ILRI 1996

Out of Africa, into a global mandate

International Livestock Research Institute

Cover photo *Homeward bound a farmer in Surin province, north-east Thailand, waters his livestock as evening draws in* (Photo C Chantalakhana, ILRI Board member)

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Out of Africa, into a global mandate

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Foreword

We chose the theme, 'Out of Africa, into a global mandate', to highlight the dynamic nature of ILRI's programmes in 1996 The 'out of , into ' theme also fits well our emphasis on moving results 'out of the laboratory, into farmers' fields' Research addresses the unknown and the benefits of research, especially strategic research, to smallholders are not always obvious This report makes the connection between research by ILRI and our partners and the needs of poor farmers in developing countries Some examples

ILRI's research on a vaccine to protect smallholders' livestock from the ravages of the disease East Coast fever began in the 1980s ILRI is ready to take the product of this research 'out of the laboratories and into farmers' fields' (see *Potential vaccine enters field testing*) If these field trials are successful, there are good prospects for commercial production Meanwhile development of new candidate vaccines continues, and the knowledge gained will be broadly applicable to the related disease, tropical theileriosis, which affects livestock from the Mediterranean to China

ILRI's research in molecular genetics is providing another technology to move 'out of the laboratory and into the field' Genetic markers help animal breeders transfer useful genes from one population to another (see *Marker-assisted breeding programmes*) ILRI's research is presently focused on the genes for trypanotolerance found in West African N'Dama cattle ILRI scientists have already identified markers for these genes in laboratory animals and are closing in on them for cattle Pilot breeding schemes to test the practical application of marker-assisted selection are being planned in collaboration with the International Trypanotolerance Centre in The Gambia While this work focuses on trypanotolerance, the techniques are of global relevance and will be applicable to other 'quantitative traits', such as milk and meat yield and resistance to other diseases and parasites

Much of ILRI's experience in Africa is applicable to crop–livestock systems in other parts of the developing world

The articles on market-oriented smallholder dairying (*Building national capacity for market-oriented smallholder dairy research and development*) and the Small Ruminant Research Network (*Networking—building for the future*) focus on ILRI's partnerships with national agricultural research systems (NARS), which help move research results 'out of research and into extension' Both articles demonstrate what can be achieved when partners combine their comparative advantages, skills and research capacities in collaborative efforts These partnerships are the cornerstone for ILRI's new medium-term plan and feature strongly in the institute's moves into Asia, West Asia and North Africa, and Latin America and the Caribbean

The article *The grass is always greener* brings together results from several areas of research, ranging from DNA fingerprint

ing to field trials of grass varieties adapted to widely differing ecozones and production systems The creation of ILRI enabled this application of molecular genetic techniques and facilities developed for animal health research *Forage legumes boost livestock and crop production* is also on taking forages 'out of the gene bank and into farmers' fields' Large-scale on-farm trials have shown farmers the advantages of improved forages This article also illustrates the benefits of south–south exchange of germplasm with the International Center for Tropical Agriculture (CIAT) in Colombia, and the reciprocal move of forage germplasm 'out of Africa into Latin America'

The final article *(Importance of assessing true credit constraint)* illustrates the need to move 'out of economic theory and into practical application' Studies on credit generally compare borrowers and non-borrowers But not everyone who borrows money is actually short of cash and many who do not borrow would if they could ILRI's study assessed true credit needs and limitations and produced practical results relevant to farmers' needs for credit

Livestock are commonly kept in plantations in South-East Asia These systems will be a focus of ILRI's work in the region

Going global

ILRI's mandate encompasses international livestock research throughout the developing world During 1996, particular emphasis was given to setting priorities and identifying partners for new ILRI research in Asia Our assessment of Asian animal agriculture indicated that the most significant and sustainable increases in livestock production are likely to come from mixed crop–livestock systems in rainfed and irrigated areas in South Asia The research priorities identified include the nutritional evaluation of novel feed resources and their integration into the farming system, impact and risk assessment of animal health interventions, and characterisation and use of resistant genotypes in livestock breeding programmes ILRI's comparative advantage stems from its strength in systems research, backed by a strong capacity for biological component research, especially relevant to smallholder crop–livestock–tree farming systems

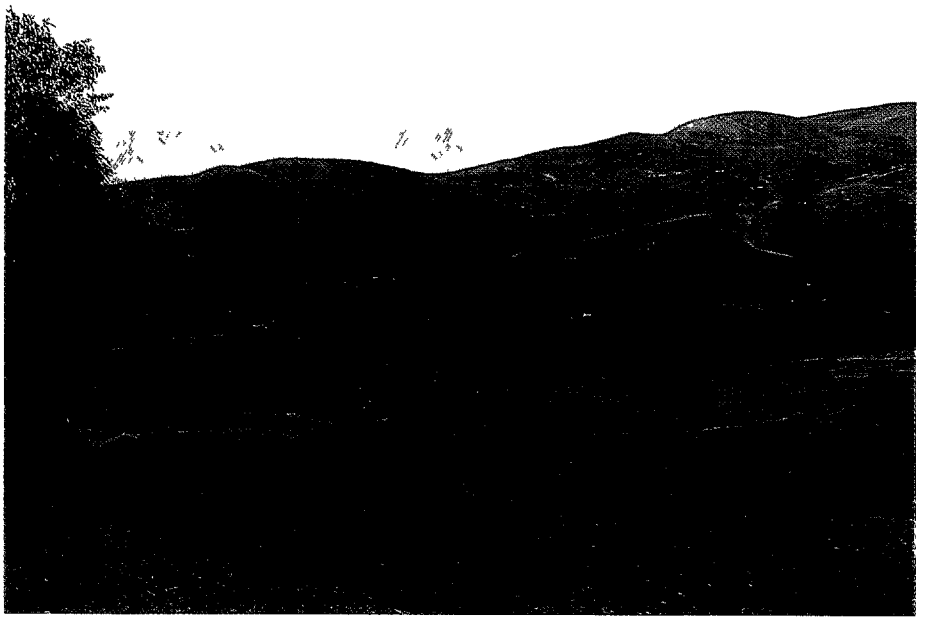
First steps in Asia

In 1996, ILRI took its first steps into Asia with the signing of a Memorandum of Agreement for co operation in livestock research and training with the Indian Council of Agricultural Research This is ILRI's first such memorandum in Asia, the start of broader collaboration with national programmes in the region Also in 1996, an ILRI animal nutritionist was based at the International Crops Research Institute for the Semi Arid Tropics (ICRISAT), Patancheru, India, to develop collaborative research with the institute's plant breeders that will improve the feeding value of stovers from ICRISAT's mandate crops

First steps in Latin America

Also during 1996, the ground was prepared for ILRI's initial work in Latin America, which will address improving productivity of dual purpose (meat–milk) cattle, and im-

proving productivity of crop–live stock systems in the High Andes re gion The research on dual purpose cattle production systems is con ducted by the Tropileche consortium, including CIAT, ILRI, Cornell University and national organisations from Costa Rica, Nicaragua and Peru The research to improve crop–livestock systems in the Andean Highlands will be conducted in the Consortium for the Sustainable Development of the Andean Ecoregion (CONDESAN), led by the International Potato Center (CIP) This consortium includes scientists from national and regional research organisations, CIAT and ILRI



ILRI's research in Latin America will focus on the Andean highlands, through the CONDESAN consortium, and on improving meat and milk production, through the Tropileche consortium

Out of the past, into the future

As ILRI moves out of an African mandate into our global mandate for international livestock research, we are building partnerships throughout the world Through these partnerships, improved livestock productivity will help to move smallholders out of poverty, food insecurity and degraded environments into better lives for them, their children and their grandchildren

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Potential vaccine enters field testing

ILRI is starting field tests of its first antigen-based vaccine against East Coast fever Building on extensive tests in the laboratory, the field trials will provide the first indications of whether the vaccine will work under farmers' conditions

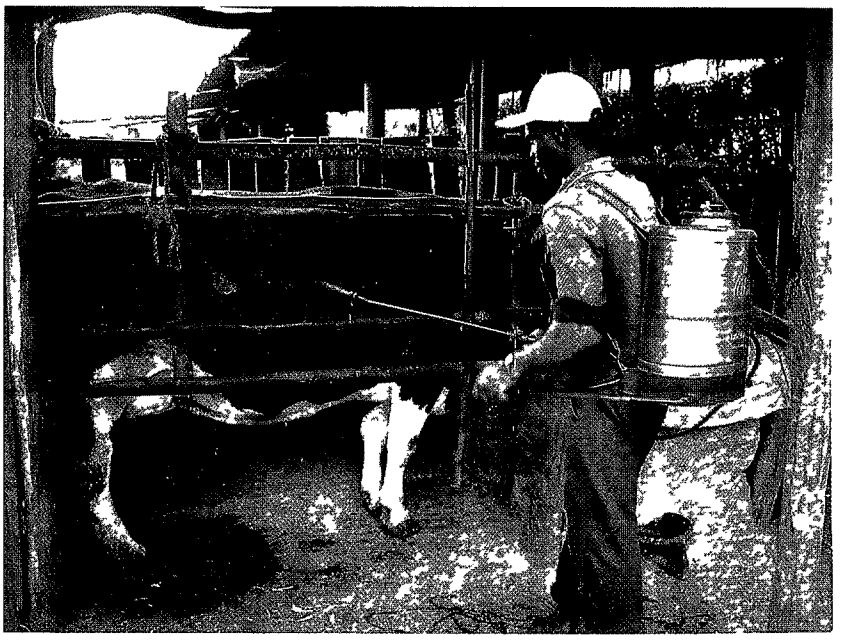
East Coast fever is a devastating disease caused by a single-celled parasite, *Theileria parva* The parasite is passed from animal to animal by the bite of the brown ear tick (*Rhipicephalus appendiculatus*) Within minutes of being injected into an animal, *T parva* parasites invade white blood cells and cause them to divide repeatedly A massive proliferation of white cells, like that in leukaemia, leads to the death of the animal in as little as three weeks

East Coast fever kills more than a million cattle a year in eastern, central and southern Africa, and reduces the growth and milk yield of millions more It costs farmers more than US$ 165 million a year in lost animals, lost production and control costs The ravages of the disease are greatest where exotic cattle are brought in to boost livestock production, because these animals have no resistance to the disease

At the moment, there are only two ways to control the disease, both of which have major drawbacks The first is to kill the tick that transmits the disease But this means farmers have to dip their animals in acaricides twice a week to kill the ticks The cost to farmers is huge—Zimbabwe spent about US$ 13 million on acaricides in 1995, and the Zimbabwean government spends half of its veterinary budget on dipping and spraying each year The cost to the environment is incalculable Not only are huge amounts of acaricides entering the environment, with unknown repercussions, but ticks are becoming resistant to all commonly available acaricides For widely scattered smallholders, the trek to communal dips can take hours, so it is unlikely that they will dip their animals as often as necessary to control the disease effectively And maintaining a communal facility is, in itself, a thorny issue Who decides when the dip gets cleaned and refilled? Who collects the money? The acaricide mix gets less effective as it is used, so who decides whose cattle go first? What can the community do if someone does not dip their cattle and hence keeps up the tick population?

The second approach is the 'infection and treatment' system of immunising cattle against East Coast fever This system, in use since the 1960s, is based on inoculating cattle with a lethal dose of live parasites while simultaneously treating them with a long-acting antibiotic to re

Spraying a dairy cow with acaricide East Coast fever, transmitted by ticks, threatens the lives of millions of cattle in eastern, central and southern Africa, especially improved dairy cattle like this one ILRI's p67 vaccine offers hope of overcoming this disease

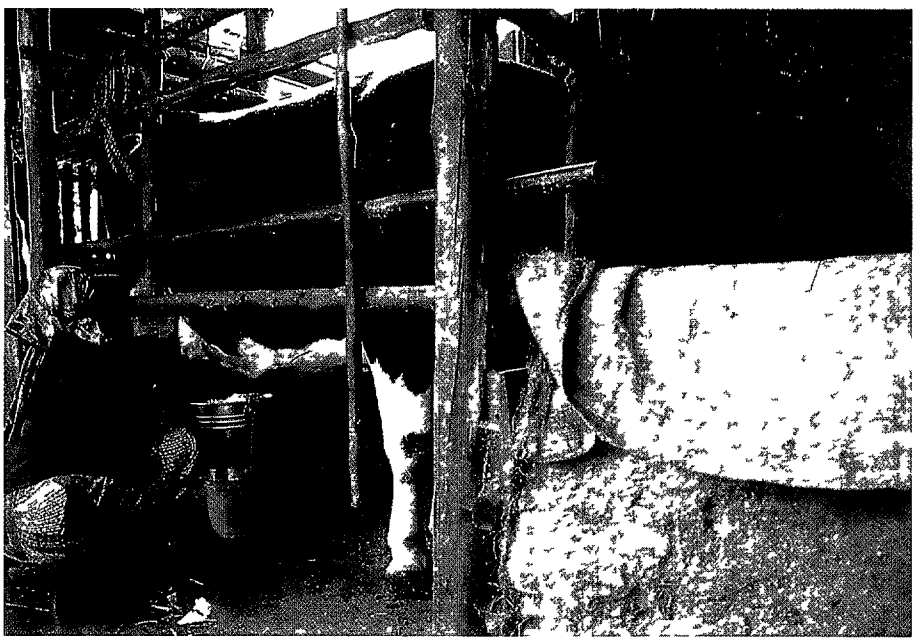


Drugs and chemicals used to control East Coast fever cost farmers and governments in eastern, central and southern Africa millions of dollars each year and do untold harm to the environment An effective vaccine will reduce these costs dramatically

duce the severity of the resultant infection, thus immunising the animals against the disease While the system works well in many areas and production systems it has three serious drawbacks First, the parasites must be kept frozen in liquid nitrogen to remain viable, and the facilities for this are rarely available in developing countries Second, the immunised animal is protected against only the strain or strains it was infected with, not against other strains it might encounter in the field And third, and in some ways the most serious drawback, once infected the animal carries a reservoir of the parasite with it for the rest of its life Since the strain of parasite used in the infection-and-treatment system is commonly not a local strain, this introduces new strains of the parasite into the area, strains that local animals will not be resistant to The system is also expensive liquid nitrogen and tetracycline—the antibiotic used—are both costly in developing countries

ILRI's search for a vaccine against East Coast fever dates back about 15 years It stems from a simple observation that blood serum taken from cattle in areas where the disease is endemic stops parasites in culture from getting inside white blood cells That told scientists that antibodies of cattle exposed to *T parva* parasites can stop the parasite invading their cells What part of the parasite, the scientists wanted to know, were these antibodies targeting? Could that parasite component be identified and used to protect animals against East Coast fever? To make a complex research story short, the answer is 'yes'

Dairying is a potentially lucrative enterprise for smallholder farmers in much of the developing world



Antigen identified

In 1984, ILRI scientists identified a protein located on the surface of the parasite that provoked an immune response in infected cattle They dubbed the molecule 'p67' because it is a protein with a molecular mass of 67 kilodaltons This protein occurs on the surface of the sporozoite form of *T parva*—the form that is injected into the animal by the tick—and has subsequently been found in every strain of cattle-derived *T parva* that ILRI has tested By 1988, ILRI's

Preparing an inoculation of p67 Field trials with the vaccine are starting in 1997

scientists had pulled out and sequenced the gene

So now ILRI had the gene The next question was how to make large quantities of the protein it encoded In 1989, ILRI scientists inserted the p67 gene into *Escherichia coli*, a ubiquitous bacterium that lives in our intestines, and got this bacterium to manufacture the p67 protein molecule With help from SmithKline Beecham (SKB) an American pharmaceutical company (now Pfizer Incorporated), ILRI created a stable form of p67 NS1 p67, that the bacteria could produce

Vaccination trials give promising results

ILRI carried out its first trial on inoculating cattle with recombinant NS1 p67 in 1989, using a 'mash' of bacteria with almost no purification Scientists inoculated two cows with five doses of the unrefined p67 in an adjuvant known as saponin over a period of four months and then injected them with a potentially lethal dose of *T parva* parasites Neither immunised animal got sick, but the two uninoculated control animals developed lethal infections This gave the first indication that p67 really could be the basis of a vaccine

Subsequent trials used partially purified NS1 p67, together with an adjuvant provided by SKB that boosted the immune response to p67 In initial trials, this mixture protected all the animals that received it against East Coast fever In subsequent trials, however, it protected about three-quarters of the animals inoculated

Again, ILRI ran into problems with the p67 NS1 p67 is insoluble One end of the p67 molecule is strongly hydrophobic—it repels water—and forces the molecule out of solution This makes it very difficult to regulate exactly the amount of the protein that is injected into the animals

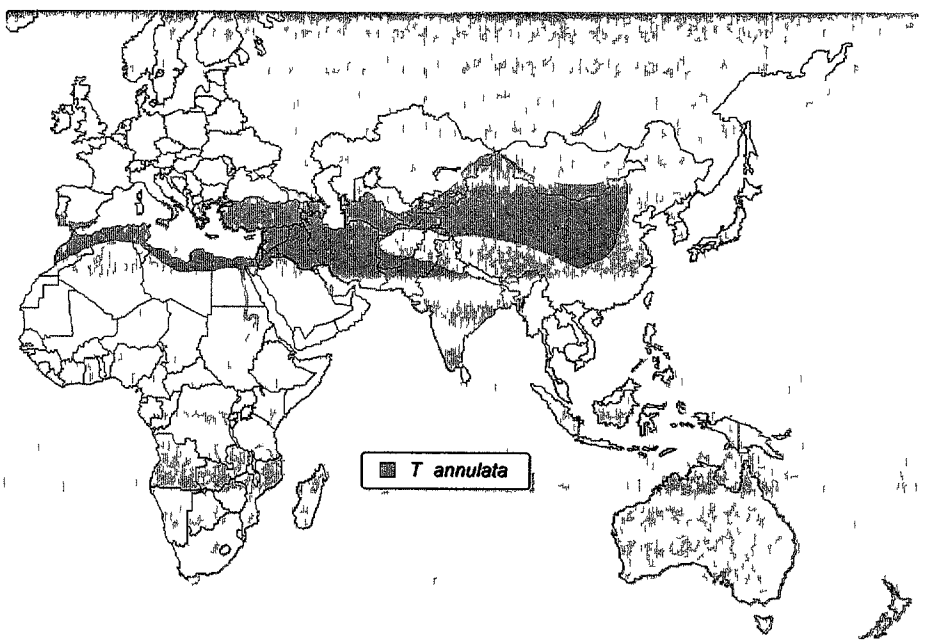
Improving the vaccine

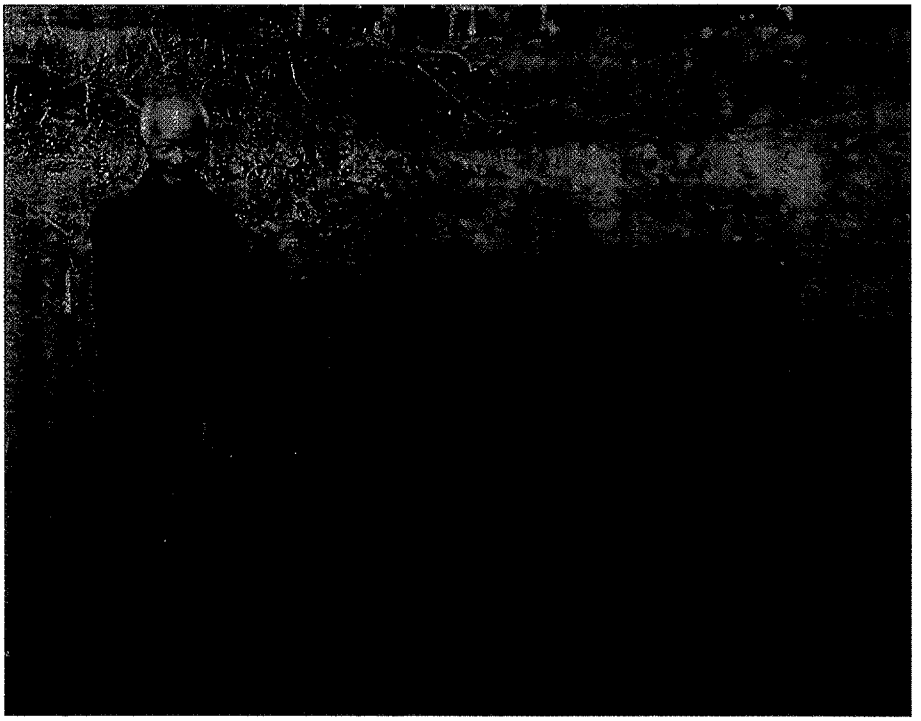
In 1993, ILRI made a 'shortened' version of p67, leaving out the hydrophobic section This molecule has been designated p635 because it consists of 635 amino acids, rather than the 709 amino acids in p67 It is more soluble than p67 and, more importantly, provides just as much protection to the animals inoculated with it

Trials continued with p635 through 1996 as scientists refined the inoculation regime to increase the level of protection while simplifying the regime In early trials, scientists inoculated calves up to five times over a period of four months before infecting them with *T parva* parasites This would be impractical for farmers, as it would entail several visits by a veterinarian—too difficult to arrange, and too expensive

Over a series of trials, this was reduced to three inoculations a month apart The total amount of p67 injected was nearly one-and-a-half milligrams of p67, a huge dose In a recent experiment, however, calves that were inoculated with only 800 micrograms of p67, split into two doses, had antibody levels (and levels of protection) as high as those inoculated with 2 milligrams or 2 5 times as much p67 Promising, but still not ideal

ILRI's early vaccine trials used Boran calves of up to eight months old that had never been exposed to





Theileria annulata, *an organism related to the parasite that causes East Coast fever, occurs in a broad swathe from Spain to China Much of ILRI's research on East Coast fever may be applicable to* T annulata *as well*

East Coast fever Recent trials have used calves as young as three months old But on farms, the calves will come up against the disease when they are only a month or so old Trials are now starting to determine the reaction of such young animals to the p67 vaccine ILRI's scientists are confident that the results will hold to the pattern found in older animals—there were no differences in the antibody response or degree of protection in animals ranging from three to eight months old

Out of the lab, into the field

With all the laboratory studies behind them, ILRI's scientists are now preparing to test p635 as a vac cine under farmers' conditions This is a three year project that will identify suitable testing sites, vaccinate animals in the chosen location, monitor responses to immunisation and assess the im pact vaccination has on the production system

ILRI and its national programme partners have identified three possible trial sites in Kenya where the vaccine could be tested The first step in determining which of them to use involves exposing groups of naive Boran cattle—i e animals that have not been exposed to disease—to natural tick challenge for two to five months to find out how severe the disease challenge will be This will start in March 1997 While this is going on, the experimental animals will be inoculated with p635, possibly as early as May, and will be ready to be exposed to natural field challenge as soon as the final test site is selected

Cautious optimism

ILRI's scientists are cautiously optimistic about the outcome of these trials The results in the laboratory are promising, but conditions in farmers' fields are radically different from those in the laboratory Farmers' animals are exposed to a range of diseases that experimental animals are not, and they are often not as well fed or tended as animals used in experiments These differences could have a marked effect on the animals' response to vaccination and their ability to fight off disease And, as one ILRI scientist noted, noone has yet developed an effective vaccine against a protozoan parasite such as *T parva* or the malaria parasite, despite world-wide efforts and millions of dollars spent

Maybe ILRI's will be the first

Building national capacity for market-oriented smallholder dairy research and development

People want milk, and there's not enough to go around, particularly for families in the developing world's burgeoning cities As people in the developing world enjoy the benefits of reviving economies, and as cities and towns grow, so does the demand for milk and dairy products That is what ILRI's research teams have found in many sub-Saharan African countries and others have found elsewhere in the developing world For a long time, dairy products imported cheaply from Europe and elsewhere met up to 40% of the demand in Africa In recent years, however, the cost of milk and milk products has been rising, and Africa is short of foreign currency to pay for imports With the right policies, marketing systems and technical support, smallholder dairy farmers in the developing world can meet the increasing demand with locally produced milk and dairy products, thereby creating wealth and jobs in their home countries, while replacing imported products and saving scarce foreign exchange

In 1989, The World Bank stressed the need to increase food production in sub-Saharan Africa by 4% a year to the year 2020 (The World Bank 1989 *Sub-Saharan Africa From crisis to sustainable growth* The World Bank, Washington, DC, USA 300 pp) This 'would be enough to feed the growing population (2 75 percent a year), improve nutrition (1 percent a year), and progressively eliminate food imports (0 25 percent a year) between 1990 and 2020 ' This implies an increase in milk production from cattle and buffalo from 8 2 million tonnes in 1988 to 35 6 million tonnes in 2025

Milk has been described as 'the perfect food' It is a vital source of nutrients and cash for smallholders and their families throughout the tropics

ILRI and smallholder dairying

ILRI's involvement with market-oriented smallholder dairying dates back to its early work on livestock production systems Field teams in several East and West African countries focused on opportunities for increasing productivity Allied to this work, economists studied dairy product demand, consumption patterns and marketing sys tems, and the influence of policies and external markets on these

These studies affirmed that there were many opportunities for increasing the productivity of smallholder crop–livestock systems through dairying, but that these

The ultimate beneficiary of research on smallholder dairying by ILRI and its partners Rural people and urban dwellers alike benefit from more plentiful supplies of milk and dairy products Children especially benefit, from better nutrition to more money in the household to pay for school fees and the like

opportunities and the constraints facing producers were largely system-specific Clearly, studying all of Africa's myriad production environments would be beyond ILRI's scope, and indeed the very system specificity of the problems placed this research firmly in the realm of the national programmes the NARS But no NARS working alone can cope with the whole gamut of problems facing small holder dairy farmers Working together, however, NARS can avoid duplication of efforts and achieve useful replication, conserving limited resources and promoting research progress With this in mind, ILRI and its NARS partners have developed a conceptual framework for research in smallholder dairying to help identify priority constraints facing smallholder dairy producers, processors and market agents, and to develop technical, institutional and policy interventions

Conceptual framework

Dairy systems are complex and research on them is fraught with difficulties A conceptual framework for such research will ensure that researchers gather all the information they need to characterise and promote development of these systems

Starting in 1992, ILRI and its partners in NARS and other international agricultural research centres drew up such a framework that applies a production-to-consumption systems approach The key objectives of the research framework are to

- characterise existing dairy systems
- identify constraints to and opportunities for dairy development and prioritise researchable issues
- develop and test cost effective technologies to improve dairy systems
- identify policy options for more efficient input and output markets
- develop methodologies and tools for use by NARS, and
- understand the evolution of dairy systems and their contribution to the intensification and commercialisation of smallholder agriculture

Under the framework, research is organised in four phases

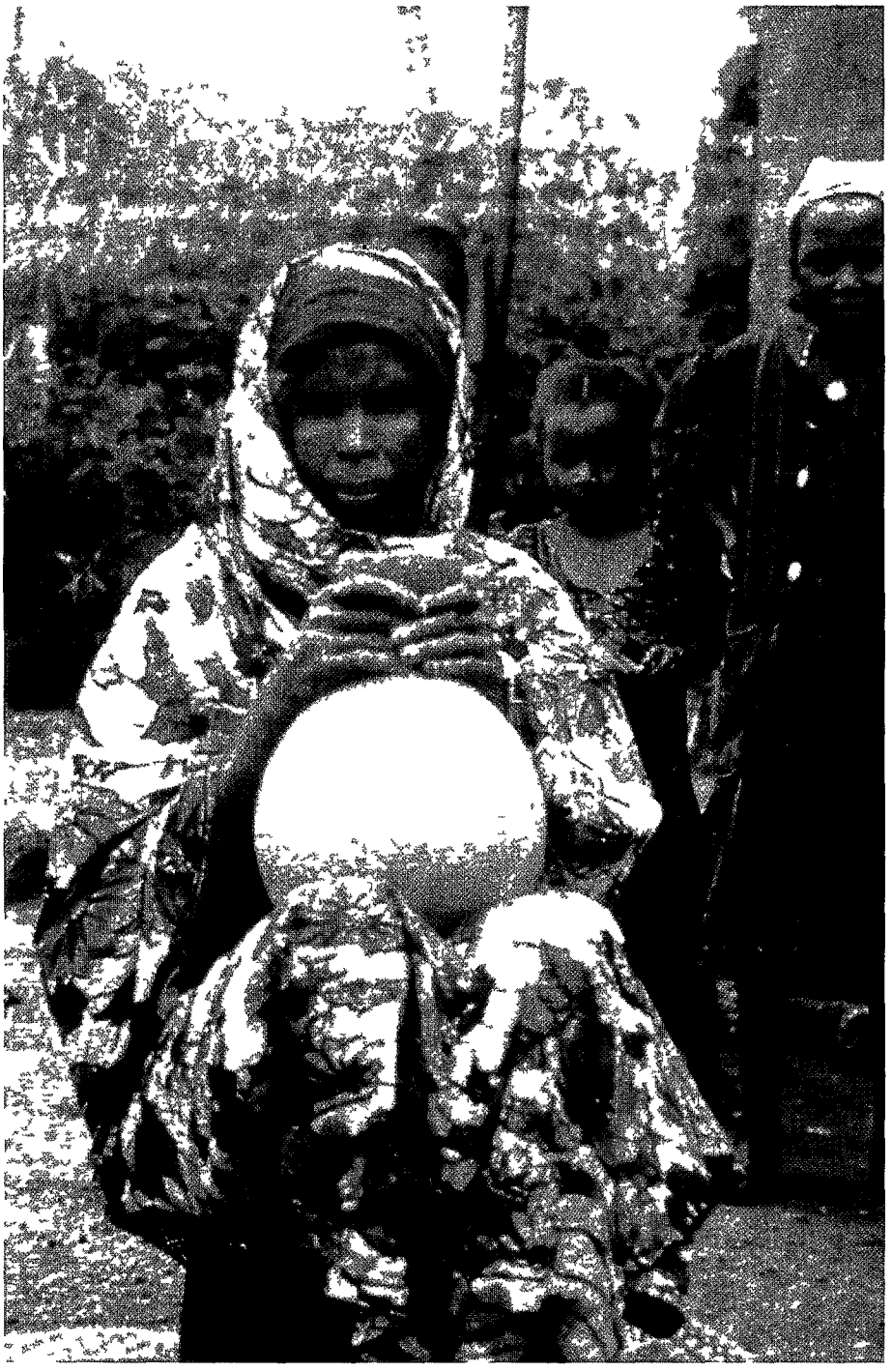
Phase 1 is a rapid appraisal to describe the main characteristics of production, processing, marketing and consumption in a dairy system In Phase 2, research characterises the subsystems in detail, at the household level for production and consumption and at the level of individual units for processing and marketing Characterising the subsystems identifies constraints to, and opportunities for, improving smallholder dairy systems and facilitates *ex ante* assessment of technical and policy interventions

Research under Phase 3 develops and tests interventions to take advantage of the opportunities and to alleviate the major constraints identified in Phase 2

Phase 4, a key one for ILRI and its partners, is the cross-site synthesis of information gathered in the earlier phases The synthesis

The ins and outs of livestock production

A Fulani woman with a 'butter churn' in Nigeria Falling imports have created market opportunities for local producers ILRI and its partners are developing improved production systems to help smallholders benefit from these opportunities



guides further research and development efforts by interpolating and extrapolating the findings to other parts of sub-Saharan Africa and to other continents

Initial development by ILRI

ILRI, through its collaborative research on smallholder dairying in Ethiopia, Kenya, Nigeria and Mali, defined a 'minimum data set' for characterising dairy systems, developed standard data collection instruments and sampling methodologies and identified standard analytical techniques that could be applied in smallholder dairy research These have now been used by NARS in a variety of collaborative projects associated with ILRI, either directly or through the cattle research network, CARNET The conceptual framework for dairy research and the methodology for characterising dairy consumption subsystems have been published by ILRI, and the methodologies for studying the production and marketing subsystems will be published in 1997

Collaborative research building partnerships

ILRI is involved in several collaborative research projects on smallholder dairying in Africa, all of which are applying the conceptual framework In Nigeria, the Institute and its NARS partners have characterised the dairy production and marketing subsystems and are addressing priority constraints This research is closely linked with that of the West African ecoregional consortium led by the International Institute of Tropical Agriculture (IITA) Elsewhere in West Africa, members of CARNET from Ghana, Mali, Nigeria and Senegal, supported by the International Development Research Centre (IDRC), Canada, and the Organization of Petroleum Exporting Countries (OPEC), have been using the conceptual framework to guide their research In East Africa, ILRI is working closely with the Kenya Ministry of Agriculture, Livestock Development and Marketing (MALD), the Kenya Agricultural Research Institute (KARI) and national universities on a study of the smallholder dairy system sup-

Spreading manure on a fodder crop Nutrient cycling is vital in intensive crop–livestock production systems

plying the Nairobi milk market This work, funded by the British Overseas Development Administration, builds on research by the partners at the Kenya coast The project has already developed links with partners in Uganda and in Tanzania In Ethiopia, ILRI is working with the Ethiopian Institute of Agricultural Research (IAR) and the Ministry of Agriculture on the use of crossbred cows both for milk production and as draft animals

Common approach to different problems

All of these studies use common methodologies and tools and standard approaches But that does not mean that they are all addressing the same problems

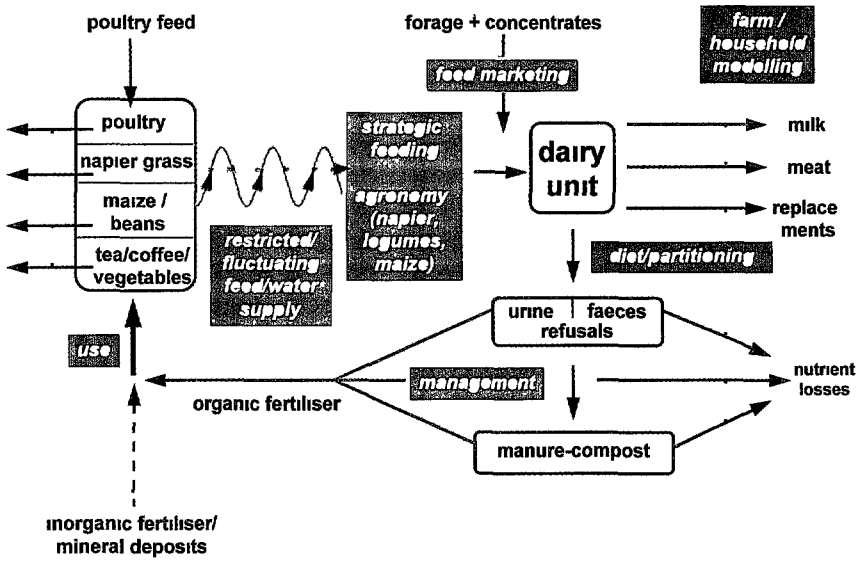
In West Africa, for example, the initial production system characterisation in Ghana, Mali, Nigeria and Senegal showed that the predominant dairy system is agropastoral, and that the key technical constraints facing farmers were shortages of feed at crucial production stages and diseases, particularly helminth infestation Comparisons across the countries of the region showed broad similarities in these problems

Based on this, the NARS developed a series of research proposals, which they presented at a regional workshop From these, the consortium developed a research programme to address these issues, based on common research protocols and analyses IDRC, through CARNET, supported the initial system characterisation phase, including the workshop, and is now funding the research developing and testing interventions Instead of each national programme working in isolation, they are now pooling their efforts, addressing common problems ILRI acted as a catalyst to get the process moving, and now provides technical assistance, especially in the field of experimental design and data analysis

Issues facing smallholder dairy producers in the highlands of East Africa are markedly different from those faced by producers in West Africa In much of the highlands of East and central Africa, particularly Kenya, dairy markets are relatively well developed Increasing the productivity of the region's intensive dairy systems focuses on develop-

ILRI and its partners in East Africa are studying the complex interactions involved in the intensive smallholder dairying systems found in this region

Partnerships for complex problems



Ploughing with crossbred dairy cows (foreground) rather than oxen (background) can increase overall farm productivity

ing improved feeding strategies to exploit profitably the high-grade European dairy breeds which dominate the smallholder dairy farms High human population pressure results in intense competition and complementarities between cash crops (tea, coffee, horticulture), food crops and forage crops Driven by the need to maximise the productivity of their land, farmers grow high-yielding fodder crops such as Napier grass, combining these with crop and agro-industrial by-products to feed their dairy cows, reducing their need to buy expensive concentrates They use manure from their cattle to fertilise their crops, reducing their need to buy inorganic fertilisers Intercropping woody, herbaceous and grain legumes and the better management of the existing feed resources and manure can contribute effectively to increasing farm productivity in these intensive systems These are amongst the options being researched by the Nairobi-based consortium which includes KARI, the University of Nairobi, the International Centre for Research in Agroforestry (ICRAF), Tropical Soil Biology and Fertility Programme (TSBF) and ILRI working with partners from London and Coventry Universities, Henry Doubleday Research Association (HDRA) and Natural Resources Institute (NRI), supported by ODA and the Rockefeller Foundation As well as addressing the regional issues, the consortium's research will yield results applicable to many current and future smallholder systems and will develop methodologies and tools for improving the efficiency of nutrient cycling research in crop–livestock systems globally

The Ethiopian highlands face similar constraints of high human population and small farm size A major difference, however, is that ox traction plays an essential role in the smallholder mixed farming systems of the Ethiopian highlands Unfortunately, draft oxen present problems for the farm They work for only a short period each year but have to be fed year-round, for the amount of feed they consume they are relatively unproductive Oxen cannot breed, and the farmer thus needs to maintain a follower herd to supply replacement oxen Fewer but more efficient animals on farms could reduce stocking rates and overgrazing, making more feed available for fewer animals, thus helping establish a more productive, sustainable farming system

Since 1989, ILRI has been collaborating with IAR and the Ministry of Agriculture in studying the possibility of using crossbred cows for both dairy and draft Research results strongly suggest that this is viable and could have a wide impact on dairy production in eastern, central and southern Africa, as well as parts of Asia, bringing major benefits to smallholder dairy producers, consumers and the environment With the assistance of the Food and Agriculture Organization of the United Nations (FAO) and the Australian Centre for International Agricultural Research (ACIAR), ILRI and its partners in six African NARS have now developed a proposal to extend these dairy–draft technologies in eastern and southern Africa

Links with extension

Linkages between research, development and extension are vital if these activities are to increase smallholder productivity Unfortunately, these linkages are weak or non-existent in many countries These multipartner collaborative projects, which involve research, development and extension agencies, offer one of the best prospects for developing and maintaining these links All of the projects are developed, planned, implemented, analysed and reported by all the partners as a group Joint 'ownership' of the project by the different members of the group encourages bridge-building and discourages the competition that commonly characterises the relations between research, development and extension workers

A recent example of effective joint ownership was ILRI's collab-

Involving extension agents in the research process ensures that the research addresses farmers' concerns and the results of the research get applied by farmers

orative project with KARI and the MALD at the Kenya coast Over its five-year life, the project developed and tested institutional mechanisms for strengthening the links between research, extension and farmers These were seen as so successful that KARI and the Ministry adopted the model for their research and extension programmes nationwide Building on this experience, ILRI, through CARNET, is now involved in a study of research-extension [illegible] funded by the Danish international development agency, DANIDA, and with collaborators from Denmark

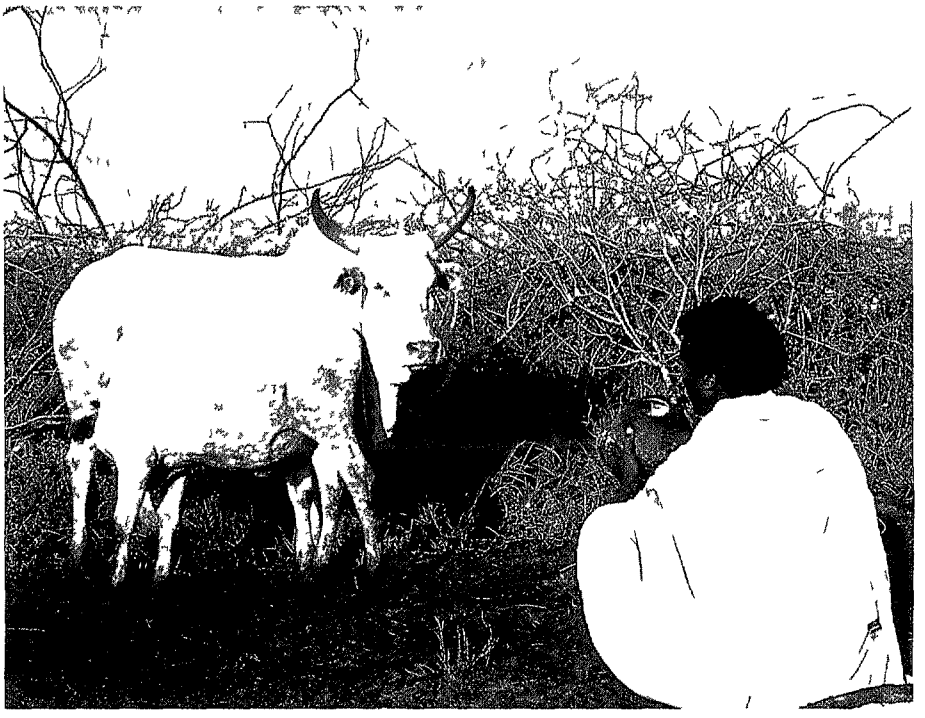
Beauty of partnerships

ILRI is a small research institute It was small when it focused only on sub Saharan Africa s problems, faced with its new global mandate it is tiny The most productive way for the Institute to contribute effectively is to develop partnerships with NARS and others working to increase food production in the developing world

A major benefit of the collaborative partnerships ILRI has developed through its smallholder dairy research is the strengthening of research capacity in the NARS At the same time that the projects are developing, testing and applying methodologies, ILRI's national partners are identifying and addressing the major priorities for research and development in their systems In Kenya, for example, it is the Ministry's extension staff, working with KARI and ILRI researchers, who gather and help interpret the data to characterise the production, consumption and marketing systems that make up the dairy system supplying the Nairobi market

Another aspect that the framework brings to the NARS, often for the first time, is multidisciplinary research Most NARS are organised along disciplinary lines—animal nutritionists separate from plant scientists, separate from economists and so on Using as it does a producer-to-consumer systems approach, the conceptual framework demands inputs from a wide range of disciplines Building the linkages needed to develop a multidisciplinary research programme strengthens the NARS' research, increasing the probability of identifying and addressing the critical issues and their interactions that constrain dairy productivity and profitability

Another important capacity-building element of these collaborative projects is that they involve graduate students, registered with universities in either their home countries or overseas The original KARI/ILRI collaborative project at the Kenya coast, for example, involved eight NARS scientists who were working towards graduate degrees, four PhDs, and four MScs These national researchers brought a wide range of skills to the project, and their links with universities drew in an even wider group of scientists to address the priority research issues A key advantage of graduate students working within such collaborative projects, rather than going off to a university to do their studies, is that they remain in their original institute, working on problems directly relevant to their



region and to their future research programmes Many scientists who leave their institutes to study for graduate degrees never return to their original project or even their original employer, these collabora tive NARS/ILRI projects not only develop the skills and knowledge of individuals, but also encourage them to remain within the NARS

For ILRI, the bridges these projects build with the NARS provide unparalleled opportunities for gain ing experiences and acquiring information from a wide range of systems ILRI does not have the manpower or resources to mount research programmes throughout Africa, let alone globally, linking with NARS increases the Institute's ability to carry out its mandate and speeds progress Experience drawn from so many diverse sys tems and institutional environ ments feeds back into refining the conceptual framework and its methodologies to match the needs of specific regions and circumstances, without losing the commonality of design that provides for cross-site and cross country analyses

Partnerships for the future

The partnerships ILRI is building bode well for the future Stronger, more confident NARS will make for better research and development These models of collaboration and partnership are ready now to be taken beyond Africa in the Institute's pursuit of its global mandate In collaboration with regional partners ILRI expects to plan projects along this line in Asia during 1997, and to strengthen its links to the existing consortia in Latin America and the Caribbean and in West Asia and North Africa These linkages will broaden the coverage of contrasting dairy systems and strengthen the programme's capacity to interpolate and extrapolate results from the local to the regional, and from current to future systems

The grass is always greener...

Find a crossbred dairy cow in tropical East Africa and chances are Napier grass will be growing somewhere nearby In Kenya, farmers plant Napier wherever there is a spare patch of land, even on roadside verges in prime residential areas A recent survey among smallholder dairy farmers near Nairobi, Kenya, found that every single farmer was growing Napier, and there is an increasing number of specialist 'Napier farmers' growing Napier to sell to dairy farmers

Napier (*Pennisetum purpureum*) is a perennial grass indigenous to sub-Saharan Africa It is hardy, withstands frequent cutting, commonly produces over 20 tonnes of dry matter per hectare per year, and livestock eat it with gusto The young, leafy material is highly nutritious Grown in mixtures with a forage legume, a hectare of Napier is enough to feed five dairy cows for a year

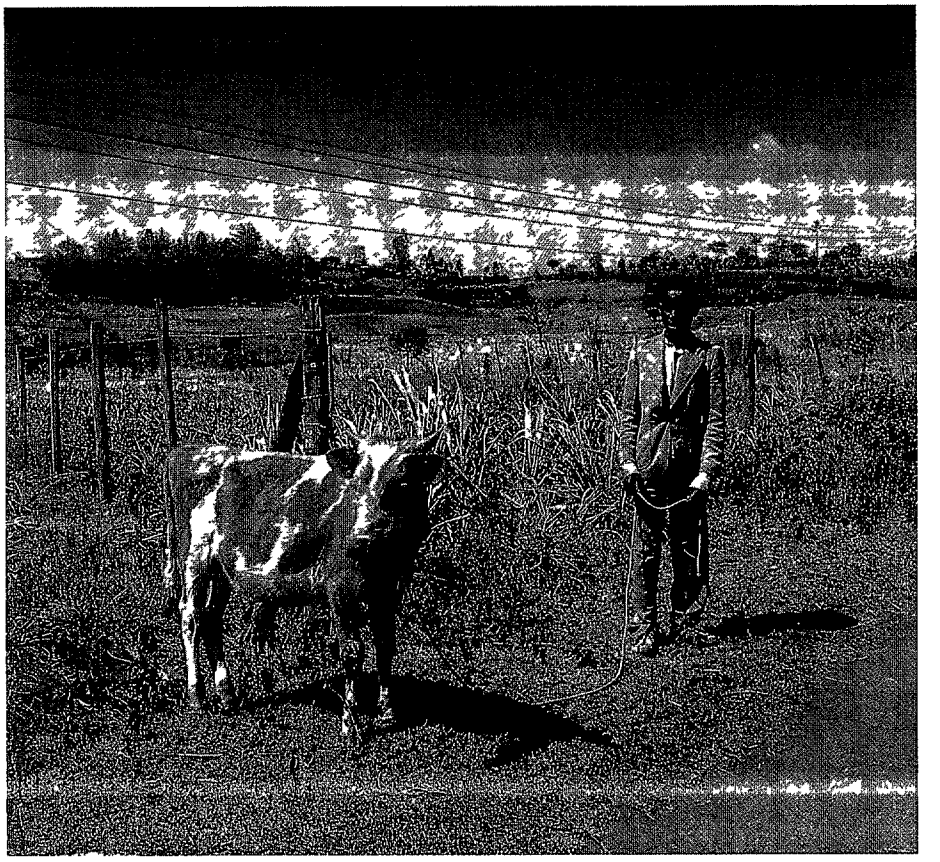
Sounds good, so what's the catch? There are several, all because Napier is vegetatively propagated—farmers plant pieces of the plant's stem to establish new plants, rather than planting seeds This means that all the Napier grass a farmer has is probably genetically identical And if the farmer got the stems to plant from a neighbour, as is often the case, then the plants will be genetically identical to the neighbour's too Across entire districts, every Napier plant could be genetically identical If a disease attacks one Napier plant in that district, every plant in the district is at risk Such a scenario is developing in Kenya at present, with increasing incidence of smut, a fungal disease that attacks many grasses and cereals

This vegetative propagation also causes problems for gene banks and germplasm distribution from two directions Seed is much easier than vegetative material for gene banks to store and handle It can be dried and kept almost indefinitely in cold stores, only occasionally having to be planted out in the field to ensure its viability And seed is small and light and thus cheap to distribute Vegetatively propagated plants, on the other hand, cannot be stored in a traditional gene bank, but have to be planted out in the field—an expensive and often complex task Vegetative material is larger and heavier than seeds, which makes it much more expensive to send to users And on top of that, live plants or bits of them can carry pests and diseases and there are strict quarantine regulations covering transfer of such material

ILRI's gene bank holds about 60 accessions of Napier and several hybrids between Napier and pearl millet (*Pennisetum glaucum*) All of these are maintained in the field at ILRI's Debre Zeit research station, in Ethiopia ILRI's germplasm specialists have long wanted to know whether some of these accessions, collected from different places and known by

Napier grass growing on a smallholder dairy farm in Kenya ILRI has an extensive, wide-ranging research programme on this important forage species

Napier is grown extensively in East, central and southern Africa, wherever crossbred dairy cows are found Markets for Napier are developing in some areas where landless farmers, like this one in Kenya, have to buy in feed for their cattle



different names, were genetically the same—a strong possibility with vegetatively propagated plants They also wanted to know the extent of the genetic variation represented in the gene bank's collec tion With such an important plant, it is vital that gene banks gather and store as wide a range of genetic variation as possible

Widespread use, wide-ranging research

ILRI has an extensive range of research activities on Napier grass, ranging from strategic research such as DNA fingerprinting to identify duplicate accessions through to field trials to determine the best accessions for different agro-ecological zones and agricultural systems

DNA fingerprints identify unique accessions

Building on the molecular genetic expertise and facilities developed for research in animal genetics,

ILRI has used DNA fingerprinting to answer some of the questions about the extent of genetic variation in its Napier collection and to identify duplicate accessions A study of Napier accessions, cultivars and hybrids from ILRI's gene bank and Napier cultivars commonly grown in Kenya, provided by the Kenya Agricultural Research Institute, showed that DNA fingerprinting can distinguish between accessions and group accessions by genetic similarity Fingerprinting clearly separated the main group of Napier accessions from a pearl mil let sample, with three of the four supposed hybrids shown as geneti cally intermediate between the two groups The fourth 'hybrid' was indistinguishable from the main Napier group, strongly suggesting that it is pure Napier, rather than a hybrid

Within the main Napier group, fingerprints could be used to group accessions that were genetically similar For example, the fingerprints of cultivars French Cameroon and Clone13 were almost indistinguishable from each other, suggesting that they are very closely related This is consistent with reports that Clone13 was bred from cultivated Napier similar to French Cameroon The technique showed that three samples of Bana, purportedly a Napier-pearl millet hybrid, are genetically alike and that cultivar Uganda Hairless is closely related to this group Uganda Hairless was bred from Bana The fingerprint of Bana clearly showed that it is pure Napier and not, as some people have suggested, a hybrid

Interestingly, the groupings according to genetic fingerprints were very similar to those based on morphological characters in the field Used together, DNA fingerprinting and morphological characterisation provide more information than has been available to germplasm specialists in the past

Diseases are easily transmitted with vegetatively propagated plants like Napier ILRI is using in vitro *culture to clean its germplasm collection of diseases and to prevent spread of pathogens*

Tissue culture for storage and distribution

ILRI has conducted a range of experiments on the use of *in vitro* culture for a variety of purposes, including *in vitro* storage and distribution, and the elimination of virus disease

Maintaining a Napier germplasm collection takes a lot of space and effort Napier can be kept *in vitro* but the plantlets outgrow the tubes that house them after only one or two weeks Recent trials at ILRI suggest that a plant hormone, abscisic acid, can be used to slow the growth of Napier plantlets enough for them to be stored for up to 24 weeks, without losing their vigour This makes *in vitro* storage a much more practical proposition It is important also for distributing Napier *in vitro*, as the plantlets tended to outgrow their tubes while in transit

During 1996, ILRI found elephant grass mosaic virus in its Napier collection and used *in vitro* culture to 'clean' the virus from several accessions The virus was eliminated by taking small sections of shoot tips—the cells of which are usually virus free even in infected plants—, growing plantlets from these *in vitro*, taking sections of the shoot tips of the *in vitro* plantlets and repeating the process By the end of the year ILRI had established virus-free cultures of 20 accessions Enzyme linked immunosorbent assays (ELISAs) have shown that the cultures are free from the virus and can safely be planted out in the field and distributed

Accessions show wide adaptation

Three Napier accessions performed well across a wide range of agro-ecological zones in a multilocational trial organised by the African Feed Resources Network (AFRNET)

The trial, started in 1992, was carried out at eight sites in Côte d'Ivoire, Ethiopia, Ghana, Kenya, Nigeria, Tanzania and Uganda, covering humid, subhumid and highlands zones Altitudes ranged from 66 to 2400 metres above sea level, and rainfall ranged from 900 to 1900 mm a year Scientists evaluated several Napier accessions and hybrids from the International Crops Research Institute for the Semi Arid Tropics (ICRISAT), India, and local Napier accessions

Despite the wide range of conditions one accession (16798) was amongst the highest yielding lines at all eight sites Two other accessions were amongst the highest yielders at six or more of the eight sites Scientists in AFRNET and their colleagues in the Cattle Research Network, CARNET, are now studying these and other 'best bet' accessions in feeding trials to determine their nutritive value and ability to provide year-round feeding for crossbred dairy cattle

From the gene bank to the field

This wide range of interrelated studies is targeted at a single goal—putting healthy plants of the best accessions of Napier grass in farmers' field to increase livestock production The results from this work are feeding into production-system research throughout sub-Saharan Africa conducted by both ILRI and the institute's partners in African agricultural research systems (NARS)

From the gene bank to the farmer's field, ILRI and its NARS partners are working to provide scientists and development workers with the knowledge and material they need to improve the lot of smallholder farmers in the developing world

Forage legumes boost livestock and crop production

Appropriately managed forage legume pastures in subhumid West Africa can support up to eight times as many cattle as native pasture and can more than double subsequent crop yields, recent studies by ILRI show

The human population in West Africa's subhumid zone is growing rapidly, through both high birth rates and immigration from both the semi-arid zone and from densely populated wetter areas The region was relatively sparsely populated in the past because its soils are poor and rapidly degrade under cropping Producing enough food for the growing population while improving the soils and protecting the environment can best be achieved by integrating crop and livestock production, especially through growing forage legumes as part of cropping systems

Potential for crop–livestock systems

Appearances can be deceptive In the dry season in West Africa's subhumid zone, cattle may be standing chest-deep in grass, giving the impression that they have plenty to eat Certainly, there is a lot to eat, but for most of the year this biomass has the nutritional value of your average cardboard box Eating dry-season foliage will do the animals little good Indeed, there is so little protein in dry-season foliage that the microbes in the animals' rumens cannot function well enough to break down the fibrous mass and this limits the amount the animals can eat

Supplementing this dry, fibrous feed with green leafy material that contains plenty of protein can dramatically increase the digestibility of the whole diet and boost livestock growth and milk production, especially in the dry season And if the green leafy material comes from legumes —plants that can, in concert with specialised bacteria living in symbiosis in nodules on the plants' roots, take nitrogen from the air and 'fix' it in a form that plants can use—grown as part of cropping systems on the farm, subsequent crop yields also can be increased

It might look like there is plenty of feed available for these cattle, but what there is is hardly worth the effort of eating it Forage legumes can supplement this dry-season forage and boost livestock productivity

ILRI's research in the subhumid zone

ILRI has been studying livestock production problems in the West African subhumid zone for nearly 20 years Developments from this effort include legume fodder banks—

Crop residues provide much of the dry-season feed in smallholder production systems Unless supplemented with better quality material, they are unlikely to support much production

dense legume pastures to improve dry-season cattle feeding, mini fodder banks, where smallholders keep sheep and goats on fenced legume pastures during the wet season both to improve their productivity and to prevent damage to crops, and a variety of systems for intercropping food crops with feed leg umes This work was supported by an extensive programme evaluating forage legumes in the zone

With funds from the German government, ILRI has tested over 1000 accessions of herbaceous forage legumes, fodder trees and grasses in the West African subhumid zone since the mid-1980s This work also linked with a series of trials in West Africa of material from the International Center for Tropical Agriculture (CIAT) Colombia CIAT has focused much of its for age work on identifying species and accessions that perform well on the red acid soils in South America These soils and conditions are very similar to those in the subhumid and derived savannah zones in West Africa The CIAT related West African forages network tested some of the best accessions from South America in West Africa, finding several accessions that performed well in their new home This reciprocates the contribution to South American livestock production of grasses of the genus *Brachiaria*, many of which originated in Africa These grasses are now probably the most widely distributed sown forages in the trop ics Brazil alone has between 30 and 70 million hectares of *Brachiaria* pastures

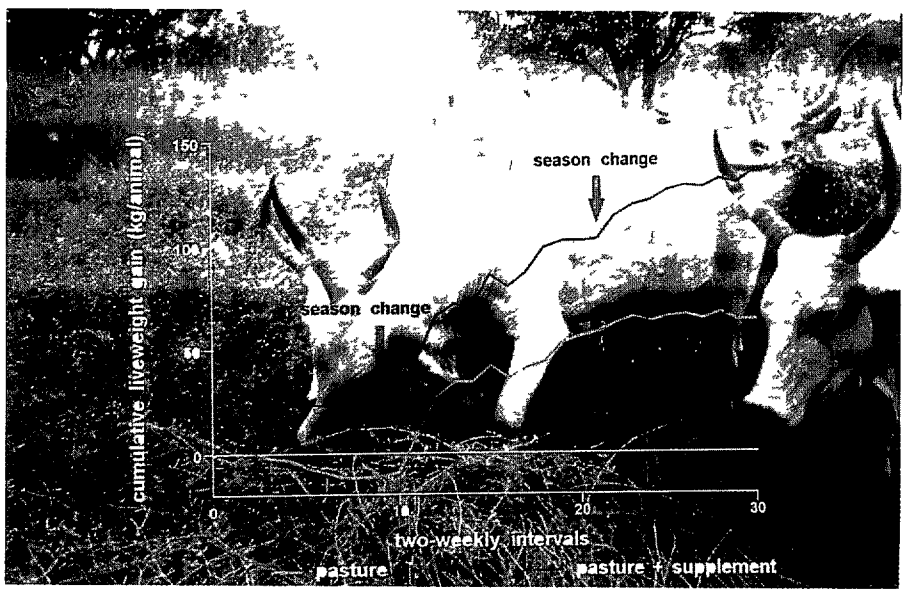
Over the past three years, again with German support, ILRI's team in subhumid West Africa has developed a range of management systems that will help farmers get the most out of the promising herbaceous legume accessions identified These systems included grass–legume mixtures for supplementing calves and legume–legume mixtures for supplementing milking cows Much of this work was done in col laboration with the University of Hohenheim, Germany

Legume mixtures

ILRI's earlier evaluation work had identified several accessions of legume species that grew well in the West African subhumid zone, including *Aeschynomene histrix, Centrosema brasilianum, C pascuorum, C pubescens, Chamaecrista rotundifolia, Stylosanthes guianensis* and *S hamata* The Institute has tested large collec tions of these species to identify accessions best adapted to the agroecological zone None of them, however, is ideal *Centrosema pascuorum* establishes well but soon disappears from a pasture, crowded out by grasses *Centrosema brasilianum* and *C pubescens* establish slowly but stay green in the dry season *Aeschynomene histrix, Stylosanthes guianensis* and *S hamata* establish well and persist in a pasture for several seasons but do not stay green throughout the dry season On their own, none of them are ideal, but in the right mixture, they might provide sustainable, year-round grazing

ILRI focused its efforts on legume mixtures, rather than the more commonly used grass–legume mixtures, because of a shortage of labour, not land Farmers are reluctant to devote much money and effort to providing feed for their livestock, focusing their resources

Cattle grazing natural pasture supplemented with legume grazing gained up to 140 g a day during the dry season Those grazing only natural pasture lost 58 g a day By the end of the dry season, animals that had access to legume pastures weighed an average of over 30 kilograms more than those that grazed only natural pasture



on staple food crops Stock in the zone commonly get most of their feed from unimproved rough pastures ILRI's research has shown that small areas planted with forage legumes can be used to supplement this low-quality bulk feed, boosting livestock productivity

ILRI's research on legume mixtures culminated in a large-scale grazing trial testing four legume mixtures as pastures used to supplement the diets of young heifers The differences were dramatic during the 1994/95 dry season, heifers grazing the best legume mixture gained an average of 140 g/day, while those that grazed only on unimproved pastures lost 58 g/day All the animals grew at similar rates during the wet season, so differences in dry-season performance were maintained throughout the trial

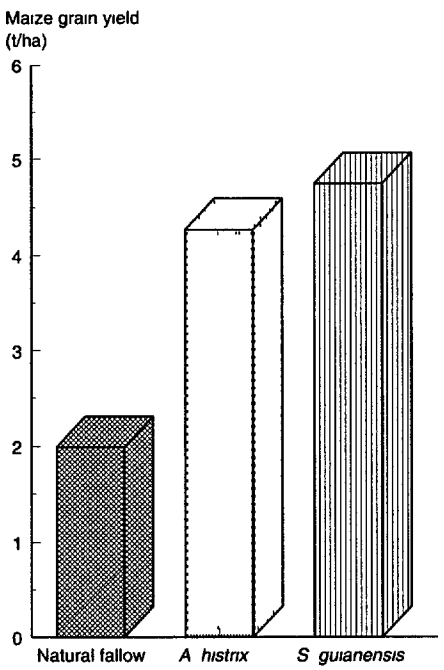
Boosting crop yields

But pasture is not the only use for forage legumes Incorporated in rotations with food crops, legumes cover the soil and protect it from rain and water erosion, help improve soil fertility and sustain food crop yields Faced with shortages of land, labour and inputs, farmers are more likely to invest money and effort in forage legumes if their crops benefit too

In a trial of a range of herbaceous legumes and shrubs, two herbaceous legumes—*Stylosanthes guianensis* and *Aeschynomene histrix*—combined good forage yields with the ability to regenerate vigorously from seed after a cereal crop and markedly increased the yields of a subsequent maize crop Maize grown on plots that had been under these two legumes for only a year yielded almost two-and-a-half times as much grain as maize that was planted on land that had been under a natural fallow for the same period (maize grain yields were 4 7 tonnes per hectare following *S guianensis,* 4 2 t/ha following *A histrix* and 1 9 t/ha following natural fallow) These yields were equivalent to those obtained by applying 90 kilograms of fertiliser nitrogen per hectare to natural fallow plots Two other herbaceous legumes—*Centrosema macrocarpum* and *Centrosema pubescens*—grew back better than the other legumes after being grazed in the dry season and also grew back well after the maize crop

These results demonstrate that herbaceous legumes can provide extra feed for livestock while helping restore soil fertility and dramatically increase the yields of subsequent food crops But farmers will take up forage legumes as part of their cropping system only if they do not entail a lot of extra expense and work These legumes all were able to re-establish themselves after having been cut back and ploughed into the soil when the maize crop was planted and could thus be used in sustainable legume–food-crop rotations on farmers' fields

Maize grown following legumes yields over twice as much grain as maize following natural pasture



Intensifying production

With more and more people to feed, farmers are cultivating more land The risk of continuous cultivation to these poor, fragile soils is huge, but integrating crop and livestock production offers ways to increase production while protecting the environment Farmers might grow forage legumes because they increase cereal yields They might plant legumes to feed their livestock better and increase farm incomes They might even plant legumes to improve and protect the soil Chances are, farmers are more likely to plant legumes for a combination of these reasons

Crops and livestock—together, they can feed more people and protect the environment for future generations

Marker-assisted breeding programmes

New breeding tools based on identifying animals with desirable genes even before they are born hold promise for developing new strains of more productive livestock adapted to specific farming systems

Many of the traits animal breeders want to select for are difficult to measure directly As one wit put it, 'You try breeding from an animal once you've sampled its meat quality or measuring milk production in a bull' Other traits, such as disease resistance, take a long time to measure accurately You may have to wait until an animal is several months old, then expose it to the disease and see what happens Even then, the environment —climate, feed availability, many other factors—will affect how the animal responds to disease challenge And just finding out how strong that challenge is may be fraught with difficulties

Milking an N'Dama cow, a trypanotolerant breed from West Africa Marker-assisted breeding schemes will help animal breeders combine the best characteristics of breeds to create new, more productive breeds

Enter genetic markers

If scientists can find a 'marker' for the genes they are interested in, let's say the genes controlling trypanotolerance, they need only check an animal for that marker to know if it has the gene or not These markers can be anything that is inherited and differs among individuals in a population—coat colour, eye colour, things like that But what animal and plant breeders are looking at now are genotypic markers—sequences of DNA that are found at a particular point on an animal's or plant's genome and 'mark' that point Scientists collaborating on the global bovine genome mapping project, including ILRI scientists, have identified over 1000 such markers spread along the genome Similar markers have been found and mapped for mice and other animal and plant species

Using this map, geneticists can begin to find out how many genes are involved in controlling a particular trait, and can find out where they are in the animal's genome Scientists around the world are already using this map in their search for genes for resistance to a variety of diseases, improved milk production and beef quality At ILRI, the principal search is for the genes control ling trypanotolerance

ILRI's search for the genes controlling trypanotolerance dates back to 1989 'Back then,' says Dr Alan Teale, an animal geneti cist working at ILRI, 'we didn't know how many genes were involved or where they were We knew we had N'Dama cattle that

were resistant to trypanosomiasis and Boran cattle that were susceptible, and we knew that resistance was inherited That's all we knew'

But they also had strains of laboratory mice that were resistant to trypanosomiasis and others that were susceptible to the disease So they started out to find the trypanotolerance genes in these Working with mice is easier, cheaper and quicker than working with cattle They are easier and less expensive to keep than cattle, reproduce faster, produce more offspring each time, and the offspring mature after only a few weeks

To find out how many genes control trypanotolerance, ILRI created a population of laboratory mice that was segregating the genes, i e some of the mice have the genes and some do not They did this by crossing trypanotolerant animals with susceptible animals, creating F_1 crosses Animals have two copies of each of their chromosomes In the F_1, one of the chro mosomes comes from, for example, the trypanotolerant father and hence carries the genes for trypano tolerance, and one chromosome comes from the susceptible mother and hence carries the equivalent susceptible genes When inbred labora tory mouse strains are used, all the offspring from a given mating are genetically the same

But when the F_1s make their gametes (sperm and eggs), the two chromosomes 'mingle' in a process called recombination The result is that each chromosome passed into the gamete is a mixture of the chromosomes from the two parents of the F_1 Some will have all the genes for trypanotolerance, some only some of them and some will have only the susceptible genes This will be true for both the male gametes, the sperm, and the female gametes, the eggs So in the F_2, the cross formed by mating an F_1 with another F_1, you will get animals with all possible combinations from those with all the tolerance genes on both chromosomes to those with all the susceptible genes on both chromosomes and everything in between

If these F_2 animals are infected with trypanosomes, you get a range of 'degrees' of trypanotolerance, from very susceptible to very resistant The assumption at this point is that the very susceptible animals have only susceptible

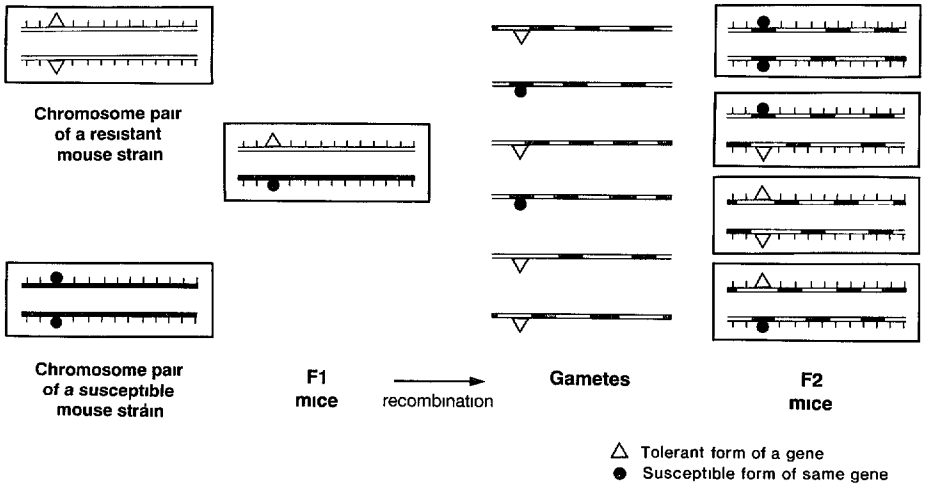
Trypanosomiasis costs farmers, governments and the environment

The tsetse fly—a fly a bit bigger than the common house fly but with a taste for blood and a vicious bite—infests over 10 million square kilometres of land in Africa, an area larger than the whole of the USA. Where there are tsetse flies, there is trypanosomiasis, a virulent disease affecting livestock and humans The disease is caused by single-celled parasites, trypanosomes, which are carried by the tsetse fly in the way the malaria parasite is carried by the mosquito Unless treated, trypanosomiasis causes heavy production losses and often eventually kills the animal

About 160 million cattle and a similar number of sheep and goats are at risk of trypanosomiasis in Africa Every year, the disease costs Africa over US$ 500 million in lost meat and milk production, lost traction power and programmes to try to control the disease

But in many areas farmers simply cannot keep livestock because the risk is too great And without livestock, crop farmers have no way to transfer nutrients from pastures, scrubland and steep slopes to their fields and they lose the opportunity to convert their crop residues and by-products into valuable products such as meat and milk This loss in *potential* livestock and crop production has been estimated at US$ 5 billion a year

When inbred laboratory mouse strains are used, all the F1 offspring are genetically the same But the F2s receive a mixture of the chromosomes of the two parents of the F1 Geneticists can use this 'segregating population' to locate genes they are interested in



Zebu cattle in the Ghibe valley, Ethiopia Zebus are susceptible to trypanosomiasis and have to be treated regularly with trypanocidal drugs to keep them in tsetse-infested areas like the Ghibe valley Breeding trypanotolerance into such animals would benefit farmers throughout tsetse-infested Africa

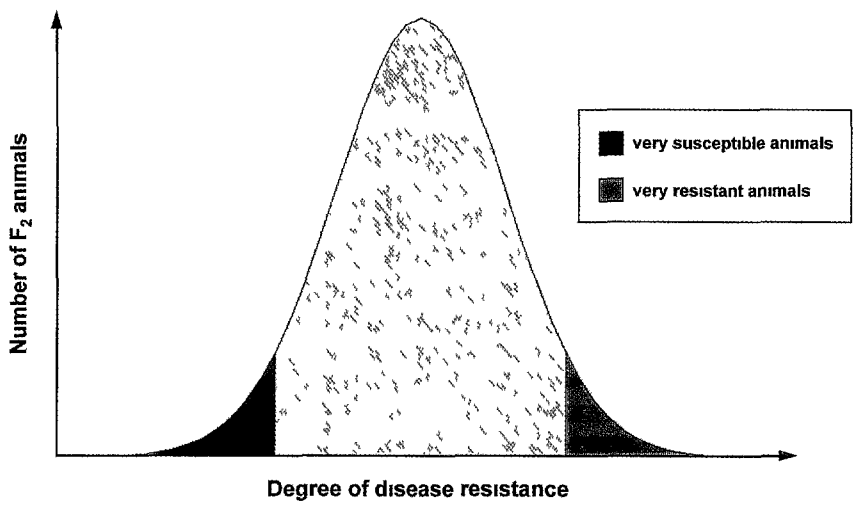
genes, and the very resistant ones have only tolerant genes So the next step is to find out which bits of the resistant grandparent's genome went into the resistant F_2s and which bits of the susceptible grandparent s genome went into the susceptible F_2s

This is where the markers come in There are known markers all along the genome, and the markers at any given point differ between the susceptible and tolerant strains By checking which of these markers are present in each of the F_2s, the scientists can tell which bits of the tolerant grandparent's genome went only into the tolerant F_2s and which bits of the susceptible grandparent's genome went only into the susceptible F_2s This gives the first indication of how many regions of the genome carry genes affecting tolerance, where they are and how much of the tolerance can be attributed to these regions

Crossing F_2 animals increases the degree of mingling of the genetic material and effectively shortens the 'length' of the pieces swapped between the chromosomes Checking again which markers are present in the tolerant animals' genome gives a clearer indication of where the putative genes for tolerance are And so forth, through several generations ILRI has now gone as far as the F_6 generation of its crosses between trypanotolerant and susceptible laboratory animals

This mapping has identified three regions of the genome that carry the genes for trypanotolerance—in the laboratory animals Three putative genes that account for nearly all of an animal's genetic ability to control trypanosomiasis In laboratory animals

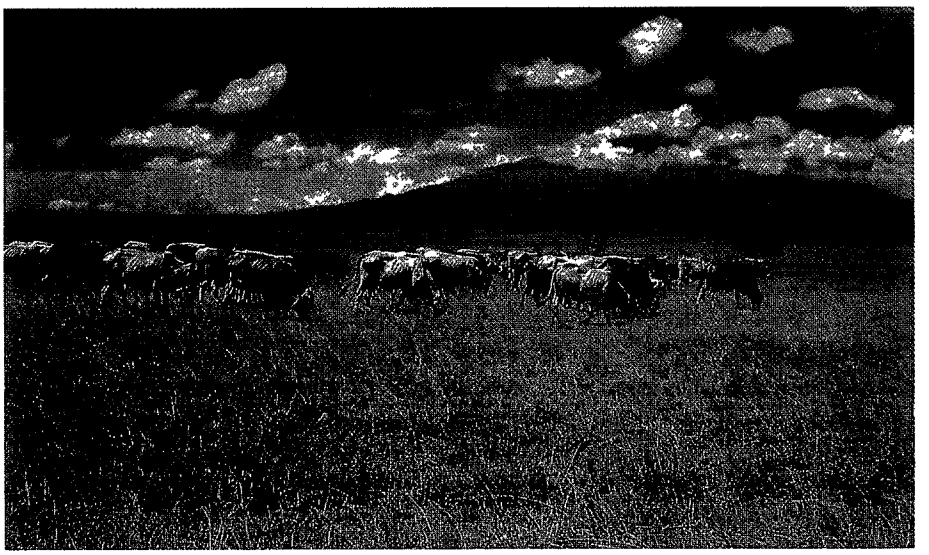
F2 animals show a range of tolerance to trypanosomiasis The assumption is that those that are highly susceptible have only genes for susceptibility, while highly resistant animals have only genes for trypanotolerance



What about cattle?

All well and good, but what about cattle?

Back in 1989 ILRI started an accelerated breeding programme crossing four trypanotolerant N'Dama bulls with susceptible Boran cows using embryo transfer Cows were induced to produce more eggs than normal These were then fertilised by artificial insemination and the embryos implanted in Boran foster mothers Crossing the F_1 animals



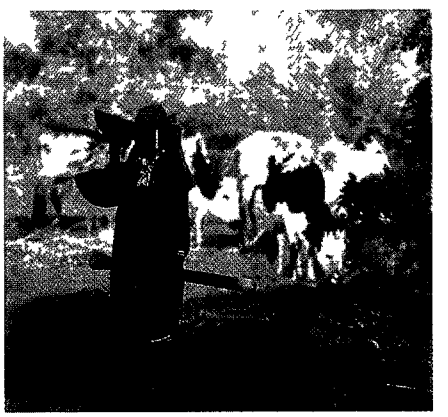
ILRI has crossed N'Dama bulls with Boran cows, like these, and crossed the F1s to produce a cattle population segregating for trypanotolerance genes Early results indicate that at least one of the regions that carry genes for trypanotolerance in mice also contributes to trypanotolerance in cattle

produced started in February 1992 and the first F_2 calves were born in November 1992 These first F_2 animals were infected with trypano somes in November 1993 and the search for DNA markers associated with trypanotolerance was started By the end of 1996, almost 150 F_2 animals had been exposed to trypanosomes, their trypanotoler ance assessed and their DNA partly screened

'It is early days yet,' says Teale, 'but it looks as if at least one of the regions that we found to carry resistance genes in the laboratory animals also contributes to resistance in cattle And it looks like this "gene" may account for most of the difference in trypanotolerance between resistant and susceptible cattle types '

Where to next?

Once scientists have identified markers for the genes breeders are interested in, they can be used to speed breeding programmes to incor porate those genes in other breeds or strains of the animal For example, if you want to incorporate trypanotolerance in the Boran breed you would start out by crossing an N'Dama with a Boran to give an F1—50% N'Dama, 50% Boran You would then backcross the F1 to a pure Boran The resulting offspring would be 75% Boran and 25% N'Dama Using the markers, the animal breeder can identify which of the offspring carry the tolerance genes, which do not, without having to wait for them to mature and then test them for trypanotolerance Those without the genes for trypanotolerance could be removed



from the breeding programme at birth, dramatically reducing the number of animals that the programme would have to support

The remaining animals would then be backcrossed again to the Boran, giving offspring that were 87 5% Boran and only 12 5% N'Dama And, again, using the markers, the scientist can identify the tolerant animals If the breeder keeps doing these backcrosses, the end result is an animal that is almost pure Boran but that has just those bits of the N'Dama genome that carry the tolerance genes And this process does not have to be used only with African breeds why not a trypanotolerant Jersey cow?

Not just trypanotolerance

This process can be applied to any other measurable trait, not just trypanotolerance ILRI is, for example, collaborating with institutes in Europe that are searching for the genes that control milk production If, or rather when, markers for these genes are identified, breeders could incorporate both milk production and trypanotolerance in their selection criteria Ultimately, breeders could be in a position to create 'designer' animals, new genotypes that combine the sorts of genes needed for specific production systems That, however, is still a long way off and quite speculative No-one knows if such animals would be viable, if such combinations of genes would work together But it's a thought

Non-genetic interventions

For marker-assisted breeding programmes, the level of 'resolution' (the proximity of markers and genes) needs to be only fairly

Marker-assisted breeding techniques are applicable to species other than cattle, characters other than disease resistance and in all parts of the world

coarse In the F_2 generation in the laboratory mice the regions that have been identified as carrying genes for trypanotolerance are 10 centiMorgans long, about 10 million base pairs—and that length of DNA could hold several hundred genes

In F_6 animals, the resolution of the map should reduce to only one or two centiMorgans, only one to two million base pairs At that level of resolution, the scientists can start thinking about trying to identify what genes are in that segment, and what they produce Say, for example, there is a gene in that section that produces a hormone that stimulates production of red blood cells Anaemia is a major feature of trypanosomiasis, and the ability to maintain high levels of red blood cells is a feature of trypanotolerance Thus, this hypothetical gene would be a strong candidate for being a gene that confers trypanotolerance

As yet, few genes have actually been mapped in cattle But large parts of DNA are 'conserved'—i e the same—across species, even if they are on different chromosomes For example, scientists have found that the genes on chromosome 23 in cattle are largely the same as those on chromosome 6 in humans And many of the genes in the human genome have been identified So scientists working on cattle or laboratory animals can look at the human databases and see what genes are being found in the areas the animal scientists are interested in

There are two main reasons for going after the genes themselves Firstly, if, for example, we can clone the genes for trypanotolerance, we could move the genes be tween animals, rather than moving chunks of genome by marker-assisted breeding And secondly, if we find the genes that control trypanotolerance, we will know what those genes do If we know what the genes do, we will know the molecular basis of the trait And if we know the molecular basis of the trait, we might be able to develop new vaccines or drugs to promote the trait

Where are we now?

ILRI has now found three regions of the genome that carry genes controlling trypanotolerance in laboratory mice and has almost completed fine mapping work on F_6 crosses between trypanotolerant and susceptible mice ILRI scientists have started mapping the regions that carry genes controlling trypanotolerance using crosses between trypanotolerant N'Dama cattle and susceptible Boran cattle Early indications are that the region carrying the major gene for trypanotolerance in laboratory mice is the same in cattle, fuelling hopes that the other two regions may also be the same in both species If this pans out, we will be able to continue working with laboratory animals, rather than cattle, to identify the genes involved, which will speed progress and reduce costs

Together with scientists of the Wageningen Institute for Animal Science, The Netherlands, and the Hebrew University of Jerusalem, Israel, ILRI scientists are already planning to use markers to introduce the trypanotolerance genes of N'Dama cattle into Boran cattle in East Africa In West Africa, in collaboration with the International Trypanotolerance Centre (ITC) in The Gambia, the markers will be used to help ensure that, as European dairy cattle are crossbred with N'Damas, the 'improved' offspring will retain the important trypano tolerance of the N'Dama

The day when large beef breeds are resistant to trypanosomiasis and when trypanotolerant livestock have greatly improved milking characteristics may be getting closer

Networking — building for the future

'Before the network, small ruminant research was marginalised in the NARS [national agricultural research systems] in sub-Saharan Africa, with little direct investment in research and only a handful of scientists doing any work on small ruminants,' says Professor Sahr Lebbie of the impact of the African Small Ruminant Research Network (SRNET) 'Today, there are over 90 NARS scientists in 28 NARS institutions directly involved in collaborative research projects supported by SRNET'

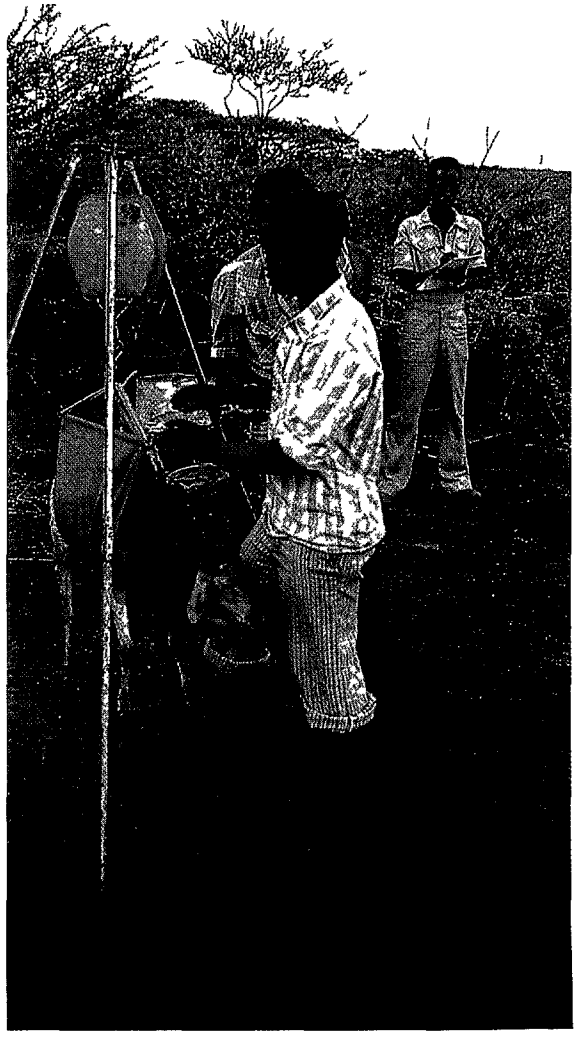
Sahr, a former chairman of the network's steering committee and now its co-ordinator, has many numbers at his disposal to provide evidence of the value of SRNET's efforts Possibly the most telling, however, is that investment by ILRI and donors—primarily the European Development Fund—in promoting and supporting the network's collaborative research with NARS in sub-Saharan Africa (a total of about US$ 1 2 million by the end of 1996) has leveraged over two and a half times as much money from the NARS institutes as their contribution to the implementation of the projects

The network was set up in 1989 by ILRI and its NARS partners to

- promote stronger partnerships between ILRI and the NARS and among the NARS
- help build the small ruminant research capacity of the NARS and
- help leverage resources to support collaborative research, training and information exchange activities in the NARS

Its key activities are in collaborative research, training and information exchange

Small ruminants tend to get less research attention than cattle despite their importance in many production systems The African Small Ruminant Research Network has helped redress the balance



Promoting research in NARS

The network's programme of collaborative research activities has encompassed 45 projects in 17 sub-Saharan African countries since 1992 These numbers hide some startling statistics

In many cases, the network projects are the only small ruminant research in the NARS Sixty per cent of the NARS institutes studying small ruminants under the network had no infrastructure for small ruminant research before starting on the network project About a fifth of those NARS that did have the infrastructure did not have any operational funds to carry out research In about half of these institutes, the only livestock research is that supported by the network

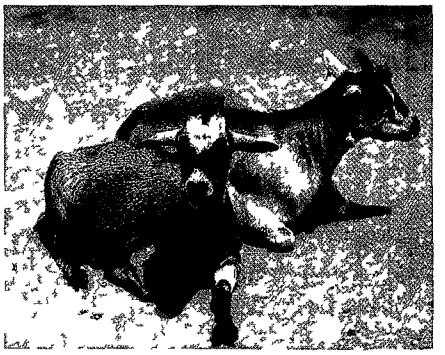
In addition to the research aspect, these projects serve as a basis for strengthening the research staff of the NARS, they have provided the basis for 10 Bachelors, 8 Masters and 5 PhD theses

Broad-based training

The second key element of SRNET's activities is training Between 1990 and 1996, 120 NARS staff took part in SRNET training activities, 110 of them attending the Small Ruminant Production Techniques course offered by ILRI, latterly with funding from the European Development Fund

The network keeps track of its alumni, and most of them are still closely involved in small ruminant research and benefiting from their experiences at ILRI Over a third of those trained by ILRI are today leading the network collaborative research teams in their countries and 60% are involved in the research A fifth of them hold administrative positions in their home NARS

Building on this extensive experience, the network has developed a training manual This will be published in 1997 and will help the NARS take over and extend the training the network has offered



Isolation hampers progress

Access to up to-date information is the cornerstone of any successful research effort, and is an area the network has focused its efforts on Many, if not most, NARS have little ready access to information through regular channels—journal subscriptions cost too much for most NARS libraries and modern information tools like the Internet and documentation databases are out of their reach Most NARS scientists work in small groups and have few opportunities for meeting with peers and sharing experiences and ideas

Breaking this information isolation was one of the key objectives of SRNET In the past six years, the network has hosted four scientific conferences, each attracting 80 to 100 participants and an average of 47 oral presentations from international and national research organisations The network has published proceedings of these conferences and distributed them widely to NARS libraries and staff in sub Saharan Africa

Broadening the participant base, the network also held eight regional scientific workshops to plan, develop, prioritise and review the

Small ruminant milk provides vital nourishment for many children—and adults—in the developing world

On the way to market Women and children are often responsible for tending sheep and goats in smallholder production systems

small ruminant research agenda in the NARS

But beyond meetings to develop, plan and report research, the net work has continued to provide in formation support to the projects in progress, producing a quarterly scientific newsletter and with ILRI's Information Services provid ing over 1000 literature searches each year for network scientists

Complex interactions

Presenting all the components of the network's activities in a linear way, like in this article, belies the complex interactions between them, interactions that multiply the effects of the activities

Even the development of the network's research programme con tributes to professional development and information exchanges The network's research agenda is set by the national programme scientists through a rigorous participatory process NARS scientists identify and prioritise their research needs as well as plan and im plement the research The whole process contributes to developing research capacity, self reliance, accountability and research leadership in the NARS

The dialogue and consultations at regional and national levels during the research planning have provided opportunities for improving linkages within and among the NARS, and between NARS and ILRI

And the process does not stop with SRNET Building on the foundations provided by SRNET, NARS scientists in Congo, Ghana, Malawi, Nigeria, Rwanda, Swaziland, Tanzania, Togo, Uganda, Zaire and Zimbabwe have created national small ruminant research networks or committees Through the efforts of network members, small ruminant research and development is now a priority in the livestock development plans of many countries in sub-Saharan Africa

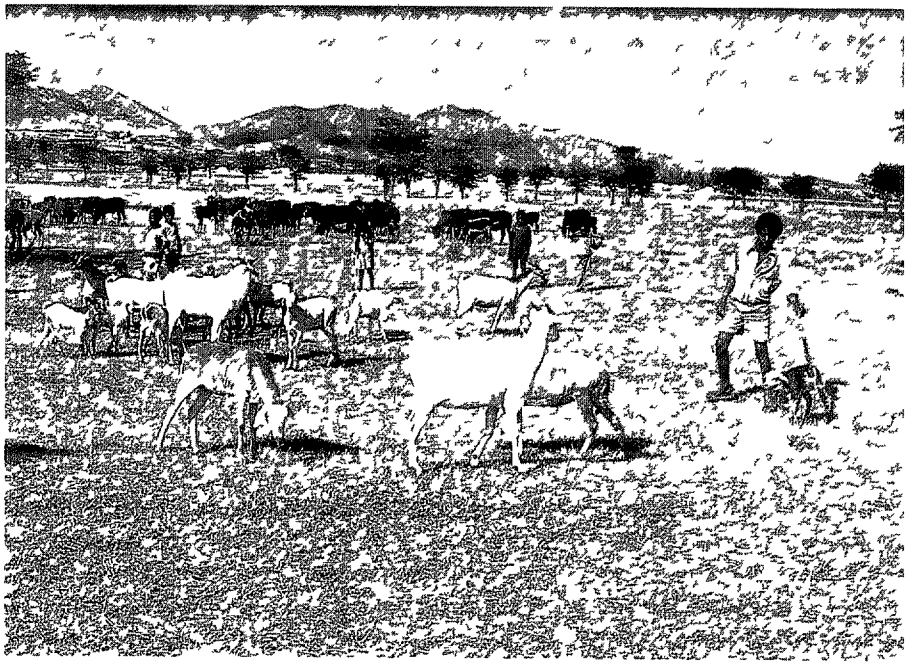
ILRI may have been instrumen tal in starting the African Small Ruminant Research Network, but

there is no doubt about who 'owns' it now—the NARS and the dedicated scientists who are the driving force behind the continuing success and development of collaborative networks in Africa

A new networking paradigm

The world has moved on since the Small Ruminant Research Network first started work in 1989 The NARS have established national and regional research priorities and local networks to address them They have set up or strengthened several regional associations such as the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), the Conference of Leaders of Agricultural Research in Africa (CORAF) and the Southern African Centre for Co-operation in Agricultural and Natural Resources Research and Training (SACCAR) These are the entry points for many of the donors who support agricultural research and development in Africa

Taking account of these changes, NARS scientists involved in the collaborative research networks associated with ILRI—SRNET, the Cattle Research Network (CARNET) and



the African Feed Resources Network (AFRNET)—proposed in March 1996 to establish multidisciplinary collaborative livestock research networks aligned to the regional associations ILRI is working with the NARS to set these networks up and during 1997 a new network structure for collaborative research in animal agriculture will take shape

As this and other articles in this report show (see *Building national capacity for market oriented smallholder dairy research and development* and *The grass is always greener*), the networks ILRI has been associated with have multiplied the resources, funds and work that have been directed at solving livestock production problems in sub-Saharan Africa The names and organisation of the networks may change, but the aim will be the same—more and better research that will ultimately put more food on the plates of poor people in the developing world

Importance of assessing true credit constraint

In Ethiopia and Kenya, a unit of credit given to a credit-constrained farmer has twice as much effect on agricultural productivity as a unit of credit given to a farmer with adequate access to financial resources, according to a recent ILRI study The study also found that giving farmers agricultural training can significantly increase farm productivity, but only if the farm is not facing a credit constraint

The study looked both at the supply of credit from financial institutions in Ethiopia, Nigeria and Uganda, particularly the bank's credit allocation policies, and at demand for credit in households in the same three countries plus Kenya The household-level study examined the effects of credit on uptake of improved dairy technology, particularly improved cows and better feeding, in smallholder dairying

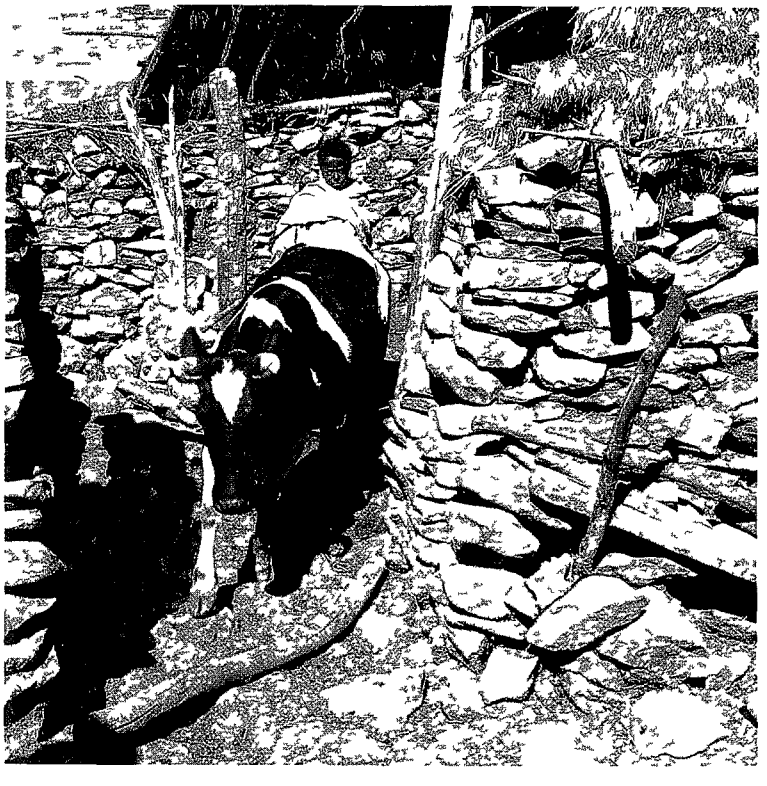
Formal lending not tailored to smallholder livestock farmers

All the banks covered by the study—the Agricultural and Industrial Development Bank (AIDB) in Ethiopia (now the Development Bank of Ethiopia), the Nigerian Agricultural and Co-operative Bank and the Uganda Commercial Bank—had a stated aim of increasing the flow of institutional credit to large numbers of smallholder livestock producers The study showed, however, that few smallholder livestock producers obtained formal credit in these three countries Many smallholders could not obtain credit because they failed to meet the criteria banks used to screen applicants The Uganda Commercial Bank, for example, requires potential borrowers to show that they have the infrastructure for keeping livestock before it will approve loans In essence, this restricts credit to relatively well-off farmers who can afford to build the infrastructure before they apply for a loan

The banks generally did not demand formal collateral security for the loans, relying instead on the personal characteristics of potential borrowers to determine their credit-worthiness While well-intentioned, this tended to exclude poorer, less influential smallholders, as bank officials tended to allocate credit on observable characteristics such as wealth or influence in the community

All three institutions provided subsidised loans, with funds from the central government or from donors This limited the amount of money available for loans, and credit was rationed

Credit is vital if farmers are to adopt new production techniques, such as keeping crossbred dairy cows But equally important is making sure that credit goes to those who need it most



Dairying can dramatically increase smallholders' incomes, but initial investments, especially in improved stock, are high

Another major problem was that the main operations of the banks in Uganda and Nigeria are short term loans with fixed repay ment patterns These are not ideal for agricultural operations, especially investments in livestock Only the AIDB in Ethiopia had the majority of its portfolio in long term loans As the study notes, there is no ideal loan term, what is important is to maintain flexibility by relating loan terms to factors such as the cash flow of the associ ated activity, the availability and demand for inputs and risk

The study made a number of recommendations, including the need for the credit institutions to re-examine their delivery systems, loan policies and loan-term structures It also recommended policies to mobilise savings, rather than relying on central government funds or donors to provide credit

Not all who borrow. . .

Studies on the role of credit in technology uptake commonly look at differences between borrowers and non-borrowers But not all borrowers are able to borrow as much as they might wish, and not all those who do not borrow money actually need to borrow money—they may have enough funds of their own to finance what they want to do

What ILRI's study did was to try to assess the true 'credit constraint' on households, i e those who did not invest because they could not get the funds rather than those who chose not to invest but had funds available

The study defined credit-constrained farmers as

- those who had borrowed money and expressed willingness to bor row more at the current interest rate
- those who had not borrowed money because
  - their loan request had been rejected
  - they did not have access to a formal or informal lender
  - they did not have access to animals to buy

Based on these criteria, the study found both credit constrained and credit non-constrained farmers among both borrowing and non-borrowing households, highlighting the importance of looking at credit constraints rather than borrowing *per se*

The study found that farmers who had adequate access to funds

(and hence were not credit constrained) had a larger proportion of crossbred cows, used more inputs—especially feed—and tended to have more profitable dairy operations than did credit-constrained farmers

The main determinant of milk output per farm was the number of crossbred cows the farmer had In most cases, credit-constrained farmers who borrowed money invested it in crossbred milking cows Interestingly, however, herd size did not affect milk production per farm, probably because of the large number of non-milking animals—draft oxen, follower animals etc—in herds Thus, farmers could reduce the number of animals they keep without reducing milk production For example, replacing draft oxen with dual-purpose, dairy–draft cows could help increase farm pro ductivity

Additional expenditure on inputs such as feed had less effect on productivity than additional investments in crossbred milking cows Few of the farmers used credit to purchase variable inputs such as feed Farmers who did buy feed generally used too little to have much effect on the productivity of their cows, largely because of lack

of credit for working capital Nevertheless, the study notes that providing credit to farmers to fund operations could encourage higher variable input use and substantially increase smallholder dairy productivity

The study clearly showed that the contribution of credit to milk output differs between credit-constrained and credit non constrained farms Using investments in crossbred cows as a proxy for the impact of credit, the study showed that the marginal contribution of crossbred milking cows to milk output is relatively high on credit-constrained farms In Ethiopia and Kenya, an additional crossbred cow on a credit-constrained farm contributes abou twice as much to milk output (in litres) per farm as it would on a credit non-constrained farm This suggests that credit should be targeted at credit constrained farms to achieve the greatest impact

The amounts of milk smallholders sell may be small, but they can make a big difference to the welfare of the household

In Ethiopia, the study found that training farmers in livestock management skills led to increased milk output on credit non-constrained farms but not on credit-constrained farms Efforts to increase milk production through training farmers should, therefore, be targeted at farmers who are not constrained by lack of credit, the study suggests

The study provided additional evidence on the importance of accu rately assessing farmers' demand for credit To do this, the study con cludes, policy makers and financial institutions need to go beyond whether farmers are borrowers or non borrowers to take account of the farmers' resource endowments and household characteristics Only by doing this can scarce credit resources be targeted accurately to those who will make greatest use of them

ILRI programme and project activities in 1996

Conservation of Biodiversity

Characterisation, conservation and use of animal genetic resources

Characterisation and conservation of indigenous animal genetic resources

Physiology of non disease adaptive traits in tropical (small) ruminants

Forage genetic resources

Characterisation and conservation of forage germplasm

Selecting and testing forage legumes for sustainable agriculture

Production Systems Research

Production systems analysis and impact assessment

Socio-economic evaluation of alternative trypanosomiasis control measures

Assessment of the economics of theileriosis control

Assessment of the economics of heartwater control

Assessment of the economics of trypanosomiasis control

The economics of rinderpest control and prevention vaccination campaigns and livestock services in Africa

Environmental and socio economic impacts of controlling trypanosomiasis

Geographical information systems database development and integration

Impact of vector-borne infections on livestock productivity

Ecoregional production systems research in the highlands of SSA

Forage integration and natural resource management in crop–livestock systems in the tropical East African highlands

Livestock production strategies for managing natural resources at a watershed scale

Alternative sources of draft power use of crossbred cows for milk production and traction

Ecoregional production systems research in subhumid SSA

Developing crop–livestock systems in the lowland moist savannahs

Epidemiology of trypanosomiasis in ruminants in sub-Saharan Africa

Trypanotolerance and the use of trypanotolerant livestock within integrated strategies for livestock production under trypanosomiasis risk

Ecoregional production systems in semi-arid SSA

Socio economic analysis of livestock production and natural resource management in semi-arid West Africa

Dynamics of livestock-mediated nutrient transfers in semi-arid West African landscapes implications on natural resource management

Market-oriented smallholder dairying

Research methodologies for dairy systems

Constraint analysis for dairy systems

Smallholder peri-urban dairy systems in moist savannah ecozones

Peri-urban dairy production identification of factors affecting on-farm milk production in the Ethiopian highland farming systems—Selale area

Development of food/feed production and management options for smallholder livestock production systems

Impact of diseases of intensification on milk production

Utilisation of Tropical Feed Resources

Strategic use of feeds for livestock improvement

Strategies to evaluate and match nutritional requirements of livestock exposed to fluctuating feed supply

Strategies for improving feed quality in mixed farming systems

Feed utilisation for traction

Feed resources and nutrition of ruminants in crop–livestock systems of semi-arid West Africa

Rumen microbiology

Rumen microbiology ruminal detoxification

Animal Health Improvement

Epidemiology and disease control

Molecular parasitology of *Theileria parva*

Development of new and improved epidemiological tools for tick-borne diseases

Dynamics of the transmission of *Theileria parva*

Application of new technologies for improved tick-borne disease control

Epidemiology of animal trypanosomiasis

Trypanosome diagnostics

Improved chemotherapy and chemoprophylaxis for trypanosomiasis in domestic livestock

Molecular biology and immunology

Antigens of tick derived stages of *Theileria* and other tick-borne pathogens

Identification and characterisation of antigens of *Theileria parva* schizonts that provoke cellular immune responses

Immunisation with *Theileria* antigens

Evaluation of antigen delivery systems in cattle

Studies of cell-mediated immune responses in cattle

Parasite–host interactions

The role of T cells and B cells in resistance to bovine trypanosomiasis

Significance of macrophage activation in the susceptibility of cattle to trypanosomiasis

Mechanisms of anaemia in bovine trypanosomiasis

Genetics of disease resistance

Molecular genetics of disease resistance

Genetics of trypanotolerance and genetic improvement of trypanotolerant livestock

Genetic resistance to gastro-intestinal parasitism in small ruminants

Livestock Policy Analysis

Policies and institutions for improving the sustainability of crop–livestock systems

Livestock, the environment and food security

Policies and livestock markets in West Africa

Competitiveness of smallholder dairy sectors

Policy environment for dairy development

Property rights, risk and sustainable livestock development

Land tenure institutions and agricultural productivity a case study from Ethiopia

Property rights, risk and livestock development

Strengthening Collaboration with National Agricultural Research Systems

Capacity development for strengthening NARS

Training

Information and publications on livestock agriculture

Information Services

Publications

Collaborative research networks

African Small Ruminant Research Network

Cattle Research Network

African Feed Resources Network

ILRI senior staff in 1996

Directorate General

Hank Fitzhugh, *Director General*
Akke van der Zijpp, *Deputy Director General*
Hugh Murphy, *Director of Administration*
Ralph von Kaufmann, *Director for External Relations and Public Awareness*
Gerard O'Donoghue, *Chief Financial Officer*
Peter Gardiner,* *Institute Planning Officer*

Animal Health Improvement Programme

Programme Leader Tom Dolan*/Anthony Irvin†

Improvement and Application of Existing Disease Control Technologies

Kenya

Alfred Adema, *research technologist*
Richard Bishop, *molecular parasitologist*
Mark Eisler,[1] *visiting epidemiologist*
Newton Gitire, *research technologist*
John Kabata, *research technologist*
Alfred Kafwa, *technical assistant*
Noah Karanja, *technical assistant*
Fredrick Karia, *research technologist*
Sammy Kemei, *research technologist*
Juma Kiundi, *research technologist*
Nelson Kuria, *research technologist*
Stephen Leak, *research associate*
Pierre Lessard,* *epidemiologist*
Clement Lugonzo, *research technologist*
Humphrey Lwamba, *research technologist*
Phelix Majiwa, *molecular parasitologist*
Jackson Makau, *research technologist*
Rachael Masake, *immunologist*
Stephen Minja, *research associate*
Deen Moloo, *entomologist*
Subhash Morzaria, *molecular parasitologist*
Joseph Muia, *technical assistant*
Stephen Mwaura, *research technologist*
Reeves Njamunggeh, *research technologist*
George Njihia, *research technologist*
Thomas Njoroge, *research technologist*
Stephen Njuguna, *research technologist*

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[1] Salary provided by the UK, *ODA (Overseas Development Administration) and the University of Glasgow*, and by the European Community

* left in 1996

† joined in 1996

Joseph Odhiambo, *research technologist*
George Oduol, *research technologist*
Ignatius Okumu, *research technologist*
Maurice Owino, *technical assistant*
David Parkin,[2†] *biochemist*
Andrew Peregrine, *parasitologist*
Rob Skilton, *research associate*
John Tangus, *technical assistant*
James Thuo, *research technologist*
Alfred Tonui, *research technologist*
Mary Waithaka, *research technologist*
Stephen Wasike, *research technologist*
Jon Wilkes, *cell membrane physiologist*

Development of New Disease Control Technologies

Kenya

Edith Authie,[3] *immunologist*
Keith Ballingall, *post-doctoral scientist*
Edward de Buysscher,[4*] *visiting immunologist*
Francis Chuma, *research technologist*
Elizabeth Carpenter,[†] *cellular immunologist*
Claudia Daubenberger,[*] *post-doctoral scientist*
Benson Gichuki, *research technologist*
Lucy Gichuru, *research technologist*
Elke Gobright, *research associate*
Volker Heussler,[*] *post-doctoral scientist*
Yoshikazu Honda, *virologist*
Linda Logan-Henfrey,[*] *pathologist*
Dismus Lugo, *research technologist*
Vittoria Lutje, *post-doctoral scientist*
Anthony Luyai, *research technologist*
Niall MacHugh, *research associate*
Guy Mareels,[5] *peptide biologist*
Yutaka Matsubara,[6] *pathologist*
John Mburu, *research technologist*
Ferdinand Mbwika, *research technologist*
Declan McKeever, *immunologist*
Francis McOdimba, *research technologist*
Bea Mertens,[7] *immunologist*
Paul Muiya, *research technologist*
Cecilia Muruiki, *research technologist*
Noel Murphy, *molecular geneticist*
Tony Musoke, *immunologist*
David Muteti, *research technologist*
Anthony Muthiani, *research technologist*
Duncan Mwangi,[8] *post-doctoral scientist*
Waithaka Mwangi, *research technologist*
Jan Naessens,[9] *immunologist*
David Ndegwa, *research technologist*
Vish Nene, *molecular biologist*
Daniel Ngugi, *research technologist*
James Ngugi, *research technologist*
Catherine Nkonge, *research associate*
Joseph Nthale, *research technologist*
John Nyanjui, *research technologist*
Elias Owino, *research technologist*
Tom Olyhoek,[†] *visiting scientist*
Pratibala Pandit, *research technologist*
Roger Pelle, *molecular parasitologist*
Rosemary Saya, *research technologist*
Maarten Sileghem,[*] *immunologist*
Baljinder Sohanpal, *research technologist*
Paul Spooner, *research associate*
Evans Taracha, *post-doctoral scientist*
Kathy Taylor, *research associate*
Philip Totte,[10*] *immunologist*
John Wando, *research technologist*
Stephen Wanyonyi, *research technologist*

Genetics of Disease Resistance

Kenya

Eric Aduda, *research assistant*
James Audho, *technical assistant*
Leyden Baker, *quantitative geneticist*
Henry Gathuo, *research technologist*
Olivier Hanotte, *post-doctoral scientist*
Alice Njeri Maina, *research technologist*
Joel Mwakaya, *research technologist*
John Ngatti, *research technologist*

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[2] Salary provided by the USA, *National Institutes of Health*
[3] Salary provided by France, *CIRAD EMVT Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement Elevage at Medecine Veterinaire des Pays Tropicaux* (Centre for International Cooperation in Agronomic Research and Development Animal Husbandry and Veterinary Medicine in Tropical Countries)
[4] Salary provided by USA, *North Carolina University*
[5] Salary provided by Belgium, *VVOB Vlaamse Verenigung Voor Ontwikkelingssamenwerking en Technische Bijstand*
[6] Salary provided by Japan, *JIRCAS japan International Research Center for Agricultural Sciences*
[7] Salary provided by Belgium
[8] Salary provided by the USA, *USAID (United States Agency for International Development) and the University of Florida*
[9] Salary provided by Belgium
[10] Salary provided by France, *CIRAD EMVT*
[*] left in 1996
[†] joined in 1996

Moses Ogugo, *research technologist*
Manassey Omenya, *research technologist*
Japheth Sore, *research technologist*
Alan Teale, *molecular geneticist*
Yasmin Verjee, *research technologist*
John Wambugu, *research technologist*

Ethiopia

Saidou Tembely, *associate scientist*

Programme Support

Kenya

Chris Hinson, *laboratory manager*
David Kennedy, *veterinarian*
Bob King, *head of experimental animal units*
James Magondu, *head of fluorescence-activated cell sorter services*
Francis Mucheru, *research technologist, fluorescence-activated cell sorter services*
Christopher Ogomo, *research technologist, electron microscopy services*
Clive Wells, *head of electron microscopy services*

Biodiversity Programme

Programme Leader Jean Hanson

Animal Genetic Resources

Kenya

Osamu Hishida,[11]* *molecular geneticist*

Ethiopia

Dawit Gezahegn, *research technologist*
Girma Abebe, *research technologist*
Kahsay Berhe, *research technologist*
Lemma Mekonnen, *technical assistant*
Mesfin Shibre, *research technologist*
Eddie Mukasa-Mugerwa, *veterinarian*
Edward Rege, *animal breeder*
Chi Lawrence Tawah,* *associate scientist*
Rita Torto,* *post-doctoral associate*
Valentine Yapi-Gnaore,* *post-doctoral associate*

Forage Genetic Resources

Ethiopia

Asebe Abdena, *research technologist*
Girma Gebre Mariam, *research technologist*
Jemal Mohammed, *research technologist*
Afui Mathias Mih,* *post-doctoral associate*
Kaburu M'Ribu,* *post-doctoral associate*
Zhi Biao Nan,* *associate scientist*
Temeselew Mamo, *research technologist*
Mark van de Wouw,* *associate scientist*

Production Systems Programme

Programme Leader William Thorpe (acting)

Systems Analysis and Impact Assessment

Kenya

Mohamed Baya, *research technologist*
Luc Duchateau,[12] *statistician and modeller*
Russ Kruska, *geographic information systems specialist*
Adrian Mukhebi, *agricultural economist*
Brian Perry, *veterinary epidemiologist/team leader*
Robin Reid, *ecologist*

Livestock Production Under Trypanosomiasis Risk

Kenya

Guy d'Ieteren, *animal scientist/team leader*
Sonal Nagda, *data analyst*
John Rowlands, *biometrician*
Brent Swallow, *agricultural economist*
Elamin Elbasha,† *agricultural economist (Rockefeller Fellow)*
Emmanuel Tambi,[13] † *agricultural economist*
Nancy McCarthy,† *post-doctoral scientist*

Ethiopia

Negussie T/Michael, *research technologist*
Tesfaye Legesse, *research technologist*
Woudyalew Mulatu, *research technologist*

Ecoregional Integrated Systems for sub-Saharan Africa Market-oriented smallholder dairying

Kenya

Matthew Kenyanjui, *research technologist*
David Njubi, *senior computer programmer*
Amos Ochieng', *research officer*†
Steve Staal,† *agricultural economist*
Jon Tanner,† *animal nutritionist*

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[11] Salary provided by Japan, *JICA*
[12] Salary provide by Belgium, *VVOB*
[13] Salary provided by European Union and facilitated by the Organisation of African Unity
* left in 1996
† joined in 1996

Ethiopia

Abebe Tessema, *research technologist*
Aberra Adie, *technical assistant*
Solomon Kebede,* *research technologist*
Victor Umunna, *animal scientist/station manager*
Azage Tegegne, *research officer*

Ecoregional Integrated Systems for Sub-Saharan Africa Highlands

Ethiopia

Abate Tedla, *research officer*
Abiye Astatke, *research officer*
Kahsai Berhane, *research technologist*
Mohamed Mohamed Saleem, *agronomist/team leader*
Mulugeta Mamo, *technical assistant*
Emmanuel Mwendera, *post-doctoral associate*
Nigist Wagaye, *research technologist*
Wagnew Ayalneh, *research technologist*
Ercole Zerbini,‡ *animal scientist*

Ecoregional Integrated Systems for sub-Saharan Africa Semi-arid zone

Niger

Salvador Fernandez Rivera, *animal scientist/team leader*
Pierre Hiernaux, *range ecologist*
Eva Schlecht, *post-doctoral associate*
Tim Williams, *agricultural economist*

Ecoregional Integrated Systems for sub-Saharan Africa Subhumid zone

Nigeria

Kwaku Agyemang, *animal production scientist*
Asmoah Larbi, *forage agronomist*
Augustine Naazie, *post-doctoral associate*
Michael Peters,[14]* *post-doctoral scientist*
Jimmy Smith, *animal scientist/team leader*
Ibrahim Magagi,† *animal scientist/research fellow*

Ecoregional Integrated Systems for sub-Saharan Africa Livestock production under trypanosomiasis risk

Burkina Faso

J B Mulumba Kamuanga, *agricultural economist*

Feed Resources Programme

Programme leader Paschal Osuji (acting)

Ethiopia

David Anindo, *associate scientist/station manager*
Ignatius Nsahlai,* *associate scientist*
Agnes Odenyo,† *associate scientist*
Karanfil Olga, *research technologist*
Asfaw Yemegnuhal, *research technologist*
Dawit Negassa, *research technologist*

Livestock Policy Analysis Programme

Programme Leader Simeon Ehui

Ethiopia

Abebe Misgina, *research technologist*
Guillaume Duteurtre,[15] *associate scientist*
Horatio A Freeman,* *associate scientist*
Sarah Gavian,* *associate scientist*
Gemechu Degefa, *research technologist*
Mohammed Jabbar, *agricultural economist*
Mohammed Mussa,* *research technologist*
Nega Gebre Selassie, *research assistant*
Charles F Nicholson, *social scientist (Rockefeller Foundation Social Sciences Fellow)*
Barry Shapiro, *agricultural economist*
Solomon G/Selassie, *research technologist*
Joan Kagwanja,† *post-doctoral scientist*

Strengthening Collaboration with NARS Programme

Programme Leader Michael Smalley

Training and Conferences

Kenya

Rob Eley, *education officer*

Ethiopia

Elizabeth Getachew,† *assistant to the SCNARS programme leader*

Training Materials and Methods

Mohammed El-Habib Ibrahim,† *training materials specialist*

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[14] Salary provided by Germany, *GTZ Deutsche Gesellschaft fuer Technische Zusammenarbeit* (German Agency for Technical Co operation)
[15] Salary provided by France, *CIRAD EMVT*
* left in 1996
† joined in 1996
‡ transferred to ILRI in Hyderabad, India

Information

Kenya

Damaris Ng'ang'a, *librarian*

Ethiopia

Azeb Abraham, *librarian*
Marcos Sahlu, *documentation supervisor*
Pramod Sinha, *head of information services*

Publications

Kenya

Dave Elsworth, *head of graphics unit*
Susan MacMillan, *science writer*
Peter Werehire, *publications assistant*

Ethiopia

Sourou Adoutan, *French translator/editor*
Paul Neate, *head of publications*
Anne Nyamu, *science writer/editor*
Tekleab H/Michael, *head of pre-print operations*
Wondwossen Girma, *head of printshop*

Networks

Kenya

Sahr Lebbie, *co-ordinator, Small Ruminant Research Network*
Jean Ndikumana, *co-ordinator, African Feed Resources Research Network*

Ethiopia

Ebenezer Olaloku, *co-ordinator, Cattle Research Network*

Institutional Support

Administrative

Kenya

Mike Craig, *business manager*
George Kanza,† *chief accountant ILRI*
Brian Lloyd,* *financial controller*
Faith Matee, *purchasing officer*
Gacheru Migwi, *chief personnel officer*
George Mzera,* *stores superintendent*
David Kinyanjui,† *chief security officer*
Charles Ndungi, *transport manager*
Onesmus Nthiwa, *chief accountant*
Janephar Owino, *housing officer*

Ethiopia

Ahmed Osman, *assistant personnel officer*
Antonio Silla, *internal auditor*
Asmelash Worede,† *catering officer*
Belayhun Wondimu, *chief accountant*
Biscut Tessema, *disbursement and collection supervisor*
Dessalegn Mammo,† *chief personnel officer*
Emmanuel T/Mariam, *budget and procurement officer*
Michael Abebe, *medical officer*
Million Gebreab, *housing officer*
Negussie Abraham, *general accounts supervisor*
Revathi Rao, *manager, housing and catering services*
Tadesse Minas, *assistant personnel officer*
Aguibou Tall, *head of administration (Ethiopia)*
Techalew Negash,* *disbursement and collection supervisor*
Tibebe G/Amlak,† *national liaison officer*

Technical

Kenya

Sylvester Kisonzo, *computer software officer*
Alex Lobo,* *engineering superintendent*
Jim Scott, *head of computing services*
David Wanzala, *building and maintenance supervisor*

Ethiopia

Abeba Goitom, *research technologist*
Ali Mohammed, *research technologist*
Aynalem Tesfahun, *computer programmer*
Azeb Haile,* *research technologist*
Mamadou Diedhiou, *biometrician*
Genet Assefa, *research technologist*
Franco Leone, *physical plant manager*
Mebrahtu Ogbai, *research technologist*
Girmaye Tamiru, *research technologist*
Beyene Ambaye, *research technologist*
James Ochang, *research technologist*
Solomon Tessema, *computer engineer*
Tekeste Gebre Wold, *research technologist*
Tenaye Serekeberhan, *research technologist*
Yimer Ahmed, *research technologist*
Yohannes Yehulashet, *project supervisor/computer services*
Hambissa Belina,† *computer programmer*
Zerihun Tadesse,† *senior computer programme*

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* left in 1996
† joined in 1996

Post-doctoral Associates and Graduate Fellows at ILRI in 1996

Post-doctoral Associates

Name/ Nationality	Project Title	Location	End Date
Biodiversity			
Afui Mathias Mih, Cameroonian	Characterisation and conservation of forage germplasm and evaluation for development of livestock feeds	Ethiopia	1996
H Kaburu M'Ribu, Kenyan	*In vitro* cultivation of Napier grass and the molecular characterisation of *Sesbania* accessions and of Napier grass	Ethiopia	1996
Michael Peters, German	Selecting and testing forage legumes for sustainable agriculture and livestock production in subhumid West Africa with special emphasis on legume–legume combinations	Nigeria	1996
Rita Torto, Ghanaian	Physiology of non disease adaptive traits in small ruminants (Ethiopian highland sheep)	Ethiopia	1996
Valentine Yapi Chia Gnaore, Ivoirien	Classification and characterisation of African small ruminant genetic resources	Ethiopia	1996
Production Systems			
Emmanuel Mwendera, Malawian	Livestock productivity and environmental interference modelling	Ethiopia	1997
Augustine Naazie, Ghanaian	Model development on aspects of digestion kinetics	Nigeria	1997
Eva Schlecht, German	Sustainable crop–livestock production and natural resource management in semi arid West Africa	Niger	1997
Utilisation of Tropical Feed Resources			
Agnes Awino Odenyo, Kenyan	Rumen manipulation to enhance fibre utilisation	Ethiopia	1996

Graduate Fellows

Name/ Nationality	University/ Institute	Degree	Project Title	Location	End Date
Biodiversity					
Lambert Muhr, German	Hohenheim	MSc	Potential of selected forage legumes planted on fallow land for fodder production and soil improvement in integrated crop–livestock systems	Nigeria	1996
Jimoh Olanite, Nigerian	Ilorin	MSc	Evaluation of promising grass–legume mixtures for feeding to early weaned calves	Nigeria	1996
Animal Health Improvement					
Morris Agaba, Ugandan	Brunel	PhD	Identification and linkage mapping of bovine expressed DNA sequence polymorphisms	Kenya	1996
Joram Buza, Tanzanian	Sokoine	PhD	B lymphocyte responses in trypanosome infected cattle	Kenya	1996
Apolinaire Djikeng, Cameroonian	Brunel	PhD	Expressed sequence tags of *Trypanosoma brucei rhodesiense* reagents for the derivation of a transitional map of the causative agent of human sleeping sickness	Kenya	1998
Maurizio Durante, Italian	Bristol	PhD	The development of DBA markers to differentiate between two strains of trypanosome, one a *Trypanosoma brucei rhodesiense* and the other a *T brucei brucei*	Kenya	1996
Dirk Geysen, Belgian	Brunel	PhD	*Theileria parva* diversity in Zambia based on molecular biology techniques	Kenya	1998
Ines Glaser, German	Wurzburg	PhD	Generating a live vaccine against *Theileria parva* on the base of attenuated salmonella	Kenya	1996
Fiona Houston, British	Glasgow	PhD	Potential role of superantigens in the pathogenesis of bovine Theileriosis	Kenya	1996
Rosmin Janoo, Kenyan	Brunel	PhD	Characterisation of GTPases regulating protein trafficking in *Theileria parva*	Kenya	1997
Henry Mwambi, Kenyan	Nairobi	PhD	A mathematical model for the life cycle of *Rhipicephalus appendiculatus* and its interaction with cattle hosts	Kenya	1996
Simon Mwangi, Kenyan	Kenyatta	PhD	Molecular cloning of cDNA encoding bovine IL 3, and characterisation of the activity of the recombinant protein	Kenya	1996
Deo Olila, Ugandan	Nairobi	PhD	Molecular epidemiology of trypanosomiasis with particular emphasis on drug resistant phenotypes in Uganda	Kenya	1997
Alex Osanya, Kenyan	Brunel	PhD	Contribution to the characterisation of the *Trypanosoma brucei* genome Identification and characterisation of differentially expressed sequence tags	Kenya	1998
Ester Sebitosi, Kenyan	Ahmadu Bello	PhD	The physiology of the tick *Rhipicephalus appendiculatus* in relation to the transmission of *Theileria parva*	Kenya	1996

Graduate Fellows (cont'd)

Name/ Nationality	University/ Institute	Degree	Project Title	Location	End Date
Animal Health Improvement (cont'd)					
Deckster Savadye, Zimbabwean	Zimbabwe	PhD	Sequencing and mapping of *Theileria parva* schizont DNAs and the establishment of a sequence data base	Kenya	1999
Girish Shukla, Indian	Brunel	PhD	Role of the 7 1 kDa extrachromosomal genetic element of *Theileria parva* in parasite biology	Kenya	1996
Hagir Suliman, Sudanese	Virginia	PhD	Molecular cloning of bovine erythropoietin (EPO) and investigation of its role in the pathophysiology of trypanosome infections associated with anaemia in cattle	Kenya	1996
Ntando Tebele, Zimbabwean	Brunel	PhD	Identification and characterisation of the gene encoding the 200 kDa diagnostic antigen of *Babesia bigemina*	Kenya	1996
Van Hooft, Dutch	Wageningen	PhD	Development and variation of microsatellite markers in buffalo	Kenya	1997
Jun Wang, American	Massachusetts	PhD	Characterisation of a gene from African buffalo encoding a trypanocidal serum protein	Kenya	1997
Nyasha Chinombe, Zimbabwean	Zimbabwe	MSc	Developing genetic markers associated with trypanotolerance trait in cattle by Genetically Directed Representational Difference Analysis (GDRDA)	Kenya	1996
Emmanuel Chirebvu, Zimbabwean	Zimbabwe	MSc	Recombinant expression of *Theileria parva* antigens in attenuated *Listeria monocytogenes*	Kenya	1996
Aladji Diack, Senegalese	Brunel	MPhil	The effect of multiple treatment of cattle that harbour drug resistant *Trypanosoma congolense* on the infectivity of the parasites for *Glossina morsitans centralis*	Kenya	1997
Margaret Okomo, Kenyan	Nairobi	MSc	Characterisation of genetic diversity of East African cattle breeds using microsatellite markers	Kenya	1997
Kevin Olouch, Kenyan	Nairobi	MSc	Identification of schizont genes located on sub telomeric fragments of the *Theileria parva* genome	Kenya	1997
Beatrice Ondondo, Kenyan	Nairobi	MSc	Interaction of trypanosome cyclophilin with parasite and host molecules	Kenya	1997
Mulugeta Wubet, Ethiopian	Brunel	MPhil	Role of trypanosomal mitochondrial energetics in the accumulation and resistance to isometamidium by bloodstream forms of trypanosomes	Kenya	1996
Production Systems					
Atse Atse Pascal, Ivoirien	Côte d'Ivoire National	PhD	Productivity of ruminant livestock exposed to trypanosomiasis risk in Côte d'Ivoire	Côte d'Ivoire	1997
Augustine Ayatunde, Nigerian	Wageningen	PhD	Livestock-mediated nutrient transfers in the semi arid West African landscape	Niger	1997

Graduate Fellows (cont'd)

Name/ Nationality	University/ Institute	Degree	Project Title	Location	End Date
Production Systems (cont'd)					
Wame Boitumelo, Botswanan	Guelph	PhD	Nutritive evaluation of forage legumes	Ethiopia	1999
Robert Delve, British	Wye	PhD	Implications of livestock feeding management for long term soil fertility in smallholder mixed farming systems	Kenya	1996
Eneyew Negussie, Ethiopian	Technische Munchen	PhD	Characterisation of the indigenous Ethiopian sheep breed for feed intake and fat deposition as adaptive characteristics	Ethiopia	1998
Getachew Gebru, Ethiopian	Wisconsin	PhD	Assessment of feed resource base and the factors that affect access to feed resources in crop–livestock systems in the Ethiopian highlands	Ethiopia	1997
George Gitau, Kenyan	Nairobi	PhD	Quantitative assessment of the impacts of endemic stability and instability of tickborne diseases on dairy production in Kenya	Kenya	1997
Jones Govereh, Zimbabwean	Michigan	PhD	The effects of tsetse control on resource management institutions in Zimbabwe	Kenya	1997
Robert Kaitho, Kenyan	Wageningen	PhD	Nutritive value of multipurpose trees and shrubs as protein supplements to poor quality roughages	Ethiopia	1997
Pokou Koffi, Ivoirien	CIRES	PhD	Economic analysis of livestock production with tsetse control, multiple species and multiple breeds	Cote d'Ivoire	1996
Chris Laker, Ugandan	Makerere	PhD	Assessment of the economic impact of bovine trypanosomiasis and its control in Uganda	Kenya	1997
John Lekasi, Kenyan	Coventry	PhD	Management of livestock excreta for enhanced nutrient cycling efficiency on intensive smallholder farms in the east and central African highlands	Kenya	1999
Denis Mpairwe, Ugandan	Makerere	PhD	Development of food/feed production and management options for smallholder dairy production systems	Ethiopia	1997
Constance Mugalla, Kenyan	Penn State	PhD	Livestock production in The Gambia and implications of trypanosomiasis control on the Gambian household	The Gambia	1998
Bartholemew Mupeta, Zimbabwean	Zimbabwe	PhD	Milk production and growth of exotic x indigenous crossbred cows and their progeny and the efficiency of utilisation of home grown protein sources in smallholder dairy sector in Zimbabwe	Kenya	1996
David Mwangi, Kenyan	Wye	PhD	Factors affecting the growth and persistency of companion legumes for cut-and carry Napier grass	Kenya	1999
Sarah Ossiiya, Ugandan	Texas A&M	PhD	Development of a nutritional profiling system for free ranging livestock in major agro ecological zones of sub Saharan Africa	Niger	1996
Mamadou Sangare, Nigerian	Prince Leopold Institute	PhD	Optimising the use of feed sources for feeding livestock and recycling nutrients	Niger	1999

Graduate Fellows (cont'd)

Name/ Nationality	University/ Institute	Degree	Project Title	Location	End Date
Production Systems (cont'd)					
Kimberly Swallow, American	Wisconsin	PhD	Local socio economic institutions and their influence on smallholder farmers' enterprise and technical adoption decisions The case of the adoption of dairy cattle enterprises and improved cattle feed production techniques in the coconut–cassava agro ecological zone of coastal Kenya	Kenya	1996
Kouadio Tano, Ivoirien	Manitoba	PhD	Trypanosomiasis and trypanotolerant livestock in West Africa	Burkina Faso	1998
Patrick Irungu, Kenyan	Nairobi	MSc	Economic analysis of factors affecting adoption of Napier grass by high potential Kenyan dairy farms	Kenya	1997
Cathrine Melard, Belgian	Notre Dame de la Paix	MSc	Labour management in the Ginchi watershed Impact on common good management	Ethiopia	1996
Mengistu Alemayehu, Ethiopian	Alemaya	MSc	Draft performance of F_1 crossbred dairy cows and local oxen under smallholder farm management conditions	Ethiopia	1996
Mengistu Buta, Ethiopian	Alemaya	MSc	Crossbred cows for milk and traction in the Ethiopian highlands A whole-farm evaluation	Ethiopia	1997
Feza Mpungu, Zairean	Notre Dame de la Paix	MSc	Land tenure in the Ginchi watershed Impact on common good management	Ethiopia	1996
Sandra Mwebaze, Ugandan	Makerere	MSc	Biomass production of maize intercropped with selected forage legumes for food and feed in smallholder farming systems	Ethiopia	1996
Mucheni Nderi, Kenyan	Kenyatta	MSc	Role of tsetse flies in the transmission of trypanosome infections to cattle in Taita/Taveta District, Coast Province, Kenya	Kenya	1996
Solomon Mamo, Ethiopian	Alemaya	MSc	On farm feeding management and production performance of crossbred dairy cows in the Ethiopian Highlands	Ethiopia	1996
Natfaly Wachira, Kenyan	Nairobi	MSc	Risk and resource management strategies in smallholder dairy farms in central Kenya	Kenya	1996
E Wekare, Zimbabwean	Nairobi	MSc	Trypanosomiasis epidemiology in Zimbabwe	Kenya	1996
Tennyson Williams, Sierra Leonean	Sierra Leone	MSc	Estimating the potential market for new vaccines against theileriosis in eastern and southern Africa	Kenya	1996
Workineh Abebe, Ethiopian	Alemaya	MSc	Assessment of nutritive value and consumer preference of goat milk and milk products	Ethiopia	1996
Utilisation of Tropical Feed Resources					
Gabriel Nakokonya, Kenyan	Moi	PhD	Effects of different rumen conditions on fibre degradation	Ethiopia	1999

Graduate Fellows (cont'd)

Name/ Nationality	University/ Institute	Degree	Project Title	Location	End Date
Livestock Policy Analysis					
Carol Cabal, Filipina	Hawaii	PhD	Integrated crop–livestock agricultural systems Impacts on household food security in the central Ethiopian highlands	Ethiopia	1997
Ika Darnhofer, Austrian	Vienna	PhD	Land tenure resource management systems	Ethiopia	1996
Solomon Desta, Ethiopian	Utah State	PhD	Banking livestock capital for pastoral risk management and urban development in Ethiopia	Ethiopia	1999
Minale Kassie, Ethiopian	Alemaya	MSc	Economics of crop–forage integration and nutrient management intervention in mixed farms in highland Ethiopia	Ethiopia	1997

Publications by ILRI staff in 1996

Annual reports

ILRI (International Livestock Research Institute) 1996 *ILRI 1995 Building a Global Research Institute* ILRI, Nairobi, Kenya 77 pp
ILRI (International Livestock Research Institute) 1996 *ILRI 1995 Building a Global Research Institute Highlights* ILRI, Nairobi, Kenya 22 pp
ILRI (Institut international de recherche sur l'elevage) 1996 *L'ILRI en 1995 Creation d'un institut mondial de recherche Synthese des programmes* ILRI Nairobi (Kenya) 22 pp
ILRI (Instituto Internacional de Investigaciones Pecuarias) 1996 *ILRI 1995 Consolidacion de un Instituto Mundial de Investigacion Reseña de las Actividades* ILRI, Nairobi (Kenia) 22 pp
ILRI (International Livestock Research Institute) 1996 *ILRI Annual Project Report 1995* ILRI, Nairobi, Kenya 216 pp

Newsletters

Livestock Research for Development vol 2
Recherche sur l'elevage pour le developpement vol 2
Investigacion pecuaria para el desarrollo vol 2

Project protocols and funding requests

ILRI (International Livestock Research Institute) 1996 *ILRI Programme Plan and Funding Request for 1997* ILRI, Nairobi, Kenya 53 pp
ILRI (International Livestock Research Institute) 1996 *1996 ILRI Project Workplans* ILRI, Nairobi, Kenya 158 pp

Manuals

FARM Africa 1996 *Goat Types of Ethiopia and Eritrea Physical description and management systems* ILRI Nairobi, Kenya 76 pp
ILRI (International Livestock Research Institute) 1996 *Training Policy and Procedures Manual* ILRI, Nairobi, Kenya 60 pp

Training module

Van Gastel A J G , Bishaw Z , Griffiths R and Hanson J 1996 *Seed Processing* Audiovisual training module ICARDA (International Center for Agricultural Research in the Dry Areas), Aleppo, Syria, and ILRI (International Livestock Research Institute), Addis Ababa, Ethiopia 16 pp

Glossary

ILCA (International Livestock Centre for Africa) 1996 *ILCA Glossary of Livestock and Related Terms English–French* ILCA, Addis Ababa, Ethiopia 236 pp

Proceedings

Bealby K A, Connor R J and Rowlands G J 1996 *Trypanosomosis in Goats in Zambia* ILRI (International Livestock Research Institute), Nairobi, Kenya 88 pp

Irvin A D, McDermott J J and Perry B D (eds) 1996 *Epidemiology of Ticks and Tick-borne Diseases in Eastern, Central and Southern Africa FAO/ILRI Workshop on Epidemiology of Ticks and Tick borne Diseases in Eastern, Central and Southern Africa, Harare, Zimbabwe, 12–13 Mar 1996* ILRI (International Livestock Research Institute), Nairobi, Kenya 174 pp

Lebbie S H B and Kagwini E (eds) 1996 *Small Ruminant Research and Development in Africa Proceedings of the Third Biennial Conference of the African Small Ruminant Research Network, UICC, Kampala, Uganda, 5–9 December 1994* ILRI (International Livestock Research Institute), Nairobi, Kenya 317 pp

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Financial Summary

INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE
STATEMENT OF ACTIVITY
for the year ended 31 December 1996
(US$ '000)

Revenue	1995	1996
Grant	23,846	24,775
Other income	1,198	1,195
Total revenue	25,044	25,970
Expenses		
Research	15,713	16,495
Information services	1,290	1,486
Training and conferences	983	897
General administration and operations	4,379	3,967
Board and management	853	787
Depreciation	2,022	2,335
Total expenses	25,240	25,967
Surplus (deficit) for the year	(196)	3

INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE
STATEMENT OF FINANCIAL POSITION
at 31 December 1996
(US$ '000)

Current assets	1996	1995
Bank and cash balances	14,665	15,987
Accounts receivable	847	1,228
Receivable from donors	1,999	2,826
Inventories	1,215	1,344
Deposits and prepayments	338	419
Total current assets	19,064	21,804
Fixed assets		
Property, plant and equipment	19,862	18,187
Construction work-in progress	90	719
Investment in subsidiary	1,816	1,816
Total fixed assets	21,768	20,722
Total assets	40,832	42,526
Liabilities		
Accounts payable	3,765	3,829
Payments in advance—donors	2,237	2,214
In-trust funds	195	264
Accruals and provisions	1,628	3,357
Total liabilities	7,825	9,664
Fund balances		
Capital invested in fixed assets	21,768	20,722
Operating funds	7,042	7,038
Capital fund	4,197	5,102
Total fund balances	33,007	32,862
Total liabilities and fund balances	40,832	42,526

INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE
1996 DONOR FUNDING
(US$ '000)

Donor	Unrestricted	Restricted		Out-sourcing	Total 1996 income
		Programme	Project		
Australia	223	0	198		421
Austria	175	0	0		175
Belgium	514	0	785	427	1,726
BMZ/Germany	1,074	0	485		1,559
Canada	911	0	0		911
Denmark	848	0	0		848
EU	0	0	1,099		1,099
France	311	0	42		353
Finland	377	0	0		377
IDRC	0	0	37		37
IFAD	0	0	205		205
India	37	0	0		37
Ireland	0	560	0		560
Italy	200	0	0		200
Japan	461	1,080	0		1,541
Luxembourg	0	0	0	3	3
The Netherlands	301	0	127		428
Norway	1,320	0	0		1,320
OPEC	0	0	31		31
Rockefeller Foundation	0	0	86		86
Spain	10	40	0		50
Sweden	670	0	0		670
Switzerland	1,952	0	0		1,952
UK	500	533	82		1,115
USA	2,600	0	70		2,670
World Bank	6,250	0	0		6,250
	18,734	2,213	3,247	430	24,624
SLP					
The Netherlands			151		151
Total	18,734	2,213	3,398	430	24,775

Credits

Text Paul Neate

Principal scientific sources A J Musoke and D McKeever (*Potential vaccine enters field testing*), W Thorpe and E Olaloku (*Building national capacity for market-oriented smallholder dairy research and development*), J Hanson (*The grass is always greener*), S Tarawali (*Forage legumes boost livestock and crop production*), A Teale and L Baker (*Marker-assisted breeding programmes*), S Lebbie (*Networking — building for the future*), H A Freeman and S Ehui (*Importance of assessing true credit constraint*)

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