in the 1988 cropping season. Application of either at 60 kg P/ha significantly increased dry-matter yield as compared with the control but there was no significant difference between the two sources. A similar trend was observed on cumulative dry-matter yield over the 1986–88 cropping seasons; ERP provided to ILCA resulted in 1.3 t/ha more dry matter of clover than the ERP supplied to the Ministry of Agriculture (Figure 14).

The efficiency of unacidulated and partially acidulated rock phosphates was compared with that of TSP when applied on *Trifolium quartinianum* (ILCA 6301) on a Vertisol at ILCA's headquarters site (Figure 15). Application of TSP at all rates significantly increased dry-matter yield relative to the control (1273 kg/ha). Clover dry-matter yield showed a quadratic response to TSP ($y = 1540 + 209\ P - 1.8\ P^2$; $R^2 = 0.81$). Applying 50% acidulated rock phosphate (50% ARP) significantly increased dry-matter yield relative to the control at all rates of application; dry-matter yield in-

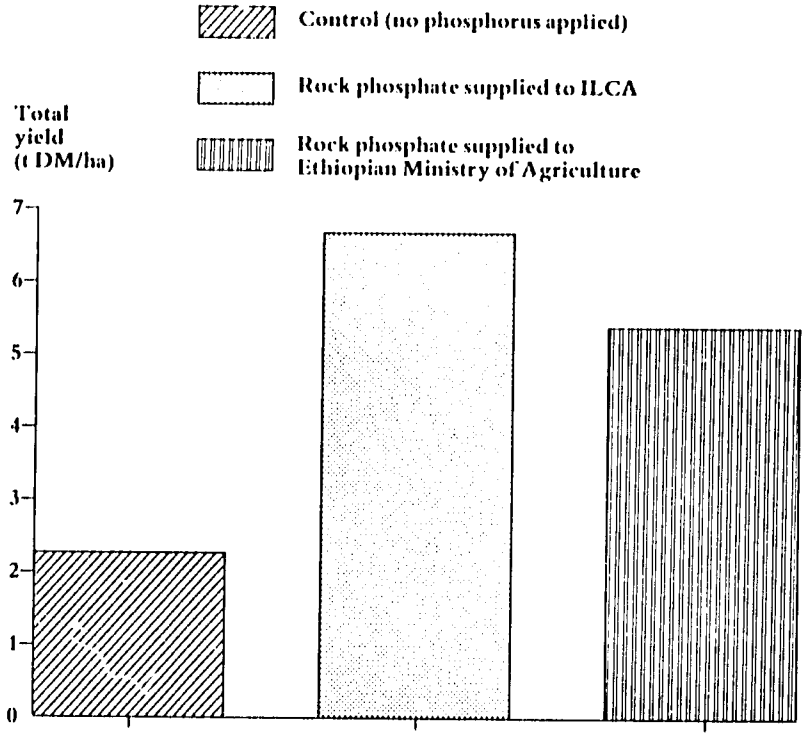


Figure 14. *Cumulative effect of applying Egyptian rock phosphate from two sources on dry-matter yield of clover grown on a Vertisol, Shola, Ethiopia, 1986–88.*

creased linearly with increased rates of 50% ARP applied (y = 1783 + 70 P; R^2 = 0.89). Applying 25% acidulated rock phosphate (25% ARP) also significantly increased dry-matter yield relative to the control, except at 20 kg P/ha. Dry-matter yield showed a linear increase with increased rates of 25% ARP application (y = 1577 + 44 P; R^2 = 0.77). Applying untreated rock phosphate did not have a significant effect on clover yield, indicating the non-reactivity of this P source (Figure 15).

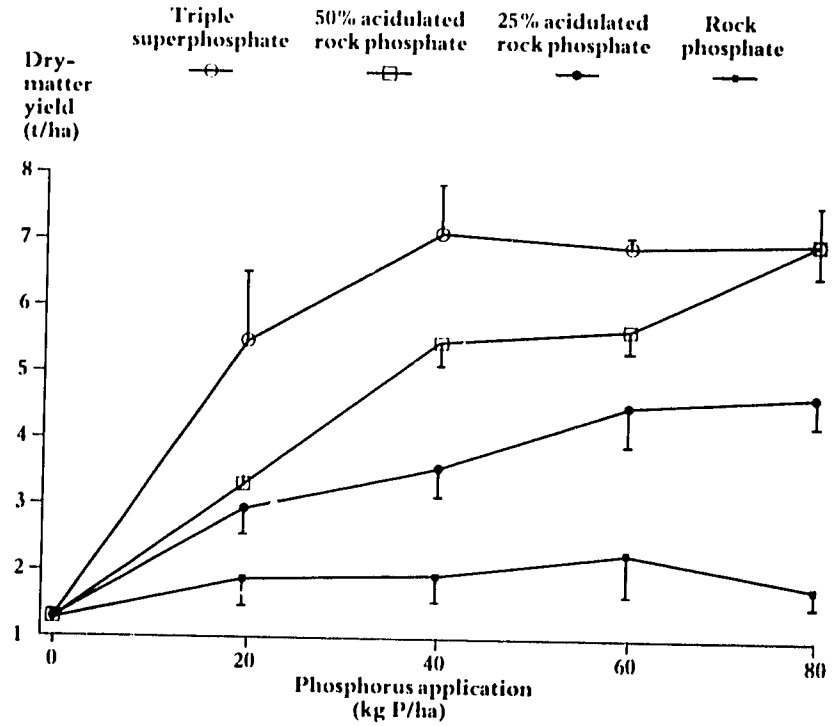


Figure 15.
Effect of triple superphosphate, unacidulated and partially acidulated rock phosphates on dry-matter yield of clover grown on a Vertisol, Shola, Ethiopia, 1988.

Biological nitrogen fixation and its effect on cereals

An experiment was conducted in 1988 to determine the amount of nitrogen fixed by eight accessions of five *Trifolium* species. Nitrogen fixation was estimated using the ^{15}N technique. The experiment included two accessions each of *T. decorum* (ILCA 6264 and ILCA 9447), *T. quartinianum* (ILCA 6301 and ILCA 9379) and *T. steudneri* (ILCA 9720 and ILCA 6253) and single accessions of *T. rueppellianum* (ILCA 6260) and *T. tembense* (ILCA 7102). Oats were used as the non-nodulating reference crop.

Both *T. decorum* accessions, one *T. quartinianum* accession (ILCA 6301) and the *T. rueppellianum* accession fixed significantly more nitrogen than either *T. steudneri* accession (Figure 16).

Cropping on drained Vertisols

Undersowing cereal crops with legumes can help maintain soil fertility, through the nitrogen fixed by the legume, and increases the feeding value of the crop residue. Trials were conducted at two medium-altitude sites in the Ethiopian highlands in 1988 to investigate the effects of undersowing wheat with clovers.

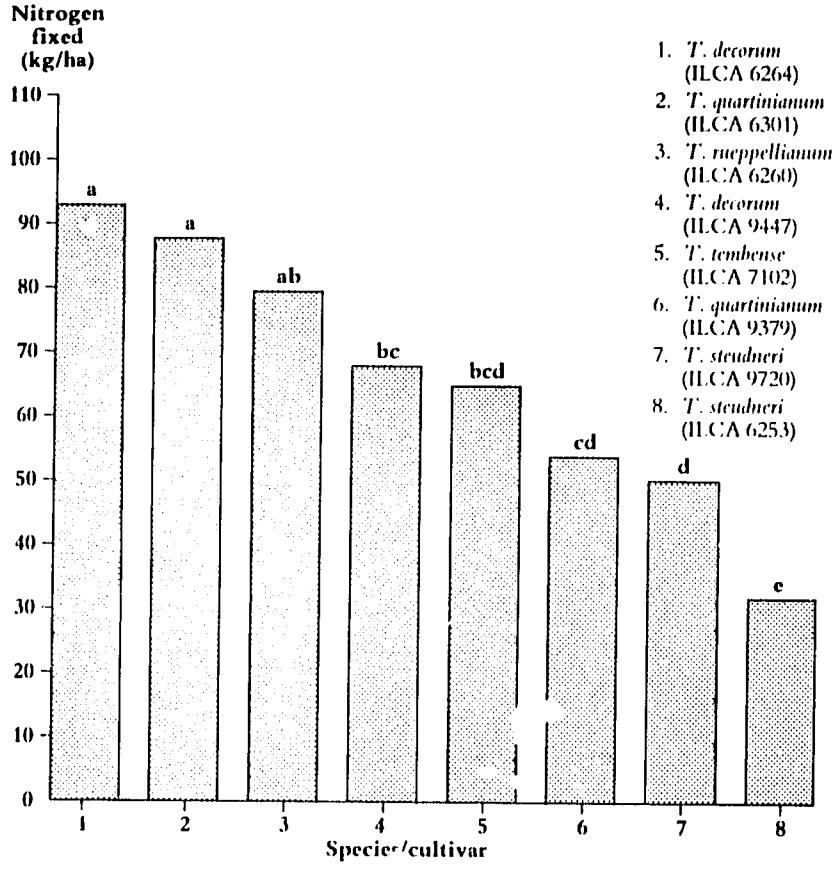


Figure 16. *Biological nitrogen fixation by various clover species/cultivars grown on a Vertisol, Shola, Ethiopia, 1988.*

Columns carrying the same letter do not differ significantly (P>0.05).

The trials used three improved wheat cultivars (Enkoy, Boohai and Gerardo) and two clovers (*Trifolium steudneri* and *T. rueppellianum*). The wheat was undersown with a mixture of the two clovers at a rate of 12 kg seed/ha.

Overall, undersowing with clover did not significantly reduce wheat grain and straw yields, but significantly increased feed production (Table 43). Further research is needed to assess the best time for sowing the legume and the long-term effects of such practices.

Improved wheat cultivars again gave higher yields of grain than local cultivars at both mid- and high-altitude sites (Tables 44 and 45). The yield advantage of the improved cultivars is related to their greater resistance to diseases, especially rust. Because of their disease resistance the improved cultivars could be planted early in the rainy season, whereas planting of the local cultivars had to be delayed until late in the rains to avoid the disease problem. The improved cultivars thus make fuller use of the potential growing season.

Vertisol management in the Ethiopian highlands—on-farm verification

Improved Vertisol management practices developed by the Vertisol project (see *ILCA Annual Report 1987*, pages 36 and 37) were tested extensively in 1988 in on-farm verification trials. These trials:

- prepare the ground for large-scale extension-oriented activities by generating on-farm data on technology performance and acceptability, and
- generate feedback into on-station research, which will fine-tune the performance and acceptability of the technology.

Table 43. *Overall mean yields of wheat grain and straw and clover straw in undersowing trials at Akaki and Ginchi mid-altitude sites, Ethiopia, 1988.*

Cropping	Wheat yield (kg/ha)		Clover yield (kg DM/ha)	Total feed yield (wheat straw + clover) (kg DM/ha)
	Grain	Straw		
Enkoy with clovers	1261	2874	1729	4603
Enkoy with no clovers	1409	3102	–	3102
Boohai with clovers	956	2397	2343	4740
Boohai with no clovers	985	2640	–	2640
Gerardo with clovers	979	2324	1989	4313
Gerardo with no clovers	1133	2657	–	2657
Mean with clovers	1065	2532	2020	4552
Mean without clovers	1176	2800	–	2800
LSD 0.05	NS	NS	–	390

Table 44. *Overall mean grain and straw yields of local and improved wheat cultivars on drained Vertisols at Wereilu, Bichena and Incwari high-altitude sites, Ethiopia, 1988.*

Wheat cultivar	Grain yield (kg/ha)	Straw yield (kg/ha)
Local check	956	2629
HAR 407	1177	2167
Enkoy	1268	2906
ET 13	1728	3256
LSD (0.05)	195	576

Table 45. *Overall mean grain and straw yields of local and improved wheat cultivars on drained Vertisols at Akaki, Ginchi and Debre Zeit mid-altitude sites, Ethiopia, 1988.*

Wheat cultivar	Grain yield (kg/ha)	Straw yield (kg/ha)
Local check	672	2962
Boohai	1074	3103
CIT 71/Candeal II	1422	3578
Gerardo	1433	3613
LSD (0.05)	651	1096

The animal-drawn broadbed maker developed by ILCA (see *ILCA Annual Report 1987*, pages 36 and 37) was again tested in 1988 against traditional land preparation practices. Traditional practices vary between the test locations in the Ethiopian highlands. At Dogolo farmers use ridges and furrows to improve surface drainage. Farmers at Inewari traditionally use broadbeds and furrows; the broadbeds are formed by hand after several passes with the *maresha* (traditional plough). At other sites farmers plant on flat seedbeds.

Crops were planted at the trial sites in the third week of June except at Inewari, where the late start of the rains delayed planting until the third week of July. Diammonium phosphate was applied at 100 kg/ha, as commonly recommended in Ethiopia. Plots at Dejen and Dogolo were topdressed with urea during the growing season at a rate of 50 kg/ha. Grain and straw yield were measured in the third week of October at Debre Zeit and in the third week of November at the other sites.

At Dogolo wheat grown on broadbeds yielded 60% more grain and 69% more straw than that grown on the traditional ridges (Table 46). At Inewari there was no significant difference in yields between plots prepared using the broadbed maker and those with broadbeds prepared by hand (Table 47). However, using the broadbed maker reduces the amount of labour needed to prepare the land and increases labour productivity. At Debre Zeit the land is naturally drained and the benefits of growing crops on

Table 46. *Grain and straw yields of wheat on traditional (ridge and furrow) seedbeds and broadbeds, Dogolo, Ethiopia, 1988.*

Seedbed preparation	Grain yield (kg/ha)	Straw yield (kg/ha)
Traditional	1266a	2210a
Broadbed and furrow	2027b	3725b

Within columns, means followed by the same letter do not differ significantly ($P > 0.001$).

Table 47. *Grain and straw yields of wheat on traditionally prepared seedbeds and broadbeds at Debre Zeit, Inewari and Dejen, Ethiopia, 1988.*

Site	Land preparation	Grain yield (kg/ha)	Straw yield (kg/ha)
Debre Zeit	Broadbed	1026	4814
	Traditional[1]	782	3299
	LSD (0.05)	384	1419
Inewari	Broadbed	1005	1595
	Traditional[2]	852	1416
	LSD (0.05)	353	751
Dejen	Broadbed	1094	2450
	Traditional[1]	633	1692
	LSD (0.05)	267	365

[1] Flat seedbed.

[2] Broadbeds made by hand.

broadbeds were generally less. Nevertheless, yields were higher on the broadbeds, although not significantly in the case of grain (Table 47). At Dejen, wheat grown on broadbeds yielded 73% more grain than that grown on flat seedbeds (Table 47).

Introduction of animal traction into new areas

Introducing draught animal power to the subhumid tropics and floodplain agriculture

Although both crop farmers and agropastoralists in the West African subhumid zone keep cattle they use very little draught animal power. Farmers cultivate and weed their land by hand.

Shortage of labour for land preparation, combined with a preference for cropping upland areas, limit the amount of *fadama*, or seasonally inundated valley, land that farmers cultivate. Using draught animals for cultivation would ease the labour shortage, increasing the area of land that farmers could crop each year.

ILCA is investigating ways to introduce the use of draught animal power in *fadama* cropping in the Nigerian subhumid zone. In 1988 studies were made of the importance of *fadama* land for dry-season grazing and five bulls and their handlers, including ILCA staff and representatives of the farming community, were trained for cultivation and hauling. This training took place first at the Rano Bull Training Centre of the Kano Agricultural and Rural Development Authority and then on site at the ILCA experimental plots in Kufana.

Cattle grazed in the *fadama* for as much as two hours a day in February, late in the dry season, and in May, at the beginning of the rains (Figure 17). The herbaceous cover of the *fadama* regenerates earlier with the first rains than does that on the uplands.

Much of the cultivation season at Kufana was spent retraining the animals and handlers trained at Kano because of differences in soils between the sites. Soils at Kano were sandy, whereas *fadama* soils are heavy clays and behave differently. This demonstrates the need to train animals and their handlers under conditions similar to those in which they will work. A crude comparison of work time suggested cultivating land with a pair of bulls took an eighth of the time needed to cultivate the land by hand. However, hand hoeing controlled weeds better than ploughing; farmers inverted the sods they hoed, covering weeds completely, whereas the plough did not fully turn the soil.

The productivity of *fadama* land could be increased if more of it were cropped and at a higher cropping intensity, e.g. through double cropping. Growing high-yielding rice varieties would increase household income and the large amounts of fodder these produce would compensate animals for the loss of *fadama* grazing due to intensified cultivation of the *fadama* land (see *ILCA Annual Report 1987*, pages 39 and 40).

The readiness of farmers to offer land for trial ploughing suggests that they are interested in using draught animal power. Many socio-economic and technical problems must, however, be resolved. These include the aptitude of farmers for working with animals and the attitude of their peers who do not want to work with animals, and the effects of different soil types and soil moisture contents on the amount of power needed to cultivate land. ILCA hopes to investigate some of these in collaboration with Ahmadu Bello University.

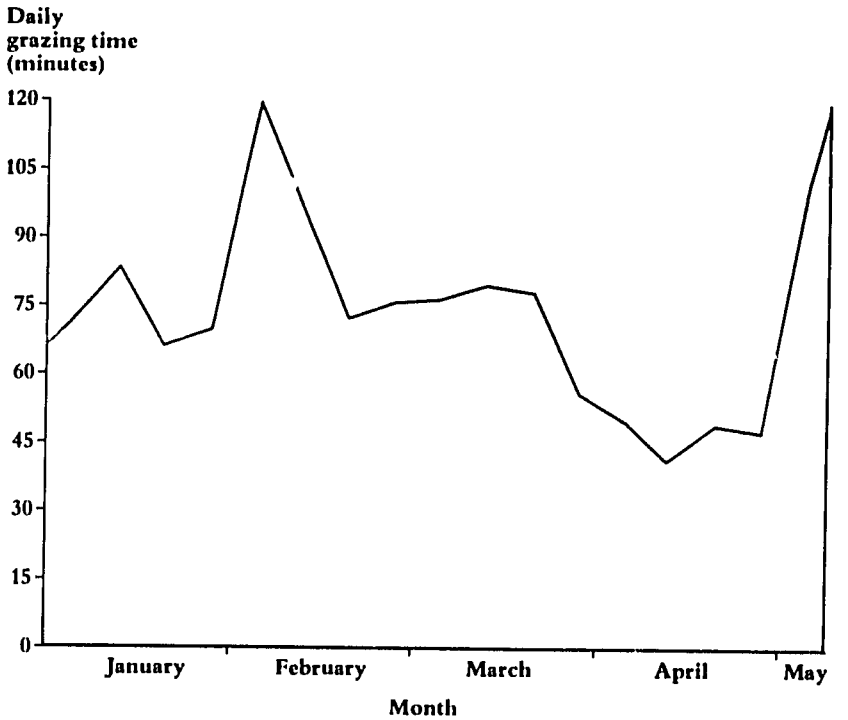


Figure 17.
Average time spent by cattle each day grazing Adama, Kufana, Nigerian subhumid zone, 1988.

Feeding strategies for draught animals

Effect of body weight and condition of oxen on their work capacity

Many farmers in Mali use animal traction to cultivate their land. However, they state that the generally poor condition of their oxen at the beginning of the cropping season limits the amount of work they can do and thus restricts cropping. Changes in the weight and condition of oxen in response to changes in feeding regime are well documented. However, the effect of supplementation on an animal's capacity for work, and hence on crop production, is not well defined. It is therefore difficult to determine appropriate or economic feeding practices for traction animals.

In an initial phase of a study intended to clarify feed supplementation requirements of oxen, a trial conducted in Mali in 1988 investigated the effects of liveweight and body condition on work output. The work was carried out in association with the Institut national de recherche zootechnique, forestière et hydrobiologique (INRZFH).

A trial compared the work performance of four groups of three oxen, representing all combinations of two levels of liveweight (310 and 360 kg) and two levels of body condition (M+ and L+ [1]). Animals were harnessed individually to sleds; these were loaded so as to require an average force of 374 Newtons when pulled around a flat earth circuit. The animals pulled the sleds for 10 km or until they showed signs of fatigue. Total work outputs and mean power outputs of the oxen are presented in Tables 48 and 49.

[1] Nicholson M J and Butterworth M H. 1986. *A guide to condition scoring of zebu cattle*. ILCA, Addis Ababa. 29 pp.

Table 48. *Mean daily work output (MJ) of oxen according to liveweight and condition score, Mali, 1988.*

Condition score	Liveweight (kg)		Mean
	310	360	
M+	0.95	3.49	2.22
L+	2.55	3.44	2.94
Mean	1.75	3.42	
SE liveweight	0.086 ***		
SE condition	0.086 ***		
SE interaction	0.135 ***		

*** = significant at P<0.001.

Table 49. *Mean power output (Watts) of working oxen according to liveweight and condition score, Mali, 1988.*

Condition score	Liveweight (kg)		Mean
	310	360	
M+	161	271	216
L+	241	279	260
Mean	201	275	
SE liveweight	14.5 **		
SE condition	14.5 NS		
SE interaction	20.5 NS		

** = significant at P<0.01.
NS = not significant.

Light animals had lower power outputs than heavy animals. However, the greatest effect of oxen liveweight was on daily work output, in which the limited duration of work of light animals in good condition was particularly evident.

Alternative sources of draught power

Economic analysis of animal traction innovations in highland Ethiopia

ILCA has, in the past, investigated the use of single oxen as draught animals for cultivation on smallholder farms in the Ethiopian highlands. It is cur-

rently looking at the use of cows for the same purpose. In 1988 a study was made of the economics of these interventions. The study was based mainly on data from a 1985/86 farm survey in the Debre Zeit area conducted by ILCA staff.

Gross margin analysis and linear programming models were used to quantify the economics of the two interventions and the traditional practice of using two oxen to pull the Ethiopian plough, the *maresha*, and to identify the best use of land and animals with each intervention. Results are presented for teff and wheat because these two crops occupy more than 70% of the total cultivated area of the farms under consideration.

For teff production, the single-ox technology had the highest gross margin per hectare and cow traction the highest labour productivity; traditional technology was second best in both categories (Table 50). In the case of wheat production, cow traction gave the highest returns to both land and labour (Table 50). Traditional and single-ox technologies ranked second in terms of labour and land productivity, respectively.

Table 50. *Gross margin analysis for teff and wheat production by technology.*

	Teff			Wheat		
	Traditional	Single ox	Cow traction	Traditional	Single ox	Cow traction
Value of production (birr/ha)						
Grain	794	849	767	938	1006	1348
Straw	147	159	142	162	178	212
Total	941	1008	909	1100	1184	1560
Variable costs (birr/ha)						
Seed	42	43	43	94	104	90
Fertilizer	42	26	45	21	0	71
Non-family labour	42	28	60	34	14	27
Total	126	97	148	149	118	188
Family labour (main-equivalent hours/ha)	341	409	303	406	681	246
Productivity						
Land (birr/ha)	815	911	761	951	1066	1372
Family labour (birr/hour)	2.4	2.2	2.5	2.3	1.6	5.6

Table 51 presents a summary of the results of the linear programming exercise for representative farms. In the optimum solutions of the various farm models, cow traction gave the highest net farm income and greatest land and labour productivity; the traditional technology was second best in each category. The optimal land-use strategy for the cow-traction model was to plant all arable land with teff and wheat; about 90% of the total acreage should be allocated to teff.

Table 51. *Optimal solutions obtained by linear programming for representative farms using traditional, single-ox and cow-traction technologies.*

Item	Optimal farm plans		
	Traditional	Single-ox	Cow traction
Net farm income (birr)	848.7	438.5	2535.0
Total arable land (ha)	2.55	2.55	2.55
Area cropped (ha)			
teff	0.68	0.68	2.28
wheat	1.66	0.27	0.27
faba beans	0.21	1.42	0.00
Area left fallow (ha)	0.00	0.18	0.00
Total labour use (man-equivalent hours)	1098.80	981.40	1881.00
Productivity			
land (birr/ha)	332.82	171.96	994.12
labour (birr per hour of family labour)	0.77	0.45	1.35

Settled Fulani ploughing their land using an animal-drawn Emcot ridging plough, northern Nigeria.

Under the assumptions of the model, the main constraints to the use of the traditional and single-ox systems were shortage of draught-animal time during the cultivation period and the amount of arable land available. The shortage of animal time was most acute in the case of the single-ox technology. This constraint can be avoided by using cows as draught animals; the amount of arable land available set the limit on farm income when using cow traction.

These results clearly indicate that, of the technologies tested, cow traction is the most efficient in terms of resource use and productivity and that further research on cow traction is warranted.

Collaborative animal traction research

Animal traction network

The first issue of the Animal Traction Research Network Newsletter was published in December 1988 and preparation of the second issue was started.

The Selected Bibliography on Animal Traction, published by ILCA in 1983, was updated and revised in 1988 in an annotated form. The bibliography is being entered on the CDS/ISIS database format, which can be used on IBM-compatible microcomputers. This will allow users, particularly African national programmes, to enter information as it becomes available. The bibliography will also be produced in book form.

THRUST STAFF

S Jutzi, *Thrust Coordinator*
Abate Tedla, *Forage Agronomist*
Abiye Astatke, *Agricultural Engineer*
P Bartholomew, *Forage Agronomist*
Getachew Asamenew, *Agricultural Economist*
M R Goe, *Animal Scientist*
I Haque, *Soil Scientist*
R von Kaufmann, *Agricultural Economist*
D A Little, *Animal Nutritionist*
M A Mohamed-Saleem, *Agronomist*
A Panin, *Economist (Post-doctoral Associate)*

Animal Feed Resources Thrust

Feed shortages during the dry season, and sometimes even the wet season, constrain livestock output in almost every production system of sub-Saharan Africa. Even where feed is plentiful it may be low in nutritive value, may provide an imbalanced diet lacking in critical elements, or may be inefficiently converted into protein and energy by the animal.

The Animal Feed Resources Thrust seeks to alleviate these constraints by providing adapted forage germplasm and suitable feed and feeding technologies to national agricultural research systems (NARS) and to ILCA/NARS commodity research programmes. These technologies combine forage legumes, fodder trees and agro-industrial byproducts with natural feed resources. The work of the thrust covers all zones except the arid. Special emphasis is given to the integration of legumes in mixed crop–livestock farming systems so as to achieve stable and sustainable feed and food production in sub-Saharan Africa.

Services and resource assessment

Agro-ecological modelling to assess suitability of land for improvement of fodder resources

The productivity of land is determined by soil, climate and applied inputs. In 1987 ILCA, in collaboration with FAO, used agro-ecological zoning methodology to estimate potential fodder production in several West African countries. Results were reported in *ILCA Annual Report 1987* (pages 44 and 45). In 1988 this study was extended to estimate the number of animals that this feed could support during the dry season.

The amount of fodder available from millet, sorghum, maize, rice and Verano stylo was estimated for Burkina Faso, Cameroon, Côte d'Ivoire, Gambia, Ghana, Liberia, Mali, Nigeria, Senegal and Togo. This information was then used to estimate the proportion of land suitable for each crop in each zone (humid, subhumid, semi-arid and arid) that was needed to support the livestock population of that zone (Table 52). These estimates were based on the assumptions that only part of the crop residue was edible (ranging from 8 to 55% of dry matter in the crops considered) and that 1.4 tonnes of dry matter were needed to support each tropical livestock unit (TLU)[1] for a 180-day dry season.

[1] 1 TLU = 250 kg liveweight.

Table 52. *Estimated percentages of land area suited to each crop in each zone needed to provide dry-season feed to support livestock populations in five West African countries.*

Country	Humid		Subhumid		Semi-arid		Arid	
	LI[1]	HI	LI	HI	LI	HI	LI	HI
	Suitable land area (%)							
Nigeria								
Livestock population (TLU)	1 510 000		2 284 000		7 403 000		227 000	
Millet		367	47	378	159	56	8	
Sorghum		90	17	326	70	66	16	
Maize	262	60	67	13	451	63	133	29
Rice	44	8	51	9	3856	944	142	35
Stylo	126	11	26	3	423	35	65	10
Cameroon								
Livestock population (TLU)	153 000		1 372 000		874 000		63 000	
Millet			383	27	83	16	142	23
Sorghum			58	8	46	7	164	13
Maize	2	1	32	6	48	7	425	18
Rice	2	1	60	10	894	222	709	177
Stylo	19	2	79	10	164	13	532	85
Ghana								
Livestock population (TLU)	610 000		406 000					
Millet			45	293				
Sorghum			15	80				
Maize	128	48	80	16				
Rice	28	5	38	8				
Stylo	70	7	24	3				
Côte d'Ivoire								
Livestock population (TLU)	214 000		476 000					
Millet			3,825	129				
Sorghum			242	30				
Maize	36	13	138	24				
Rice	7	1	67	11				
Stylo	14	2	29	4				
Mali								
Livestock population (TLU)			63 000		1 853 000		2 596 000	
Millet			50	9	378	34	478	64
Sorghum			15	4	135	27	596	120
Maize			13	3	121	24	1476	272
Rice			25	3	6514	1604	5841	1446
Stylo			5	1	118	12	724	111

[1] LI = low input; HI = high input.

In some countries there are clear imbalances between livestock populations and fodder availability in some zones (Table 52). For example, in Mali there is not enough fodder to support the large livestock populations in the semi-arid and arid zones, whereas in the subhumid zone the entire livestock population could be supported by growing stylo on only 5% of the land suitable to the crop, even with low inputs.

Feed supplies could be increased by intensifying agriculture but this would require mechanisation, improved seeds, agrochemicals, soil conservation, and food storage and delivery systems. This would be beyond the means of most African countries. An alternative would be to grow legumes such as Verano stylo; as well as providing high-quality feed for livestock, legumes help maintain and improve soil fertility and structure, which in turn helps increase yields of other crops.

Forage genetic resources

Forages are important feeds for animals in sub-Saharan Africa. Development of adapted forages relies upon the evaluation of and selection from a wide range of germplasm under the varied environmental zones and farming systems of the region.

ILCA's forage genebank collects, acquires, documents, maintains, characterises and distributes forage germplasm. The genebank offers its services to ILCA's programmes and to research and development workers in African national agricultural research systems (NARS).

In 1988, 581 accessions of grasses, legumes and browses were added to ILCA's genetic resources collection. The collection now comprises 9223 accessions covering 227 genera and 840 species. Notable acquisitions included 163 accessions of *Stylosanthes hamata* collected in Venezuela and Colombia in 1986 by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia, and 118 accessions of *Brachiaria* species collected in Zimbabwe by the Centro Internacional de Agricultura Tropical (CIAT), Colombia, in 1985.

Accessions from low- to mid-altitude, tropical to subtropical areas are regenerated at Zwai and Soddo, Ethiopia. Temperate and highland materials are multiplied at ILCA's headquarters site at Shola, on the outskirts of Addis Ababa. In 1988 a further 830 accessions were planted at Zwai, bringing the total number of accessions being multiplied to more than 2400. Two hundred accessions of temperate materials were planted at Shola. Many of these were grass accessions that were shown in 1987 to have low seed viability. Data are recorded on morphological and agronomic characters of plants in the regeneration plots.

The number of seed samples distributed increased from about 5000 in 1987 to 6191 in 1988. Some 237 requests for seed were received from organisations in 47 countries, mainly in sub-Saharan Africa. The proportion of the requests coming from African countries other than Ethiopia increased.

ILCA, in collaboration with the International Board for Plant Genetic Resources (IBPGR), is developing in vitro techniques for collecting, conserving, multiplying, establishing and disseminating selected grass and browse species that cannot be adequately managed using traditional methods which involve seeds. In vitro cultures of *Cynodon* and *Digitaria* grasses have been successfully initiated, multiplied and rooted. Slow-growth, low-temperature conservation techniques for these species have also been developed. A minimal facility method has been developed for transferring *Cynodon* and *Digitaria* cultures to soil, and a method for collecting these grasses is being tested in the field.

Feasibility studies were carried out with forage legumes. *Sesbania*, *Leucaena* and *Erythrina* species were successfully cultured in vitro from nodal cuttings. Numerous adventitious shoots were regenerated from embryo-derived cotyledons and hypocotyls, and multiple shoots were induced from embryo axes of *Sesbania sesban*. Adventitious shoots were also regenerated from cotyledons of *Acacia albida* and *A. tortilis*.

In vitro techniques were also used to help establish accessions that had few seeds or seed with low vigour. Seed was first germinated in vitro and later planted out in pots, thus avoiding wastage of limited seed stocks.

Characterisation of soils, nutrients and water, reviews and analytical service

Soils differ in their chemical, physical and mineralogical properties and hence their suitability for different forages and crops. Determining the soil characteristics at proposed research sites and relating these to known plant requirements can indicate whether sites are useful for screening certain plant groups.

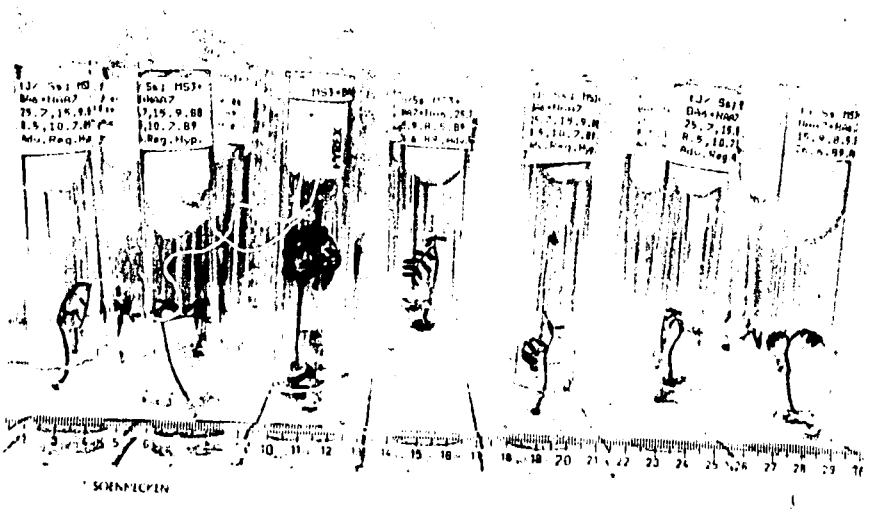
This subproject aims at determining the physico-chemical and mineralogical properties of various soil types and compiling results of previous research through literature searches as the basis for developing research strategies. Analytical service is also provided to ILCA field sites, forage networks and other ILCA units.

Characterisation of upland soils at ILCA research sites in Ethiopia

Soil profiles at 15 upland sites in the Ethiopian highlands were described in 1988. The physico-chemical properties of the soil were determined in ILCA's soils laboratory at headquarters. The main characteristics of some of the sites are outlined in Table 53.

State-of-the-art knowledge

A bibliography on micronutrients in soils, plants and livestock of sub-Saharan Africa was completed in 1988. The bibliography was compiled from



Sesbania sesban *plantlets growing in vitro.*

Table 53. *Characteristics of soils at seven ILCA research sites in Ethiopia.*

Soil property	Debre Birhan (0-20)[a]	Debre Zeit (0-20)	Guder (0-16)	Sidamo Range-land (0-19)	Sidamo Yabello (0-23)	Sidamo Dembel Wachu camp (0-22)	Zwai (0-22)
Total sand (%)	36.96	45.40	24.56	72.56	71.12	27.84	46.40
Silt (%)	35.44	27.28	23.28	8.56	12.56	32.56	26.00
Clay (%)	27.60	28.32	52.16	18.88	16.32	39.60	27.60
Bulk density (g/cm^3)	1.21	1.40	1.09	1.67	1.81	1.22	1.24
Moisture content (%)							
at 0.033 MPa	39.10	31.30	34.10	18.70	8.26	28.76	28.40
at 1.5 MPa	18.28	15.40	22.04	7.82	6.67	11.95	16.34
pH (H_2O 1:1)	5.95	6.83	6.36	6.80	6.39	7.08	8.12
pH (KCl 1:1)	4.25	5.31	5.13	5.84	5.49	5.77	6.72
Organic matter (%)	4.74	2.34	2.76	1.72	1.57	4.32	1.62
Total N (%)	0.27	0.10	0.11	0.06	0.06	0.16	0.07
Available P (Bray II) (mg/kg)	1.18	41.48	1.07	1.84	192.33	87.12	3.47
Exchangeable cations (meq/100 g of soil)							
Na	0.12	0.10	0.25	0.03	0.04	0.06	2.21
K	1.00	1.15	1.33	1.03	1.17	4.21	3.09
Ca	15.43	12.89	15.33	7.72	3.45	16.16	44.14
Mg	4.40	7.99	5.20	2.43	1.76	6.51	3.50

[a] Numbers in brackets are the soil depths (cm) tested at each site.

Commonwealth Agricultural Bureaux International (CABI) and AGRIS databases and documents in ILCA's library. It comprises 1206 references on various aspects of micronutrients. The bibliography is being used as the basis for reviews on copper, zinc, manganese, iron and boron in soil–plant–livestock systems of sub-Saharan Africa.

Analytical service

The soils service laboratory received 911 soil samples and 92 water samples from various ILCA programmes. A total of 7003 determinations were made on these samples. The soil and plant chemistry laboratory received 1958 soil samples, on which 5660 determinations were made. A total of 1436 plant samples were analysed for 5284 determinations. The soil physics laboratory received 1540 soil samples and made 1276 determinations.

Animal feed supplies in sub-Saharan Africa

Poor nutrition is probably the main constraint to livestock production in sub-Saharan Africa. National policies that affect animal nutrition are, therefore, important.

The objectives of this work are to:

- review macro data on feed supplies in sub-Saharan Africa;

- review response functions to feeds, using micro data;
- estimate such functions; and
- calculate economic returns to feedstuffs used for various purposes, especially as exports.

A study was made in 1988 of production, domestic feed use, and international trade in major agricultural byproducts in sub-Saharan Africa. The region produced a total of about 1.9 million tonnes of byproducts such as molasses, oilseed cake and fish meal, and exported 51% of them to developed countries for a total value of US$ 91 million a year between 1961 and 1984 (Table 54).

Table 54. *Average annual production, domestic consumption and exports of agricultural byproducts in sub-Saharan Africa, 1961–84*

Region	Production	Domestic livestock feed	Exports	Export value
	(thousands of tonnes)			(millions US$)
East Africa	617	303	295	22.9
West Africa	629	195	375	49.3
Central Africa	149	97	56	3.8
Southern Africa	485	173	233	14.9
Sub-Saharan Africa	1880	768	959	91.0

Source: Derived from "Agricultural supply/utilization accounts tape, 1985". FAO, Rome, 1987.

Production of byproducts increased steadily between 1961 and 1984 and this trend is likely to continue. Exports of byproducts have decreased since the 1970s, while domestic feed use of byproducts has increased steadily since 1961 (Figure 18).

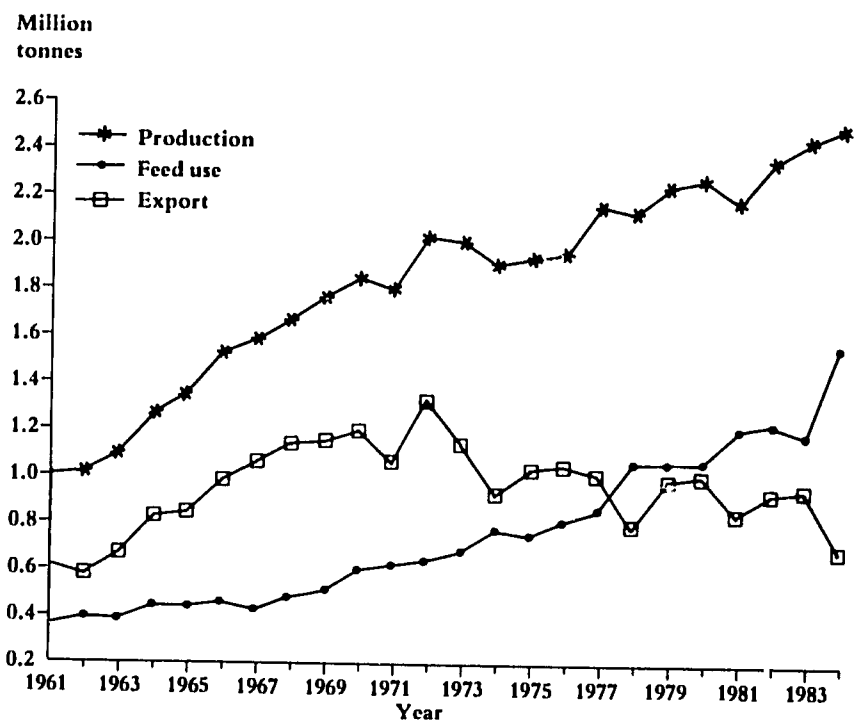


Figure 18. *Production, use as feed and export of agricultural byproducts in sub-Saharan Africa, 1961–84.*

Initial evaluation of feed resources

Initial evaluation of forage germplasm—mid-altitude, subtropical

The agronomic characteristics of forage germplasm are initially evaluated in unreplicated seed multiplication plots and evaluation plots. All accessions planted at Zwai (on basic soil) and Soddo (on acid soil) are examined 8 or 12 times a year. They are scored for 24 general parameters, including plot cover, new growth, height, spread, leafiness, flowering, seeding and pest and disease damage. Other parameters are recorded on specific collections where appropriate. Hand-held computers were used at Zwai in 1988 for collecting data in the field and this has considerably simplified data management.

In 1988 data were recorded on some 2900 seed multiplication plots at Zwai and Soddo. Promising germplasm has been selected from these materials. A severe attack of anthracnose in 1987–88 at Soddo allowed selection of *Stylosanthes* accessions for resistance to local strains of *Colletotrichum*, the fungus that causes the disease. All *Stylosanthes fruticosa* lines present were severely affected, while at least half of the *S. guianensis* lines showed good resistance or were unaffected.

Ninety-one additional lines of *S. guianensis* and the recently received collection of 163 lines of *S. hamata* from Venezuela and Colombia were established in evaluation plots at Soddo in 1988.

Between 1982 and 1987 ILCA also screened herbaceous and browse legumes at Abernossa Ranch, a semi-arid site in the Ethiopian Rift Valley. Initial evaluation data collected during this period were analysed in 1988. Of the 522 accessions screened the most productive were genotypes of *Vigna unguiculata*, *Lablab purpureus*, *Stylosanthes scabra* and *Desmodium distortum*. Productivity of the perennial herbaceous legumes and browses was generally very low due to the droughty nature of the soil and the lower-than-average rainfall during the period when the research was done.

Work at Soddo was expanded in 1988 to examine the fertilizer response of 25 promising legumes and the effect of regular clipping on the dry-matter (DM) yields of 20 selected *Stylosanthes guianensis* lines and three shrubby legumes. In the latter trial one accession, ILCA 11879, yielded 181 kg DM/ha at the end of the first growing season, 61% more than *S. guianensis* cv Cook, which was the control. Cook is the most promising herbaceous forage identified so far for the area. Six other lines gave yields similar to that of the control.

Initial evaluation of forage germplasm—humid zone

Screening of herbaceous forage legumes, which was started in 1987, continued in 1988. Legumes under evaluation include six lines of *Stylosanthes*, 10 lines of *Centrosema*, 8 lines of *Desmodium* and single lines of *Pueraria phaseoloides*, *Macroptilium atropurpureum*, *Calopogonium caeruleum*, *Desmanthus virgatus*, *Lablab purpureus*, *Cassia rotundifolia* and *Tephrosia bractiolata* (see *ILCA Annual Report 1987*, page 52).

Several lines died during 1988. These include *Tephrosia bractiolata*, *Desmodium canum*, *D. tortuosum*, *D. discolor*, *Centrosema pascuorum*, *C. schotii*, *C. plumieri* and *C. virginianum*. Lines that grew well and retained much of their leaf during the dry season included *Stylosanthes guianensis* cv

Graham, *Centrosema pubescens*, *C. macrocarpum*, *Macroptilium atropurpureum* and *Lablab purpureus*. *Centrosema macrocarpum* did not flower in the first year but flowered in 1988 in uncut stands. *Stylosanthes scabra* showed reasonable growth and dry-season leaf retention under continuous growth but low tolerance to pruning. Conversely, *Desmanthus virgatus* died in uncut stands but remains productive in plots that have been pruned.

Several lines, including *S. scabra* cv Seca, *S. guianensis*, cv Graham and *C. pubescens*, were selected in 1988 for productivity studies in which they will be grown in pure stand and mixed swards with selected grasses.

Initial evaluation of forage germplasm—subhumid zone

Adaptation of forage legumes

Forage legumes could help boost livestock production in West Africa but most forage legume interventions depend on one or very few species or cultivars. For example, fodder banks in subhumid Nigeria use only *Stylosanthes hamata* cv Verano. Alley farming relies on *Leucaena leucocephala* and *Gliricidia sepium*. ILCA is trying to increase the range of legumes available for use in such interventions by acquiring and evaluating forage legumes for introduction into West African farming systems in various ecological zones. The project is based at ILCA's subhumid zone research site, Kaduna, Nigeria, within easy reach of the semi-arid and humid zones.

The performance of forage legumes under various amounts of rainfall was assessed by growing various legume accessions at six sites in northern Nigeria; rainfall at these sites ranged from 453 mm at Maiduguri to 993 mm at Jos. *Stylosanthes hamata* cv Verano was used as a control at each site. The eight accessions for each site were selected from preliminary trials in 1986 and 1987 in which 47 accessions were planted at each site (*ILCA Annual Report 1986/87*).

Dry-matter yields were generally low at Maiduguri and Katsina in 1988 because of low and erratic rainfall which resulted in poor establishment and growth (Figure 19). Verano grew best at Bauchi; this was the only site at which Verano gave the highest yield. This experiment will continue in 1989 to investigate the regeneration ability of the accessions at each site.

In a separate trial, 49 legume accessions from ILCA's Addis Ababa genebank were evaluated for the first time in 1988. Among these, *Centrosema pascuorum* cv Cavalcade (ILCA 14972) and *Stylosanthes guianensis* (ILCA 15557) performed best.

Evaluating *Stylosanthes* accessions for anthracnose tolerance

Stylosanthes species are adapted to a range of climatic and edaphic conditions and have been widely used for forage improvement in West Africa. *Stylosanthes* fodder banks, used to provide high-quality feed to supplement natural forage in the dry season, are popular in Nigeria and are being spread to other West African countries. Unfortunately, *Stylosanthes* species are susceptible to the disease anthracnose, caused by the fungi *Colletotrichum gloeosporioides* and *C. dematium*.

In 1987, 17 *Stylosanthes guianensis* accessions from CIAT (Centro Internacional de Agricultura Tropical, Colombia), *S. guianensis* cv Cook and

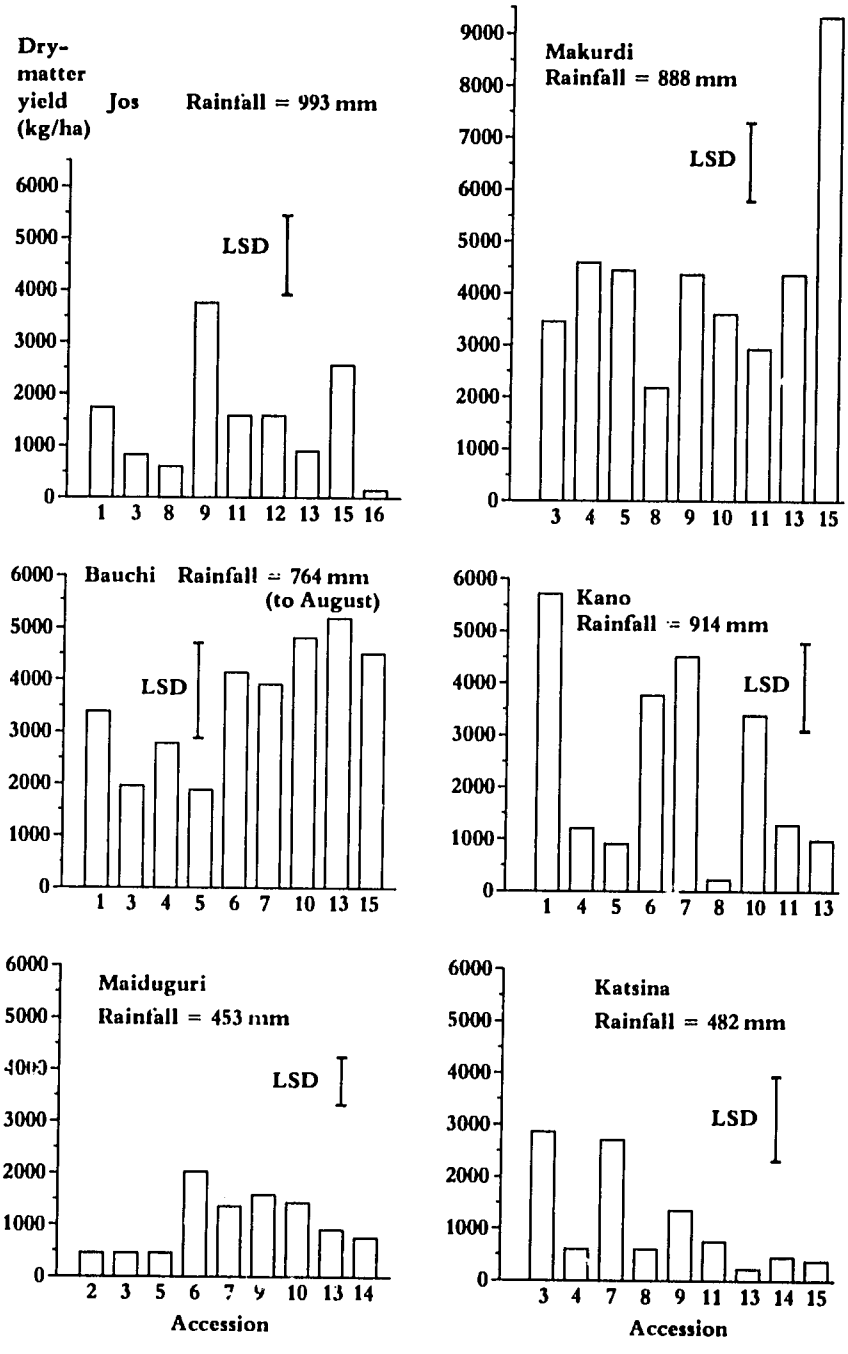


Figure 19.
Dry-matter yields at the end of the wet season of selected forage legume accessions at six sites in northern Nigeria (means of three replicates), 1988.

Key to accessions

1: *Cassia rotundifolia* ILCA 10915; 2: *C. rotundifolia* ILCA 10916; 3: *C. rotundifolia* ILCA 10918; 4: *Centrosema brasilianum* ILCA 6773; 5: *C. brasilianum* ILCA 9940; 6: *C. pascuorum* ILCA 9290; 7: *C. pascuorum* ILCA 9857; 8: *Clitoria ternatea* CSIRO 37195; 9: *Lablab purpureus* ILCA 147; 10: *L. purpureus* ILCA 11609; 11: *Macroptilium atropurpureum* ILCA 69, 12: *Macrotyloma axillare* ILCA 6756; 13: *Stylosanthes hamata* ILCA 75 (Verano); 14: *S. humilis* ILCA 7363; 15: *S. scabra* ILCA 441; 16: *Zornia latifolia* CIAT 728.

S. hamata cv Verano were screened for anthracnose tolerance at Kaduna in the Nigerian subhumid zone after being inoculated with extracts from diseased plants (see *ILCA Annual Report 1987*, pages 52–54). The 16 stylo lines that survived anthracnose attack were clipped to a height of 10 cm above ground level in April 1988 and thereafter every 8 weeks until November 1988. The plants were scored for anthracnose symptoms before each clipping.

The 19 *Stylosanthes* lines screened in 1987 were sown again in 1988 on an adjacent site. The plots were managed in the same way as in 1987 except that they were not inoculated with extracts from diseased plants. The plants were scored once for anthracnose attack before harvest in November 1988.

Plant samples from the trials were examined for pathogens at the Institute of Agricultural Research, Shika, Nigeria, and CIAT. Samples of *Stylosanthes* accessions from the 1987 regional forage screening trials, including *S. guianensis*, *S. hamata*, *S. capitata*, *S. humilis*, *S. scabra* and *S. macrocephala*, were also examined for pathogens at CIAT.

Colletotrichum fungi were isolated from all the *Stylosanthes* lines planted in 1988. However, only Cook showed symptoms of anthracnose. Several lines planted in 1988 were almost as productive as CIAT 184 and 136, the most productive lines under high disease challenge in the 1987 trial (Table 55), reflecting the low disease challenge in the 1988 trial.

Table 55. *Dry-matter yield (kg/ha) of 17* Stylosanthes guianensis *accessions, S. guianensis cv Cook and S. hamata cv Verano, Nigerian subhumid zone, 1987 and 1988.*

Accession/ cultivar	Regrowth on 1987 trial[1]	Yield in 1988 trial[2]
CIAT 11370	10356	6811
CIAT 11366	Died	7822
CIAT 11371	10278	5689
CIAT 11374	7360	6556
CIAT 11372	9280	7188
CIAT 11369	10110	7344
CIAT 11365	8239	6160
CIAT 136	11681	8210
CIAT 11375	8775	5422
CIAT 11364	Died	6056
CIAT 184	11761	9130
CIAT 11362	8700	7862
CIAT 11363	6256	6089
CIAT 11373	8689	7710
CIAT 11367	10894	8720
CIAT 11368	8034	6133
CIAT 11376	8350	6930
Cook	Died	4030
Verano	7668	6056

[1] Total of four cuts.

[2] Single cut at the end of the growing season in November.

Clipping every 8 weeks maintained a low leaf area index in stylo planted in 1987 but the cumulative dry-matter yields were higher than the single-cut yields of those planted in 1988

Throughout Nigeria *Colletotrichum dematium* was the major pathogen on stylos except Cook, on which *C. gloeosporioides* was found at all sites.

Although the stylos planted in 1987 had been exposed to high anthracnose challenge, cutting the plants every 8 weeks during the 1988 wet season prevented resurgence of the disease. Pathogenic specialisation on Cook stylo of *C. gloeosporioides*, which causes a more severe form of anthracnose than does *C. dematium*, suggests that continued use of Cook should be discouraged.

Growing stylos under varying levels of disease challenge and cutting frequencies has demonstrated differences in their tolerance to anthracnose and should allow development of mixtures of cultivars with different levels of tolerance. This could increase the productivity of stylo pastures by reducing the severity of disease episodes or slowing their progress in the pasture.

Soil fertility and water-use studies on forages

Many African upland soils are acidic and deficient in plant-available phosphorus. The fertility of acidic soils can be increased by applying lime to reduce their acidity or by applying phosphate fertilizer, or both. But these remedies have only a temporary effect and are generally beyond the reach of the African smallholder. Moreover, their effect is usually limited to the upper layers of the soil and does not reach the soil layers in which most forage and crop plants root.

The objectives of this sub-project are to:

- determine the phosphorus and lime requirements of various forages on upland soils;
- evaluate cheaper sources of nutrients such as rock phosphates and manure; and
- identify forage plants that make most efficient use of native and applied nutrients or that are productive on nutrient-deficient soils.

In 1988, trials were conducted on acid red soils at Soddo, Ethiopia. *Medicago sativa* (lucerne or alfalfa) cv Hunter River was used as the indicator crop.

Effect of lime and phosphorus on dry-matter yield of lucerne

Lime (2, 6 or 10 t/ha) and phosphorus (75, 150 or 300 kg P/ha) were applied to the trial plots on 11 June 1987. The lucerne was planted on 9 July 1987. During 1987 and 1988 seasons, 7 harvests were made and dry matter was estimated. Applying phosphorus significantly increased the dry-matter yield of lucerne but there was no significant difference in yield between rates of application. Dry-matter production showed a quadratic response to phosphorus application ($y = 361 + 3.2\,P - 0.008\,P^2$; $R^2 = 0.107$).

Applying lime also significantly increased dry-matter yield of lucerne. Dry-matter yield was significantly higher when lime was applied at the rate of 10 t/ha than at 2 or 6 t/ha. Dry-matter production showed a linear increase with increased rates of lime (L) applied ($y = 383 + 57\,L$; $R^2 = 0.99$). Applying lime at 2, 6 and 10 t/ha increased soil pH to 4.99, 5.75 and 6.74 respectively, as compared with a pH of 4.50 for non-limed control plots.

Effect of unacidulated and partially acidulated rock phosphates on dry-matter production of lucerne on Soddo acid soil

This trial examined the effect of four phosphorus fertilizers (triple superphosphate, unacidulated rock phosphate and 25% and 50% acidulated rock phosphates) on the dry-matter yield of lucerne. The rock phosphate came from Chilembune, Zambia.

Lucerne was planted in the trial plots on 1 June 1988 and the various P fertilizers were applied at 50, 100, 150 or 200 kg P/ha. No P fertilizer was applied to control plots. The lucerne was harvested twice during the year and its dry-matter yield was estimated.

Applying triple superphosphate (TSP) increased the dry- matter yield of lucerne significantly over the control (599 kg/ha) when applied at 100, 150 and 200 kg P/ha, but not when applied at 50 kg P/ha. Dry-matter production showed a quadratic response to TSP application ($y = 570 + 8\ P - 0.03\ P^2$; $R^2 = 0.83$). The 50% acidulated rock phosphate (50% ARP) increased lucerne dry-matter yield significantly only at the highest rate of application and showed a linear increase in dry-matter yield with increased rates of application ($y = 650 + 1.76\ P$; $R^2 = 0.44$). Twenty-five per cent acidulated rock phosphate (25% ARP) and unacidulated rock phosphate did not have a significant effect on lucerne yield. This indicates that 25% acidulation is not enough to release significant amounts of P on an acid soil (Figure 20).

Effect of manure on lucerne grown on Soddo acid soil

Manure was applied at various rates on Soddo red soil on 11 May 1988 and *Medicago sativa* cv Hunter River was planted on 31 May 1988 at a seed rate of

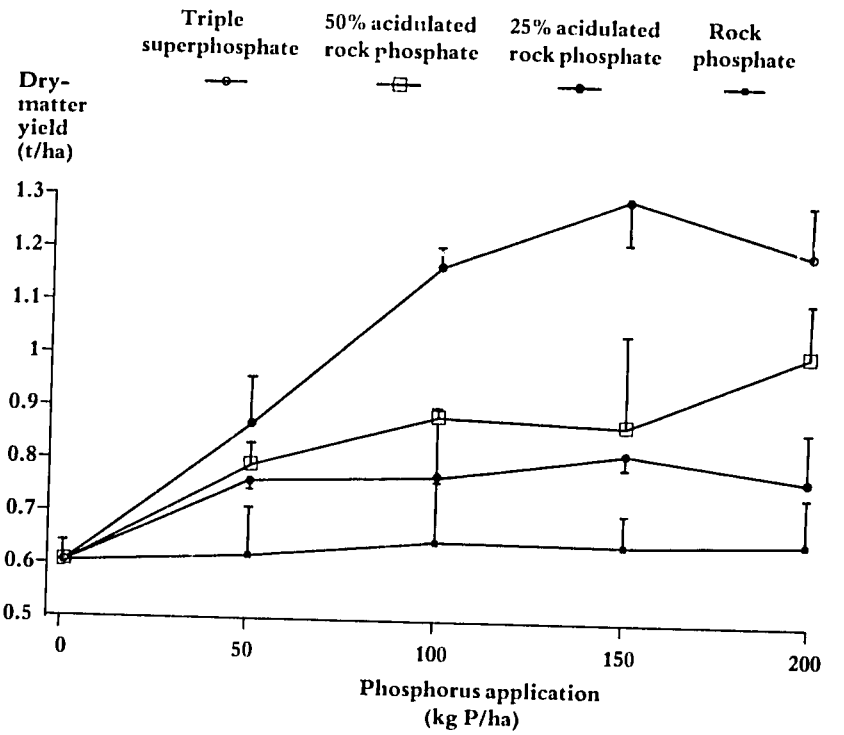
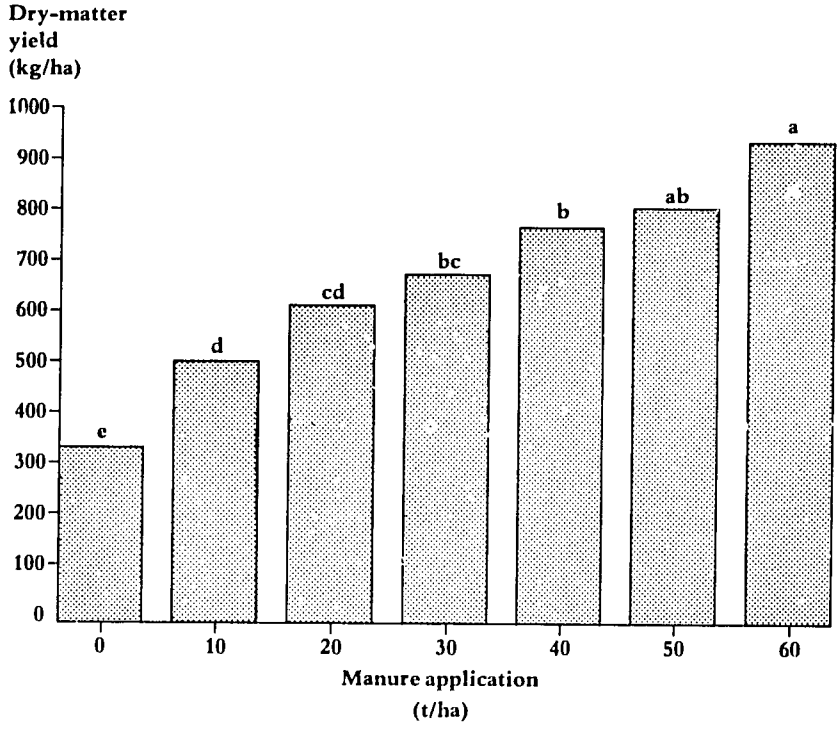


Figure 20. *Effect of triple superphosphate, unacidulated and partially acidulated rock phosphates on dry-matter yield of lucerne* (Medicago sativa) *grown on acid soil, Soddo, Ethiopia, 1988.*

20 kg/ha. Two harvests were made during the year to estimate dry-matter yield. Application of manure at various rates (10, 20, 30, 40, 50 and 60 t/ha) significantly increased dry-matter yield as compared with the control (348 kg/ha) (Figure 21). Dry-matter production showed a linear increase with increased rates of manure applied ($y = 406 + 9\,M$; $R^2 = 0.84$).



Columns carrying the same letter do not differ significantly ($P > 0.05$).

Figure 21. *Effect of manure on dry-matter yield of lucerne* (Medicago sativa) *grown on acid soil, Soddo, Ethiopia, 1988.*

Establishing nutrient criteria for promising legumes: determination of nutrient deficiencies in major soils

Forage legumes are important for the improvement of livestock nutrition and soil fertility in West African farming systems. Although the agroclimatic conditions of the West African subhumid zone suit many legumes, nutrient imbalances in many soils can limit forage and livestock production.

In a pot trial, the nutrient omission technique was used to investigate nutrient status of Ferric Luvisols, Orthic Acrisols and Plinthic Luvisols; *Stylosanthes hamata* cv Verano and *Centrosema pascuorum* were used as test species. Field trials investigated the effect of phosphorus application on the growth of *S. hamata* cv Verano and *C. pascuorum* on Ferric Luvisols and Dystric Nitosols.

In the pot trial applying a mixture of 10 nutrients (phosphorus, potassium, sulphur, calcium, magnesium, boron, copper, zinc, molybdenum and cobalt) resulted in the highest dry-matter yield on the Ferric Luvisol (Figure 22). Omitting phosphorus or copper or not applying any nutrients resulted in the lowest dry-matter yield on this soil with *Stylosanthes*; yield of *Centrosema* was lowest when no nutrients were applied. On the Orthic Acrisols the highest yields of both *Stylosanthes* and *Centrosema* were obtained when boron was omitted from the nutrient mixture (Figure 23).

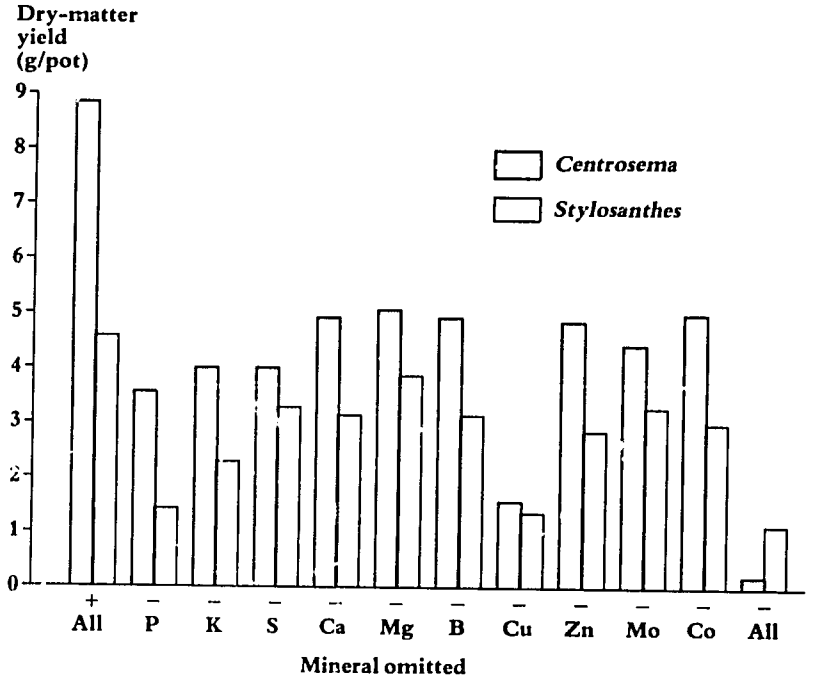


Figure 22.
Dry-matter yield of Stylosanthes hamata *cv Verano and* Centrosema pascuorum *grown on a Ferric Luvisol in pots, 1988.*

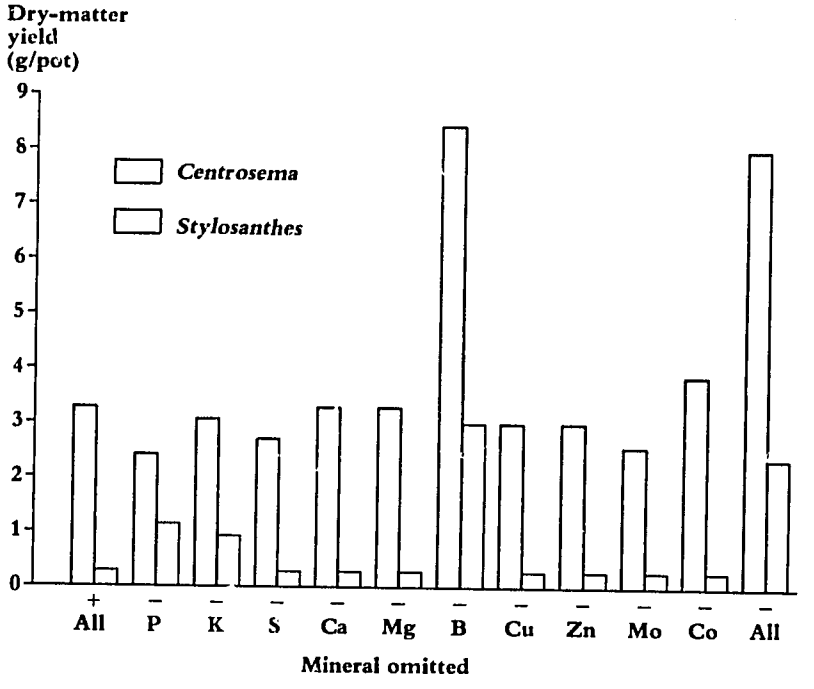


Figure 23.
Dry-matter yield of Stylosanthes hamata *cv Verano and* Centrosema pascuorum *grown on an Orthic Acrisol in pots, 1988.*

In the field trial, stylo showed only a small response to phosphorus on the Ferric Luvisol whereas applying 20 kg P/ha increased the dry-matter yield of *Centrosema* by about 1.5 t/ha (Figure 24). On the Dystric Nitosol stylo showed a dramatic response to phosphorus application, its dry-matter yield increasing from about 3.5 t/ha when no phosphorus was applied to about 9 t/ha when phosphorus was applied at a rate of 40 kg/ha. The causes of this will be investigated in 1989.

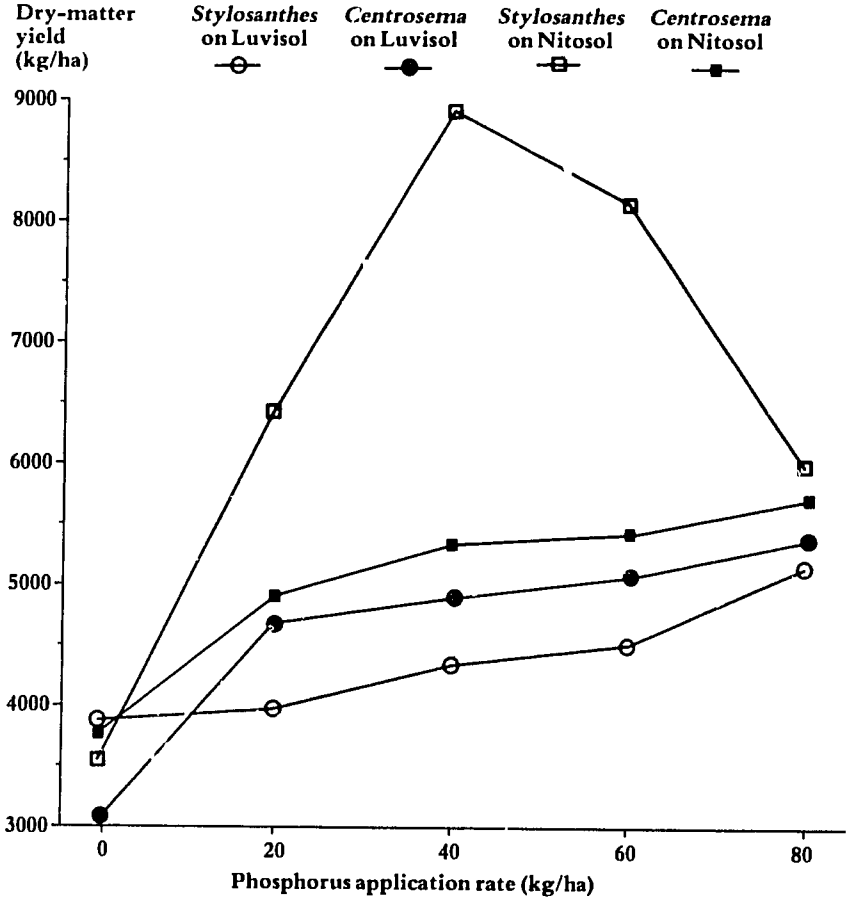


Figure 24. *Effect of phosphorus application on the dry-matter yield of* Stylosanthes hamata *cv Verano and* Centrosema pascuorum *on a Ferric Luvisol and a Dystric Nitosol, Nigerian subhumid zone, 1988.*

Nutritive value of crop residues

Identification of polyphenols in sorghum crop residues

ILCA and the Institute of Grassland and Animal Production (IGAP), UK, are collaborating in research on the utilisation and nutritive value of sorghum crop residues.

Sorghum plants synthesise large amounts of polyphenols. Plant breeders exploit this in breeding bird-resistant sorghums. Bird-resistant (BR) varieties have higher concentrations of polyphenols in their leaves than do varieties that are not bird resistant (non-BR varieties). Leaf fibre from BR

varieties is less digestible in vitro than leaf fibre from non-BR varieties (*ILCA Annual Report 1987*, pages 57 and 58).

The nature of sorghum leaf polyphenols is poorly understood. In experiments conducted at IGAP in 1988, high-performance liquid chromatography (HPLC) gave incomplete separation of sorghum polyphenols: sharp peaks were superimposed on a very broad peak (Figure 25). High-speed counter-current chromatography (CCC) followed by HPLC gave better separation of the polyphenols.

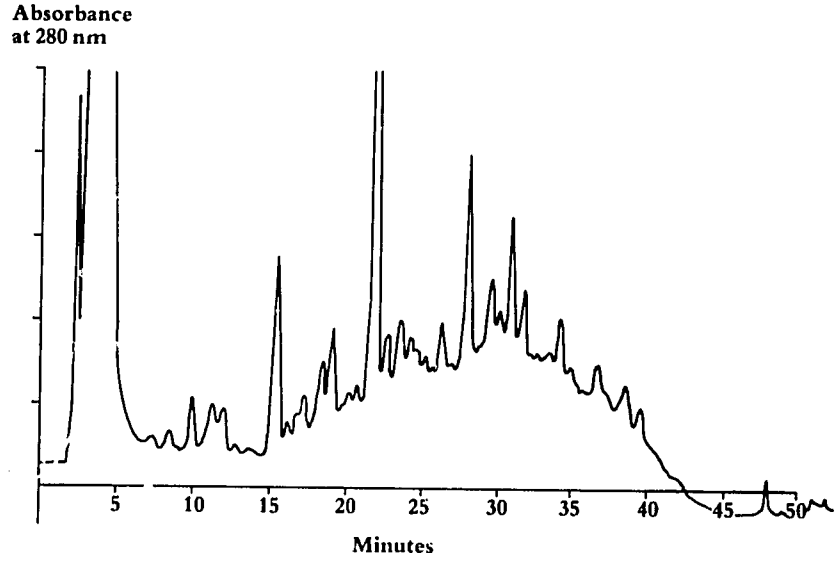


Figure 25.
High performance liquid chromatography of sorghum polyphenols.

Treating the first CCC fraction with hydrochloric acid (HCl) and butanol at 95°C produced an unstable compound with maximum absorbance at 540 nm, suggesting the presence of a flavan-4-ol (Figure 26). Treatment with 2M HCl at 95°C yielded a compound with an HPLC retention time of 6.1 minutes and maximum absorbance at 485 nm. In comparison, luteolinidin eluted after 11.2 minutes and also had maximum absorbance at 485 nm. The two spectra were identical (Figure 27).

These results suggest that sorghum crop residues contain complex flavan-4-ols based on luteoforol. Current research at IGAP is aimed at determining the effects of these phenolic compounds on digestibility of fibre and on the activity of rumen micro-organisms.

Multipurpose trees

Initial evaluation of multipurpose trees—humid zone

Since 1984 staff at ILCA's humid zone research site at Ibadan, Nigeria, have been involved in collecting germplasm of *Gliricidia sepium*, a multipurpose tree, and have evaluated it for use in forage production and other agroforestry uses. As part of this activity the team has also been involved in multiply-

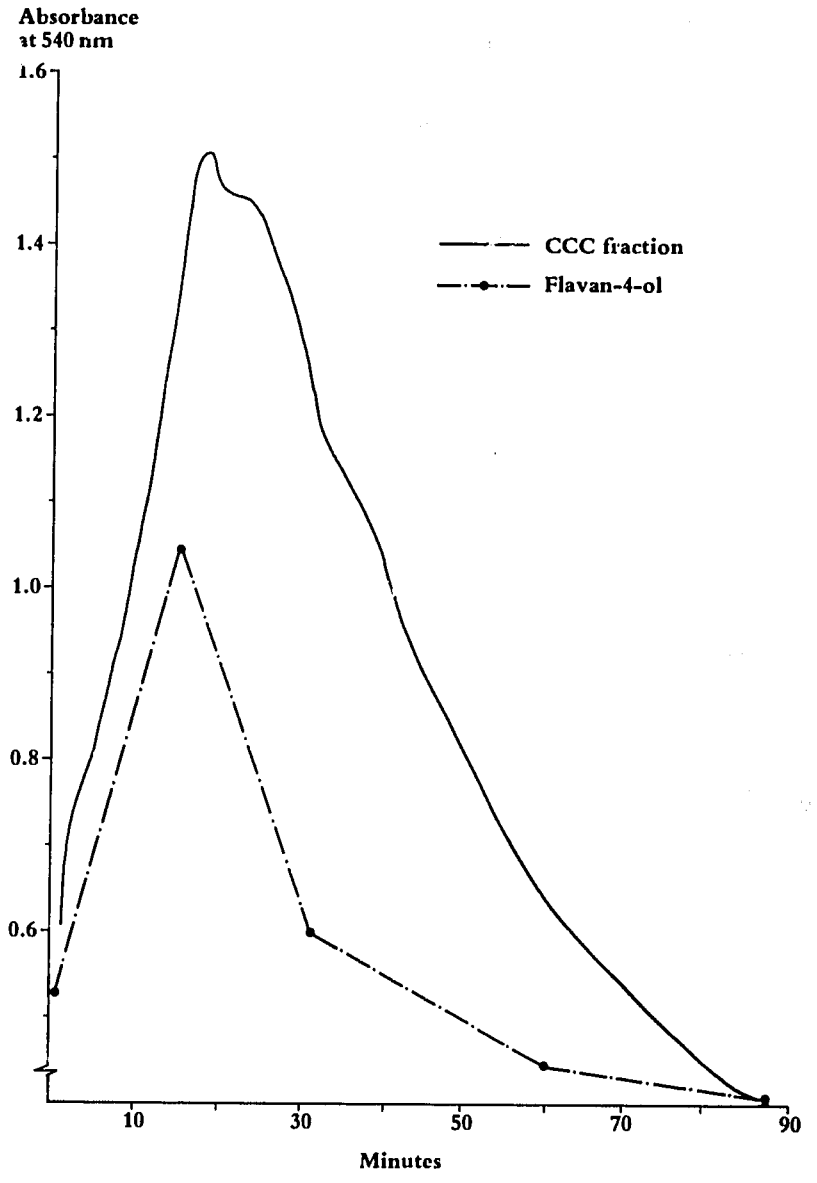


Figure 26.
Colour development and disappearance after treating first fraction from counter-current chromatography (CCC) and a flavan-4-ol standard with HCl/butanol reagent.

ing and distributing seed of this species. *Gliricidia* germplasm was collected in Central America by the Oxford Forestry Institute in 1984, 1985 and 1986. This material has been evaluated at 15 sites in 10 West and central African countries through a network coordinated by ILCA. Accessions being evaluated at the various sites include ILGs 55, 58, 52 and HYB, a composite accession.

In order to have a complete picture of the relative performance of the various accessions, the entire *Gliricidia* collection was planted at Ibadan in 1987 and at three other sites (Uyo, Nigeria; Dindresso, Burkina Faso; Sotuba, Mali) in 1988.

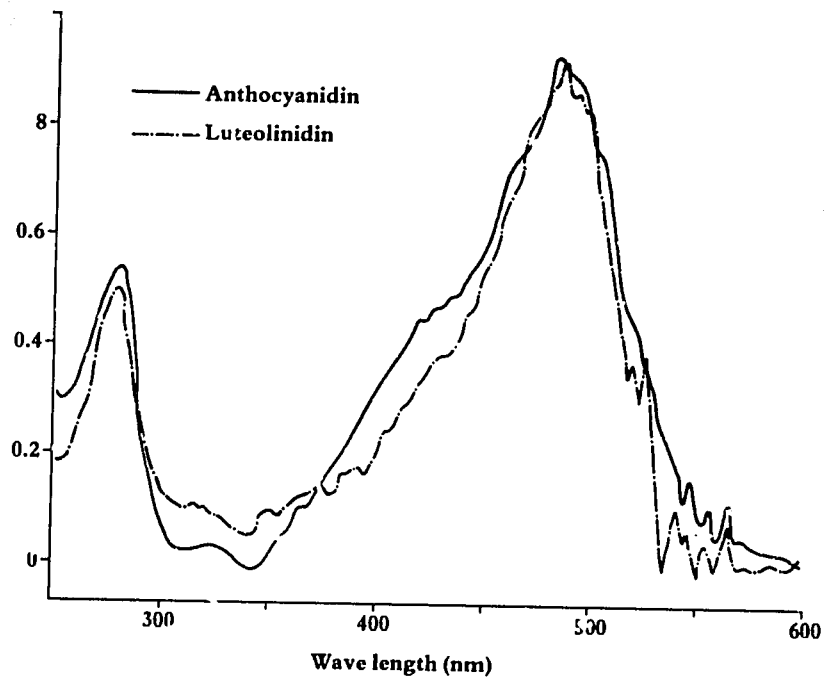


Figure 27.
Comparison of ultra-violet–visible spectra from luteolinidin (standard) and an anthocyanidin formed from the first counter-current chromatography fraction.

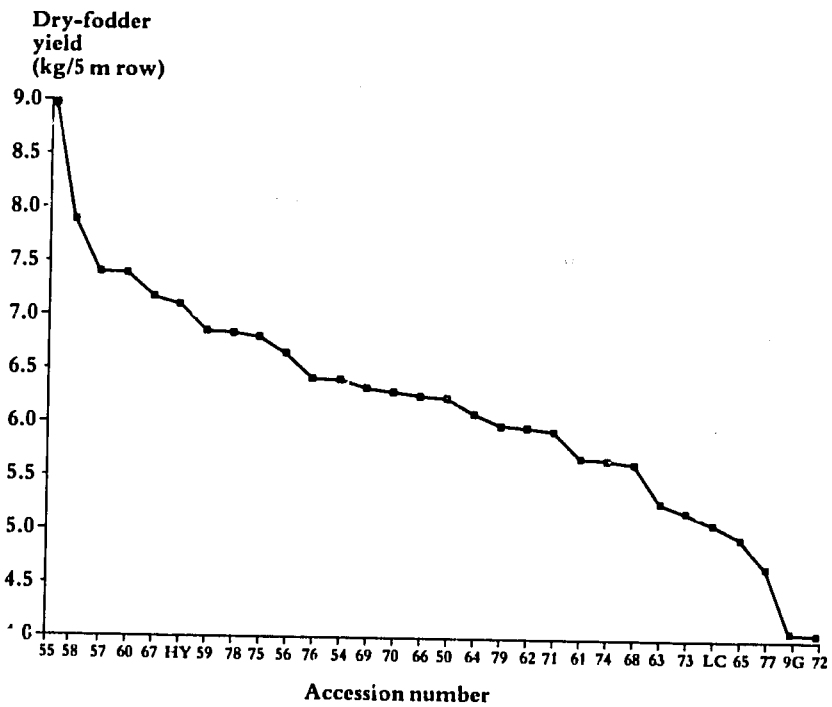


Figure 28.
Total fodder yield of Giiricidia *accessions 9 months after planting (sum of two coppice harvests), Nigerian humid zone, 1988.*

Results obtained at Ibadan in 1988 confirmed the wide range in height growth, coppice regrowth vigour and yield among the accessions observed in previous trials. ILG 55 had the greatest increase in height; 9 months after planting it had achieved a height of 5.3 m. Six other accessions also were more than 5 m tall at 9 months after planting: HYB and ILGs 54, 57, 69, 74 and 79. The local Ibadan accession, ILG 50, was in the intermediate class with a height of 4.5 m at 9 months. ILG 58 also confirmed its dwarf stature as in previous evaluations.

In addition to being the tallest line at 9 months after planting, ILG 55 gave the largest biomass yield. Other high-yielding accessions were HYB and ILGs 58, 57, 60 and 67 (Figure 28). A large number of the 'new' lines outyielded ILG 50.

The wide variation in production characters among the *Gliricidia* accessions indicates a scope for development of improved cultivars through selection and breeding.

Agronomic studies on best-bet lines of multipurpose trees—highlands

Sesbania sesban was first tested by ILCA in 1985 at Debre Zeit research station in Ethiopia. This leguminous shrub grew well both in hedgerows and in pure stand (*ILCA Annual Report 1985/86*, page 6). Trials to evaluate a range of *Sesbania* germplasm were carried out in 1987 and 1988 at Debre Zeit and at ILCA's headquarters site at Shola. Species included in the trial were *Sesbania sesban*, *S. goetzii*, *S. arborea*, *S. bispinosa*, *S. cannabina*, *S. formosa*, *S. grandiflora*, *S. macrantha* and *S. rostrata*.

Accessions in the trial were evaluated on height increase in 1987, the establishment year, and leaf dry-matter yields when cut once, twice or four times during the 24-week wet season in 1988. *Sesbania sesban* var *nubica* was used as the control.

Several *S. sesban* accessions yielded more than the control at both sites (Table 56). The other species gave lower yields than *S. sesban* at both sites.

Table 56. *Leaf dry-matter yield of* Sesbania sesban *elite accessions under three cutting regimes at Debre Zeit and Shola, Ethiopian highlands, wet season 1988.*

	Leaf yield (g DM/tree) from:		
	4 cuts	2 cuts	1 cut
Debre Zeit (1850 m)			
Mean of best 7 accessions	773	698	1317
S. sesban var *nubica*	205	295	391
Shola (2340 m)			
Mean of best 5[a] accessions	52	52	78
S. sesban var *nubica*	17	34	15

[a] Includes four of the best seven accessions from Debre Zeit.

Leaf dry-matter yields at Shola were generally less than 10% of those at Debre Zeit, reflecting the higher altitude of the Shola site. The relative performance of the accessions was, however, very similar. Pruning the trees only once, at the end of the wet season, gave the highest yields in 1988.

Leaf dry-matter yields of accessions were closely related to the height of the accessions at the end of the establishment year. Thus plant height in the establishment year could be used to indicate potential productivity of *Sesbania* accessions, shortening the time needed to evaluate accessions.

Agronomic studies on best-bet lines of multipurpose trees—humid zone

Propagation of local browse species

High human populations in south-east Nigeria have led to intensive cultivation and the development of compound farming. Livestock are confined at least during the cropping seasons and local browse trees are an important source of cut-and-carry feed for them.

ILCA's humid zone research team in Nigeria is working in collaboration with three national institutions to develop feed production strategies based on local browses. In 1988 a trial was set up to determine the most suitable planting material and the best way to propagate some selected indigenous browse species.

The propagules studied were seeds subjected to various scarification techniques (hot water, concentrated sulphuric acid (H_2SO_4) and mechanical) and stem cuttings from the basal, middle and apical sections of the plants.

Seeds of *Alchornea cordifolia, Dialium guineense, Harungana madagascariensis* and *Acioa barteri* germinated without scarification. Seed of several other species needed to be scarified either with hot water or concentrated H_2SO_4. Many of the species, especially *Acioa barteri, Alchornea cordifolia, Baphia nitida, Ficus capenses, Macaranga barteric* and *Mannniophytum fulvum*, sprouted very well from stem cuttings. Cuttings from basal and middle sections of stems sprouted better than those from the apical section.

Agronomic studies on best-bet lines of multipurpose trees—subhumid zone

Establishment of *Gliricidia*

Alley farming, in which foliage from the leguminous trees *Gliricidia* and *Leucaena* is used both to improve the soil and as livestock feed, has been successfully developed by ILCA and the International Institute of Tropical Agriculture (IITA) for the humid zone of Nigeria. Trials were started in 1985 in the Nigerian subhumid zone to determine the suitability of various *Gliricidia* lines for use in alley farming and as live fences.

In initial trials at Ganawuri, established in 1985, two lines (ILGs 52 and 63) were among the best performers. These have since been tested further alongside the three top performers (ILGs 55 and 58 and HYB) from Ibadan, in the Nigerian humid zone. Selected accessions from dry and wet areas have also been evaluated at the subhumid zone site at Abet.

Each trial was a randomised complete block design with three replicates. At Ganawuri each plot consisted of three 5-m-long ridges spaced 1.5 m apart. Within rows, trees were planted 25 cm apart. At Abet each accession occupied a single ridge 5 m long. Ridges were 2 m apart and within

rows trees were planted 50 cm apart. The trials were established in the 1988 wet season. Data collected included plant height, basal diameter of the trunk and fodder yield at harvest.

The growth of the trees in the first year was generally poor, especially at Ganawuri, but a few lines showed promise. At Abet, lines ILGs 67, 50 and 55 and HYB grew best with plant heights of about 176, 172, 168 and 164 cm, respectively (Figure 29). ILGs 70, 64, 69 and 71 were amongst those showing the least growth with heights of 99, 104, 111, and 111 cm, respectively. ILGs 70, 69 and 71 were also amongst the lines most susceptible to insect damage. At Ganawuri there was almost no increase in plant height in 1988. ILGs 50 and 55 and HYB grew best at this site, with final plant heights of 58, 50 and 48 cm, respectively. At both sites the growth of the accessions was poorer than that achieved at sites in the humid zone. This was due largely to the lower rainfall of the subhumid zone and restriction of root growth by the hard pan typical of subhumid zone soils.

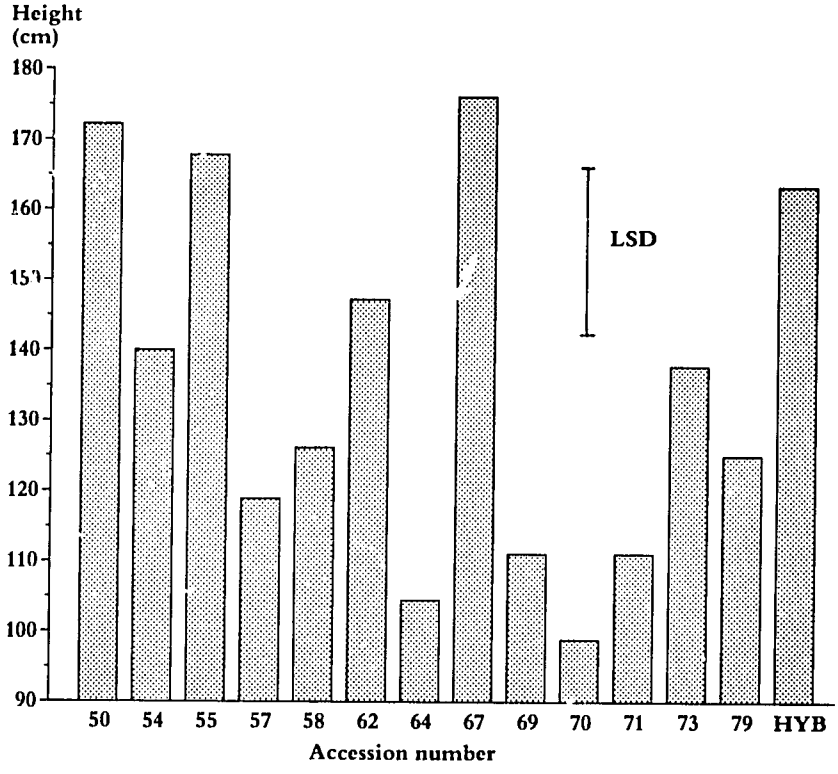


Figure 29. *Heights of* Gliricidia *accessions at Abet, Nigerian subhumid zone, December 1988.*

Nutrient management and water-use studies in multipurpose trees—highlands

Most upland soils are easily eroded and soon lose their fertility when cropped. Planting trees can help stabilise the soil and increase its organic matter content. ILCA is investigating ways to include multipurpose trees, especially legumes, in farming systems to maintain or increase the organic matter content and fertility of the soil by mulching and to provide feed for

livestock. *Sesbania sesban* has shown promise in an alley farming system in the Ethiopian highlands.

In 1988 a trial was conducted to examine the effect of the timing of mulching with *Sesbania* prunings on the yield of sorghum. Dry prunings (5 t/ha) were applied on each treatment plot on one of five occasions: 1, 2 or 3 weeks before planting, at the time of planting, and 4 weeks after planting. Control plots received no prunings. All plots received 50 kg P/ha.

Applying *Sesbania* prunings before planting the sorghum significantly increased sorghum dry-matter yield relative to the unmulched control (Table 57). Applying the prunings at planting or after planting did not significantly increase sorghum dry-matter yield. The response of grain yield was similar except that prunings applied after planting also increased yield significantly (Table 57).

Table 57. *Dry-matter and grain yield of sorghum as affected by timing of pruning applications on an upland soil in Debre Zeit, Ethiopian highlands, 1988.*

Time of mulching	Dry-matter yield (kg/ha)	Grain yield (kg/ha)
3 weeks before planting	9321a	3703a
2 weeks before planting	9593a	3689a
1 week before planting	9435a	3788a
At planting	7470ab	3222ab
4 weeks after planting (thinning)	8521ab	4138a
Control	6093b	2447b

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

Applying the prunings at planting may have immobilised soil N, making it unavailable to the sorghum during establishment.

Evaluation of multipurpose trees in management systems—alley farming

Dry-season feed shortages, and the poor quality of feed that is available, limit livestock production in the subhumid zone. More feed, from a variety of sources, is needed to overcome these problems.

In Mali, ILCA is testing alley cropping as a way of integrating multipurpose trees into existing cropping systems. Hedgerows of *Gliricidia* and *Leucaena* were established from seed in July 1986. The trees were first pruned in December 1987, when *Gliricidia* yielded 750 kg leaf DM/ha and *Leucaena* yielded 604 kg leaf DM/ha. Corresponding yields from the second harvest, taken in July 1988, were 4475 kg DM/ha for *Gliricidia* and 2459 kg DM/ha for *Leucaena*.

Table 58 gives the mean yield of maize in pure stand and in alley cropping plots with *Gliricidia* and *Leucaena* between 1986 and 1988. Maize received 50 kg fertilizer N/ha. There were no significant differences between treatments in either stover or grain yield. However, averaged over 3 years, growing maize without trees gave the highest grain yield.

Table 58. *Average annual grain and stover yields of maize grown in pure stand and in alley cropping plots, subhumid zone, Mali, 1986 to 1988.*

Treatment	Average maize yield (kg DM/ha)	
	Stover	Grain
Maize alone (control)	1950	1160
Gliricidia + maize	1520	960
Leucaena + maize	1560	800
SE	183	183
	NS[1]	NS

[1] NS = not significant.

Evaluation of multipurpose trees in management systems—intensive feed garden

Effect of interrow spacing and cutting frequency on fodder yield of *Leucaena*

Since 1985 ILCA has been studying the effects of interrow spacing and cutting frequency on fodder yield of *Leucaena* under intensive production. Earlier results have shown that both factors influence biomass yield. Reducing the interval between harvests from 12 weeks to 6 weeks increased the number of harvests in a growing season but reduced total fodder yield. Increasing interrow spacing from 0.5 to 2.0 m generally reduced total yield per unit area (see *ILCA Annual Report 1986/87*, pages 8 and 9, and *ILCA Annual Report 1987*, page 63).

In 1988, the third consecutive year of pruning, yields were generally lower than in previous years. However, the same trends in responses to interrow spacing and cutting interval were observed. As in 1986 and 1987, the highest yield of fodder (33 tonnes/ha) was obtained from the combination of 0.5 m interrow spacing with a cutting interval of 12 weeks. The lowest yield (5 tonnes/ha) was obtained from the combination of the highest cutting frequency (every 6 weeks) and the widest interrow spacing (2.0 m).

Fodder yield of selected accessions of *Gliricidia sepium*

The fodder yield of five accessions of *Gliricidia sepium* has been assessed under intensive management in a trial started in 1986. The accessions were among selections from an earlier *Gliricidia* germplasm evaluation trial involving 15 lines, and included the local Ibadan *Gliricidia* (ILG 50). Other accessions were HYB (a composite line of four Costa Rican parent accessions), ILG 55, ILG 58 and ILG 56, all Central American *Gliricidias* collected by the Oxford Forestry Institute.

Accessions were planted in plots consisting of three rows, each 5 m long, spaced 1.5 m apart. Within rows trees were planted 50 cm apart. The trees were cut approximately every 3 months after an initial coppice harvest 6 months after planting.

There were only slight differences in fodder yield between the accessions in 1988. The highest yielding accessions were ILGs 55 and 58, both of which yielded about 18% more than ILG 50 (Ibadan local). These two ac-

cessions were also among the best in the initial evaluation under alley farming management. The mean fodder dry-matter yield over all five accessions was 11.6 t/ha in 1987 and 13.9 t/ha in 1988.

Nutritive value of multipurpose trees

Nutritive value of fodder trees and shrubs in sub-Saharan Africa

Browse is important in the diets of domestic and wild animals in sub-Saharan Africa. Some browse species can be used as multipurpose trees (MPTs). Indigenous MPTs are adapted to local ecological and climatic conditions. Many are extremely drought resistant (e.g. *Maerua crassifolia)* or still have all their leaves even late in the dry season (e.g. *Balanites aegyptiaca)*. Acacias are probably the most important MPTs because of their wide distribution and economic use (e.g. gum arabic from *A. senegal)*.

Browse species are potential sources of protein and minerals for feeding cattle, sheep and goats. Some, however, contain tannins and other polyphenolic compounds that may limit their nutritive value. Therefore, MPTs, fodder trees and shrubs were screened to identify the most promising species.

A forage legume screening trial in northern Nigeria.

Leaves and fruits of 86 browse species were collected at Niamey (ICRISAT, Niger), Kaduna (ILCA, Nigeria) and Cotonou (Direction de la recherche agronomique, Benin). Average annual rainfall at these sites is 550, 1050 and 1200 mm respectively.

The samples were air-dried and analysed at ILCA headquarters for protein, fibre, phenolics and mineral contents and in vitro digestibility of dry matter and fibre. In vitro digestibility of protein was determined at the University of Hohenheim.

Crude protein content of leaf material ranged from 10 to 38% of dry matter (DM). Content of soluble phenolics, including tannins, ranged from 6 to 52% of DM. Cell wall content ranged from 6% of DM in *Acacia nilotica* to 77% of DM in *Vitex doniana*.

True digestibility of DM ranged from 34 to 94%. Digestibility of protein ranged from zero to 88%, and that of fibre from zero to 75%. This variation in digestibility may be due to the effects of lignin or secondary metabolites such as tannins and other phenolics. Lignin content had a high negative correlation with DM digestibility ($r = -0.77$) and fibre digestibility ($r = -0.74$). Content of soluble polyphenolics had a high negative correlation with protein digestibility ($r = -0.66$).

Several Australian *Acacia* species analysed at ILCA had high contents of soluble phenolics, insoluble proanthocyanidins and lignin and very low in vitro digestibilities. They are thus of little use as animal feed.

Although laboratory analyses can provide useful information on plant nutrient composition, specific interactions between phenolics and nutrients make prediction of nutritive value unreliable. Therefore, in vivo experiments are essential to assess feed quality of browse.

Nutritive value and polyphenolics content of *Sesbania sesban* accessions grown at three sites in Ethiopia

Sesbania sesban is found throughout sub-Saharan Africa and in other tropical regions. Previous ILCA studies have shown that leaves from a local accession of *S. sesban* from Debre Zeit, Ethiopia, are highly nutritious. The crude protein content of the leaves is high (25–30% of dry matter) and they contain little tannin and other polyphenolics (*ILCA Annual Report 1987*). *Sesbania sesban* is thus a useful source of protein for ruminant diets.

In 1988 research was carried out to determine the influence of accession, environment, individual tree within an accession, and content of polyphenolics on the nutritive value of *S. sesban*. Six accessions were selected from evaluation trials at three sites in Ethiopia (Shola, Debre Zeit and Zwai). Samples of fresh leaves were taken from five trees of each accession at each site. Approximately 100 grams of fresh leaves were collected from each tree and placed in a plastic bag; the bags of leaves were then immediately packed in dry ice. The leaves were later lyophylised in ILCA's headquarters laboratory, ground through a 1 mm screen in a hammer mill and analysed for N, neutral-detergent fibre (NDF), in vitro true digestibility, lignin, insoluble proanthocyanidins, and soluble phenolics.

Parameters of nutritive value and content of polyphenolic compounds varied widely between accessions and sites (Table 59). Nitrogen and NDF contents, in vitro true digestibility and lignin content differed significantly between accessions and between sites. Soluble phenolic and insoluble proanthocyanidin contents, averaged across sites, differed significantly between accessions but, averaged across accessions, did not vary significantly from one site to another.

Table 59. *Range in components of nutritive value in leaves among six accessions of* Sesbania sesban *and significance of the effect of accession and site.*

	Range	Mean ± SD	Significance	
			Accession	Site
Nitrogen (% DM)	2.5–4.6	3.3 ± 0.5	0.004	0.001
Neutral-detergent fibre (% DM)	11.3–28.6	17.1 ± 3.8	0.001	0.001
In vitro true digestibility (% DM)	81.0–94.1	89.5 ± 2.9	0.001	0.009
Lignin (% DM)	0.8–5.3	2.8 ± 1.0	0.001	0.001
Soluble phenolics (% DM)	9.3–33.8	17.7 ± 8.3	0.001	0.570
Insoluble proanthocyanidins (A550/g NDF)[1]	3–411	46.8 ± 70.2	0.001	0.246

[1] Absorbance of light with a wavelength of 550 nm.

Three of the accessions contained little soluble phenolics and no insoluble proanthocyanidins (absorbance values less than 20). The other three accessions had much higher contents of both types of phenolics, with large variation among trees within accessions. The correlation coefficients for the relationship of in vitro true digestibility with lignin, soluble phenolics and insoluble proanthocyanidins were negative and significant (Table 60).

Table 60. *Correlation coefficients between contents of phenolic compounds and in vitro true digestability in leaves from* Sesbania sesban *collected from six accessions at three sites in Ethiopia.*

	r	p
Lignin (% DM)	−0.57	0.001
Soluble phenolics (% DM)	−0.48	0.001
Insoluble proanthocyanidins (A550/g NDF)	−0.66	0.001

The large differences in nutritive value between accessions was largely related to differences in polyphenolic contents. Polyphenolic compounds have large effects on the availability of protein in browse. When large amounts of polyphenolics are present they complex protein and reduce its availability. However, low levels of polyphenolics can increase the nutritive value of feed by preventing bloat and improving protein utilisation.

In feeding trials in 1988, sheep fed leaves from *S. sesban* gained 48 g/day over 90 days. This equalled the growth rate achieved by sheep fed *Vicia dasycarpa* hay, the best legume hay treatment. Animals fed *Acacia cyanophylla*, *A. sieberiana* or *A. seyal* gained less than 24 g/day. Sheep fed *S. sesban* had high N intake, moderate faecal N and high retained N.

Legume forages in crop–livestock systems

Agronomic studies on selected forage legumes—subhumid zone

Fodder banks (small, densely planted legume pastures) have been adopted by agropastoralists throughout the Nigerian subhumid zone. In farmer-

managed fodder banks the proportion of grass in the herbage varies from 5 to 80%. Studies were started in 1985 to examine the effect of different grass densities on soil nitrogen content, forage quality, crude protein yield and the yield of subsequent crops.

Legumes used in fodder banks must withstand periodic grazing by cattle and small ruminants. A second trial established in 1988 investigated the effects of defoliation on three promising legumes (*Stylosanthes hamata*, *S. capitata* and *Centrosema pascuorum*). *Centrosema pascuorum* did not establish well and is not included in this report.

Stylosanthes hamata was sown at a rate of 10 kg seed/ha in 4 × 3 m plots in June 1985. The population of emerging grasses, from natural infestation, was adjusted so that grass accounted for 0, 25, 50, 75 or 100% of the plant population. The plots were kept under these grass/legume mixtures for 3 years and then planted with maize in 1988 (results of the second and third years of the experiment were reported in *ILCA Annual Report 1987*, pages 66 and 67). No nitrogen was applied to the maize crop. The trial used a randomised complete block design with four replicates.

In the defoliation trial, *S. hamata* and *S. capitata* were established in 5 × 3 m plots in a randomised complete block design with four replicates. Plots were cut at 1-, 3-, 6- or 9-week intervals during the 1988 wet season. Control plots were not cut until the final harvest at the end of the growing season in November.

Increasing grass density significantly reduced the grain yield of the subsequent maize crop (Table 61). This demonstrates the need to minimise the amount of grass present in fodder banks, both to produce high-quality feed for livestock and to benefit crops.

Table 61. *Effect of grass density in* Stylosanthes *fodder banks on the grain yield of a subsequent maize crop, Nigerian subhumid zone, 1988.*

Grass density (%)	Maize grain yield (kg/ha)
0	1387a
25	1058b
50	775bc
75	661c
100	220d

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

In the defoliation trial *S. hamata* yielded more than *S. capitata* under all defoliation regimes (Figure 30). The superior performance of *S. hamata* was due largely to its better establishment. The yield of *S. hamata* was greatest when it was cut every 6 weeks and lowest when cut only once at the end of the growing season. The yield of *S. capitata* was greatest when it was cut every 9 weeks and lowest when cut weekly.

Evaluation of forage legumes in management systems—highlands

ILCA's site at Soddo, Ethiopia, is at 1900 m altitude on a Nitosol. Annual rainfall averages 1100 mm. The site is representative of medium altitude,

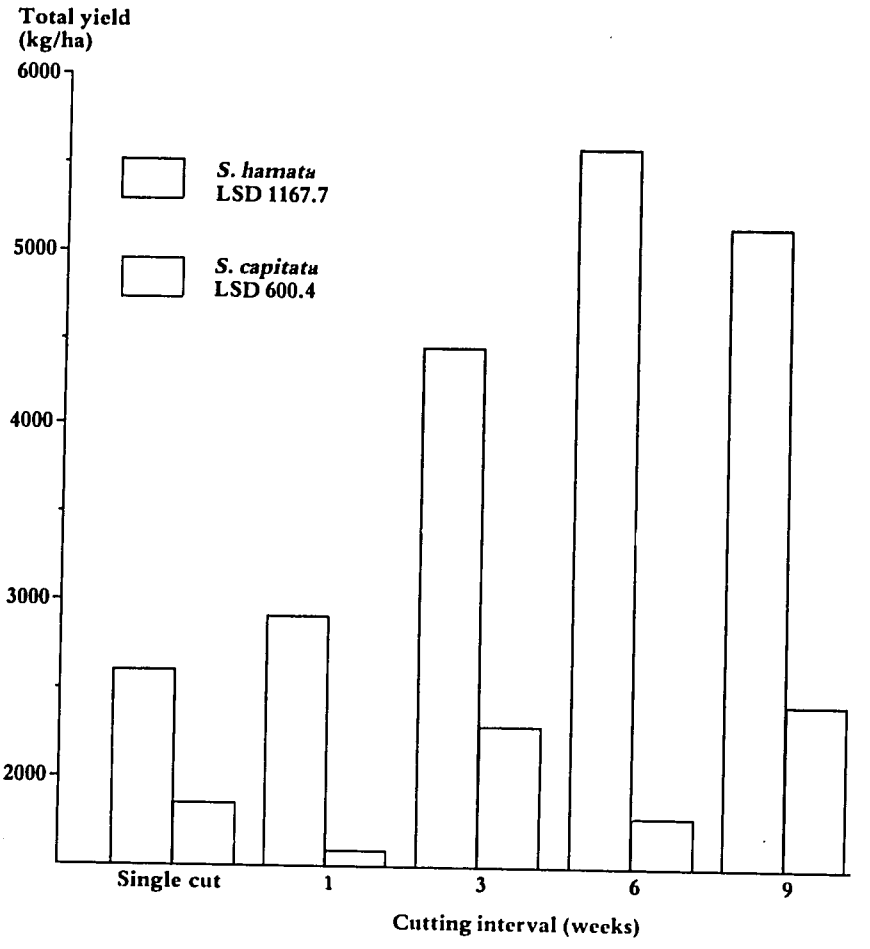


Figure 30.
Effect of cutting interval on the yield of Stylosanthes hamata *and* S. capitata, *Nigerian subhumid zone, 1988.*

medium rainfall, acid soil areas of western Ethiopia, Kenya, Tanzania, Uganda, Rwanda, Burundi and highland areas of Cameroon. Legumes that have shown promise as forages for use in smallholder systems are being tested further in replicated yield trials at the Soddo site and in unreplicated plots on neighbouring farms.

The initial replicated yield trial for forage legumes at Soddo was planted in 1984. Twelve potentially adapted legumes were planted in mixture with *Chloris gayana* cv Pioneer. The grass and many of the legumes were either unproductive or did not persist. *Stylosanthes scabra* and *S. guianensis* cultivars gave the highest yields and were reasonably persistent. *Stylosanthes scabra* cvs Seca and Fitzroy produced the highest total legume yields (Table 62). They initially yielded less than *S. guianensis* cv Cook, but yielded more than Cook from the third (1986) wet season onwards (Table 63). The productivity of all lines apparently fell after the fourth (1987) wet season, probably because of the age of the plants.

The effect of undersowing coffee trees with *Desmodium intortum* cv Greenleaf on the yield of coffee berries has been studied on three farms since 1986. In 1986 and 1987 trees undersown with the Greenleaf produced more

Table 62. *Dry-matter yield of* Chloris gayana *cv Pioneer, alone and in mixture with 12 legumes, over the period May 1984 to October 1988, Soddo, Ethiopia (total of 35 harvests).*

	Cultivar/ accession number	Cutting height (cm)	Yield (t/ha)			
			Sown			
			Legume	Grass	Weed[1]	Total
Chloris gayana	Pioneer	5	–	5.0	7.4	12.4
Desmodium intortum	Greenleaf	15	5.1	4.5	8.2	17.8
Desmodium sandwicense	ILCA 6995	15	1.3	4.1	6.8	12.1
Leucaena leucocephala	Peru	50	1.3	3.8	7.1	12.2
Macroptilium atropurpureum	Siratro	15	2.8	2.2	6.2	11.2
Medicago sativa	Hairy Peruvian	5	0	2.2	6.4	8.6
Stylosanthes guianensis	Cook	20	13.4	1.7	4.0	19.2
Stylosanthes guianensis	Endeavour	15	11.9	1.5	2.5	15.9
Stylosanthes guianensis	Graham	15	7.3	3.1	6.0	16.4
Stylosanthes hamata	Verano	10	4.5	1.4	5.7	11.7
Stylosanthes hamata	Paterson	5	1.0	2.9	12.3	16.2
Stylosanthes scabra	Fitzroy	15	15.0	0.9	4.8	20.7
Stylosanthes scabra	Seca	15	17.5	2.2	5.9	25.5
LSD (0.05)			4.0	2.8	4.0	5.9

[1] Includes sown legumes that invaded from adjacent plots.

Table 63. *Seasonal dry-matter productivity of* Stylosanthes *cultivars over the period May 1984 to October 1988 in Soddo, Ethiopia.*

Year	Season	Length (days)	Harvests (number)	Dry-matter productivity (kg/ha per day)			LSD (0.05)
				Cook	Fitzroy	Seca	
1984	wet	175	1	17.14	4.62	9.01	4.27
1984/85	dry	126	3	1.75	0.46	1.07	1.03
1985	wet	210	5	16.39	12.41	16.64	4.99
1985/86	dry	168	4	9.39	6.36	7.59	3.45
1986	wet	128	3	7.60	18.35	21.72	6.19
1986/87	dry	210	5	8.84	11.66	12.75	3.02
1987	wet	252	6	7.46	12.95	12.24	2.99
1987/88	dry	126	3	1.59	5.41	4.25	1.87
1988	wet	210	5	0.34	1.76	2.01	0.83

berries than trees that were not undersown with the legume. In 1988 the undersown trees produced fewer berries than trees that were not undersown (Table 64). Trees that are not undersown with Greenleaf are occasionally manured and the land under them is ploughed each year. These treatments are not applied to undersown trees. The cumulative effect of manuring and ploughing could have caused the higher berry yields of non-undersown trees

observed in 1988. Alternatively, undersown trees may have been exhausted by their heavier berry yields in 1987. Competition for water between the legume and the coffee is unlikely to be an important factor as the Greenleaf is cut to ground level early in the dry season, during coffee harvest, and does not regrow until the beginning of the next rainy season. Greenleaf under unpruned coffee trees yielded an average of 3.6 t of dry matter/ha in 1988 compared with 4.0 t/ha in 1987.

Table 64. *Coffee berry yields from 5 trees with and without* Desmodium intortum *planted beneath, Ethiopia, 1986–88.*

	Average number of berries per tree			
	1986	1987	1988	Total
Trees with *Desmodium*	505	4949	285	5739
Trees without *Desmodium*	480	4145	495	5120
Difference (%)	5.2	19.4	−42.4	12.1

Evaluation of forage legumes in management systems—fodder banks

Nigerian subhumid zone

Nitrogen builds up in the soil under fodder banks and encourages invasion of the fodder banks by nitrophilous grasses and termites. This can be avoided by periodically cropping the fodder bank, to the benefit of crop yields (see *ILCA Annual Report 1987*, page 67). Experiments were conducted in 1988 to compare cropping strategies and determine appropriate management techniques.

Maize, sorghum and soya bean were planted in both pure stand and mixed crops inside and outside five fodder banks in Nigeria. Plots were fertilized with one of six levels of nitrogen (0, 40, 80, 120, 160 or 200 kg/ha). Each plot consisted of four 3-m-long ridges. The ridges were 1 m apart. Within rows, maize and sorghum were planted 20 cm apart; soya bean plants were 5 cm apart.

A separate experiment investigated the effect of cropping on the subsequent productivity of fodder banks. Cropped and uncropped areas of fodder banks were examined for stylo seedling density and samples were taken to determine yield and botanical composition.

Crops grown in fodder banks yielded more than those grown on previously fallowed land (Figure 31). Soya bean yield was lower from soya bean/maize mixtures than from soya bean/sorghum mixtures; this explains why soya bean/sorghum is the most common intercrop in the Nigerian subhumid zone. Maize/sorghum mixtures produced low yields of both cereals due to low total plant population and competition between the two species. The total yield of maize/sorghum mixtures was lower than that of maize/soya bean mixtures but higher than that of sorghum/soya bean mixtures.

Cropping fodder banks reduced stylo seedling density (although not significantly) but did not affect the dry-matter yield of the pasture (Table 65). Cropping the fodder bank for only one year significantly reduced the proportion of grasses in the herbage, whereas in uncropped parts of the fodder banks stylo was being replaced by grasses. This shows the benefit to pasture productivity and quality of regular cropping within fodder banks.

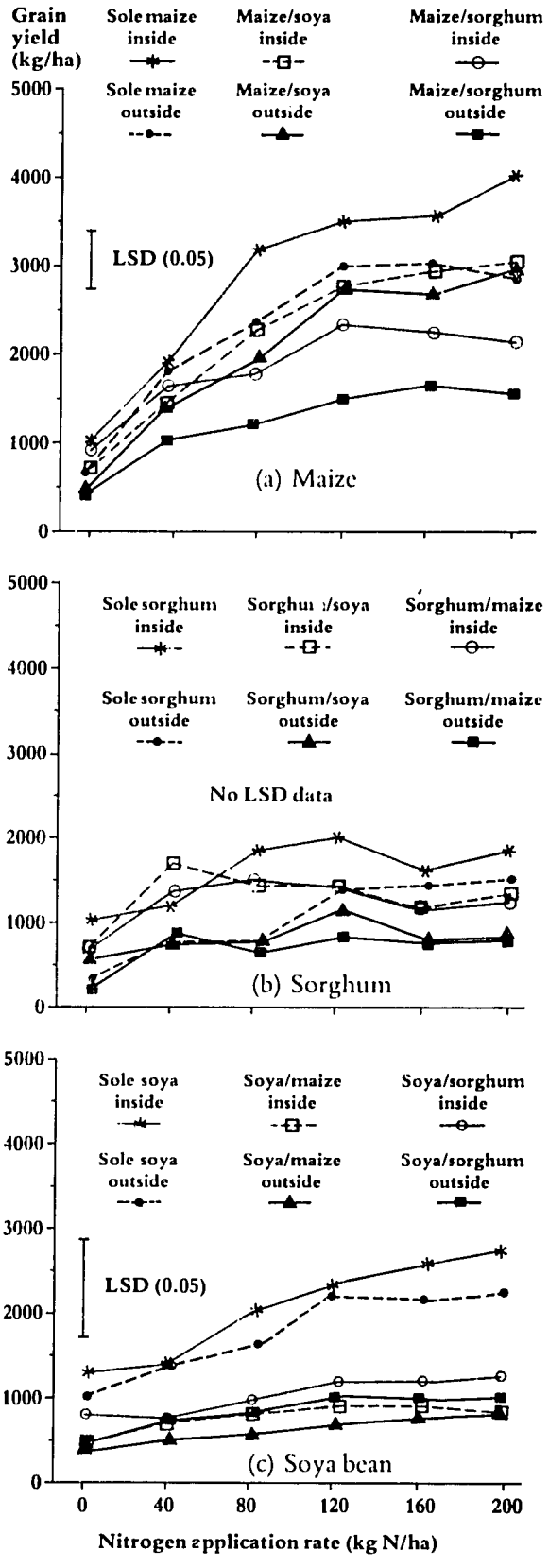


Figure 31.
Grain yields of (a) maize, (b) sorghum and (c) soya bean grown in pure stands and mixed crops inside and outside fodder banks, Nigerian subhumid zone, 1988.

Table 65. *Effect of cropping on stylo productivity, seedling population and botanical composition of fodder banks, Nigerian subhumid zone, 1988.*

Land history	Stylo seedlings/ m^2	Dry-matter yield (kg/ha)	Botanical composition (%)		
			Stylo	Grasses	Forbs
Uncropped	106a	5567a	43.0a	39.0a	18.0a
Cropped for one year	75a	5452a	58.0a	23.0b	19.0a
Cropped for two years	67a	6182a	56.0a	26.0ab	18.0a

Within columns, means followed by the same letter do not differ significantly ($P>0.05$).

Malian subhumid zone

Dry-season feed shortages, and the poor quality of feed that is available, limit livestock production in the subhumid zone. Forage production must be increased and diversified to overcome these problems. In Mali, research concentrates on forages that meet the needs of milk producers in peri-urban areas and on integrating these forages into traditional agricultural systems.

Crop production systems in Mali are typically subsistence-oriented. The main crop is either millet or sorghum, with groundnut or cotton as a subsidiary cash crop. Very few farmers grow forage crops. Other than natural pasture, the main feed resources are crop residues from cereals, groundnut or cotton, and small amounts of hay from cowpea grown in association with cereals.

Stylosanthes fodder banks are being tested in Mali as a way of integrating perennial herbaceous legumes into traditional cropping systems. Table 66 shows the yields obtained in 1987 and 1988 at two sites in the subhumid zone of Mali. The low yield at Site 2 in the establishment year was due to late sowing (mid-August) and poor seed scarification, which resulted in low plant density. The dramatic increase in the proportion of stylo in the biomass in 1988 at Site 2 demonstrates the ability of *Stylosanthes* to regenerate by self-seeding.

Table 66. *Characteristics of* Stylosanthes *fodder banks at two sites in the subhumid zone of Mali, 1987 and 1988.*

	Site 1		Site 2	
	1987	1988	1987	1988
Rainfall (mm)	850	1031	1000	1200
Density[1] (plants/m^2)	40	1570	18	1492
Height (cm)	74	72	49	83
Biomass[2] (kg DM/ha)	8000	10200	1800	5540
Stylosanthes (%)	78	71	39	87
Grasses (%)	9	18	36	7
Broadleaved weeds (%)	13	11	25	6

[1] Measured in July/August.

[2] Measured in November.

Nutrient management and water-use studies in legume-based cropping systems—highlands

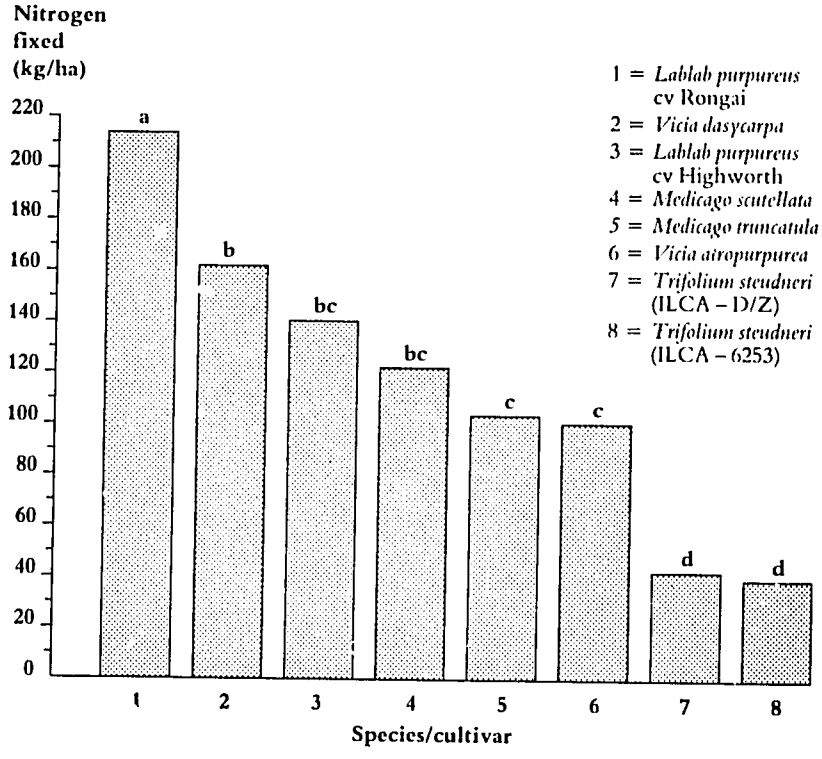
Nitrogen deficiency limits plant growth on many African soils. Nitrogen (N) fertilizers are too expensive for most small-scale farmers in sub-Saharan Africa. The main alternative to applying fertilizer N is to grow legumes, which "fix" atmospheric N and make it available to subsequent crops. Legumes are also valuable as high-quality animal feed.

Studies were conducted in 1987 and 1988 to determine the amount of N fixed by several forage legumes and their N contribution to cereals in rotations and intercrops.

Nitrogen fixation by forage legumes and its residual effect on wheat

The amount of N fixed by several forage legumes was determined at Debre Zeit using the ^{15}N technique. The legumes tested were *Vicia dasycarpa* (woolly-pod vetch), *Lablab purpureus* cvs Rongai and Highworth, *Medicago scutellata* (Snail medic), *Medicago truncatula* (Barrel medic), *Vicia atropurpurea* (purple vetch) and *Trifolium steudneri* (ILCA D/Z and ILCA 6253). Oats (*Avena sativa* cv Lampton) were used as the non-nodulating reference crop.

The vetches, lablabs and medics fixed significantly more N than the *Trifolium steudneri* accessions (Figure 32). The amount of N fixed by *T. steudneri* was low, probably because establishment of this species was poor due to erratic rainfall in June and July during its establishment phase.



Columns carrying the same letter do not differ significantly ($P > 0.05$).

Figure 32. *Biological nitrogen fixation by various forage legume species/cultivars grown on an upland soil, Debre Zeit, Ethiopia, 1988.*

The dry-matter yields of wheat were significantly higher on plots previously planted to the legumes (except *T. steudneri* ILCA D/Z) or fallowed than on plots previously under oats (Table 67). Grain yields were also generally higher on plots following the legumes, although not significantly ($P>0.05$) in the case of the *Trifolium* and Snail medic plots. Fallowing did not significantly affect subsequent wheat grain yield. The differences between dry-matter and grain yields in response to previous cropping may have been due to bird damage to the wheat ears.

Table 67. *Effect of previous cropping on dry-matter and grain yields of wheat, Debre Zeit, Ethiopia, 1988.*

	Yield (kg/ha)	
Previous crop	Dry matter	Grain
Trifolium steudneri (ILCA D/Z)	2009de	861bc
Trifolium steudneri (ILCA 6253)	2230cd	995abc
Vicia dasycarpa	2820a	1096ab
Vicia atropurpurea	2503abc	1105ab
Lablab purpureus cv Rongai	2803ab	1153ab
Lablab purpureus cv Highworth	2659abc	1208a
Medicago scutellata	2343cd	1032abc
Medicago truncatula	2379bcd	1272a
Fallow	2269cd	893bc
Oats	1790e	744c

Within columns, values followed by the same letter do not differ significantly ($P>0.05$, Duncan's Multiple Range Test).

Effect of intercropping on nitrogen nutrition of maize

In a 1988 trial, a local cultivar of maize and *Macrotyloma axillare* cv Archer were planted in pure stand and as intercrops (3:1 ratio) on acid soil at Soddo, a mid-altitude site in Ethiopia. All plots received 50 kg P/ha as triple superphosphate at planting. Maize and intercrop plots received either 0 or 60 kg N/ha. *Macrotyloma* did not receive N fertilizer whether in pure stand or in intercrops.

Intercropping maize with *Macrotyloma* reduced maize dry-matter yield but increased total dry-matter yield relative to maize in pure stand (Table 68). Within fertilizer treatments, intercropping reduced maize grain yield, but the effect was small and not significant (Table 68).

The large increase in yield and quality of fodder achieved by intercropping maize with *Macrotyloma* could support increased livestock production. This benefit might be sufficient to persuade farmers to adopt intercropping.

Nutrient management and water use under rotations and intercrops—subhumid zone

The soils of the Nigerian subhumid zone commonly have petroferric hard layers, or pans, typical of tropical ferruginous soils. These pans impede root

Table 68. *Dry-matter and grain yields of maize and* Macrotyloma axillare *grown in pure stand or intercropped on acid soil, Soddo, Ethiopia, 1988.*

Cropping systems	Dry-matter yield (kg/ha)			Maize grain yield (kg/ha)
	Maize	*Macrotyloma*	Total	
Maize	4227	–	4227c	3348ab
Maize + 60N	5081	–	5081bc	4341a
Maize: *Macrotyloma*	3041 (28)	2427 (54)	5468ab	2882b (14)
Maize: *Macrotyloma* + 60N	3756 (26)	2432 (54)	6188a	3596ab (17)
Macrotyloma	–	5269	5269ab	–

Numbers in brackets are percentage yield reductions.

Within columns, values followed by the same letter do not differ significantly (P>0.05, Duncan's Multiple Range Test).

penetration and restrict drainage, leading to a perched water table and forcing farmers to plant their crops on ridges.

A 1987 field experiment investigating the effects of subsoiling, harrowing and ridging on the growth of maize and stylo (see *ILCA Annual Report 1987*, pages 55–57) was repeated at a new site. Observations were continued on the 1987 trial plots to examine the residual effect of subsoiling on crop and fodder yields. Maize was planted at both sites and *Stylosanthes hamata* cv Verano regenerated at the old site. Grain and fodder yields were determined. Soil bulk density and moisture storage were monitored at the old site to assess the residual effects of the tillage treatments.

On the 1987 site, plots that had been subsoiled in 1987 had significantly lower soil bulk density in the 20 to 30 cm layer than did plots that had been harrowed or ridged (Table 69). They also had significantly higher moisture content in the 10 to 20 cm layer (Table 69). As expected there was no clear residual effect of subsoiling on bulk density or moisture content of the upper soil layer. These results indicate that the loosening effect of subsoiling persisted into the second season only in lower layers.

Table 69. *Residual effect of tillage method on bulk density and moisture storage 6 weeks after planting, Nigerian subhumid zone, 1988.*

Tillage method	Soil layer (cm)		Soil layer (cm)	
	0–10	10–20	0–10	20–30
	Moisture content (g/g)		Bulk density (g/cm^3)	
Subsoil	0.156	0.143	1.428	1.306
Harrow	0.143	0.112	1.407	1.466
Ridge	0.129	0.131	1.315	1.432
LSD(0.05)	0.018	0.001	0.080	0.100

At the new site, grain and fodder yields from subsoiled plots were about 17% higher than those from harrowed plots (Table 70). There were no

significant differences in grain and fodder yields between subsoiled and ridged plots. At the old site, maize grain yield did not differ significantly between treatments (Table 70). Stover yields from plots that had been ridged were significantly higher than those from subsoiled plots; stover yield from harrowed plots was not significantly different from those on either ridged or subsoiled plots. In contrast stylo yields were significantly higher from subsoiled plots than from either harrowed or ridged plots.

Table 70. *Effect of tillage method on grain and stover yields of maize and yield of stylo, Nigerian subhumid zone, 1988.*

	Dry-matter yield (kg/ha)				
	Old site (residual effect)			New site	
Tillage method	Maize grain	Maize stover	Stylo	Maize grain	Maize stover
Subsoil	2978	3781	6374	2325	3835
Harrow	2962	4375	3100	1975	3300
Ridge	3325	4438	4529	2225	4167
LSD(0.05)	386	601	922	278	493

Breaking the hard pan requires substantial labour or mechanical power. This study indicates that the beneficial effects of subsoiling on food crop yields do not carry over to a second year and subsoiling may not, therefore, be worthwhile. Ridging seems to be a more practicable way to avoid the effects of the hard pan in these soils. The disadvantage of ridging is that it leaves the soil surface bare for most of the year.

The residual effect of subsoiling on scylo yields suggests that a legume cover crop is beneficial to the management of these soils, especially when the hard pan is broken by subsoiling.

Networks, training and research support

Outreach activities of the Animal Feed Resources Thrust aim at increasing and improving forage research in sub-Saharan Africa through courses, workshops, support for networks, multilocation trials and improved communication between researchers.

ARNAB—African Research Network for Agricultural Byproducts

The main event of 1988 for the African Research Network for Agricultural Byproducts (ARNAB) was the first joint ARNAB/PANESA Annual Workshop, held at Lilongwe, Malawi in December. The meeting was attended by 85 people from 21 countries. Fifty-one papers from 18 countries were presented on the use of feed resources, on-farm feeding systems, feed resource evalution, and technology testing, evaluation and adoption.

Following the workshop, ARNAB held its first formal research planning meeting. This was attended by 26 researchers from national agricultural research systems in 15 African countries. Working groups, focusing on highland, humid, subhumid and semi-arid zones, initially developed research objectives aimed at enhancing use as feed of crop residues and agro-industrial

byproducts in each zone. Participants then developed individual protocols for research projects. These will form the basis for the Network's future collaborative research.

Forage Network in Ethiopia

The 2-day annual workshop of the Forage Network in Ethiopia (FNE) was attended by 131 participants from 31 organisations. Two issues of the FNE Newsletter were published in 1988. During a week-long field trip, 28 network participants visited forage research and development sites in central Ethiopia. Multilocation trials were designed for the 1989 planting season and those from the period 1985–1987 were analysed and written up.

Pasture Network for Eastern and Southern Africa

The Pasture Network for Eastern and Southern Africa (PANESA) held a special meeting at ILCA headquarters in September 1988 to review progress during the 1987/88 growing season in the implementation of the Network's collaborative research programme (see *ILCA Annual Report 1987*, pages 67 and 69). The meeting was attended by 26 Network members from Botswana, Ethiopia, Lesotho, Kenya, Madagascar, Mauritius, Sudan, Tanzania, Uganda, Swaziland, Zambia, Zimbabwe and ILCA.

The review covered:

- Forage germplasm introduction and evaluation for the semi-arid zone. This work was carried out in the 1987/88 growing season at Kampi ya Mawe (Kenya), Sebele and Pelotshetlha (Botswana) and the Livestock Production Research Institute, Mpwapwa (Tanzania).

Nearly 50 forage legume accessions were evaluated in strip trials at each location. Ten lines were identified as being suitable for establishment by strip cultivation in the semi-arid zone, including species of the genera *Stylosanthes*, *Lablab*, *Neonotonia* and *Clitoria*.

- Multilocational forage legume germplasm evaluation in the subhumid zone for eventual oversowing of natural grasslands and incorporation in cereal cropping systems. This work was carried out at Mzuzu (Malawi) and Kabanyolo Farm of the University of Makerere, Uganda.

Thirty-eight accessions were grown in strip trials at each site. Species showing promise in the establishment phase included *Cassia rotundifolia*, *Cajanus cajan*, *Macroptilium axillare*, *Stylosanthes scabra* and *S. guianensis* Several of these have shown promise in earlier trials in Uganda and Malawi.

- Screening subtropical forage legumes for adaptation to highland conditions. This work was carried out at Uyole Agricultural Centre in the southern highlands of Tanzania.

A strip trial was conducted with two *Trifolium semipilosum* accessions, two *Stylosanthes guianensis* accessions, and one accession each of *T. burchellianum*, *T. repens*, and *Vicia sativa*. *Vicia sativa* showed the highest potential, yielding four times as much dry matter as the best *Trifolium* accession.

- Screening multipurpose browse species in the medium- and high-elevation semi-arid/subhumid zone of Kenya. This work was carried out at the National Dryland Farming Systems Research Station, Katumani, Kenya.

Eight accessions of *Leucaena leucocephala*, one accession of *Sesbania sesban* and one accession of *S. grandiflora* were planted using 8-week-old pre-germinated seedlings. Two *Leucaena* accessions yielded more than 3 t of leaf dry matter per hectare over the 1987/88 wet season and the 1988 dry season. The local *Leucaena* accession and the *Sesbanias* gave the lowest yields.

PANESA is also collaborating with the Ministry of Livestock Development/SR-CRSP (Small Ruminants Collaborative Research Support Program) at Maseno, Western Kenya in screening 200 *Seshania* species accessions collected in 1987 from Tanzania and Western Kenya.

- Evaluating the feed potential of *Crotalaria ochroleuca (marejea)*. *Marejea* is widely grown in farming systems of southern Tanzania, where farmers use it to improve soil fertility and to control weeds. This study, carried out by the Department of Animal Science of Sokoine University of Agriculture at Morogoro, Tanzania, investigated its use as an animal feed.

Marejea gave good yields (4670 kg dry matter/ha after 16 weeks of growth) and maintained its digestibility well, giving a digestible dry-matter yield of 3007 kg/ha at 10 weeks after planting. A feeding trial showed that supplementing a basal diet of *Chloris gayana* hay with *marejea* significantly increased the growth rate of young male sheep. *Marejea* thus appears to be a useful protein supplement for growing sheep.

Training and research support

Two training courses on forage germplasm collection and evaluation were offered in 1988 (see Table 75, Training and Information). The 2-week courses, one in English and one in French, were given in cooperation with the Ethiopian Ministry of Agriculture at their station at Soddo in the Rift Valley. A further 3-week practical course on forage germplasm introduction and evaluation techniques was given to four participants, two from France and two from Ethiopia.

Advice on forage research and development was also provided to workers in ILCA's mandate region and elsewhere, mainly through correspondence.

THRUST STAFF

J Tothill, *Thrust Coordinator*
A N Atta-Krah, *Agronomist*
P Bartholomew, *Forage Agronomist*
T Bedingar, *Economist (Post-doctoral Associate)*
M I Cisse, *Ecologist*
B H Dzowela, *PANESA Coordinator*
I V Ezenwa, *Graduate Associate (until September 1988)*
P A Francis, *Agro-economist (until May 1988)*
J Hanson, *Genebank Manager*
I Feque, *Soil Scientist*
J Kahurananga, *Ecologist*
R von Kaufmann, *Agricultural Economist*
J Lazier, *Forage Agronomist*
M A Mohamed-Saleem, *Forage Agronomist*
J D Reed, *Animal Nutritionist*
L Reynolds, *Animal Scientist*
Ulrich Rittner, *Graduate Associate*
T J Ruredzo, *Tissue-culture Specialist (Post-doctoral Associate)*
A Russell-Smith, *Agronomist*
A N Said, *Animal Nutritionist/ARNAB Coordinator*
N Steinmueller, *Graduate Associate*
G Tarawali, *Forage Agronomist*
Tekalegn Tadesse, *Chief Research Assistant*

Trypanotolerance Thrust

The goal of the Trypanotolerance Thrust is to contribute to improved livestock production in tsetse-infested Africa by developing a better understanding of the factors affecting the performance of trypanotolerant animals and the effectiveness of trypanosomiasis control measures. In pursuing this goal, ILCA and the International Laboratory for Research on Animal Diseases (ILRAD) have been collaborating with national agricultural research systems (NARS) for several years in the African Trypanotolerant Livestock Network. Scientists at the various network research sites address aspects of Trypanotolerance Thrust research that their situations are best equipped to handle cost-effectively. Collaborating scientists use standardised approaches in taking field measurements, making analyses and interpreting the data.

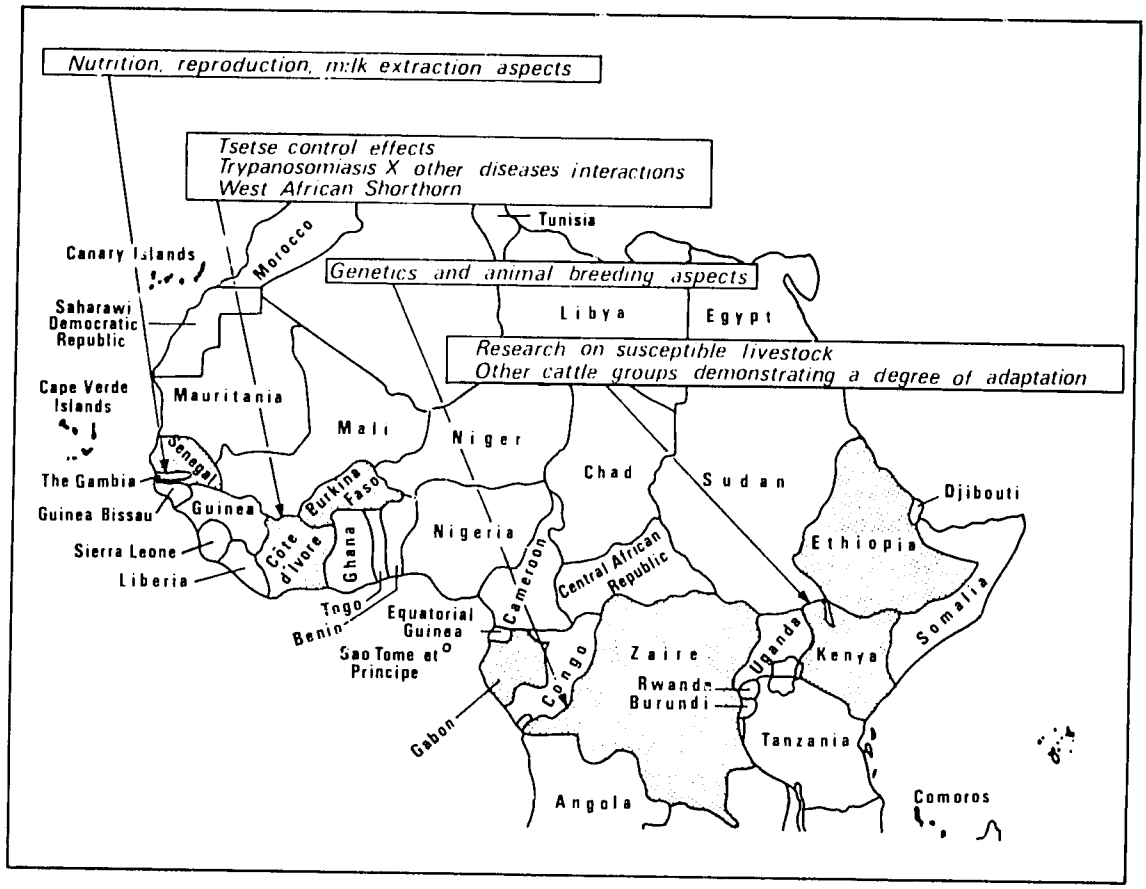
Plans for focusing the Thrust's research programme within regional groups of sites were completed in 1988 (Figure 33) and were mostly implemented during the year. Sites in The Gambia, at the International Trypanotolerance Centre (ITC), and in Senegal, at the Institut sénégalaise de recherches agronomiques (ISRA), Kolda, concentrated on research in nutrition, reproduction and milk extraction. The site at the Société de développement des productions animales (SODEPRA) at Boundiali, Côte d'Ivoire, focused on interaction between trypanosomiasis and other diseases and tsetse control aspects. Work at sites in Gabon and Zaire concentrated on aspects of genetics and animal breeding under high natural trypanosomiasis challenge. Associated sites in Ethiopia and Kenya focused on susceptible livestock and specific cattle groups that have demonstrated a degree of adaptation to a trypanosomiasis-affected environment.

The Thrust continued to pursue its objectives under four major themes: Trypanosomiasis epidemiology, trypanotolerance, genetics of trypanotolerance, and biological and economic evaluation of productivity responses to interventions.

Trypanosomiasis epidemiology

Research under this theme aims at determining the potential contribution of evaluating parameters relating to the tsetse population to predicting animal

Figure 33. *Sites for in-depth research in 1988.*



health and performance, and evaluating the various factors affecting susceptibility of livestock to trypanosomiasis.

Results presented in *ILCA Annual Report 1987* (pages 73 to 75) showed that there was a significant relationship between tsetse challenge and trypanosome prevalence in domestic livestock across network sites, where tsetse challenge was estimated from the relative density of tsetse flies and their trypanosome infection rates alone. However, the proportion of feeds taken by the flies from domestic livestock is an important additional parameter determining tsetse challenge. In 1988, data from analyses of residues of blood meals taken by tsetse flies have indicated the relative importance of different tsetse species as vectors of trypanosomiasis to domestic livestock.

Species of tsetse are grouped by their morphology and ecological distribution into three subgenera or species groups: *fusca* (subgenus *Austenina*), *palpalis* (subgenus *Nemorhina*) and *morsitans* (subgenus *Glossina*). The preferred habitat of a species has a large influence on its role as a vector of trypanosomiasis to domestic livestock. Thus, although *fusca* group tsetse flies inhabit vast areas of the forest zones of West and central Africa, they have rarely been implicated in outbreaks of trypanosomiasis in domestic livestock because of the relatively sparse population of domestic livestock in these zones. Studies at sites of the African Trypanotolerant Livestock Network in 1988 enabled re-examination of the significance of *fusca* group tsetse as vectors of trypanosomiasis to domestic livestock.

Glossina tabaniformis is one of the most widespread species of the *fusca* group of tsetse flies and occurs at three Network sites:

- a state ranch of the Office gabonais pour l'amélioration de la production du viande (OGAPROV), Gabon;
- a commercial ranch at Mushie in Bandundu district, Zaire; and
- villages in the Idiofa region of central Zaire.

Results of analyses of blood meals taken by *G. tabaniformis* at Mushie ranch, Zaire, indicate that this species will take a considerable proportion of its feeds from cattle when it comes into contact with them (Table 71). At Idiofa, *G. fuscipes*, of the *palpalis* group, took fewer feeds from cattle, suids and humans being the most important hosts (Table 71). There were too few *G. tabaniformis* flies at this site for collection of suitably fed flies.

Table 71. *Results of blood meal analyses for* G. tabaniformis *from Mushie and OGAPROV ranches and* G. fuscipes *from Idiofa, Zaire.*

	G. tabaniformis				*G. fuscipes*	
	Mushie		OGAPROV		Idiofa	
Host species	No.[a]	%[a]	No.	%	No.	%
Cow	58	49.2	3	13.6	7	7.7
Goat	9	7.6	-	-	4	4.4
Sheep	2	1.7	-	-	-	-
Unidentified suid	9	7.6	4	18.2	8	8.8
Domestic pig	9	7.6	-	-	10	11.0
Warthog	3	2.5	4	18.2	17	18.7
Bushpig	15	12.7	4	18.2	7	7.7
Man	8	6.8	3	13.6	35	38.5
Monkey	-	-	-	-	3	3.3
Duiker	4	3.4	4	18.2	-	-
Reptile	1	0.8	-	-	-	-

[a] No. and % refer to identified blood meals.

A highly significant ($P<0.001$; $r = 0.892$) relationship was found between tsetse challenge (calculated as the product of the relative density and trypanosome infection rate of the most abundant tsetse species at each site and the percentage of feeds taken from cattle) and trypanosome prevalence in N'Dama cattle over 3 or 4 years at the three sites (Figure 34). These analyses indicate that the data give an accurate indication of tsetse challenge and that at these Network sites tsetse species of the *fusca* group are important vectors of trypanosomiasis to cattle.

Thus in 1988 a further step has been taken towards being able to predict aspects of animal health and performance from tsetse challenge.

In relation to understanding the factors that affect the susceptibility of trypanotolerant livestock to trypanosomiasis, a start has been made in quantifying the relative effects of genetic and environmental factors on trypanosome prevalence and parasitaemia in livestock and building up a coherent picture across a range of sites.

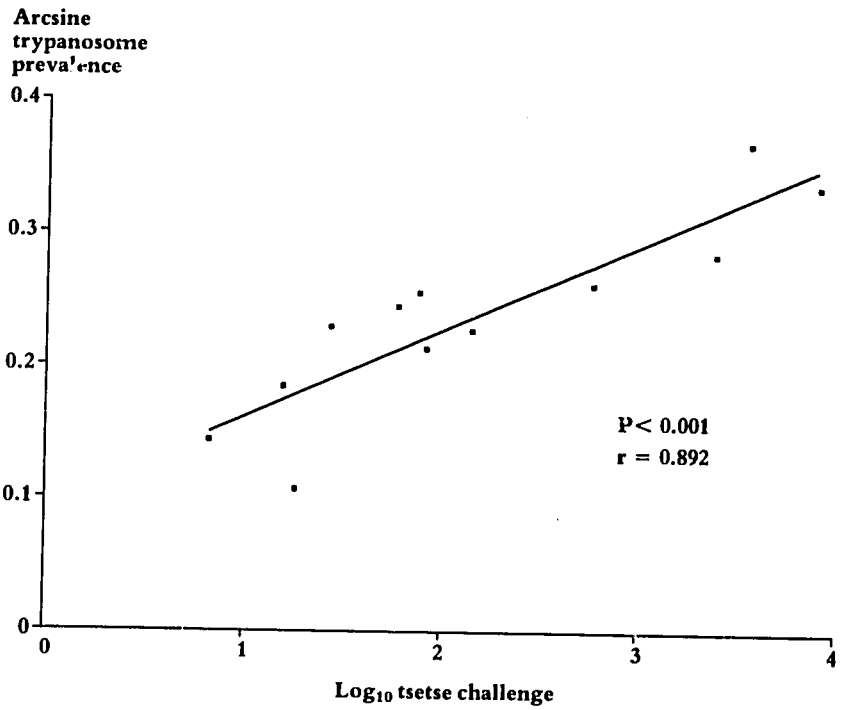


Figure 34.
Relationship between $\log_{10}$ tsetse challenge and arcsine trypanosome prevalence in N'Dama cattle at sites of the African Trypanotolerant Livestock Network with fusca group tsetse.

Trypanotolerance

Research under this theme aims at:

- quantifying the health and productivity of trypanotolerant and susceptible livestock under varying conditions and evaluating differences between breeds in their trypanotolerance and associated performance;
- estimating the effects on the frequency and severity of trypanosome infection of possible interactions between trypanosome infections and other major diseases; and
- defining criteria for trypanotolerance and evaluating the relationships between these criteria and production traits.

In 1987, initial results from a study of N'Dama cattle under high natural challenge at OGAPROV Ranch, Gabon, indicated that the number of months when trypanosomes were detected was linearly related to growth rate; an above-average parasitaemia score reduced growth by more than a below-average score; and animals that maintained their blood packed cell volume (PCV) above average had higher growth rates than those with below-average PCV (*ILCA Annual Report 1987*, pages 75 and 76).

In 1988 a detailed study was carried out at OGAPROV Ranch, in which 120 weaned N'Dama calves were exposed to a very high natural tsetse challenge for 20 weeks. The animals were weighed every 2 weeks and blood samples were taken. The darkground/phase contrast buffy coat technique was used to detect trypanosome presence and to quantify parasitaemia. Anaemia was estimated by measuring PCV. Phenotypic relationships be-

tween parasitaemia aspects, anaemia control aspects and daily liveweight change were estimated simultaneously using least squares.

Sixteen per cent of the animals had no detectable parasitaemia during the study period; these animals grew faster than those that had detectable parasitaemia (Figure 35). There was a significant negative linear relationship between the percentage of the study period during which the animals were parasitaemic and growth rate (Figure 35). This relationship did not differ significantly between animals with an above-average parasitaemia score and those with a below-average score (Figure 36). There was a highly significant relationship between ability to maintain above-average PCV levels and growth rate in animals that were parasitaemic for 20% or more of the study period (Figure 37). Animals that were detected as parasitaemic for up to 35% of the 20-week period grew at the same rate as non-parasitaemic animals if they were able to maintain their PCV levels above the average for their group.

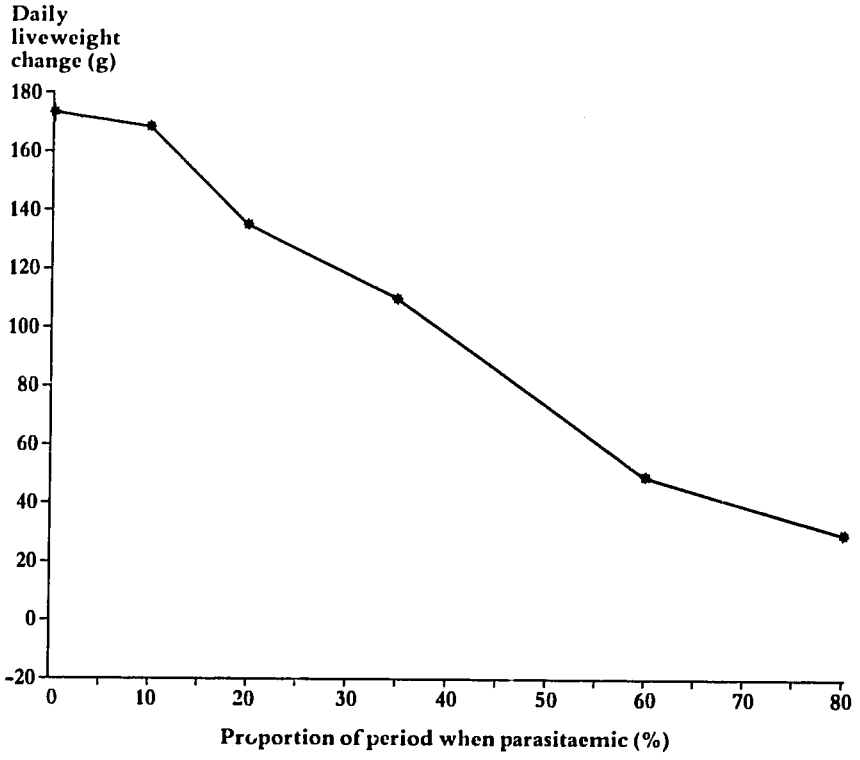


Figure 35.
Effect of proportion of 20 weeks when parasitaemic on overall daily liveweight change.

Thus in 1988 further progress has been made in quantifying the relative effects of components of trypanosome infection on animal performance. The importance of anaemia control has been highlighted: cattle that can control anaemia continue to be productive even when parasitaemic for considerable periods. Heritability of some aspects of anaemia control may be high enough for use in breeding programmes (*ILCA Annual Report 1987*, pages 76 and 77), and in 1989 considerable resources will be put into both quantitative genetic approaches and attempts to identify markers that will allow selection for this trait. More sensitive diagnostic tests will be used on

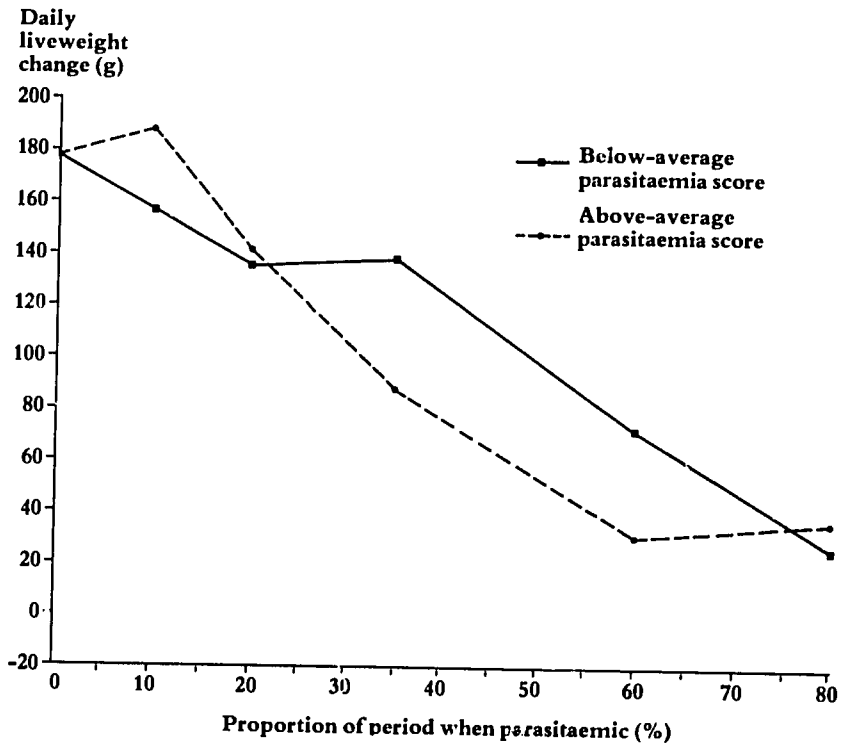


Figure 36.
Effect of above-average or below-average parasitaemi score on overall daily liveweight change.

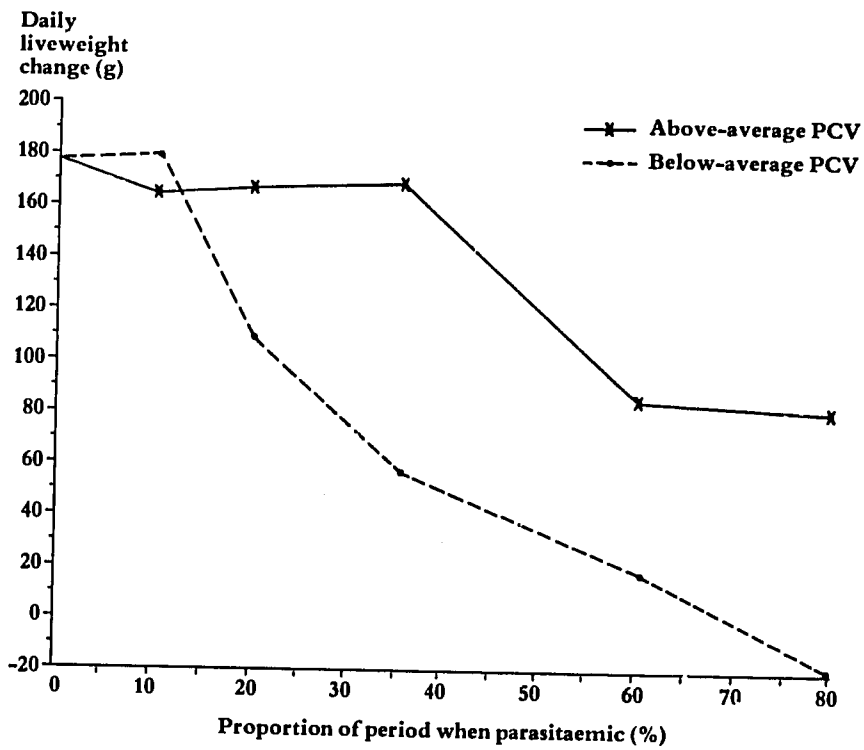


Figure 37.
Effect of above-average or below-average PCV level on overall daily liveweight change.

animals that presently show no detectable parasitaemia, some of which may have very low levels of parasitaemia and excellent anaemia control.

Across sites, further progress has been made in quantifying aspects of trypanotolerance and productivity in both tolerant and more susceptible breeds and a biological productivity index is being developed. Little evidence has been found of an interaction between trypanosomiasis and other anaemia-producing pathogens.

Genetics of trypanotolerance

The objectives of this theme are to:

- define selection criteria for trypanotolerance and estimate phenotypic and genetic variances of, and covariances between, trypanotolerance and health and production traits;
- test for possible relationships between polymorphic systems of bovine lymphocyte antigens, such as the major histocompatibility complex (MHC), and performance; and
- evaluate and use blood-typing procedures to identify half-sib groups in N'Dama cattle from known dams but with unknown sires.

Preliminary results mentioned in the *ILCA Annual Report 1987* (pages 76 and 77) suggest that, where animals become detectably infected, ability to maintain PCV levels under high natural challenge may have a sufficiently high heritability to be used as the basis of a practical selection approach for anaemia control. Similarly the ability to acquire resistance appears to be under genetic control and could well have a heritability high enough to allow its use in selection programmes. In 1988 paternal half-sib groups were built-up at OGAPROV Ranch, Gabon, and Mushie, Zaire, using both single-sire matings and blood-grouping techniques. These groups will be used to obtain reliable heritability estimates and genetic correlations for possible selection criteria. Blood samples were taken from more than 1000 N'Damas in 1988 and sent for blood grouping to the Pirbright Veterinary Quarantine Station, UK. Grouping was performed by collaborating scientists from the Institute of Animal Physiology and Genetics of the Agriculture and Food Research Council, UK. Sires with widely differing blood groups are, for the first time, being put together in multiple-sire breeding herds.

In the search for genetic markers, ILCA, in collaboration with ILRAD scientists, is studying two polymorphic systems of bovine lymphocyte antigens: the major histocompatibility complex (MHC) and a more limited polymorphic system of common leukocyte antigens (CLA), which has been detected in cattle only relatively recently. Work conducted in 1988 had two objectives:

- to survey the MHC and CLA phenotypes of different populations of N'Dama cattle in Zaire and The Gambia and compare these with the profiles of trypanosensitive Boran cattle in Kenya; and
- to determine, for those MHC and CLA phenotypes that are more closely associated with N'Dama than susceptible breeds, whether there are any indications of associations with aspects of health and productivity of N'Dama cattle under trypanosome challenge.

In the survey of MHC and CLA phenotypes, several antigens occurred more frequently in both N'Dama populations than in the susceptible Boran population (Figure 38).

The possibility of associations of MHC and CLA phenotypes with production and health parameters was investigated in a subset of the Zaire N'Dama population. The cattle had been maintained under relatively high trypanosome challenge for 3.5 years, during which parasitaemia and PCV aspects were measured monthly. Reproductive performance and calf growth

data covered 146 calving intervals. Several significant relationships were found between four phenotypes and health and performance parameters. For example, the IL-A37-defined CLA phenotype is positively associated with superior performance (14% increase in cow productivity); the ED-A13-defined MHC phenotype is negatively associated (11% increase in cow productivity); and the two combine additively (25% increase in cow productivity) (Table 72).

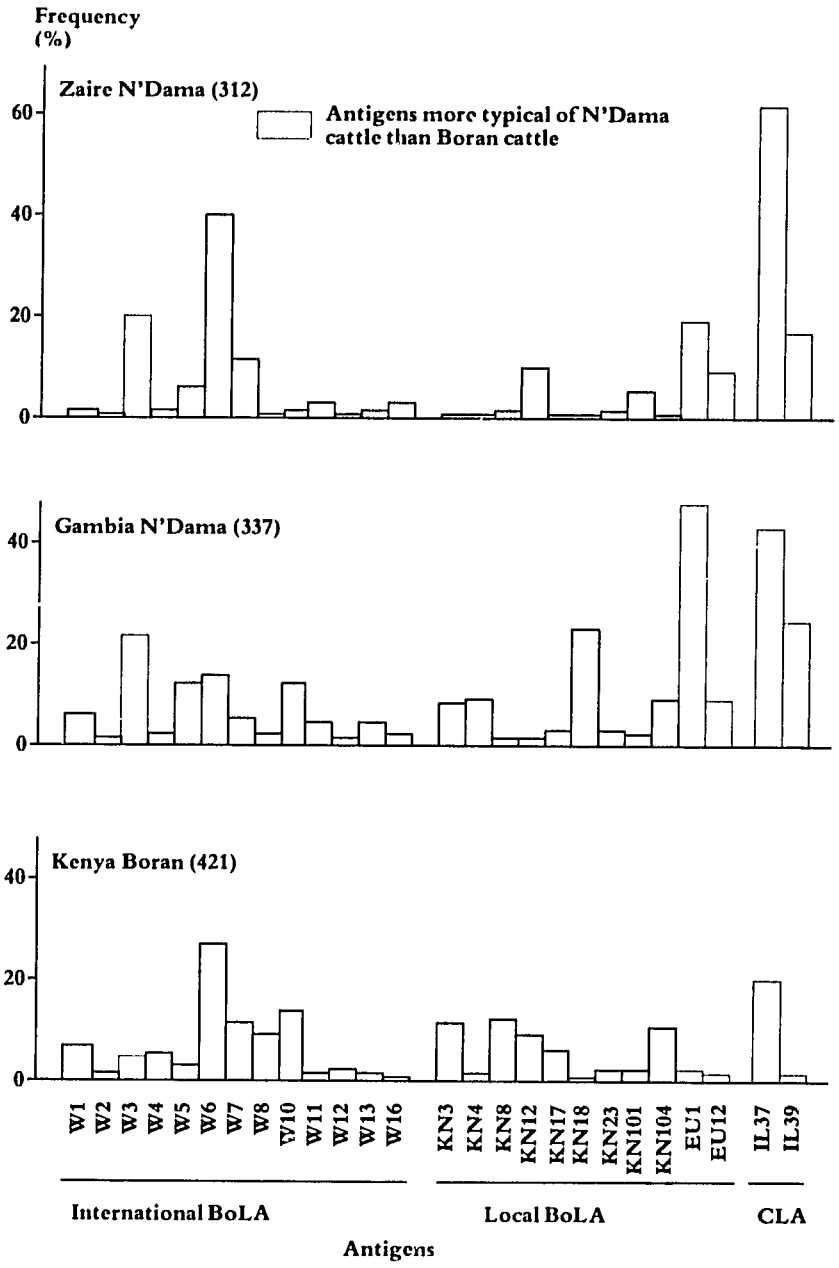


Figure 38.
The frequencies of major histocompatibility complex antigens (BoLA) and common leukocyte antigen (CLA) phenotypes in two populations of N'Dama (Gambia and Zaire) and one population of Boran cattle.

Sample numbers are shown in parentheses. The antigen prefix 'W' denotes an MHC antigen recognised at a full international workshop. The prefixes KN and EU denote antigens defined by ILRAD and a European workshop, respectively. All MHC antigens shown are defined by clusters of typing reagents. The common leukocyte antigens IL37 and IL39 are detected by mAb IL-A37 and IL-A39, respectively.

Table 72. *Least-squares means for effects of IL-A37-defined CLA phenotype, ED-A13-defined MHC phenotype, and both combined, on performance.*

Phenotype defined by	No. of records	Calving interval (days)		Calf weaning weight (kg)		Cow productivity[1] (kg)	
		$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
IL-A37 +	67	420	16.1	138	3.0	125	3.6
IL-A37 -	79	473	14.5	133	2.7	109	3.3
ED-A13 +	77	461	15.4	133	2.8	111	3.4
ED-A13 -	69	435	16.3	138	2.9	123	3.6
IL-A37+/ED-A13-	35	418	22.3	141	4.2	129	4.7
IL-A37+/ED-A13+	32	422	23.3	135	4.1	121	5.0
IL-A37-/ED-A13-	34	452	22.2	135	4.4	118	4.8
IL-A37-/ED-A13+	45	489	19.4	132	3.6	103	4.2

[1] Weight of weaned calf per cow per year.

Work was started in 1988 on determining heritabilities and genetic correlations between the various components of trypanotolerance, covering numbers, types and intensities of parasitaemias; control of anaemia; and ability to acquire resistance. Use of blood grouping has been shown to be feasible as a means of determining parentage and key N'Dama populations in Zaire and Gabon have been sampled. The search for genetic markers is well under way, and already there have been promising indications.

It is now clear that the monthly recording of matching animal health and performance characteristics has, at certain sites, allowed more accurate classification of animals than has ever before been available. Once the routine blood grouping operations have provided the necessary family linkages, there are distinct possibilities of progress through identification of genetic markers. This would of course allow breeding decisions to be made without having to expose animals to a controlled trypanosomiasis challenge and the resultant loss of production.

Biological and economic evaluation of productivity responses to interventions

This theme evaluates the integration of technology into production systems. Work areas in 1988 included:

- the use of insecticide-impregnated traps and screens and the use of deltamethrine insecticide in cattle dip for tsetse control;
- the effect on cattle health and production of using trypanocidal drugs;
- the efficacy of nutritional supplementation for improving the health and productivity of trypanotolerant cattle;
- the introduction of N'Dama cattle under a village metayage system; and
- preparations for pilot selection programmes with N'Dama cattle.

A tsetse control programme was started in early 1988 in the Boundiali area of northern Côte d'Ivoire. The programme uses cypermethrin-impregnated biconical tsetse traps sited along the Bogoue river, a tributary of the Niger flowing northwards through Boundiali District. The prevalences of trypanosomes in cattle herds both within and outside the area of tsetse control and tsetse populations in these areas have been monitored simultaneously to evaluate the effectiveness of the control campaign. Data

on other animal health and productivity parameters are also being obtained, while baseline data collected before the tsetse control campaign will be used for additional evaluation. Initial indications are that the relative densities of *G. palpalis* and *G. tachinoides* fell dramatically within the first few months of the campaign.

As reported in *ILCA Annual Report 1987* (page 75), at Muhaka, Kenya, the use of chemoprophylaxis increased the overall productivity of East African Zebu cattle maintained under village conditions by 20% and that of younger stock by 19%. Subsequent economic analyses showed that cattle production was more profitable when the animals were treated prophylactically with trypanocidal drugs than when they received therapeutic treatments. Prophylaxis was still profitable even if expenditure on the prophylactic drug, Samorin, doubled. Within herds, the profitability of prophylaxis was directly related to the increase in lactation yield. There were clear indications that the use of Samorin was economically favourable only above a certain level of trypanosomiasis risk, which depended on the relationship between drug cost and product value.

Previous studies have suggested that the degree of trypanotolerance can be influenced by the nutritional status of the animal. Therefore in 1988 a trial was conducted at ITC sites in The Gambia to investigate the effect of partial supplementation on changes in PCV levels of infected and non-infected trypanotolerant cattle. Two groups of animals were exposed to the same levels of trypanosomiasis risk: animals in the control group grazed only natural pasture, while animals in the second group received in addition a daily supplement of 4 kg of a rice bran and groundnut cake or sesame cake mixture.

Supplementation significantly reduced the effect on PCV levels of trypanosome infection (Table 73). PCV fell only slightly in response to trypanosome infection in supplemented animals, whereas there were large falls in PCV in non-supplemented animals. These preliminary results confirm that improved feeding contributes to maintenance of PCV levels under trypanosomiasis risk.

The use of trypanotolerant cattle is being evaluated in areas where they have not traditionally been found. Trypanotolerant cattle were recently introduced to the Idiofa villages in Zaire, and health and performance data from these villages are being used to assess the biological and economic response to the use of these cattle in this area.

Table 73. *Least-squares means for packed cell volume (PCV) levels (%) under different nutritional supplementation and trypanosome infection statuses.*

Supplementation status	Trypanosome infection status		
	Not infected	1 parasitaemic month	> 1 parasitaemic month
	Mean PCV ± SE		
3 months post-infection			
Supplemented	30.6 ± 1.01	29.4 ± 1.31	29.3 ± 1.52
Non-supplemented	27.4 ± 1.05	24.3 ± 1.16	21.5 ± 2.02
6 months post-infection			
Supplemented	30.5 ± 0.90	30.1 ± 1.16	29.0 ± 1.35
Non-supplemented	26.7 ± 0.93	24.3 ± 1.03	21.9 ± 1.80

Collaboration with national agricultural research systems

Fifteen professional staff in NARS were closely involved in research activities of the Trypanotolerance Thrust in 1988. In addition, 38 papers based on Thrust research were published or presented at scientific meetings during the year. Of the 62 authors of these publications, 35 were from NARS, 15 were from ILCA, and 12 were from other international organisations in Africa or overseas.

Training

Fifty-six scientist-days were spent on individual training at field sites by an entomologist and two veterinarians from the coordinating office. The areas covered were:

- Aspects related to cattle–tsetse interactions and the role of biting flies in trypanosomiasis epidemiology (7 days at OGAPROV, Gabon)
- Aspects of trypanosome identification using DNA probes, and improvement of tsetse dissection and trypanosome identification by standard methods (13 days in Boundiali, Côte d'Ivoire; 6 days in Ghibe, Ethiopia)
- Use of trypanocidal drugs, aspects of drug resistance and diagnostics of anaemia-producing diseases (12 days in Boundiali, Côte d'Ivoire)
- Aspects of trypanosomiasis epidemiology and infertility in male and female cattle (6 days at OGAPROV, Gabon)
- Use of blood groups for parentage determination (10 days in Zaire ranches, 2 days at OGAPROV, Gabon).

THRUST STAFF

J C M Trail, *Thrust Coordinator*
G d'Ieteren, *African Trypanotolerant Livestock Network Coordinator*
K Agyemang, *Animal Scientist*
P Itty, *FAO Associate Specialist*
D Little, *Animal Nutritionist*
J McIntire, *Agricultural Economist*
S Nagda, *Data Analyst*
A Ouattara, *Assistant to the Network Coordinator*
M Rarieya, *Senior Data Analyst*
F van Winckel, *Agronomist (Assigned to ILCA by AGCD*, Belgium)*
Woudyalew Mulatu, *Veterinarian, Project Supervisor (Ghibe)*
Getachew Tikubet, *Graduate Associate (Ghibe)*

---

* *Administration générale de la coopération au développement.*

Livestock Policy and Resource Use Thrust

Better policies and resource management are crucial to livestock development in Africa. Policy problems are ubiquitous and broadly similar 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 environments.

Problems of resource use 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.

The research in this thrust therefore focuses on cross-country comparison of critical policy issues affecting production and technology uptake, and on the sustainability of crop and livestock production in the rangelands and the semi-arid zone.

Policy services

Effective policy making and analysis require well-informed policy makers and well-trained policy analysts. This theme aims to provide policy makers with useful information and to train Africa's livestock policy analysts.

The main policy services activities in 1988 were:

- running the African Livestock Policy Analysis Network (ALPAN);
- preparation of a policy training manual;
- running a training course in English on livestock policy analysis; and
- writing a manual of livestock systems research

The sixth series of ALPAN papers was issued in October. The papers, all by non-ILCA authors, covered pastoral development interventions, stall-feeding of cattle and price policy, and collecting and processing livestock statistics.

The draft policy training manual was substantially revised during 1988 in the light of experiences gained from courses offered in 1986 and 1987.

The third policy training course was held in September. This year the 4-week course was offered in English, and was attended by 21 participants (14 from East Africa, 2 from southern Africa and 5 from West Africa).

Substantial progress was made during the year in writing a manual of livestock systems research. This is intended to make available to national research organisations past experience of livestock systems research, especially, but not exclusively, that gained by ILCA during the past 10 years. The manual has two main sections, the first dealing with systems description and diagnosis, and the second with on-farm trials. A first draft of the manual was completed at the end of 1988, with the exception of the modules on animal traction and data-analysis. The manual will be completed in the first half of 1989. The contents of the manual are as follows:

Section one

User's guide to section 1
Module 1. Using baseline data and exploratory surveys in livestock systems research
Module 2. Diagnostic surveys in livestock systems research
Module 3. Labour inputs
Module 4. Household budgets and assets
Appendix 1.1 Wealth ranking as a method of identifying target groups or recommendation domains
Module 5. Animal production
Module 6. Range resource evaluation
Module 7. Animal nutrition
Module 8. Animal health
Module 9. Animal traction
Module 10. Livestock marketing
Module 11. Management practices
Module 12. Organisation, presentation and analysis of results

Section two

Module . Definitions, problems and initial considerations in planning livestock on-farm trials
Module 2. Implementation, monitoring and evaluation of livestock on-farm trials
Appendix 2.1 On-farm feeding trials: Additional considerations
Appendix 2.2 On-farm animal health trials: Additional considerations

Policy research

Financing and staffing of livestock services in sub-Saharan Africa: A cross-country analysis

There have been strong indications (e.g. the resurgence of rinderpest after the JP15 campaign) that the livestock services in many African countries tended to deteriorate in the 1970s. Although this was recognised, both by African policy makers and external donors, as a policy and management issue, there has been little investigation of how financing and staffing policies may have contributed to this deterioration. Between 1984 and 1988 ILCA carried out a cross-country study on financing and staffing of livestock services to:

- determine how livestock services are financed in different African countries;
- analyse the factors determining the pattern of government recurrent expenditure and staffing;

- analyse the relationship between financing policy and the quantity and quality of services; and
- draw implications for policy.

Unpublished official reports for 22 countries in sub-Saharan Africa were reviewed. Supplemental information was obtained from a literature review and from discussions with staff of livestock services in some countries. Data, mostly for the 1970s, were used for both the descriptive and analytic parts of the study. Complete data were not available for all 22 countries and some analyses do not cover all 22 countries. The analysis was carried out using multiple regression methods.

A detailed report of the study was given in *ILCA Annual Report 1987* (pages 82–84). Across countries, increases in total recurrent expenditure on livestock services were accompanied by increases in the proportion expended on salaries, resulting in a declining proportion of non-salary expenditure. Staffing structures favoured increases in the proportion of high-level staff relative to junior staff, particularly in countries where cattle accounted for a large proportion of the national livestock population.

Richer countries and those with a higher proportion of animal protein consumption spent more per person on livestock services. There was an overall significant and negative relationship between changes in livestock numbers (dependent variable) and changes in both total and salary expenditure per tropical livestock unit (TLU). Changes in milk yield indices (dependent variable) were positively and significantly related to the rate of increase in total and staff expenditure per TLU, the proportion of the agricultural gross domestic product (GDP) provided by livestock and the cost of purchased inputs relative to the gross value of livestock output, expressed as a percentage. The relationship between real expenditure per person (dependent variable) and the proportion of the country's land area that was infested with tsetse flies was negative and significant. The current lack of economic methods of tsetse/trypanosomiasis control or eradication is likely to have been a factor.

Impact of livestock pricing policies on meat and milk output in selected countries of sub-Saharan Africa

Livestock pricing policies in sub-Saharan Africa often have broad objectives such as efficient expansion of output and promotion of food security and sustainability. Each of these objectives can be achieved through a variety of policy instruments such as taxes, subsidies and price controls. While some of these objectives and policy instruments are mutually reinforcing, they can also conflict. The overall aim of this research is to quantify the effects of different policy options, thereby helping to promote better decision making and better incentives for producers. The specific objectives of this project are to:

- compare objectives and policy instruments relating to the livestock sector in selected sub-Saharan African countries; and
- estimate the effects of direct and indirect price interventions on livestock output, incentives and technology adoption.

The study is being conducted through interviews with policy makers and officials involved in livestock marketing, and analysis of a wide range of primary and secondary published materials.

A summary measure of the incentives or disincentives created by government pricing policies that affect output markets is provided by the

nominal protection coefficient (NPC). This is defined as the ratio of the domestic price to the border price. An NPC of less than one indicates a potential disincentive to production, i.e. producers are being taxed. Conversely, an NPC greater than one indicates that domestic producers are being protected, i.e. subsidised, by such policy measures as tariffs or other import restrictions. For consumers, the NPC is interpreted vice-versa. Results are presented here for three of the countries included in the study. Between 1973 and 1986, it appears that policy measures in Mali have implicitly taxed producers and subsidised consumers, while the converse is the case in Nigeria (Figures 39 and 40). Both producers and consumers in Zimbabwe were implicitly subsidised (i.e. protected) for most of the period.

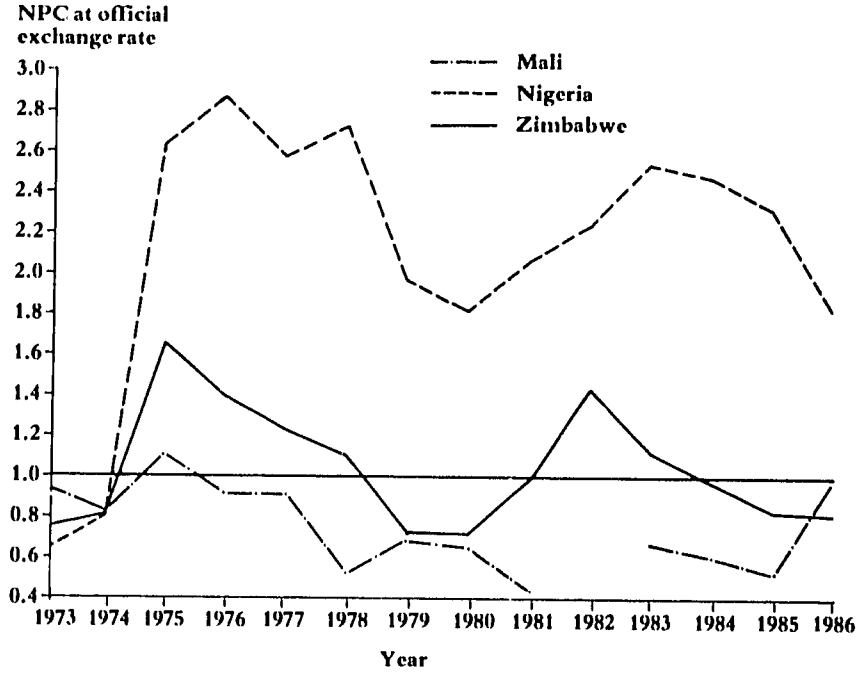


Figure 39.
Nominal protection coefficients (NPCs) for beef producers in Mali, Nigeria and Zimbabwe, 1973–86.

A comparative study of the humid and subhumid zones: land tenure policy and technology adoption

Alley farming, feed gardens and fodder banks will only be adopted by people with rights and access to land. This study investigated the implications of land and tree tenure systems for the acceptability and viability of these innovations. The study covered areas of the humid and subhumid zones in Nigeria.

A detailed study was made in 1988 of the land tenure rules in the humid areas of Oyo State. Interviews were conducted first with indigenous farmers and later with settled Fulani pastoralists who have been in the area for various

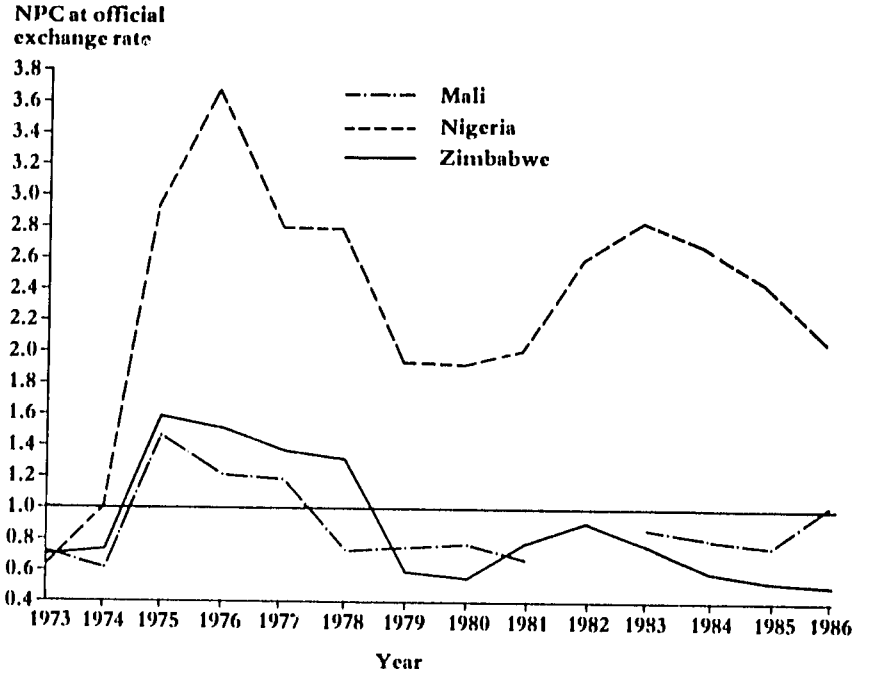


Figure 40. *Nominal protection coefficients (NPCs) for beef consumers in Mali, Nigeria and Zimbabwe, 1973–86.*

lengths of time. This supplemented earlier work in south-east Nigeria. In the subhumid zone, indigenous farmers and pastoral Fulani were interviewed in three areas where fodder banks had been established. Rules of land tenure examined included those covering the acquisition, inheritance and disposal of land, the role of male kin, women's rights to land and the relationship of indigenous farmers to the Fulani. A literature review was also carried out.

Problems relating to land tenure have not changed radically over time and appear particularly important as constraints to the adoption of fenced fodder banks or planted trees. Communal control of farm land undermines both the right to plant trees and the incentive to invest in increasing soil fertility. This is especially so in south-east Nigeria, where the rights of the individual to dispose of family land are restricted. Although the individual has more rights to dispose of land in the south-west and in the subhumid zone areas studied, these rights may still be subject to family veto. Family members may overrule any individual transaction that affects the total family holding.

In many areas there is a tradition of allowing non-indigenes access to land. This cannot be taken as an indication of increasing division of land holdings as it does not involve title to land. Conflict can result from government interference and pastoral settlement. Relationships between the Fulani and indigenous farmers improve over time as a relationship based on socio-economic exchange develops.

Farmers tend to classify forage legumes as a relatively permanent investment, especially where these require fencing for fodder banks. Indigenous landowners must anticipate benefits to themselves before they allow non-indigenous farmers to plant legumes or fence for fodder banks. Planting legumes on crop land primarily to improve soil fertility would be generally acceptable to the indigenous farmers. Intensive feed gardens or small fodder banks are also acceptable and could benefit women who own small ruminants.

Range trends

Trends in the productivity of range resources of the West African Sahel

ILCA scientists in Mali continued monitoring range resources at 20 sites in the Gourma. At nine sites, 0.1 ha plots have been fenced to allow investigation of seed production and dispersion, plant establishment, tillering, root development and nitrogen and phosphorus export under different management conditions.

Between 1984 and 1987 rainfall in the Gourma was below the region's long-term average. In contrast, rainfall in 1988 was above average and was well distributed. This allowed assessment of the potential for regeneration of natural pastures suffering varying degrees of degradation or desertification. At most sites the amount of plant biomass produced by the end of the growing season was substantially more than in the previous year, demonstrating the resilience of these Sahelian rangelands.

The amount of biomass produced on some sites is still well below potential yields calculated using the ANAPLUIE model (Table 74). This difference between potential and actual biomass production is mainly due to low soil seed-stocks and a change in plant stand in favour of short-season colonising plant species. The plant community is beginning to diversify at some, less degraded sites, but this will take longer on sites where the soil has been eroded.

Table 74. *Actual and potential[1] herbaceous biomass production at four pasture sites in the Gourma, Mali, 1984 to 1988.*

	Site 1		Site 5		Site 10		Site 19	
	Actual	Potential	Actual	Potential	Actual	Potential	Actual	Potential
	Maximum standing biomass (kg/ha)							
1984	276	188	63	281	116	-	172	-
1985	<50	194	138	460	<50	349	564	782
1986	<10	402	538	736	722	1516	824	1255
1987	270	640	640	518	(12)	53	790	617
1988	681	641	1566	1086	478	1266	1175	1034

[1] Potential biomass production calculated using the ANAPLUIE model. This model is described in: Hiernaux P. 1984. Distribution des pluies et production herbacée au sahel: Une méthode empirique pour caractériser la distribution des précipitations journalières et ses effets sur la production herbacée. ILCA Programme Document AZ 98. 48 pp.

On the fenced plots, harvesting the annual grass pasture every 15 days during the growing season halved total dry-matter yield compared with the maximum amount of biomass produced on uncut areas (564 vs 1232 kg DM/ha). Repeated harvesting also increased nitrogen offtake by 19% (17.0 vs 14.3 kg N/ha) and phosphorus offtake by 26% (1.01 vs 0.80 kg P/ha) relative to the highest offtakes from a single cut. This indicates that heavy grazing is likely to reduce the amount of feed available to livestock and may degrade the ecosystem by depleting soil nitrogen and phosphorus.

Prediction of vegetation cover, rainfall, growing season and crop yield using satellite data

In many African countries the wide separation of meteorological stations and the poor reporting and reliability of data prevent early analysis of crop growing conditions. Existing approaches to drought early warning and crop forecasting rely mostly on analysis of climatic data and field observations. However, remotely sensed data are increasingly used to complement conventional sources of information in forecasting. Green vegetation absorbs red (R) and infrared (IR) light differentially, and it has been shown that the "normalised difference vegetation index" [NDVI = (IR – R)/(IR + R)] is roughly proportional to green cover and biomass.

The use of satellite data has shown promise in range and crop monitoring, but there have been few studies in Africa that relate such data to vegetation conditions on the ground. Therefore in 1985, ILCA and the United Nations Environment Programme (UNEP) started a project in Kenya aimed at testing the use of NDVI generated from satellite data (satellite NDVI[1]) as an indicator of plant growth and growing conditions over a wide range of vegetation types, from high-altitude forest, through agricultural land, to semi-arid and arid rangelands. Low-altitude flights were made with a light aircraft on which was mounted a radiometer and camera. NDVI from the aircraft-mounted radiometer (aircraft NDVI) and vegetation parameters recorded from the corresponding aerial photographs were cross-correlated with satellite NDVI. Vegetation parameters were measured at ground level at the start of the project. The project was designed to elucidate how the four main vegetation parameters (herbaceous cover and greenness, and woody cover and greenness) were correlated with aircraft and satellite NDVI.

[1] Recent satellites of the National Oceanic and Atmospheric Administration (NOAA), USA, are equipped with advanced very-high-resolution radiometers (AVHRR). Data from the AVHRR was used for the "satellite NDVI" in this study.

Results of the project, completed in 1988, lead to five tentative conclusions concerning the use of satellite NDVI to predict and monitor plant growing conditions:

- For rangeland areas in arid and semi-arid zones where woody cover is low, satellite NDVI can predict end-of-season forage supplies to within about 0.4 t DM/ha, particularly when NDVI is integrated over the whole growing season.
- Rough estimates of woody cover can be obtained for dry seasons, provided the NDVI values are not strongly influenced by atmospheric haze or other distorting factors. These estimates can be used to adjust predictions of herbaceous biomass.
- Correlations between integrated NDVI and seasonal rainfall offer promise in identifying rainfall conditions in broad classes over large areas. Coupled with analyses of temporal NDVI profiles, the start and the end of the "green season" can be determined. This time span appears closely related to the length of the growing season as defined by soil-moisture-balance techniques.
- The initial increase in NDVI after the dry season appears to be a sensitive indicator of the start of the growing season. Where relationships have been established between crop yields and the onset of the rains and the amount of early rain, NDVI values can help provide early forecasts of yields over large areas. However, this requires rapid and efficient means of satellite data transfer.
- Low-altitude radiometry and aerial photography have a continued role in calibrating satellite NDVI responses in both rangeland and cropping areas with unreliable rainfall. Further research is needed to explore approaches that combine rainfall analyses, crop simulation modelling, temporal NDVI monitoring and airborne spot calibration.

Resource services

Resource survey

For more than 10 years, ILCA has been using low-level aerial surveys to estimate livestock populations and associated ecological parameters. However, recently ILCA has had less need of such surveys in relation to its own work. The Centre owns two aeroplanes suitable for low-level aerial surveying and has an experienced survey team. At the time of ILCA's strategy review in 1987, it was decided that ILCA should continue to provide its low-level aerial survey capacity to research and development organisations in Africa on a cost-recovery basis.

There was little demand for low-level aerial surveys in Africa in 1988. Early in the year, ILCA took part in a third round of survey work for the Centre de suivi écologique, Senegal (see *ILCA Annual Report 1987*, page 85). The work was, however, hampered by bad weather. This appears to have been the only such aerial survey work on a significant scale to have been carried out by anyone in sub-Saharan Africa in 1988.

For 1989, ILCA has been subcontracted to provide a plane and pilot for a very large study in Nigeria, and has been selected to carry out a survey of Isiolo District of Kenya.

THRUST STAFF

S Sandford, *Thrust Coordinator*
Addis Anteneh, *Economist*
Assefa Eshete, *Photo Interpreter*
A N Atta-Krah, *Agronomist*
L Diarra, *Ecologist*
P A Francis, *Agro-economist (until May 1988)*
P Hiernaux, *Ecologist*
P N de Leeuw, *Ecologist*
Michel Corra, *Ecologist*
Tassew G/Medhin, *Pilot*
T O Williams, *Visiting Research Fellow*

Training and Information

In 1988 the Training and Information Department, ILCA's "seventh Thrust", channelled its work through five major themes. These are reported on here.

The Department works closely with, and complements, the six research thrusts in strengthening the technical expertise of the national agricultural research systems (NARS). ILCA's researchers teach in the Centre's courses and supervise individual "trainees"; the Training and Information Department leads the educational design of courses and training materials and handles the administration of training activities. The Department's library and documentation resources and expertise provide support to training activities, ILCA research, NARS research and ILCA/NARS collaborative projects. By offering a range of publishing outlets the Department also assists in writing up and communicating results of ILCA/NARS research projects.

Increasingly the Department is channelling its programmes and services through the research networks coordinated by ILCA. As they develop, the networks and the collaborative research projects they foster become the focus for ILCA's training and information activities. They help in selecting the most appropriate training participants and to target the Department's information services more accurately. Above all they provide a way to assess accurately the training and information needs of ILCA's clients and collaborators.

Training

Group training

Nine group training courses were offered in 1988 (Table 75), compared with eight in 1987. Six of the courses were given in English; three were in French. Two (*Standardisation of Livestock Production Data* and *Rural Dairy Processing*) were organised jointly with the Food and Agriculture Organization of the United Nations (FAO).

The number of applications received increased from 355 in 1987 to 426 in 1988. The number of people attending courses also increased, from 160 in 1987 to 177 in 1988. Training courses are being developed in line with ILCA's six research thrusts and collaborative research networks.

Table 75. *Group training courses at ILCA, 1988.*

Course title	Language of instruction[1]	Thrust focus[2]	Number of participants	Number of countries
Forage Evaluation Techniques	F	4	19	15
Small Ruminant Production Techniques	E	2	20	13
ILCA/FAO Standardisation of Livestock Production Data	F	1,2,3,5	19	13
Applied Statistics for African Animal Scientists[3]	E	A	20	14
Economics of Animal Health and Disease Control	F	1,2,3	20	14
ILCA/FAO Rural Dairy Processing	E	1	15	10
Livestock Policy Analysis	E	6	21	11
Forage Evaluation Techniques	E	4	23	10
Animal Nutrition and Forage Analysis	E	1,2,3,4	20	13
Total			177	40

[1] E = English; F = French.

[2] 1 = Cattle Milk and Meat; 2 = Small Ruminant Meat and Milk; 3 = Animal Traction; 4 = Animal Feed Resources; 5 = Trypanotolerance; 6 = Livestock Policy and Resource Use; A = all thrusts.

[3] Course given for the first time.

During the year the Department increased its follow-up of trainees to determine how valuable ILCA courses have been in participants' subsequent activities and careers.

Individual training

Thirty-four scientists completed individual associateships with ILCA in 1988.

Two Post-doctoral Associates (from Ghana and Mali) completed assignments with the Cattle Milk and Meat Thrust, and two (from Tanzania and Uganda) with the Animal Feed Resources Thrust. Six Graduate Associates completed their ILCA research projects and higher degree theses. In the short-term individual training categories, three Undergraduate Associates completed final-year research projects during 1988 and three Research Fellows used ILCA's computer facilities to complete analysis of data from their national research projects. Eighteen Technician Associates completed training periods in 1988, principally in animal nutrition and analytical laboratory techniques, and in the provision of library and documentation services.

ILCA research teams trained and supervised several other NARS staff during the year. These included four animal scientists, five agronomists and two M.Sc. students in Mali. Staff of the Trypanotolerance Thrust also gave individual training on a range of topics related to the work of the African Trypanotolerant Livestock Network to NARS staff in Côte d'Ivoire, Ethiopia and Gabon.

Such individual training arrangements have enabled ILCA to further develop its joint programmes with its collaborators in the African NARS.

Training materials and methods

The Training Materials and Methods Unit of the Training Section was created in 1988 under the direction of an agricultural education specialist. This Unit incorporates the former Audio-Visuals and Mapping Unit. It leads the development of training materials and teaching methods, but also provides services in preparing presentation aids and photographic materials.

In 1988 the Unit started to develop a variety of training materials and helped IITA staff in the design of courses and the use of various teaching methods. It also provided graphic, photographic, mapping and audio-visual services to IITA staff and the Centre's NARS collaborators. The Unit's main emphasis was on improving the quality of overhead and slide transparencies. A new IITA slide show was produced. Four video-tape presentations were also produced in 1988.

Information

Documentation

IITA's Information Section has created an information database on the NARS of sub-Saharan Africa—the primary partners in IITA's research, training and information programmes. The database contains information at both the national level (economic indicators, policy, human and animal population, relations with IITA etc) and the institutional level (objectives, organisational structure, manpower, budget, facilities, research programmes, publications, relations with IITA etc). Sources of information include survey data, NARS reports, back-to-office reports of IITA staff, trainees and visitors, and general publications. In 1988 information on 39 countries and 54 NARS was collected and entered in the database.

Some 800 searches of IITA's bibliographic database were made in 1988 for IITA staff and others. The database now holds more than 54 000 entries. The library also gained on-line access to external databases: the Pan-African Documentation and Information System (PADIS) database of the United Nations Economic Commission for Africa and the Inter-Agency Development Research Information (IDRIS) database from the International Development Research Centre (IDRC), Canada.

IITA's selective dissemination of information (SDI) service provided 900 NARS users in sub-Saharan Africa with monthly updates of abstracts from the databases of the Commonwealth Agricultural Bureaux International (CABI) and the FAO agricultural information system, AGRIS. The Section continued to provide its Current Titles service to 109 libraries throughout sub-Saharan Africa. Under this service the Section photocopies the contents pages of journals recently acquired by the IITA library, groups these by subject area and distributes them to other libraries. In 1988 the Section made more than 410 000 photocopies and 30 000 microfiches and distributed them to users of its services.

The Section introduced a new bibliography series, *Quick Bibliographies*, in 1988. These are generated from IITA's database and list references on key topics. The series is primarily aimed at members of the networks coordinated by IITA. The first quick bibliography, on *Trypanosomiasis and tsetse flies*, was prepared in two volumes, covering the periods 1907–1979 and 1980–1988. Bibliographies for Kenya and Madagascar, listing non-conventional literature collected through the IITA/IDRC microfiche project, were

published and distributed to participating institutes in these countries and to other users.

Four visiting scientists (three of them from Africa) each spent from 3 to 6 months reviewing one of the following topics:

- Reproductive wastage in small ruminants.
- The role of multipurpose trees in ruminant nutrition.
- Calf nutrition and management in sub-Saharan Africa.
- Crop residues in African farming systems.

The reviews will be published in 1989 and 1990. This project is funded by IDRC.

The Information Section updated in 1988 its microfiche collection of non-conventional documents from Ethiopia. Staff visited the Ministry of Agriculture, the Institute of Agricultural Research and the Alemaya University of Agriculture and microfilmed 970 non-conventional documents dealing with livestock production and related fields.

One month in-service training on documentation techniques was given to each of three staff members of national agricultural research institutes of Kenya, Nigeria and Togo. Four staff members of various national institutes in Ethiopia were given short training courses on microfiche techniques.

Publishing

Several of ILCA's publications were redesigned or altered in scope in 1988 to encourage our NARS partners to publish through ILCA and to reflect the changes in the Centre's research orientation. The *ILCA Newsletter* now carries articles about work by NARS, either in collaboration with ILCA or alone. The *ILCA Annual Report* has been redesigned to allow thrust-based reporting. Other publications, including the *ILCA Bulletin* and the monograph series, are also being redesigned.

Questionnaires were sent to 6500 people on ILCA's mailing list in January 1988 to determine the usefulness of the Centre's publications and remove from the mailing list those who do not need or use ILCA's publications. Reminders were sent in June and September to those who failed to respond to the first questionnaire. By the end of the year just over half the people who were sent questionnaires had responded; those who did not respond are being removed from the mailing list.

In October 1988 the Section organised an inter-centre meeting of international agricultural research centres (IARCs) on translation issues. The meeting, the first of its kind, highlighted the short- and long-term activities needed to improve centres' translation services and explored avenues for collaboration among the centres. It was attended by representatives from 10 IARCs, the CGIAR Secretariat and four other organisations.

Staff list

Professional and Supervisory staff (as at 31 May 1989)

DIRECTOR GENERAL's OFFICE

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

RESEARCH DEPARTMENT

K J Peters, *Deputy Director General (Research)*
A Tall, *Assistant to the Deputy Director General (Research)*

Animal Science Division

Animal Nutrition and Management

P Chigaru, *Animal Production Scientist*
B S Capper, *Animal Scientist*
H Khalili, *Associate Scientist*
E A Olaloku, *Visiting Scientist*
A N Said, *Animal Nutritionist/ARNAB Coordinator*
Tekalegn Tadesse, *Chief Research Assistant*
T Varvikko, *Associate Scientist*

Animal Management

D L Coppock, *Animal Scientist/Ecologist*
Belete Dessalegn, *Animal Scientist*

Animal Traction

M R Goe, *Animal Scientist*
E Zerbini, *Animal Scientist (Post-doctoral Associate)*

Dairy Technology

C B O'Connor, *Dairy Technologist*

Small Ruminant Network

R T Wilson, *Animal Scientist/Network Coordinator*

Animal Reproduction and Health

O B Kasali, *Head of Section*
R Franceschini, *Veterinarian (Research Associate)*
E Mukasa-Mugerwa, *Animal Scientist*
S Sovani, *Veterinarian (Research Associate)*
Tamrat Yigzaw, *Chief Laboratory Technician*
Tekelye Bekele, *Veterinarian*

Plant Science Division

J Tothill, *Head of Division*

Forage Agronomy

R Griffiths, *Head, Herbage Seed Unit*
J Hanson, *Genebank Manager*
J Lazier, *Forage Agronomist*
T J Ruredzo, *Tissue-culture Specialist (Post-doctoral Associate)*

Soil and Plant Nutrition

I Haque, *Soil Scientist*
N Luyindula, *Soil Microbiologist (Post-doctoral Associate)*

Livestock Economy Division

S Sandford, *Head of Division*
Addis Anteneh, *Economist*
R Brokken, *Economist*
J McIntire, *Economist*
P Ngategize, *Economist (Post-doctoral Associate)*
A Pann, *Economist (Post-doctoral Associate)*
Senait Seyoum, *Chief Research Assistant*

Research Support Division

Computer Science and Biometrics

E Bruns, *Manager, Computer Services*
T Metz, *Scientific Programmer*
E Richardson, *Biometrician*

Experiment Stations

Aklilu Askabe, *Farm and Grounds Manager*
Tadesse Tessema, *Station Coordinator (Debre Zeit)*

Negussie Akalework, *Station Coordinator (Debre Birhan)/Project Supervisor*

Resource Assessment and Management

Assefa Eshete, *Photo Interpreter*
Michel Corra, *Ecologist*
Tassew G. Medhin, *Pilot*

Zonal Research Sites

Highlands—Ethiopia

S Jutzi, *Team Leader/Agronomist*
Abate Tedla, *Forage Agronomist*
Abiye Astatke, *Agricultural Engineer*
H Airaksinen, *Associate Expert*
K-D Gautsch, *Animal Scientist*
Getachew Asamenew, *Agricultural Economist*
U Schulthess, *Agronomist (Research Associate)*

Humid Zone—Nigeria

L Reynolds, *Team Leader/Animal Scientist*

Subhumid Zone—Nigeria

R von Kaufmann, *Team Leader/Agricultural Economist*
C desBordes, *Animal Scientist*
M A Mohamed-Saleem, *Forage Agronomist*
G Tarawali, *Forage Agronomist*

Subhumid/Semi-arid Zone—Mali

P Bartholomew, *Team Leader/Forage Agronomist*
M Cissé, *Ecologist*
S Debrah, *Economist*
D Diakite, *Administrator*
A K Diallo, *Animal Scientist/Special Assistant to DDG (R)*
L Diarra, *Ecologist*
K Fofana, *Chief Accountant*
P Hiernaux, *Ecologist*
S Maiga, *Veterinarian*
M Mattoni, *Veterinarian*
A Reese, *Animal Scientist*
S Soumare, *Sociologist*
A Traoré, *Sociologist*

Semi-arid Zone/Trypanotolerance—Kenya

J C M Trail, *Team Leader/Animal Geneticist*
F Chabari, *Agricultural Economist*
P N de Leeuw, *Ecologist*
G d'Ieteren, *Trypanotolerance Network Coordinator*
B H I Dzowela, *PANESA Coordinator*
S Nagda, *Senior Biological Data Analyst*
A Okuome, *Administrative Officer*
A Ouattara, *Bilingual Assistant to the Trypanotolerance Network Coordinator*
J M Rarieya, *Biological Data Assistant*
G J Rowlands, *Animal Production Scientist*
W Thorpe, *Animal Scientist*

Semi-arid Zone—Gambia-Senegal

K Agyemang, *Animal Production Scientist*
D A Little, *Animal Nutritionist*

Network Sites

Network Site—Trypanotolerance, *Ethiopia*
Woudyalew Mulatu, *Project Supervisor*

OUTREACH DEPARTMENT

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

TRAINING AND INFORMATION DEPARTMENT

Training

L Padolina, *Administrative Assistant*
B Tripathi, *Agricultural Educator, Training Materials and Methods*
Werqu Mekasha, *Training and Conferences Officer*

Information

Michael Hailu, *Head of Information Section*
S Adoutan, *Translator/Editor*
I Alipui, *Assistant Editor*
Azeb Abraham, *Librarian*
Manyahlishal Kebede, *Production Manager*
Marcos Sahlu, *Supervisor, Documentation*
P J H Neate, *Science Writer*
D Niang, *Revisor/Editor*
J Stares, *English Editor/Writer*
C De Stoop, *Assistant Translator*

ADMINISTRATION

B Johri, *Personnel Manager*
Ahmed Osman, *Assistant Personnel Officer*
A Conti, *Personnel Officer*
F Leone, *Physical Plant Manager*
Pietro Monaia, *Supervisor, Maintenance*
Sahle Kebede, *Catering Officer*
Tekeste B. Habtu, *Procurement Officer*
Tesfaye Mekoya, *Chief Safety Officer*
J Thersby, *Warden*

FINANCE

M Klass, *Financial Controller*
Belayhoun Wondimu, *Chief Accountant*
Emmanuel Tesfamariam, *Budget Officer*
Negussie Abraham, *Supervisor, General Accounts*
Kiros Tsegaye, *Supervisor, Disbursement and Collection*

List of publications by ILCA staff in 1988

Annual Reports

ILCA Annual Report 1987
CIPEA Rapport Annuel 1987

Programme and budget

Sustainable production from livestock in sub-Saharan Africa: ILCA's programme and funding requirements, 1989–1993.

Research reports

Edwards K A, Classen G A and Schroten E H J. 1988. *L'exploitation des ressources hydrauliques en Afrique tropicale*. CIPEA Rapport de recherche 6, Addis Abeba.

Wagenmaar K T, Diallo A and Sayers A R. 1988. *Productivité des bovins peuls transhumants dans le delta intérieur du Niger au Mali*. CIPEA Rapport de recherche 13, Addis Abeba.

Wilson R T. 1988. *La productivité animale au Mali central: études à long terme sur les bovins et les petits ruminants dans le système agropastoral*. CIPEA Rapport de recherche 14, Addis Abeba.

Bulletins

ILCA Bulletin Nos 30, 31 and 32
Bulletin du CIPEA Nos 27, 28, 29 and 30

Newsletters

ILCA Newsletter Vol 7 (Nos 1, 2, 3 and 4) (E and F)*
ALPAN Newsletter No. 6 (E)
ALPAN Network Papers Nos 16, 17 and 18 (E)
ARNAB Newsletter Vol.7 (Nos 1, 2 and 3)
PGRC/E-ILCA Germplasm Newsletter Nos 16 and 17
Forage Network in Ethiopia Newsletter Nos 17, 18, 19 and 20
The Animal Traction Newsletter No. 1
The PANESA Newsletter Nos 5, 6 and 7
The Small Ruminant Newsletter Nos 11, 12 and 13 (E and F)

* E = English; F = French

Training manual

O'Mahony F. 1988. Rural dairy technology. Experiences in Ethiopia. *ILCA Manual* No. 4. 64 pp.

Indexes/bibliographies

Tesfai Berhane and Sirak Teklu (compilers). 1988. *Index to livestock literature microfiched in Kenya*. ILCA, Addis Ababa.

Mekonnen Asefa (compiler). 1988. *Index des documents microfichés par l'équipe CIPEA/CRDI à Madagascar*. ILCA, Addis Abeba.

Conference reports

ILCA/ILRAD (International Laboratory for Research on Animal Diseases). 1988. *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. 473 pp.

Jutzi S C, Haque I, McIntire J and Stares J E S (eds). 1988. *Management of Vertisols in sub-Saharan Africa*. Proceedings of a conference held at ILCA, Addis Ababa, Ethiopia, 31 August to 4 September, 1987. 435 pp.

Pasture Network for Eastern and Southern Africa (PANESA). 1988. *African forage plant genetic resources, evaluation of forage germplasm and extensive livestock production systems*. Proceedings of the Third Workshop held at the International Conference Centre, Arusha, Tanzania, 27–30 April 1987. ILCA, Addis Ababa. 488 pp.

Reed J D, Capper B S and Neate P J H (eds). 1988. *Plant breeding and the nutritive value of crop residues*. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 7–10 December 1987. ILCA, Addis Ababa. 334 pp.

Papers, books and chapters of books

Addis Anteneh, Sandford S and Berhanu Anteneh. 1988. Policy, finance and technology in livestock development in sub-Saharan Africa: Some critical issues. *ILCA Bulletin* 31:2–13.

Agyemang K, Nkhonjera L P, Butterworth M H and McIntire J. 1988. Productivity and profitability of cattle stall-fed for beef on smallholder farms in Malawi. *ILCA Bulletin* 32:2–13.

Atta-Krah A N. 1988. Research on *Gliricidia* germplasm evaluation and improvement in West Africa. In: Gliricidia sepium *(Jacq) Walp: Management and improvement*. NFTA Special Publication 87–01. 255 pp.

Atta-Krah A N and Sumberg J E. 1988. Studies with *Gliricidia sepium* for crop/livestock production systems in West Africa. *Agroforestry Systems* 6:97–118.

Bedingar T and Bobst B W. 1988. A dynamic analysis of demand and supply relationships for the U.S. beef cattle industry and their policy implications. *Kentucky University Agricultural Economics Research Report* 49. 47 pp.

Chabari F N, Ackello-Ogutu C A and Odhiambo M O. 1987. Factors determining market prices of small ruminants from a pastoral production system in Kenya. *East African Agricultural and Forestry Journal* 52(4):286–292. [Published in 1988]

Coppock D L, Ellis J E and Waweru S K. 1988. A comparative *in vitro* digestion trial using mocula of livestock from South Turkana and Kitale, Kenya. *Journal of Agricultural Science (Cambridge)* 110:61–63.

Coppock D L, Ellis J E and Swift D M. 1988. Seasonal patterns of activity, travel and water intake of livestock in South Turkana, Kenya. *Journal of Arid Environments* 14:319–331.

Coppock D L, Ellis J E and Swift D M. 1987. Seasonal food habits of livestock in South Turkana, Kenya. *East African Agricultural and Forestry Journal* 52(3):196–207. [Published in 1988]

Coppock D L, Swift D M, Ellis J E and Waweru S K. 1987. Seasonal nutritional characteristics of livestock forage in South Turkana, Kenya. *East African Agricultural and Forestry Journal* 52(3):162–175. [Published in 1988]

Cossins N J and Upton M. 1988. The impact of climatic variation on the Boran pastoral system. *Agricultural Systems* 27:117–135.

Diarra L. 1988. Changes in *Vetiveria nigritiana* and *Eragrostis barteri* grasslands in the Niger floodplain, central Mali. *ILCA Bulletin* 31:14–18.

Ezenwa I V. 1988. Utilisation of forage legumes in pastures in southwest Nigeria. M. Sc. thesis, University of Ibadan, Nigeria.

Francis P A. 1988. Ox draught power and agricultural transformation in northern Zambia. *Agricultural Systems* 27:35–49.

Francis P A. 1988. Some aspects of sheep and goat management in southeast Nigeria. *ILCA Bulletin* 30:20–25.

Grandin B E. 1988. *Wealth ranking in smallholder communities: A field manual*. Intermediate Technology Publications Ltd., London, UK. ISBN 185339005 4.

Grandin B E. 1988. Wealth and pastoral dairy production: A case study from Maasailand. *Human Ecology* 16(1):2–21.

Gryseels G. 1988. Role of livestock on mixed smallholder farms in the Ethiopian highlands. A case study from the Baso and Worena Wereda near Debre Berhan. Dissertation, Agricultural University, Wageningen, The Netherlands. 263 pp.

Hiernaux P. 1988. Vegetation monitoring by remote sensing: Progress in calibrating a radiometric index and its application in the Gourma, Mali. *ILCA Bulletin* 32:14–21.

Holden S j. 1988. Dairy marketing and pastoralism: Implications for development in the southern Ethiopian rangelands. M.Sc. thesis, Department of Agricultural Economics and Management, University of Reading, Reading, UK. 67 pp.

Hoste C H, Chalon E, d'Ieteren, G D M and Trail J C M. 1988. *Le bétail trypanotolerant en Afrique occidentale et centrale. Tome 3 – Bilan d'une décennie*. Etude FAO. Production et santé animales 20/3. Food and Agriculture Organization of the United Nations, Rome, Italy.

Hulet H. 1988. Improving millet/cowpea intercropping in the semi-arid zone of Mali. *ILCA Bulletin* 31:27–31.

Kabaija E and Smith O B. 1988. The effect of age of regrowth on content and release of manganese, iron, zinc and copper from four tropical forages incubated in sacco in rumen of sheep. *Animal Feed Science and Technology* 20:171–176.

Kabaija E and Smith O B. 1988. Trace element kinetics in the digestive tract of sheep fed diets with graded levels of dietary fibre. *Journal of Animal Physiology and Animal Nutrition* 59:218–224.

de Leeuw P N and Wilson R T. 1987. Comparative productivity of indigenous cattle under traditional management in sub-Saharan Africa. *Quarterly Journal of International Agriculture* 26:377–390.

Marcos Sahlu. 1988. Data transfer from an HP computer to a Linotype typesetter: ILCA's experience. *MINISIS Newsletter* 7(1):11–12.

Mukasa-Mugerwa E and Tekelye Bekele. 1988. The reproductive performance of Ethiopian highland sheep. *Animal Reproduction Science* 17:95–102.

Mukasa-Mugerwa E, Tekelye B and Kasali O B. 1988. The effect of handling methods on subsequent plasma progesterone levels in sheep. *Veterinary Research Communications* 13:75–79.

Neate P J H. 1988. A systems approach to livestock research in sub-Saharan Africa. *Entwicklung + ländlicher raum* 3/88:16–18.

Neate P J H. 1988. Livestock: A key to African food production. *African Sunrise* 2(2):30–33.

Nicholson M J and Little D A. 1988. Skinfold thickness, condition score and tritiated water space in Boran cattle. *ILCA Bulletin* 30:8–9.

Njau B C, Kasali O B and Scholtens R G. 1988. Abomasal impaction associated with anorexia and mortality in lambs. *Veterinary Research Communications* 12:491–495.

Njau B C, Kasali O B, Scholtens R G and Mesfin Degefa. 1988. Review of sheep mortality in the Ethiopian highlands, 1982–86. *ILCA Bulletin* 31:19–22.

Njau B C, Kasali O B, Scholtens R G and Mesfin Degefa. 1988. Field and laboratory studies of causes of sheep mortality in the Ethiopian highlands, 1986/87. *ILCA Bulletin* 31:23–26.

Nnadi L A and Haque I. 1988. Root nitrogen transformation and mineral composition in selected forage legumes. *Journal of Agricultural Science (Cambridge)* 111:513–518.

Nnadi L A and Haque I. 1988. Agronomic effectiveness of rock phosphates in an Andept of Ethiopia. *Communications in Soil Science and Plant Analysis* 19(1): 79–90.

Nnadi L A and Haque I. 1988. Forage legumes in African crop–livestock systems. *ILCA Bulletin* 30:19–19.

Peters K J and Tothill J C. 1988. Strategy of ILCA to improve productivity of pasture and forage resources in Africa. *Giessener Beiträge zur Entwicklungsforschung*, Reihe I, Band 17:35–49.

Reynolds L and Ekwuruke J O. 1988. The effect of *Trypanosoma vivax* infection in West African Dwarf sheep at two planes of nutrition. *Small Ruminant Research* 1:175–188.

Reynolds L and Francis P A. 1988. The effect of PPR control and dipping on village goat populations in southwest Nigeria. *ILCA Bulletin* 32:22–27.

Rodriguez G Jr and Anderson F M. 1988. A case study of risk–return tradeoffs in a mixed farming system in highland Ethiopia. *Agricultural Systems* 27:161–177.

Senait Seyoum. 1988. The economics of a biogas digestor. *ILCA Bulletin* 30:2–7.

Sumberg J E and Atta-Krah A N. 1988. The potential of alley farming in humid West Africa: A re-evaluation. *Agroforestry Systems* 6:163–168.

Tanner J C. 1988. *Acacia* fruit supplementation of maize stover diets fed to sheep. M.Sc. thesis, Department of Animal Production, University of Reading, Reading, UK. 85 pp.

Tawonezvi H P R, Ward H K, Trail J C M and Light D E. 1988. Evaluation of beef breeds for rangeland weaner production in Zimbabwe. 1. Productivity of purebred cows. *Animal Production* 47:351–359.

Tawonezvi H P R, Ward H K, Trail J C M and Light D E. 1988. Evaluation of beef breeds for rangeland weaner production in Zimbabwe. 2. Productivity of crossbred cows and heterosis estimates. *Animal Production* 47:361–367.

Tekelye Bekele, Mukasa-Mugerwa E and Kasali O B. 1988. The prevalence of cystic ercosis and hydatidosis in Ethiopian sheep. *Veterinary Parasitology* 28:267–270.

Ward P N, Saeed A M, Light D E and Wilson R T. 1988. Reproductive performance of Kenana cows in Sudan. *Tropical Agriculture (Trinidad)* 65:73–76.

Waters-Bayer A. 1988. Dairying by settled Fulani agropastoralists in central Nigeria. The role of women and implications for dairy development. *Farming Systems and Resource Economics in the Tropics*, Volume 4. 328 pp.

Wilson R. T. 1988. The productivity of Sahel goats and sheep under transhumant management in northern Burkina Faso. *Bulletin of Animal Health and Production in Africa* 36:348–355.

Wilson R T and Bourzat D. 1988. Past, present and future research on the one-humped camel in Africa. A review. *Journal of Arid Environments* 14:1–15.

Wilson R T and Durkin J W. 1988. Livestock production in central Mali: Reproductive components in traditionally managed sheep and goats. *Livestock Production Science* 19:523–529.

Wilson R T and Murayi T. 1988. Production characteristics of African long-fat-tailed sheep in Rwanda. *Small Ruminant Research* 1:3–17.

Wilson R T and Traoré A. 1988. Livestock production in central Mali: Reproductive performance and reproductive wastage in ruminants in the agro-pastoral system. *Theriogenology* 29:931–944.

Woodward A. 1988. Chemical composition of browse in relation to relative consumption of species and nitrogen metabolism of livestock in southern Ethiopia. Ph.D. dissertation, Department of Animal Science, Cornell University, Ithaca, New York, USA. 195 pp.

Papers published in proceedings

Abiye Astatke, Jutzi S C and Grunder M. 1988. Effects of surface soil drainage on soil erosion and wheat growth on a gently sloping Vertisol at Debre Zeit, Ethiopia. In: S C Jutzi, I Haque, J McIntire and J E S Stares (eds), *Management of Vertisols in sub-Saharan Africa*. Proceedings of a conference held at ILCA, Addis Ababa, Ethiopia, 31 August–4 September, 1987. ILCA, Addis Ababa. pp. 288–289 (Abstract).

Adeoye K B, Folorunso O A and Mohamed-Saleem M A. 1988. Effects of adsorbed cations on the physical properties of Vertisols in the Lake Chad basin of northeast Nigeria. In: S C Jutzi, I Haque, J McIntire and J E S Stares (eds), *Management of Vertisols in sub-Saharan Africa*. Proceedings of a conference held at ILCA, Addis Ababa, Ethiopia, 31 August–4 September, 1987. ILCA, Addis Ababa. pp. 127–128 (Abstract).

Agyemang K, Jeannin P, Grieve A S, Bah M L and Dwinger R H. 1988. Milk extraction for human consumption from N'Dama cattle under village management conditions. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi,

Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 231–245.

Akyeampong E and Tekalign Mamo. 1988. Response of *Sesbania sesban* to nitrogen and phosphorus fertilization on two Ethiopian Vertisols. In: S C Jutzi, I Haque, J McIntire and J E S Stares (eds), *Management of Vertisols in sub-Saharan Africa*. Proceedings of a conference held at ILCA, Addis Ababa, Ethiopia, 31 August–4 September, 1987. ILCA, Addis Ababa. pp. 256–257 (Abstract).

Cobbina J. 1988. Vertisols of Ghana: Uses and potential for improved management using cattle. In: S C Jutzi, I Haque, J McIntire and J E S Stares (eds), *Management of Vertisols in sub-Saharan Africa*. Proceedings of a conference held at ILCA, Addis Ababa, Ethiopia, 31 August–4 September, 1987. ILCA, Addis Ababa. pp. 359–378.

Coulibaly L, Diarrasouba I, d'Ieteren G D M, Itty P, Maehl J H H, Mahamat B, Nagda S M, Paling R W, Rarieya J M, Schuetterle A, Thorpe W and Trail J C M. 1988. Effect of endemic diseases including trypanosomiasis on the blood packed cell volume of livestock in northern Ivory Coast. *International Scientific Council for Trypanosomiasis Research and Control, Nineteenth Meeting, Lome, Togo, 1987*. Organization of African Unity Scientific and Technical Research Commission. pp. 552–555.

Coulibaly L, Diarrasouba I, d'Ieteren G D M, Hecker P, Itty P, Maehl J H H, Mahamat B, Nagda S M, Paling R W, Rarieya J M, Schuetterle A, Thorpe W and Trail J C M. 1988. Disease interactions in cattle and sheep in northern Côte d'Ivoire. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 110–118.

Defly A, Awuome K, Bokovi K, d'Ieteren G D M, Grundler G, Handlos M, Itty P, Maehl J H H, Morkramer G, Nagda S M, Rarieya J M, Thorpe W and Trail J C M. 1988. Effect of trypanosome infection on livestock health and production traits in two areas of Togo. *International Scientific Council for Trypanosomiasis Research and Control, Nineteenth Meeting, Lome, Togo, 1987*. Organization of African Unity Scientific and Technical Research Commission. pp. 526–529.

Defly A, Awuome K, Bokovi K, d'Ieteren G D M, Grundler G, Handlos M, Itty P, Leak S G A, Maehl J H H, Mawuena K, Morkramer G, Nagda S M, Paling R W, Rarieya J M, Thorpe W and Trail J C M. 1988. Effect of trypanosome infection on livestock health and production in Togo (poster presentation). In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 251–256.

d'Ieteren G D M and Trail J C M. 1988. An overview of the African Trypanotolerant Livestock Network. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 31–34.

d'Ieteren G D M, Awuome K, Bokovi K, Chema S, Coulibaly L, Defly A, Dumont P, Feron A, Grundler G, Handlos M, Itty P, Jeannin P, Maehl J H H, Maloo S H, Morkramer G, Mulungo M, Nagda S M, Ordner G, Paling R W, Rarieya J M, Schuetterle A, Sheria M, Thorpe W, Trail J C M and Yangari G. 1988. Genetic and environmental factors affecting the epizootiology and pathogenesis of trypanosomiasis in livestock at eight sites within the African Trypanotolerant Livestock Network. *International Scientific Council for Trypanosomiasis Research and Control, Nineteenth Meeting, Lome, Togo, 1987*. Organization of African Unity Scientific and Technical Research Commission. pp. 275–281.

d'Ieteren G D M, Awuome K, Bokovi K, Chema S, Colardelle C, Coulibaly L, Defly A, Feron A, Grundler G, Handlos M, Hecker P, Itty P, Kakiese O, Leak S G A, Maehl J H H, Maloo S H, Mawuena K, Minengu M, Morkramer G, Mukendi F, Wudyalew Mulatu, Mulungo M, Nagda S M, Nankodaba G, Ngamuna S, Ordner G, Paling R W, Pelo M, Rarieya J M, Schuetterle A, Sheria M, Thorpe W, Getachew Tikubet, Trail J C M and Yangari G. 1988. Genetic and environmental factors affecting trypanosome prevalence and parasitaemia in livestock. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 87–99.

d'Ieteren G D M, Awuome K, Bokovi K, Chema S, Colardelle C, Coulibaly L, Defly A, Feron A, Grundler G, Handlos M, Hecker P, Itty P, Kakiese O, Leak S G A, Maehl J H H, Maloo S H, Mawuena K, Minengu M, Morkramer G, Mukendi F, Wudyalew Mulatu, Mulungo M, Nagda S M, Nankodaba G, Ngamuna S, Ordner G, Paling R W, Rarieya J M, Schuetterle A, Sheria M, Thorpe W, Getachew Tikubet, Trail J C M and Yangari G. 1988. Trypanosome infections and other factors influencing PCV in livestock. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 161–167.

Dwinger R H, Grieve A S, Jeannin P, Agyemang K and Faye J. 1988. Anti-trypanosomal antibodies in sequentially collected sera of N'Dama cattle under natural trypanosomiasis risk in The Gambia. In: *The African Trypanotolerant Livestock Network:*

Livestock production in tsetse affected areas of Africa. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 100–109.

Feron A, d'Ieteren G D M, Itty P, Maehl J H H, Mulungo M, Nagda S M, Paling R W, Rarieya J M, Sheria M, Thorpe W and Trail J C M. 1988. Can PCV be used as an indicator of trypanosomiasis and production level in cattle? *International Scientific Council for Trypanosomiasis Research and Control, Nineteenth Meeting, Lome, Togo, 1987*. Organization of African Unity Scientific and Technical Research Commission. pp.534–537.

Feron A, d'Ieteren G D M, Durkin J W, Itty P, Kakiese O, Maehl J H H, Mulungo M, Nagda S M, Paling R W, Pelo M, Rarieya J M, Sheria M, Thorpe W and Trail J C M. 1988. Productivity of ranch N'Dama cattle under trypanosomiasis risk. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 246–250.

Francis P A. 1988. Livestock and farming systems in southeast Nigeria. In: O B Smith and H G Bosman (eds), *Goat production in the humid tropics*. PUDOC, Wageningen, The Netherlands. pp. 159–169.

Getachew Asamenew, Jutzi S C, Abate TedPa and McIntire J. 1988. Economic evaluation of improved Vertisol drainage for food crop production in the Ethiopian highlands. In: S C Jutzi, I Haque, J McIntire and J E S Stares (eds), *Management of Vertisols in sub-Saharan Africa*. Proceedings of a conference held at ILCA, Addis Ababa, Ethiopia, 31 August–4 September, 1987. ILCA, Addis Ababa. pp. 263–283.

Getachew Asamenew, Jutzi S C, McIntire J and Abate Tedla. 1988. Diagnosis of traditional farming systems in some Ethiopian highland Vertisol areas. In: S C Jutzi, I Haque, J McIntire and J E S Stares (eds), *Management of Vertisols in sub-Saharan Africa*. Proceedings of a conference held at ILCA, Addis Ababa, Ethiopia, 31 August–4 September, 1987. ILCA, Addis Ababa. pp. 384–385 (Abstract).

Getachew Tikubet, Wollega Duffera, Girma Tegene, Leak S G A, Wudyalew Mulatu and Richardson T. 1988. Odour attractants for *Glossina pallidipes* in south-western Ethiopia. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 125–129.

Goe M R. 1988. Effect of tillage frequency of clay soils on the draught of the Ethiopian ard (*maresha*). In: S C Jutzi, I Haque, J McIntire and J E S Stares (eds), *Management of Vertisols in sub-Saharan Africa. Proceedings of a conference held at ILCA, Addis Ababa, Ethiopia, 31 August–4 September, 1987*. ILCA, Addis Ababa. pp. 380–381 (Abstract).

Goe M R and Reed J D. 1988. Utilisation of feed resources by draught animals on smallholder farms in the Ethiopian highlands. In: S C Jutzi, I Haque, J McIntire and J E S Stares (eds), *Management of Vertisols in sub-Saharan Africa*. Proceedings of a conference held at ILCA, Addis Ababa, Ethiopia, 31 August–4 September, 1987. ILCA, Addis Ababa. pp. 382–383 (Abstract).

Gryseels G. 1988. The role of livestock in the generation of smallholder farm income in two Vertisol areas of the central Ethiopian highlands. In: S C Jutzi, I Haque, J McIntire and J E S Stares (eds), *Management of Vertisols in sub-Saharan Africa*. Proceedings of a conference held at ILCA, Addis Ababa, Ethiopia, 31 August–4 September, 1987. ILCA, Addis Ababa. pp. 345–358.

Hakiza J J, Lazier J R and Sayers A R. 1988. Characterisation and preliminary evaluation of accessions of *Zornia* species from the ILCA collection. In: Pasture Network for Eastern and Southern Africa (PANESA), *African forage plant genetic resources, evaluation of forage germplasm and extensive livestock production systems*. Proceedings of the Third Workshop held at the International Conference Centre, Arusha, Tanzania, 27–30 April 1987. ILCA, Addis Ababa. pp. 149–173.

Hakiza J J, Lazier J R and Sayers A R. 1988. Characterisation and evaluation of forage legumes in Ethiopia: Preliminary examination of variation between accessions of *Stylosanthes fruticosa* (Retz.) Alston. In: Pasture Network for Eastern and Southern Africa (PANESA), *African forage plant genetic resources, evaluation of forage germplasm and extensive livestock production systems*. Proceedings of the Third Workshop held at the International Conference Centre, Arusha, Tanzania, 27–30 April 1987. ILCA, Addis Ababa. pp. 174–191.

Hanson J and Lazier J R. Forage germplasm at the International Livestock Centre for Africa. In: Pasture Network for Eastern and Southern Africa (PANESA), *African forage plant genetic resources, evaluation of forage germplasm and extensive livestock production systems*. Proceedings of the Third Workshop held at the International Conference Centre, Arusha, Tanzania, 27–30 April 1987. ILCA, Addis Ababa. pp. 69–73.

Itty P. 1988. Modelling possible effects of nutritional interventions on natural N'Dama cattle production in The Gambia. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 404–410.

Itty P, Chema S, d'Ieteren G D M, Durkin J W, Leak S G A, Maehl J H H, Maloo S H, Mukendi F, Nagda S M, Rarieya J M, Thorpe W and Trail J C M. 1988.

Economic aspects of chemoprophylaxis for control of trypanosomiasis in village East African Zebu in Kenya. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 360–376.

Jeannin P, Grieve A S, Agyemang K, Clifford D J, Munro C D and Dwinger R H. 1988. Reproductive performance of N'Dama cattle kept under village management in The Gambia. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 174–183.

Jibbo J M C, Durkin J W, Light D E, Murray M, Sones K and Trail J C M. 1988. Chemoprophylaxis: Its successful use in the control of trypanosomiasis in Boran cattle, at Mkwaja Ranch, Tanzania. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 274–282.

Jutzi S C, Abate Tedla, Mesfin Abebe and Desta Beyene. 1988. Inter-institutional modes of operation in research and development of improved Vertisol technologies for the Ethiopian highlands. In: S C Jutzi, I Haque, J McIntire and J E S Stares (eds), *Management of Vertisols in sub-Saharan Africa*. Proceedings of a conference held at ILCA, Addis Ababa, Ethiopia, 31 August–4 September, 1987. ILCA, Addis Ababa. pp. 389–398.

Kabaija E. 1988. Influence of supplementary phosphorus on performance of crossbred dairy calves fed a basal ration of poor quality grass hay. In: *Proceedings of the VI World Conference on Animal Production*. World Animal Breeding Association, Helsinki, Finland. p. 449.

Kabaija E and Little D A. 1988. Nutrient quality of forages in Ethiopia with particular reference to mineral elements. In: Pasture Network for Eastern and Southern Africa (PANESA), *African forage plant genetic resources, evaluation of forage germplasm and extensive livestock production systems*. Proceedings of the Third Workshop held at the International Conference Centre, Arusha, Tanzania, 27–30 April 1987. ILCA, Addis Ababa. pp. 440–448.

Kabaija E and Smith O B. 1988. Effect of season, fertilizer application and age of regrowth on mineral content of guinea grass (*Panicum maximum* Schum) and Giant Star grass (*Cynodon nlemfuensis* Chedda). In: Pasture Network for Eastern and Southern Africa (PANESA), *African forage plant genetic resources, evaluation of forage germplasm and extensive livestock production systems*. Proceedings of the Third Workshop held at the International Conference Centre, Arusha, Tanzania, 27–30 April 1987. ILCA, Addis Ababa. pp. 458–467.

Kahurananga J. 1988. The screening of perennial *Trifolium* species mainly from the Ethiopian highlands and their potential for use in pasture. In: Pasture Network for Eastern and Southern Africa (PANESA), *African forage plant genetic resources, evaluation of forage germplasm and extensive livestock production systems*. Proceedings of the Third Workshop held at the International Conference Centre, Arusha, Tanzania, 27–30 April 1987. ILCA, Addis Ababa. pp. 120–126.

Kamara C S and Haque I. 1988. Soil moisture storage along a toposequence in the Ethiopian highlands. In: S C Jutzi, I Haque, J McIntire and J E S Stares (eds), *Management of Vertisols in sub-Saharan Africa*. Proceedings of a conference held at ILCA, Addis Ababa, Ethiopia, 31 August–4 September, 1987. ILCA, Addis Ababa. pp. 183–200.

Kamara C S and Haque I. 1988. Soil moisture related properties of Vertisols in the Ethiopian highlands. In: S C Jutzi, I Haque, J McIntire and J E S Stares (eds), *Management of Vertisols in sub-Saharan Africa*. Proceedings of a conference held at ILCA, Addis Ababa, Ethiopia, 31 August–4 September, 1987. ILCA, Addis Ababa. pp. 201–222.

Kasali O B, Njau B C and Tekelye Bekele. 1988. Controlling livestock diseases in the tropics by breeding: A perspective. In: E F Thomson and F S Thomson (eds), *Increasing small ruminant productivity in semi-arid Areas*. ICARDA, Aleppo, Syria. pp. 237–242.

Leak S G A, Awuome K, Wollega Duffera, Dumont P, Feron A, Jeannin P, Mahamat B, Mawuena K, Minengu M, Mulungo M, Nankodaba G, Ordner G, Sheria M, Getachew Tikubet, Tsotsi E, Toure M and Yangari G. 1988. Determination of tsetse challenge and its relationship with trypanosome prevalence in livestock within the African Trypanotolerant Livestock Network. *International Scientific Council for Trypanosomiasis Research and Control, Nineteenth Meeting, Lome, Togo, 1987*. Organization of African Unity Scientific and Technical Research Commission. pp. 542–547.

Leak S G A, Awuome K, Colardelle C, Wollega Duffera, Feron A, Mahamat B, Mawuena K, Minengu M, Mulungo M, Nankodaba G, Ordner G, Pelo M, Sheria M, Getachew Tikubet, Toure M and Yangari G. 1988. Determination of tsetse challenge and its relationship with trypanosome prevalence in trypanotolerant livestock. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 43–54.

de Leeuw P N and Nyambaka R. 1988. The prediction of rangeland production from rainfall data in arid and semi-arid eastern Africa. In: Pasture Network

for Eastern and Southern Africa (PANESA), *African forage plant genetic resources, evaluation of forage germplasm and extensive livestock production systems*. Proceedings of the Third Workshop held at the International Conference Centre, Arusha, Tanzania, 27–30 April 1987. ILCA, Addis Ababa. pp. 260–268.

Maehl J H H, Coulibaly L, Defly A, d'Ieteren G D M, Dumont P, Feron A, Grundler G, Itty P, Jeannin P, Leak S G A, Morkramer G, Mulungo M, Nagda S M, Ordner G, Paling R W, Rarieya J M, Schuetterle A, Sheria M, Thorpe W, Trail J C M and Yangari G. 1988. Health and performance of trypanotolerant cattle breeds exposed to quantified trypanosomiasis risk at five sites within the African Trypanotolerant Livestock Network. *International Scientific Council for Trypanosomiasis Research and Control, Nineteenth Meeting, Lome, Togo, 1987*. Organization of African Unity Scientific and Technical Research Commission. pp. 548–551.

Maehl J H H, Coulibaly L, Defly A, d'Ieteren G D M, Feron A, Grundler G, Hecker P, Itty P, Mawuena K, Morkramer G, Mulungo M, Nagda S M, Paling R W, Pelo M, Rarieya J M, Schuetterle A, Sheria M, Thorpe W and Trail J C M. 1988. Factors influencing liveweight in a range of Network situations. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 219–230.

Maloo S H, Chema S, Connor R, Durkin J W, Kimotho P, Maehl J H H, Mukendi F, Murray M, Rarieya J M and Trail J C M. 1988. Efficacy of chemoprophylaxis for East African Zebu cattle exposed to trypanosomiasis in village herds in Kenya. *International Scientific Council for Trypanosomiasis Research and Control, Nineteenth Meeting, Lome, Togo, 1987*. Organization of African Unity Scientific and Technical Research Commission. pp. 425–429.

Maloo S H, Chema S, Connor R, Durkin J W, Kimotho P, Maehl J H H, Mukendi F, Murray M, Rarieya J M and Trail J C M. 1988. The use of chemoprophylaxis in East African Zebu village cattle exposed to trypanosomiasis in Muhaka, Kenya. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 283–288.

McIntire J. 1988. Introduction to economic analysis in the African Trypanotolerant Livestock Network. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 350–359.

McIntire J, Reed J D, Jutzi S C, Abate Tedla and Yilma Kebede. 1988. Evaluating sorghum cultivars for grain and straw yield. In: Reed J D, Capper B S and Neate P J H (eds), *Plant breeding and the nutritive value of crop residues*. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 7–10 December 1987. ILCA, Addis Ababa. pp. 283–306.

Morkramer G, Defly A, d'Ieteren G D M, Grundler G, Itty P, Leak S G A, Maehl J H H, Mawuena K, Nagda S M, Rarieya J M, Thorpe W and Trail J C M. 1988. Economic aspects of recently introduced trypanotolerant livestock production under trypanosomiasis risk, in Avetonou area, Togo. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 377–388.

Msiska H D C, Dzowela B H and Munthali J T. 1988. Forage dry-matter productivity variation of *Panicum* and *Cynodon* ecotypes in Malawi. In: Pasture Network for Eastern and Southern Africa (PANESA), *African forage plant genetic resources, evaluation of forage germplasm and extensive livestock production systems*. Proceedings of the Third Workshop held at the International Conference Centre, Arusha, Tanzania, 27–30 April 1987. ILCA, Addis Ababa. pp. 104–111.

Msiska H D C, Munthali J T and Dzowela B H. 1988. Distribution of potential forage plants in Malawi. In: Pasture Network for Eastern and Southern Africa (PANESA), *African forage plant genetic resources, evaluation of forage germplasm and extensive livestock production systems*. Proceedings of the Third Workshop held at the International Conference Centre, Arusha, Tanzania, 27–30 April 1987. ILCA, Addis Ababa. pp. 46–53.

Mulungo M, d'Ieteren G D M, Feron A, Itty P, Maehl J H H, Nagda S M, Paling R W, Rarieya J M, Thorpe W and Trail J C M. 1988. Trypanosomiasis in N'Dama cattle in Zaire and its effects on their health and production. *International Scientific Council for Trypanosomiasis Research and Control, Nineteenth Meeting, Lome, Togo, 1987*. Organization of African Unity Scientific and Technical Research Commission. pp. 530–533.

Ngamuna S, d'Ieteren G D M, Itty P, Leak S G A, Maehl J H H, Minengu M, Nagda S M, Paling R W, Rarieya J M, Thorpe W and Trail J C M. 1988. Trypanosomiasis in N'Dama cattle under village management in Zaire. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 119–124.

Onim J F M and Dzowela B H. 1988. The distribution of *Sesbania* species in the PANESA region. In: Pasture Network for Eastern and Southern Africa (PANESA), *African forage plant genetic resources, evaluation of forage germplasm and extensive livestock production systems*. Proceedings of the Third Work-

shop held at the International Conference Centre, Arusha, Tanzania, 27–30 April 1987. ILCA, Addis Ababa. pp. 54–65.

Ordner G, Colardelle C, d'Ieteren G D M, Dumont P, Itty P, Jeannin P, Leak S G A, Maehl J H H, Nagda S M, Paling R W, Rarieya J M, Thorpe W, Trail J C M and Yangari G. 1988. Health and productivity of trypanotolerant and susceptible cattle in Gabon and the impact of strategic chemotherapy. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 310–317.

Ordner G, d'Ieteren G D M, Dumont P, Itty P, Jeannin P, Maehl J H H, Nagda S M, Paling R W, Rarieya J M, Thorpe W, Trail J C M and Yangari G. 1988. Comparative performance of trypanotolerant and more susceptible cattle breeds exposed to trypanosomiasis in Gabon. *International Scientific Council for Trypanosomiasis Research and Control, Nineteenth Meeting, Lome, Togo, 1987*. Organization of African Unity Scientific and Technical Research Commission. pp. 538–541.

Peters K J and Thorpe W. 1988. Current status and trends in on-farm performance testing of cattle and sheep in Africa. In: *Proceedings of the 3rd World Congress on Sheep and Beef Cattle Breeding*. Institut national de la recherche agronomique, Paris, France. pp. 275–293.

Reed J D, Yilma Kebede and Fussel L K. 1988. Factors affecting the nutritive value of sorghum and millet residues. In: J D Reed, B S Capper and P J H Neate (eds), *Plant breeding and the nutritive value of crop residues*. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 7–10 December 1987. ILCA, Addis Ababa. pp. 233–249.

Reynolds L. 1988. Livestock in agroforestry — a farming systems approach. In: M E Avery, M G R Cannell and C K Ong (eds), *Applications of biological research in Asian agroforestry*. Winrock International, Morrilton, Arkansas, USA (In press).

Reynolds L and Adediran S O. 1988. The effects of browse supplementation in the productivity of West African Dwarf sheep over two reproductive cycles. In: O B Smith and H G Bosman (eds), *Goat production in the humid tropics*. PUDOC, Wageningen, The Netherlands. pp. 83–91.

Reynolds L, Atta-Krah A N and Francis P A. 1988. A strategy for improving goat productivity under village production systems in the humid tropics. In: O B Smith and H G Bosman (eds), *Goat production in the humid tropics*. PUDOC, Wageningen, The Netherlands. pp. 29–37.

Riley J A, Agyemang K, Dwinger R H, Jeannin P, Grieve A S and Little D A. 1988. N'Dama cattle production in relation to nutritional interventions in villages in The Gambia. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 399–403.

Schuetterle A, Coulibaly L, Diarrasouba I, d'Ieteren G D M, Itty P, Konin N, Maehl J H H, Mahamat B, Nagda S M, Paling R W, Rarieya J M, Thorpe W and Trail J C M. 1988. Effect of trypanosome infection on livestock health and production traits in northern Côte d'Ivoire. *International Scientific Council for Trypanosomiasis Research and Control, Nineteenth Meeting, Lome, Togo, 1987*. Organization of African Unity Scientific and Technical Research Commission. pp. 521–525.

Sow R S, Denis J P and Trail J C M. 1988. Facteurs de variation génétique de la productivité du zébu Gobra: Croissance avant et après sevrage. In: *Proceedings of the 3rd World Congress on Sheep and Beef Cattle Breeding*. Institut national de la recherche agronomique, Paris, France. pp. 376–378.

Tarawali G. 1988. A forage intervention for agropastoralists in West Africa. Proceedings of the British Grassland Society Research Meeting held in Aberystwyth, Wales, from 13th–15th September, 1988.

Tarawali G, Mohamed-Saleem M A and von Kaufmann R. 1988. Legume-based cropping: A possible remedy to land tenure constraint to ruminant production in the subhumid zone of central Nigeria. In: Pasture Network for Eastern and Southern Africa (PANESA), *African forage plant genetic resources, evaluation of forage germplasm and extensive livestock production systems*. Proceedings of the Third Workshop held at the International Conference Centre, Arusha, Tanzania, 27–30 April 1987. ILCA, Addis Ababa. pp. 417–429.

Tekalign Mamo, Haque I and Kamara C S. 1988. Phosphorus status of some Ethiopian highland Vertisols. In: S C Jutzi, I Haque, J McIntire and J E S Stares (eds), *Management of Vertisols in sub-Saharan Africa*. Proceedings of a conference held at ILCA, Addis Ababa, Ethiopia, 31 August–4 September, 1987. ILCA, Addis Ababa. pp. 232–252.

Tessema S, Emojong E E, Maluti M and de Leeuw P N. 1988. A strategy of livestock research adapted to semi-arid small-scale mixed farming systems – the Katumani experience. In: Pasture Network for Eastern and Southern Africa (PANESA), *African forage plant genetic resources, evaluation of forage germplasm and extensive livestock production systems*. Proceedings of the Third Workshop held at the International Conference Centre, Arusha, Tanzania, 27–30 April 1987. ILCA, Addis Ababa. pp. 405–416.

Thorpe W, Coulibaly L, Defly A, d'Ieteren G D M, Feron A, Grundler G, Hecker P, Itty P, Maehl J H H, Mawuena K, Morkramer G, Mulungo M, Nagda S M, Paling R W, Pelo M, Rarieya J M,

Schuetterle A and Trail J C M. 1988. Factors influencing reproductive performance in a range of Network situations. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 210–218.

Thorpe W, d'Ieteren G D M, Feron A, Mundia M, Ross D, Sheria M, Spooner R and Trail J C M. 1988. Practical possibilities of blood grouping for parentage information: A pilot study in Zaire. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 430–432.

Trail J C M. 1988. Network research: Future developments. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 466–473.

Trail J C M, Colardelle C, d'Ieteren G D M, Dumont P, Itty P, Jeannin P, Maehl J H H, Nagda S M, Ordner G, Paling R W, Rarieya J M, Thorpe W and Yangari G. 1988. Evaluation of criteria of trypanotolerance. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 425–429.

Trail J C M, Feron A, Mulungo M, Pelo M, Kakiese O, d'Ieteren G D M, Itty P, Maehl J H H, Nagda S M, Rarieya J M, Thorpe W and Paling R W. 1988. Genetic aspects of criteria of trypanotolerance. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 433–439.

Trail J C M, Feron A, Pelo M, Colardelle C, Ordner G, d'Ieteren G D M, Durkin J W, Maehl J H H and Thorpe W. 1988. Selection in trypanotolerant cattle breeds in Africa. *Proceedings of the 3rd World Congress on Sheep and Beef Cattle Breeding*. Institut national de la recherche agronomique, Paris, France. pp. 613–624.

Vabi M B. 1988. Technology transfer in ruminant production systems of Kwara State, Nigeria. M.Sc. thesis, University of Ibadan, Ibadan. 235 pp.

Wagnew Ayalneh, Haile Regassa, Huda A K S and Virmani S M. 1988. Agroclimatic data analysis of selected locations in the Vertisols regions of Ethiopia. In: S C Jutzi, I Haque, J McIntire and J E S Stares (eds), *Management of Vertisols in sub-Saharan Africa*. Proceedings of a conference held at ILCA, Addis Ababa, Ethiopia, 31 August–4 September, 1987. ILCA, Addis Ababa. p. 108 (Abstract).

Wilson R T. 1988. Reproductive performance of African indigenous small ruminants under research station and traditional management. In: *Proceedings of the 17 World Conference on Animal Production*. World Association of Animal Production, Helsinki, Finland. p. 585.

Wissocq N M, Bell R, Durkin J W, Gettinby G, Light D E and Trail J C M. 1988. IDEAS: A tool for improved evaluation and utilization of animal genetic resources. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 449–455.

Wudyalew Mulatu, Getachew Tikubet, Wollega Duffera, Girma Tegene, d'Ieteren G D M, Itty P, Leak S G A, Maehl J H H, Nagda S M, Rarieya J M, Thorpe W, Trail J C M and Paling R W. 1988. Health and performance of zebu cattle exposed to quantified tsetse challenge in S W Ethiopia. In: *The African Trypanotolerant Livestock Network: Livestock production in tsetse affected areas of Africa*. Proceedings of a meeting held 23–27 November 1987, at Nairobi, Kenya. ILCA/ILRAD, Nairobi, Kenya. pp. 257–261.

Meetings attended by ILCA staff in 1988

African Association of Science Editors Meeting, Addis Ababa, Ethiopia, February.

All Africa Soil Science Society, Kampala, Uganda, December.

Alley Farming Research Network for Tropical Africa, Steering Committee Meeting, Ibadan, Nigeria, September.

Animal Production Society of Kenya Regional Conference, Nairobi, Kenya, November.

Collaborative Cattle Milk and Meat Research in West Africa, ILCA, Ibadan, October.

Development Alternatives for Women in a New Era (DAWN), African Regional Meeting, Ibadan, Nigeria, September.

First Meeting of the Joint Ministry of Agriculture/ILCA/Institute of Agricultural Research Rangelands Research Steering Committee, Ministry of Agriculture, Addis Ababa, Ethiopia, September.

Forage Network in Ethiopia General Meeting, ILCA, Addis Ababa, February.

ILCA Workshop on Collaborative Cattle Milk and Meat Research in West Africa, Ibadan, Nigeria, October.

Indigenous Browse for Small Ruminant Production, ILCA, Port Harcourt, Nigeria, September.

International Board for Plant Genetic Resources/United Nations Environment Programme/International Institute for Tropical Agriculture Workshop on Plant Genetic Resources in Africa, Nairobi, Kenya, September.

International Conference on Dryland Farming, Amarillo, Texas, USA, August.

International Crops Research Institute for the Semi-Arid Tropics/ILCA/UH Workshop on Adapted Farming in West Africa, Niamey, Niger, December.

International Development Research Centre East and Southern African Network Co-ordinators' Review Meeting, Nairobi, Kenya, May.

International Development Research Centre Science and Technology Information Project Management Meeting, ILCA, Addis Ababa, Ethiopia, November.

International Institute for Tropical Agriculture/ILCA/UH Workshop on Adapted Farming in West Africa, Cotonou, Benin, September.

International Irrigation Management Institute/Rockefeller Foundation Workshop on Social Science Perspectives on Managing Agricultural Technology, Lahore, Pakistan, September.

International Livestock-Tree-Cropping Workshop, FAO/MARDI, Serdang, Malaysia, December.

International Potato Centre/Rockefeller Foundation Workshop on Farmers and Food Systems, Lima, Peru, September.

IUFRO Workshop on Breeding Tropical Trees, Pattaya, Thailand, November/December.

Joint African Research Network for Agricultural Byproducts/Pasture Network for Eastern and Southern Africa Workshop on Utilisation of Research Results in Forages and Agricultural By-products in Africa, Lilongwe, Malawi, December.

Joint Food and Agriculture Organization/Netherlands Government Mission on the Promotion of Alley Farming and Small Ruminant Production in West Africa, Rome, January.

Meeting of International Agricultural Research Centres on Translation Issues, ILCA, Addis Ababa, Ethiopia, October.

National Conference on Pastoralism, National Animal Production Research Institute, Zaria, Nigeria, June.

National Crop Improvement Conference, Institute of Agricultural Research, Addis Ababa, Ethiopia, March.

National Workshop on Alternative Formulations of Livestock Feeds in Nigeria. Cabinet Office, The Presidency, Ilorin, Nigeria, November.

National Workshop on Guidelines for the Development of Settlements in Grazing Reserves in Nigeria, Bauchi, Nigeria, August.

Organization of African Unity/Inter-African Bureau on Animal Resources Workshop on the Improvement of Small Ruminants in West and Central Africa, Ibadan, Nigeria, November.

Potential of Cassava as Livestock Feed in Africa, International Institute for Tropical Agriculture, Ibadan, Nigeria, November.

Regional Conference of the Animal Production Society of Kenya, Nairobi, Kenya, November.

Second National Livestock Improvement Conference, Addis Ababa, Ethiopia, February.

Seventh World Holstein Friesian Conference, Nairobi, Kenya, February.

Sixteenth International Congress of Genetics, Toronto, Canada, August.

Sixth Tanzania Veterinary Association Scientific Conference and 20th Anniversary Celebration, Arusha, Tanzania, December.

Sixth Technical Consultation of AGRIS Participation Centres, FAO, Rome, Italy, June.

Southern Rangelands Pilot Project Monitoring and Evaluation Workshop. Southern Rangelands Development Unit, Yabello, Ethiopia, October.

Symposium on Agricultural Networks for Countries of the Gulf Co-operative Council, Kuwait, October.

Tenth Anniversary Conference of the Ethiopian Journal of Agricultural Sciences, Institute of Agricultural Research, Addis Ababa, Ethiopia, October.

Tenth MINISIS Users Group Meeting, Ottawa, Canada, September.

Third Conference of the African Association for Biological Nitrogen Fixation, Dakar, Senegal, November.

Third World Congress on Sheep and Beef Cattle Breeding, Paris, France, June.

West Africa Animal Traction Network Workshop on Animal Traction for Agricultural Development in West Africa, Sely, Senegal, July.

Workshop on Natural Disasters in Northern Ethiopia and Their Impact on Biological Diversity, Asmara, Ethiopia, June.

XXth International Conference of Agricultural Economists, Buenos Aires, Argentina, August.

Collaborative research activities in 1988

Cattle Milk and Meat Thrust

Blood parasites of cattle in the derived savannah of south-west Nigeria
University of Ibadan

Livestock and farming systems in four states of south-east Nigeria
University of Nigeria

Rapid appraisal of livestock systems in two southern provinces of Benin
Direction de la recherche agronomique
Cellule nationale de soutien de la recherche appliquée en millieu rural
Unité des recherches vétérinaires et zootechniques

Mineral nutrition of cattle and supplementation with legumes and/or non-protein nitrogen—Nigeria
National Veterinary Research Institute
Kaduna State Government Cattle Breeding Ranch
Katsina State Government
Federal Ministry of Agriculture, Water Resources and Rural Development
National Livestock Projects Department
National Animal Production Research Institute

Genetic evaluation—Nigeria
School of Agriculture and Animal Science, Ahmadu Bello University

Livestock farming systems research—Mali
Institut national de recherche zootechnique, forestière et hydrobiologique (INRZFH)
United States Agency for International Development

Cattle milk production—Mali
INRZFH

Small Ruminant Meat and Milk Thrust

Browse supplementation and productivity of small ruminants—Nigeria
Obafemi Awolowo University, Ile-Ife
Commonwealth Scientific and Industrial Research Organisation, Australia
Swiss Development Cooperation
Nitrogen Fixing Tree Association (NFTA), Hawaii, USA

***Leucaena*/DHP toxicity and bacteria—Nigeria**
Obafemi Awolowo University, Ile-Ife

Undernutrition and trypanotolerance—Nigeria
University of Ibadan

Intake of *leucaena* and *gliricidia* for village small ruminants— Nigeria
Federal Livestock Department

Identification of causes of differences in productivity among herds in the same production system—Mali
Station d'élevage et de recherche zootechnique du Sahel

Epidemiology of lung diseases in small ruminants—Mali
Laboratoire central vétérinaire, Mali
Laboratoire national d'élevage et de recherches vétérinaires, Sénégal

Sheep breed performance—Ethiopia
Institute of Agricultural Research (IAR)
Veterinary Research Institute
Ministry of Agriculture (MoA)
Alemaya University of Agriculture

Small Ruminant Research Network
MoA/4th Livestock Project – Gewane Training Centre, Ethiopia
Smallstock Unit, MoA, and the Animal Production Research Unit, Botswana
Central Rangeland Development Project, Somalia
Kenya Agricultural Research Institute (KARI)
Direction général de la recherche scientifique et technique, Congo
Centre de recherches vétérinaires et zootechniques, Congo
Société de développement des productions animales (SODEPRA), Côte d'Ivoire
Institut d'élevage et de médecine vétérinaires des pays tropicaux, France
Association des français à l'étranger
Gesellschaft für Technische Zusammenarbeit (GTZ), Federal Republic of Germany (FRG)
University of Göttingen, FRG
University of Hohenheim, FRG

Animal Traction Thrust

Improved management of Vertisols in Ethiopia
MoA
IAR
Addis Ababa University
Alemaya University of Agriculture
Relief and Rehabilitation Commission
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India
International Board on Soil Research and Management (IBSRAM), Thailand
Government agencies of Switzerland, Norway and Finland
Caritas/Switzerland
Oxfam America

Constraints to the use of draught animals—Nigeria
Nigerian Cereal Research Institute
Federal Agricultural Coordination Unit

Animal Traction Network
18 African countries participating
ICRISAT, India
European Economic Commission (EEC)
Southern African Centre for Cooperation in Agricultural Research, Botswana

Animal Feed Resources Thrust

Forage research—Genetic resources, rhizobiology and tissue culture, soils and plant nutrition, forage seed production
Forage Network in Ethiopia
International Board for Plant Genetic Resources (IBPGR), Italy
Centro Internacional de Agricultura Tropical (CIAT), Colombia
International Council for Research in Agroforestry, Kenya
IBSRAM, Thailand
University of Hohenheim, FRG
University of British Columbia, Canada
International Development Research Centre (IDRC), Canada
Virginia Polytechnic Institute, USA

Fertilizer/rhizobium interaction on farmers' alley farms—Nigeria
Agricultural research centres in south-west Nigeria
International Institute of Tropical Agriculture (IITA), Nigeria

Initial evaluation of feed resources and incorporation of forage legumes into farming systems of West Africa
National institutes in Côte d'Ivoire, Ghana, Mali and Nigeria
Food and Agriculture Organisation (FAO) of the United Nations, Italy
University of Bergen, Norway
University of Giessen, FRG

Multipurpose tree trials—West Africa
Federal School of Forestry, Nigeria
INRZFH, Mali
CIAT, Colombia
IITA, Nigeria
University of Hohenheim, FRG
Canadian International Development Association
IDRC, Canada
Organisation of Petroleum Exporting Countries
NFTA, Hawaii, USA

ARNAB
26 African countries participating
ICRISAT, India
Scientific and Technical Research Commission of the Organization of African Unity
IDRC, Canada
Norwegian Agency for International Development (NORAD)

PANESA
19 African countries participating
IITA, Nigeria
IDRC, Canada

Trypanotolerance Thrust

African Trypanotolerant Livestock Network
International Centre of Insect Physiology and Ecology, Kenya
Kenya Trypanosomiasis Research Institute KARI, Kenya
International Trypanotolerance Center, The Gambia
Institut sénegalaise de recherche agronomique, Sénégal
SODEPRA, Côte d'Ivoire
Centre de recherche et d'élevage d'Avetonou, Togo
MoA, Ethiopia
Office Gabonais pour l'amélioration de la production du viande, Gabon
Institut national pour l'étude et la recherche agronomique, Zaire
EEC
Overseas Development Administration, UK
GTZ, FRG

Livestock Policy and Resource Use Thrust

ALPAN
42 African countries participating

Aerial survey
Centre de suivi des écosystèmes, Sénégal
SODEPRA, Côte d'Ivoire
FAO, Italy
United Nations Environment Programme, Kenya

Training and Information

FAO, Italy
IDRC, Canada

Research support

Laboratories

Laboratory analyses performed for national programmes in:
Burkina Faso
Ethiopia
Ghana
Niger
Nigeria

Computer and Biometrics

Assistance in data analysis given to scientists from:
Botswana
Côte d'Ivoire
Ethiopia
Madagascar
Mali
Mozambique
Sudan

IDEAS package installed in:
Botswana
Cameroon
Congo
Côte d'Ivoire
Ethiopia
The Gambia
Kenya
Malawi
Mali
Mauritius
Mozambique
Nigeria
Senegal
Swaziland
Tanzania
Zimbabwe

INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA
BALANCE SHEET at December 31, 1988

(US$ '000)

ASSETS

Current assets	1988	1987
Cash	6 420	2 713
Receivable from - donors	1 385	3 304
- employees	84	44
- others	565	461
Inventories	1 250	735
Deposits and prepayments	201	183
Construction work in progess	119	–
Total current assets	10 024	7 440
Fixed assets		
Buildings	9 547	9 360
Research and laboratory equipment	3 411	3 125
Computer	1 601	1 284
Furnishings and office equipment	2 468	2 648
Vehicles and aircraft	3 274	2 709
Other	81	152
Total fixed assets	20 382	19 278
Total assets	30 406	26 718

LIABILITIES AND FUND BALANCES

Current liabilities		
Accounts payable employees	317	340
Other payables and accruals	4 608	3 105
Contributions received in advance	1 427	425
Total current liabilities	6 352	3 870
Fund balances		
Invested in fixed assets - Core	19 726	18 769
- Special projects	656	509
Working capital	2 489	2 834
Capital development fund	1 183	736
Total fund balances	24 054	22 848
Total liabilities and fund balances	30 406	26 718

INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA
STATEMENT OF REVENUE, EXPENDITURE AND FUND BALANCES
for the year ended December 31, 1988

(US$ '000)

	1988	1987
Revenue		
CGIAR contributions	16 487	14 603
Special project grants	1 830	1 969
Earned income	453	539
Capital development fund	446	436
Total revenue	19 216	17 547
Operating expenditure		
Research	9 777	8 478
Information services	1 280	1 434
Training and conferences	1 262	1 278
General administration and operations	2 977	1 516
Board and management	699	697
Total operating expenditure	15 995	13 403
Capital expenditure	1 289	877
Special projects	1 830	1 969
Total expenditure	19 114	16 249
Excess of revenue over expenditure	102	1 298

FUND BALANCES

Opening balances		
Working capital	2 834	1 972
Capital development fund	736	300
Total opening balances	3 570	2 272
Excess of revenue over expenditure	102	1 298
Closing balances		
Working capital	2 489	2 834
Capital development fund	1 183	736
Total closing balances	3 672	3 570

INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA
SCHEDULE OF CGIAR CONTRIBUTIONS AND SPECIAL PROJECT GRANTS
for the year ended December 31, 1988

(US$ '000)

CGIAR Contributions	1988	1987
African Development Bank	201	200
Austria	175	175
Belgium	608	727
Canada	933	744
Denmark	391	335
Federal Republic of Germany	1 089	1 027
Finland	748	675
France	296	270
India	25	25
International Development Research Centre (IDRC)	293	154
Ireland	160	436
Italy	1 505	1 640
The Netherlands	407	398
Nigeria	32	35
Norway	559	438
Organization of Petroleum Exporting Countries (OPEC)	50	112
Sweden	322	361
Switzerland	1 639	1 369
United Kingdom	554	482
United States of America (USAID)	4 000	3 000
World Bank	2 500	2 000
Total CGIAR contributions	16 487	14 603

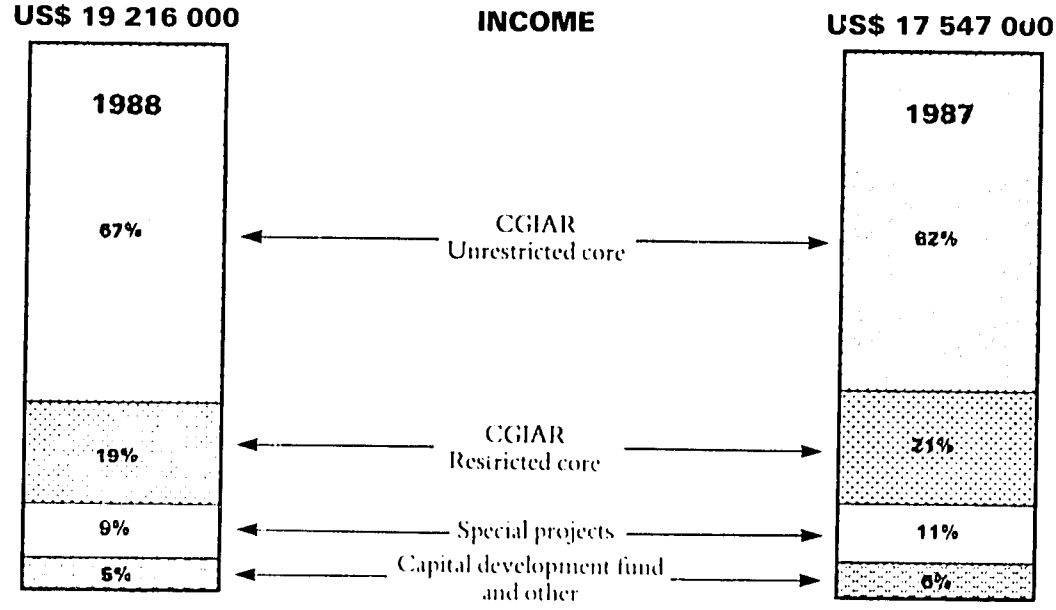
Special project grants		
Agence de Coopération culturelle et technique	18	–
Australia (ACIAR)	7	24
Australia (ADAB)	46	–
CARE – Ethiopia	–	5
Caritas (Switzerland)	199	95
European Economic Commission (EEC)	86	489
Federal Republic of Germany	423	338
Ford Foundation	15	7
Finland	135	148
International Board for Plant Genetic Resources (IBPGR)	47	17
IDRC	156	138
Ireland	82	27
Medios (Belgium)	1	5
Nigeria (FLD)	–	6
Nigeria (NLPD)	35	–
Norway	300	300
Organization of African Unity (OAU)	15	–
Oxfam America	117	113
Rockefeller Foundation	3	–

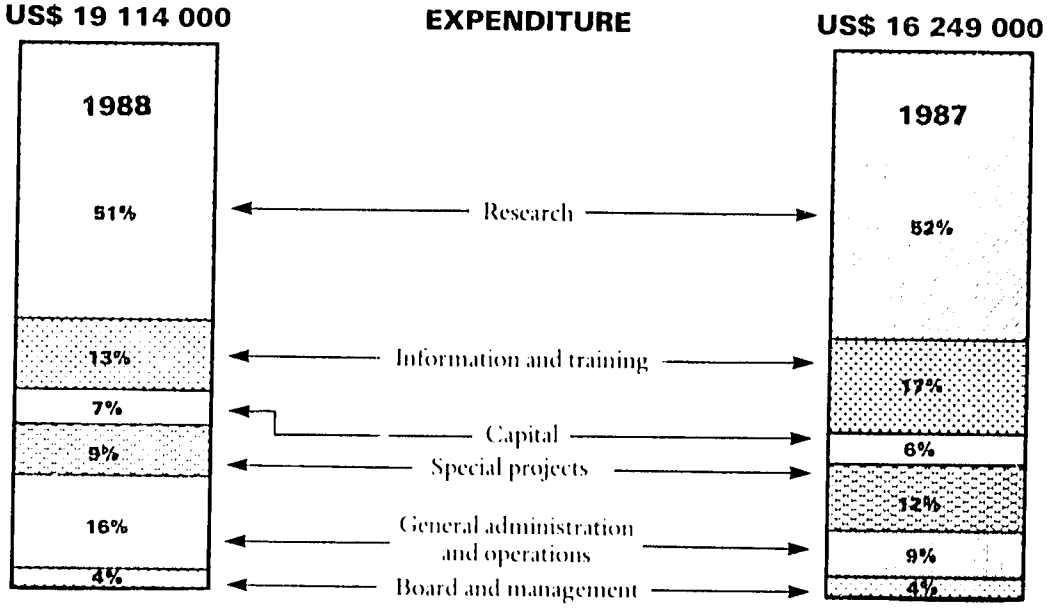
CGIAR Contributions and Special Project Grants (Cont'd)

(US$ '000)

	1988	1987
United Nations Environment Programme (UNEP)	–	40
United States of America (USAID)	93	217
University of Hohenheim	51	–
West Africa Milk Company	1	–
Total special project grants	1 830	1 969

Source and application of funds, 1988 and 1987





Percentage of research expenditure by thrust