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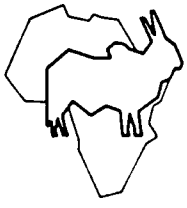

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Foreword

The content of *ILCA Annual Report 1989* reflects the continuing consolidation and implementation of the Centre's strategies and plans[1]. It demonstrates the continuing increase in both the quality and quantity of the Centre's output, while on-going review processes indicate that the programme choices and implementation modes developed in 1987/88 are as valid now as they were then. ILCA's six thrust-based programmes, together with training and information programmes, give a necessary and apparently appropriate delineation and focus to both the Centre's own programmes and collaborative work in the National Agricultural Research Systems (NARS) of sub-Saharan Africa.

[1] For details, see *ILCA's Strategy and Long-term Plan* (ILCA, 1987) and *Sustainable Production from Livestock in sub-Saharan Africa: ILCA's programme plans and funding requirements 1989–1993* (ILCA, 1988).

Research in the cattle and small ruminant thrusts in 1989 emphasised the importance of feeding and management in improving the output of livestock systems. It also highlighted the importance of herd fertility management, breed evaluation and improved and appropriate milk processing technology. Studies carried out under the Animal Traction Thrust again demonstrated the very considerable increases in food production that can be achieved through the use of animal-drawn land-shaping implements and consequent improved drainage.

Work under the Animal Feed Resources Thrust offers promise of support for NARS research through germplasm storage, evaluation and distribution, and for improved feeding of livestock in a range of agro-ecological conditions, in particular through such interventions as fodder banks, multipurpose trees and other forage and feed management systems.

The Trypanotolerance Thrust has extended its study of methods for controlling tsetse challenge and has quantified, in animal production terms, the relationships between trypanosome prevalence, tsetse challenge and animal production in susceptible and trypanotolerant cattle. In trypanotolerant cattle, the ability to control the development of anaemia has a much greater effect on daily weight gain than the ability to control parasitaemia. High genetic correlations between average packed red cell volumes (PCV) and growth rates suggest the possibility for selection on PCV values to improve overall productivity under tsetse challenge.

Scientists working in the Livestock Policy and Resource Use Thrust have continued to monitor the effect of environmental stress on the long-term productivity of rangeland production systems and have greatly added to our knowledge of such processes.

In training, 42 scientists completed individual study programmes at ILCA, while 12 group training courses were attended by a total of 216 participants from 39 countries in sub-Saharan Africa. The Centre's Information Section, covering library, documentation and publishing activities, continued to disseminate results of ILCA's research and to provide NARS scientists with the information so vital to the success of any research programme.

Collaborative programmes (see page 137), especially those involving partnerships in research networks with colleagues in NARS, help extend the scientific mass of the Centre to levels necessary to have an impact on Africa's livestock production. The development of networks associated with ILCA's thrusts progressed well in 1989 and this increasingly allowed the Centre's work, if not its role, to be merged with that of the NARS in sub-Saharan Africa.

The progress demonstrated in this Report took place against a background of stable donor support and participation of the Board of Trustees and management in elaboration of the Centre's programmes. By the end of 1989, ILCA's administrative and financial structures had been effectively aligned in support of the Centre's programmes.

By the end of the year, the effects of political, economic and social upheavals taking place throughout the world in the late 1980's were increasingly affecting the role and scope of the CGIAR (Consultative Group on International Agricultural Research) system and, with it, ILCA. Donor support was being realigned to recognise newly elected governments in Eastern Europe, emerging nations throughout the world and a changed alignment of global operating policies and commodity markets. In addition to these changes, growing concerns of donors with regard to global issues such as the protection of the environment, sustainability of agricultural systems, gender issues and the protection of genetic resources, were added to poverty alleviation as major issues for the international research centres.

Improving the output of livestock systems is uniquely related to poverty alleviation since livestock affect most aspects of the economic, social, labour and financial structures of African nations. This role of livestock is so pervasive as to give the prospect of effecting profound economic progress in Africa to those who can develop sustained improvements in livestock production. ILCA joins with its donors in the pursuit of this important objective.

Ralph W. Cummings

Ralph Cummings
Chairman, Board of Trustees

John Walsh

John Walsh
Director General

Highlights of 1989

Cattle Milk and Meat Thrust

Pastoral dairying: In rural Ethiopia, sales of dairy products, especially butter, provide 20% of household income. This money goes to the women, and is typically their only source of cash. For the very poor, this income is the only means to buy food grain, essential for subsistence.

On-farm butter-making: ILCA has developed a wooden agitator which, when fitted inside a traditional Ethiopian clay-pot butter churn, reduces the time taken to make butter from the 139 minutes needed with an unmodified churn to 50–65 minutes. Butter yield is also increased; the fat content of the buttermilk is only one-third of that found with the traditional method.

Peri-urban dairying: Surveys and analyses of secondary data indicate that rising urban demand for dairy products is coming at a time when most African countries must limit imports because of scarce foreign exchange. ILCA is, therefore, placing more emphasis on research to improve productivity of dairies primarily serving urban markets.

Feeding and management: Allowing calves to suckle their dams before and after hand milking increases cows' milk yield during early lactation, compared with a bucket-feeding regime. Partially suckled calves consumed more milk than bucket-fed calves, and hence showed higher growth rates up to six months of age. However, the amount of milk available for sale was not reduced.

N'Dama vs Fulani: Cattle-owners in southern Nigeria believe that the advantages of the N'Dama over the White Fulani are its greater disease resistance (72%), its ability to graze a variety of grasses (30%), its better quality milk and meat (30%), and its ability to produce a calf yearly (19%) and maintain weight in the dry season (16%). Its disadvantages are thought to be its small size (84%), wild temperament (47%), low milk yield (29%) and low market price (16%) relative to the White Fulani.

Early feed supplementation: A long-term study in southern, semi-arid Ethiopia indicated that early supplementation of calves with legume hay (to compensate them for milk lost to human consumption) does not lead to sustained increases in growth or reduce the time to maturity. The practice is therefore not cost-effective. Interventions in such environments should focus more on reducing calf mortality and improving management efficiency than on cattle growth *per se*.

Small Ruminant Meat and Milk Thrust

Supplementation and drenching: Menz ewes (two to four years old) supplemented with 300 g of wheat bran and 150 g of noug cake daily showed increased ovulation rates and higher milk yields than unsupplemented animals. Drenching (against nematodes and trematodes) alone had no effect on the reproductive or productive parameters studied, but had an additive effect in combination with supplementation. Economic analysis of these on-station trials indicated that drenching and supplementation together gave the highest gross margin, but drenching gave the highest return on investment.

Forage evaluation: Trials in Niger compared the palatability and nutritional value of cowpea hay and six local browses — *Azadirachta indica* (neem), *Bauhinia rufescens, Combretum aculeatum, Guiera senegalensis, Maerua crassifolia* and *Ziziphus mauritiana* — as supplements to a basal diet of millet leaves. Sheep readily ate *Bauhinia, Combretum, Ziziphus* and cowpea hay, but not the other browses. In general, the rumen ammonia level for sheep fed browse remained below that required to maintain rumen microbial growth.

Alley farming: Alley farming research in Nigeria, including livestock components, began in the early 1980s. A 1989 survey among 151 alley-farming households found that improvement of soil and higher crop yields were the main interests of the farmers in alley farming. However, 90% of the farmers had, at some time, used prunings as forage, indicating that alley farming is recognised as beneficial to livestock production.

Animal Traction Thrust

New implements: A tine bar which attaches to the broadbed maker reduced tillage time to one-sixth of that needed with a traditional Ethiopian plough (4 h/ha versus 24 h/ha). Reduced tillage also extends the life of broadbeds over several seasons.

Soil drainage: On Ethiopia's Vertisols, using draught-animal power for landshaping and to provide drainage allows farmers to plant high-yielding, long-season bread wheat at the beginning of the rainy season. Yields are twice those of the local, short-season durum wheat commonly planted after the rains to avoid waterlogging, a problem of Vertisols.

Feeding strategies: In Mali, on-farm trials with draught oxen revealed no relation between the liveweight, size or body condition of oxen and their performance in terms of speed or duration of working, or force exerted. This suggests that dry-season supplementation to support weight gain and general condition at the start of cultivation will not improve work output or lead to increases in the amount of land cropped or crop production.

Animal Feed Resources Thrust

Forage germplasm: In 1989, ILCA's forage germplasm collection grew to more than 10 000 accessions of grass, legume and browse species. The Herbage Seed Unit was established to stimulate and sustain the production and supply of forage seed in national agricultural systems.

Tropical forage legumes: Forage legumes which showed promise in initial evaluation trials in 1988 were tested in agronomic evaluation trials in 1989. Accessions of *Centrosema pascuorum* and *Stylosanthes guianensis* significantly outyielded the *S. hamata* cv Verano check. *Stylosanthes guianensis* remained green during the dry season and proved resistant to the fungal disease anthracnose.

Fodder banks: In Nigeria, fodder banks were initially developed to produce high quality feed for the dry season, but recent work has indicated that they could also be used to provide wet-season feed. Studies on fodder banks of *Stylosanthes hamata* and *Centrosema pascuorum* indicated that optimum benefit can be obtained by grazing them every three to nine weeks; less frequent grazing leads to reduced crude-protein and dry-matter yields.

Nitrogen cycling: Nitrogen builds up in fodder-bank soil, which encourages invasion by nitrophilous weeds, reducing the nutritive value of the forage. This can be avoided by cropping the fodder bank periodically. Studies have shown that yields from crops planted in fodder banks are higher than those from crops planted on natural fallow. Although nitrogen application still increases yields, less is needed on fodder-bank plots.

Trypanotolerance Thrust

Animal response to tsetse challenge: At sites in Côte d'Ivoire, Ethiopia, Gabon and Zaire trypanosome prevalence among livestock was directly and significantly related to tsetse challenge. However, for a given level of tsetse challenge, the mean trypanosome prevalence in trypanosome-susceptible cattle was twice that in trypanotolerant breeds.

Trypanotolerance: Packed cell volume (PCV) appears to be an effective, relatively easy way to measure trypanotolerance. Studies in Zaire show that the ability to control the development of anaemia (measured as maintenance of high PCV during trypanosome infection) was significantly related to shorter calving intervals, increased calf weaning weight and increased productivity of N'Dama cows.

Field test for trypanotolerance: In Gabon, yearling N'Dama were maintained on ranches for 12, 18 or 24 weeks under moderate natural tsetse challenge. The ability to control anaemia had greater effect on weight gain than did the ability to control parasitaemia. The minimum test period required to evaluate anaemia control under this level of tsetse challenge was found to be six weeks.

Effect of trypanosome infection on N'Dama reproduction: Studies on N'Dama cows under ranch conditions in Gabon showed that neither treatment with Samorin nor parasitaemia in untreated animals affected the calving rates of cows that had been dry during the breeding season. Among lactating cows, however, the calving rate was lower in untreated than in treated animals, indicating that trypanosomiasis impairs fertility of cows stressed by lactation.

Genetics of trypanotolerance: In Gabon, the genetic parameters for control of anaemia were evaluated for the first time under field conditions. Heritabilities for average PCV and lowest PCV were 64% and 50%, respectively, when environmental factors and parasitaemia were taken into account. Genetic correlations with growth were 0.70 and 0.28, respectively.

Parasitaemia was detected in only 28% of the animals. If all animals could have become parasitaemic over the short test period, either naturally or artificially, the values for heritability and genetic correlations would probably have been even higher. Thus, selection for PCV measured over a short test period appears to be an effective strategy for rapid genetic improvement of trypanotolerant cattle.

Livestock Policy and Resource Use Thrust

Livestock pricing policy: Economic analysis of beef-price data from Nigeria indicated that, on the basis of official exchange rates, beef production was subsidised between 1975 and 1986. However, when the exchange rate was adjusted for the differential inflation rate between domestic and foreign economies, it was apparent that beef producers were implicitly taxed from 1979 to 1985 by the over-valuation of local currency.

Land and tree tenure: In West Africa, tree rights may be separate from land rights and depend on whether trees are already planted or self-sown, who planted them, species, and how and in what way they are used or disposed of (destroyed, lent, leased, pledged, sold, given away).

Control over land allocation generally rests in the hands of larger corporate groups, such as the village (or its designated representative). Women rarely have land rights. Even their right to use land comes through their husbands or other male family members. Women's rights to and their control over trees can differ from those of men. Some differences, such as prohibition on women planting trees, can serve as obstacles to fodder-tree development.

Training and Information

Future programme: A Training and Information planning meeting produced a plan of action at ILCA for 1991–95. The meeting, which brought together seven ILCA staff members and six scientists from national research and training institutes in sub-Saharan Africa, used a goal-oriented project planning method.

Training policy: Work began on a *Training policy and procedures manual* which will provide a written reference to all policies, procedures and guidelines on ILCA training opportunities for ILCA staff (advisors and supervisors) and for trainees.

Individual and group training: Forty-two scientists completed individual study programmes with ILCA in 1989. Twelve group training courses were offered during the year, including five new courses. Six courses were in French and six in English. From the 857 applications received, 216 participants, from 39 sub-Saharan countries, were able to attend.

Library: Library acquisitions in 1989 brought the total holdings to 25 456 books, 6139 reprints, 26 099 microfiches and 1804 periodical titles. The library has also acquired the AGRICOLA database on CD–ROM.

Information services: The number of users of the Selective Dissemination of Information (SDI) service has increased to 1015 in 46 African countries.

Publications: More than 50 000 publications were distributed in 1989. New publications during the year included: *ILCA in print*, a catalogue listing all the major publications produced by ILCA staff since 1974, two new Monographs and three new Research Reports.

New journal: Issue 35 of *ILCA Bulletin*, published in December 1989, was the final issue of that publication. During 1989 plans were made to launch a new internationally reviewed journal, *African Livestock Research*.

Networks

During 1989, major progress was made in the organisation and operation of collaborative research networks involving scientists from African national agricultural research systems (NARS).

Cattle Research Network: The decision to form a collaborative cattle research network for

West and central Africa was taken in October 1988 at a workshop held in Ibadan, Nigeria, attended by 67 NARS participants from eight countries in the region. A similar network for East and southern Africa was established at a second workshop, held at Kadoma, Zimbabwe, in June 1989, and attended by 48 participants from NARS in seven countries.

Small Ruminant Research Network: At a meeting held in Bamenda, Cameroon, in January 1989, the Small Ruminant Research Network began the transformation from an information exchange group to a fully fledged collaborative research network. Later in the year, regional workshops were held in Togo and Zimbabwe.

West African Animal Traction Network (WAATN): In May 1989 ILCA hosted a protocol planning meeting of this Network. Research protocols presented by participants from 11 countries were reviewed before presentation to donors.

Feed resources networks: The Pasture Network for Eastern and Southern Africa (PANESA) held a workshop on "Regional Collaborative Research Planning on *Sesbania* Multilocational Evaluation" at Kisumu, Kenya, in August/September 1989. Twelve major screening sites, covering a wide range of environments, were identified in Kenya, Rwanda, Tanzania, Uganda and Zimbabwe.

A joint ARNAB (African Research Network for Agricultural Byproducts)/PANESA training workshop on "On-farm Animal Feed Resources Research Methodology and Data Analysis" was held at Egerton University, Njoro, Kenya, in November 1989. It was attended by 23 participants from seven countries.

The decision to form the West and Central African Feed Resources Network was taken at a meeting in Avetonou, Togo. Participants from nine countries in the region, and from the French Institute d'élevage et de médecine vétérinaire des pays tropicaux (IEMVT), Centro Internacional de Agricultura Tropical (CIAT) and ILCA elected an interim steering committee and formulated research protocols for 1990.

The three Networks have agreed to merge in 1990 into a single African feed resources network.

African Trypanotolerant Livestock Network: The Network held its biennial meeting in Kenya in April 1989 at which scientists from nine NARS presented research results and redesigned protocols.

African Livestock Policy Analysis Network (ALPAN): Membership of this Network has now increased to over 1000: 80% of the members work in sub-Saharan Africa, with about two-thirds of these serving in government.

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Cattle Milk and Meat Thrust

The basic goal of the Cattle Milk and Meat Thrust is to increase the sustainable output of milk and meat from cattle in the mixed crop–livestock smallholder production systems of sub-Saharan Africa. The Thrust's research programme focuses on these production systems because they appear to offer the best opportunities for increasing milk and meat output, and hence food production as a whole, in the foreseeable future.

This is largely due to mutually beneficial interactions between crop and livestock production in these systems. Draught power and manure from cattle are important inputs in crop production, while crop byproducts and residues provide feed for cattle. This is particularly true in the highlands of East Africa and in most subhumid areas. In these areas, the potential for increased milk and meat output is further enhanced by possibilities of incorporating forages in the cropping lands.

In the humid zone of West and central Africa, diseases, especially trypanosomiasis and dermatophilosis, are major constraints to cattle production. However, if they can be controlled the potential for milk and meat production in this zone is vast. The incidence of trypanosomiasis decreases markedly where the rain forests of the humid zone have been opened up by fire and prolonged human activity. This area, known as the derived savannah, is being increasingly cropped, offering new opportunities for cattle production. The challenge for the Thrust here is to devise technologies that allow sustainable production of milk and meat.

This report presents results from some of the Thrust's subprojects executed during 1989.

Economics of cattle production

Research under this theme focuses on constraints arising from socioeconomic and institutional factors which limit sustainable increases in milk and meat from cattle.

Major activities under this theme include:

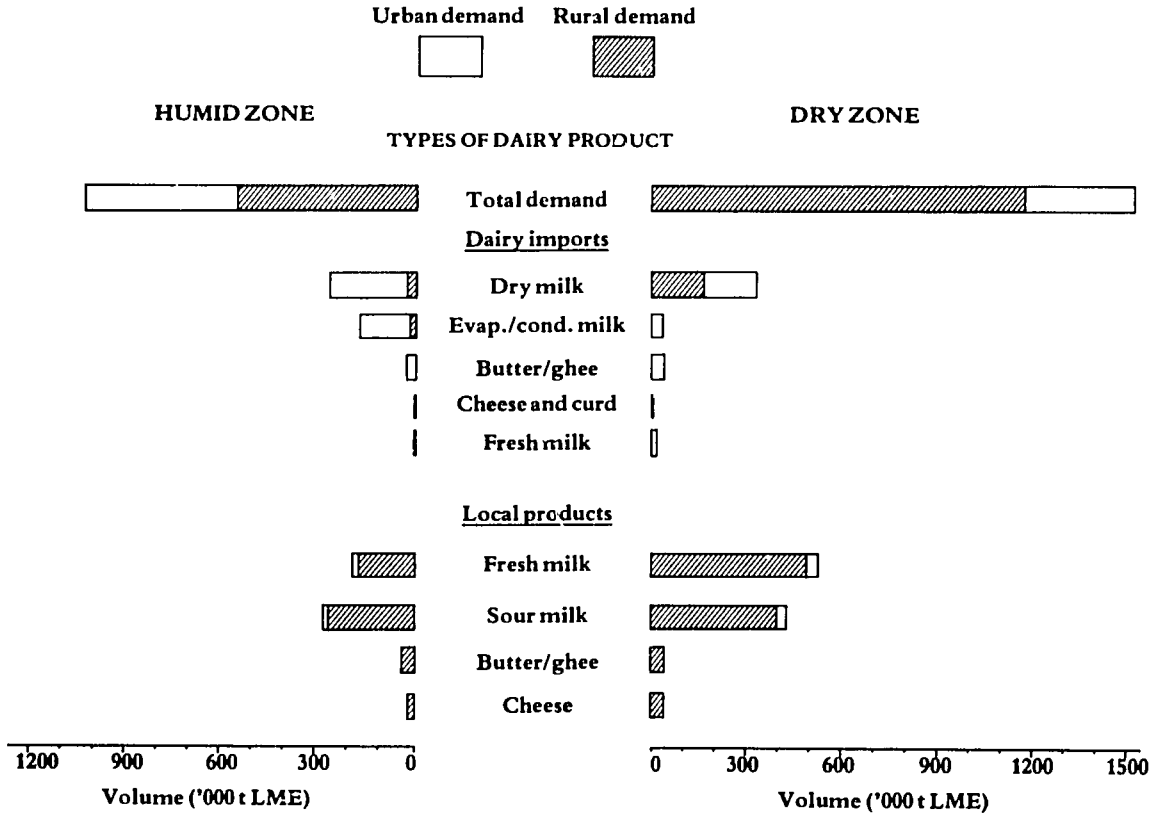
- identifying constraints to and opportunities for increased meat and milk production, in particular through examining commodity price policies, the supply of inputs and marketing systems

- investigating marketing strategies, quantifying present and future demand for milk, milk products and meat, and analysing credit policies for smallholder cattle producers
- assessing the economics of new technologies to determine how much productivity needs to be increased, or what risks need to be reduced, to ensure adoption. There is also a need to determine the benefits of new technologies in terms of output, income stability and welfare and to whom such benefits accrue.

Patterns of consumption of dairy products in West Africa

Data from the Food and Agriculture Organization of the United Nations (FAO) indicate that annual consumption of milk and milk products in West Africa increased from 15 kg per person in 1974–76 to 18 kg per person in 1983–85 but fell to only 12 kg per person in 1985–87. Milk production increased only slowly during the 1970s and 1980s and even declined in drier areas of the region. In contrast, imports increased rapidly during the 1970s but subsequently declined, their share of total consumption falling from 45% in 1983–85 to 36% in 1985–87.

Figure 1. *Distribution of aggregate 1985–87 demand for milk and milk products in West Africa.*



LME = Liquid milk equivalent.

Source: Adapted from FAO 1985–87 data on dairy production and imports.

A study was carried out in 1989 to determine the pattern and distribution of dairy consumption in West Africa in 1985–87 and trace some of the more obvious factors that have led to this consumption situation.

Aggregate dairy demand in West Africa for 1985–87 was estimated from FAO milk production and import data. This was then disaggregated by product type and origin (local or imported), by ecological zone (dry or humid) and by rural and urban areas.

In the 16 countries of West Africa, consumption of milk and milk products averaged 2.6 million tonnes (liquid milk equivalent) annually in 1985–87. This is roughly 0.5 million tonnes a year less than in 1983–85. Per caput dairy consumption fell from 11 kg in 1983–85 to about 6 kg in 1985–87 in the humid zone, and from 45 kg to 41 kg in the dry zone. This large fall in per caput consumption in the humid zone was reflected in a fall in the proportion of consumption accounted for by that zone, from 49% in 1983–85 to about 40% in 1985–87.

Figure 1 shows the amount and type of dairy products consumed in West Africa in 1985–87. Local products accounted for about 71% of consumption in the dry zone, compared with only 54% in the humid zone. The equivalent figures for 1983–85 were 72% in the dry zone and 38% in the humid zone, reflecting the decline in imports between 1983–85 and 1985–87.

In the dry zone, the proportion of consumption accounted for by urban dwellers increased slightly from 21% in 1983–85 to 23% in 1985–87, whereas in the humid zone it fell from 62% to 46%.

Dairy consumption in West Africa is falling, especially in the humid zone, which depends heavily on imported dairy products. Imports are likely to continue to decline as their cost increases (Figure 2) and as income growth

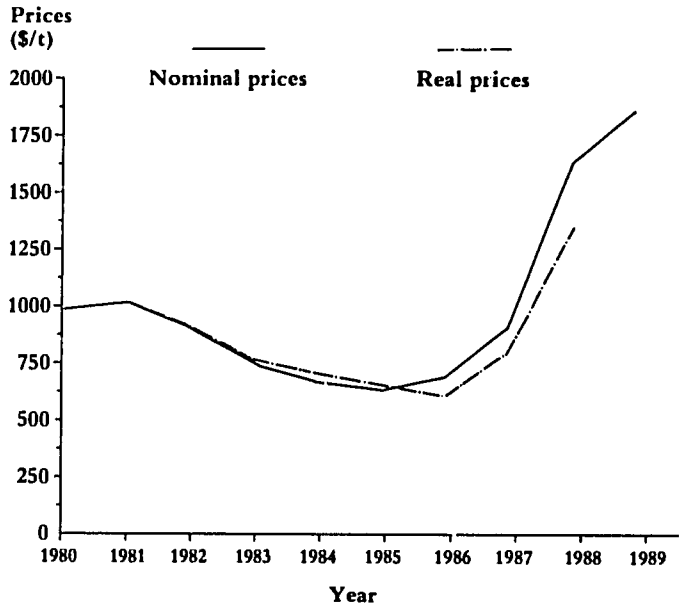


Figure 2.
Nominal and real prices of non-fat dry milk on international markets, 1980–89.

Real (constant) prices are nominal (current) prices deflated by the Manufacturing Unit Value Index for industrial countries (1980 = 100).

Sources: World Bank, *Commodity and price trends* (various editions).
USDA (United States Department of Agriculture), *World dairy situation* (various years).
IMF (International Monetary Fund), *International financial statistics* (various years).

slows. Further studies are required to develop a fuller understanding of the different milk supply and demand relationships in the region as the basis for policies that will promote efficient use of local dairy production resources and more sustained milk consumption patterns.

Senait Seyoum and R. Brokken

Socio-economic obstacles to increased production and consumption of milk

A study was conducted in Bamako, Mali, from October 1988 to September 1989 to investigate differences between income groups in consumption of the various dairy products available in Bamako; to ascertain why some dairy products were not consumed; and to determine the relationships between dairy consumption, income and prices, as well as the influence of season and socio-economic and demographic parameters on dairy consumption.

A two-stage sampling procedure was used to select 240 households in Bamako. In the first stage, city wards *(quartiers)* were selected from each of the city's six administrative zones *(communes)*, based on knowledge of where in the city the majority of the poor, middle-income and rich households are concentrated. In the second stage, households were selected at random and those that were willing to participate in the year-long survey were included in the sample. An initial questionnaire ascertained the number and ages of people in each sample household, and their level of education, ethnicity, religion and employment, as well as the total monthly income of each household. Data were subsequently collected from each household between October 1988 and September 1989. Household heads were interviewed weekly for eight weeks during each of the three seasons (cool dry, hot dry and rainy) of the year. Data collected included the amounts and types of dairy products acquired and consumed, and the amount spent on them.

Preliminary results for the cool dry season in 1988 were reported in *ILCA Annual Report 1988* (pages 24–26). This report presents results covering the full-year study.

Household income averaged 85 000 FCFA/month ($284) (Table 1), ranging from 4500 FCFA/month ($15) to 700 000 FCFA/month ($2333). The poorest 10% of the households had 1% of the total income, while the richest 10% received 36%. Although the sample was initially post-classified into five homogeneous income categories, it was later reclassified into three income categories: the poorest 25% of households, the middle 50% and the richest 25%. Poor households had monthly incomes of between 4500 FCFA ($15) and 30 000 FCFA ($100) and middle-income households had incomes of between 30 000 FCFA and 100 000 FCFA ($333) per month. Rich households had monthly incomes of more than 100 000 FCFA.

The average household comprised 10.6 people, half of whom were less than 16 years of age. Poor households were smaller than middle-income or rich households, yet spent a larger proportion of their monthly income on dairy products. They also had a larger proportion of members who were uneducated or involved in manual labour than did rich households. Only 4% of people in the sample had six or more years of formal education; 32% had none. Nearly half of the workers in the sample were employed by government.

Thirty per cent or more of the households consumed locally produced fresh and sour milk, factory reconstituted liquid milk, imported concentrated milk and milk powder at least once a week. Locally made sweetened

Table 1. *Household dairy consumption patterns by income, Bamako, Mali, 1988/89.*

	Income category			
	Whole sample	Poorest 25%	Middle 50%	Richest 25%
Number of households	237[a]	54	120	63
Average household income (FCFA/month)	85 370 (85 949)	19 472 (8 012)	61 722 (21 593)	185 309 (109 189)
Dairy consumption pattern (% of households)				
Regularly consume dairy products	75	51	79	92
Rarely or never consume dairy products	25	49	21	8
Consumption				
kg LME/person per year	12 (10)	6.4 (4.7)	11.8 (5.2)	22 (8.1)
Local products (%)	34	37	33	60
Factory products (%)	12	29	19	15
Imported products (%)	54	34	48	25
Dairy expenditures				
% of household budget	2.6	3.4	2.5	1.8

[a] Three households dropped out of the study before its completion.

Figures in parentheses are standard deviations.

LME = liquid milk equivalent.

sour milk, local butter, factory produced butter and cheese and imported fresh UHT milk, yoghurt, cheese and butter were consumed very irregularly. Shortage of money was cited as the major reason limiting consumption, particularly by poor households in respect of imported and factory produced products. Other reasons cited included dislike of dairy products, non-availability of some products, or lack of awareness of what products were available.

Sample households consumed an average of 12 kg liquid milk equivalent (LME) per person per year, consumption ranging from 6.4 kg in poor households to 22 kg in rich households (Table 1). The type of product consumed differed markedly between income groups, with rich households showing a strong preference for local products. Fresh and sour milk together accounted for 96% of total local dairy product consumption.

The amount of imported dairy products consumed did not differ significantly ($P > 0.05$) between seasons, but consumption of local products was markedly higher during the rainy season than in the hot dry or cool dry seasons. In the hot dry season, for example, only 60% as much local dairy product was consumed as during the rainy season. Socio-economic parameters did not significantly affect demand for dairy products, which was generally income inelastic, with coefficients ranging from 0.14 for factory pasteurised milk to 0.49 for imported concentrated milk. Demand for factory reconstituted and imported concentrated milk was price elastic (−1.62 and −1.50, respectively), while demand for local fresh milk was price inelastic (−0.53). The cross price effects show mixed results, but in general, local fresh milk has

positive cross price coefficients with imported dairy products (substitutes), and negative coefficients with local sour milk (complements).

The income and price elasticities for each income group were used to assess the implications of the Malian Government's goal of increasing annual dairy consumption to 40 kg LME per person by the year 2000. To achieve this, dairy consumption will, over the next 10 years, have to increase by 13% a year for the sample as a whole, by 23% a year for poor households and by 6% a year for rich households. This would require substantial reductions in dairy-product prices or large increases in incomes, or both. Increasing local milk production by introducing low-cost production techniques, efficient feeding systems, improved health programmes and efficient marketing systems may lead to lower prices for dairy products, which may in turn increase dairy consumption.

S. Debrah and S. Soumare

Collaborator: Institut national de recherche zootechnique, forestière et hydrobiologique, Mali

Milk marketing and consumption in Nigeria

The indigenous people of southern Nigeria, mainly Yoruba and Igbo, did not traditionally keep cattle for their milk, and hence rarely consumed milk. Their consumption of milk and milk products has increased in recent years due to the influx of transhumant and semi-settled Fulani cattle rearers in some parts of the region, which has increased the availability of these products.

Since the 1940s, an increasing proportion of consumption of dairy products by urban dwellers in Nigeria has been met by imports, much of them consumed in the south. The introduction of the Structural Adjustment Programme in 1986 increased the price of dairy products and may have caused a decline in dairy-product consumption.

A survey was conducted between October 1988 and March 1989 to determine the dairy consumption patterns of various segments of the population in southern Nigeria and factors shaping these patterns. The objectives were to help predict future demand, particularly for domestic products, and devise production and marketing strategies. This report presents results of preliminary analyses of the survey data.

A stratified random sample of 1185 households were interviewed in Oyo State in the south-west and Anambra and Imo States in the south-east. The sample comprised 996 households of people indigenous to the region, 412 in rural areas and 584 in urban areas, and 189 Fulani or Hausa households, 101 of them rural and 88 urban. Data were collected on family composition and income, how often each household consumed various dairy products and how much they consumed, from where they obtained dairy products, the form in which they were used and their prices. Data on expenditure on selected food items were also collected.

Table 2 summarises information on the frequency with which sample households consume different dairy products. The type of product consumed and frequency of consumption differ markedly between ethnic groups, urban and rural populations and between south-east and south-west. Indigenes in the south-east do not consume local dairy products. In contrast, 80% of indigenes in the south-west consume *wara*, a local soft cheese, and some consume fresh or sour milk or butter. People in rural areas consume local dairy products more often than do those in urban centres.

Table 2. *Frequency of household consumption of dairy products by location and type of the consumer, southern Nigeria, 1989.*

Product and frequency of consumption	Southern indigenes		Fulani/Hausa	
	South-west	South-east	South-west	South-east
	% of households consuming			
Local products				
Fresh/sour milk				
Regular	5		98	96
Irregular	10		2	
Yoghurt				
Regular			34	93
Irregular			7	
Wara				
Regular	30		70	
Irregular	50		11	4
Butter (Regular)	2		79	97
Imported products				
Liquid milk	2		8	
Yoghurt				
Regular	10		22	
Irregular	24		10	7
Evaporated milk				
Regular	46	48	41	27
Irregular	44	23	11	4
Powder milk				
Regular	16	14		
Irregular	26	15	4	
Baby milk	12	10	10	11
Butter (Irregular)	6	3	3	
Ice cream				
Regular	14	10	11	
Irregular	31	17	11	

Regular = daily/weekly; irregular = monthly/rarely.

Indigenes in both the south-west and the south-east consume similar proportions of imported or import-based dairy products, the most frequently used being evaporated milk.

Consumption of imported dairy products is more common among Fulani and Hausa households in the south-west than among those in the south-east; nearly all those that consume imported products are urban residents. Among the local products consumed in the south-west, rural Fulani take fresh milk whereas urban Hausa take sour milk because fresh milk is not available. In the south-east rural and urban Fulani consume both fresh and sour milk.

Preliminary analyses and observations indicate that the market for domestic products is limited more by lack of appropriate ways to preserve and transport dairy products than by lack of demand. This hypothesis will be more rigorously tested.

M.A. Jabbar and L. Reynolds

Characterisation of coastal subhumid farming systems in Kenya

The coastal subhumid zone of Kenya and similar environments elsewhere in East and southern Africa have good potential for milk production, yet demand exceeds supply. Most milk sold on the Kenya coast comes from dairy cattle kept on large and medium-scale farms, but development efforts are directed at a smallholder zero-grazing scheme. During the rainy seasons some milk from zebu herds in the neighbouring semi-arid rangelands is also sold.

Smallholders are increasingly interested in dairying because of recent advances in the control of the major cattle diseases, trypanosomiasis and East Coast Fever, and in forage production. This interest is being supported by the development of the zero-grazing scheme and by a programme of collaborative research by the Kenya Agricultural Research Institute and ILCA, assisted by several other national and international institutions. The research began in late 1988 with surveys to describe the farming systems and to assess the importance of cattle, and particularly dairy cattle, in those systems.

The surveys were carried out in Kaloleni Division, Kilifi District, an administrative area to the north-west of Mombasa, in which there are three distinctive agro-ecological zones, the semi-arid "livestock–millet" zone and the subhumid "cashew-nut–cassava" and "coconut–cassava" zones. Some 1800 households in the two subhumid zones were interviewed in December 1988 and January 1989. This sample represents 10 to 15% of all farmers in the two systems.

Households comprised an average of more than 12 people, nearly half of whom were under 16 years old. Only 4% of household members were over 60 years old. More than 86% of adult females resided permanently on the farm, in contrast to only 60% of adult males. These results suggest a population growth rate of 4% a year since the last census in 1979 and a mean population density of about 250 people per square kilometre. They also indicate the importance of off-farm male employment.

Ninety-five per cent of the farms surveyed were freehold and occupied by the owner. In the coconut–cassava zone 70% of household plots were less than 4 ha. The mean and modal sizes were close to 2 ha. However, 64% of the households in this zone had access to at least one other plot of land. By contrast, household plot sizes in the cashew-nut–cassava zone were similar to those in the coconut–cassava zone, but only 22% of respondents had an additional plot of land. Mean distance to the second plots was 3 km in both systems.

Tree cropping predominated in both systems. Coconuts were grown as a cash crop by 90% of farmers in the survey. Cashew-nuts (51%), citrus (27%), mangoes (18%) and oil crops (19%) were the other cash crops recorded. Maize and cassava were the major subsistence crops and were grown by more than 90% of farmers. Other subsistence crops were peas

(27%), rice (21%), bananas (14%) and *Phaseolus* beans (10%). Most plots were intercropped and farmers in the coconut–cassava zone commonly planted two crops a year, whereas those in the cashew-nut–cassava zone grew only one crop a year.

The proportions of farms with livestock and the types of livestock kept were very similar between the two zones (Table 3). Mean herd and flock sizes were small: 12.9 and 9.1 in the coconut zone and 20.7 and 9.7 in the cashew-nut zone.

Table 3. *Number of farms surveyed in the coconut–cassava and cashew-nut–cassava agro-ecological zones of Kaloleni Division, Kenya, classified by presence or absence of cattle and small ruminants.*

	Numbers of farms			
	Coconut–cassava zone		Cashew-nut–cassava zone	
Type of livestock	Number	%	Number	%
None	505	36	164	35
Small ruminants only	642	46	207	44
Cattle and small ruminants	175	13	72	15
Cattle only	69	5	26	6
Total	1391	100	469	100

Farmers ranked crop and livestock diseases and lack of capital as the most critical problems facing them. Cattle owners ranked poor extension support and shortages of feed as their most critical problems.

These results indicated that government statistics overestimate the number of dairy cattle in the Kaloleni study area. A census of all farms with cattle in Kaloleni Division was carried out, mainly in April and May 1989, in collaboration with the Ministries of Livestock and Agriculture to verify this and to describe the cattle subsystems. Cattle were classified as either local East African Zebu or grade cattle, ie, exotic breeds or their crosses with zebu.

Of 1552 households with cattle, 32% were in the coconut zone, 39% were in the cashew-nut zone and 29% were in the semi-arid livestock–millet zone. Mean herd size was larger in the subhumid zone than in the semi-arid zone: more than half of the 56 000 zebu cattle covered by the survey were found in the semi-arid zone. In contrast, more than 80% of the nearly 900 grade cattle were in the subhumid zones, more than half of them in the coconut zone. The exotic breeds contributing most to the grade cattle population were Sahiwal (36%), Ayrshire (34%), Channel Island breeds (26%) and Friesian (18%).

The number of grade cattle per farm was small; more than 90% of farms had fewer than 10 (Figure 3). All grade cattle were stall-fed whereas 23% of zebu cattle had access only to grazing. Thirty-six per cent of herds with grade cattle used zero-grazing and semi-zero grazing systems based on planted forages, concentrate feeding or both. Maize bran and copra cake were the most frequently used concentrates.

Natural pasture is still the main feed source for cattle in these zones, but increasing population pressure and farm subdivision is likely to lead to increasing intensification. Research is therefore being focused on the technical and socio-economic constraints to intensification. The research includes

farm management economic analyses to estimate the relative contributions of the various farm enterprises and of any off-farm income to household income in a stratified sample of smallholder farms.

F.N. Chabari and W. Thorpe

Collaborator: Kenya Agricultural Research Institute (KARI)

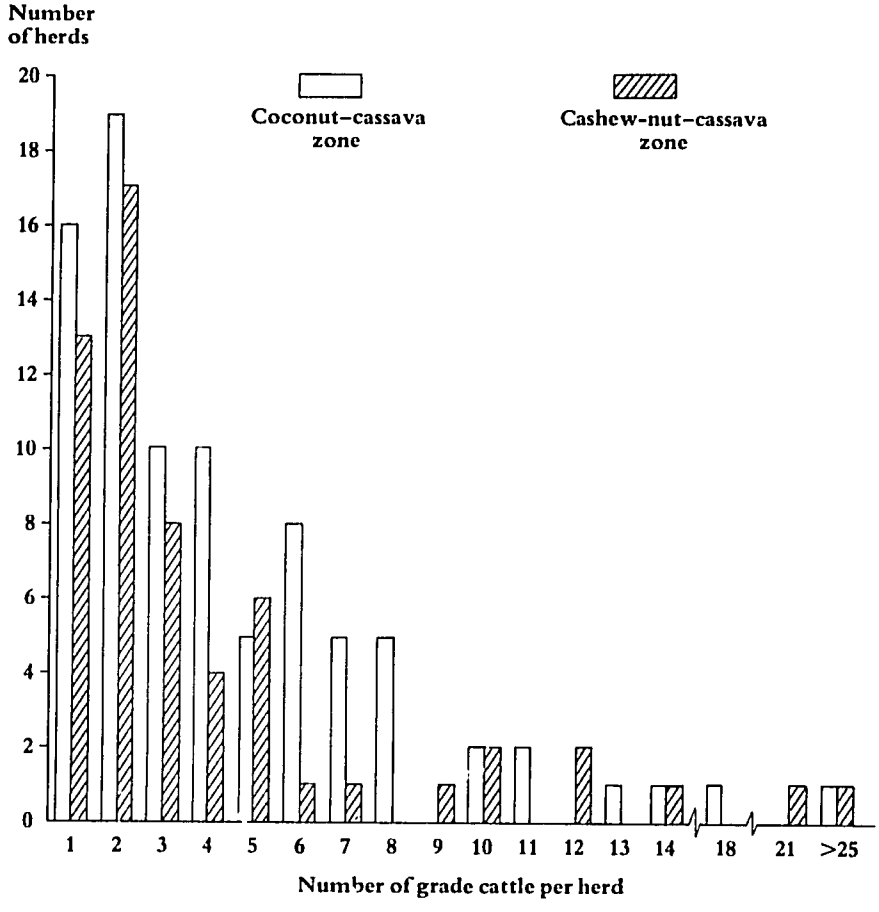


Figure 3.
Frequency distribution of number of grade cattle per herd in the coconut–cassava and cashew-nut–cassava agro-ecological zones of Kaloleni Division, Kenya, 1989.

Pastoral dairy-marketing interactions and their implications for calves and humans in semi-arid Ethiopia

Recent studies have shown that pastoralists sell dairy products more than was previously thought, and that income from dairy sales can be important to pastoral economies. Development projects in semi-arid Ethiopia are exploring ways to diversify the source and facilitate generation of pastoral income and hence improve food security.

In 1987/88, ILCA, at the request of the Third Livestock Development Project of the Ethiopian Ministry of Agriculture, surveyed a total of 140 Borana households to investigate:

- the effects of distance to market, season and family wealth on dairy sales

- the contribution of dairy sales to the household economy
- the implications of dairy marketing for the nutritional welfare of people and calves
- appropriate interventions to facilitate dairy marketing.

The results of this survey were analysed in 1989.

The households surveyed were stratified by wealth class, based on the ratio of lactating cows to reference adults (poor = 0.5 lactating cows per adult African male equivalent [AAME], wealthy = 2 lactating cows per AAME), and distance to one of two small market towns. Adult women at pastoral encampments were questioned about milk production, sources of income, frequency of dairy sales, income from dairy sales, use of dairy income and variation in dairy sales between seasons. Cattle productivity was estimated from cow histories developed through interviews with owners. Data were analysed using standard procedures for four-way (market site, season, wealth and distance) ANOVA for dairy marketing and for two-way (wealth and distance) ANOVA for cattle production studies.

Dairy marketing contributed an average of 20% to the annual mean household income of Ethiopian Birr 405 (US$ 195) (n = 86). This money went to the women and was typically their only source of cash. Among poor families, dairy income accounted for between 37% of annual income for those within 10 km of market and about 1% for those 20–30 km from market. The figures for wealthy families (over the same distances) were less variable at 22% and 14%, respectively.

Dairy sales were highest in the wet season, falling to only 17% as much in the dry season (Figure 4). Households within 10 km of market sold up to 12 times as much dairy products as those 20 to 30 km from the market. Across distances and seasons, wealthy households sold much more dairy

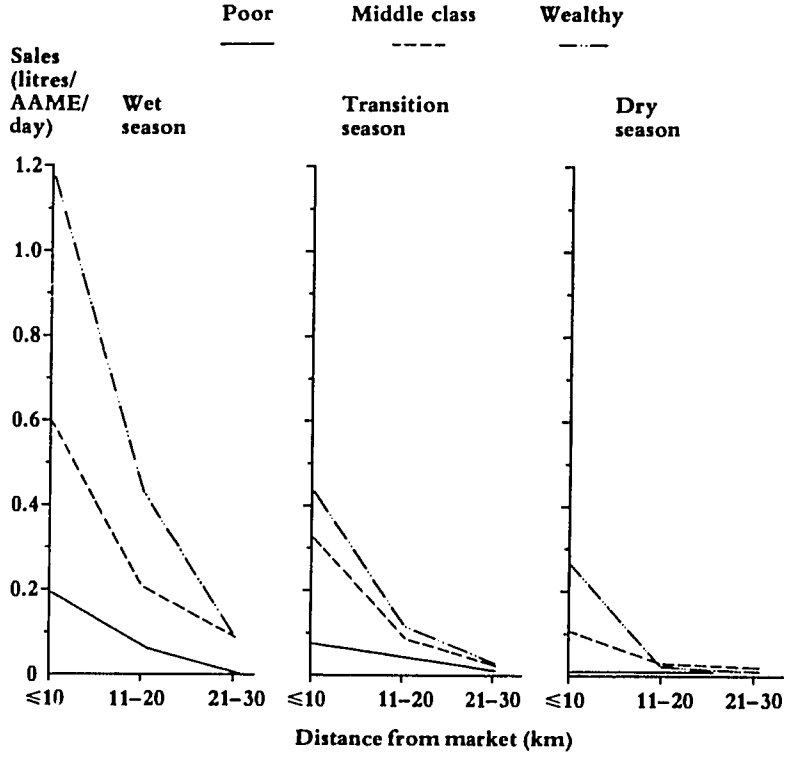


Figure 4.
Reported dairy sales (litres of milk equivalents on an energy-content basis) per reference individual (adult African male equivalent–AAME) per day for pastoral households of varied wealth, at various distances from market and at different seasons, southern Ethiopia, 1987.

products than poor households, but income from selling dairy products provided a larger proportion of income for poor households, which had few animals and did not produce other marketable commodities. Poor families typically used dairy income to buy food grain, while wealthier families used dairy income in a more discretionary fashion. Butter was the product most commonly sold, and was consumed locally or taken by traders, using the public transport system, to the nearby southern highlands.

Poor families within 5 km of a market reported the highest rate of milk offtake per cow (63% of quarters milked versus an overall mean of 47%), which suggests that marketing opportunity intensified competition between people and calves for milk. This additional offtake, which equates to about 500 ml of milk a day per household, was primarily sold to purchase grain, buying about 1.75 kg. Women in households within 5 km of a market consumed 32% more grain than did those more than 11 km from a market.

The loss of milk to the calf may have led to higher calf morbidity; poor families close to markets reported significantly ($P < 0.05$) higher incidence of calf illness than did those further from a market.

These results suggest that pastoral dairy marketing is common in the southern rangelands within 30 km of small towns, and wealth classes differ in their response to the opportunity to sell, which varies with their proximity to market and their milk supply as influenced by household demand and season. Women sell more when closer to market because they have less walking to do to get to the market. The poor sell milk as part of their survival strategy, selling small quantities of milk that would not have met their subsistence needs to buy larger amounts of energy in the form of grain. This is possible because of the favourable terms of trade and demonstrates that a family need not have a milk "surplus" for dairy marketing to be important. In addition, dairy sales improve food security for all households by providing more regular income and by delaying crisis sales of livestock.

Dairy marketing could best be assisted by facilitating transport of butter to market from remote areas. There is also a need to increase the availability of grain for sale in the rangelands and to improve forage-based calf feeding management to reduce the risk of nutrition-related calf mortality resulting from competition for milk. The poorest women need opportunities to generate income other than selling milk to alleviate the pressure on them to sell dairy products that might otherwise be consumed at home.

D.L. Coppock, S. Holden and Mulugeta Assefa

Collaborator: Third Livestock Development Project, Ministry of Agriculture, Ethiopia

Multilocational testing of fodder banks in the subhumid zone

Fodder banks arose from ILCA's research on dry-season feed supplementation of traditionally managed cattle in the Nigerian subhumid zone. Producer-managed trials have demonstrated that using fodder banks helps boost livestock productivity and they are being adopted widely. However, little is known of the effect they are having on adopters who have not been associated with the original research programme. Feedback from such adopters provides valuable information for evaluating the innovation and improving the effectiveness and adaptability of fodder banks. Technical and economic par-

ameters related to fodder banks are being surveyed to determine the benefits of adopting fodder banks and constraints to their adoption.

Fodder-bank owners and extension agents were interviewed in 1989 to determine factors influencing fodder-bank adoption. An adapted multiple-choice questionnaire was used, in which the respondent had to give a quantitative value to each answer, with the total value of all choices summing to 10 regardless of the number of alternatives selected.

Fodder-bank owners rated lack of extension as the most important reason for non-adoption ($R^2 = 0.52$), with inappropriate land tenure as the second most important ($R^2 = 0.3$). The extension staff rated inappropriate land tenure ($R^2 = 0.33$) and inadequate input procurement and delivery ($R^2 = 0.33$) as the primary constraints.

Fodder-bank owners confirmed the lack of help from the extension services by reporting that their main source of information about the fodder-bank concept came from the Miyetti Allah Cattle Breeders Association ($R^2 = 0.33$), with extension staff as the second most important source of information ($R^2 = 0.22$). Radio and newspapers were not important sources of information.

All cited R^2 were highly significant.

Fodder banks were originally designed for settled Fulani agro-pastoralists but are also being adopted by other ethnic groups. Less than half of the adopters are Fulani (Figure 5). Non-Fulani adopters have easier access to extension services because they are more literate and therefore seek such services, and because there are more extension staff from their own communities, so it is easier for them to communicate with the extension staff than it is for the Fulani. Land tenure also poses a bigger problem for agro-pastoralists. In most areas crop farmers and their traditional rulers control access to land. The government is gazetting grazing reserves to help

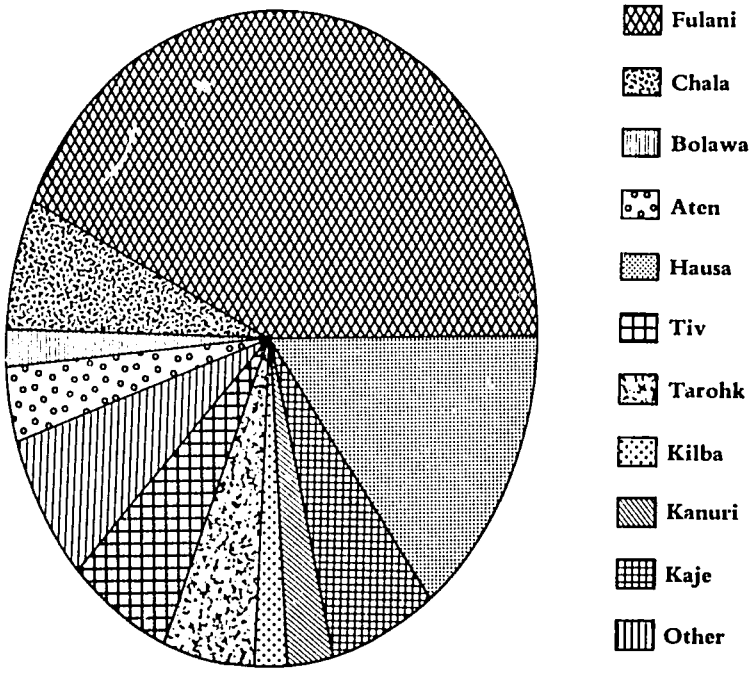


Figure 5.
Fodder-bank adoption in Nigeria by ethnic group.

agropastoralists acquire land but to date only 3.5% of the land under fodder banks is in the grazing reserves. Apart from that within grazing reserves, 60% of the land under fodder banks was inherited (Figure 6). Agro-pastoralists are able to acquire land for fodder banks mainly by buying it or, more commonly, borrowing it from arable farming communities, but only 16% of the land under fodder banks had been obtained this way.

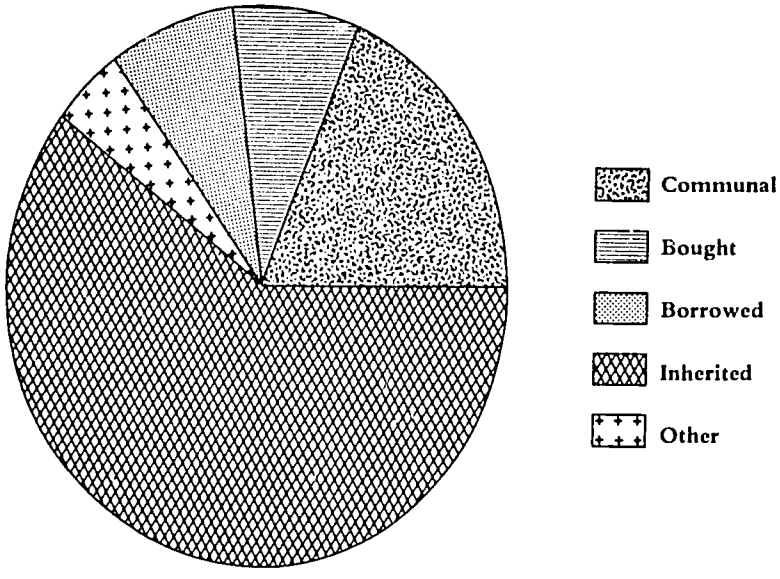


Figure 6.
Means by which land was acquired by fodder-bank owners in Nigeria.

These preliminary results indicate that rapid spread of fodder banks is dependent on a strong and effective extension service. New adopters need more extension support than was originally envisaged and it will be necessary to involve crop-oriented extension staff, who are more numerous than livestock-oriented extensionists, in spreading the forage legume production technology. Research on crop–livestock interactions has demonstrated strong benefits to crops, which should encourage their participation.

R. von Kaufmann and B. Hassane

Collaborator: Utah State University, USA

Feeding and management systems

The amount and quality of feed available are the main determinants of the productivity of cattle in sub-Saharan Africa. Feed shortages occur mainly in the dry season but may also occur during the wet season.

Poor nutrition can lead to morbidity and death in young cattle, reproductive inefficiency, low milk yield and short lactations in cows and low weight and poor carcass quality in animals for slaughter. The extent to which these effects are manifested varies between agro-ecological zones and production systems and with disease incidence.

Development of appropriate feeding systems for dairy cattle in the Ethiopian highlands

Calf rearing: Restricted suckling versus bucket rearing for crossbred calves

In most smallholder dairying systems, calves are reared using restricted suckling. In the Ethiopian highlands, however, the Ministry of Agriculture has recommended that, where crossbred cows are used, calves should be separated from the dams a few days after birth and bucket-fed. Crossbred cows in this environment produce about 6 kg of milk a day, of which the calf is fed up to 3 kg a day for the first three months after calving. An experiment was conducted at ILCA's Debre Zeit research site between September 1987 and April 1989 to investigate the effects of partial suckling, bucket rearing and cow supplementation on milk yield and offtake, calf growth and cow reproductive performance.

The trial consisted of four treatment groups each comprising 18 crossbred heifers (nine 75% Friesian/25% Boran and nine 50% Friesian/50% Arsi). Treatments comprised a factorial combination of the two calf-feeding systems (bucket rearing and partial suckling) and two cow-feeding regimes (supplemented and non-supplemented). All calves were weaned at 84 days old. Bucket-fed calves were fed twice a day and received a total of 208 kg of milk between birth and weaning. Partially suckled calves were allowed to suckle before and after the morning and evening milkings, for 2 minutes before the dam was milked and again for 30 minutes after milking. Cows each received a basal diet of *ad libitum* teff straw plus 2 kg of noug *(Guizotia abyssinica)* cake daily. Supplemented cows received an additional daily ration of 2 kg of legume hay throughout their lactations. Calves were weighed weekly until 180 days of age. Results are shown in Table 4.

Table 4. *The effect of calf-feeding system, dam supplementation and dam breed on milk yield, calf milk consumption, calf growth and digestible dry-matter intake, Debre Zeit, Ethiopia, 1989.*

	Milk yield (kg/cow per day)		Saleable milk (kg/cow per day)	Calf milk intake (kg/calf per day)	Calf growth rate (g/day)		Digestible dry-matter intake (kg/cow per day)	
	4–84 days	4–305 days	4–84 days	0–84 days	0–84 days	0–180 days	4–84 days	4–305 days
Calf feeding								
Bucket-fed	5.4	4.5	2.7	2.7	304	268	4.3	4.2
Partially suckled	6.2	4.8	3.1	3.1	390	323	4.5	4.3
Cow feeding								
Non-supplemented	5.7	4.4	2.9	2.8	323	282	4.1	3.9
Supplemented	5.9	4.9	2.9	3.0	371	309	4.7	4.5
Dam breed								
Friesian/Arsi	5.5	4.4	2.6	2.9	348	285	4.4	4.2
Friesian/Boran	6.1	4.9	3.2	2.9	345	306	4.4	4.3
SE	0.21	0.16	0.19	0.07	16.0	13.0	0.07	0.07

Partial suckling in early lactation significantly ($P<0.05$) increased milk yield between the fourth and eighty-fourth day of lactation. The difference in saleable milk production in the period 4–84 days of lactation was not significant.

Partially suckled calves had significantly ($P<0.05$) higher daily growth rates to weaning at 84 days and to six months old than bucket-fed calves. This was associated with significantly ($P<0.05$) higher milk intake by partially suckled calves.

Supplementary feeding significantly ($P<0.001$) increased digestible dry-matter intake by cows over both 4–84 days and 4–305 days. Calves of supplemented cows had significantly ($P<0.05$) higher growth rates to weaning, although the milk yield of supplemented cows was not significantly different from that of unsupplemented cows.

Friesian/Boran cows had significantly ($P<0.05$) higher milk yield up to the 84th day of lactation than Friesian/Arsi cows. Calf milk intake was similar, hence Friesian/Boran cows produced significantly ($P<0.05$) more saleable milk than Friesian/Arsi cows.

Partial suckling tended to increase the interval from calving to conception, but the difference was not significant.

The results of this study show that milk yield per cow can be increased in early lactation by allowing calves to suckle their dams before and after hand milking. Partial suckling also increased calf growth rate up to six months of age by increasing the amount of milk the calf consumes, yet did not affect the amount of milk available for sale.

D.A. Little, P. Chigaru, S. Crosse and A. Doyle

Strategies for small-scale oxen fattening in the Ethiopian highlands

Most smallholders in the Ethiopian highlands own one or more draught oxen. Some smallholders fatten cull oxen for sale during festivals. This is being promoted by the Fourth Livestock Development Project (FLDP) of the Ethiopian Ministry of Agriculture, which is giving private farmers and producer cooperatives in the Debre Zeit and Modjo regions access to credit and agro-industrial byproducts for oxen fattening. Preliminary extension guidelines recommend a daily feed intake of 7 to 8 kg per head (as-fed) of a ration consisting of 25% wheat-milling byproducts, 13% noug *(Guizotia abyssinica)* cake, 6% liquid molasses and 56% teff *(Eragrostis tef)* straw. The guidelines suggest that this ration should support an average daily gain of about 650 g.

Feed intake and liveweight changes of Arsi oxen under producer management were monitored at two producer cooperatives, Babogaya and Dibandiba, near Debre Zeit for 15 and 17 weeks from February 1989. Each cooperative had 10 recently purchased oxen, weighing an average of 308 kg, that were stall-fed, and another 10 oxen of similar initial weight that were still working and subsisted on grazing alone. Animals were weighed every two weeks. The amount of feed offered to and refused by the stall-fed animals was recorded daily.

Oxen at Babogaya were fed according to the FLDP recommendations and received an average of about 7.5 kg of feed per head per day, about half of which was teff straw. In contrast, oxen at Dibandiba ate about 13 kg of feed per head per day, 9 kg of which was the concentrate mix, over the first 11 weeks and nearly 20 kg a day (13 kg concentrate) over the last month. Feed

refusals were typically negligible in all cases. Despite the large differences in feed intake between the two cooperatives the animals gained an average of 25 to 30 kg at both sites, with an overall average daily gain of 230 g. The grazing work oxen all lost 15 to 20 kg over the same period.

These results indicate that not all farmers receive the FLDP's feeding guidelines, or that they ignore them. Weight gains were similar at the two cooperatives, and hence the extra feed given at Dibandiba was wasted. The rate of weight gain achieved was less than 40% of that anticipated.

D.L. Coppock and Getaneh Hailu

Collaborator: Fourth Livestock Development Project, Ministry of Agriculture, Ethiopia

Evaluation of grass/legume mixtures for stall-fed cattle in southern Nigeria

Shrubby forage legumes such as *Stylosanthes scabra*, *Desmanthus virgatus* and *Desmodium cinereum* have several advantages for use in cut-and-carry feeding systems. They are intermediate in growth characteristics between herbaceous pasture legumes and browse species. They remain green well into the dry season and can persist longer than herbaceous species.

A trial was started in 1988 at Ibadan, Nigeria, to assess the productivity of *Panicum maximum* var *ntchisi* in mixtures with *Desmanthus virgatus*, *Desmodium cinereum* and *Stylosanthes scabra* cv Seca. Plots were planted in June 1988. Legumes and legume/grass plots received 20 kg P/ha as single superphosphate. A uniform harvest was taken in February 1989. Yield data were subsequently collected from six harvests taken at six-week intervals between April and October 1989.

The *Panicum/Stylosanthes scabra* pasture gave the highest total dry-matter yield (Table 5) but yields did not differ significantly among the mixtures or from *Panicum* grown in pure stand. Yields of *Panicum* in mixtures

Table 5. *Dry-matter yield of* Panicum maximum *var* ntchisi *grown in pure stand and in mixtures with three shrubby forage legumes at Ibadan, Nigerian humid zone, 1989.*

Treatment	Dry-matter yield[1] (t/ha)		
	Grass	Legume	Total
Panicum alone	24.8		24.8
Desmodium cinereum alone		6.6	6.6
Desmanthus virgatus alone		7.1	7.1
Stylosanthes scabra alone		9.0	9.0
Panicum + *Desmodium cinereum*	22.7	0.6	23.4
Panicum + *Desmanthus virgatus*	23.9	1.6	25.5
Panicum + *Stylosanthes scabra*	24.3	2.5	26.8
LSD (5%)	2.5	2.5	3.0
CV (%)	5.4	30.2	9.2

[1] Total of six harvests.

were slightly but not significantly lower than that in pure stand. In contrast, legume yields were significantly lower in the mixtures than in pure stand, falling to only 9% of the pure-stand yield in the case of *Desmodium cinereum*. This demonstrates the poor ability of these shrubby legumes to compete with the tall *Panicum* variety.

A.N. Atta-Krah and L. Reynolds
Collaborator: University of Ibadan, Nigeria

Optimal fodder-bank utilisation in the Nigerian subhumid zone

Supplementary feeding during the dry season using forage from fodder banks has been shown to significantly increase both cow and calf performance in the Nigerian subhumid zone, but the levels of productivity achieved are still below the potential productivity of the animals. A trial was started in 1987 at Idon Ranch, Kaduna State, to investigate the effect on heifer performance of feeding both forage legume and molasses/urea supplements.

Twenty Bunaji heifers were allocated to each of five treatments:

- G — grazed on open range
- GNP — grazed on conserved natural pasture without access to molasses/urea blocks
- GUM — grazed on conserved natural pasture with access to molasses/urea blocks
- GL — grazed on a fodder bank without access to molasses/urea blocks
- GLUM — grazed on a fodder bank with access to molasses/urea blocks.

Animals in the fodder-bank treatments grazed the fodder bank only in the afternoon. Molasses/urea blocks were given to the animals during night kraaling. All animals had access to mineral salt blocks and were weighed every two weeks. Treatments were applied during the 1988 and 1989 dry seasons (January to May). In 1989, rumen-fistulated heifers were used to study the rate of dry-matter degradation of *Andropogon gayanus* and *Stylosanthes hamata* and rumen ammonia concentrations.

More cows grazing fodder banks had calves in 1989 than did cows in any of the other groups (Table 6). This was consistent with the ovarian activity

Table 6. *Distribution of calvings of the experimental herd, Idon Ranch, Nigerian subhumid zone, 1987–89.*

Treatment group	Number of calvings		
	1987	1988	1989
G	–	3	5
GNP	1	–	5
GUM	–	4	8
GL	1	5	13
GLUM	1	1	11

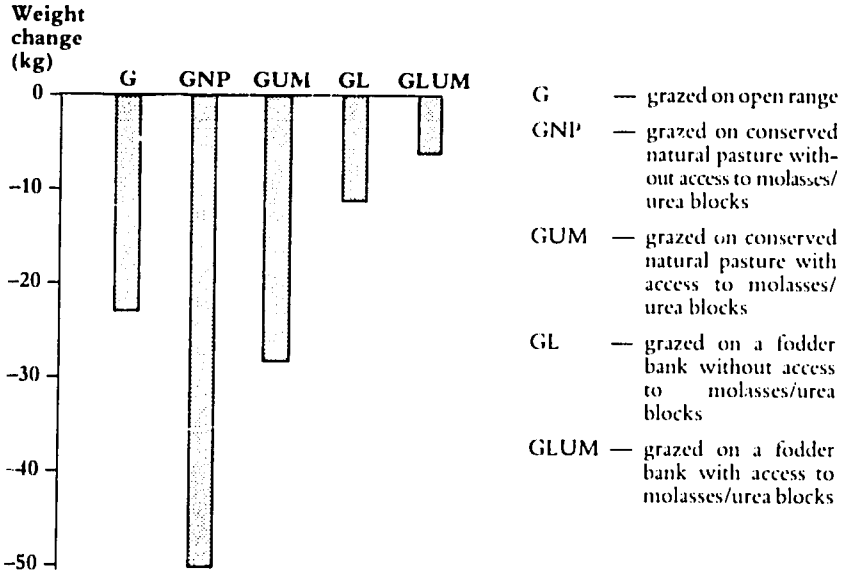


Figure 7.
Effect of dry-season feeding on weight loss of Bunaji cows, subhumid zone, Nigeria, 1989.

observed in 1988. Animals in the fodder-bank groups also lost less weight during the 1989 dry season than did animals in the other groups (Figure 7), although the differences were not significant. Several animals in the groups grazing open range or conserved pasture without supplementation had to be removed from the trial because they were suffering severe nutritional stress at the peak of the dry season. The treatments had no significant effect on either the rate of dry-matter disappearance of *A. gayanus* and *S. hamata* or rumen ammonia levels.

Trials starting in 1990 will investigate the effect of using fodder banks to provide supplementary feed in the wet season rather than the dry season. It is thought that animals that are heavier at the beginning of the dry season will be the same weight at the end of the dry season as cattle that are supplemented during the dry season, but that the better wet-season feeding will result in a larger increase in herd fertility than does supplementation during the dry season.

R. von Kaufmann and J. Aguru

Collaborators: Australian Centre for International Agricultural Research; Kaduna State Government and Katsina State Government, Nigeria; Melbourne University, Australia; National Animal Production Research Institute and National Livestock Projects Division, Nigeria

Traditional cattle systems in the derived savannah in Nigeria and improved production systems

The derived savannah zone in southern Nigeria offers considerable potential for cattle production but little is known about the zone's traditional production systems. Aerial surveys reported in *ILCA Annual Report 1988* (pages

18–20) showed that large numbers of cattle were present in this zone throughout the year. ILCA is studying the traditional management systems of the zone and the health and productivity of cattle in these systems, and investigating potential forage production systems and the impact that these could have on cattle production.

Sedentarisation of cattle owners

Data from a survey of cattle owners in Ogun, Oyo, Ondo, Bendel and Kwara States analysed in 1989 showed that 80% of the herds were owned by Fulani; the remaining 20% were owned by Yoruba, the ethnic group indigenous to south-west Nigeria. Most of the herd owners had lived at or near the same location for several years, grew crops and had permanent housing, indicating considerable sedentarisation among the cattle owners in the zone.

The average herd comprised 60 cattle and 10 small ruminants. Herd sizes tended to decline with the length of stay and degree of sedentarisation of the owner. Thirty-eight per cent of the herds consisted of only Muturu or Keteku, southern trypanotolerant breeds; the remainder consisted of either zebu or a mixture of zebu and the southern breeds. Herds that consisted of only Keteku or Muturu cattle, or in which these breeds predominated, were smaller than zebu or mainly zebu herds.

As more cattle owners settle permanently in the derived savannah zone, interaction and competition between crops and livestock will increase. Further research is needed to clarify how land rights for grazing and cropping are acquired and maintained, and how crop–livestock interactions evolve.

A preliminary survey of cattle production systems in the derived savannah

Fifty livestock owners with herds comprising pure Fulani or Fulani–N'Dama crossbreds were surveyed between June and August 1989 in five Local Government Areas in north-west Oyo State. Data were collected monthly on grazing/feeding patterns and on births and deaths of calves under one year. The herd owners were asked for their opinion of the N'Dama breed.

In general, cattle grazed on grass pastures for eight months from April to November, fed on second-season crop residues (primarily maize stover) between December and February, and then a mixture of pasture regrowth and tree browse from February until the new grass growth in April (Table 7).

Between April and September 86% of livestock owners grazed their animals within 2 km of their settlements; 98% grazed within 3 km. From January, herds travelled further from the homesteads: 50% of herds travelled only slightly beyond their wet season grazing area, 42% trekked 10–15 km from their homesteads and were based in temporary homesteads or *rugas* for one to four weeks, and the remainder trekked up to 25 km and remained away from their homesteads for up to 12 weeks.

Although 36% of the livestock owners produced crops, only one used first-season residues as animal feed because pasture grasses available at that time were of better nutritional value. All livestock owners used second-season crop residues by arrangement with the neighbouring crop farmers. Crop residues were fed during December–February but from January pasture regrowth after burning assumed greater importance; 86% of farmers said their cattle gained more weight grazing regrowth than when fed crop residues.

Table 7. *Distribution of farms according to monthly use of feeds for cattle, derived savannah, south-west Nigeria, 1989.*

Month	% of farms using			
	Grass	Crop residue	Regrowth	Browse
April–October	100	2[a]	–	–
November	100	10	–	–
December	–	96	2	2
January	–	84	88	24
February	–	30	100	60
March	–	8	94	82

[a] Only in July.

Most calves were born between February and April, with peak calving in April in N'Dama and crossbred herds and in March in Fulani herds. This corresponds with peak conception in June–July. Fewest calves were conceived in November–December.

Ninety-six per cent of livestock owners reported that most calf deaths occurred in the early wet season and were mainly due to worm infestation (86%), diarrhoea (60%) and eating sand (24%). Overall calf mortality was 29.5%, with 36.5% mortality in Fulani herds, 24.2% in crossbred herds and 2.25% in N'Dama herds.

Twelve livestock owners said that they had never heard of the N'Dama breed, three Yoruba farmers who employed Fulani herdsmen had always reared N'Dama cattle, two had bought or inherited crossbred or mixed herds and 20 had previously owned purebred White Fulani herds but had adopted other breeds, mainly because of high calf mortality. N'Dama rearers considered the main advantages of the breed relative to the White Fulani to be its greater disease resistance (72%), its ability to graze a wide variety of grasses (30%), its better quality milk and meat (30%), and its ability to produce a calf every year (19%) and maintain weight in the dry season (16%). Its disadvantages were its small size (84%), wild temperament (47%), low milk yield (29%) and low market price (16%) relative to the White Fulani.

Further research is needed to determine why mortality rates differ between breeds and to define conception patterns and why they differ.

Methods for establishing leguminous trees in pasture

Applying nitrogen fertiliser to pasture is not economical in most of tropical Africa. An alternative is to plant legumes in the pasture, but herbaceous legumes often do not persist when grazed. Leguminous fodder trees or shrubs such as *Leucaena leucocephala* and *Gliricidia sepium* may be more persistent, but no information is currently available on how to establish them in pasture or on when the pasture should first be grazed.

In 1989, trials were started at Ibadan, Nigeria, to investigate the effect of time to first grazing on growth, survival and yield of *Leucaena leucocephala* in a *Panicum maximum* pasture. Plots were ploughed and harrowed at the start of the rains. Scarified seeds of *Leucaena* were planted in rows 4 m apart, with

25 cm between holes within the row. *Panicum* crown splits were planted about four weeks after the *Leucaena*.

The grass was cut twice during the growing season but still shaded the tree seedlings, resulting in poor tree stands. This indicates that the best way to establish *Leucaena* in a new pasture would be to plant the trees in the first season with a food or cash crop such as maize and then plant the grass in the second season or, preferably, in the following year.

A second trial was started at Avetonou, Togo, in July 1989 to study ways to establish *Gliricidia sepium* in existing *Panicum maximum* pasture. The trial compared three methods of land preparation (hoeing a strip 0.5 m wide, rotovating a strip 0.5 m wide and discing a strip 1.0 m wide), two methods of establishing the trees (direct seeding and transplanting seedlings) and three methods of post-planting weed control (hoeing a strip 1 m wide every six weeks, slashing a strip 1 m wide every six weeks and no weed control).

Transplanting seedlings into 1-m-wide disced strips resulted in the tallest plants at the end of the growing season (Table 8). Transplanted seedlings competed better with the grass and weeds than did direct-seeded plants and were significantly ($P<0.05$) taller at the end of the growing season.

L. Reynolds

Collaborator: Centre de recherche et d'élevage d'Avetonou, Togo

Table 8. *Effect of method of land preparation, tree planting and weed control practices on growth of* Gliricidia *planted in established pasture, Avetonou, Togo, 1989.*

Tree planting/weed control method	Tree height (cm)			
	Discing	Hoeing	Rotovating	Mean
Direct seeding/hoeing	77.0	47.3	55.5	56.9bc
Direct seeding/slashing	64.5	50.5	49.3	54.8bc
Direct seeding/no weeding	65.3	47.5	46.3	53.0c
Seedling/hoeing	100.0	75.8	79.5	85.1a
Seedling/slashing	95.3	71.3	72.0	79.5a
Seedling/no weeding	84.5	61.8	52.0	66.1b
Mean	81.1a	59.0b	59.1b	

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

Milk preservation and processing technologies

Few African smallholder milk producers have access to formal milk marketing systems. Most thus sell any surplus they may have through informal markets or process it into other marketable products such as butter and cheese. ILCA's studies indicate that better milk processing methods and more favourable milk pricing policies could encourage smallholders to produce more milk.

This theme focuses on identifying constraints to milk processing, developing appropriate processing technologies and equipment for small

amounts of milk and widening the range of products that smallholders can produce.

On-farm churning efficiency of a traditional clay-pot churn fitted with an internal agitator

In Ethiopia, butter is traditionally made from soured milk. Small amounts of milk are collected in a clay pot over several days, during which the milk sours naturally. When sufficient milk, usually about 3–8 litres, has been collected it is churned by shaking the clay pot until butter granules form. Previous studies by ILCA showed that churning took up to three or four hours and the buttermilk contained up to 2% butterfat. In response to these findings, ILCA developed a wooden agitator that could be fitted to the traditional clay-pot churn. Several on-station and on-farm trials demonstrated that using the agitator improved churning efficiency.

Trials in 1989 monitored the use of the agitator on five farms near Debre Birhan, in the Ethiopian highlands. The farmers used their usual manufacturing procedure, ie, the same churning temperature and amount and acidity of milk, except that the clay pot used was fitted with the agitator.

Churning time ranged from 50 to 65 minutes, with an average of about 57 minutes (Table 9), compared with an average of 139 minutes observed in a previous study of the use of the unmodified traditional churn. The average fat content of the buttermilk was also much lower than observed with the unmodified churn (0.36% vs 1.1%).

Table 9. *Characteristics of milk churned and churning time, fat content of buttermilk and butter yield using a clay pot fitted with an internal agitator, Debre Birhan, Ethiopia, 1989.*

	Mean[1]	Range
Milk temperature (°C)	17.4	15–19
Milk (% fat)	7.2	6.9–7.5
Milk acidity (% lactic acid)	0.96	0.88–0.99
Churning time (minutes)	57.4	50–65
Buttermilk (% fat)	0.36	0.3–0.5
Butter yield (kg milk/kg butter)	14.6	13.9–15.7

[1] Mean of 59 observations.

These trials demonstrate the benefits of using the internal agitator, in terms of saving time and boosting butter yield. Increased butter yield is of particular economic importance since the price of butter is about seven times that of the cheese made from buttermilk.

C.B. O'Connor

Production and use of milk and milk products by smallholders in eastern Shewa, Ethiopia

The vast majority of Ethiopians are smallholders living in rural areas. Milk and milk products are important both nutritionally and economically to these smallholders and their families.

A survey of production, processing, marketing and use of milk and milk products was conducted in 1989 among smallholders in the highlands south-east of Addis Ababa. The survey covered 160 smallholders, two from each of 80 peasants' associations within a radius of about 55 km of Debre Zeit, a town some 50 km south-east of Addis Ababa.

The smallholders each kept between one and five cows, with an average of 2.3 cows per smallholder. Three smallholders each had one crossbred (Friesian–zebu) cow; all the rest kept local zebu cows. Most smallholders preferred local cows because they are easier to manage and less prone to disease. However, 17% of smallholders expressed a preference for crossbred cows because of their greater milk yield (up to 6 litres a day, compared with an average yield of only 2 litres a day for local cows). However, they are reluctant to keep them because they are more susceptible to disease, require more feed and need good management.

Most households (93%) consumed fresh milk and almost all (99%) made butter and cheese. Only three households sold fresh milk. The smallholders feel that they make more money by making and selling butter and cheese than they would from selling fresh milk. Milk is processed by women and children, mainly using traditional methods; only one smallholder was using the improved local churn developed by ILCA.

A third of households used all the butter they produced themselves. Butter is used for cooking and cosmetic purposes. All households used some butter cosmetically and 97% used some for cooking. Buttermilk was used to produce a cottage-type cheese *(ayib)* or was consumed by the family. *Ayib* was consumed by the family (64% of households consumed all the cheese they made) or sold.

All smallholders stated that they had problems with buttermaking, including poor milk hygiene and quality, long churning times and fluctuations in milk temperature prior to and during churning. However, only two of them had received any instruction on milk processing.

These findings indicate the need for a major educational programme to improve smallholders' milk production and processing methods. Further work is needed to extend the shelf life of existing products and to explore the possibility of making other milk products with better storage properties.

C.B. O'Connor

Improved methods for milk processing

Smallholder dairy farmers in the Arusha-Kilimanjaro region of Tanzania have been the focus of assistance from the FAO Rural Dairy Development Training Team. Efforts have been directed at boosting milk production, in particular by providing extension services, improving management and provision of an artificial insemination service. ILCA has been assisting this project by investigating the possibilities for smallholder production of scamorza, a pasta-filata-type cheese, including:

- making it with milk with a reduced fat content, which would release fat for other purposes, such as buttermaking

- reducing weight losses during ripening of the cheese
- improving its appearance and shape.

One hundred and twelve individual cheeses were made using milk containing 2.12, 2.97 and 4.45% fat. Data collected included the amount of fat lost during a four-week ripening period, the amount of milk required to produce 1 kg of cheese and weight loss of uncoated cheese or cheese that had been coated with butter.

After a four-week ripening period fat loss ranged from 22.5% (SE 5.1) for cheese made from milk containing 2.12% fat to 39.38% (SE 3.07) for cheese made from milk containing 4.45% fat. The amount of milk required to produce 1 kg of cheese ranged from 10.36 litres (SE 0.48) for the low-fat milk to 9.01 litres (SE 0.21) for the high-fat milk.

Initially, cheese coated with butter lost less weight than uncoated cheese (9.75% (SE 1.15) vs 11.43% (SE 1.43) over the first week) but after the four-week ripening period there was no significant difference between the coated and uncoated cheeses (21.97% (SE 2.24) vs 22.15% (SE 2.98)). There was no significant difference between the total solids content of coated and uncoated cheese at the end of the ripening period (about 62%).

These results indicate that scamorza cheese should be made from milk containing 2.5 to 3% fat, as a compromise between fat loss and cheese yield. Further studies are needed to determine the profitability of standardising milk to this fat content. The recovery of the protein and total solids during the process should also be investigated.

M. Moens and C.B. O'Connor

Collaborator: FAO Rural Dairy Development Training Team in Tanzania

Breed evaluation and improvement

Most countries in sub-Saharan Africa do not have clear strategies on the improvement and maintenance of their cattle genetic resources. Sound breeding programmes are essential to sustainable genetic improvement. Such programmes should define the economic traits to be included in the evaluation of animals, the most effective and practical evaluation procedures and the most suitable mating/breeding system or systems.

ILCA's current efforts concentrate on helping national agricultural research systems (NARS) analyse their breed evaluation data, characterise indigenous genetic resources, establish performance recording systems under smallholder conditions and develop appropriate breeding programmes and policies. The most effective way to do this is by working directly with NARS scientists involved in breed evaluation. This report gives an example of this approach from Kenya.

Evaluation of dairy cattle genotypes for smallholder production in subhumid coastal Kenya

Smallholder dairy production in subhumid coastal Kenya has developed mainly through the use of crosses between zebu breeds and European dairy breeds. These crosses have a much higher potential for milk production than the local East African Zebu. Dairy crosses (grade cattle) are kept in a range of production systems on small-, medium- and large-scale farms and in institutional herds. A few pure dairy breed herds are also found. ILCA, in collab-

oration with the Kenya Agricultural Research Institute, is studying performance records from some of these herds to:

- compare the health and performance of dairy cattle genotypes in this zone, with emphasis on their use in smallholder production systems
- propose breeding systems to produce dairy replacements of the optimal genotypes.

Purebreeding and two-breed rotational crossbreeding are the two most convenient systems for smallholder dairy producers. The performance of these systems and F_1 crosses were compared using records collected since the 1960s in a breeding programme with Ayrshire, Sahiwal and Friesian breeds at the Kenya Agricultural Research Institute's Mariakani Animal Production Research Centre. The Centre is in the coastal lowland livestock–millet zone and has a mean annual rainfall of 860 mm. Cows grazed natural pastures with little or no supplementation, were mated year round and were hand milked. Calves were bucket reared. Major diseases were controlled by routine preventive measures.

The reproductive and lactation performance of the five genotypes produced by the three breeding systems are shown in Table 10. Age at first calving was earliest in the F_1 crosses and latest in the high-grade Sahiwals. All genotypes had similar mean calving intervals. Lactation lengths and daily milk yields increased as the proportion of genes from European breeds increased, resulting in markedly higher lactation milk yields.

Table 10. *Least squares means and standard errors for reproductive and lactation traits of five cattle genotypes in three breeding systems, coastal Kenya.*

Breeding system/ genotypes	Age at first calving (days)			Calving interval (days)			Lactation length (days)			Daily milk yield (kg)		Lactation yield (kg)	
	n	Mean	SE	n	Mean	SE	n	Mean	SE	Mean	SE	Mean	SE
Purebreeding													
>87.5% Sahiwal	75	1106	16	121	405	7	203	264	6	4.3	0.13	1135	44
F_1 crossbreeding													
Ayrshire × Sahiwal	57	979	19	122	404	7	184	273	6	5.5	0.14	1504	48
Friesian × Sahiwal	34	967	24	60	397	10	95	284	9	5.5	0.20	1533	66
Rotational crossbreeding													
2/3 Sahiwal–1/3 Ayrshire	78	1042	15	130	396	7	224	272	6	4.5	0.13	1228	44
2/3 Ayrshire–1/3 Sahiwal	62	1005	18	112	424	7	174	291	7	5.6	0.15	1609	58

F_1 crossbreds gave about 35% more milk per cow per year than pure Sahiwals (Table 11), while the rotational crosses gave an average of 23% more than the Sahiwal. At herd level, the advantage of the F_1 crossbreeding system will be reduced by the proportion of purebred Sahiwals retained to produce the F_1 crosses. A more practical breeding system for the smallholder is producing alternate generations of the two rotational crosses, 2/3 Ayrshire–1/3 Sahiwal and 2/3 Sahiwal–1/3 Ayrshire.

W. Thorpe and J.C.M. Trail

Collaborator: Kenya Agricultural Research Institute (KARI)

Table 11. *Mean annual milk yield of five cattle genotypes in three breeding systems, coastal Kenya.*

Breeding system/ genotypes	Mean annual milk yield[1] (kg)	Improvement over Sahiwal (%)
Purebreeding		
>87.5% Sahiwal	1023	
F_1 crossbreeding		
Ayrshire × Sahiwal	1359	33
Friesian × Sahiwal	1409	38
Rotational crossbreeding		
2/3 Sahiwal–1/3 Ayrshire	1132	11
2/3 Ayrshire–1/3 Sahiwal	1385	35
Mean of rotational crosses	1259	23

[1] (Lactation milk yield × 365)/calving interval.

Reproductive wastage and hygiene management

Reproductive performance is a major determinant of the productivity of cattle production systems. Reproductive performance is poor in most cattle production systems in sub-Saharan Africa mainly because cows either fail to become pregnant, primarily due to prepubertal or postpartum anoestrus, or fail to maintain the pregnancy, and because of high calf mortality.

Cows commonly calve first at more than four years old and have subsequent calving intervals of more than two years. Between 20 and 50% of calves die before weaning.

Research under this theme is aimed at improving reproductive performance by reducing the effects of diseases, particularly through improved management and feeding.

Effects of early supplementation with legume hay and water on cattle performance in semi-arid Ethiopia: Impact on weaning weight, growth and time to maturity

Calves and people compete for milk in many pastoral and agropastoral societies in Africa. People consume up to half of all milk produced and this may limit herd performance by lowering weaning weights, which reduces cash income because animals sold are smaller than they should be for their age, and by stunting animals and delaying puberty.

A trial was started in 1986 on the Borana plateau, southern Ethiopia, to study the effects of early supplementation of calves with various levels of legume hay and water under simulated pastoral management to determine:

- if supplementation could compensate the calves fully for milk deprivation in terms of weaning weight
- whether increases in growth resulting from supplementation persist, improve subsequent performance and reduce time to maturity

- the average age at the onset of puberty of zebu cattle under extensive grazing management, and the target weight at which this takes place.

Animals were considered to have reached puberty if they stood to be mounted by the bull, rectal palpation (conducted monthly) detected the presence of a corpus luteum and their plasma progesterone level (measured every 10 days) exceeded 1.0 ng/ml.

The trial was described in detail, and initial results were presented, in *ILCA Annual Report 1988* (pages 2–4).

Among animals born in 1986, liveweight of animals in different treatment groups continued to converge in 1989. Animals on the best hay and water treatment were 45% heavier at one year old than those in the unsupplemented control group, but were only 4% heavier at 36 months old (196 kg vs 188 kg; Figure 8). There was a similar convergence between animals that had received all their mothers' milk and the control animals, which received only half.

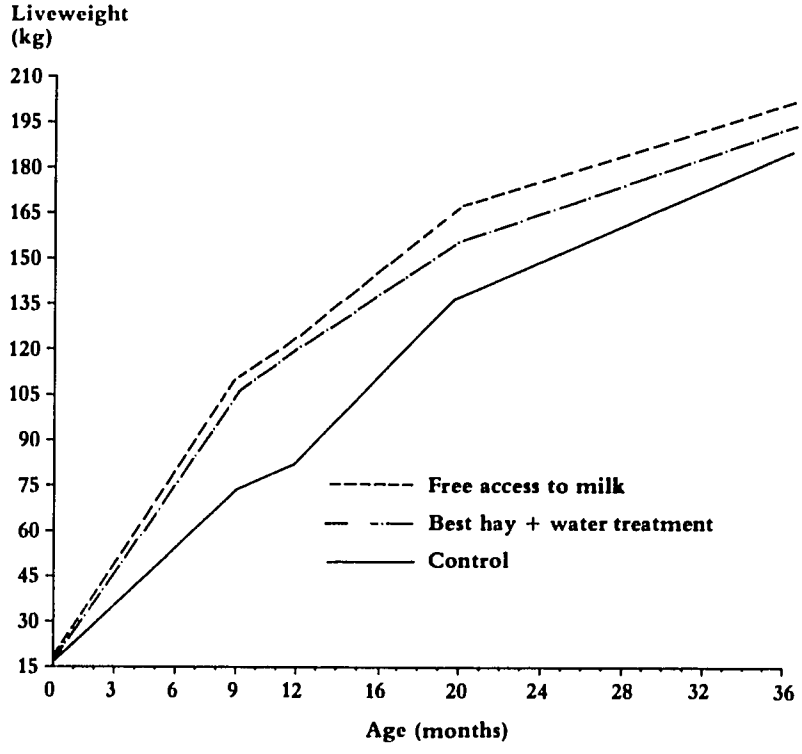


Figure 8.
Growth to three years for cattle on semi-arid rangeland in southern Ethiopia following various preweaning treatments from two to nine months of age.

The 62 heifers born in 1986 averaged 19 kg (SD 3) at birth and 94 kg (SD 22) at weaning (322 days (SD 65)), with an overall average daily gain to weaning of 224 g (SD 48). By January 1990, when the average age of these animals was 43 months, only 30 animals had reached puberty. The average age at puberty among these 30 animals was 1231 days (SD 117) with no significant differences among treatments. However, animals that had reached puberty had significantly ($P<0.01$) higher average daily gain to weaning than those that had not reached puberty. Animals achieved puberty at an average liveweight of 218 kg (SD 23), which is close to the mature body weight of the Boran breed.

Twenty-one (70%) of the 30 pubertal animals conceived at their first oestrus, while another five did so within 58 days of their first oestrus. These 26 animals conceived at an average age of 1233 days (SD 111). The conception rate at first service was 40%, with an overall rate of 58%.

These preliminary results for age and weight at puberty agree with previous surveys in the region. As noted in *ILCA Annual Report 1988*, this work invalidates the assumption that supplementing calves for less than one year automatically leads to sustained increases in growth or reduces time to maturity. It also indicates that weaning weight is not a reliable indicator of future performance in unstable, traditional production environments, and the results challenge the idea that moderate levels of milk restriction influence longer-term patterns of cattle growth. It also indicates that attempting to improve long-term production parameters in variable environments is risky. In this example, about 136 kg of legume hay and 1050 litres of water were effectively "lost" over the long term in the best treatment. Interventions in this and similar environments should thus focus more on reducing calf mortality and improving management efficiency rather than on cattle growth *per se*.

D.L. Coppock, S. Sovani and O.B. Kasali

Collaborators: Third Livestock Development Project, Ministry of Agriculture, Ethiopia, and CARE-Ethiopia

Disease risk to dairy cattle in coastal subhumid Kenya

Disease is a major factor limiting smallholder dairy production in subhumid coastal Kenya. A recent farming systems study in the area found that smallholder farmers rate disease as the most critical problem they face (see *Characterisation of coastal subhumid farming systems in Kenya*, page 10 of this report). Dairy (grade) and local zebu cattle in the Kaloleni study area were surveyed in July and September 1989 to estimate the prevalence of major diseases on smallholder farms.

Blood and faeces were collected from 736 grade cattle and 220 local East African Zebu cattle in 134 herds and were examined in collaboration with the Kenya Veterinary Department and the International Laboratory for Research on Animal Diseases (ILRAD).

A summary of the results obtained to date is presented in Table 12.

The buffy coat technique indicated a trypanosomiasis prevalence of less than 1% in the 956 cattle sampled. However, analysis of 777 serum samples using enzyme-linked immunosorbent assay (ELISA), which detects trypanosomal antigens, gave prevalences of 30, 24, and 15% for grade cattle in the coconut–cassava, cashew-nut–cassava and livestock–millet zones, respectively, and 30% for zebu cattle.

Mean packed cell volume (PCV) was high, particularly in zebu cattle. A recent study of similar zebu cattle in Muhaka, some 60 km south of Kaloleni, reported a mean PCV of less than 27%, compared with a mean of more than 30% in this study. Further studies are needed to determine whether the higher trypanosome challenge suspected in the Muhaka area is the major factor depressing PCV there.

More than 95% of tick-borne haemoparasites detected on blood smears were piroplasma. Piroplasm prevalence ranged from 1 to 20% in grade cattle. Prevalence was lower in the semi-arid zone than in the subhumid zone. In the subhumid zone prevalence was higher in free-grazing grade

Table 12. *Prevalence of trypanosomiasis, tick-borne haemoparasites, East Coast Fever and intestinal parasites, and levels of packed cell volume (PCV) in grade and zebu cattle in three agro-ecological zones in coastal Kenya, 1989.*

	Coconut–cassava zone		Cashew-nut–cassava zone		Livestock–millet zone	
	Grade	Zebu	Grade	Zebu	Grade	Zebu
Number of herds	76	32	47	20	10	5
Number of cattle	338	121	287	84	111	15
Trypanosomiasis (%)						
Buffy coat	1.5			1.2	0.9	
ELISA	30	–[1]	24		15	
Tick-borne haemo-parasites (%)	15	26	15	7	9	7
East Coast Fever (%)[2]	74	83	76	78	47	
Intestinal parasites (%)[3]	29	27	28	16	25	15
Mean PCV (%)	33.2	31.8	33.0	31.8	32.9	29.5

[1] Overall, 30% of zebus showed positive.

[2] East Coast Fever of >40, immuno-fluorescent antibody test.

[3] Animals up to 18 months old: >200 eggs per gram of faeces.

cattle than in those that were semi-zero and zero grazed. These results reflect expected tick challenges.

Prevalence of *Theileria parva* antibodies detected with the immuno-fluorescent antibody (IFA) test on 623 samples was high (29–95%) irrespective of age group, grazing system, agro-ecological zone or cattle type, confirming the major importance of East Coast Fever.

Faecal egg counts indicated no major differences between cattle types or agro-ecological zones, although counts were lower in zero-grazed grade cattle.

These results confirm the importance of East Coast Fever and trypanosomiasis, the epidemiology of which will be studied during continuous recording in 1990. The studies will be supported by an ethnoveterinary survey of farmers' understanding of disease and disease control to identify possible constraints to the delivery, adoption and sustainability of the disease control measures which may be proposed.

W. Thorpe and S. Maloo

Collaborators: Kenya Veterinary Department; International Centre for Insect Physiology and Ecology, Kenya; University of Glasgow, UK; International Laboratory for Research on Animal Diseases, Kenya

Network coordination

ILCA sees its role in the establishment of the Cattle Research Network as catalytic in the process of the pooling and sharing of available knowledge, experience and research facilities by scientists and institutions in national agricultural research systems (NARS).

The Cattle Research Network was established following a consultative workshop held at the University of Ibadan, Nigeria, in October 1988, at which 67 participants from NARS in Cameroon, Côte d'Ivoire, Ghana, Guinea, Mali, Nigeria, Senegal and Togo resolved to establish a collaborative cattle research network for West and central Africa. A second workshop, held at Kadoma, Zimbabwe, in June 1989, and attended by 48 participants from NARS in Botswana, Ethiopia, Kenya, Malawi, Tanzania, Zambia and Zimbabwe, resolved to establish a similar network for East and southern Africa.

Participants in each workshop elected an interim working committee (IWC) to develop the research agenda and other programmes of the network. The IWC of the West and central Africa network held its first meeting at ILCA headquarters, Addis Ababa, in January 1989; the IWC of the East and southern Africa network met in Nairobi, Kenya, at the end of August 1989. The committees made recommendations on the objectives and organisational structure, research and training priorities, operational modes and information exchange, and recognised that adequate funding for grants was crucial and would depend largely on the network's ability to present technically sound collaborative research, training and information exchange protocols to donors.

The West and central Africa network held a research protocol planning workshop at Saly, Senegal, in September 1989 to establish its collaborative research programme. Network participants developed project protocols in three themes identified by NARS as priority areas for regional collaborative research:

- improvement of reproductive performance and calf survival in traditional herds and peri-urban dairy production systems
- evaluation, characterisation and genetic improvement of cattle breeds
- development of feeding and management strategies for sustainable cattle production.

The participants at this meeting also elected a six-member steering committee to replace the interim working committee.

In May 1989 the network published the first issue of the Cattle Research Network Newsletter in both English and French. The newsletter was distributed to more than 750 scientists and institutions in sub-Saharan Africa and elsewhere.

E.A. Olaloku and P. Chigaru

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* *Joined ILCA in 1989*
** *Left ILCA in 1989*

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Small Ruminant Meat and Milk Thrust

Sheep and goats, with their small body size, high reproductive capacity and rapid growth rates, are ideally suited to production by resource-poor smallholders. They can be integrated into the overall production system, absorbing surplus labour and consuming small amounts of otherwise unused feed. The low capital requirement for starting or expanding small ruminant production means that risks are low and that the enterprise is well suited to low-input systems.

Small ruminants provide almost 30% of the meat consumed and around 16% of the milk produced in sub-Saharan Africa. Increased production will boost farm income, generating cash with which to purchase inputs for other production activities.

The objective of the Small Ruminant Meat and Milk Thrust is, therefore, to increase the sustained output of small ruminant meat and milk in mixed crop–livestock farming systems, thereby improving the quality of life of the people of sub-Saharan Africa.

Economics of small ruminant production

The economic constraints to and opportunities for small ruminant production and marketing in sub-Saharan Africa, and the socio-economic conditions in which the systems exist, must be understood so that appropriate technological innovations can be developed. The social and economic benefits of innovations designed to increase production must be quantified to ensure that the innovations will be sustainable and benefit the intended target group.

Marketing and demand studies: Sheep marketing and intra-annual price variation in central Ethiopia

Intra-annual price variation and effects of animal characteristics

Information about intra-annual variation in sheep prices is important for designing controlled breeding programmes and feeding programmes to take advantage of the best markets and assess the importance of animal characteristics on prices.

Nine sheep markets in the central highlands of Ethiopia were included in a survey of intra-annual price variation and the effects of animal characteristics on prices. Each market was surveyed on the main market day of each week throughout 1989. Records were taken throughout the market day of transactions including data on price per head, weight, sex, age, condition, breed, colour, buyer purpose, seller type, buyer type and time of sale. In addition, data on the number offered and the total number sold were noted. During normal marketing periods all transactions during the day were recorded. On heavy marketing days, preceding major holidays or festivals, enumerators worked continuously throughout the day recording as many transactions as possible. A total of 50062 transactions were recorded.

Markets were classified as terminal or redistributive on the basis of buyer purpose, whether predominantly for direct consumption, resale or production (fattening or breeding). Four were classified as terminal, four as redistributive and one as intermediate, having equal proportions of sheep sold for direct consumption and for resale. This report presents comparisons between the major terminal market in Addis Ababa (Shola), the intermediate market in Debre Birhan and a primarily redistributive market in Degollo.

Price per head and price per kg data were regressed against animal characteristics, time and festival periods using the general linear model. Key results are summarised in Table 13.

Table 13. *Summary of market data and general linear model results, Shola, Debre Birhan and Degollo, Ethiopia, 1989.*

	Shola	Debre Birhan	Degollo
No. of observations	6226	8551	7782
Mean price per kg (EB)	2.84	2.26	1.85
R^2	0.33	0.26	0.35
Weight	**	*	*
Weight squared	**	**	**
Sex	**	**	**
Age		**	**
Condition		**	**
Colour	**	**	**
Buyer purpose		*	**
Season	**	**	**

* = $P<0.05$; ** = $P<0.01$.

US$ 1 = EB 2.07.

Mean annual prices varied from Ethiopian Birr (EB) 1.85 per kg in the Degollo market, a rural redistributive market, to EB 2.84 per kg at Shola, an urban terminal market. Weight, sex and colour, all very identifiable characteristics, were the only animal characteristics to have a significant ($P<0.05$) effect on price per kg in the urban Shola market. (Ninety-eight per cent of animals purchased in the Shola market were for direct consumption.) In contrast, in the rural market animal age and condition and buyer purpose also had a significant ($P<0.05$) effect on prices.

Animal weight had a non-linear effect on price per kg in all markets, with animals of intermediate weight having lower prices per kg than either lighter or heavier animals. Mean weekly animal weights varied substantially from week to week and, in particular, between seasons. Hence, the pattern in weekly price variation per kg differed from the pattern in price per head.

Weekly mean prices per kg for the three markets are shown in Figure 9. It should be emphasised that these represent weekly mean prices for all animals and that the animals are not uniform in their distribution of characteristics from one week to the next. Mean weights vary markedly over the year, and there is considerable variation in the distribution of sex, age, condition and colour among the animals offered for sale.

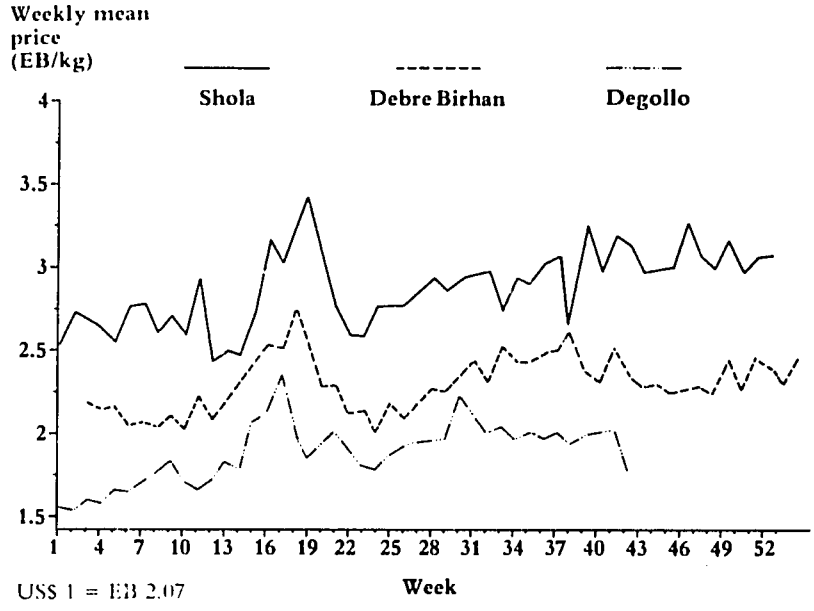


Figure 9.
Weekly mean price per kg for sheep in three markets in the Ethiopian highlands, 1989.

Market integration and market efficiency

Information about participants, practices, market integration and price differentials among markets is important for assessing market efficiency and potential for improvements. Transaction data from various markets were used to test whether the prices in one market were independent of or dependent on prices in other markets. The analysis used a simple bivariate model relating prices between pairs of markets, with a lag structure of one or two weeks between redistributive and terminal markets.

The markets were characterised by a large number of traders, no restrictions on entry to or exit from the market and physical linkage by regular transport. Given such characteristics, markets are integrated if prices in one are significantly dependent on prices in others.

Such tests require the use of a single homogeneous product, and homogeneity of product was tested for by testing the behaviour of prices over a period of time with respect to the various characteristics. A log–linear regression of price against animal characteristics was used. Homogeneity is indicated when interaction coefficients are not individually or jointly different from zero.

The test was applied individually for the three sex categories relating price to interaction of animal characteristics and time as well as buyer

purpose and time. Results showed that male sheep were homogeneous with respect to condition in all markets, female sheep were homogeneous with respect to buyer purpose in all markets and castrates were homogeneous with respect to colour and buyer purpose. However, only male sheep had sufficient numbers for testing market integration and then only among four markets.

Results of the market integration test indicated that all the markets are integrated.

A test of efficiency of markets is made by determining whether price differences among markets are explained by arbitrage costs alone. The test involves determining whether arbitrage costs vary with prices. In theory, with no technical or policy changes, arbitrage costs should not vary with price levels.

Results indicated inefficiency in the main terminal market of Addis Ababa, ie, all relationships estimated for this market with the other markets show arbitrage costs changed with the price level. In contrast, this arbitrage cost was constant among all other markets. The possible explanation of this inefficiency in the Addis Ababa market is the existence of *delalas* (brokers) who are not present in other markets. These brokers impose their services on all buyers and extract variable commissions.

Andargachew Kebede and R. Brokken

An economic analysis of nutritional supplementation and endoparasite control on the performance of Menz sheep

Endoparasites, including *Fasciola hepatica*, *Haemonchus contortus*, *Dictyocaulus fibaria*, *Trichostrongylus colubriformis* and *Trichuris skrjabini*, are a major cause of death and morbidity in sheep in the Ethiopian highlands. This study investigated the economics of feed supplementation and endoparasite control for sheep at ILCA's Debre Birhan research station.

The trial consisted of four treatment groups, each comprising 50 ewes aged between two and four years. Treatments were:

- no drenching or supplementation (control)
- drenching against nematodes and trematodes
- supplementary feeding
- drenching and supplementary feeding.

All groups grazed together during the day and had free access to water and mineral blocks. Supplementary feeding started in March 1988, and consisted of 300 g of wheat bran and 150 g of noug *(Guizotia abyssinica)* cake daily for each supplemented animal. This provided 8 MJ of digestible energy and 100 g of crude protein. The effects of these treatments on the reproductive and productive performance of the sheep are presented on page 53.

Partial budgeting was used to compare returns to the four treatments.

Drenching and supplementation together gave the highest gross margin but drenching alone gave the highest rate of return (Table 14). Thus endoparasite control is profitable on-station and, if the veterinary inputs and extension advice are available, should also be profitable on-farm.

R. Brokken and P. Ngategize

Table 14. *Partial budgets for feed supplementation and health control treatments, Debre Birhan, Ethiopian highlands, 1989. Values are in Ethiopian Birr and apply to flocks of 50 sheep.*

Item		Ethiopian Birr			
		Grazing (control)	Supplementary feeding	Health control	Supplementary feeding and health control
A	Initial flock value	2405	2844	2597	2678
B	Final flock value	2082	3207	2554	3326
C	Weaned lamb value	643	952	705	865
D	Gross revenue (B + C – A)	320	1315	662	1513
E	Cost of supplements	–	796	–	796
F	Cost of anthelminthics	–	–	109	109
G	Total incremental costs (E + F)	–	796	109	905
H	Gross margin (D – G)	320	519	553	608
Incremental returns over control					
I	Gross revenue (D – control D)	–	995	342	1193
J	Gross margin (H – control H)	–	199	233	288
K	Rate of return to incremental cost (J/G × 100)	–	25	214	32

US$ 1 = EB 2.07.

Sources of revenue of smallholders in the semi-arid zone of Mali

Rural households in Mali derive their income from a combination of crop production, animal production and a variety of off-farm activities. The rural economy can be understood only if information is available on household resource allocation and income. Studies were started in Mali in 1987 to provide such information.

A study site was chosen 150 km north of Bamako, Mali, in the Bambara region. This area receives 600 to 800 mm annual rainfall, most of which falls between June and September. The main agricultural activity is mixed crop–livestock production. The principal crops are millet, sorghum, cowpea and groundnut. Livestock include cattle, sheep, goats, poultry and donkeys.

Thirty-five households were surveyed regularly throughout the year and data were collected on:

- agricultural activities, ie, cropped area, crops, agronomic practices, yields, crop sales and on-farm consumption
- family size and composition, labour availability and use for farm and non-farm activities
- livestock holdings and their composition and dynamics
- off-farm generation of income, ie, construction work, trade, handicrafts, fruit gathering and remittances.

This report covers a representative group of 15 households, monitored between January 1987 and February 1988.

The average household cropped about 14 ha (54% with millet intercropped with cowpea or groundnut), owned 24 cattle and 34 small ruminants, and comprised 15 people, 7 of whom were agriculturally active.

Table 15. *Origin and amount of income in rural households, semi-arid zone, Mali, 1987/88.*

Sector	Subsector	Value (FCFA/household)	Per cent of total
Arable	Grains	220 500	43
	Agricultural byproducts	43 000	9
	Non-grain	26 750	5
	Subtotal	290 250	57
Livestock	Milk	79 000	15.5
	Small ruminants	72 750	14
	Cattle	49 750	10
	Subtotal	201 500	39.5
Gathering (wood, shea butter)		3 750	1
Artisanal (arts, crafts, weaving)		3 000	0.5
Remittances		11 750	2
Total		510 250	100

French Franc 1 = FCFA 50.

Cropping provided 57% of household income, livestock about 40% (Table 15), including the value of on-farm consumption. Millet and groundnut accounted for about 76% of arable income. Sales of cow and goat milk provided 40% of livestock income, small ruminant sales accounted for 35% and cattle sales the remaining 25%. Remittances from family members or relatives in urban or neighbouring areas were the most important source of non-farm income, but provided only 2% of total income.

S. Debrah

Collaborator: Institut national de recherche zootechnique, forestière et hydrobiologique, Mali

Genetic resource evaluation and breed improvement

Information on the performance potential of indigenous breeds is a basic prerequisite for the development of national breeding policies and for improving productivity. Few of Africa's indigenous breeds have been adequately studied and accurate performance data are scarce. This research theme aims at developing and testing appropriate methodologies for comparing the productivity of different breeds under various production systems.

Evaluation of the performance of Ethiopian sheep breeds under various management regimes

Many smallholders in the Ethiopian highlands fatten rams and castrates for sale during festival periods, when demand is high. A trial was conducted in the 1989 dry season to assess the fattening performance of three Ethiopian

highland breeds, Arsi, Menz and Wello, at ILCA's Debre Birhan research station.

The trial used a total of 53 adult male sheep, aged about 22 months, of the three breeds. Their initial mean weights were 25.7 kg for Arsi, 22.0 kg for Menz and 27.3 kg for Wello. Twenty-nine of the 53 animals were castrated at the beginning of the trial. The trial lasted 28 weeks.

All animals grazed on native pasture for eight hours a day and received either 200 g or 500 g a day of a concentrate mixture (30.75% noug *(Guizotia abyssinica)* cake, 50% wheat bran, 18% maize, 1% limestone and 0.25% salt).

Growth rate did not differ significantly between breeds or between castrates and entire males (Table 16). Growth rate dropped dramatically after the 18th week, and fattening beyond 18 weeks cannot, therefore, be recommended. Feeding level had a significant ($P<0.05$) effect on growth rate, high-plane animals gaining about twice as much weight as low-plane animals (Table 16). Low-plane animals weighed between 28.6 kg (Menz) and 33.2 kg (Wello) at the end of the 28-week fattening period, which is at the lower limit of the preferred weight range for sheep to be slaughtered at festival periods.

Table 16. *Least squares means and standard errors for average daily gains of three highland sheep breeds, starting at 22 months of age, at different fattening stages, Debre Birhan, Ethiopia, 1989.*

	Average daily gain (g)											
	0–8 weeks			9–18 weeks			19–28 weeks			0–28 weeks		
Variable	n	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE
Overall	53	67	2.5	52	54	3.0	52	25	1.9	52	47	1.7
Breed												
Arsi	17	62	4.3	17	61	5.2	17	30	3.4	17	49	3.0
Menz	18	67	4.2	18	50	5.1	18	22	3.3	18	45	2.9
Wello	18	71	4.2	17	51	5.2	17	24	3.4	17	46	3.0
Feeding level												
Low	26	44	3.5	26	32	4.2	26	20	2.8	26	29	2.4
High	27	89	3.4	26	76	4.2	26	31	2.8	26	64	2.4
Castration status												
No	24	68	3.6	24	53	4.4	24	28	2.9	24	49	2.5
Yes	29	65	3.3	18	55	4.1	28	22	2.6	26	45	2.3
R^2	0.69			0.63			0.41			0.73		

High-plane sheep had a better dressing-out percentage than low-plane animals (46.3% vs 42.0%), a higher empty body weight and accumulated more fat in subcutaneous and intermuscular depots than low-plane animals.

These results show that male sheep of the Arsi, Menz and Wello breeds can be successfully fattened during the dry season if supplemented with a moderate (500 g a day) amount of concentrates. A lower rate of supplementation would be unlikely to produce reliably the standard of carcass required in the market.

K.-D. Gautsch and K. J. Peters

Forage production and feeding systems

Inadequate nutrition is one of the most serious constraints to livestock production in sub-Saharan Africa. Underfed animals are unable to fulfil their genetic potential. Improvement of forage production and feeding systems is thus a key element in ILCA's Small Ruminant Meat and Milk Thrust.

Feed resource assessment is a necessary first step, identifying needs at particular times of year. Concurrent studies screen "best bet" forages, and investigate their management and use taking into account the farming system in which they will be used.

In mixed crop–livestock systems forage legumes can play a central role; they provide high-quality feed for livestock and help improve soil fertility and boost crop yields. Crop residues are a valuable feed resource but are currently underused.

Effects of oilseed cake and clover hay as supplements to sheep on a basal diet of teff straw

Teff *(Eragrostis tef)* straw is an important crop residue in the Ethiopian highlands but, like many cereal straws, it is deficient in protein and poorly digestible. Clovers (*Trifolium* species) are widely distributed and well adapted to conditions in the Ethiopian highlands, producing 5–6 t dry matter/ha on Vertisols, and are thus a potential supplement to cereal-straw-based diets. Noug *(Guizotia abyssinica)* cake is a readily available oilseed cake but, since the hull is not removed during processing, it has relatively high acid- and neutral-detergent fibre contents and hence its digestibility is poor.

A trial was conducted at ILCA's Debre Zeit research station to compare clover *(Trifolium quartinianum)* hay and noug cake as supplements to sheep fed a basal diet of *ad libitum* teff straw. There were nine treatment groups, each comprising six male sheep. Supplements offered, feed intake and liveweight gain are shown in Table 17. Liveweight change was subject to statistical analysis (t test) but feed intake was not because the six sheep in each treatment group were group-fed.

Table 17. *Dry-matter and crude-protein intake and liveweight gain of male sheep, Debre Zeit, Ethiopia, 1989.*

Treatment	Group mean feed intake (g/day)		Liveweight gain (g/day)
	Dry matter	Crude protein	
100 g *Trifolium* + 300 g noug	540	113	35c
225 g " + 200 g noug	635	101	47bc
350 g " + 100 g noug	685	85	61a
200 g noug	425	72	8d
250 g "	425	86	3de
350 g "	400	100	–7e
350 g *Trifolium*	699	57	36c
400 g "	715	63	42bc
600 g "	788	84	53ab

Means followed by the same letter do not differ significantly ($P > 0.001$).

Noug cake as sole supplement resulted in poor dry-matter intake and low or negative rates of weight gain. Daily gain increased significantly ($P<0.001$) as the amount of clover hay on offer increased. The highest rate of gain was achieved by supplementing the diet with 350 g of clover hay and 100 g of noug cake daily, but this level of gain was not significantly different from that achieved by supplementing the diet with 600 g of clover hay.

These results show that noug cake is not a good sole supplement to a teff-straw diet. A combination of medium levels of clover hay and noug cake gives as good a rate of weight gain as feeding a high level of clover hay without noug cake. This has important practical implications where noug is readily available and cheap, as is the case in most of central Ethiopia.

A.N. Said

The value of *Desmodium intortum, Stylosanthes guianensis* and *Macrotyloma axillare* hays as feed supplements

Crop residues are an important animal feed for smallholder farmers but crop-residue-based diets must be supplemented if animals are to achieve adequate growth rates. A feeding trial was conducted in 1989 at Debre Zeit, Ethiopia, to assess the potential of three locally grown legumes (*Desmodium intortum, Stylosanthes guianensis* and *Macrotyloma axillare*), fed as hay, as supplements to sheep fed a basal diet of maize stover.

The 80-day trial consisted of nine treatment groups, each with six animals. Maize stover was offered *ad libitum* as a basal ration. The legume hays were offered at three levels (250, 350 and 450 g/head per day).

Intake of maize stover declined significantly ($P<0.05$) as legume intake rose, with variable effects on total intake (Table 18). Increasing the amount

Table 18. *Voluntary feed intake and body weight gain of lambs fed a basal diet of maize stover supplemented with different levels of legume hays.*

Supplement (g/head per day)	Dry-matter intake ($g/kg^{0.75}$ per day)			Liveweight gain (g/day)
	Maize stover	Legume hay	Total	
Desmodium intortum				
250	28.9a	26.8c	55.7b	7.3b
350	26.9b	35.0b	61.9a	24.9a
450	17.0c	44.7a	61.7a	30.9a
Stylosanthes guianensis				
250	33.4a	26.0c	59.4b	15.0b
350	22.2b	36.6b	58.8b	13.9b
450	20.3c	44.4a	64.7a	30.3a
Macrotyloma axillare				
250	18.4a	27.6c	46.0c	−19.3b
350	15.2b	37.5b	52.7b	− 0.9ab
450	10.0c	44.6a	54.6a	− 3.2a

Within legume species, values in the same column followed by the same letter do not differ significantly ($P>0.05$).

of *D. intortum* on offer to 350 g/day from 250 g/day resulted in a significant ($P<0.05$) increase in daily weight gain, but increasing the amount on offer to 450 g/day did not result in any further significant increase in growth rate. There was no significant difference in growth rate between sheep fed *S. guianensis* at 250 and 350 g/day, but increasing the level on offer to 450 g/day resulted in a large and significant ($P<0.05$) increase in growth rate. All sheep offered *M. axillare* hay lost weight, but those receiving 450 g/day lost significantly less weight than those receiving 250 g/day.

Mean rumen ammonia concentrations four hours after feeding the legume hays were significantly ($P<0.05$) lower in sheep fed *D. intortum* (106 mg/litre) than in those fed *S. guianensis* (120 mg/litre) and *M. axillare* (117 mg/litre). Corresponding values eight hours after feeding were 121, 146 and 157 mg/litre, respectively. Animals fed *M. axillare* had a relatively low proportion of propionate in the volatile fatty acids in their rumens compared with animals fed the other two hays. Propionate is a major source of energy for weight gain.

These results indicate that, fed as hay, both *D. intortum* and *S. guianensis* show promise as supplements to sheep diets based on *ad libitum* maize stover, but that *M. axillare* hay has no potential as a sole supplement. Further studies are needed to re-evaluate *M. axillare* as a cut-and-carry green fodder and also to investigate its metabolism in the rumen.

A.N. Said and Adugna Tolera

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

Fattening of rams and castrates up to 30–40 kg for sale during festival periods is common practice on smallholder farms in the Ethiopian highlands, where ILCA agronomic studies on Vertisols have shown that crop and crop-residue yields can be increased. Development of fattening systems using these crop residues would be especially valuable for areas of land shortage, with limited grazing opportunities.

On-farm studies were conducted in 1989 in collaboration with peasant cooperatives at Deneba and Hidi, in the Ethiopian highlands, to investigate the effects of nutrition and health control on sheep fattening under producer management.

Deneba

Grazing land is in short supply at Deneba and the sheep were stall-fed. There were four treatment groups, each comprising 10 male sheep with an initial average weight of about 20 kg. Treatments were:

- low-plane diet
- high-plane diet
- low-plane diet plus health control
- high-plane diet plus health control.

The low-plane diet consisted of 1000 g oat straw, 100 g faba beans and 50 g *Lathyrus sativa* seed. The high-plane diet consisted of 100 g oat straw, 100 g faba beans, 50 g *Lathyrus sativa* seed and 450 g oat grain. Health control measures included drenching against nematodes and trematodes, dipping against ectoparasites and vaccinating against sheep pox and pasteurellosis. The trial lasted 36 weeks up to Easter 1989.

Animals on the low-plane diet refused much of the straw on offer until week 22 of the trial, whereas those on the high-plane diet consumed all the feed on offer as from week 4.

Animals on the high-plane diet had significantly ($P<0.05$) higher growth rates than animals on the low-plane diet over the 36-week fattening period (44.9 vs 14.4 g/day). Health control did not significantly affect growth rate. All four treatments were uneconomic, the cost of feed generally exceeding the value of the liveweight gained. This was in large part due to the high price of faba beans and *Lathyrus sativa* seed, both of which are eaten by people in the Ethiopian highlands. This demonstrates the need to base feeding systems on resources that cannot be consumed directly by people, eg, oilseed cakes and brans.

Hidi

There were six treatment groups at Hidi, each comprising 10 sheep:

- grazing alone (control)
- grazing plus supplementation
- pen feeding
- grazing plus health control
- grazing plus supplementation plus health control
- pen feeding plus health control.

The feed supplement consisted of 200 g of *Sesbania* leaves, 50 g of noug *(Guizotia abyssinica)* cake, 50 g of wheat bran, 8 g of salt and 5 g of bone meal daily. Pen-fed animals received the feed supplement plus 700 g of teff *(Eragrostis tef)* straw daily. Health control measures were the same as at Deneba. The trial lasted 60 days.

Supplemented grazing animals had significantly higher average daily weight gain (56 g/day) than either pen-fed (38 g/day) or control group (41 g/day) animals. Health control had no significant effect on growth rates.

K.-D. Gautsch

Improved feeding systems for small ruminants in the semi-arid zone of West Africa

In the Sahel, crop residues, pasture and browse are the most important feed resources during the seven–eight-month dry season. A series of studies was initiated in Niger to identify forage legumes that grow well in this semi-arid environment and to develop a sustainable land-use system by integrating forage legumes into cereal-based cropping systems.

Initial evaluation of forage germplasm

A total of 45 forage legume genotypes from local and introduced accessions were screened, including several accessions of *Stylosanthes*, *Desmodium*, *Vigna*, *Cajanus*, *Lablab* and *Centrosema* species and single lines of *Alysicarpus ovalifolium*, *Indigofera hirsuta*, *Macroptilium lathyroides* and *Tephrosia purpurea*. Plants were grown in 5-m rows, with 1 m between rows, in a randomised complete block design with four replicates.

Several lines died after an early season drought, including all of the *Desmodium* species and more than half of the *Stylosanthes* lines. However, all seven *Vigna* lines grew well; a local cultivar was the most vigorous and had the greatest seed yield. *Tephrosia* and *Indigofera* also appeared promising and

will be included in productivity trials in 1990, together with the three most promising *Vigna* accessions (ILCA 6784, 9334 and 9628).

Evaluation of millet/stylo intercropping systems

The effect of intercropping millet (*Pennisetum glaucum*) with *Stylosanthes fruticosa* or *S. hamata* was investigated in 1989. Intercropping treatments were alternate single rows and three rows of millet alternating with three rows of the legume. Rows were 75 cm apart, with interplant spacings of 1.30 m for millet and 30 cm for stylo. Plots were 16 × 8.25 m and were arranged as split plots in a randomised complete block design with four replicates.

Intercropping millet with stylo significantly ($P<0.05$) increased total and usable biomass and crude protein yields compared with millet in pure stand, but significantly reduced millet grain yield (Table 19).

These results suggest that farmers are unlikely to adopt millet/stylo intercropping, as their primary goal is millet grain production.

Table 19. *Biomass, crude-protein and millet-grain yields of millet/stylo intercrops, Niger, 1989.*

	Yield (kg/ha)				
Cropping system	Total biomass[1]	Edible biomass[2]	Total crude protein[3]	Edible crude protein[4]	Millet grain
Pure stand					
Millet	2114	942	96	65	494
S. fruticosa	3075	3075	401	401	–
S. hamata	1062	1062	123	123	–
Alternate single rows					
Millet/*S. fruticosa*	2889	2361	261	248	243
Millet/*S. hamata*	5703	5155	595	585	215
Alternate triple rows					
Millet/*S. fruticosa*	3126	2809	299	289	106
Millet/*S. hamata*	4936	4226	524	519	139
LSD (5%)	1157	824	118	115	228

[1] Millet stover and/or stylo herbage yields.

[2] Millet leaf and/or stylo herbage yields.

[3] N × 6.25.

[4] Crude protein of edible material.

Comparison of the feeding value of local browse species

Browse is an important feed for ruminants, especially in the dry season when other feeds are scarce. Browses are often high in protein and mineral content, but their palatability may be limited by high levels of tannins. A trial was conducted in 1989 to determine the value of six local browses, *Azadirachta indica* (neem), *Bauhinia rufescens*, *Combretum aculeatum*, *Guiera senegalensis*, *Maerua crassifolia* and *Ziziphus mauritiana*, and cowpea hay, offered to sheep as supplements to a basal diet of millet leaves.

An initial palatability trial showed that the sheep readily ate *Bauhinia*, *Combretum*, *Ziziphus* and cowpea hay but generally not the other browses.

Examination of rumen ammonia levels showed that, while a daily intake of 75 to 100 g of crude protein from cowpea hay resulted in rumen ammonia levels of 90 to 100 mg/litre, similar protein intakes from the browse species resulted in only 20 to 40 mg/litre, below the level required to maintain microbial growth in the rumen. These browses are thus unlikely to be effective as supplements to nitrogen-deficient diets.

J.M. Powell, D. Roxas, J. Lambourne and S. Hoefs

Development of small ruminant feeding systems for the humid zone

A comparison of fresh and dried *Leucaena* as supplementary feed for sheep

Agronomy trials have shown that *Leucaena* and *Gliricidia* produce most foliage when cut twice a year, in October and January. The October surplus can be sun-dried and stored for use as feed in the dry season, and can augment the January cut. A trial was conducted in 1989 to compare fresh and sun-dried *Leucaena* foliage, offered at two levels, as a supplement to a basal diet of *ad libitum Panicum maximum* and 50 g/day of sun-dried cassava peel. The trial used four groups of lambs, initially aged about 10 months.

The animals readily ate both fresh and dried *Leucaena*, the amount eaten reflecting the amount offered (Table 20). Over the eight-week trial period animals on dry *Leucaena* grew faster (40 g/day) than those on fresh material (12 g/day). This may have been due to sun-drying reducing the level of mimosine, a toxic amino acid contained by *Leucaena*. This study will be continued in 1990 with N-balance and digestibility trials.

Table 20. *Effect of fresh and dry* Leucaena *fed as a supplement to a basal diet of* Panicum maximum *on the growth rate of lambs between 10 and 12 months of age, humid zone, Nigeria, 1989.*

Supplement	Feed intake (g dry matter/day)		Growth rate (g/day)
	Supplement	Grass	
Dry *Leucaena*	84	581	42a
Fresh *Leucaena*	91	580	13bc
Dry *Leucaena*	119	576	38ab
Fresh *Leucaena*	187	556	12c

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

On-farm use of *Leucaena* and *Gliricidia* as small ruminant feed

A survey of the use of *Leucaena* and *Gliricidia* by farmers in south-west Nigeria in 1987 showed that they offered cultivated browse to their small ruminants on 8.8 days each month, at a rate of approximately 125 g dry

matter/animal on each occasion (*ILCA Annual Report 1987*, pages 24–25). A similar study was conducted in 1989, when farmers had gained more experience with alley farming. The study covered farmers in two villages in south-west Nigeria, six farmers with alley farms and five without in each village. Information was collected on the type and quantity of supplementary feed offered and how often it was offered.

Surprisingly, both alley and non-alley farmers offered *Leucaena* and *Gliricidia* browse to their animals (Table 21). Non-alley farmers obtained *Leucaena* and *Gliricidia* from fallow alley farms, often without the permission of the owner. However, 93% of the cultivated browse offered by non-alley farmers in Owu-Ile and 42% of that offered in Iwo-Ate was provided during the first month of the trial. If the first month is omitted, non-alley farmers fed *Leucaena* and *Gliricidia* on only one day each month.

Table 21. *Quantity of supplementary feed offered, and frequency of offer, to village goats by alley farmers and non-alley farmers in two villages in south-west Nigeria, 1988/89.*

	Owu-Ile				Iwo-Ate			
	Alley farmers		Non-alley farmers		Alley farmers		Non-alley farmers	
Supplement	Amount (kg/occasion)	Frequency (days/month)	Amount (kg/occasion)	Frequency (days/month)	Amount (kg/occasion)	Frequency (days/month)	Amount (kg/occasion)	Frequency (days/month)
Leucaena and *Gliricidia*	2.9	5.3	5.1	2.5	4.7	10.1	4.1	2.5
Grass	0.6	<0.1	3.2	0.1	0.4	0.2	0	0
Indigenous browse	1.8	0.8	0.8	0.1	3.7	0.8	4.3	0.1
Cassava tuber and peel	2.1	13.2	2.0	17.2	3.8	13.8	2.9	18.4
Household wastes	2.1	12.0	2.4	14.3	3.6	7.8	3.4	11.8

In all groups the most common supplement was cassava peel, followed in three out of the four groups by household wastes. Only among alley farmers in Iwo-Ate were *Leucaena* and *Gliricidia* more important than household wastes. Farmers in Iwo-Ate kept more animals than farmers in Owu-Ile, hence the amount of supplements offered per animal was lower in Iwo-Ate.

L. Reynolds, A.N. Atta-Krah, J. Cobbina and M.A. Jabbar

Evaluation of multipurpose trees in production systems — alley farming

Alley cropping with grazed fallow using *Gliricidia sepium* on degraded land

A long-term trial was started in 1983 with *Gliricidia sepium* planted on degraded land to study the effects of fallow and grazed fallow on soil fertility and crop yields.

Maize-grain yield in 1989 was close to the five-year mean in both the continuous alley cropping and the continuous no-tree plots (Table 22). Yield in plots that were fallowed in 1986–87 generally regressed towards the continuously cropped means after a sharp rise in yield in 1988. With the exception of P, soil nutrient status was higher in 1989 in the alley farming plots than in continuously cropped plots (Table 23). Between 1985 and 1989, nitrogen and potassium levels were maintained better in alley farming plots than under conventional management, but declined on all plots.

In the first year of cropping after fallow, grazed fallow plots and ordinary fallow plots produced significantly ($P<0.05$) more tree foliage (5.40 and 6.37 t dry matter/ha, respectively) than continuously cultivated, and hence continuously pruned, plots (4.13 t dry matter/ha). This shows that the trees benefit from remaining uncut during fallow.

Table 22. *Maize-grain yield from* Gliricidia *alley farms with and without fallow, Nigerian humid zone, 1985–89 (totals for two cropping seasons per year).*

	Maize-grain yield (t dry matter/ha)				
	1985	1986	1987	1988[a]	1989
Continuous alley farming	1.9	2.4	2.8	1.9	2.0
Alley farming with fallow 1986–87	1.8	–	–	2.3	1.9
Alley farming with grazed fallow 1986–87	1.8	–	–	2.3	1.7
Continuous no-tree	1.8	1.9	1.6	1.4	1.7
No-tree with fallow 1986–87	1.8	–	–	2.0	2.2
No-tree with grazed fallow 1986–87	1.7	–	–	2.4	2.1

[a] First season only.

All treatments received a basal application of 45 kg N/ha during cropping years.

Table 23. *Effects of fallow on soil chemical properties on alley farms with* Gliricidia *and conventional no-tree farms, Nigerian humid zone, 1985–89.*

	Organic C (%)		Total N (%)		Bray P (ppm)		Exchangeable K (meq/100 g)	
	1985	1989	1985	1989	1985	1989	1985	1989
Continuous alley farming	1.32a	0.99a	0.117a	0.121a	35.9	10.2	0.52	0.37a
Alley farming with fallow	1.40ab	1.33b	0.125ab	0.143b	26.8	12.7	0.54	0.40a
Alley farming with grazed fallow	1.40ab	1.10a	0.125ab	0.127a	26.8	8.4	0.54	0.41a
Continuous no-tree	1.46bc	0.79c	0.128ab	0.101c	35.9	11.8	0.52	0.23b
No-tree with fallow	1.51c	0.99a	0.133ab	0.124a	26.9	8.2	0.52	0.29b
No-tree with grazed fallow	1.35a	1.05a	0.139b	0.123a	27.6	8.8	0.63	0.37a

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

On-farm comparison of alley farming and conventional farming

A trial was started in 1985 to study the effect on maize yield of removing various proportions of tree foliage as cut-and-carry feed. The trial used four alley farms and four adjacent conventional no-tree farms. None, 50% or 100% of the tree foliage produced on the alley plots was applied as mulch on the alley plots. Surplus foliage from the alley plots was transferred to the conventional farming plots for the mulch treatment. The plots were not directly comparable as the alley farms had been cropped for five years, whereas the conventional farms were cleared from fallow in 1987.

Maize grain yield generally increased on the alley farms as the level of mulch applied rose, from a mean of 2.14 t/ha when no mulch was applied to 3.04 t/ha when all the tree foliage was applied as mulch. Effects of mulching were similar, but more marked, on the conventional, no-tree plots.

Excluding weeding, slightly more labour was required to produce a maize crop on the alley farms than on the conventional plots (285 vs 260 worker-hours/ha) but the difference was not significant.

Alley farms required additional labour for each pruning (21 worker-hours/ha) and spreading the mulch (12 worker-hours/ha) but less labour for clearing and ridging the land. Farmers reported fewer weeds on the alley farms, which suggests that less labour would be needed for weeding. (In an on-station trial, weeding an alley farm took around 105 worker-hours/ha, compared with 175 worker-hours/ha for conventional no-tree plots.) This suggests that less labour will be needed to produce maize on an alley farm than on a conventional farm, although the distribution of the work will be different.

Survey of farmer perceptions of, and attitudes towards, alley farming

ILCA started on-farm research with alley farming in south-west Nigeria in 1981/82 and in the south-east in 1983/84. Since then the number of farmers involved in on-farm research has steadily increased in the south-west but has decreased in the south-east. A few farms were intensively monitored; most farmers received advice but their activities and performance were not intensively monitored. These farmers can be considered between active participants in on-farm research and autonomous adopters of alley farming. A survey was carried out in 1989 to determine their perceptions of and attitudes towards alley farming as the basis for further research and to aid wider diffusion of the technology.

A total of 151 alley farming households in or near ILCA's on-farm research areas in both the south-west and south-east were interviewed; 75 (50%) in south-west villages where on-farm research is intensive, 59 (39%) in south-west villages where on-farm research is not intensive and 17 (11%) in south-east villages where on-farm research is being conducted. The corresponding samples of non-alley households were 80 (42%), 89 (47%) and 20 (11%), respectively. The data were collected on a single visit using a questionnaire.

Preliminary results show that most (89%) of the alley farmers gave mulch as an important reason for using alley farming. This was confirmed by the fact that 73% of the alley farmers applied fertiliser to non-alley plots but not to alley plots, while only 9% applied fertiliser to both. Ninety per cent of the alley farmers had, at some time, used a part of the prunings as feed

for their animals. Although the quantities used as feed were apparently small, farmers said that the animals benefited from the better quality feed. Forty-nine per cent of the alley farmers mentioned multiple uses, including the provision of staking material for yams; 28% also used dried branches as firewood. A few farmers in the south-east have planted fodder trees as living fences to mark compound boundaries and enclose animals and crops.

Only 19% of the alley farmers were satisfied with the amount of land being alley farmed; 18% had already planted an additional alley farm, and 9% said they would have increased the number of alley farms if they had had more land available. Among the non-alley farmers, 18 (10%) were ex-alley farmers. Ten had given up alley farming because their trees failed to establish; eight because they had lost interest. Some of these farmers also mentioned higher demand and expenses for labour as other reasons for abandonment.

Seventy-seven per cent of the alley farms were closer to the house than the non-alley farms owned by the same farmer. This reduced the time and effort expended in going to the alley farms and carrying feed for the small ruminants.

Thus, improvement of soil and crop production remain, as ILCA envisaged, the main interest of the farmers in alley farming, but use of prunings as forage by 90% of farmers indicates that alley farming is recognised as also beneficial to livestock production.

J. Cobbina, A.N. Atta-Krah, C. di Domenico, M.A. Jabbar and L. Reynolds

Reproductive wastage and hygiene management

The biological and economic efficiency of livestock production is primarily constrained by animal health problems. Young stock and animals under physiological stress during pregnancy, lactation and periods of rapid growth are often the most severely affected, so that reproductive efficiency remains disappointingly low.

Low reproductive efficiency is caused by a combination of health, nutrition and management factors. For most of the small ruminant livestock kept by smallholder farmers and agropastoralists in sub-Saharan Africa, veterinary care and imported drugs are not viable options because of their cost and lack of availability. It is therefore necessary to devise interventions that farmers are able to implement.

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

Reproductive and productive performance are major influences on the economics of sheep production. Nutrition and health controls may affect overall performance directly or through their interactive effects.

Two hundred ewes, aged two to four years, were allocated to one of four treatments:

- no drenching or supplementary feed (control)
- drenching against nematodes and trematodes
- supplementary feeding
- drenching and supplementary feeding.

All groups grazed together during the day and were given free access to water and mineral blocks. Supplementary feeding started in March 1988; each supplemented animal received 300 g of wheat bran and 150 g of noug *(Guizotia abyssinica)* cake daily, providing 8 MJ of digestible energy and 100 g of crude protein. Drenching was done in January, June and September.

Supplementation significantly ($P<0.05$) increased ovulation rate; 35% of supplemented animals had multiple ovulations, compared with 17% of control-group animals. Lambing rates and lamb survival to weaning also benefited from supplementation. Ewes yielded between 300 and 900 g of milk a day, with supplemented animals yielding about 150 g a day more than unsupplemented animals. Drenching alone had no effect on the reproductive or productive parameters studied, but drenching had an additive effect in combination with supplementation. The results of a preliminary economic analysis are reported on page 40.

Zere Eizaz, O.B. Kasali, E. Mukasa-Mugerwa and Negussie Akalework

Causes of mortality in sheep flocks in the Ethiopian highlands

The influence of passive (colostric) immunity on neonatal lamb mortality

Previous studies have shown that the acquisition of passive (colostric) immunity increases survival of new-born lambs. Levels of serum immunoglobulins (Ig) were investigated in Menz-type lambs at ILCA's Debre Birhan research station to determine the efficiency of passive immune transfer. Preliminary data are available for 165 lambs that reached 30 days of age, hence were classified as survivors of the neonatal period. Nine lambs died during the trial.

At 48 hours postpartum the mean serum Ig level was 3.77 g/dl (SD 1.49). If failure of passive transfer is defined as two standard deviations (SD) below the mean Ig level, and partial failure as one SD below, 18.8% of lambs showed failure or partial failure of passive transfer. The mean serum Ig level for the nine dead lambs was 2.91 g/dl, which was not significantly different from those that survived. However, 44% of lambs that died had serum Ig levels that indicated failure or partial failure of passive transfer, compared with only 17% of lambs that survived.

This study was made during the rainy season when pasture was abundant, which may have contributed to the high survival rate observed. A repeat study is planned for the dry season.

O.B. Kasali, Tekelye Bekele and K.-D. Gautsch

Management systems

Integrated packages of improved health, feeding and management practices must be tested in a farming systems context in on-farm trials to determine their biological and socio-economic effects. In any given area, the productivity of livestock herds belonging to farmers with apparently the same access to resources may vary markedly. Studies of the management of these herds may show how the allocation of resources under the control of individual farmers can lead to improved efficiency with which individually and communally owned resources are used.

Constraint quantification in highland sheep production

In the Ethiopian highlands, sheep in on-station trials perform much better than their counterparts on farms. ILCA is investigating the causes of this performance gap.

Measurement of performance levels and identification of environmental and management effects on productivity

Eight flocks, comprising a total of 2000 sheep, near Debre Birhan in the Ethiopian highlands were monitored throughout 1989. Lambings occurred throughout the year, reflecting the absence of seasonality of oestrus in Menz sheep. However, conception rates were highest in June and July when feed was plentiful following the onset of the main rains, and most lambs were born in November and December. Twinning rate was low (4.1%). Mean weight gain from birth to 180 days was 59 g/day.

During the year 1172 animals left the flocks; mortalities accounted for 39%. Sales and slaughter were the other reasons for exit, and were equally divided between males and females.

Feed resources for sheep in highland Vertisol areas

A survey was carried out between May and December 1989 of the grazing practices of 12 sheep flocks at two sites in the highlands, Debre Birhan, 120 km north of Addis Ababa, and Inewari–Deneba, 50 km north-west of Debre Birhan. In Debre Birhan natural pastures are plentiful, whereas at Inewari–Deneba pasture is scarce because of high cropping intensity.

Sheep at Debre Birhan spent about 8.5 hours a day grazing, of which 6 hours were spent feeding; from May to October grazing was entirely on natural pasture, but then stubble grazing increased in importance to 25% of the grazing time by December (Figure 10). At Inewari–Deneba grazing time was 11.5 hours each day, with a mean of 8 hours spent feeding (Figure 11). The proportion of time spent feeding on pasture varied widely throughout the study period, with stubble grazing making a contribution in six of the eight months. Farmers at Inewari–Deneba also practised cut-and-carry feeding throughout the period, mainly using weeds collected from crop land.

In general, sheep at both sites spent least time feeding during the peak of the rainy season, which coincided with the lowest rate of weight gain. During frosty periods, common at Debre Birhan during the winter, sheep remained penned until 9 or 10 o'clock in the morning. If supplementary feeds were available cattle had priority over sheep. In Inewari–Deneba small quantities of straw, hay, grain and local brewers grains were commonly given to all animals, whereas at Debre Birhan these were fed exclusively to ewes in late pregnancy or early lactation and fattening castrates.

K.-D. Gautsch and H. Airaksinen

Network

During 1989 the Small Ruminant Research Network began the process of transformation from an information exchange group to a fully fledged collaborative research network. Direction of the Small Ruminant Research

Figure 10. *Monthly time distribution between different activities and monthly feeding time distribution between different feeds of on-farm sheep at Debre Birhan, May–December 1989.*

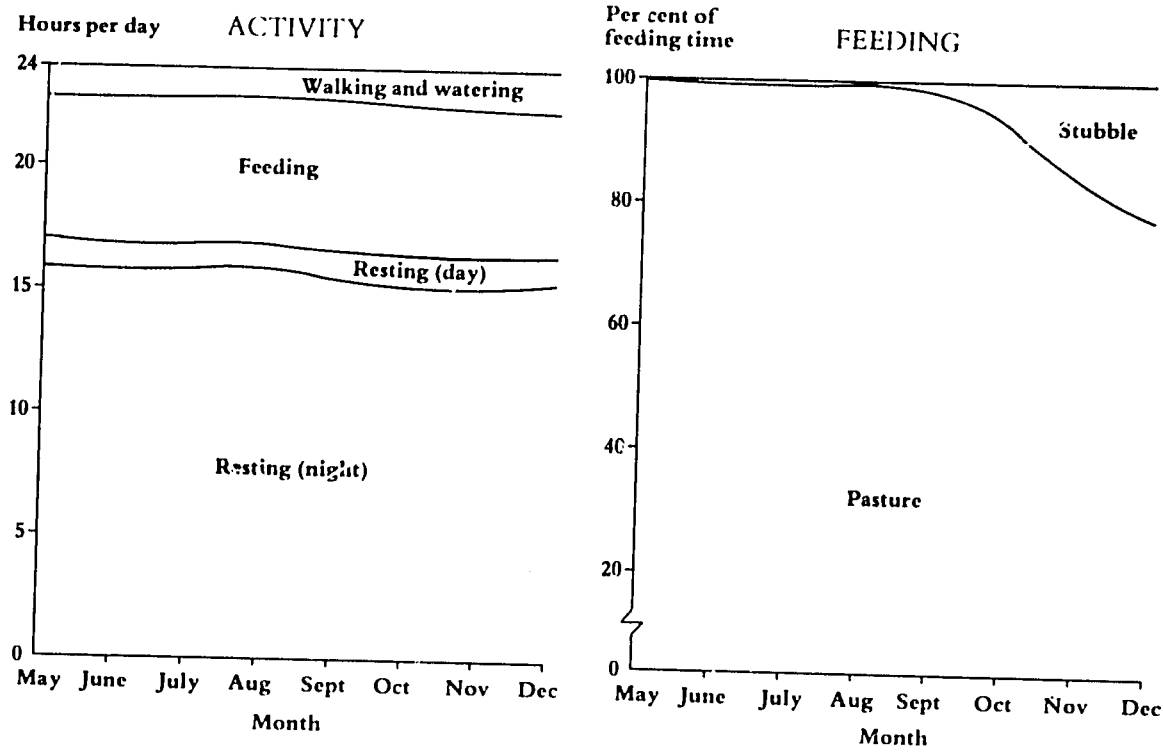
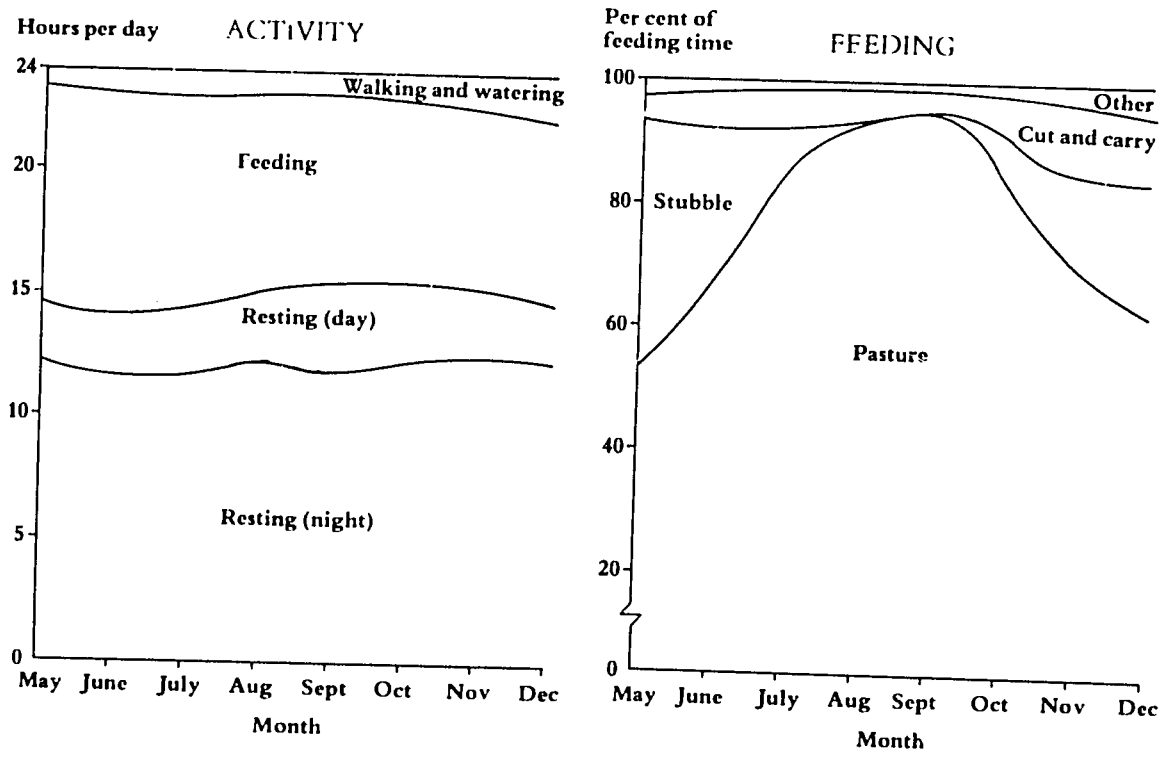


Figure 11. *Monthly time distribution between different activities and monthly feeding time distribution between different feeds of on-farm sheep at Inewari–Deneba, May–December 1989.*



Network is controlled by an elected steering committee, comprising national scientists from different regions and disciplines, with an ILCA representative. An interim committee was elected by participants at a conference held at Bamenda, Cameroon, in January 1989. The committee comprises two representatives from each of five regions in Africa.

Information exchange

The Network publishes a newsletter four times a year, issued simultaneously in English and French, with a circulation of over 1500, divided in the same ratio (approximately 72:28) as the speakers of these languages in Africa.

Proceedings of workshops and conferences organised by the Network are published by ILCA and distributed free to participants. Proceedings of the Bamenda conference, held in January, were published in April.

A research directory of individuals and institutions involved in small ruminant research is under preparation.

Training

The well established training course, "Small ruminant production techniques", was held at Niamey, Niger, in French during May 1989. The two-week course was attended by 24 participants. Individual training, linked to collaborative research within the Network, is proposed for the future.

Collaborative research

During discussions at the Bamenda meeting, working groups identified four principle themes for coordinated and collaborative research:

- constraint identification and analysis, and policy and economic issues
- nutrition and the development of feed resources and feeding systems
- reproductive wastage and health management
- genetic resources and their improvement.

Within each theme current research and capabilities, problem areas, possible research topics and likely outputs were identified.

Regional workshops were held in Togo, for West Africa, and in Zimbabwe for the nine countries of the region covered by the Southern Africa Development Coordination Conference, and were attended by national representatives from countries in each region and by ILCA resource persons. General research protocols were developed on a regional basis within the main research themes, and collaborating sites, participating personnel and current resources were identified. A proposal for funding was submitted to a donor, and it is expected that research, under the Network umbrella, will start in 1990.

R.T. Wilson, D. Bourzat and B. Rey

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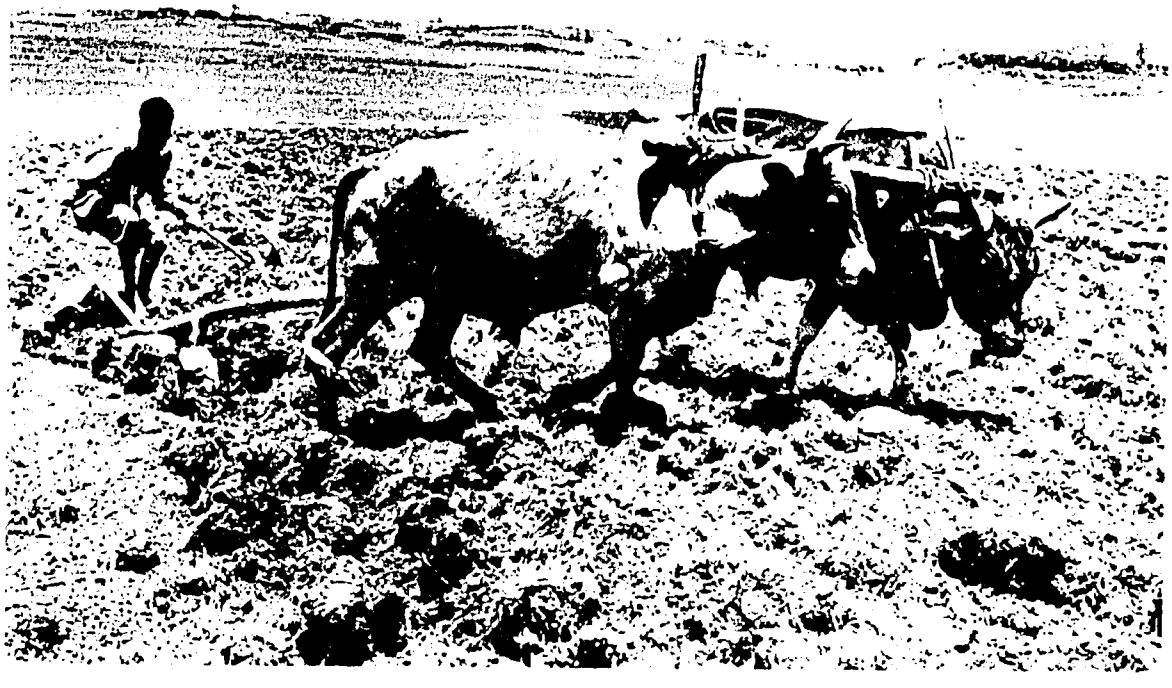

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Animal Traction Thrust

There was a period in the middle of this century when many people believed that use of draught animals had no place in African agriculture. Tractorisation schemes were promoted by governments buoyed by oil and aid funds. In today's changed economic circumstances these have proved unsustainable and animals are again coming to the forefront of agricultural research and development in Africa.

Farming based solely on manual labour can do little more than sustain the farm family. Animal power has thus again become the key to alleviating some of the drudgery of farm labour and helping create the surpluses needed to feed Africa's growing non-farm population.

ILCA's animal traction research in 1989 focused on two zones, the highland Vertisols area in Ethiopia and the Sahelian zone. Animal traction is already widely used in the farming systems of both zones.

Scientists at ILCA's highland Vertisols research sites are looking at ways to overcome waterlogging in these soils so that the high potential of the Vertisols can be exploited. Research at these sites is carried out under two themes, *Intensified and diversified use of animals* and *Alternative sources of animal power*.

In contrast with research in the high-rainfall Vertisols areas, scientists at ILCA's Sahelian research sites in Mali and Niger are trying to devise ways to trap as much of the rainfall as possible and maximise its use by crops. An important constraint to the use of draught animals in this zone is their poor condition at the beginning of the cropping season, and much of the work at these sites falls under the theme *Feeding strategies for draught animals*.

In each case, the use of draught-animal technology offers sustainable and secure opportunities for increasing productivity and reducing drudgery.

ILCA recognises that with its limited resources it can have little impact on African agriculture if it works alone. It thus aims at supporting the resurgence of draught-animal research and technology development by collaborating with researchers in African national agricultural research systems, both directly with individual programmes and through networking. The Centre is closely involved in the West African Animal Traction Network (WAATN), which was established in 1985 and has done much to focus attention on possibilities for using animal traction in West African farming systems. ILCA is also working closely with the Institute of Agricultural Research, Ethiopia, and some results of this collaboration are reported here.

Intensified and diversified use of animals

ILCA's animal traction research is most advanced at its Ethiopian highland research sites, where an integrated series of research protocols is being executed within this theme. The work at these sites is aimed at realising the agricultural potential of Vertisols, which cover 3.5% of Africa and are particularly important in this densely populated and poor region of the continent.

Vertisols have a high water storage capacity. In the Ethiopian highlands they become waterlogged soon after the rainy season starts and remain so until the rains stop. On-station and on-farm trials have demonstrated that broadbeds and furrows, formed using the animal-drawn broadbed maker developed jointly by the UK Agricultural and Food Research Council's Institute of Engineering Research (AFRC Engineering) and ILCA, improve drainage and thus can lead to substantial increases in food and fodder production from Vertisols. Removing the waterlogging constraint also opens up several cropping alternatives including:

- early planting of crops to increase grain and fodder yields
- sequential cropping
- companion or relay cropping of cereals with other food or forage crops.

Scientists must have a thorough understanding of the climate, soils, farming systems and agricultural potentials of the areas for which they are trying to develop improvements in order to develop successful alternative cropping and management systems. Reports here outline some of ILCA's activities in these areas.

Vertisol resource assessment: Baseline data

ILCA's scientists collect data on farm management practices as the basis for identifying target groups and "recommendation domains" for the introduction of improved technologies. In 1989 ILCA and the Institute of Agricultural Research (IAR), Ethiopia, together surveyed farming systems in Ginchi, 90 km west of Addis Ababa. Ginchi is at 2200 m above sea level and receives 1000 mm annual rainfall. More than 65% of the land is Vertisols. A total of 102 farmers were selected at random from four peasant associations in the district, each of which comprised 300–350 households.

The mean farm size was 3.1 ha (SE 0.1), of which 2.56 ha (SE 0.1) were cultivated. The average farm family comprised 5.5 people. Teff (*Eragrostis tef*) was grown by almost all farmers and occupied 49% of the cultivated area. Wheat was the second most important crop, grown by 62% of the farmers and occupying 13% of the cultivated area. Farmers also grew pulses (chickpea and *Lathyrus sativa*), noug (*Guizotia abyssinica*), maize and sorghum.

The mean livestock holding at Ginchi was 4.3 Tropical Livestock Units (TLUs[1]). Cattle accounted for 89% of TLUs. Small ruminants were not important, with an average of only about one animal per farm. There was an average of 1.6 oxen per farm. Farmers with only one ox or no oxen cultivate less than 1.5 ha; those with two or more oxen cultivate more than 1.5 ha (Figure 12). Total landholding and area cultivated were both positively correlated with the number of livestock owned.

[1] 1 TLU = 250 kg liveweight.

Getachew Asamenew

Animal-drawn implements for Vertisols

Work in this subproject has focused on developing implements based on the traditional Ethiopian plough, the *maresha*, for improved management of Vertisols. The *maresha* was chosen as the basis for the new implements be-

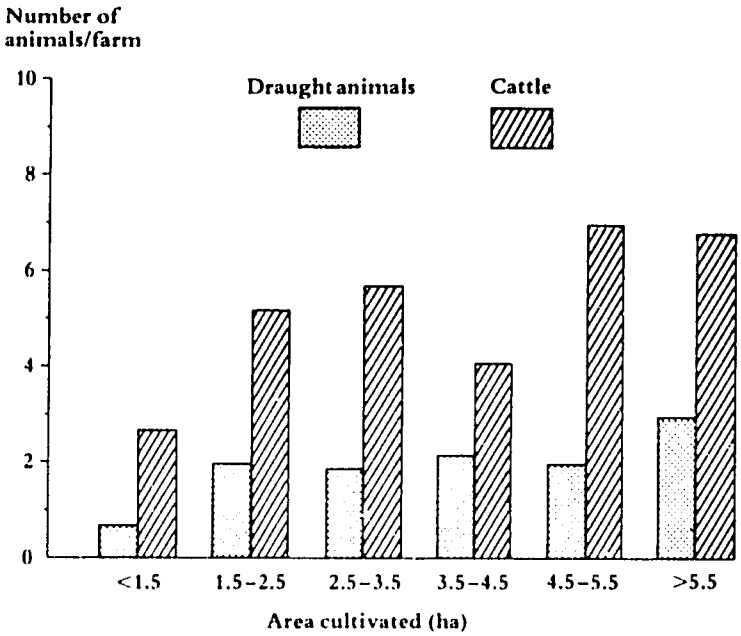

Figure 12.
Number of draught animals and cattle by area cultivated, Ginchi, Ethiopian highlands, 1989.

cause most farmers in the Ethiopian highlands already own one and because it is made locally from local materials and is thus appropriate to the farming system.

If animal-drawn implements are to be used for weed control, crops must be planted in rows, rather than broadcast as at present. Hence, one new implement developed is a simple, hand-metered seed drill that mounts on the broadbed maker. The initial design used a wooden funnel, into which seed was dropped by an operator walking alongside the implement. Field tests showed that seed did not flow smoothly through this, leading to considerable variations in the amount of seed passing into each coulter tube. As a result, the funnel was redesigned and fabricated from sheet metal.

Initial tests in the workshop showed much improved consistency of seed delivery. With the seeder set up for wheat, with five coulter tubes, a mean of 260 g of seed passed through each coulter, varying between 220 and 290 g; when set up for chickpea, with three coulter tubes, a mean of 629 g of seed passed through each coulter, with a range of 613 to 641 g.

Under current practices, broadbeds and furrows are ploughed and reformed every year. Reduced tillage would extend the life of broadbeds to several seasons. A tine bar that attaches to the broadbed maker and that can be used for reduced tillage was developed in 1989 in collaboration with AFRC Engineering.

The tine bar consists of five tines, three straight and two curved, mounted on a wooden bar. In initial tests the tine bar was used to cultivate 0.2 ha of land that had been under maize in the previous season and 0.3 ha that had been under wheat. Two passes were needed to achieve a good tilth. This took about 4 h/ha, compared with 24 h/ha for primary cultivation with the *maresha*. There was very little sign of bending or wear on the tines. The tine bar thus shows considerable promise for use in a reduced tillage system to extend the life of broadbeds.

Abiye Astatke

Land shaping for water management and soil conservation

The movement of water through any drainage system is accompanied by the risk of soil erosion. ILCA is therefore investigating the effect of the broadbed-and-furrow system on soil erosion. In 1989 a trial was conducted to quantify loss of soil from Vertisols with different slopes.

The trial was conducted at two sites, Debre Zeit and Hidi, in the Ethiopian highlands. The trial plots had a slope of 0.65% at Debre Zeit and 2.7% at Hidi. Each trial consisted of six plots measuring 30 × 6 m running down the slope. The plots were surrounded by corrugated iron sheets pressed into the soil to a depth of 15 cm to prevent run-off from above as well as from adjacent plots. Run-off was collected in watertight tanks at the bottom end of each plot.

Three plots were prepared with broadbeds and furrows and three with traditional flat seedbeds. All plots were planted with wheat at a rate of 150 kg seed/ha at the onset of the main rains in June.

Both run-off and soil loss were greater from broadbed and furrow plots than from traditionally managed plots (Table 24). On the moderate slope at Hidi, the amount of soil lost from the broadbed and furrow plots was high but less than the 11 t/ha considered acceptable for African clay soils. On the gentler slope at Debre Zeit, however, both run-off and soil losses were low.

Table 24. *Run-off and soil loss from broadbeds and furrows and flat plots, Debre Zeit (0.65% slope) and Hidi (2.7% slope), Ethiopian highlands, June–September 1989.*

	Debre Zeit		Hidi	
Land preparation	Run-off (m^3/ha)	Soil loss (t/ha)	Run-off (m^3/ha)	Soil loss (t/ha)
Broadbeds and furrows	280	2.2	1230	7.0
Flat	115	0.7	660	3.6
Significance	NS	*	*	NS

NS = not significant; * = $P<0.05$.

A second trial investigated the possibility of sequential cropping of wheat and chickpea. Wheat was planted on broadbeds in mid-June, at the beginning of the main rainy season, and was harvested in September. The topsoil of the broadbeds was then cultivated using a blade harrow. Chickpea was broadcast on the broadbeds and covered using the blade harrow.

Four treatments were applied to the chickpea crop:

- no irrigation (control)
- irrigation at planting
- irrigation at planting and during the vegetative stage
- irrigation at planting, during the vegetative stage and at 50% flowering.

Plots comprised four broadbeds and five furrows and were 50 m long and 4.8 m wide. Irrigation water was applied via the furrows.

Chickpea did not germinate in the unirrigated control plots, whereas 70 to 80% of seeds germinated in plots irrigated twice or three times. Plants on plots irrigated only at planting were significantly ($P<0.05$) shorter than those growing on plots that were irrigated twice or three times. Plots that were irrigated three times gave grain yields significantly ($P<0.05$) lower

than plots irrigated once or twice (1.1 vs 1.4 t/ha). Straw yield did not differ significantly between treatments.

These results show that it is possible to grow chickpea following wheat in the same season if water is available to irrigate the chickpea at planting.

Abiye Astatke

Cropping systems on drained Vertisols

ILCA has been conducting researcher-managed trials at several sites in the Ethiopian highlands since 1986 to test various crop and forage species and varieties: the aim is to develop appropriate cropping systems for Vertisols.

Experiments were carried out in 1989 to test high-yielding wheat cultivars on drained Vertisols and the technical viability, stability and sustainability of, and economic returns from, a variety of cropping systems.

Undersowing wheat with clovers

An experiment started in 1988 to test the effect of undersowing wheat varieties with clovers was continued in 1989. The trial was conducted at three sites: Debre Zeit (1800 m above sea level), Ginchi (2200 m) and Akaki (2300 m). Improved wheat varieties (Enkoy bread wheat, and Boohai and Gerardo durum wheats) were grown in pure stand and undersown with a mixture of *Trifolium steudneri* and *Trifolium rueppellianum*, sown at a rate of 12 kg/ha.

Undersowing wheat with clover did not significantly affect wheat grain and straw yields but significantly ($P<0.001$) increased total fodder yields (Table 25). These results are consistent with those obtained in 1988 (*ILCA Annual Report 1988*, pages 62–63). Undersowing wheat with clovers thus appears to be a viable cropping practice for the Ethiopian highlands, offering larger amounts of higher quality feed for livestock without depressing food crop yields.

Abate Tedla

Performance of wheat on broadbeds

An experiment started in 1988 to evaluate wheat varieties on drained Vertisols at medium and high altitudes was continued in 1989. Trials compared the performance of three improved durum wheat varieties with that of a local

Table 25. *Overall mean wheat grain, wheat straw and clover stubble yields for three improved wheat cultivars in pure stand and undersown with clover*[1] *at Debre Zeit, Ginchi and Akaki, Ethiopia, 1989.*

Cropping system	Yield (kg/ha)			
	Wheat grain	Wheat straw	Clover stubble	Total feed
Enkoy with no clovers	988	2880	–	2880
Enkoy with clovers	1026	2799	4990	7789
Boohai with no clovers	784	2687	–	2687
Boohai with clovers	851	2473	5462	7935
Gerardo with no clovers	975	2664	–	2664
Gerardo with clovers	863	2414	6486	8900
LSD (5%)	153	256	–	770

[1] A mixture of *Trifolium steudneri* and *Trifolium rueppellianum*.

durum wheat check at Debre Zeit, Ginchi and Akaki medium-altitude sites. Trials at Bichena and Inewari high-altitude sites compared the performance of three improved bread wheats with that of a local durum wheat.

Grain yield did not differ significantly between varieties at the medium-altitude sites, but two of the improved varieties (CIT 71/Candeal and Boohai) produced significantly ($P<0.05$) more straw than the local check (Table 26). At the high-altitude sites, bread wheat ET 13 yielded significantly ($P<0.05$) more grain and straw than the other varieties tested, yielding almost twice as much grain as the local durum wheat check (Table 27). Enkoy also yielded significantly more grain than the check.

Table 26. *Overall mean grain and straw yields of durum wheat cultivars on drained Vertisols at Debre Zeit, Akaki and Ginchi mid-altitude sites, Ethiopia, 1989.*

Cultivar	Yield (kg/ha)	
	Grain	Straw
Local check	1358	3245
Boohai	1446	3781
Cocorit	1217	3391
CIT 71/Candeal II	1571	4096
LSD (5%)	245	318

Table 27. *Overall mean grain and straw yields of a local durum wheat and three bread wheat varieties on drained Vertisols at Bichena and Inewari high-altitude sites, Ethiopia, 1989.*

Cultivar	Yield (kg/ha)	
	Grain	Straw
Local check	831	3456
HAR 407	805	1951
Enkoy	1203	3755
ET 13	1641	4391
LSD (5%)	122	332

Farmers in the Ethiopian highlands usually plant short-season durum wheat at the end of the rains to avoid the problem of waterlogging on Vertisols. The trials at Bichena and Inewari demonstrate how improved drainage can increase their yields and productivity by allowing them to plant higher-yielding, long-season bread wheat at the beginning of the rains.

Abate Tedla

Legume production on drained Vertisols

Improved drainage of Vertisols also offers the opportunity for early planting of forages to exploit the full length of the growing period. The impact of improved drainage on the productivity of a tree legume, *Sesbania sesban* (Debre

Zeit ecotype), and two annual forage legumes, *Lablab purpureus* (cv Rongai) and *Vigna unguiculata* (cowpea), was assessed on Vertisols at Debre Zeit in 1989.

Sesbania, *Lablab* and cowpea were planted on 20 June 1989 at seeding rates 20, 50 and 75 kg/ha, respectively. The seed and fertiliser (100 kg diammonium phosphate/ha) were broadcast and then covered using the broadbed maker or a *maresha* (for flat plots). The experiment was laid out in a split-plot design with four replications, the three legume species as the main plots and the two land preparation methods as the subplots. Plot size was 25 × 20.4 m (17 beds). Dry-matter yield was assessed 6, 12 and 18 weeks after emergence.

Lablab and cowpea gave significantly higher dry-matter yields than *Sesbania* at each harvest (Table 28). Cowpea yield was significantly higher than that of *Lablab* six weeks after emergence, but thereafter did not differ significantly. *Sesbania* grew better on broadbeds throughout, cowpea grew better on broadbeds only up to six weeks after emergence and *Lablab* grew better on flat plots up to 12 weeks after emergence. However, *Lablab* grown on broadbeds gave the highest yield of the trial 18 weeks after emergence. There were significant ($P<0.05$) interactions between legume species and land preparation methods, indicating that the legumes responded differently to the improved drainage.

Table 28. *Dry-matter yields of* Sesbania sesban, Lablab purpureus *(cv Rongai) and* Vigna unguiculata *on traditionally prepared plots (flat) and broadbeds and furrows (BBF) in Debre Zeit, Ethiopia, 1989.*

Time of harvest (weeks after emergence)	Dry-matter yield (kg/ha)					
	Sesbania		*Lablab*		*Vigna*	
	Flat	BBF	Flat	BBF	Flat	BBF
6	250	540	650	470	830	1040
12	1980	2490	4450	3360	4780	4000
18	2500	3650	6410	7140	6010	5930

These results show that forage legumes differ in their response to improved drainage of Vertisols. Further studies are needed to characterise the response of different forages for use in broadbed-based cropping systems.

H. Airaksinen and Abate Tedla

Vertisol management in the Ethiopian highlands: On-farm technology verification

The ultimate proof of an intervention is its acceptance by farmers, and ILCA is involved in a programme of on-farm verification trials with the broadbed maker to determine its acceptability to farmers. This programme, which started in 1986, is also aimed at paving the way for large-scale, extension-oriented activities.

The verification programme in 1989 involved 40 individual farmers and 25 producer cooperatives with some 9000 member farmers near Debre Zeit, Dejen and Inewari, in the Ethiopian highlands. Trials compared crop yields achieved on broadbeds made using the broadbed maker with those achieved on plots prepared using traditional practices (flat seedbeds at Debre Zeit and

Dejen and broadbeds made by hand at Inewari). Farmers divided their fields into two plots; one was prepared traditionally, the other using the broadbed maker. All other management practices and inputs were kept the same for the two plots.

Land was ploughed using the traditional *maresha* in April, during the short rains. Second and third cultivations, also with the *maresha*, were completed by mid-June, during the main rains. The plots were planted with wheat (cv Boohai at Debre Zeit and cv ET 13 at all other sites) between mid-June and early July. Seeding rate was 150 kg/ha. Plots received 100 kg of diammonium phosphate/ha at planting and another 50 kg at tillering, in accordance with the recommendations of the Ethiopian Ministry of Agriculture. Plots were kept weed-free. Data were collected on labour and animal traction inputs, grain and straw yields and market prices for inputs and products. Grain and straw yields were estimated by sampling 1% of the plot area.

At Debre Zeit and Dejen, wheat grown on broadbeds gave significantly (at least $P<0.01$) higher grain and straw yields than wheat grown on the traditional flat plots (Table 29), resulting in a significant ($P<0.001$) increase in gross revenue and gross margin from broadbed plots. Yields and revenue were also less variable from broadbed plots than from traditional plots.

Table 29. *Grain and straw yields, gross revenue and gross margins from wheat grown on broadbeds and on traditionally managed plots at Debre Zeit, Dejen and Inewari, Ethiopia, 1989*[1].

	Debre Zeit		Dejen		Inewari	
	Broadbed	Trad.[2]	Broadbed	Trad.[2]	Broadbed	Trad.[3]
Grain yield						
kg/ha	1353	1029	1281	892	1274	1347
CV (%)	10	20	20	33	59	69
Sig. level	P<0.01		P<0.001		P = 0.72	
LSD (5%)	162		172		403	
Straw yield						
kg/ha	3335	2628	2235	1761	2820	2554
CV (%)	8	24	15	24	49	55
Sig. level	P<0.01		P<0.001		P = 0.43	
LSD (5%)	447		240		665	
Gross revenue						
EB/ha	1083	830	737	516	994	1071
CV (%)	8	18	20	32	56	67
LSD (5%)	114		97		292	
Gross margin						
EB/ha	904	652	542	321	799	822
CV (%)	10	23	27	51	70	82
LSD (5%)	114		97		292	

[1] Means of 10 plots at Debre Zeit, 21 plots at Dejen and 35 plots at Inewari.

[2] Flat seedbed.

[3] Hand-made broadbeds.

US$ 1 = EB 2.07.

At Inewari, grain and straw yields did not differ significantly between crops grown on broadbeds made by hand and those on broadbeds made using the broadbed maker. The relatively high CV at this site may have been due to micro-ponding on some of the broadbeds.

These results are consistent with those obtained in previous years (see *ILCA Annual Report 1988*, pages 63–66), and again demonstrate that using the broadbed maker can increase crop yields where crops are traditionally planted on flat seedbeds. At Inewari, where broadbeds are traditionally made by hand, using the animal-drawn broadbed maker can reduce the drudgery of land preparation.

The full benefits of the broadbed maker will only be realised if other components of the cropping system are changed, in particular early planting of improved varieties and use of fertiliser. Farmers involved in this testing programme were keen to plant improved wheat varieties and apply fertiliser, but were concerned that they may not always be available when needed. Some also fear that dry spells soon after planting could affect crop establishment on broadbeds and that their crops could be devastated by severe grasshopper infestation, particularly at lower altitudes, thereby wiping out their investment in seeds and fertilisers. All these potential problems must be solved if the broadbed maker is to be widely adopted.

Getachew Asamenew

Feeding strategies for draught animals

Feed supplementation and work output of oxen

Shortages of feed, and the poor quality of feed available, make it difficult for Sahelian farmers to maintain the body condition of their draught animals. Work started by ILCA in Mali in 1987 is aimed at determining the effect of feed supplementation on work output of oxen.

On-station trials carried out in 1987 and 1988 showed that supplementing work oxen during the dry season increased their body weight and condition but had little effect on their capacity for work. A further assessment of the effect of various animal characteristics on capacity for work was conducted in 1989. The work undertaken by 20 oxen pairs owned by smallholders was monitored under village conditions throughout the rainy season. Working time, speed of working and force exerted were measured every four days. The oxen were weighed each month and their condition scored[1] every second month. At the end of the cropping season all the farmers in two villages were interviewed to determine the extent to which they used draught oxen and problems they experienced during field operations.

The oxen had a mean weight of 277 kg (SD 61.2) and an average body condition of M at the start of field operations at the beginning of the rainy season.

From the middle of July to the end of September all animals gained an average of 0.60 kg/day, for a final mean liveweight of 325 kg (SD 67.9), and gained in body condition to M+.

Of the 99 farmers interviewed, 95 used oxen for ridging and 72 used them for weeding. Between 40 and 50 used oxen for ploughing, harrowing or re-ridging, but only 24 had sown crops using ox-drawn equipment.

Average daily working time, number of days worked, speed of working and force exerted by a pair of oxen for the major field operations are

[1] Nicholson M J and Butterworth M H. 1986. *A guide to condition scoring of zebu cattle*. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. 29 pp.

Table 30. *Average daily working time, number of days worked per year, speed of operation and force exerted by an ox-pair in different field operations, Mali, 1989.*

Operation	Minutes/ day	Days	Force (N)	Speed (m/s)
Harrowing	250	3.4	652	1.07
Flat ploughing	171	2.7	825	0.85
Ridging	273	16.2	835	0.74
Seeding	na	0.9	292	na
Weeding	209	11.2	656	0.77
Re-ridging	282	2.7	708	0.72

na = not available.

presented in Table 30. The force exerted in relation to the weight of the oxen pairs was generally high, with an average load on an oxen pair of 15% of liveweight in ridging and 12% in weeding. However, there was little evidence of problems with oxen in work. This may have been due to heavy work being limited to short bursts. During ridging, for example, oxen worked on average on a cycle of 67 seconds, over an average field length of 51 m, followed by a break of 27 seconds while the equipment was turned at the end of the field.

At the beginning of the working period oxen pairs weighed between 404 kg and 762 kg. Irrespective of this wide range in weight there was no evident trend in performance in terms of speed of working, duration of working or force exerted.

None of the physical characteristics assessed (liveweight, size and body condition) appeared to affect working performance of oxen under practical conditions, whether in terms of speed of work, duration of work or, perhaps most surprisingly, force exerted or total work output. These results suggest that dry-season supplementation and weight gain would not improve work output and would be unlikely to increase the amount of land cropped or crop production.

P. Bartholomew

Animal traction network in Africa

In May 1989 ILCA hosted a protocol planning meeting of the West African Animal Traction Network (WAATN) at the Centre's headquarters in Addis Ababa, Ethiopia. Participants from 11 countries (Benin, Burkina Faso, Côte d'Ivoire, The Gambia, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo) presented research protocols, which were refined during the meeting and will be presented to potential donors at the next WAATN workshop, to be held in Nigeria in July 1990.

The proceedings of the conference on "Animal Traction for Agricultural Development", held in Senegal in 1988, were edited in 1989 and will be published in mid-1990. Work was largely completed on an annotated bibliography on the use of animal traction in sub-Saharan Africa. This is being prepared both in book form and as a computer database on the UNESCO CDS/ISIS software. Both will be available by mid-1990.

R. von Kaufmann

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Animal Feed Resources Thrust

Seasonal feed shortages and the low nutritive value of feeds available are two fundamental constraints to ruminant livestock production throughout sub-Saharan Africa. The Animal Feed Resources Thrust, together with the plant science programmes of the three commodity thrusts and the Policy and Resource Use Thrust, addresses these constraints.

The Thrust aims at developing feed technologies that use herbaceous forage legumes, legume fodder trees and agro-industrial byproducts to supplement indigenous pastures and food crop residues. Its goal is to achieve higher, sustainable levels of meat and milk production.

Services and resource assessment

The major constraints to more vigorous development of feed resources in sub-Saharan Africa are the scarcity of adapted, high-yielding forages, insufficient knowledge of the effects of nutrient and water limitations on plant performance, the absence of effective herbage seed supplies, inadequate use of biological pathways for effective supply and use of nutrients, inadequate knowledge of the characteristics of plant constituents that affect plant nutritive value and inappropriate integration of advanced feed material into mixed production systems.

Some of these constraints can be overcome by developing and strengthening support facilities and services, such as the genebank, the herbage seed unit and the soils and feed laboratories. Others require substantial research to determine the potentials and limitations of feed resources. Some activities in these areas are reported under this theme, which is the core of the strategic support provided by the Animal Feed Resources Thrust to the feeding systems research in the commodity thrusts.

Forage genetic resources

ILCA's forage germplasm collection grew in 1989 to more than 10 000 accessions of grasses, legumes and browse species. The objectives of the genebank are to collect, acquire, store, document and determine the morphology of a wide range of forage germplasm that may be of use in the various environments of sub-Saharan Africa. The genebank's material is freely available to bona fide forage research and development workers in sub-Saharan

Africa, and 6746 samples were discributed in 1989 in response to 245 requests. A total of 3565 accessions were in the field for regeneration and bulking of seed in 1989, most of them at ILCA's Zwai field site in the Ethiopian Rift Valley.

Work was started in 1989 on *in vitro* culture of multipurpose trees, with support from the International Development Research Centre, Canada. Germplasm of leguminous trees is difficult to manage because the trees take years to mature and produce seed and because many species outbreed and thus the genetic purity of accessions is difficult to maintain. *In vitro* culture is being studied as the basis for alternative methods for multiplication that overcome these constraints.

Research on breeding systems and pollination behaviour of selected species commenced in 1989. Research on *Sesbania sesban* showed that flowers from different accessions are self-compatible, but that they probably need to be tripped by insects for pollination, and thus seed set, to take place. Preliminary results on *Trifolium* species showed that *T. tembense*, *T. steudneri*, *T. lugardii*, *T. multinerve*, *T. pichisermollii* and *T. baccarinii* are self-compatible and produce seeds without insect tripping.

J. Hanson

Herbage Seed Unit

The Herbage Seed Unit became operational in January 1989. Its objectives are to stimulate and sustain the production and supply of forage seed in national livestock production systems.

In its first year of operation the Unit, based at ILCA's Debre Zeit research site, started bulking up best-bet accessions of forage legumes and other accessions that are frequently requested from the genebank. Extensive consultations with national seed industry personnel in ILCA's mandate region in 1989 confirmed that the main demand on the Herbage Seed Unit from national agricultural research systems (NARS) will be primarily in the service and support area. Thus, the Unit is concentrating on:

- initial increase of promising, high-yielding accessions demanded by users, particularly those in collaborative networks
- promoting and organising training sessions and consultancies in seed-quality enforcement for national seed industry personnel
- seed production, harvesting, storage and handling technology
- suggesting guidelines for effective marketing of herbage seed
- promoting discussions on policy and economic constraints to herbage seed production
- assembling baseline data on herbage seed production in the countries of sub-Saharan Africa.

R. Griffiths

Nutrient cycling in forage legumes and forage-legume-based cropping systems on Vertisols

Waterlogging and deficiencies in plant-available nitrogen and phosphorus are the main constraints to food crop and forage yields on Vertisols in the Ethiopian highlands. Yields on these soils can be increased substantially in several ways, including growing more forage legumes in the crop rotation as intercrops or undersown in food crops, using cheap sources of nutrients such as rock phosphates and plants tolerant of low soil phosphorus.

Phosphate nutrition of highland clovers on Vertisols

A greenhouse experiment was conducted in 1989 to investigate differences among clovers in their response to phosphorus application. Twenty clover accessions from 11 species (*T. baccarinii*, *T. decorum*, *T. rueppellianum*, *T. steudneri*, *T. tembense*, *T. pichisermollii*, *T. polystachyum*, *T. bilineatum*, *T. mattirolianum*, *T. quartinianum* and *T. schimperi*) were grown for 60 days in pots filled with Vertisol from ILCA's headquarters site at Shola, Ethiopia. Phosphorus was applied at 0, 12.5, 25, 37.5 and 50 mg P per pot (0, 25, 50, 75 and 100 kg P/ha) as $Na_2HPO_4.12H_2O$.

Applying phosphorus at a rate of 12.5 mg P/pot significantly ($P<0.05$) increased the above-ground dry-matter yield of all accessions compared with the unfertilised control, but applying larger amounts of phosphorus led to no further increase in the dry-matter yield of *T. baccarinii* (ILCA 8158), *T. rueppellianum* (ILCA 9690), *T. pichisermollii* (ILCA 8065 and 9960) and *T. polystachyum* (ILCA 6298). Two accessions of *T. decorum* (ILCA 6264 and 9682) produced the highest dry-matter yields. Root dry-matter yields followed generally similar trends.

The "ideal" accession or species for use under smallholder conditions is one that gives high yields when little or no phosphorus fertiliser is applied yet responds well to applied fertiliser. Based on these criteria, the best accessions were *T. decorum* (ILCA 6264 and ILCA 9682) followed by *T. quartinianum* (ILCA 6301), *T. bilineatum* (ILCA 8351) and *T. tembense* (ILCA 9681, 8635 and 8501).

Biological nitrogen fixation in highland clovers

A field trial was conducted at ILCA's headquarters site to determine the amount of nitrogen fixed by eight accessions of five *Trifolium* species (*T. quartinianum*, *T. steudneri*, *T. decorum*, *T. rueppellianum* and *T. tembense*). The amount of nitrogen fixed was estimated using both the nitrogen difference method, with oats as the nitrophilous reference crop, and the ^{15}N method.

The two methods gave similar results and ranking, but the ^{15}N method indicated slightly larger amounts of nitrogen fixed. *Trifolium quartinianum* (ILCA 6301) and *T. decorum* (ILCA 6264) fixed most nitrogen (Table 31). Fixation met from 84 to 89% of the nitrogen needs of the various species and accessions.

I. Haque and L. Mugwira

Table 31. *Biological nitrogen fixation by various clover (*Trifolium*) species/accessions grown on a Vertisol, Shola, Ethiopia, 1989 (^{15}N method).*

Accession	Amount of N fixed (kg N/ha)
T. quartinianum (ILCA 6301)	122a
T. decorum (ILCA 6264)	112ab
T. rueppellianum (ILCA 6260)	100bc
T. decorum (ILCA 9447)	89cd
T. tembense (ILCA 7102)	84d
T. quartinianum (ILCA 9379)	81d
T. steudneri (ILCA 9720)	75d
T. steudneri (ILCA 6253)	55e

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

Initial evaluation of feed resources

ILCA is evaluating forage legumes at several sites in Ethiopia and Nigeria; this section presents some of the results obtained at these sites in 1989.

Forage legume evaluation in a subhumid, mid-altitude environment on an acid soil (Ethiopian Rift Valley)

Three *Stylosanthes* species (*S. hamata*, *S. scabra*, *S. guianensis*) were screened in 1989 in large nurseries on acid soil at Soddo, a mid-altitude site in Ethiopia.

In the *S. hamata* nursery (163 accessions) cultivar Verano (ILCA 167), which was developed in Australia from seed collected in Venezuela, yielded 10 t dry matter/ha in 18 cuts during 1989, more than three times as much as the second highest yielding accession.

In the *S. scabra* nursery (93 accessions) cultivars Seca (ILCA 140) and Fitzroy (ILCA 441), both of which were developed in Australia from seed collected in Brazil, were outyielded by several accessions in a single cut at the end of the establishment year. ILCA 12555, an early maturing line obtained from the United States Academy of Science, but which probably originated in Brazil, gave significantly ($P<0.05$) higher yield than both cultivars (2174 kg dry matter/ha, compared with 762 kg DM/ha for Seca and 661 kg DM/ha for Fitzroy).

In the *S. guianensis* nursery (20 accessions) cultivars Oxley (ILCA 1) and Cook (ILCA 4), developed in Australia from seed collected in Paraguay and Colombia, respectively, were outyielded by several accessions, in particular by ILCA 11879, which yielded 12.2 t/ha in eight cuts during 1989, significantly more than Oxley (2.4 t/ha) and Cook (8.1 t/ha).

J. Lazier and J. Kahurananga

Evaluation of tropical forage legumes for subhumid West Africa

Evaluation trials for subhumid West Africa are conducted in the subhumid zone near Kaduna, northern Nigeria.

Seven accessions (three of *Stylosanthes guianensis* and one each of *Centrosema acutifolium*, *C. pascuorum*, *S. fruticosa* and *S. scabra*) that showed promise in initial evaluation trials in 1988 were tested in an agronomic evaluation trial in 1989. *Centrosema pascuorum* (ILCA 14972) and *S. guianensis* (ILCA 15557) again gave the highest yields (1886 kg/ha and 1837 kg/ha), significantly ($P<0.05$) more than the *S. hamata* cv Verano check (1244 kg/ha). *Stylosanthes guianensis* remained green throughout the dry season and has so far proved resistant to anthracnose, a fungal disease common on stylos.

In another experiment, 13 *S. hamata* lines selected from among 163 lines tested in an initial evaluation trial in 1988 were agronomically evaluated in 1989. Three (ILCA 15876, 15868 and 15861) gave significantly ($P<0.05$) higher dry-matter yields at the end of the wet season than Verano.

Among 10 accessions (two *Aeschynomene histrix*, two *S. guianensis*, and one each of *Desmodium virgatus*, *D. discolor*, *D. distortum*, *D. tortuosum*, *Galactia striata* and *Vigna caracalla*) under agronomic evaluation for the second year in 1989, both *A. histrix* accessions (SODEPRA and ILCA 12463) and both *S. guianensis* accessions (CIAT 136 and CIAT 184) gave significantly ($P<0.05$) higher dry-matter yields than the *S. hamata* cv Verano check.

Aeschynomene histrix accession SODEPRA gave the highest yield of about 13 t/ha, compared with about 10 t/ha for ILCA 12463 and the two CIAT accessions and 3 t/ha for Verano.

S. Tarawali and M. Peters

Agronomic evaluation of herbaceous legumes in humid West Africa

ILCA has been screening herbaceous forage legumes for ease of establishment, herbage productivity and persistence at Ibadan and Fashola, south-west Nigeria, since 1987, when 31 accessions were sown. These included 10 accessions of *Centrosema*, 8 of *Desmodium*, 6 of *Stylosanthes* and single accessions of *Pueraria phaseoloides*, *Macroptilium atropurpureum*, *Calopogonium caeruleum*, *Desmanthus virgatus*, *Lablab purpureus*, *Cassia rotundifolia* and *Tephrosia bractiolata*. Several accessions died in 1988; those that survived were evaluated again in 1989.

Several accessions persisted over 24 months and produced more than 2 t dry matter/ha over a three-month period at both sites, including *Centrosema arenarium*, *C. macrocarpum*, *C. pubescens*, *Desmanthus virgatus*, *Pueraria phaseoloides*, *Stylosanthes guianensis* cv Graham, *S. hamata* cv Verano, *S. scabra* cv Seca and *S. viscosa* (Table 32).

Table 32. *Yields of forage legume accessions following three months regrowth*[1], *Ibadan and Fashola, south-west Nigeria, 1989.*

Species/cultivar	ILCA accession no.	Dry-matter yield (kg/ha)	
		Ibadan	Fashola
Centrosema macrocarpum	12146	5350	5005
Pueraria phaseoloides	156	4780	4069
Stylosanthes scabra cv Seca	140	4400	2877
Desmodium tortuosum	174	3626	495
Centrosema arenarium	12451	3000	2138
Stylosanthes hamata cv Verano	75	2975	2533
Calopogonium caeruleum	272	2800	Died
Desmanthus virgatus	312	2350	2125
Stylosanthes viscosa	6860	2300	6558
Centrosema pubescens	219	2175	2755
Stylosanthes guianensis cv Graham	73	2100	2879
Desmodium cinereum	448	1960	3264
Centrosema sp.	153	1775	Died
Desmodium ovalifolium	10870	1460	Died
Stylosanthes scabra cv Fitzroy	441	1148	3563
Desmodium sandwicense	6990	1032	Died
Centrosema sp.	12184	650	1106
Macroptilium atropurpureum	69	600	1343
Cassia rotundifolia	10789	600	2835
Centrosema sp.	12182	483	593
Stylosanthes guianensis cv Cook	4	333	Died
Desmodium distortum	7263	96	1909
Calopogonium mucunoides	6750	Died	1597
Lablab purpureus	6520	Died	565

[1] Regrowth harvest taken 25 months after planting.

These results indicate that several herbaceous legumes are showing promise in the humid zone and can be considered as additional options to leguminous tree species, such as *Leucaena leucocephala* and *Gliricidia sepium*, already identified as useful species for the region.

A. N. Atta-Krah

Soil fertility studies on herbaceous legumes

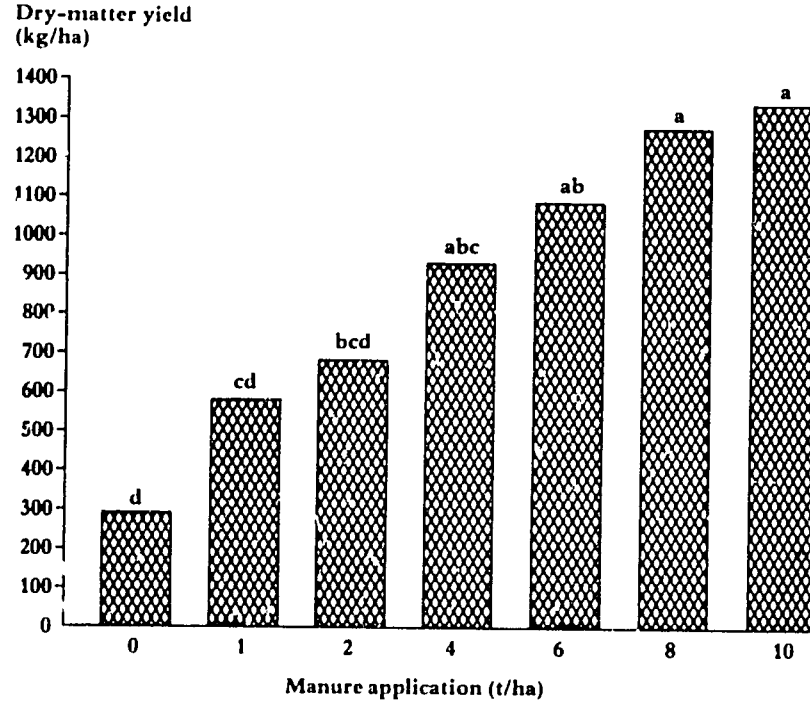
There are some 400 million hectares of acid soils in sub-Saharan Africa. These soils suffer from such acidity-related problems as aluminium and manganese toxicity and phosphorus, calcium and magnesium deficiency. The fertility of these soils can be increased by applying lime, phosphorus or manure, separately or in combination. Lime is too expensive for smallholders to use, and so ILCA is studying the effects of cheap sources of nutrients on forages grown on various soil types. The objectives of this subproject are to:

- evaluate cheap sources of plant nutrients such as manure and rock phosphates
- identify forage plants that make the most efficient use of native and applied nutrients or that are productive on infertile soils.

As in 1988, trials in 1989 used *Medicago sativa* (lucerne or alfalfa) cv Hunter River as the indicator crop.

Effect of manure on lucerne grown on acid soil

The effect of dairy cattle manure on lucerne grown on an acid soil was investigated in a replicated trial at Soddo, a mid-altitude site in Ethiopia, in 1989. Manure was applied at 0, 1, 2, 4, 6, 8 and 10 t/ha in May 1989. *Medicago sativa* cv Hunter River was planted in June 1989 at a seed rate of 20 kg/ha and was harvested on 30 November 1989.



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

Figure 13. *Effect of manure on lucerne grown on Soddo acid soil, Ethiopia, 1989.*

Lucerne dry-matter yield increased linearly with increased rates of manure application (Figure 13). Thus using the manure available in mixed crop–livestock systems in the highlands as fertiliser can help increase the amount of feed available to livestock.

Effect of various sources of phosphorus on dry-matter yield of lucerne on acid soil

Research on residual effects of four phosphorus fertilisers (triple superphosphate (TSP); 50% and 25% acidulated rock phosphate (ARP) and pure rock phosphate) on dry-matter yield of lucerne continued in 1989. Five harvests were made during the year and total dry-matter yield for 1989 was analysed.

Lucerne dry-matter yield showed a quadratic response to the amount of TSP applied in 1988. Applying TSP at 50, 100 or 200 kg P/ha in 1988 significantly ($P<0.05$) increased 1989 yield relative to the unfertilised control (Table 33). Yields increased linearly with the amount of acidulated rock phosphates applied in 1988, the yield difference being significant at all levels of application except 50 kg P/ha as 25% ARP (Table 33). There was no clear trend on plots that had received untreated rock phosphate in 1988, demonstrating the non-reactivity of this source on acid soil.

I. Haque

Table 33. *Lucerne dry-matter yield, as affected by application in 1988 of triple superphosphate (TSP), 25% and 50% acidulated rock phosphate (ARP) and pure rock phosphate (RP), Debre Zeit, Ethiopia, 1989.*

Fertiliser application (kg/ha)	Lucerne dry-matter yield (kg/ha)			
	TSP	50% ARP	25% ARP	RP
0	1263b	1263c	1263c	1263a
50	1763a	1543b	1463bc	1348a
100	2071a	1823a	1736ab	1616a
150	2111a	1790ab	1802ab	1457a
200	2147a	2054a	1854a	1580a

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

Multipurpose trees

Multipurpose trees have considerable potential for use in mixed crop–livestock production systems. They provide high-quality fodder for livestock, fertiliser in the form of mulch, fuelwood, poles and building timber, shade and shelter from the wind. They also curb soil erosion, conserve moisture, and build up soil fertility. Such plants offer advantages over herbaceous species in that they are more persistent, give higher forage yields, are more tolerant of mismanagement and are better able to retain high-quality forage under stress conditions.

ILCA is evaluating multipurpose trees in several ecological areas of sub-Saharan Africa. The objective of this work is to identify indigenous and introduced leguminous trees with superior nutritive values.

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

Nine accessions of five *Leucaena* species (*L. leucocephala*, *L. diversifolia*, *L. pallida*, *L. pulverulenta* and *L. revoluta*), selected from an initial evaluation trial, were established on an Alfisol at ILCA's Debre Zeit research station in the Ethiopian highlands in August 1988. *Sesbania sesban* (ILCA 10865) was included as the check. The accessions were planted in three blocks, each consisting of rows 24 m long and 1.5 m apart. Trees were planted 50 cm apart within rows. The trees were cut in August 1989, in the wet season, at 75 cm above ground level and again 50, 86 and 128 days later. The first cut provided an estimate of the amount of foliage that would be available as mulch for an associated cereal crop in an alley-cropping system. Subsequent regrowth cuts were aimed at determining when foliage should be cut during the dry season to maximise yield and avoid excessive leaf-drop.

Foliage dry-matter yields were generally low in August, except for accessions of *L. pallida*, *L. revoluta* and *Sesbania sesban* (Table 34). *Leucaena pallida* ILCA 14203 produced the highest foliage yield, as in the initial evaluation trial. Several accessions had lower yields on day 128, 82 days after the final rainfall, than on day 86, probably due to leaf-drop resulting from soil moisture stress. *Sesbania sesban* was particularly badly affected in this respect.

Sesbania sesban had the highest nitrogen and ash contents, was low in lignin and had the highest *in vitro* dry-matter digestibility (IVDMD). All *Leucaena* accessions had high nitrogen contents and IVDMD values greater than 65%.

Two accessions of *L. pallida* combined good dry-matter yields with high nitrogen content and digestibility. These thus are alternatives to *S. sesban* for use at middle to higher altitudes in sub-Saharan Africa.

J. Tothill

Table 34. *Effect of cutting interval on dry-matter yield in accessions of* Leucaena, *Debre Zeit, Ethiopia.*

Species	ILCA accession number	Dry-matter yield (kg/ha)			
		First cut in wet season (August 1989)	Following rest cut at		
			50 days	86 days	128 days
L. leucocephala	71	276f	882a	991ab	536ab
(cv. Peru)	14198	227f	230bc	481bc	799a
	14200	128f	466bc	399c	539ab
L. diversifolia	11676	447ef	410bc	462bc	624a
	14193	885de	547abc	587bc	356b
L. pallida	14189	1565bc	593abc	1187a	699a
	14203	2500a	504abc	1240a	808a
L. pulverulenta	14197	634def	411bc	657bc	726a
L. revoluta	14201	1078cd	190c	661bc	556ab
Sesbania sesban	10865	1907b	354bc	460bc	57c

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

Nutrient cycling in leguminous fodder trees — highlands

Evaluation of *Rhizobium* strains in *Sesbania sesban*

A greenhouse experiment was undertaken to compare the effectiveness of six strains of *Rhizobium* (USDA 3110, 3117, 3781, 3782, 3785 and 3786) in symbiotic association with *Sesbania sesban*. The *S. sesban* was planted in pots containing either Vertisol from ILCA's Shola site in the Ethiopian highlands or an acid soil from Soddo, a mid-altitude site in Ethiopia. Control plants were not inoculated and received either no nitrogen or 100 mg N/pot (equivalent to 100 kg N/ha) as urea. The plants were harvested 70 days after planting and shoot dry weight and number of root nodules were determined.

Only strain USDA 3117 induced nodules in plants grown on the acid soil; it also induced significantly ($P<0.05$) more root nodules in plants grown on the Vertisol (Table 35). Plants inoculated with this strain produced significantly ($P<0.05$) more shoot dry matter than the unfertilised control or plants inoculated with other strains on the Vertisol, but did not significantly affect yield on the acid soil. The fertilised control treatment gave the highest yield on both soils. Plants grew more vigorously on the acid soil than on the Vertisol, which may have been due to more mineralisation of nitrogen in the well-drained acid soil than in the Vertisol.

The persistence of strain USDA 3117 is being determined on these two soil types under field conditions.

Table 35. *Effect of* Rhizobium *strains on* Sesbania sesban *grown in two soil types in Ethiopia*

	Shola Vertisol				Soddo acid soil		
	Nodules per pot		Shoot dry weight	Relative effectiveness[1]	Nodules per pot		Shoot dry weight
Treatment	Number	Dry weight (mg)	(g/pot)	(%)	Number	Dry weight (mg)	(g/pot)
Control	0.00c	0c	0.113c	4.1	0	0	9.29b
Control + N	0.00c	0c	2.750a	100.0	0	0	12.08a
Rhizobium strain (USDA)							
3117	70.67a	113a	1.117b	40.6	80	280	10.97ab
3781	22.67b	77ab	0.410c	14.9	0	0	11.01ab
3782	12.00bc	60ab	0.307c	11.2	0	0	11.65ab
3110	9.67bc	80ab	0.320c	11.6	0	0	10.93ab
3786	8.33bc	67ab	0.297c	10.8	0	0	10.32ab
3785	3.67c	23bc	0.190c	6.9	0	0	10.32ab

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

All the treatments were supplied with P (50 mg/pot). N rate was 100 mg/pot as urea.

[1] $\text{Relative effectiveness} = \frac{\text{Shoot dry weight of inoculated plants}}{\text{Shoot dry weight of nitrogen control}} \times 100$

Growth of and biological nitrogen fixation by *Sesbania goetzii*

A pot experiment was undertaken in the greenhouse to investigate the effect of inoculating *Sesbania goetzii* with *Rhizobium* and applying phosphorus and nitrogen fertiliser on the plant's growth, nodulation and nitrogen fixation.

Seeds of *S. goetzii* were sterilised and scarified by immersing them in concentrated sulphuric acid for 20 minutes. They were then washed several times in sterile distilled water before being sown in pots (15 seeds per pot) containing Vertisol. The treatments applied were:

- no fertiliser or inoculation, sown in unsterilised soil (control)
- control planted in sterilised soil
- inoculated with *Rhizobium* strain USDA 3117
- fertilised with 50 kg P/ha
- inoculated and fertilised.

Each pot also received the equivalent of 20 or 100 kg N/ha as ^{15}N-labelled urea to determine the proportion of nitrogen derived from fixation. Plants were thinned to five per pot 17 days after planting and the number of nodules on the roots counted.

Inoculation and phosphorus application together significantly ($P<0.05$) increased shoot, root and total dry-matter yields and plant height relative to all other treatments (Table 36). Inoculation alone or applying phosphorus in the absence of inoculation had no significant effect on any of the parameters. A similar pattern was observed in shoot nitrogen yield and the proportion of nitrogen derived from fixation.

These results suggest that lack of phosphorus limited nodulation and nitrogen fixation by the *Rhizobium* and re-emphasise the need to apply phosphorus fertilisers to legumes.

N. Luyindula and I. Haque

Table 36. *Effect of* Rhizobium *inoculation and phosphorus application on nodulation and growth of* Sesbania goetzii *grown on Shola Vertisol, Ethiopia.*

Treatment	Nodules per pot		Shoot dry weight (g/pot)	Root dry weight (g/pot)	Mean plant height (cm)
	Number	Dry weight (mg)			
Control	0	0	0.23b	0.052b	2.52b
Control, sterilised soil	0	0	0.39b	0.147b	3.46b
Rhizobium (R)	4	5	0.22b	0.102b	2.21b
Phosphorus (P)	0	0	0.26b	0.122b	2.90b
P + R	66	220	2.37a	0.735a	11.53a

Based on five plants per pot.

All pots received 20 mg N/pot as urea.

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

Legume forages in crop–livestock systems

Forage legumes play an important role in developing ecologically sustainable and economically viable production systems. Legumes provide high-quality feed for livestock and, by fixing nitrogen, also enhance soil fertility, boost-

ing subsequent grain crop yields. The capacity of legumes to improve soil fertility and soil physical properties is particularly important in the fragile environments of sub-Saharan Africa.

ILCA has been studying three basic systems — rotations with annual or perennial legumes, intercrops, and undersowing annual crops — on different soil types. The objective of this work is to determine the technical and economic feasibility of these systems, and to compare their effects on soil fertility, crop yields and livestock production.

Integrating herbaceous forage legumes in subsistence cropping systems — subhumid zone, Mali

The benefits of *Stylosanthes hamata* fodder banks to both livestock and crop production have been well demonstrated in the Nigerian subhumid zone. This legume also grew well in trials in the subhumid zone in Mali in 1987 and 1988 (*ILCA Annual Report 1988*, page 104). However, the recommended establishment practice for fodder banks is to apply superphosphate fertiliser at planting, and this is too expensive for the average small farmer in Mali. A replicated small-plot trial was thus conducted in 1988 and 1989 to investigate the possibility of reducing establishment costs by using local rock phosphate instead of imported superphosphate.

Plots were fertilised with superphosphate (150 kg/ha) or rock phosphate (150, 300 or 450 kg/ha). Control plots received no phosphorus fertiliser. Phosphorus application had no significant effect on stylo yield over two years, irrespective of source or rate. Average dry-matter yield over the two years was 7.2 t/ha.

A second trial was conducted in 1989 to investigate the effect of growing *S. hamata* for two years on the yield of a subsequent sorghum crop. Sorghum following stylo yielded significantly ($P<0.05$) more grain than sorghum following sorghum. Applying nitrogen at up to 50 kg N/ha had no significant effect on sorghum yield, but applying 22 kg P/ha resulted in a highly significant ($P<0.001$) increase in sorghum grain yield (Table 37).

P. Bartholomew and M. I. Cissé

Table 37. *Effect of level of nitrogen and phosphorus fertiliser and previous cropping with* Stylosanthes hamata *on sorghum grain yield, subhumid zone, Mali.*

Main treatment effects	Grain yield (t/ha)
Previous cropping	
With *Stylosanthes hamata*	1.56
Without *Stylosanthes hamata*	1.37
SE	0.05*
Nitrogen application	
None	1.42
25 kg N/ha	1.51
50 kg N/ha	1.45
SE	0.08 NS
Phosphorus application	
None	1.02
22 kg P/ha	1.90
SE	0.06***

* = $P<0.05$; *** = $P<0.001$; NS = not significant.

Agronomic studies on selected forage legumes — subhumid zone, Nigeria

Effect of grass density on the productivity of *Stylosanthes hamata* and the grain yield of a subsequent cereal crop

Grass may account for 80% or more of the foliage in farmer-managed fodder banks. A trial was started in 1985 to investigate the effect this might have on soil nitrogen, forage quality and crude-protein yield from fodder banks and the yield of subsequent crops. *Stylosanthes hamata* was sown at a rate of 10 kg seed/ha in 4 × 3 m plots in June 1985. Emerging grasses were thinned to 0, 25, 50, 75 or 100% of the plant population. The plots were kept under these grass/legume mixtures for three years. They were then planted with maize in 1988 (see *ILCA Annual Report 1988*, pages 98–99) and 1989. No nitrogen was applied to the maize crop in either year. The trial was laid out in a randomised complete block design with four replicates.

As in 1988, maize yields in 1989 declined as the proportion of grass in the previous treatment increased (Table 38). These results re-emphasise the importance of controlling grass invasion in fodder banks.

Table 38. *Effect of grass density in a* Stylosanthes hamata *pasture on the grain yield of a subsequent maize crop, subhumid zone, Nigeria*

Grass density (%)	Maize-grain yield (kg/ha)
0	585a
25	469ab
50	316bc
75	230cd
100	131d

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

Effect of frequency of defoliation on legume productivity and crude-protein content

Fodder banks were initially intended to produce high-quality supplementary feed for use during the dry season, but subsequent studies have indicated that they could also be used beneficially to provide wet-season feed. A trial was started in 1987 to investigate the implications in this change for management of fodder banks.

Three legumes that show most promise in the Nigerian subhumid zone (*Stylosanthes hamata*, *S. capitata* and *Centrosema pascuorum*) were sown in 1987 in 5 × 3 m plots in a randomised complete block design with four replicates. Seed rate was 10 kg/ha. The plots were harvested every one, three, six or nine weeks during the 1988 and 1989 wet seasons (May–November). Control plots were cut only at the end of each wet season. Results of the 1988 trial were presented in *ILCA Annual Report 1988* (pages 98–99).

Yield generally increased as the length of the cutting interval increased from one to nine weeks (Figure 14). Cutting once, at the end of the wet season, gave the highest yield for *S. capitata* but in *S. hamata* and *C. pascuorum* resulted in lower yields than cutting every nine weeks.

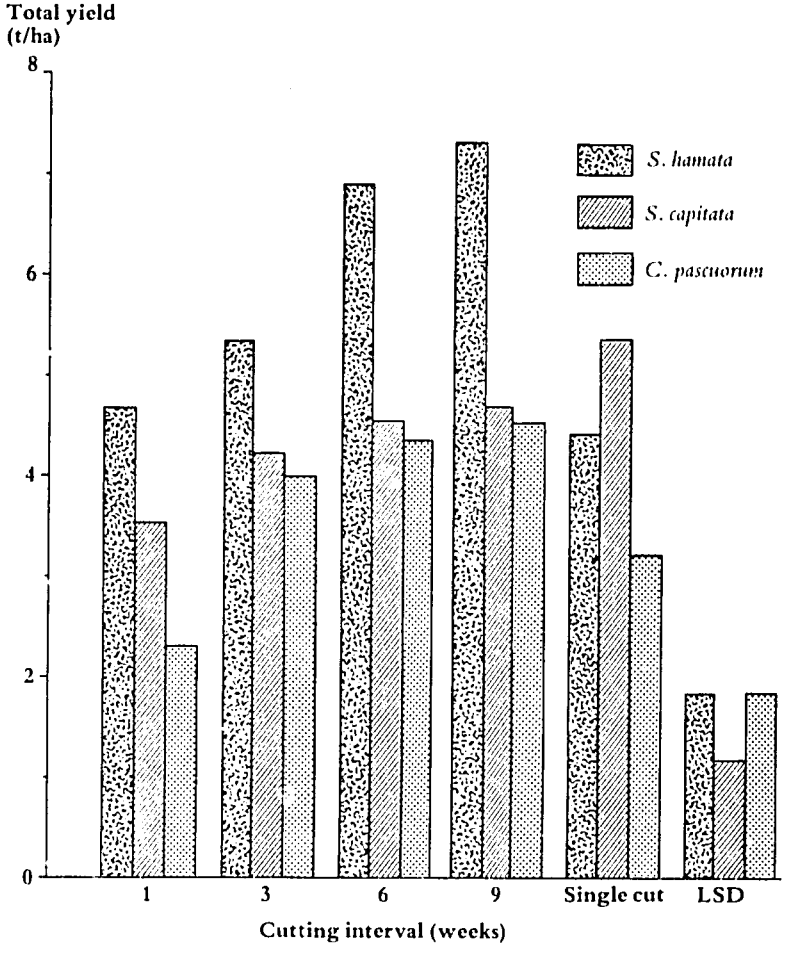


Figure 14.
Effect of cutting interval on the yields of Stylosanthes hamata, S. capitata *and* Centrosema pascuorum, *subhumid zone, Nigeria, May–November 1989.*

Analysis of foliage collected from the 1988 study showed that crude-protein content declined as cutting frequency decreased. For example, *S. hamata* that was not cut until final harvest had a crude-protein content of 10.95%, compared with 15.33% in plants cut every week.

These results show that fodder banks used for wet-season supplementation should be grazed every three to nine weeks. Delaying defoliation until the final harvest reduces both dry-matter and crude-protein yield.

G. Tarawali

Evaluation of legumes in management systems — fodder banks

Fodder banks were designed primarily to promote livestock production by agropastoralists in the subhumid zone of Nigeria, although they are being adopted by small-scale livestock farmers both in Nigeria and in neighbouring countries. However, nitrogen builds up in the soil under fodder banks, which encourages invasion by nitrophilous weeds, reducing the nutritive value of the forage. This can be avoided by cropping the fodder bank periodically. Experiments were established in 1988 to compare cropping strategies and determine appropriate management practices for cropping fodder banks (see *ILCA Annual Report 1988*, pages 102–104).

In 1988 maize, sorghum and soya bean were grown either alone or in combination inside and outside five fodder banks in the Nigerian subhumid zone. Plots received one of six levels of nitrogen (0, 40, 80, 120, 160 and 200 kg N/ha). The trial was established as a split-split plot design with each treatment occupying four 3-m-long ridges. In 1989 each plot was further split into two parts. The amount of fertiliser applied in 1988 was again applied to one half of each plot; the other half received no nitrogen.

Results from fertilised plots were similar to those obtained in 1988: crops planted within the fodder banks produced higher grain yields than those sown on the natural fallow. Yields on unfertilised plots were low, and there was no evidence of a residual effect of the nitrogen applied in 1988. However, plots inside fodder banks again yielded more than those outside.

The poor yields of the crops that received no fertiliser in 1989 emphasise the need to apply some nitrogen fertiliser to all soils during each cropping season, although less need be applied to plots that have been under stylo.

G. Tarawali

Nutrient cycling in legume-based cropping systems on upland soils — highlands

Nitrogen deficiency limits crop growth on most highland soils, but nitrogen fertilisers are expensive or not available to poor farmers. One alternative to applying nitrogen fertiliser is to grow legumes, which fix atmospheric nitrogen and make it available to subsequent crops. They also provide high-quality feed for livestock.

Studies were continued in 1989 at two highland sites to determine the yield of various legumes grown as intercrops and in crop rotations.

Effect of intercropping maize with *Macrotyloma axillare* on feed output and grain yield

In 1988 a local cultivar of maize and the legume *Macrotyloma axillare* cv Archer were planted in pure stand and as intercrops (3:1) on an acid soil at Soddo, a mid-altitude site in Ethiopia. All plots received 50 kg P/ha as triple superphosphate at planting. Maize and the intercrop plots received either 0 or 60 kg N/ha. No nitrogen was applied to pure-stand *Macrotyloma* plots. Results of the first year were reported in *ILCA Annual Report 1988* (page 107).

In 1989 the legume was harvested twice, in March and May, during the off season, and again at the end of the main cropping season. Maize was planted in June 1989 without any additional N application.

Macrotyloma that had been planted in pure stand yielded significantly ($P<0.05$) more dry matter at the May harvest than did *Macrotyloma* that had been established in intercropping treatments, but overall off-season yield did not differ signficantly between treatments (Table 39). *Macrotyloma* in pure stand again gave the highest dry-matter yield at the end of the cropping season.

Maize intercropped with *Macrotyloma* yielded less than half as much dry matter and grain as maize in pure stand, but intercropping treatments produced significantly more total dry matter than maize plots. The significant ($P<0.05$) reduction in maize-grain yield due to intercropping was probably due to competition between the maize and *Macrotyloma* for water and nutrients.

Table 39. *Dry-matter and grain yield of maize and* Macrotyloma axillare *cv Archer grown in pure stand or intercropped on an acid soil, Soddo, Ethiopia.*

Cropping system	Dry-matter yield (kg/ha)						Maize-grain yield (kg/ha)
	Off season			Main cropping season			
	9/3/89	17/5/89	Total	Maize	*Macrotyloma*	Total	
Maize				2422		2422c	2980a
Maize + 60 N				2484		2484c	3214a
Maize: *Macrotyloma*	1970	2503b	4474	1173	5122ab	6296a	1351b
Maize: *Macrotyloma* + 60 N	1936	2223b	4141	1005	4357b	5362b	1164b
Macrotyloma	1394	2960a	4354		6116a	6116ab	

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

The production of large amounts of high-quality feed during the dry season by *Macrotyloma* may be sufficient to offset the loss in maize-grain yield for farmers with mixed crop–livestock farms and encourage them to adopt cereal–legume intercropping. The effects of growing the legume on a subsequent maize crop will be investigated during the 1990 cropping season.

Effect of crops and cropping systems on feed output and nitrogen nutrition of maize on an upland soil

In 1989, a field experiment was initiated at ILCA's Debre Zeit research station in the Ethiopian highlands to estimate the quantity and quality of feed produced by various crops and cropping systems and to study the nitrogen nutrition of maize grown after either pure cereal or intercrops. Two cultivars of *Lablab purpureus* (Rongai and Highworth) were grown either in pure stand or intercropped with maize. Maize and intercrop plots received either 50 kg N/ha or no nitrogen fertiliser. The trial was laid out in a randomised complete block design with four replicates.

Lablab tended to produce more nodules, and hence greater weight of nodules, in pure stand than in intercrops, but the effect was not generally significant. Highworth produced significantly (P<0.05) more nodules than Rongai in both pure stand and intercrops (Table 40).

Intercropping maize with *Lablab* significantly (P<0.05) reduced maize-grain yield relative to maize grown in pure stand (Table 40). Maize/Rongai intercrops produced significantly (P<0.05) more dry matter than maize in pure stand, but the yield of maize/Highworth intercrops was not significantly different from that of maize in pure stand.

The relative emphasis placed by farmers on grain yield versus feed production will determine whether they adopt such intercropping systems.

I. Haque

Network coordination

The Animal Feed Resources Thrust is involved in the coordination of two collaborative networks, the African Research Network for Agricultural Byproducts (ARNAB) and the Pasture Network for Eastern and Southern Africa (PANESA). During 1989 it also collaborated with CIAT (Centro Internacional de Agricultura Tropical) and IEMVT (Institut d'élevage et de médecine vétérinaire des pays tropicaux) in the establishment of a West and Central African Feed Resources Network.

Table 40. *Effect of cropping systems on nodulation, dry-matter and grain yield of maize and* Lablab purpureus *grown on an upland soil, Debre Zeit, Ethiopia.*

Cropping system	No. of nodules per 10 plants	Dry wt. of nodules (g/10 plants)	Dry-matter yield (kg/ha)			Maize-grain yield (kg/ha)
			Maize	*Lablab*	Total	
Maize			3408		3408c	4214b
Maize + 50 N			3475		3475c	4978a
Maize: *Lablab* cv Rongai	30d	1.6b	2727	2686	5413b	3342c
Maize: *Lablab* cv Rongai + 50 N	40d	1.5b	2419	3200	5619b	3067c
Maize: *Lablab* cv Highworth	159ab	2.4ab	2214	1380	3594c	3218c
Maize: *Lablab* cv Highworth + 50 N	124bc	2.2ab	2134	1477	3611c	3003c
Lablab cv Rongai	57cd	2.1ab		6596	6596a	
Lablab cv Highworth	211a	3.2a		4043	4043c	

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

Feed resources network activities

PANESA and ARNAB play vital roles in testing the results of the Thrust's work in various crop–livestock production systems. They are instrumental in training national agricultural research system (NARS) staff in forage evaluation and production and in facilitating the supply of seed for multi-locational trials. The information exchange links between ILCA and NARS are being strengthened through training courses, workshops, conferences and network newsletters.

PANESA held a workshop on "Regional Collaborative Research Planning on *Sesbania* Multilocational Evaluation" in Kisumu, Kenya, in August–September 1989. Participants exchanged information on *Sesbania* evaluation, developed standardised evaluation methodologies and planned future multi-locational evaluation trials. The workshop was attended by scientists from Kenya, Malawi, Rwanda, Tanzania, Uganda and Zimbabwe, and from the International Council for Research in Agro-Forestry, IDRC (the International Development Research Centre, Canada), ILCA and the International Board for Plant Genetic Resources. As a consequence of this workshop, 12 major screening sites, covering a wide range of environments, were identified in Kenya, Rwanda, Tanzania, Uganda and Zimbabwe.

A joint ARNAB/PANESA training workshop covering "On-farm Animal Feed Resources Research Methodology and Data Analysis" was held at Egerton University Agricultural Resources Centre, Njoro, Kenya, 6–17 November 1989. It was sponsored by the IDRC Fellowship and Awards Division, Ottawa, Canada. The 23 participants came from Botswana, Burundi, Ethiopia, Kenya, Malawi, Mozambique and Somalia. The objectives of the meeting were to develop the ability of biologists involved in animal feed resources research and development in NARS to formulate on-farm experimental research designs and analyse statistically data from on-farm surveys, and to familiarise NARS scientists with methods used in development and transfer of technology packages in animal feed resources research.

The Proceedings of the joint ARNAB/PANESA workshop on "Utilization of Research Results on Forage and Agricultural By-Product Materials as Animal Feed Resources in Africa", held in Malawi in December 1988, were edited and are being printed.

The decision to form the West and Central African Feed Resources Network was taken at a meeting held at Avetonou, Togo, in late October–early November 1989. The meeting was attended by scientists from Benin, Cameroon, Central African Republic, Côte d'Ivoire, France (IEMVT), Ghana, Mali, Nigeria, Sierra Leone and Togo, and from the CIAT and ILCA. An interim Steering Committee was appointed and research protocols formulated for 1990.

In order to rationalise network collaboration with NARS, the three networks, ARNAB, PANESA and the new West and Central African Feed Resources Network, agreed to merge in 1990 into a single African feed resources network. The first general workshop of this new pan-African network will be held in late 1990 in either Botswana or Zimbabwe.

B. Dzowela and A.N. Said

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* *Joined ILCA in 1989*
** *Left ILCA in 1989*

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), Nairobi, Kenya, 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 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.

The Thrust's research programme is focused within regional groups of sites (see *ILCA Annual Report 1988*, pages 111–112). Scientists at sites in The Gambia, at the International Trypanotolerance Centre (ITC), and in Senegal, at the Institut sénégalais de recherches agronomiques (ISRA), Kolda, concentrate on research in nutrition, reproduction and milk extraction. Staff at the site at the Société de développement des productions animales (SODEPRA) at Boundiali, Côte d'Ivoire, focus on interaction between trypanosomiasis and other diseases and on tsetse-control aspects. Work at sites in Gabon and Zaire concentrates on aspects of genetics and animal breeding under high natural trypanosomiasis challenge. At associated sites in Ethiopia and Kenya, work focuses on susceptible livestock.

The Thrust has 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

The objectives of research under this theme are to:

- determine the contribution that studies of the tsetse population can make in planning for increased livestock production by predicting animal health and performance
- evaluate in the field diagnostic tests for trypanosomiasis that have been developed by other agencies
- evaluate the various factors affecting susceptibility of livestock to trypanosomiasis.

Prediction of animal responses to tsetse challenge

The potential contribution that tsetse challenge evaluation can make in predicting animal health and production responses to exposure to various levels of trypanosomiasis risk was further clarified during 1989.

The relationship between estimates of tsetse challenge and trypanosome prevalence in trypanotolerant and susceptible cattle was examined at five Network sites in Ethiopia, Gabon, Zaire (ranch and village systems) and Côte d'Ivoire. Estimates of tsetse challenge were determined as the product of tsetse relative densities, their trypanosome infection rates and the proportions of feeds taken by them from cattle. Trypanosome prevalence in both trypanotolerant and susceptible breeds of cattle was estimated from monthly examinations.

Regression equations relating estimates of trypanosome prevalence to tsetse challenge were fitted using an arcsine transformation of trypanosome prevalence and a $\log_{10}$ transformation of tsetse challenge. The relationship was highly significant ($P<0.01$) both for sites with trypanotolerant cattle and for sites with susceptible cattle. The slopes of the regression lines for the two groups of cattle were significantly different ($P<0.05$).

Comparison of the two curves on detransformed scales (Figure 15) showed that, for a given level of tsetse challenge, mean trypanosome prevalence was at least twice as high in susceptible cattle as in trypanotolerant cattle. This confirms the superior ability of trypanotolerant cattle to withstand tsetse challenge in the field. The curves illustrate the need in tsetse-control campaigns for a major reduction of tsetse populations to take place before significant decreases in trypanosome incidence in livestock can be achieved.

G.J. Rowlands, G. d'Ieteren, J.C.M. Trail and Woudyalew Mulatu

Collaborators: Société de développement des productions animales, Côte d'Ivoire; International Laboratory for Research on Animal Diseases, Kenya; Office gabonais d'amélioration et de production de viande, Gabon; Compagnie J. van Lancker, Zaire; Développement du progrès populaire, Zaire

Recurrent trypanosome infections

There have been strong indications at the Network site at Ghibe in Ethiopia that high levels of recurring trypanosome infection coincided with lower levels of animal productivity.

Data have been collected at this site on the health and productivity of East African Zebu cattle kept in village herds under comparatively high tsetse challenge. It was found that many animals were repeatedly being detected parasitaemic despite their having been treated with trypanocidal drugs. This, together with the fact that overall trypanosome prevalence was increasing and appeared to be higher than might be predicted from the level of tsetse challenge, suggested that trypanocidal treatment was becoming less effective. In order to understand these infection patterns better, a practical approach was developed for distinguishing between new and recurrent infections when it is possible to take only one sample per month.

Mean monthly trypanosome prevalence between January 1988 and June 1989 was 36.5% in cattle over 32 months old, with *Trypanosoma congolense* the predominant species (30.7%). Among animals that were both free of trypanosomes and had a packed cell volume of greater than 26% in each of the previous three months, *T. congolense* prevalence was 14.1%. This value was taken as a measure of the "new infection" rate and the difference between it and 30.7% as an indication of the high level of recurrent infection.

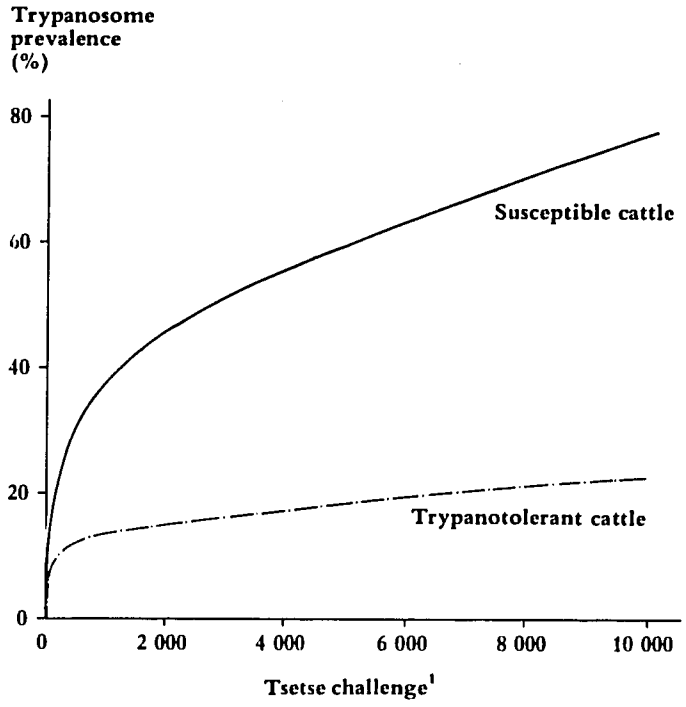

Figure 15.
Predicted relationships between tsetse challenge and trypanosome prevalence in susceptible and trypanotolerant breeds of cattle.

[1] Tsetse challenge is estimated as the product of tsetse relative density, infection rates in the flies and meals taken by the flies from cattle.

These results point to the possible existence of drug resistance among certain stocks of *T. congolense* in these herds. Consequently, several field isolates have been obtained for testing. The results also show that additional measures are needed to reduce overall levels of trypanosomiasis; a tsetse-control campaign is therefore being mounted using insecticide-impregnated screens. Subsequent monitoring of trypanosome prevalence and animal health and productivity will allow the benefits of the campaign to be assessed alongside alternative chemotherapy regimes.

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Collaborator: International Laboratory for Research on Animal Diseases, Kenya

Trypanotolerance

Research under this theme aims at:

- quantifying the health and productivity of trypanotolerant and susceptible livestock under various 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
- defining criteria for trypanotolerance and evaluating the relationships between these criteria and production traits.

Effect of components of trypanotolerance on cattle productivity

The ability to control the development of anaemia has a major effect on N'Dama reproductive performance, calf growth and cow productivity, as demonstrated at Mushie Ranch, Zaire. A total of 146 calving-interval records were built up from 64 N'Dama cows maintained for 3.5 years under high natural tsetse challenge. Matching health and performance data were recorded monthly to allow simultaneous evaluation of the effects on reproductive performance, calf weaning weight and cow productivity of various criteria of trypanotolerance, ie, time detected parasitaemic, parasitaemia score and packed cell volume (PCV).

Control of development of anaemia, measured by the maintenance of a higher average PCV during trypanosome infection, had a major effect on all three performance traits (Table 41).

The repeatabilities of the various traits, measured between successive calving intervals, set upper limits to their degrees of genetic determination and heritabilities. The repeatability of PCV value was reasonably high (0.33) and almost equal to that of calf weaning weight (0.35). Thus, the ability to control development of anaemia, as indicated by PCV, might well be the most reliable criterion of trypanotolerance with which to identify animals with a greater degree of trypanotolerance.

Simultaneous evaluation of the relative effects on calf performance of control of development of anaemia in both the pre-weaner calf and its dam indicated that its measurement in an animal might be feasible at an early stage after weaning. This study has also clearly indicated that investigations into the practicality of field tests for trypanotolerance should initially focus on:

- use of post-weaners, maintained for varying lengths of time in as high a natural challenge as possible, with evaluation of the effects of different trypanosome species

Table 41. *Influence of various criteria of trypanotolerance on calving interval, calf weaning weight and cow productivity, Mushie Ranch, Zaire, 1989.*

	Decrease in calving interval		Increase in calf weaning weight		Increase in cow productivity[1]	
Criterion	days	%	kg	%	kg	%
Low versus high time detected parasitaemic	68	14.2	2.8	2.1	17.1	15.5
Low versus high parasitaemia score (within high time detected parasitaemic)	20	4.1	3.2	2.4	5.6	5.2
High versus low PCV (within low time detected parasitaemic)	27	6.3	7.8	5.8	12.6	10.4
High versus low PCV (within high time parasitaemic)	59	11.5	12.2	9.4	23.7	24.1

[1] Weight of eight-month-old weaned calf produced per cow per year.

PCV = Packed cell volume

- confirming that control of anaemia development is the most important practical criterion indicating trypanotolerance and evaluating different measures of this, eg, average PCV throughout a test, average PCV only when detected as parasitaemic, lowest PCV reached
- measuring the degree of genetic determination in criteria for trypanotolerance, their heritabilities and genetic correlations with production aspects, and/or the possibilities of detection of marker genes.

G. d'Ieteren and J.C.M Trail

Collaborator: Compagnie J. van Lancker, Zaire

A field test for trypanotolerance in young N'Dama cattle

A field test for trypanotolerance was evaluated using three groups of one-year-old N'Dama cattle (436 in total) maintained for 12, 18 or 24 weeks under medium natural tsetse–trypanosome challenge at a ranch belonging to the Office gabonais d'amélioration et de production de viande (OGAPROV), Gabon. Matching health and performance data were recorded on 4, 10 and 13 occasions, respectively, to allow simultaneous evaluation of the effect of various criteria of trypanotolerance on animal performance. Trypanosome prevalence was 25, 31 and 9%, respectively, during the three tests.

Ability to control the development of anaemia had a much greater effect on daily weight gain than ability to control parasitaemia, while previous exposure to trypanosome infection had no effect (Table 42).

Table 42. *Effects of parasitaemia control, anaemia control and previous exposure on daily weight gain, OGAPROV Ranch, Gabon, 1989.*

Exposure to trypanosomiasis risk (weeks)	Statistic	Parasitaemia control[1]		Anaemia control[1]		Previous exposure[2]	
		High score	Low score	High PCV	Low PCV	Past parasitaemia	No past parasitaemia
12	No. of animals	57	57	58	56	62	117
	Growth (g/day)	248	273	283	238	238	290
	SE	23.5	23.9	21.9	20.6	11.6	8.9
18	No. of animals	51	51	46	56	62	54
	Growth (g/day)	97	106	135	68	109	126
	SE	14.4	11.0	27.2	26.3	7.8	8.3
24	No. of animals	27	49	40	36	51	90
	Growth (g/day)	81	89	111	59	106	114
	SE	15.6	19.5	21.1	32.0	8.3	6.8
Overall	No. of animals	135	157	144	148	175	261
	Growth (g/day)	142	156	176	122	167	177
	SE	19.0	19.1	23.2	25.9	8.3	8.1
Mean difference in growth (%)		+10		+44		−5	

[1] Constructed from least squares means for classes nested within all periods when detected as parasitaemic.

[2] Least squares means.

PCV = Packed cell volume.

Three separate measures of anaemia control were compared: average PCV over the test period, lowest PCV reached, and average PCV when the animal was detected as parasitaemic. The first two measures were more closely associated with animal performance than the last, and both could serve as indices of the control of development of anaemia. For detecting major differences in anaemia control, the minimum test period for an animal to be detected as parasitaemic was shown to be about six weeks. Thus, in practice, a suitable test would be to effect natural infection as early as possible and measure PCV over six weeks of detected parasitaemia. If satisfactory correlation could be obtained between the effects of natural infection and those of artificial infection, a practical test would be even more feasible.

G. d'Ieteren and J.C.M. Trail

Collaborator: Office gabonais d'amélioration et de production de viande, Gabon

Effect of trypanosome infection on N'Dama reproduction

Important results were obtained in 1989 in the evaluation of the effects of trypanosome infection on reproduction. A detailed study was carried out on five herds of N'Dama cows at OGAPROV Ranch, Gabon, in which half the cows in each herd were treated prophylactically with Samorin before the breeding season and the other half were not. Two breeding seasons, December 1986 to March 1987 and December 1987 to February 1988, were followed. Monthly trypanosome prevalence over the two seasons was 8.6% in the untreated group.

Neither treatment nor parasitaemia in untreated animals affected calving rate in cows that were dry during the breeding season but among lactating cows the average calving rate was lower in untreated animals than in treated animals (Table 43). When a linear model using the logit function appropriate for the analysis of binomial data was fitted with parameters for treatment, month of calving, year, herd and age, this difference was shown to be significant ($P<0.01$) with fitted values of 0.50 and 0.66, respectively. The difference was brought about by the low calving rate of 0.29 in 68 untreated animals which became parasitaemic during the breeding season. Thirty-eight of these animals were treated with Berenil because PCV was below 25% and the calving rate in these cows (0.13) was even lower. These results demonstrate how trypanosomiasis can impair fertility of cows when stressed by lactation, particularly those failing to maintain control of development of anaemia in response to trypanosome infection.

G. d'Ieteren, G.J. Rowlands and J.C.M. Trail

Collaborator: Office gabonais d'amélioration et de production de viande, Gabon

Table 43. *Effect of Samorin treatment on calving rate in N'Dama cows, OGAPROV Ranch, Gabon, 1989.*

Cow status during the breeding season	Treated		Not treated	
	No. of cows	Per cent calving	No. of cows	Per cent calving
Dry	93	86	114	91
Lactating	267	64	255	52

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
- evaluate and use blood-typing procedures to identify half-sib groups in N'Dama cattle from known dams but with unknown sires.

Genetic aspects of control of anaemia development

Genetic parameters of measures of control of anaemia were evaluated for the first time in field tests in 1989. A total of 148 one-year-old N'Dama cattle, progeny of 29 sires, were exposed for 92 days to a medium level of natural tsetse–trypanosome challenge at OGAPROV Ranch, Gabon. Matching health and performance data were recorded on 11 occasions. Average PCV and lowest PCV reached during the period were evaluated as measures of ability to control the development of anaemia. Attempts were made to systematically control other possible causes of anaemia.

In animals detected as parasitaemic, those with above-average average PCV values or above-average lowest PCV reached had 34 and 35%, respectively, higher weight gains than those with below-average values. Even when not detected as parasitaemic, those with above-average average PCV or above-average lowest PCV reached had 14 and 12%, respectively, higher gain indicating that some of these animals actually were parasitaemic.

The heritabilities of, and genetic and phenotypic correlations between, growth, average PCV and lowest PCV reached on test are shown in Table 44.

Table 44. *Heritabilities of, and genetic and phenotypic correlations between, growth, average packed cell volume (PCV) and lowest PCV reached on test.*

	Growth	Average PCV	Lowest PCV reached
Parasitaemia detection and parasitaemia score not included in analysis			
Growth	0.22 ± 0.28	0.41 ± 0.73	−0.13 ± 0.74
Average PCV	0.35	0.35 ± 0.30	0.96 ± 0.20
Lowest PCV reached	0.29	0.72	0.48 ± 0.31
Parasitaemia detection included in analysis			
Growth	0.38 ± 0.30	0.71 ± 0.42	0.28 ± 0.55
Average PCV	0.32	0.63 ± 0.33	0.99 ± 0.17
Lowest PCV reached	0.25	0.66	0.51 ± 0.32
Parasitaemia detection and parasitaemia score included in analysis			
Growth	0.39 ± 0.31	0.70 ± 0.42	0.28 ± 0.55
Average PCV	0.32	0.64 ± 0.33	1.00 ± 0.17
Lowest PCV reached	0.25	0.67	0.50 ± 0.32

± SE.

Heritability is the value on the diagonal.

Genetic correlation is the value above the diagonal.

Phenotypic correlation is the value below the diagonal.

The heritability of body weight at the start of the test, when animals were approximately 50 weeks old, was 0.49 (SE 0.32). This is within the normally reported range for this trait, while the large standard error may be a reflection of the small number of progeny per sire. When all environmental and parasitaemia information was taken into account, the heritability of growth over the test period was 0.39 (SE 0.31), again within the expected range for growth over a three-month period.

The heritabilities of both PCV measures were higher than the corresponding heritability of growth in all analyses and were 0.64 (SE 0.33) and 0.50 (SE 0.32) when all environmental and parasitaemia information was used.

When all environmental and parasitaemia information was taken into account, the genetic correlation between average PCV and growth was 0.70 (SE 0.42) and between lowest PCV reached and growth, 0.28 (SE 0.55). These values, coupled with the higher heritabilities of the PCV measures, indicate some possibility of selection on PCV values for control of anaemia development.

Both heritability and genetic correlation values increased when parasitaemia information was included in the analysis, although parasitaemia was detected in only 28% of the animals. More sensitive field tests being developed for trypanosome detection will allow more accurate classification of parasitaemia status, which should in turn further raise the heritability estimates of PCV measures and their genetic correlations with performance.

If all animals could become parasitaemic during a test, either through very high natural infection or through an acceptable artificial alternative, the heritability estimates of PCV measures could be higher still. This would allow the test period to be reduced to the minimum time needed to accurately evaluate the PCV values of the animals when parasitaemic, which would allow the economic impact of the deleterious effects of trypanosome infection on animal performance to be minimised. Over a shortened test period PCV values can be measured much more accurately than can animal performance. Thus selection on the most appropriate PCV measure could well allow rapid progress to be made in genetic improvement of trypanotolerant N'Dama cattle.

J.C.M. Trail and G. d'Ieteren

Collaborator: Office gabonais d'amélioration et de production de viande, Gabon

Biological and economic evaluation of productivity responses to interventions

The Thrust is putting emphasis on developing practical packages for farmers to use, and studies in 1989 included:

- the use of insecticide-impregnated traps and screens 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 under trypanosomiasis risk
- the introduction of N'Dama cattle under a village *metayage* system
- preparations for pilot selection programmes based on criteria of trypanotolerance.

Effects of cypermethrin-impregnated tsetse traps on challenge and trypanosome prevalence

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 Bagoue river, a tributary of the Niger flowing northwards through Boundiali District. Because of heavy rains, traps have to be removed each year during the rainy season. The second tsetse-control cycle followed at the beginning of 1989 and on this occasion all animals were treated with Berenil in April. Tsetse challenge (*Glossina palpalis* and *G. tachinoides*) fell dramatically during 1987 and early 1988 in the area where the tsetse-control programme was implemented (Figure 16). In contrast, there were no changes of any significance in tsetse challenge in the adjacent "uncontrolled" area.

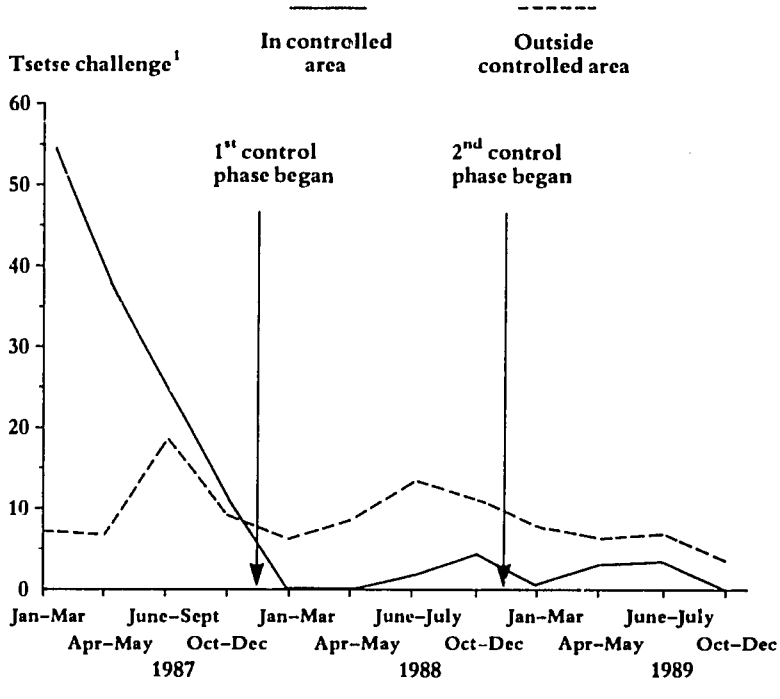

Figure 16. *Tsetse challenge in "controlled" and "uncontrolled" areas, Boundiali area, Côte d'Ivoire, 1987–89.*

[1] Tsetse challenge is estimated as the product of tsetse relative density, infection rates in the flies and meals taken by the flies from cattle.

Average monthly trypanosome prevalences in 10 herds of cattle and seven sheep flocks in the "controlled" area declined from mid-1987 (Figure 17); mean prevalences in 1989 were about one quarter of those in 1987. However, similar reductions also occurred in cattle herds and sheep flocks in the "uncontrolled" area. The decline in trypanosome prevalence in animals in the "uncontrolled" area may have been due, in part, to the close proximity of some of the herds and flocks to the border of the "controlled" area.

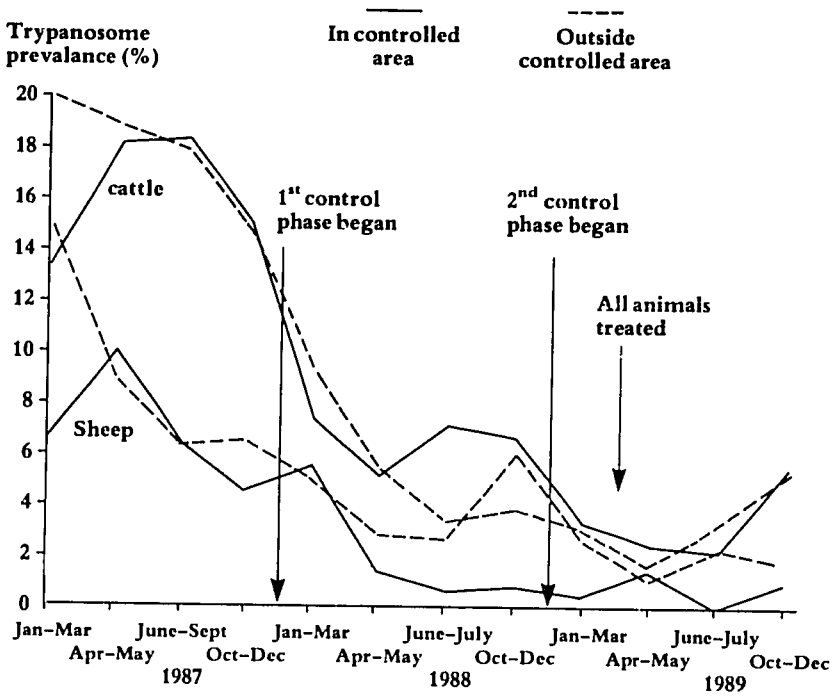

Figure 17.
Trypanosome prevalence in sheep and cattle in "controlled" and "uncontrolled" areas, Boundiali area, Côte d'Ivoire, 1987–89.

In 1990 tsetse traps will be used in both areas and monitoring of herds and flocks will continue. Data on other animal health and productivity parameters have also been collected and these will be used to evaluate the benefits of tsetse control on animal health and productivity.

G. d'Ieteren, P. Itty, G.J. Rowlands and J.C.M. Trail

Collaborators. Société de développement des productions animales, Côte d'Ivoire; International Laboratory for Research on Animal Diseases, Kenya

Economic evaluation of the introduction of N'Dama cattle in Idiofa region, Zaire

A study was conducted in 1989 of the economics of introducing N'Dama cattle for beef production in Idiofa region, central Zaire. This is the first study of its kind based on complete economic data and recorded productivity. It provides first-hand information on the economic feasibility of introducing trypanotolerant cattle into village systems in tsetse-affected areas where cattle husbandry has not been practised in the past. Herd structures and mean productivity values were derived for 18 herds monitored from January 1986 to December 1989. Economic data were obtained in May 1989.

The study used cost-benefit analysis involving a herd simulation model to take into account the dynamics of livestock production. A society-level economic analysis was performed and profitability was looked at from the

point of view of the society as a whole and not strictly from the point of view of individual cattle producers. The analysis used shadow prices, obtained by deducting taxes and subsidies from market prices, and opportunity costs (the values of goods, services or capital in their best alternative use) when appropriate. An individual-level financial analysis was also carried out to complement the society-level economic analysis.

The society-level economic analysis showed an overall net benefit investment ratio of 1.11, using a 10% discount rate, and an internal rate of return of 11.7%. The individual-level financial analysis revealed a net benefit investment ratio of 1.22 and an internal rate of return of 13.4%. In both cases the returns were positive but not outstanding

The study shows that in spite of reasonable cattle productivity and low inputs the economic and financial returns were limited. Two factors that contributed to this were, first, the relatively higher costs of purchase of breeding animals brought about by the shortage of cattle available for purchase in the Idiofa region and, second, the high costs of beef relative to the purchasing power of the local population. Nevertheless, the case study provides clear indications of the economic feasibility of introducing trypanotolerant cattle in villages where cattle husbandry has not been practised in the past.

G. d'Ieteren, P. Itty, G.J. Rowlands, J.C.M. Trail and F. van Winckel
Collaborator: Développement du progrès populaire, Zaire

Collaboration with national agricultural research systems

Thirteen professional staff in NARS were closely involved in research activities of the Trypanotolerance Thrust in 1989. Twenty-four papers based on Thrust research were published, submitted for publication or presented at scientific meetings during the year. Of the 67 authors of these publications, 30 were from NARS, 19 were from ILCA, and 18 were from other international organisations in Africa or overseas.

Network meeting

The biennial meeting of the African Trypanotolerant Livestock Network was held in Mombasa and Nairobi, Kenya, from 10 to 21 April 1989. Network scientists reviewed progress in their research and modified or redesigned some of their protocols. New projects were planned. In addition, scientists from Côte d'Ivoire, Ethiopia, Gabon, The Gambia and Zaire presented key results from their research at sessions of the 20th meeting of the Organization of African Unity's International Scientific Council for Trypanosomiasis Research and Control (OAU–ISCTRC), held at the same time in Mombasa.

The Network maintains good links with the OAU–ISCTRC and uses its biennial meeting, one of the most important gatherings of scientists involved in all aspects of research on trypanosomiasis, as a forum for major exchange of results and ideas, and to reach representatives of all the African countries and regional and international organisations concerned by or working on trypanosomiasis.

Training

Individual training was provided in Nairobi to six scientists from research sites in Côte d'Ivoire, Ethiopia, Gabon and Zaire on focused aspects of Network protocols and on data handling and analysis procedures.

Scientists at Network sites in Ethiopia, The Gambia and Zaire provided training to nationals from their own or neighbouring countries, adding a new dimension to Network training activities and allowing a better penetration of research findings into national agricultural systems.

THRUST STAFF

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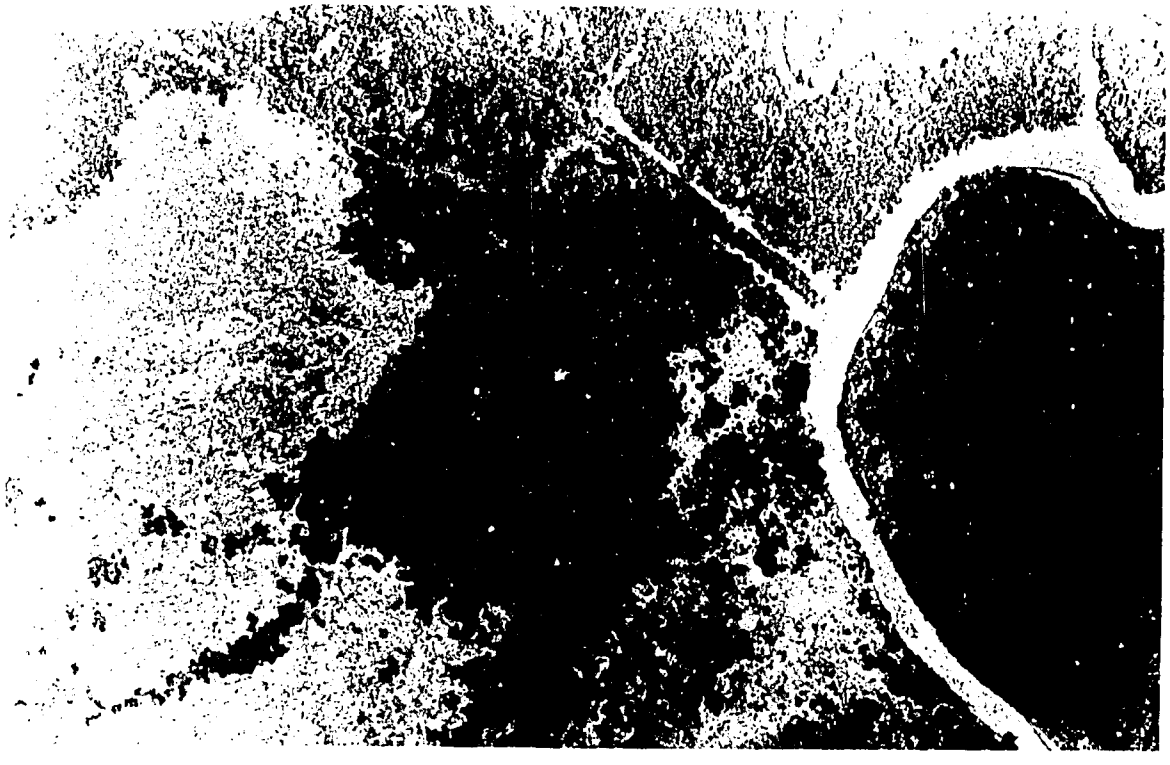
* *Joined ILCA in 1989*



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Livestock Policy and Resource Use Thrust

Farmers will not adopt new technologies unless this is favoured by satisfactory government policies and natural resources are being used efficiently and sustainably. The Livestock Policy and Resource Use Thrust aims at assisting the efforts of governments to make improvements in these areas. In 1989 about 26% of the Thrust's funds were devoted to policy work and 74% to resource use.

Policy research

ILCA carries out research on a few key issues at a time under the Policy Research theme. Subjects chosen are those where the relationship between policy instruments and objectives is obscure and where ILCA has some comparative advantage over other organisations in carrying out the research, for example in cases where intercountry comparisons can be made. In 1989 work continued on the impact of pricing policies and on the relationship between land tenure and technology adoption. However, the land-tenure study took on a new orientation with the start of collaborative work on land tenure and trees in West Africa with the Land Tenure Center of the University of Wisconsin, USA, which will in turn lead to collaboration with several other researchers in West Africa.

Impact of livestock pricing policies on meat and milk output in selected countries in sub-Saharan Africa

Livestock pricing policies in countries of sub-Saharan Africa are important in three main respects. First, many of the rural people in these countries derive their livelihood from livestock production and their incomes are directly related to the prices they obtain for the commodities they produce. Second, prices represent a cost to consumers who spend an important part of their income on livestock products. Third, livestock pricing policies are important to governments because of their implications on producer incentives, and on government revenue and expenditure. Because of these different and contradictory functions of prices, most governments are unwilling to leave the determination of prices to market forces and instead try to control the effects

of prices through a variety of institutional interventions. The objectives of this study were to:

- compare the objectives and instruments of livestock pricing policies in selected countries in sub-Saharan Africa
- estimate the effects of direct and indirect interventions on producer price incentives, livestock output and consumer welfare.

Data collected on market and official prices from the study countries during 1988 were supplemented with statistics from a wide range of primary and secondary published materials for the analytic part of the study.

A report in *ILCA Annual Report 1988* (pages 125–126) presented nominal protection coefficients (NPCs) for beef for the period 1973–86. These NPCs, which are a measure of the incentives provided by government pricing policies, were estimated using official exchange rates. Because it is widely known that many countries maintained overvalued exchange rates during this period, the NPC for Nigeria was re-estimated in 1989 using an adjusted exchange rate to show the effect of currency overvaluation on producer price incentive.

The extent of overvaluation of the exchange rate was estimated using the differential inflation rate between domestic prices (approximated by the consumer price index) and foreign prices (based on the consumer price index of industrialised countries). The year Nigeria's currency was changed from the pound to the naira, 1973, was used as the base year.

The NPC based on the official exchange rate indicated that beef producers were protected, ie, subsidised, from 1975 onwards, whereas the NPC estimated using the adjusted exchange rate indicated that producers were implicitly taxed between 1979 and 1985 as a result of the overvaluation of the currency during this period (Figure 18).

Another indication of price incentives is the ratio of the price of a livestock product to that of another domestic product, such as millet or sorghum, for which the livestock product can be easily exchanged. This avoids the

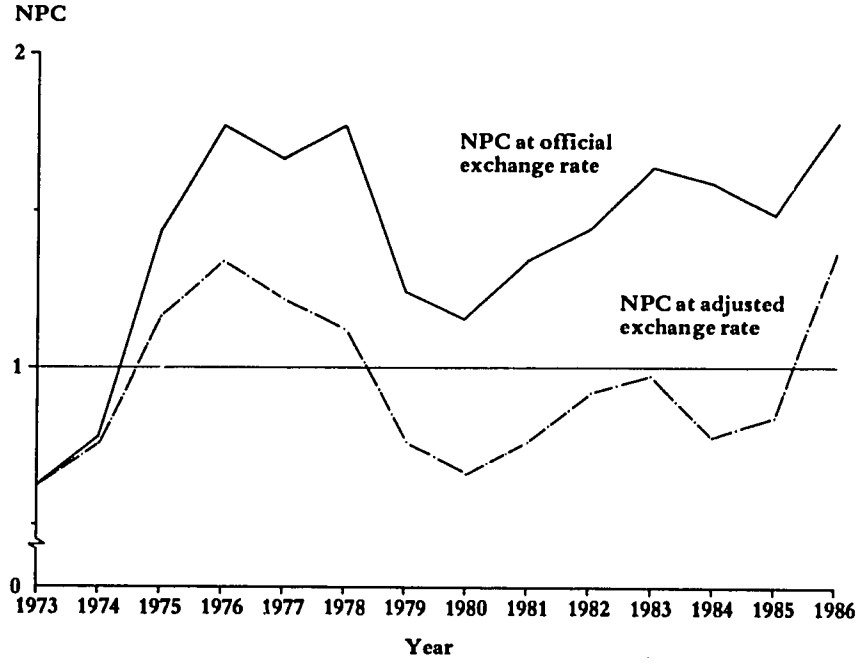


Figure 18.
Comparison of nominal protection coefficients (NPCs) for beef at official and adjusted exchange rates, Nigeria, 1973–86.

problems of exchange rate conversion. Between 1975 and 1985, animal product prices in Nigeria declined by about 50% relative to the price of millet (Table 45). The devaluation of the naira following the introduction of the Structural Adjustment Programme (SAP) in September 1986, which served to raise the domestic prices of tradable goods such as livestock products, has reversed their price decline relative to non-tradables which in the Nigerian case include millet.

Table 45. *Indices of prices of beef, mutton and poultry meat relative to millet, Nigeria, 1975–86*[a].

Year	Beef/ millet	Mutton/ millet	Poultry/ millet
1975	100	100	100
1976	111	100	98
1977	89	94	90
1978	66	67	72
1979	56	57	55
1980	79	83	79
1981	48	53	53
1982	45	47	56
1983	56	63	66
1984	38	40	41
1985	42	53	52
1986	88	93	87

[a] 1975 = 100.

The issue of price incentives was also examined, albeit in a slightly different way, for producers in Côte d'Ivoire and Mali. The underlying causes of annual changes in the NPCs estimated for producers in these countries were examined, in conjunction with trends in real price changes, to illustrate the pattern of changing price incentives for mutton and milk producers. In this case, the NPCs used for the analysis were not adjusted for overvaluation of the exchange rate in order to show more clearly the effects of factors other than the exchange rate on price incentives.

Figure 19 shows the NPC for mutton in Côte d'Ivoire. The NPC fell below 1.0 between 1972 and 1975, but was above 1.0 from 1976 until 1986. Thus there was a move away from taxation towards protection of mutton producers during this period. Decomposition of the annual change in NPC indicated that changes in nominal producer prices generally helped raise the NPC. Rising international prices lowered the NPC between 1971 and 1973 and between 1979 and 1980. The fall in NPC between 1980 and 1982 and between 1983 and 1984 was primarily as a result of nominal devaluations in the CFA franc.

In the case of milk in Mali, the decomposition of the NPC shows that nominal producer prices remained unchanged between 1971 and 1972 and between 1973 and 1975, with the result that changes in NPC in those years were entirely due to changes in the exchange rate and international prices (Figure 20). The changes in the latter two variables were quite small and consequently the changes in NPC were also small. A large increase in nominal

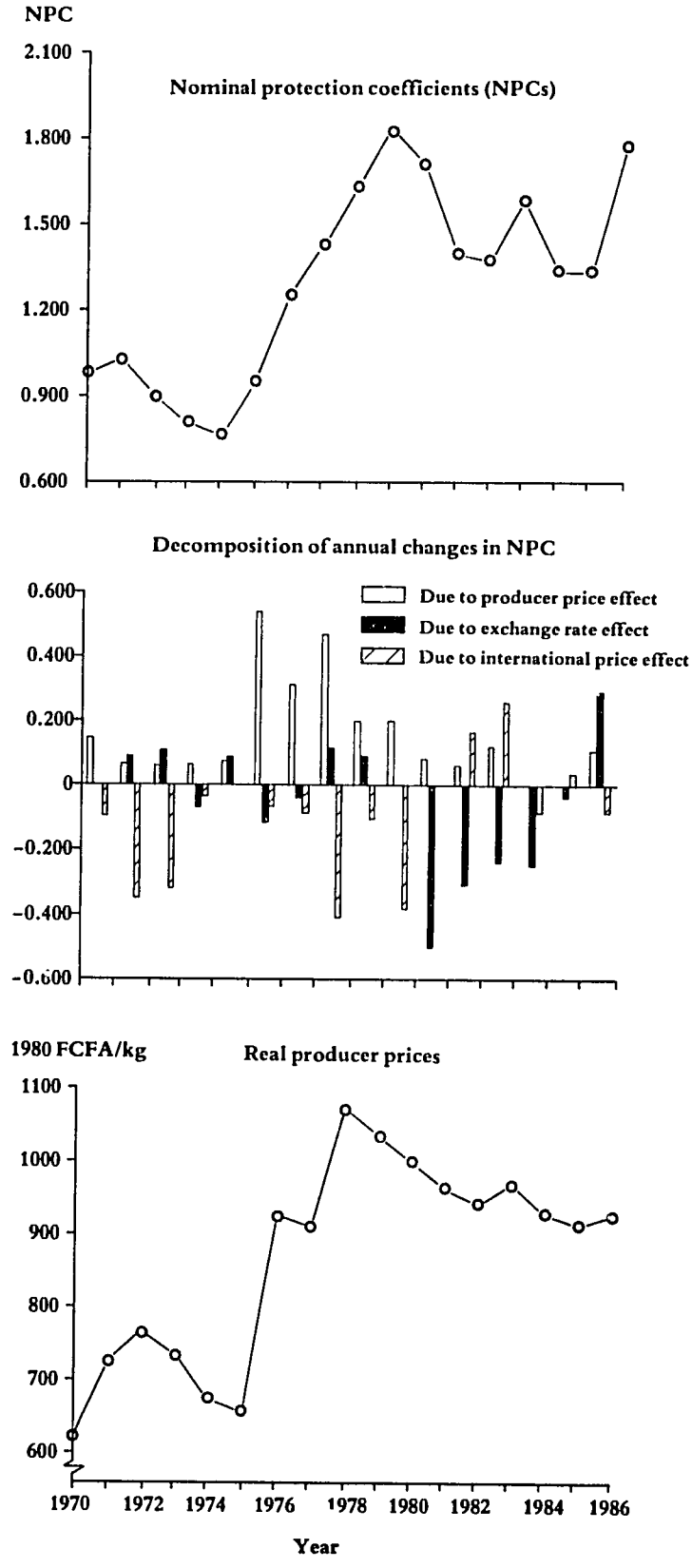


Figure 19.
Annual changes in price incentives to mutton producers in Côte d'Ivoire, 1970–86.

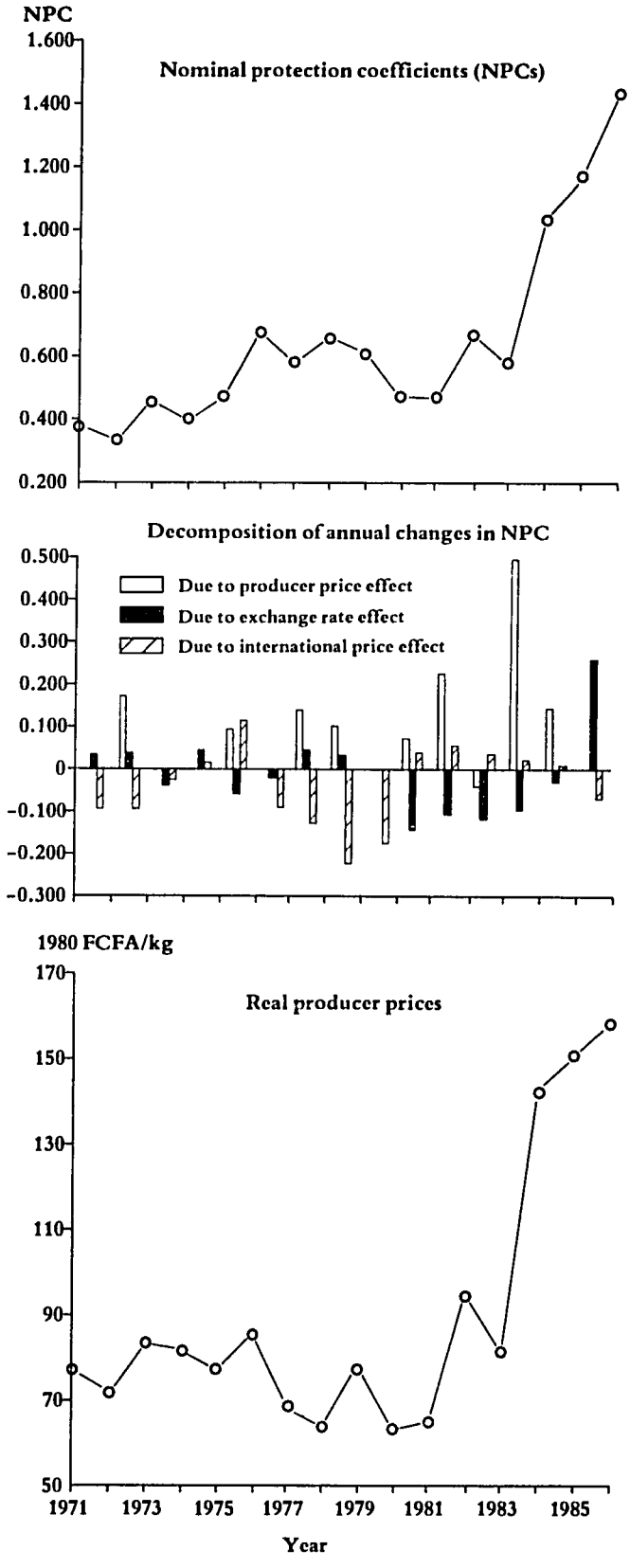


Figure 20.
Annual changes in price incentives to milk producers in Mali, 1971–86.

producer price between 1983 and 1984 helped to raise the NPC above the NPC values of the early 1970s. There was also an upward trend in the real producer price around this period (Figure 20).

The results presented here show that there were wide variations between countries in the extent to which producers were taxed or subsidised over the period considered. The results also indicate that the scope for governments to increase incentives to livestock producers depends on several factors, including policies affecting nominal producer prices, macroeconomic policies influencing the rate of inflation, as well as the exchange rate and international prices. Governments can directly influence the first three factors, but less so international prices.

T.O. Williams

Land tenure and trees in West Africa

ILCA started on-farm trials with alley farming in Nigeria in the early 1980s. Land- and tree-tenure systems were found to have a large influence on who participated in the trials and on what parcels of land they planted alley farms. Research into the relationship between tenure and alley farming in the humid zone of West Africa was started in 1989 with a review of literature to outline the salient features of land- and tree-tenure systems in the zone.

West African tenure systems treat land and trees as separate entities. Individual members of households often farm discrete parcels of land but control over the allocation of land parcels ordinarily rests in the hands of a larger corporate group or its representative, usually based on lineage. This may be of matrilineal, patrilineal or double-descent types. Women are rarely allocators of land rights; even their right to use land generally comes through men, either from a husband as a part of his holdings or from other male family members. Group rights to and control over land allocation rarely belong to groups larger than the village, where descent is direct and demonstrable. At a lower level, the head of a family, be it extended or nuclear, allocates land-use rights to members of his immediate family who will actually work the land. The right to allocate pasture may reside at a higher level than that for farmland.

With population pressure increasing, the amount of land under higher level lineage control is diminishing and land is being loaned, pledged, rented and sold, although such transactions may not have the sanction of law. Farmers using land under a temporary arrangement are prohibited from making long-term investments such as planting trees. Under the system of fallow rotation practised in West Africa, a land user may not get access to the same plot of land at the end of each rotation. Even if an individual is accorded long-term use rights for farming, the land often reverts to communal grazing after the crop is harvested.

Rights over trees may be held separately from rights over the land they grow on, and may depend on whether the trees were planted or self-sown, who planted and owns them (state, group, individual, male, female), what species they are, what spatial planting arrangements are used, how they are used (subsistence, commercial), the form in which they are used (gathered, cut, harvested, standing), how they are disposed of (destroyed, lent, leased, pledged, sold, given away) and under what tenure system the land is held (inherited, purchased, rented, pledged, share-cropped, leased). When all these aspects are combined, some tree-tenure rights will appear to be partial and overlapping, thus creating problems for long-term investment in tree planting.

Contrary to conventional wisdom, West African women may possess resources (land, animals, trees) and responsibilities distinct from those of men and they face different constraints on their resource management choices. Women's rights to trees tend to derive from their spouse, their position in the lineage or both. Thus women's control over the components and products of trees as well as responsibilities with respect to trees may be subject to rules different from those for men. Some, such as the prohibition on women planting trees, may act as a barrier to fodder-tree planting.

Following on from this review, research will examine issues related to security of land and tree tenure, the balance of rights between the lineage and the farmer, long-term use rights of people who do not belong to the lineage, limitations on tree planting in various tenancy arrangements, the role of overlying community use rights in farmland, differences between men and women in their rights to land and trees, and state regulation on tree use.

L. Reynolds and M.A. Jabbar

Collaborator: Land Tenure Center, University of Wisconsin, USA

Range trends

There is still considerable ignorance about the direction and magnitude of trends in the productivity of rangeland resources or about the causes of these trends. This ignorance is a major cause of the poor performance of range development projects and the unsatisfactory adoption of technology tried in them. The task of the Range Trends theme is to alleviate this ignorance by helping national agricultural research systems (NARS) to establish suitable range monitoring systems; by developing techniques suitable for such monitoring; and by studying some of the key mechanisms that determine whether, after periods of environmental stress, the productivity of range production systems recovers to previous levels or collapses to much lower ones. This task is to be accomplished by a combination of networking activities, training and research by ILCA, either alone or in conjunction with other organisations.

Sahelian rangeland monitoring network

In February 1989 a workshop was held at Niamey, Niger, to discuss issues related to the monitoring of rangeland resources in the Sahel. The workshop was convened by ILCA and AGRHYMET, the regional programme and centre set up by the Sahelian states to deal with agrometeorology and hydrology issues, and was attended by representatives of all the Sahelian countries (Burkina Faso, Cape Verde, Chad, The Gambia, Guinea Bissau, Mali, Mauritania, Niger and Senegal) and various international and regional organisations, including FAO (Food and Agriculture Organization of the United Nations), UNEP (United Nations Environment Programme), IUCN (International Union for the Conservation of Nature and Natural Resources), UNSO (United Nations Sudano-Sahelian Office) and CILSS (Permanent interstate committee for drought control in the Sahel). Several researchers from African and First World (Australia, France, UK, USA) universities and research organisations also attended. At the final session of the workshop, participants agreed to establish a Sahelian rangelands (pastoral) monitoring network. They appointed a provisional steering committee which met, formulated a work programme and prepared proposals for funding.

P. Hiernaux and L. Diarra

Resource services

Livestock research and development programmes in Africa are unlikely to succeed unless they have reliable, up-to-date information on livestock numbers, land use and the environment. Yet such data can be difficult and expensive to obtain and data collection and analysis take a great deal of time. Low-level aerial sample surveys can help overcome these problems by providing reasonably reliable data when they are needed and at moderate cost, particularly in the drier, more open and less populated areas where most of Africa's livestock are found.

Over the past decade ILCA has built up the equipment and skills to carry out such surveys, and has a specialist unit, the Resource Survey Unit, to do this kind of work. It can provide a complete aerial survey and analysis facility to research and development organisations or it can provide parts of the facility, eg, a survey plane and pilot, if the organisation prefers to do some of the tasks with its own resources but cannot provide the complete package.

In 1989 ILCA provided the plane and pilot for two surveys carried out by Resource Inventory and Management, one in Mali and one in Nigeria, and subsequently carried out three complete aerial surveys, in May, July and September, on 35 000 km^2 of rangelands east of Isiolo in northern Kenya.

The Isiolo surveys are of particular interest since the area has been the subject of repeated aerial surveys to estimate livestock populations since 1970. Each survey used sampling but differed slightly in its other techniques. There were also minor differences in the size of the area surveyed. The area surveyed by ILCA in 1989 was about 5% smaller than that surveyed by others in previous years; except in the case of cattle, when ILCA's figures may understate the larger area's population by about 25%, the populations from the different years and surveys can be directly compared.

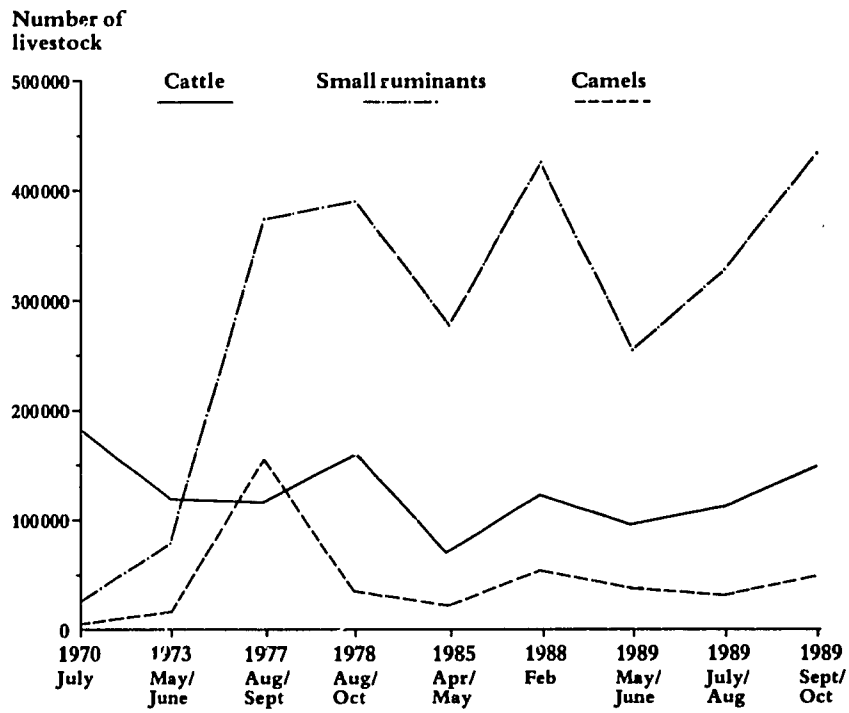


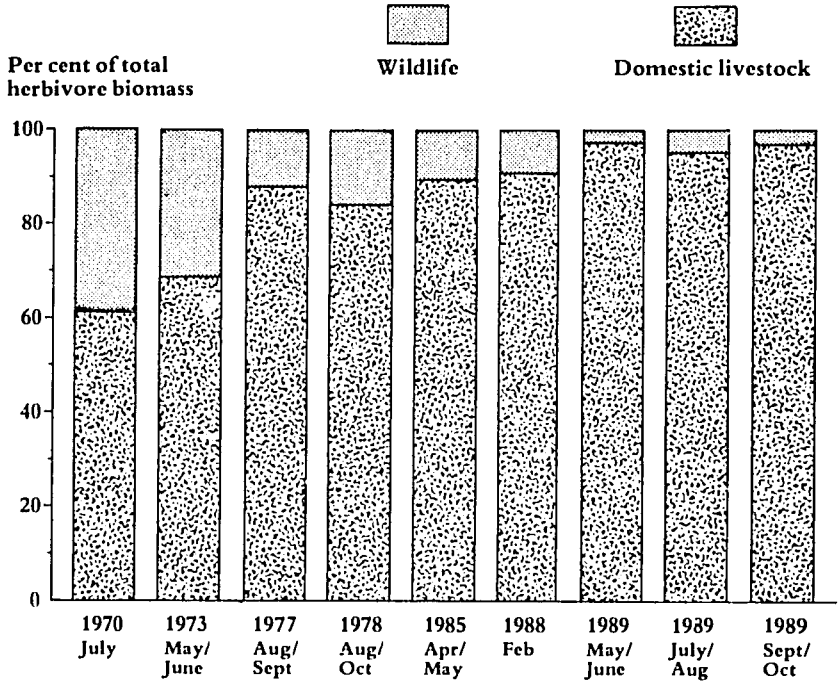
Figure 21.
Domestic ruminant livestock populations in Isiolo District, northern Kenya, as estimated by aerial survey, 1970–89.

NB. Horizontal axis not to scale.

Surveyors were Resource Management and Research (1970 and 1973), Kenya Rangelands Ecological Monitoring Unit (1977, 1978, 1985 and 1988) and ILCA (1989).

Figure 21 summarises the results of these surveys. They provide an excellent quantitative foundation to what is known qualitatively about the impact of civil strife (the "Shifta" war of the 1960s), drought and seasonal transhumance and more permanent migration by various ethnic groups in this pastoral area. Neither the quantitative nor the qualitative information is sufficient without the other. Figure 22 shows changes over the same years in the relative contributions to grazing pressure of domestic livestock and wildlife.

Assefa Eshete, Michel Corra, Tassew G/Medhin and S. Sandford



Surveyors were Resource Management and Research (1970 and 1973), Kenya Rangelands Ecological Monitoring Unit (1977, 1978, 1985 and 1988) and ILCA (1989).

Figure 22.
Relative contributions of domestic livestock and wildlife to total herbivore biomass in Isiolo District, northern Kenya, 1970–89.

Policy services

The specific aims of the Policy Services theme are to disseminate appropriate information to policy makers in the livestock subsector, and to train those needed to analyse policy issues and their solutions. The main instruments used to achieve these aims are ALPAN, the African Livestock Policy Analysis Network, and an annual training course in policy analysis. In addition, manuals on livestock policy analysis and livestock systems research and a handbook on African livestock statistics are being produced under this theme.

African Livestock Policy Analysis Network

Two sets of ALPAN papers, comprising two newsletters and five articles, were produced in 1989. A supplement to one of the newsletters listed all the publications of the ILCA Livestock Economics Division from 1986 to 1989.

ALPAN membership increased slightly during the year to over 1000 by the end of 1989, of whom 60% work in sub-Saharan Africa with about two-

thirds of these serving in government. About 40% of the African members are natural scientists, while a little over a quarter are social scientists. Table 46 summarises the structure of the ALPAN membership by region, employment, discipline and language.

Addis Anteneh

Table 46. *Employment, discipline and main language of ALPAN membership at December 1989.*

		Employment				Discipline			Language	
Region	Total	Government	International organisation	Private	Academia	Social scientist	Natural scientist	Un-classified	English	French
Central Africa	108	87	7	1	13	21	56	31	15	93
East Africa	241	153	25	8	55	88	99	54	240	1
Southern Africa	150	104	14	8	24	36	68	46	133	17
West Africa	330	210	60	6	54	77	125	128	142	188
Total sub-Saharan Africa	829	554	106	23	146	222	348	259	530	299
Other African countries	6	1	5	0	0	1	1	4	6	–
Total African countries	835	555	111	23	146	223	349	263	536	299
Non-African countries	189	16	118	18	37	49	41	99	177	12
Total	1024	571	229	41	183	272	390	362	713	311

Policy analysis training course

The fourth annual course in livestock policy analysis was held at ILCA headquarters in September 1989. The course, offered in French, was attended by 20 participants, 13 from ministries or development organisations, 5 from agricultural or livestock research institutes, one from a university and one from a regional intergovernmental organisation. Table 47 sets out the regional origins and linguistic backgrounds of participants in these courses over the past four years.

S. Sandford and Senait Seyoum

Table 47. *Regional origin and main language of people attending the livestock policy analysis courses, 1986–89.*

	East Africa	Southern Africa	West Africa	Central Africa	Total
1986	11	6	3	–	20
1987	1	1	13	8	23
1988	14	2	5	–	21
1989	-	1	12	7	20
Total	26	10	33	15	84
Anglophone	25	8	8	–	41
Francophone	1	2	25	15	43

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Addis Anteneh, *Economist*
Assefa Eshete, *Photo Interpreter*
L Diarra, *Ecologist*
P Hiernaux, *Ecologist*
M A Jabbar, *Agricultural Economist**
P N de Leeuw, *Ecologist*
Michel Corra, *Ecologist*
J M Powell, *Agro-ecologist**
L Reynolds, *Animal Scientist*
D Roxas, *Animal Scientist**
Senait Seyoum, *Chief Research Assistant*
Tassew G/Medhin, *Pilot*
A Traore, *Veterinarian*
T O Williams, *Livestock Economist*

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* *Joined ILCA in 1989*

SILENCE PLEASE

Training and Information

With the firm establishment of the research thrusts and the ILCA-associated networks, the Training and Information Department worked during 1989 to ensure that its activities and services supported and complemented the objectives of the Centre, and of ILCA's colleagues in the national agricultural research systems (NARS).

The work of the Department was delivered through five themes, which are reported in this chapter.

Of great importance to the Department was a planning meeting held in October 1989, which produced a plan of action for training and information at ILCA for the period 1991–95. The meeting, which brought together seven ILCA staff members and six scientists from national research and training institutes in sub-Saharan Africa, used a goal-oriented project (GOPP) method. Priority activities were identified:

Training

- help NARS train scientists capable of leading research programmes by providing research opportunities at ILCA to graduate students, post-doctoral scientists and senior scientists
- train NARS scientists and technicians in research methods and techniques through courses and individual study programmes
- develop production-oriented training courses
- provide research management training
- prepare training manuals and self-learning packages based on ILCA courses and the work of the thrusts and networks and make them available to trainees and to teaching institutions in sub-Saharan Africa
- establish an ILCA–NARS forum to ensure that the Centre's training programmes meet the needs of NARS.

Information

- ensure the effective distribution of ILCA information and research results throughout sub-Saharan Africa
- be a partner in the distribution of information and results produced by NARS throughout sub-Saharan Africa
- assemble information relevant to livestock research and production for sub-Saharan Africa, obtained worldwide, and provide it to NARS

- strengthen NARS information services by collaboration and training
- provide appropriate mechanisms for NARS scientists to publish their results.

With respect to both training and information, ways should be sought by which ILCA can encourage and help African scientists to remain in active research in the continent.

The emphasis is clear. The Training and Information Department must be an active interface between ILCA and the NARS and deliver programmes and activities that are sought by and needed by the NARS but which are supported and backed by the resources and expertise of the Centre.

Training

Work started in 1989 on a *Training policy and procedures manual* which will provide a written reference to all policies, procedures and guidelines on ILCA training opportunities for ILCA staff (advisors and supervisors) and for trainees. It will make clear the responsibilities of all those involved in designing, supervising and organising training at ILCA and of the participants in group and individual training programmes.

Individual training

Forty-two scientists completed individual study programmes with ILCA during 1989.

Two visiting scientists spent their sabbatical leaves with the Centre. Dr E.A. Olaloku, from Obafemi Awolowo University, Nigeria, worked under Dr P. Chigaru to assess the biological aspects of the potential for milk production by smallholder farmers in the humid and subhumid zones of West Africa. Dr O.A. Ikwuegbu, from the National Veterinary Research Institute in Vom, Nigeria, supervised research on technical aspects of livestock extension with the Fulani in northern Nigeria, under Mr R. von Kaufmann.

Four post-doctoral associates completed their studies in 1989. Dr T. Bedingar, from Chad, supervised by Dr J. McIntire, worked on socio-economic considerations of feed supply policies and crop–livestock interactions. Dr A. Panin, Ghanaian, investigated the possible use of dairy cows and single oxen for land cultivation in Debre Birhan and Debre Zeit, Ethiopia, under the supervision of Mr S. Sandford. Dr T. Williams, Nigerian, who also worked with Mr S. Sandford, studied the impact of pricing policies on meat and milk output in sub-Saharan Africa. Finally, Dr T.J. Ruredzo, Zimbabwean, completed his work on the *in-vitro* conservation of forage grasses, supervised by Dr J. Hanson.

Forty graduate students worked at ILCA during 1989, and 11 of them completed their studies during the year (Table 48). The 40 students were each registered at one of the 32 universities worldwide with which ILCA is collaborating. These universities are in North America (5), Europe (16), Australia (4) and Africa (7). It is the intention of the Department to increase its collaboration with African universities.

Short-term training was provided for three undergraduate associates, four research fellows and seven meeting fellows.

Individual study programmes, particularly for long-term individual trainees, will be expanded during 1990 because the Department considers that they make a major impact on the work and future resources of NARS, particularly for research leadership, and that they assist the Centre in achieving its own research objectives.

Table 48. *Graduate Associates who completed their studies at ILCA during 1989.*

Graduate Associate	Nationality	Degree	ILCA supervisor	Registering university	Project title
Menwyelet Atsedu	Ethiopian	MSc	D L Coppock	Colorado State	Prospects for using fodder banks and native acacia trees for calf management intervention in semi-arid Ethiopia
Mulugeta Assefa	Ethiopian	MSc	D L Coppock	Colorado State	Economic evaluation of calf management intervention in semi-arid Ethiopia
B J Hamminga	Dutch	MSc	O B Kasali	Wageningen	The effect of nematode and trematode infections on the growth performance of Ethiopian highland sheep
Alemayehu Mamo	Ethiopian	MSc	I Haque	Justus Leibig	Vertisols management in Ethiopian highlands
Fisseha Itanna	Ethiopian	MSc	S Jutzi	Hohenheim	Distribution patterns of deficient and toxic elements limiting crop production in some agro-ecological zones of Ethiopia
Wondimagegne Chekol	Ethiopian	PhD	I Haque	Göttingen	Characterisation and management of Ethiopian highland black soils
Getachew Tikubet	Ethiopian	PhD	R Scheltens	Sierra Leone	Tsetse ecology and trypanosomiasis challenge in south-west Ethiopia
M Frenken	German	MSc	S Sandford	Göttingen	Farming systems in the semi-arid zone of Ethiopia
A Doyle	Irish	MSc	K J Peters	University College Dublin	Rearing of crossbred calves in Ethiopia by restricted suckling
Takele Tilahun	Ethiopian	MSc	D L Coppock	New South Wales	Complementarity and conflict between traditional and post-revolutionary governmental leadership in the Borana pastoral system and the implications for development
Solomon Desalegn	Ethiopian	MSc	D L Coppock	New South Wales	Bush encroachment in the southern Ethiopian rangelands; prospects for control using fire and chemical/ mechanical techniques

Group training

Twelve group training courses were offered in 1989, including five new courses. Six courses were in French and six in English. From the 857 applications received, 260 participants were selected but only 216 were able to attend. The participants came from 39 sub-Sahara countries (Table 49).

Each course was managed by an administrative coordinator from the Training Department, and a technical coordinator from the Research Department. In all, 39 ILCA staff members participated in the training courses as lecturers (Table 50).

Training materials and methods

The Training Materials and Methods Unit is responsible for the educational design of ILCA courses and training materials and provides graphic, photographic, mapping and audiovisual services to all ILCA units and ILCA's NARS collaborators.

Table 49. *Group training courses at ILCA, 1989.*

	Course title	Language of instruction	Thrust focus[1]	Number of participants	Number of countries
1.	Forage evaluation techniques	French	4	27	15
2.	Animal production and research methods[2]	English	1	15	4
3.	Small-ruminant production techniques	French	2	24	13
4.	On-farm livestock performance testing[2]	English	1	18	10
5.	Applied statistics for animal scientists[2]	French	A	19	10
6.	Livestock hygiene and production relationships[2]	English	1,2	15	7
7.	Economics of animal health and disease control	English	1,2,3	13	10
8.	Rural dairy processing	French	1	10	8
9.	Livestock policy analysis	French	6	20	11
10.	Forage evaluation techniques	English	4	23	11
11.	Animal nutrition and forage analysis	French	1,2,3,4	17	7
12.	Improving milk production in Africa[2]	English	1	15	7
	Total			216	39

[1] 1 = Cattle Milk and Meat; 2 = Small Ruminant Meat and Milk; 3 = Animal Traction; 4 = Animal Feed Resources; 6 = Livestock Policy and Resource Use; A = All Thrusts (including Thrust 5, Trypanotolerance).

[2] Courses given for the first time.

In 1989 the Unit worked closely with the Research Department to restructure the statistics and research methods courses so as to achieve a more useful developmental sequence. The "On-farm livestock performance testing" and "Animal production and research methods" courses were redesigned to form two new courses, namely, "Biometrics and data management in applied research" and "Livestock research methods", both of which will be staged in 1990. A result of this process is the development of a three-tier structure, from basic statistics to advanced applied research:

- Applied statistics for African animal scientists
- Biometrics and data management in applied research
- Livestock research methods

In addition, the content of the "Forage evaluation techniques" course was expanded to cover production aspects as well. This course has been renamed the "Forage evaluation and production" course and will also be offered in 1990.

The focus of training materials development has been on training manuals and slide/tape modules. The texts for two ILCA manuals, *Applied statistics for African animal scientists* and *Soil physics laboratory methods* were edited for technical content. The Unit also worked with the International Laboratory for Research on Animal Diseases (ILRAD) in the preparation of a manual entitled *Gastro-intestinal parasites of ruminants in Africa*. Two slide/tape modules, *Introduction to milk* and *Milk processing techniques*, were revised and produced and are now ready for testing and validation.

One new activity of the Unit in 1989 has been to add a teaching component on communication to each ILCA training course. This is intended to train course participants in the preparation and verbal presentation of material.

Table 50. *ILCA lecturers (in alphabetical order).*

ILCA scientist	Course taught[1]
Addis Antench	12
P Bartholomew	10
R Brokken	2,4,12
E Bruns	4,5,12
B Capper	12
D L Coppock	12
S Crosse	12
S Debrah	7
Ephraim Bekele	7
K-D Gautsch	4
Getachew Asamenew	4
M Goe	4
J Hanson	9
O B Kasali	5,6,12
J Lambourne	3
J Lazier	1
P N de Leeuw	4
T Metz	4
Michel Corra	1
M A Mohamed-Saleem	12
E Mukasa-Mugerwa	5,12
Negussie Akalework	4
J Ochang	1,2
C B O'Connor	7,12
E A Olaloku	7,12
K J Peters	2,4,5
E W Richardson	2,6,10,11
Marcos Sahlu	2
A N Said	8
S Sandford	2,8,12
Senait Seyoum	8
J Stares	2
Tekelye Bekele	4,5
W Thorpe	4
J C M Trail	5
A Traoré	3
B R Tripathi	2,5,7,12
J Walsh	2
R T Wilson	3

[1] See Table 49 for course numbers.

As in the past, the Unit provided services to ILCA scientists in the preparation of graphic and photographic materials and aerial-survey maps. The ILCA slide show was revised in 1989 and a French version was prepared.

Information

Documentation

The Library and Documentation Centre provides ILCA staff and NARS with the information that is so vital to the development of livestock production in sub-Saharan Africa.

The library now has 300 external members and participates in an inter-library loan network with UN agencies and with selected universities, government ministries and research institutes, and has exchange programmes with 350 institutions around the world.

The library holding on livestock research and production in Africa is unique, and the additions to the collection in 1989 are shown in Table 51.

Table 51. *ILCA library acquisitions and holdings, 1989.*

Items	Additions during 1989	Total
Books	4358	25 456
Reprints	534	6 139
Microfiches	2718	26 099
Periodical titles	53	1 804

In 1989 more than 404 000 photocopies and 16 000 microfiches were made against 4993 and 146 requests, respectively.

The number of users of the Selective Dissemination of Information (SDI) service has increased to 1015 in 46 African countries. The service continues to provide users with monthly updates of abstracts from the database of the Commonwealth Agricultural Bureaux International (CABI).

Some 750 retrospective literature searches were conducted for ILCA staff and external users on ILCA's in-house database, which now contains 59 000 records, and on AGRIS, CABI and AGRICOLA databases. The AGRICOLA database is now available on CD–ROM in the library.

The second Quick Bibliography, *Small ruminants in sub-Saharan Africa,* was prepared in two volumes. The first volume covers small-ruminant management and productivity; the second deals with the economic, nutritional and disease aspects of small ruminants.

ILCA In Print, a catalogue listing all the major publications produced by ILCA staff since the Centre's inception in 1974, was made available. The catalogue contains 1749 citations, categorised by discipline, of articles published in refereed journals, monographs, technical papers, books, reports and dissertations.

The ILCA mailing list was again reviewed using update forms sent to the recipients of ILCA publications in early 1988. Out of a total of 6330 update forms distributed, 4695 were returned (75%) and these now form the new mailing list: 69% of the addresses are in Africa.

A total of 41 940 publications were distributed in 1989 to scientists on the Centre's mailing list. A further 8191 publications were dispatched as the result of specific requests.

During 1989, one-month in-service training on information processing, especially on the CDS/ISIS database management system and on cataloguing and indexing, was given to two staff members from NARS libraries in Tanzania and Côte d'Ivoire.

Part of ILCA's database, containing 25 000 records on sub-Saharan Africa, was installed using the CDS/ISIS package at ILCA's zonal research sites at Bamako (Mali) and Ibadan and Kaduna (Nigeria). A short training course on the management of the CDS/ISIS database system was given to the ILCA librarian in Bamako and scientists in the zonal research sites were given demonstrations of the system to enable them to make full use of the database.

Publishing

ILCA's publications continued to reflect the research orientation of the Centre. Both the Monograph and Research Report series were expanded by additional titles in each: *A review of reproductive performance of female* Bos indicus *(zebu) cattle*, by E. Mukasa-Mugerwa (Monograph 6); *Rôle des ligneux fourragers dans la nutrition des ruminants en Afrique subsaharienne. Etude bibliographique*, by R. Miranda (Monographie 7); and *Dairy imports into sub-Saharan Africa: Problems, policies and prospects*, by V. von Massow (Research Report 17). French translations of two previous English Research Reports were also published in 1989.

The Annual Report for 1988 again reflected the thrust-based research structure of the Centre.

During 1989 plans were made to launch a new internationally reviewed journal, *African Livestock Research*. The plans for the journal were approved by the ILCA Board of Trustees at their meeting in April 1989, and were endorsed by the Fifth Biennial Meeting between ILCA and Leaders of Livestock Research, Development and Training in sub-Saharan Africa, held in October 1989. By the end of 1989 guidelines for the pre-review and statistical review of manuscripts and notes for contributors had been completed, and an international Editorial Advisory Board had been recruited. The first issue of the journal is planned for 1990. The journal will replace the *ILCA Bulletin*, for which issue 35, published in December 1989, was the final issue.

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* *Joined ILCA in 1989*
** *Left ILCA in 1989*

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R A Stewart, *Assistant to the Director General and Director of the Donor and Board Secretariat*
J Reeves, *Public Awareness Specialist**
Tehout Workalemahu, *Executive Secretary*
Antonio Silla, *Internal Auditor*

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J A Kategile, *Liaison/Facilitator, Eastern and Southern Africa**
A Tall, *Assistant to the Deputy Director General (Research)*

Animal Science Division

Animal Nutrition and Management

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B S Capper, *Animal Nutritionist***
A N Said, *Animal Nutritionist/ARNAB Coordinator*

Animal Production and Management

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D L Coppock, *Animal Scientist/Ecologist*
W Mwenya, *Animal Breeder (Visiting Scientist)**
E A Olaloku, *Cattle Research Network Coordinator**
S Okantah, *Animal Breeder (Visiting Scientist)**

Small Ruminant Research Network

R T Wilson, *Animal Scientist/Network Coordinator*
D Bourzat, *Veterinarian/Animal Production Scientist (seconded from the Institut d'élevage et de médecine vétérinaire des pays tropicaux)***
B Rey, *Veterinarian/Animal Production Scientist (seconded from the Institut d'élevage et de médecine vétérinaire des pays tropicaux)**

Animal Reproduction and Health

O B Kasali, *Veterinarian/Pathologist (Head of Section)*
Azage Tegegne, *Veterinarian (Post-doctoral Associate)**
E Mukasa-Mugerwa, *Animal Scientist*
Tamrat Yigzaw, *Chief Laboratory Technician*
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J Tothill, *Forage Agronomist (Head of Division until October)*
D Thomas, *Forage Agronomist (Head of Division from October)**
E Agishi, *Forage Agronomist (Visiting Scientist)**
S Jutzi, *Forage Agronomist*
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J Lazier, *Forage Agronomist***
L Mugwira, *Plant Nutritionist (Visiting Scientist)**
D Siaw, *Forage Agronomist (Post-doctoral Associate)**

Genetic Resources

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T J Ruredzo, *Tissue-culture Specialist (Post-doctoral Associate)***

Soils and Plant Nutrition

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N Luyindula, *Soil Microbiologist (Post-doctoral Associate)**
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R Brokken, *Economist*
J McIntire, *Economist***
P Ngategize, *Economist (Post-doctoral Associate)*
A Panin, *Economist (Post-doctoral Associate)***
Senait Seyoum, *Chief Research Assistant*

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E W Richardson, *Biometrician*
J Sherington, *Biometrician**

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Resource Survey

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Michel Corra, *Ecologist*
Tassew G/Medhin, *Pilot*

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Highlands—Ethiopia

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Abate Tedla, *Forage Agronomist*
Abiye Astatke, *Agricultural Engineer*
H Airaksinen, *Agronomist (Associate Expert)*
K-D Gautsch, *Animal Scientist*
Getachew Asamenew, *Agricultural Economist*
M R Goe, *Animal Scientist***
Negussie Akalework, *Station Coordinator (Debre Birhan)*
U Schulthess, *Agronomist (Research Associate)*
T Varvikko, *Animal Nutritionist (Associate Scientist)**
E Zerbini, *Animal Scientist (Post-doctoral Associate)**

Debre Zeit Experiment Station, Ethiopia

S Crosse, *Animal Scientist (Team Leader)**
R Franceschini, *Veterinarian (Research Associate)*
R Griffiths, *Seed Production Specialist (Head of Herbage Seed Unit)**
H Khalili, *Animal Nutritionist (Associate Scientist)**
M Moens, *Dairy Technologist (FAO Associate Specialist)*
C B O'Connor, *Dairy Technologist*
S Sovani, *Veterinarian (Research Associate)*
Tadesse Tessema, *Station Coordinator*

Humid Zone—Nigeria

L Reynolds, *Animal Scientist (Team Leader)*
A N Atta-Krah, *Forage Agronomist***
M A Jabbar, *Agricultural Economist**
T A Mohammed, *Animal Scientist (Post-doctoral Associate)**
E Sabiiti, *Range Ecologist (Post-doctoral Associate)**

Subhumid Zone—Nigeria

R von Kaufmann, *Agricultural Economist (Team Leader)*
J Agwu, *Reproductive Physiologist (Post-doctoral Associate)*
C desBordes, *Animal Scientist***
O A Ikwuegbu, *Animal Nutritionist (Visiting Scientist)***
G Tarawali, *Forage Agronomist*

Subhumid/Semi-arid Zone—Mali

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M I Cissé, *Ecologist*
S Debrah, *Economist*
D Diakite, *Administrator*
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, *Veterinarian*

Subhumid Zone/Trypanotolerance—Kenya

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G d'Ieteren, *African Trypanotolerant Livestock Network Coordinator*
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S Nagda, *Senior Biological Data Analyst*
A N Ouattara, *Assistant to the Network Coordinator*
J M Rarieya, *Biological Data Analyst*
G J Rowlands, *Animal Scientist**
W Thorpe, *Animal Scientist*

Semi-arid Zone—The Gambia

K Agyemang, *Animal Production Scientist*
D A Little, *Animal Nutritionist*

Semi-arid Zone—Niger

J M Powell, *Agro-ecologist (Team Leader)**
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T O Williams, *Livestock Economist*

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Woudyalew Mulatu, *Veterinarian*

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Tesfaye Mekoya, *Chief Safety Officer*
J A Thersby, *Warden*

FINANCE

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Negussie Abraham, *Supervisor, General Accounts*

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* *Joined ILCA in 1989*
** *Left ILCA in 1989*

Publications by ILCA staff in 1989

Annual Reports

ILCA Annual Report 1988
CIPEA Rapport Annuel 1988

Programme and budget

ILCA's strategy and long-term plan
Stratégie et plan à long terme du CIPEA

Research reports

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Meetings attended by ILCA staff in 1989

Application of Modern Technology to African Trypanosomiasis. 25th Trypanosomiasis Seminar of the British Society for Parasitology, Glasgow, UK, September.

CIMMYT [Centro Internacional de Mejoramiento de Maiz y Trigo] Workshop on "Issues Related to Planning, Management and Evaluation of On-Farm Experiments", Arusha, Tanzania, December.

Commissions Techniques Spécialisées des Productions Animales, Bamako, Mali, March.

Conference on "The Future of Maasai Pastoralists in Kajiado District", Limuru, Kenya, May.

Design and Analysis of On-farm Trials. Workshop held at IITA (International Institute of Tropical Agriculture), Ibadan, Nigeria, March.

Deuxième Symposium du Réseau d'Etude des Systèmes de Production en Afrique de l'Ouest (RESPAO), Accra, Ghana, August/September.

Editing into the Nineties. Joint Meeting of the Council of Biology Editors, the European Association of Science Editors and the Association of Earth Science Editors, Ottawa, Canada, September.

Fifth Meeting of the National Liaison Officers to the FAO [Food and Agriculture Organization of the United Nations] Programme for the Control of African Animal Trypanosomiasis and Related Development, Banjul, The Gambia, April.

First Annual Conference of the Cameroon Biosciences Society, Ngaoundere, Cameroon, December.

First Natural Resources Improvement Conference, Institute of Agricultural Research (IAR), Addis Ababa, Ethiopia, March.

First Research Coordination Meeting of the FAO/IAEA [Food and Agricultural Organization of the United Nations/International Atomic Energy Agency] Regional Africa Project on BNF, Tunis, Tunisia, May.

Fourth International DLG-Symposium on "Modern Cattle Production", Giessen, Federal Republic of Germany, November.

Inaugural meeting of the Alley Farming Network for Tropical Africa (AFNETA), IITA (International Institute of Tropical Agriculture), Ibadan, Nigeria, August.

Integrating Research to Improve Agricultural Production and Natural Resource Management. Workshop Organised by Winrock International and the Southern African Centre for Cooperation in Agricultural Research, Lilongwe, Malawi, November.

International Board for Soil Research and Management (IBSRAM) Workshop on Vertisol Management in Africa, Harare, Zimbabwe, January.

International Conference on the Application of Biotechnology to Livestock in Developing Countries, Centre for Tropical Veterinary Medicine, University of Edinburgh, Edinburgh, UK, September.

International Study Workshop on Tsetse Population and Behaviour, Nairobi, Kenya, August.

Maize Research and Technology Transfer. Workshop Organised by IITA (International Institute of Tropical Agriculture), Ibadan, Nigeria, October.

Methodology Workshop for Dairy Consumption Surveys, National Livestock Projects Division, Kaduna, Nigeria, March.

National Workshop on Draught Animal Power Research and Development in Nigeria, National Animal Production Research Institute (NAPRI), Zaria, Nigeria, June.

National Workshop on Fadama and Irrigation Development in Nigeria, Bauchi, Nigeria, October.

SAFGRAD Conference on Appropriate Technologies for Semi-Arid Tropics, Ouagadougou, Burkina Faso, April.

Second Symposium of the West African Farming Systems Research Network on "The Contribution of Farming Systems Research to the Development of Improved Technologies for the Different Agro-ecological Zones in West Africa", Accra, Ghana, August/September.

Sixth International Conference of Institutes for Tropical Veterinary Medicine, Wageningen, The Netherlands, August/September.

Small Ruminant Development Workshop Organised by Rivers State Agricultural Development Programme, Port Harcourt, Nigeria, April.

Third Session of the African Ministerial Conference on the Environment, United Nations Environment Programme, Nairobi, Kenya, May.

Twentieth Meeting of the International Scientific Council for Trypanosomiasis Research and Control, Mombasa, Kenya, April.

West and Central African Feed Resources Network Meeting, Avetonou, Togo, October/November.

Women and Agriculture in Nigeria. Seminar at the University of Ibadan, Nigeria, October.

XVI International Grasslands Congress, Nice, France, October.

Research collaborators, 1989

Africa

Cameroon

Institut de recherche zootechnique (IRZ)

Congo

Direction général de la recherche scientifique et technique (DGRST)

Côte d'Ivoire

Société de développement des productions animales (SODEPRA)

Ethiopia

Addis Ababa University, Awasa College of Agriculture
Agricultural Implements Research and Improvement Centre (AIRIC)
Alemaya University of Agriculture
Ambo Junior College of Agriculture
CARE-Ethiopia
Dairy Development and Rehabilitation Project
Ministry of Agriculture: Agricultural Development Department; Agricultural Extension Department; Land Use and Regulatory Department; Soil and Water Conservation and Community Forestry Department (Soil Conservation Research Project); Southern Rangeland Development Unit (SRDU)
Ministry of State Farms
Forestry Resource Inventory Project
Fourth Livestock Development Project
Institute of Agricultural Research (IAR)
Relief and Rehabilitation Commission (RRC)
Selale Peasant Dairy Development Pilot Project
Third Livestock Development Project

Gabon

Office gabonais d'amélioration et de production de viande (OGAPROV)

Ghana

Animal Research Institute

Kenya

Baobab Farms Ltd, Mombasa
Kenyan Agricultural Research Institute (KARI)
Kenya National AI Service
Kenya Veterinary Department
Ministry of Agriculture
Ministry of Livestock Development, Small Ruminant Collaborative Research Support Programme (SR-CRSP)
University of Nairobi

Mali

Centre de recherche zootechnique (CRZ)
Institut national de recherche en santé publique (INRSP)
Institut national de recherche zootechnique, forestière et hydrobiologique (INRZFH)
Laboratoire central vétérinaire

Nigeria

Agricultural Development Project (ADP)
Ahmadu Bello University College of Agriculture and Animal Science
Calabar Polytechnic
Cross Rivers State University
Kaduna State Ministry of Agriculture
Kano Agriculture Development Project (KADP)
Katsina State Ministry of Agriculture
Michael Okpara College of Agriculture, Owerri
Ministry of Agriculture and Natural Resources, Oyo State
National Animal Production Research Institute (NAPRI)
National Livestock Projects Division (NLPD)
National Veterinary Research Institute (NVRI)
Obafemi Awolowo University, Ile-Ife

University of Ibadan
University of Nigeria, Nsukka

Senegal

Institut sénégalais de recherche agronomique (ISRA)
Laboratoire national d'élevage et de recherches vétérinaires (LNERV)

Togo

Centre de recherche et d'élevage d'Avetonou, Togo (CREAT)
Projet petit ruminant

Zaire

Compagnie J van Lancker
Développement du progrès populaire, Idiofa
Diocese d'Idiofa
Laboratoire vétérinaire de Kinshasa
Institut national d'étude et de recherche agronomique (INERA)

Outside Africa

Australia

Australian Centre for International Agricultural Research (ACIAR)
Melbourne University

France

Institut d'élevage et de médecine vétérinaire des pays tropicaux (IEMVT)
Office pour la recherche scientifique et technique d'outre mer (ORSTOM)

Finland

Agricultural Research Centre of Finland

Federal Republic of Germany

Association for Tropical and Subtropical Agricultural Research (ATSAR)
Gesellschaft für Technische Zusammenarbeit (GTZ)
Technical University Munich
University of Giessen
University of Göttingen
University of Hohenheim

Italy

University of Milan

The Netherlands

University of Wageningen

Norway

Agriculture University of Norway

United Kingdom

Agricultural and Food Research Council: Institute of Engineering Research; Institute for Animal and Grassland Production (IGAP); Institute of Physiology and Genetics Research
Overseas Development Administration (ODA)
University College of North Wales
University of Glasgow
University of Reading

United States of America

Colorado State University
Michigan State University
Purdue University
Texas A&M University
University of California (Berkeley)
University of Florida
University of Louisiana
University of Wisconsin
Utah State University

International organisations

African Development Bank (ADB)
Centre régional de formation et d'application en agrométéorologie et hydrologie opérationnelle (AGRHYMET)
Centre régional de télédétection Ouagadougou (CRTO)
Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT)
Centro Internacional de Agricultura Tropical (CIAT)
Comité inter-états de lutte contre la sécheresse au Sahel (CILSS)
Food and Agricultural Organization of the United Nations (FAO)
Institut de Sahel (INSAH)
Inter-African Bureau for Animal Resources (OAU/IBAR)
International Board for Plant Genetic Resources (IBPGR)
International Board for Soil Research and Management (IBSRAM)
International Centre of Insect Physiology and Ecology (ICIPE)
International Council for Research in Agroforestry (ICRAF)
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
International Development Research Centre (IDRC)
International Fertilizer Development Center (IFDC)
International Food Policy Research Institute (IFPRI)
International Fund for Agricultural Development (IFAD)
International Institute for Applied Systems Analysis (IIASA)
International Institute for Tropical Agriculture (IITA)
International Laboratory for Research on Animal Diseases (ILRAD)
International Trypanotolerance Centre (ITC)
International Union for the Conservation of Nature and Natural Resources (IUCN)

INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA
BALANCE SHEET at 31 December 1989

(US$ '000)

ASSETS

Current assets	1989	1988
Cash	6 373	6 420
Receivable from - donors	3 008	1 385
- employees	88	84
- others	1 140	565
Inventories	1 148	1 250
Deposits and prepayments	191	201
Construction work in progress	57	119
Total current assets	12 005	10 024
Fixed assets		
Buildings	10 407	9 547
Research and laboratory equipment	3 563	3 411
Computer	1 612	1 601
Furnishings and office equipment	2 745	2 468
Vehicles and aircraft	3 438	3 274
Other	81	81
Total fixed assets	21 846	20 382
Total assets	33 851	30 406

LIABILITIES AND FUND BALANCES

Current liabilities		
Accounts payable employees	317	317
Other payables and accruals	5 023	4 608
Contributions received in advance	1 117	1 427
Total current liabilities	6 457	6 352
Fund balances		
Invested in fixed assets - Core	21 056	19 726
- Special projects	790	656
Working capital	4 212	2 489
Capital development fund	1 336	1 183
Total fund balances	27 394	24 054
Total liabilities and fund balances	33 851	30 406

INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA
STATEMENT OF REVENUE, EXPENDITURE AND FUND BALANCES
for the year ended 31 December 1989

(US$ '000)

Revenue	1989	1988[a]
CGIAR contributions	18 294	16 487
Special project grants	2 315	1 830
Earned income	1 989	931
Capital development fund	376	446
Total revenue	22 974	19 694
Operating expenditure		
Research	12 433	11 640
Information services	1 183	1 313
Training and conferences	1 699	1 275
General administration and operations	3 219	3 228
Board and management	786	699
Total operating expenditure	19 320	18 155
Capital expenditure	1 778	1 437
Total expenditure	21 098	19 592
Excess of revenue over expenditure	1 876	102

FUND BALANCES

Opening balances		
Working capital	2 489	2 834
Capital development fund	1 183	736
Total opening balances	3 672	3 570
Excess of revenue over expenditure	1 876	102
Closing balances		
Working capital	4 212	2 489
Capital development fund	1 336	1 183
Total closing balances	5 548	3 672

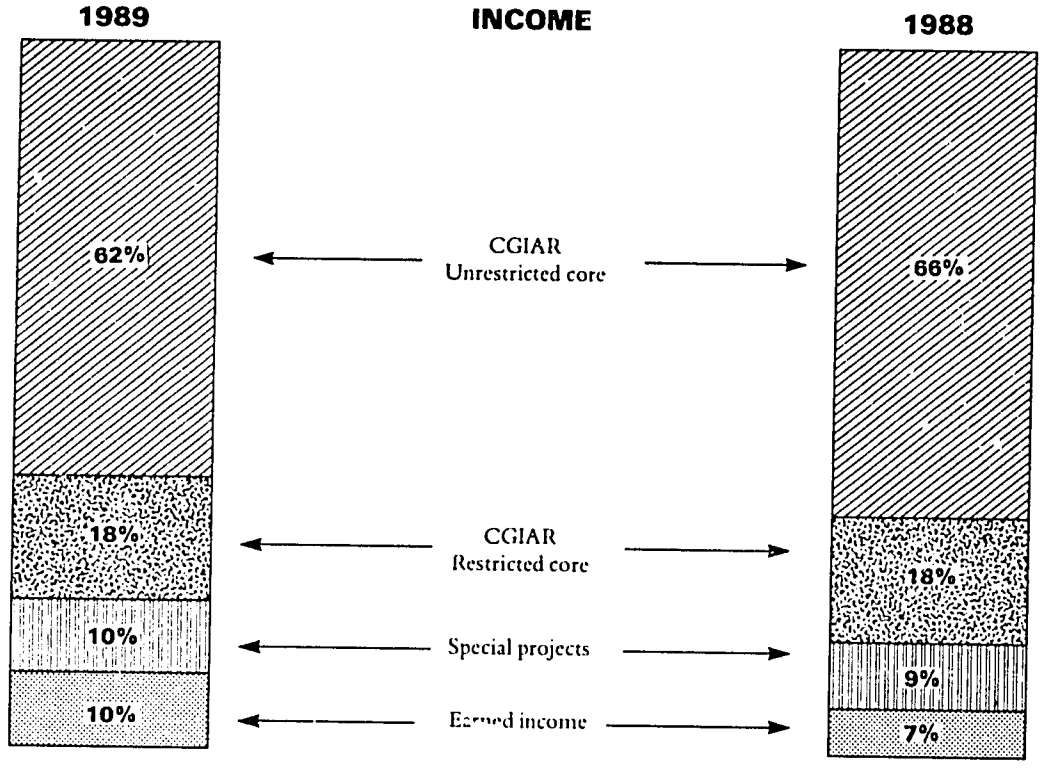
[a] The 1988 financial statement has been restated to conform with 1989 treatment of auxiliary units income, previously netted against operating expenditure.

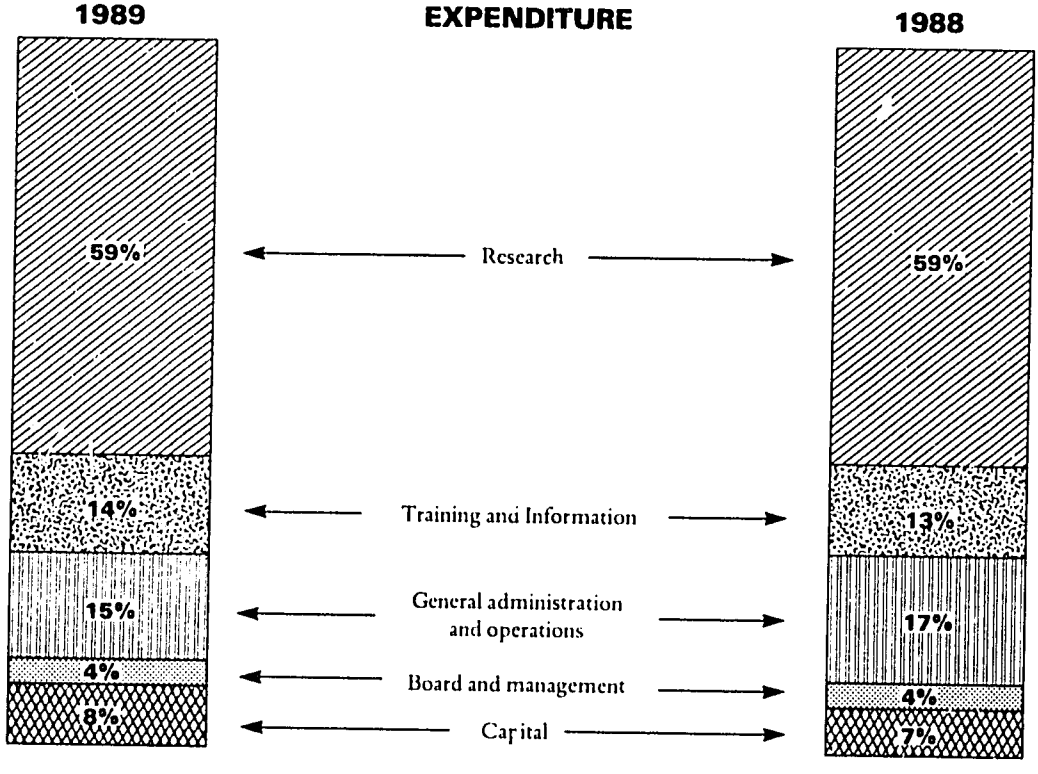
INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA
STATEMENT OF GRANT REVENUE
for the year ended 31 December 1989

(US$ '000)

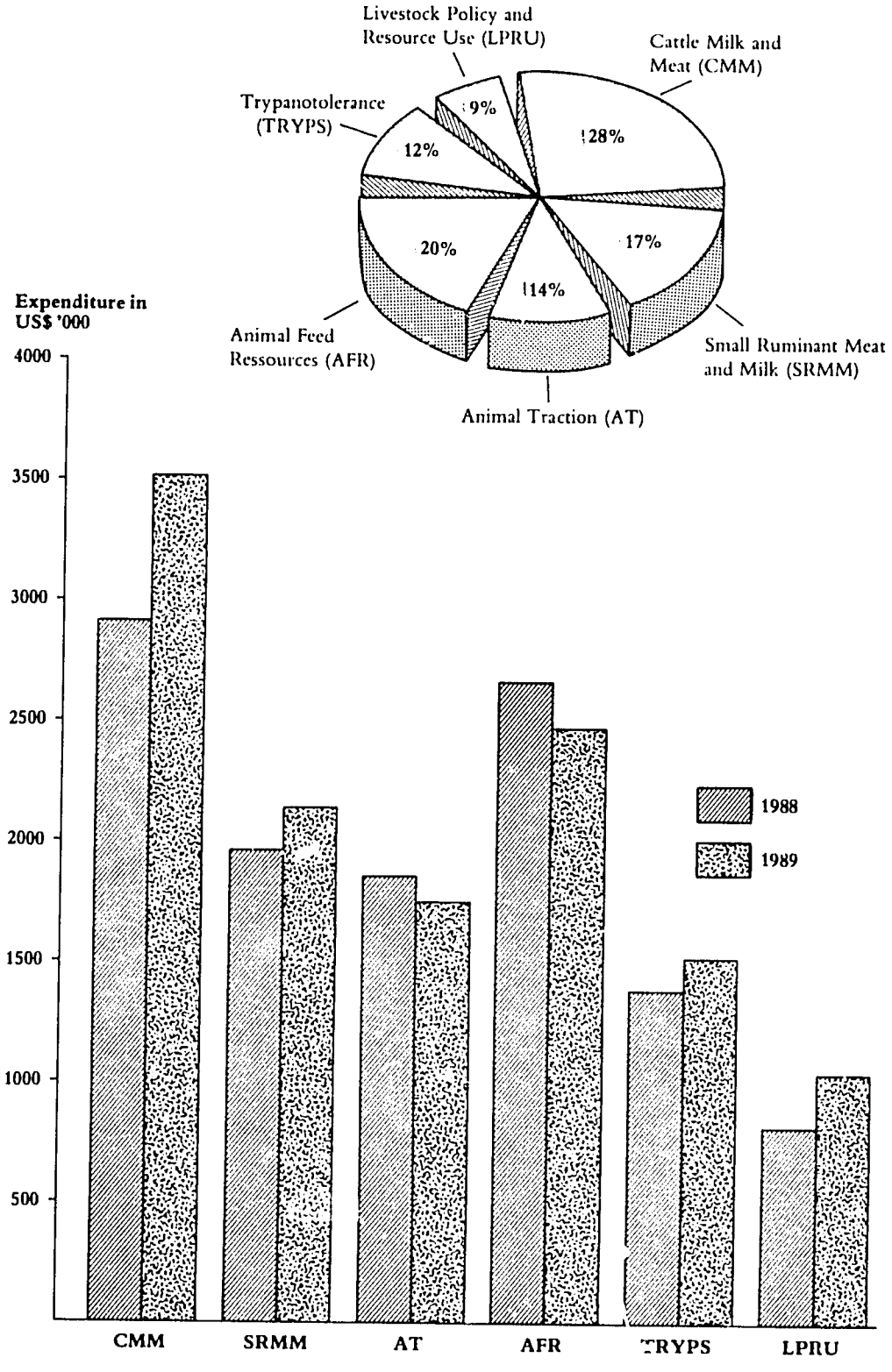
CGIAR Contributions	1989	1988
African Development Bank	200	201
Austria	175	175
Belgium	663	608
Canada	881	933
Denmark	398	391
Federal Republic of Germany	1 034	1 089
Finland	1 184	748
France	328	296
India	24	25
International Development Research Centre (IDRC)	200	293
Ireland	275	160
Italy	1 509	1 505
Japan	255	–
The Netherlands	384	407
Nigeria	–	32
Norway	515	559
Organization of Petroleum Exporting Countries (OPEC)	60	50
Sweden	272	322
Switzerland	1 597	1 639
United Kingdom	515	554
United States of America (USAID)	3 000	4 000
World Bank	4 065	2 500
Stabilisation Fund	760	–
Total CGIAR contributions	18 294	16 487
Special project and cooperative		
Agence de coopération culturelle et technique (ACCT)	7	18
Australia	108	46
Australian Centre for International Agricultural Research (ACIAR)	10	7
Caritas (Switzerland)	–	199
European Economic Commission (EEC)	642	86
Federal Republic of Germany	617	423
Finland	418	135
Ford Foundation	7	15
International Board for Plant Genetic Resources (IBPGR)	28	47
IDRC	95	156
International Fund for Agricultural Development (IFAD)	179	–
Ireland	4	82
Medios (Belgium)	–	1
Nigeria (NLPD)	–	35
Norway	200	300
Organization of African Unity (OAU)	–	15
Oxfam America	–	117
Rockefeller Foundation	–	3
United States of America (USAID)	–	93
University of Hohenheim	–	51
West Africa Milk Company	–	1
Total special project and cooperative	2 315	1 830

Source and application of funds, 1989 and 1988





Percentage of research expenditure by thrust



ILCA's addresses

Headquarters

PO 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/
Animal Feed Resources/
Livestock Policy and Resource Use

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

Small Ruminant Meat and Milk

PO Box 80147, Mombasa, Kenya
Telex: 21465
Tel: 485839/485842

Animal Traction

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

Trypanotolerance

PO 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

PO 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)

PO Box 80147, Mombasa, Kenya
Telex: 21465
Tel: 485839/485842

Subhumid/semi-arid zone

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

Semi-arid zone

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