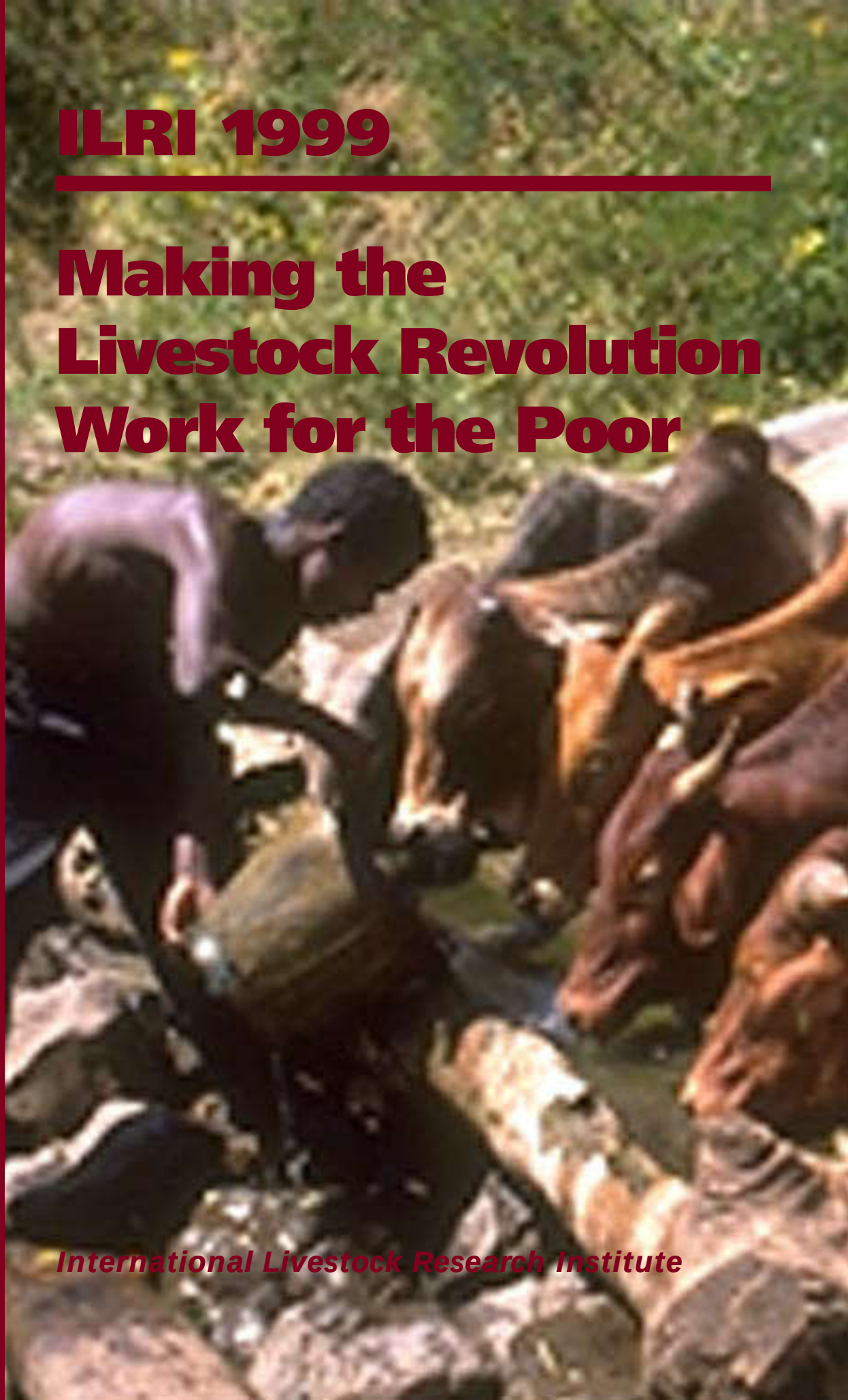
ILRI

INTERNATIONAL
LIVESTOCK RESEARCH
INSTITUTE

ILRI 1999

Making the Livestock Revolution Work for the Poor



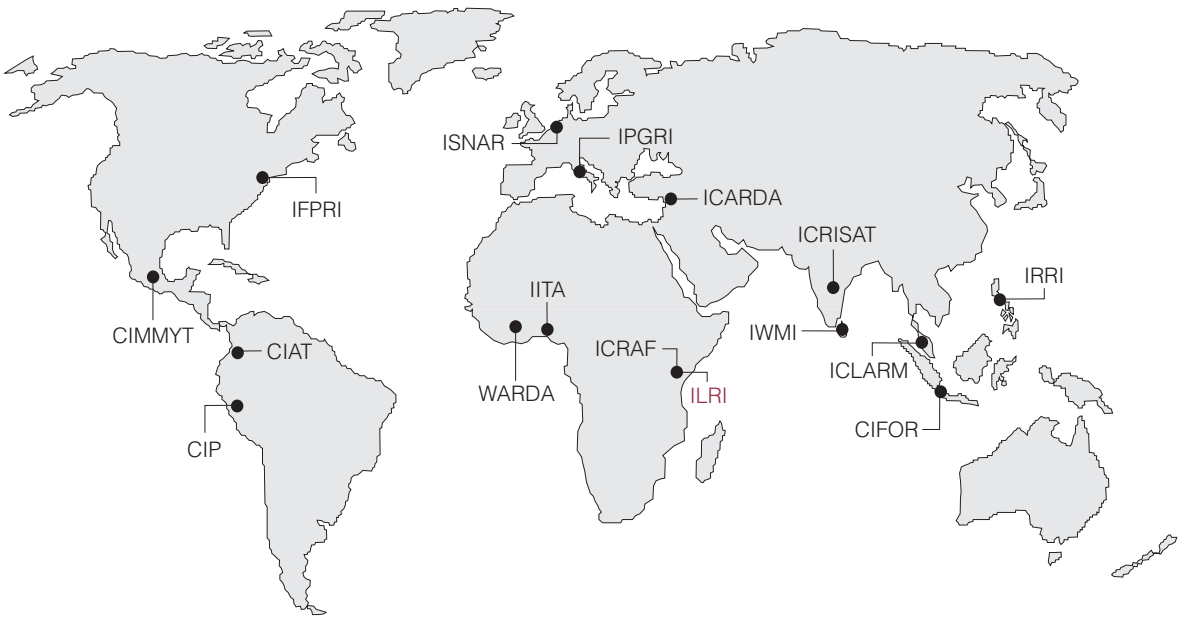
International Livestock Research Institute

About ILRI

The International Livestock Research Institute (ILRI) is a public-sector international agricultural research centre under the aegis of the Consultative Group on International Agricultural Research (CGIAR). ILRI's mandate is to enhance the well-being of present and future generations in developing countries through research to improve sustainable livestock production. It works in partnerships and alliances with other organizations, national and international, in the fields of livestock research, training and information exchange. ILRI was formed in 1994 and is headquartered in Nairobi, Kenya.

About the CGIAR

Established in 1971, the Consultative Group on International Agricultural Research (CGIAR) is an informal association of public- and private-sector members that supports a network of 16 international agricultural research centres. The CGIAR's mission is to contribute to food security and poverty eradication in developing countries through research, partnership, capacity building and policy support. It promotes sustainable agricultural development based on the environmentally sound management of natural resources.



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Foreword

ILRI's Annual Report this year takes as its theme the central challenge facing the Institute and its partners at the start of the new millennium: making the Livestock Revolution work for the poor.

What is the Livestock Revolution and why does it matter? In essence, it is a massive demand-driven increase in the production of meat, milk and eggs in developing countries that is taking place now and will continue for the foreseeable future. It matters because of its profound implications for equity, the environment and human health. In all three of these fields, the outcome of the Revolution is uncertain, depending greatly on what governments and others can do to make it come right. The major equity issue is the extent to which poor livestock producers will be able to benefit from the Revolution, meeting the rising demand for livestock products from their farms and enjoying increased incomes and living standards as the just reward for their work.

Our report begins and ends on a farm in central Ethiopia, whose mixed crop–livestock producers are just beginning to participate in the expanding dairy market of the country's capital, Addis Ababa. In between, we explore the anatomy of the Revolution—what has happened and what will happen to supply and demand for different livestock products in different parts of the world—then discuss the implications for equity, the environment and human health, before briefly reviewing some of the policy, institutional and technological interventions that can ensure that the Revolution has a 'benign' outcome. Many of these interventions are already under research by ILRI and its partners around the world. Others will be in the coming years.

Nineteen ninety-nine was a year in which the magnitude of the Livestock Revolution and its implications were brought home to the international agricultural research community in no uncertain terms. June saw the publication of a major report on the subject under the 2020 Vision Initiative of ILRI's sister institute in the CGIAR, the International Food Policy Research Institute (IFPRI). Entitled *Livestock to 2020: The Next Food Revolution*, the report is the fruit of collaboration between IFPRI, the Food and Agriculture Organization of the United Nations (FAO) and ILRI. It formed the subject of a joint IFPRI–ILRI presentation at International Centers Week in October and provides the major source for this annual report. In July, the USA-based Council for Agricultural Science and Technology (CAST) published a

balanced yet upbeat assessment of the contribution livestock can make to future global food supplies. That is not to downplay the real concerns raised by the Revolution, which also made themselves felt. In April, for example, came news from Malaysia of the slaughter of a million pigs following the outbreak of a new and lethal form of paramyxovirus that had jumped the species barrier to human beings—a potent reminder of what can go wrong with the Revolution and of the urgent need for research to mitigate potential problems.

ILRI is well prepared to meet the challenges posed by the Livestock Revolution. That, at least, was the opinion of a distinguished group of experts who in 1999 completed a review of the Institute's progress over the five years since its foundation. The Panel of ILRI's first External Programme and Management Review (EPMR), whose report was presented to ILRI's Board and management in March 2000, strongly endorsed the quality of the Institute's science and the value of the investments made in its programmes. The Panel noted that ILRI is becoming 'a world leader' in the areas of animal genetic resources and disease resistance/tolerance, and hailed its research on smallholder dairying as 'a model of effectiveness'. It commended the Institute for its increased activities in policy research and impact analysis, together with its keen awareness of the need for impact. The review team meted out constructive criticism along with its praise, providing ILRI with much useful guidance on how to improve its programmes still further in the opening years of the new century.

The Panel's overall conclusion was that ILRI strongly deserves increased investment. ILRI embodies the international community's sole major effort to confront the full range of researchable problems faced by resource-poor livestock keepers throughout the developing world. Its current funding is well below the level recommended by the CGIAR's Technical Advisory Committee (TAC), with the result that its resources are in danger of being spread too thinly. As the Livestock Revolution gathers pace the demands on the Institute can only grow, a prospect that makes the case for increased investment today even stronger.

The dynamic and rapidly evolving livestock sector presents ILRI with new and exciting research opportunities. At the same time, the Institute's limited resources will continue to impose difficult choices as to the problems it can address. That is why, hard on the heels of the EPMR and in response to its recommendations, ILRI began the task of developing a new strategic plan.

The approach taken to strategic planning was participatory yet rigorous. The process took as its starting points a series of consultations with partners and stakeholders held in the world's developing regions between 1995 and 1998, together with a comprehensive background paper on the external environment with which future livestock research and development will interact. Measurable criteria for assessing and deciding on priorities were established. Seven priority areas in which ILRI would work in the future were identified and explored in detail through thematic focus groups. These groups comprised both ILRI staff and external participants, with the latter drawn from different backgrounds including non-governmental organisations (NGOs) and the private sector in addition to national research systems. Research needs and opportunities were assessed for each theme and relevant research and related activities proposed. The criteria used for choosing activities were researchability, relevance to poverty alleviation, current or potential comparative advantage of ILRI over alternative suppliers, a clear role for ILRI to play, and the potential for outputs that will be international public goods. The planning process was orchestrated by a steering committee consisting of ILRI management and staff, which in turn was overseen by the ILRI Board and senior management.

ILRI's Strategy to 2010, which was approved by the Board in April 2000, represents its considered response to the challenges posed by the Livestock Revolution over the first decade of the new millennium. Through the strategy, ILRI renews its commitment to livestock research as a tool for alleviating poverty in developing countries, promising to continue and intensify its efforts to bring new science to bear on the constraints that currently hold back livestock productivity and threaten the natural resource base. While the bulk of ILRI's research will continue to focus on ruminants in smallholder systems, the strategy envisages activities in several new areas, including the social and environmental issues raised by large-scale industrial production systems and the control of emerging diseases of trade and zoonotic diseases. In addition, there will be increased emphasis in a number of areas where ILRI has already made its mark, including the conservation and use of indigenous forage and livestock biodiversity and policy research to encourage technology adoption.

The EPMR and the strategic planning exercise were major accomplishments in 1999, but the year also saw significant operational and scientific advances. Marking further progress in the development of a geographical spread of activities that reflects its

global mandate, ILRI launched a new programme in South-East Asia, based at Los Baños in the Philippines. In the wake of the severe financial crisis that hit this region in 1997, livestock are a possible route out of poverty for many millions of its people. The task of increasing animal productivity is therefore an urgent one, not only to raise incomes but also to protect an increasingly threatened natural resource base. The new programme, which will benefit greatly from the activities already under way in South Asia, includes research in disease control, nutrient cycling in mixed crop–livestock systems and the analysis of policy options to help smallholders compete with large-scale industrial production.

ILRI's continuing pursuit of excellence in science that serves the needs of the poor brought special recognition to its staff. For the third year running, ILRI featured in the CGIAR Chairman's Awards at International Centers Week. This time the award was for Outstanding Locally Recruited Scientist, which went to Kenyan-born veterinarian and epidemiologist, Amos Omore. Amos is on secondment to ILRI from the Kenya Agricultural Research Institute (KARI), with which ILRI shared the Chairman's Award for Outstanding Scientific Partnership in 1997. He is currently investigating the public health risks associated with the informal marketing of unprocessed milk, which comprises most of the milk consumed in Kenya and other developing countries.

ILRI's first EPMR endorsed the Institute's mandate as more relevant now than at any time since the CGIAR embarked on livestock research. We thank all our investors and partners for their part in enabling ILRI to pursue this mandate. With your continuing support, we shall succeed in making the Livestock Revolution work for the poor.

Hank Fitzhugh
Director General
ILRI

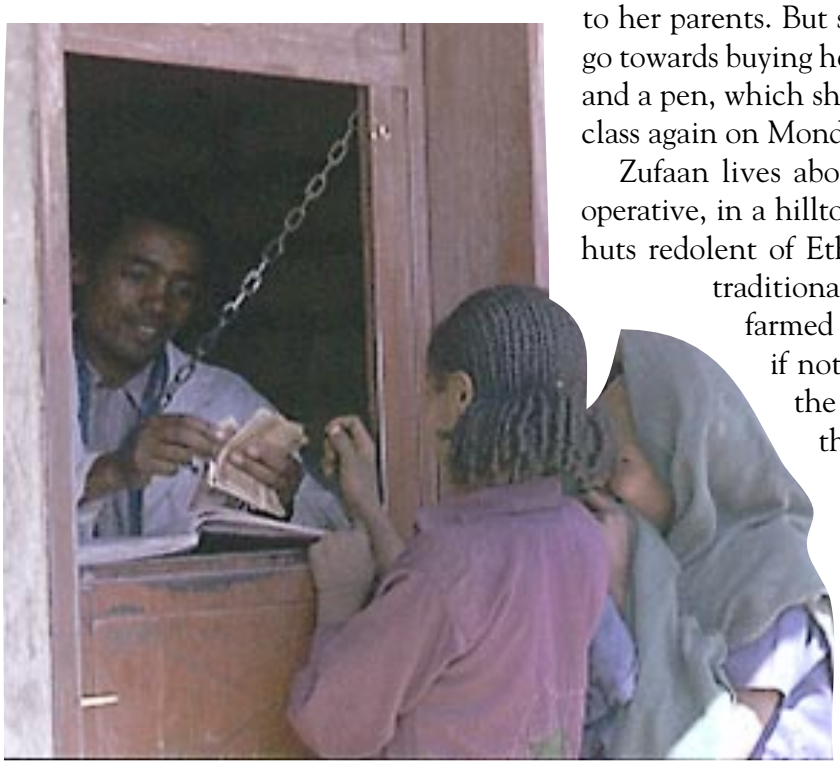
John Vercoe
Chairman
ILRI Board of Trustees

Making the Livestock Revolution work for the poor

Changing times

Friday is pay-day at the Edoro milk co-operative. As she queues to receive the 100 or so Ethiopian birr (US$ 12.25) owing to her family, 16-year-old Zufaan Assefaw is missing a morning at school but getting a lesson in economics just the same.

The money is a measure of the importance to her family of the small-scale dairy enterprise that now takes up much of their time. Zufaan, like her brothers and sisters, knows how to milk, feed and care for the family's crossbred cows and, on the days when she's not at school, frequently helps her parents out by doing so. When she gets home, Zufaan will hand the money over to her parents. But she knows that part of it will go towards buying her a new school exercise book and a pen, which she will need when she attends class again on Monday.



Zufaan lives about a kilometre from the co-operative, in a hilltop hamlet of thatch-and-daub huts redolent of Ethiopian rural life at its most traditional. Here, where her family has farmed for generations, it appears as if nothing could ever change. But the appearance is deceptive, for the bucket of milk delivered to the co-operative every day from her parents' household represents a radical departure from the farming practices of the past.

Zufaan's father, Assefaw Belachew, remembers how the family used to farm

when he was a boy. 'At Zufaan's age I never went to school at all but helped my father by doing the ploughing,' he says. 'We had local oxen and grew barley, oats, horse beans, broad beans and wheat. We ate most of what we produced and sold the small amounts we had left over.' The family's farming system began to change in 1988, when the household received its first crossbred dairy cow under a project funded by the Finnish International Development Agency (FINNIDA). The project's aim was to stimulate dairy production in the central highland plain that is the hinterland of Ethiopia's capital city and largest urban market, Addis Ababa. Over the past decade the family has increased its herd to three crossbred cows, six bulls and their calves—numbers which fluctuate according to the need to sell animals. To feed them, Assefaw has given up growing wheat and switched to oats, a dual-purpose crop well suited to the rugged highland environment. In a sheltered spot behind the homestead he has also created a well-manured garden planted mainly to vetch and fodder beet.

This year the family will earn over 3000 birr (US$ 368) from dairying, about a third of it from milk and two-thirds from live animals.

Asked which he prefers, the past or the present, Assefaw doesn't hesitate. 'Life is better now,' he replies. 'Our incomes have increased and we're able to spend more on household goods, clothes and extra food.' Assefaw's earnings from livestock also pay the school fees for his children—perhaps the most important investment he can make in his family's future.

A demand-driven Revolution

'A revolution is taking place in global agriculture that has profound implications for our health, livelihoods and environment.' —2020 study.

The shift from subsistence cropping to market-oriented livestock production undergone by Assefaw and his family is being repeated in varying forms and to varying degrees in millions of households across Africa, Asia and Latin America. For all these households, to acquire livestock is to set foot on the first rung of the ladder out of poverty. All are participating in what ILRI and its partners call the Livestock Revolution.

Put simply, the Livestock Revolution is a fundamental change in the way people eat. As their incomes rise, people diversify their diets, giving up traditional staple cereals in favour of more milk, meat, fish and eggs. The change is accentuated in cities, where incomes are higher and life-styles more sophisticated. And it is underpinned by continuing population growth, which increases the need for all kinds of food. The result is accelerating demand for livestock products, to which producers respond by increasing supplies.

Why a revolution and not an evolution? 'We call it a revolution to draw people's attention to the fact that the change is happening rapidly and on a massive scale,' says Simeon Ehui, co-ordinator of ILRI's Livestock Policy Analysis Programme. If the word 'revolution' serves as something of a wake-up call, that is no bad thing, according to Ehui. Like its well-known predecessor, the Green Revolution in cereal crops, the Livestock Revolution offers poor producers tremendous opportunities to increase their incomes and feed their families better. But it isn't guaranteed that they will be able to take advantage of those opportunities. The right policies and technologies need to be in place to enable them to do so. In addition, the Livestock Revolution has profound implications for the environment and human health. Here too, action will be needed to avoid its potentially negative effects. Government policy makers, planners, scientists and development workers, as well as the farming community, need to work out how

they are going to respond to the Revolution. 'It's happening, whether we like it or not,' says Ehui. 'We can't just sit back and watch.'

In 1998, ILRI became a partner in a comprehensive study of the implications of the rapidly rising demand for livestock products in developing countries. The study, whose authors coined the term 'Livestock Revolution' as they came to grips with those implications, formed part of the 2020 Initiative of the International Food Policy Research Institute (IFPRI), ILRI's sister institute within the CGIAR and the study co-ordinator. The third partner in the study was the Food and Agriculture Organization of the United Nations (FAO).

The study's report, of which Ehui is a co-author, was published by IFPRI in 1999 (see Delgado et al. in the list of sources on p. 37). It highlights the part that research must play in developing the necessary technologies and policies to support a Livestock Revolution that benefits poor producers and consumers while enhancing the environment and human health. The accelerating Livestock Revolution has major implications for the allocation of research resources at the international, regional and national levels. It is the main reason why the Technical Advisory Committee (TAC) of the CGIAR continues to recommend an increase in the resources made available to ILRI, which remains the world's only international research institution with a global mandate devoted entirely to livestock research.

Our Annual Report this year, which draws on the 2020 study as its major source, explores the Livestock Revolution and its implications. It shows how the research conducted by ILRI and its partners is already helping to ensure the Revolution's positive outcome. It is a companion report to the Institute's new strategic plan, which takes the Revolution as its basis in determining how ILRI's programme should evolve in the first decade of the 21st century.

'The stakes for the poor in developing countries are enormous.'—2020 study.

Winners and losers

Let's begin by looking at the Livestock Revolution in more detail. We'll start with what has already happened and project this forward over the next 20 years. It's safe to do this because the forces fuelling the Revolution—income growth, urbanisation and population growth—show no signs of abating.

First, the global picture. Aggregate data on consumption and production show the scale on which change is taking place. Between the early 1970s and the mid-1990s, the amount of meat eaten in the developing countries as a whole rose three times faster than in the developed countries, while the amount of milk drunk rose twice as fast (Table 1). Producers in the developing countries have responded to this soaring demand. In the decade to 1993, they increased their share of global production from 36% to 47% for meat and from 24% to 32% for milk. In short, livestock production, with all its costs and benefits, is shifting from the developed to the developing world.

Table 1. Increases in the consumption of livestock products in developed and developing countries, 1971–95.

	Consumption increase		Monetary value of consumption increase		Caloric value of consumption increase	
Commodity	**Developed**	**Developing**	**Developed**	**Developing**	**Developed**	**Developing**
	(million metric tonnes)		(billion 1990 US$)		(trillion kilocalories)	
Meat	26	70	37	124	38	172
Milk	50	105	14	29	22	64
Fish	5	34	27	68	4	20
Major cereals	25	335	3	65	82	1,064

Source: Delgado et al. (1999).

That is good news, reflecting as it does an improvement in diets, incomes and living standards for many millions of producers and consumers. But when the data are broken out for each region, a more complex picture emerges—and a far less reassuring one. Some regions and countries have witnessed extraordinarily rapid growth in consumption and production, while others have fared less well and still others downright badly. Predictably, the fastest growth has occurred in Asia, reflecting that region's relatively rapid overall economic growth and rapidly rising incomes. Asia's star performers have been China and India, the former doubling its consumption of meat in just a decade while the latter achieved astonishingly rapid progress in milk production. Latin America has also seen healthy rises in the production and consumption of both meat and milk, accompanied by strong growth in meat exports. West Asia-North Africa too has gained overall, although per capita milk production has fallen slightly. The big exception to the upward trend—and the region that continues to give rise to the greatest concern—is sub-Saharan Africa (excluding South Africa), where the amount of meat and milk produced and consumed per head of population has fallen steadily over the past quarter century. The poor performance of

this region's livestock sector reflects its poor overall economic performance, with per capita incomes declining despite rapid urbanisation.

Trends in the production and consumption of individual livestock commodities have also mirrored income growth. At annual rates of over 7% and 6% respectively, pork and poultry have grown fastest, reflecting their status as city dwellers' foods *par excellence*. At over 3%, beef and milk have still grown considerably faster than human population, with consumption being more equally distributed between town and country. Trends at regional and national levels have also been influenced by differences in tastes, culture and other factors. For example, lactose intolerance has curbed the demand for milk in East Asia, vegetarianism has depressed meat consumption in South Asia, and Muslims everywhere have eschewed pork.

Despite the dramatic changes it has brought to many people's lives, the Livestock Revolution of the past 20 years looks modest compared to the one that is to come. Figure 1 shows how far the Revolution has yet to run. In 1993, the 23% of the world's population living in developed countries still consumed three to four times as much meat and fish and five to six times as much milk as people in developing countries. By 2020, if present trends continue, over half the world's milk and nearly two-thirds of its meat will be produced and consumed in the developing countries, although per capita consumption will still lag behind that of the developed world.

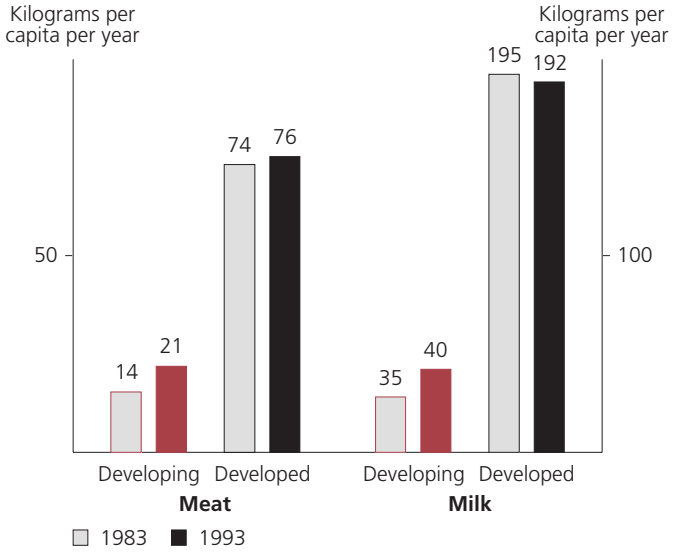
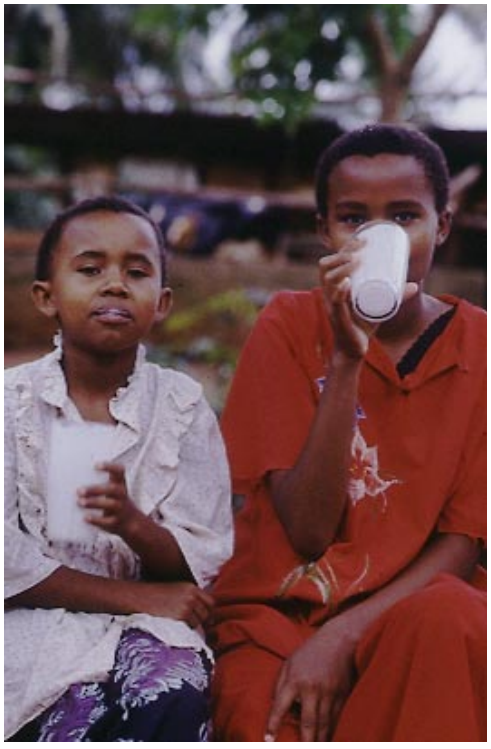


Figure 1. Per capita consumption of meat and milk in developing and developed countries, 1983 and 1993.

Source: Delgado et al. (1999).

Once again, the picture for individual regions and commodities is more complex and more worrying. Per capita meat consumption in 2020 is projected to remain relatively low in sub-Saharan Africa, partially vegetarian India and other countries in South Asia. Per capita milk production will be highest in Latin America and India, but sub-Saharan Africa will again fare relatively badly.

These projections assume that present trends are merely extended. But suppose they get pushed off course by unforeseen changes in the factors that underlie them. Using the IMPACT model developed at IFPRI, the economists conducting the 2020 study worked out what would happen to supply and demand under different assumptions as to what the future held. The assumptions they tested were that Asia would suffer a prolonged slump, that Indian tastes would change so that the subcontinent consumed more meat, and that the efficiency with which feed is converted to meat and milk would either increase or decrease over time. Their results showed that the Livestock Revolution is remarkably durable under all these different assumptions. For example, even in the event of a severe and prolonged Asian crisis, the long-term prospects for expansion of the livestock sector in Asia and the rest of the world continue to look reasonably good. And, surprisingly, large changes in the efficiency of feed grain conversion would have little impact on the consumption of livestock products but would rather affect the amount of cereal used in livestock production, because producers would switch to different feeds if cereal prices rose.



One of the most significant effects of the Livestock Revolution in developing countries is that it will suck in imports of cereal feed grains, needed mainly to feed the rapidly rising population of swine and poultry. These imports will probably come mainly from the developed world. Compared to 1993, net grain imports in developing countries in 2020 are projected to rise by 133 million tonnes—an amount equivalent to roughly 60% of the entire USA maize crop in the early 1990s.

The Livestock Revolution will generate a substantial economic surplus for both producers and consumers. As in the Green Revolution in crops, consumers seem likely to capture more of the benefits than producers. Prices of livestock products have fallen steadily over the past 20 years and will probably

continue to do so (Figure 2). Grain producers stand to benefit more than livestock producers: in 1994–96, the price of beef was only 34% of its level 20 years earlier, whereas that of maize was 54%. However, as we shall see, there will be opportunities for livestock producers too.

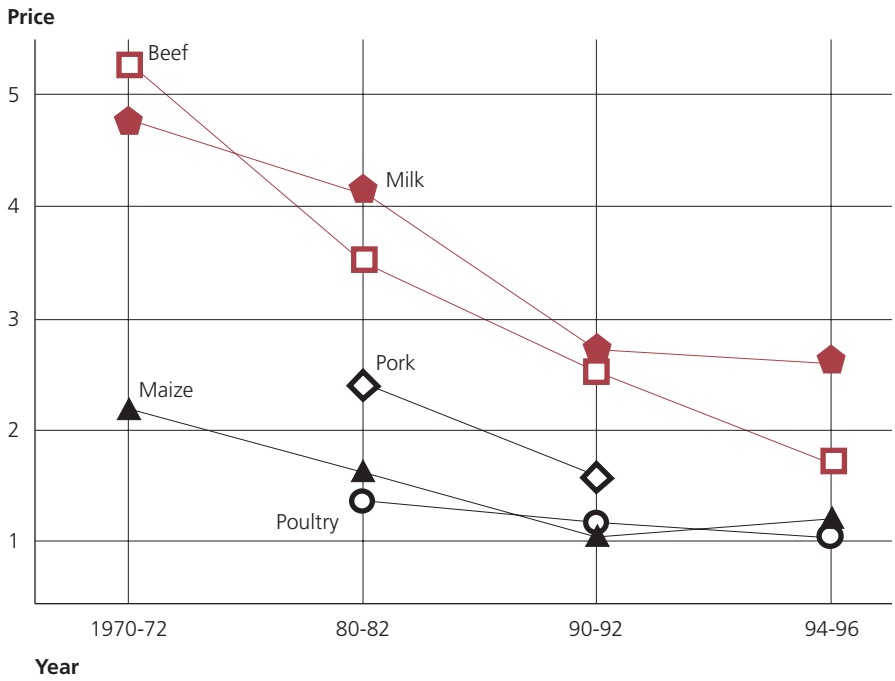


Figure 2. Real prices (1990 US$/tonne) of livestock products and maize, 1970–96.

Source: Delgado et al. (1999).

Saint or sinner?

So much for the facts about the Livestock Revolution. But what are its implications? 'Like all big changes on this small planet, the Livestock Revolution has an up-side and a potential down-side,' says Ehui.

The Livestock Revolution could be a powerful force for delivering more equitable development in the world's poorest countries and areas. Over 1.3 billion people—nearly a third of the population of the developing world—live below the poverty line. Sub-Saharan Africa, where per capita incomes average only US$ 480 per year, remains the world's poorest developing region, so it is here that an equity-oriented Revolution is most needed.

But South Asia still has the world's highest absolute numbers of poor people—an estimated 417 million of them—and poverty persists in several other parts of the developing world, including the Andean region of Latin America and pockets of West Asia-North Africa. Generally, peri-urban producers tend to be better off than the more deeply rural, while the most disadvantaged are those living in remote mountainous areas or areas that are too dry for cropping.

The 2020 study cites several reasons why the Livestock Revolution should be good for the incomes of poor producers. The poor can more easily increase their incomes when they enter a market that is growing, especially if they add value to primary produce by processing it. In areas under pressure from population growth, the rising demand for livestock products comes at a time when poor farmers desperately need higher returns to their shrinking and deteriorating land resources than crops alone can offer. And livestock are an enterprise that the poor can launch relatively easily, using feed and other resources present in their local environments. Case studies in Africa, Asia and Latin America show that the poor and landless derive a higher share of their income from livestock than do better-off people in the same communities (Table 2). It is worth dwelling for a moment on the dramatic difference in living standards that even small livestock-related interventions can make in resource-poor farming households. For a family like Assefaw's, replacing a local cow with a crossbred one changes a food deficit, with its attendant risks of

'Livestock production offers one of the few rapidly growing markets that poor rural people can join even if they lack substantial amounts of land, training and capital.'—2020 study.

malnutrition, into a healthy surplus that brings in a steady cash income. Multiply that by a million, and you unleash a powerful engine for economic growth in deprived rural areas.

Country/Zone	Reference	Sub-sample	
		Richest	Poorest
Senegal (arid zone)	Kelly et al. (1993)	14	24
Senegal (semi-arid)	Kelly et al. (1993)	8	10
Philippines	Bouis (1989)	10	23
Pakistan	Adams and He (1991)	9	25
		Large landowners	**Landless**
Egypt	Richards and Martin (1983)	14	63

Source: Adapted from Delgado et al. (1999).

Table 2. Share of income (%) from livestock in rich and poor households.

Countries that take decisive action to introduce the policies and technologies that will enable poor producers to participate in the market should, therefore, quickly reap the benefits. By the same token, those that adopt a *laissez-faire* approach to the Livestock Revolution run the risk of allowing their poor producers to be shut out of one of the few expanding markets available to them. It is by no means clear that small-scale farmers using traditional methods will be able to compete with the new capital-intensive industrial farms springing up around the developing world's major cities. A combination of poor infrastructure, lack of support services and a hostile policy environment means that all too often the odds are stacked against them at present. And they could find it even harder to compete if the productivity of their enterprises is further undermined by a deteriorating natural resource base.

That brings us to a second set of benefits and risks associated with the Livestock Revolution: its environmental implications. Here it is worth remembering that animals themselves are neutral in their effect on the environment; what matters is how people manage their livestock and the degree to which government policies and regulations motivate sustainable production.

In extensive smallholder or pastoral production systems, livestock benefit the environment by providing manure to fertilise the soil. They also provide the economic incentive to plant resource-conserving trees, shrubs and forage crops for feed. The down-side is that, unless effective measures regulating land ownership and use are put in place, rising livestock numbers in

these systems could exacerbate any existing problems of overgrazing, leading to severe soil erosion. The pressure to increase livestock production could also lead to the clearance of more rain forest, as has already occurred in Latin America. The rapid development of intensive landless and industrial livestock systems in or near urban areas raises special environmental concerns, including the disposal of slurry and manure, the pollution of air and water resources with gases and chemicals and the entry of antibiotics into the human food chain. These problems strengthen the case for curbing the growth of such systems in favour of more participation by small-scale producers. Lastly, all livestock, whether raised extensively or intensively, emit a certain amount of methane and carbon dioxide—gases that contribute to global warming. The amount can, however, be reduced by efficient feeding practices.

The Livestock Revolution also has positive and negative implications for human health in developing countries. On the one hand, raising the consumption of meat and milk by even a small amount can greatly improve nutrition and health in poor households. On the other, over-consumption could eventually—though not for a long time—lead to increased heart disease and other health problems. Two further health risks attend the rising numbers of animals traded and the growing volume of livestock products processed and marketed: the first is the spread of zoonotic diseases, including 'traditional' endemic diseases such as tuberculosis or new and highly contagious epidemic diseases such as avian flu or viral encephalitis; and the second is the contamination of meat and milk with bacteria such as *Salmonella* and *Escherichia coli*.

Two myths about the Livestock Revolution need dispelling. The first is that, by diverting grain from human to animal consumption, the Revolution will deprive the poor of the staple foods essential to their survival. The 2020 study predicts that the price of maize, the grain most widely used to feed both human beings and animals, will rise by only 10% from the all-time low at which it stands today. There are several reasons for this optimistic assessment. First, prices have fallen steadily over the past 20 years as yields have risen, a trend that looks set to continue. Second, the world has the capacity to increase both the area and the yields of maize, particularly in large grain-exporting countries such as Canada, the USA and Australia. We can expect that to happen if prices start to rise. Third, countries with alternative feed sources will switch over to them if feed grain prices rise too far. And fourth,

when consumers in cities switch from cereal to livestock products, this liberates some grain for direct food consumption.

The price of maize predicted for 2020 depends greatly on the assumptions made about the efficiency with which grain fed to animals is converted to meat and milk. Grain conversion is already more efficient than many critics of the Livestock Revolution allow—and it is likely to become even more so. A study carried out by the USA-based Council for Agricultural Science and Technology (CAST) has helped to throw light on this often controversial issue (Box 1).

'Real cereal prices …are not likely to rise very much by 2020, contrary to the fears of some.'—2020 study.

Box 1: Beefing up on conversion rates

Widely differing estimates of grain-to-meat conversion rates have recently appeared in both the popular and the scientific press. There are several reasons for these differences.

First, some authors assume that livestock diets are 100% grain, neglecting the forages and crop by-products that make up part, if not most, of their diets. These materials are not edible by human beings unless they are first converted to meat or milk by livestock—a factor often overlooked by the proponents of vegetarianism. Second, authors often base their estimates on only part of the animals' life cycle. In the USA, for example, calves are raised almost entirely on forage before being sent to feedlots for fattening, with the result that only 35–55% of their growth is produced from grain. Third, authors reach different conversion rates because they use different end products in their calculations: conversion appears a lot more efficient if the live weight of the animal is used rather than the carcass weight.

So how much grain does it take to make a kilogram of meat? According to the CAST report, the short answer is about 3 kg. But this average figure hides sizeable variations according to region and species (Table 3). Livestock in developing countries consume far less grain than those in the developed world, often none at all. And ruminants, which can digest forages and crop residues, consume less grain than monogastric species. For example, the ratio of grain consumed per unit of carcass weight is 2.6 for beef in developed countries, but only 0.3 in developing countries. Pigs, in contrast, have ratios of 3.7 in developed countries and 1.8 in developing countries.

What do these ratios imply for human nutrition? The protein in foods from animals has a nutritional value about 1.4 times greater than that in foods from plants. The CAST report concludes that diverting grains from animal production to direct human consumption in developing countries would limit long-term increases in total food protein supplies. It would also decrease dietary quality and diversity.

The CAST report highlights several other facts that strengthen the case for livestock production and that tend to get overlooked in the often heated food-versus-feed debate. In developing countries, feed grains are already diverted to direct human use during periods of food shortage, so livestock serve more as a buffer for absorbing surpluses, helping to ensure smallholder farmers receive a fair price for their crops, than as a means of depriving the poor of food. Maize, the principal feed grain, yields much more grain per hectare than wheat, the number one food grain. And feed conversion rates have for some time been heading downwards and look set to continue that trend. This underscores the importance of research to ensure further gains in the efficiency of production.

Source: CAST (1999).

Table 3. Grain fed per unit of carcass meat in developed and developing countries.

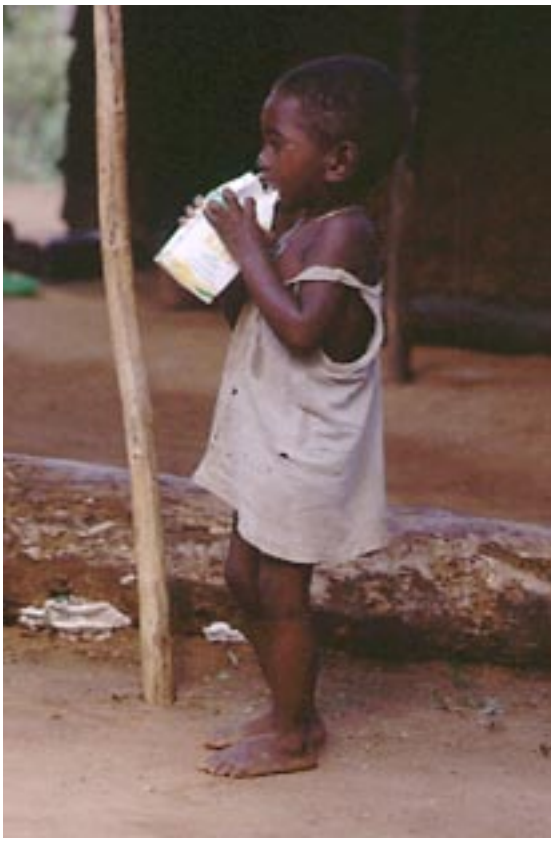
	Grain per unit of product	
Product	**Developed countries**	**Developing countries**
Beef	2.6	0.3
Sheep and goat meat	0.8	0.3
Pork	3.7	1.8
Poultry meat	2.2	1.6

Source: CAST (1999).

'Diverting grains from animal production to direct human consumption would, in the long term, result in little increase in total food protein and would decrease average dietary quality and diversity.'—CAST (1999).

'Popular discussion of the effect of the Livestock Revolution on developing countries is occasionally highly emotional and often imperfectly grounded in the facts.'—2020 study.

The second myth is that increasing the consumption of livestock products in developing countries will be bad for people's health. True, in the developed world there is some evidence linking meat and milk consumption with various health problems, including heart disease. But these problems start only when per capita consumption reaches levels far higher than those seen today among developing-country consumers. Almost a third of all children and perhaps an even higher proportion of pregnant or nursing women in developing countries suffer from protein-energy malnutrition. Many children also lack key micronutrients vital in promoting normal mental and physical development. For such people, even a small increase in the consumption of meat and milk can improve health markedly over a short period (Box 2). The 2020 study concludes that the Livestock Revolution could have many benefits for human nutrition in developing countries.



So, on balance, is the Livestock Revolution a saint or a sinner? 'The answer depends crucially on how governments and other agencies respond to the challenges it poses,' says Ehui. 'We believe

Box 2: Milk is good for you

Livestock products make unique contributions to human nutrition that can benefit the most vulnerable members of poor farming households. That's the message from a study conducted recently by the Ethiopian Health and Nutrition Institute (EHNRI), in partnership with the Ethiopian Agricultural Research Organization (EARO) and ILRI. Conducted around Holetta in the country's central highlands, the study compared the nutritional status of households owning crossbred cows with that of households that only had local cows, which yield much less milk.

One of the criticisms levelled at improved dairying projects is that, as poor households start to participate in the market, their nutritional status could actually decline if all the milk they produce is sold in order to maximise income. Women, who buy most of the family's food, could lose the income they have gained through traditional dairying, as control over the more lucrative improved enterprise passes to their husbands. Their nutritional status, and that of their children, could suffer as a result.

The study's findings dispelled these fears. Families with crossbred cows spent 7% more on food, grew and ate up to 30% more high-protein pulses and consumed 17% more calories, 24% more fat and 13% more protein than did families with local cows. They drank twice as much milk, with children especially enjoying increased consumption. Women played an active part in processing and selling both liquid milk and butter, retaining control over the income they derived from these activities. Their expenditure on food rose by 4%, while that of men also rose, by up to 28%. All members of the household enjoyed better health as a result (Figure 3).

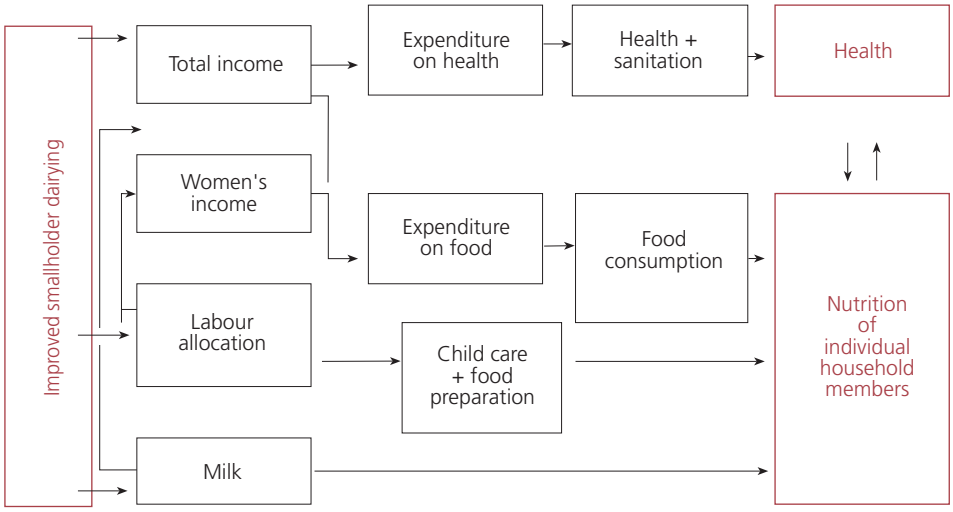
Besides providing carbohydrates, protein and calcium, dairy products also contain micronutrients essential for physical and mental development, such as vitamins A and B_{12}. EHNRI's previous surveys around Holetta had revealed that many local children suffered from eye problems caused by vitamin A deficiency. A year after the introduction of crossbred cows, these problems had all but vanished in adopting households. In addition, fewer children had stunted growth (Table 4).

The study's findings reinforce a view that is already gaining ground among nutrition experts and others in the international development community: that food-based interventions, especially those associated with livestock, can be just as effective at relieving nutrient deficiencies as programmes that dispense vitamin pills and dietary supplements. Indeed, food-based interventions are preferable because they involve local communities in creating their own solutions, rather than fostering a culture of dependency.

Sources: Haider et al. (1998); Shapiro et al. (1998).

'The possibility that the people who could most benefit from increased meat consumption may not share in the Livestock Revolution should be a greater concern than over-consumption.'— 2020 study.

Figure 3. Positive intra-household impact of improved smallholder dairying.



Source: Shapiro et al. (1998).

Table 4. Chronic malnutrition in pre-school children in households with crossbred and local cows, Holetta, Ethiopia.

Degree of malnutrition	CBC households		LBC households	
	No. of children	%	No. of children	%
Normal	54 *	80	48 *	57
Stunted	14 *	20	36 *	43
All	68	100	84	100

* Significant at the 0.05 level
CBC: Crossbred cow
LBC: Local bred cow

Source: Shapiro et al. (1998).

that the outcome can be immensely positive. But to secure that outcome we'll need better institutions, policies and technologies than those we've got in place today.' Developing and disseminating these is the task of ILRI and its partners.

Creating a level playing field

The simple brick building by the roadside to which Zufaan delivers her family's milk hasn't always been there. The milk parlour that forms the larger of the co-operative's two sections was built in 1996, under the FINNIDA project. It now employs two people, who use hand-operated equipment to separate milk and, according to demand, convert it into butter, cottage cheese and yoghurt.

A small proportion of the parlour's produce is sold locally, but most is collected by the Dairy Development Association (DDA), a government parastatal that markets mainly in Addis Ababa, some 2 hours drive away. At the height of the rainy season, around 65 local families deliver milk to the parlour every day. In 1999 the co-operative's profits were used to build a modest extension, intended for use as a bar selling yoghurt and fresh milk drinks to passers by.

Such arrangements for pooling and processing milk locally have big advantages for small-scale producers. Bulky, liquid and perishable, fresh milk is awkward to market in small quantities. Sellers must carry it long distances on foot without spilling it and find a buyer before the heat of the day. Well aware of the seller's predicament, buyers often play hard to get, beating down the price. Most producers respond by avoiding marketing fresh milk, seeking instead to add value by processing it into butter or cheese at home. But this is a time-consuming chore that takes family members away from more important activities. Before the advent of the co-operative, Zufaan and her brothers and sisters spent 6 to 8 hours churning every day. 'It made my wrists grow strong,' Zufaan says, 'but it kept me out of school.' The co-operative's establishment within easy walking distance links such families to a larger and more distant market that would otherwise be inaccessible to them. In so doing it reduces what economists call their transaction costs—the costs of doing business. And it strengthens their bar-

gaining power: in 1997 the Edoro co-operative had to raise the price of milk to producers as deliveries had tailed off.

The process of linking producers to the market via formal institutions for processing and trading is known as vertical integration. Behind the jargon of the economists lies a powerful idea: that such institutions can create a more level playing field for small-scale producers, enabling them not only to participate in the market but to do so competitively, by achieving the same economies of scale that normally place large-scale producers at an advantage. Many economies of scale in livestock production are located in input supply and output processing and distribution, not in production *per se*—a feature conducive to participation by poor, small-scale producers lacking the capital to expand their own enterprises. Collective institutions such as co-operatives are the most favourable model of vertical integration in terms of promoting equity, because in addition to achieving economies of scale they also increase producers' bargaining power and, if properly managed, can become profitable small businesses in their own right, creating additional employment. An alternative model is contract farming, in which processing or marketing institutions undertake to buy individual farmers' produce at a predetermined price. These can still achieve economies of scale, but the lack of a collective means that bargaining power is not as strong and no additional business is formed. It is, of course, possible to combine both models.

Building collective institutions to promote vertical integration is one of the 'pillars' of policy making identified by the 2020 study as essential in creating a Livestock Revolution that benefits poor producers. Its flip side is another pillar—the removal of unfair policy distortions that tip the balance of participation in favour of large-scale producers by artificially magnifying their economies of scale. 'In too many developing countries, large-scale producers still enjoy subsidies, tax holidays, free government services and better access to public facilities such as roads, water and electricity,' says Ehui. 'They also tend to get let off complying with pollution and public health regulations. Eliminating or redirecting these subsidies would do much to shift the market in favour of the poor.'

Credit is an obvious candidate for reform. For the purpose of creating a level playing field for small-scale producers, it is potentially the most powerful weapon in the policy maker's armoury. Evidence from studies by ILRI and its partners show that credit provided to poor farmers can be highly effective at improving

their productivity and hence promoting equitable growth in the rural economy. Yet few such farmers are able to get access to credit at present (Box 3).

Box 3: Give credit where credit is due

ILRI and its national partners conducted a study of credit for small-scale livestock producers in four African countries: Ethiopia, Kenya, Nigeria and Uganda.

The researchers began by examining the credit supply policies and practices of lending banks. All the banks had the stated aim of providing credit to smallholders, but their records showed that they did not in fact do so. The lending criteria used often discriminated against smallholders. For example, borrowers in Uganda had to demonstrate that they had the necessary infrastructure on their farms to keep improved livestock—a condition that effectively restricted credit to people who could afford to build the infrastructure before receiving a loan. The banks did not demand collateral security against loans, but they often relied on the personal characteristics of would-be borrowers to assess creditworthiness, including known wealth and standing in the community. Most banks gave only short-term loans with a fixed repayment regime instead of long-term or flexible loans tailored to individual circumstances. The study recommended that banks reconsider both their lending criteria and their loan terms and conditions.

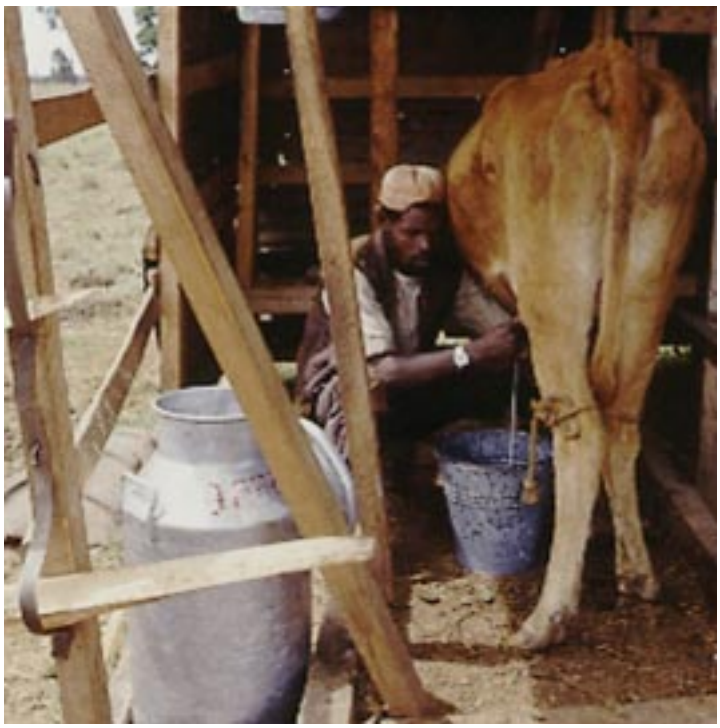
Next the researchers investigated the uptake of loans by farmers and the loans' impact on farm productivity. All previous studies on credit have analysed borrowers separately from non-borrowers. The unique feature of this study was that it also distinguished between those who needed to borrow and those who did not. In so doing it eliminated the confounding effect caused by the impossibility of telling whether or not the provision of credit has relieved a real cash constraint.

Data analysis showed that credit is twice as effective in improving agricultural productivity when it is directed towards those who need it most—poor farmers who lack the capital to invest in new technology. In Kenya, for example, a 1% increase in the credit needed to buy a dairy cow led to a 1.6% increase in milk production on cash-constrained farms, but to an increase of only 0.9% on farms where cash was not a constraint. In other words, poor farmers used their credit more efficiently.

The provision of credit needs to be carefully co-ordinated with the introduction of new technology and with training in its use. The study found that few farmers used credit to buy additional feed for their animals. Credit provided specifically for this purpose could therefore increase productivity still further. In addition, training in the use of yield-increasing technology was only effective in households where credit was not a constraint. It is therefore important to remove the credit constraint first, before providing training.

Source: Freeman et al. (1998).

One of the reasons cited by policy makers for withholding credit from small-scale producers is their alleged poor repayment record. There certainly have been times and places when this has given cause for concern. For example, the record was particularly poor in Latin America during the 1980s, when high inflation in the rest of the economy made investment in almost any other sector besides agriculture more profitable. Loans intended for agriculture typically found their way into bricks and mortar instead. Small-



holders have also earned an unenviable reputation for defaulting on loans, the problems here being more often associated with the general riskiness of agriculture. Farmers who lose their entire harvest to a drought are simply not in a position to repay—a powerful argument for making loans more flexible than they usually are at present. But Ehui believes that many of the allegations of poor repayment levelled against small borrowers are unfair. Large borrowers are just as likely to default, he argues. And whatever the record of the past, this shouldn't be used as an excuse for refusing to even consider credit for poor producers today. 'There are several well-known principles in the design of credit schemes which, if applied, could improve repayment records,' says Ehui. 'For a start, most schemes don't go nearly far enough in making farmers collectively responsible for repayment.' The Grameen Bank scheme, which has been so successful in Asia, provides the model here. Credit in this scheme is provided to groups, so there is peer pressure to repay. Another principle is that credit in kind tends to work better than credit in cash, since it reduces the scope for diverting credit to other purposes. Livestock are well suited for use as credit in kind. Indeed, they provide an ideal form of flexible, long-term loan, because repayment can be made with offspring.

Economic liberalisation has done much to level the playing field for small producers throughout the developing world during the 1990s. But in some cases the process of reform has not been thorough enough and producers are still receiving mixed signals from government. Kenya's smallholder milk sector provides a good example: it is one of Africa's success stories, yet, after initial steps towards liberalisation, an ILRI study showed that poor producers still weren't benefitting to the extent that they should. The reason? The government had overhauled pricing and marketing arrangements but had failed to get rid of other obstacles to market participation (Box 4). Further steps have since been taken to facilitate smallholder access to markets.

Box 4: Liberalisation: The need to be thorough

Government policy has been a major factor in Kenya's success in increasing the supply of dairy products to Nairobi's urban market. The introduction of crossbred cows and new forages, coupled with the provision of veterinary services, encouraged the adoption of dairying by smallholders throughout the country's high-potential highlands. Founded in 1962 with a monopoly in the trading of processed milk, Kenya Co-operative Creameries (KCC) successfully lowered the transaction costs and risks of smallholders wishing to participate in the market. The building of a road network in the highlands facilitated milk collection and transport.

During the 1980s, KCC's operations gradually ran into trouble. Farm input prices rose faster than the farm-gate milk price offered by KCC, which was controlled by the Dairy Development Board. As the price of raw milk on the informal market overtook KCC's price, producers began supplying this market instead, reducing the volume traded by KCC. Short of cash, KCC delayed its payments to producers, discouraging them still further. By the early 1990s the amount of milk handled by KCC had fallen to a trickle and Nairobi was experiencing severe shortages.

In May 1992 the government responded by decontrolling dairy prices and lifting KCC's monopoly. KCC immediately raised its prices to producers and retailers, milk began flowing its way again and processed milk and dairy products reappeared on Nairobi's supermarket shelves.

The removal of KCC's monopoly was intended to encourage self-help groups and small co-operatives processing and trading in milk to form at local level. Larger, private-sector firms were also encouraged to enter the market. However, bureaucratic hurdles and limited access to credit meant that few new small businesses were able to form. Where they did form, they found it hard to operate.

Economic analysis showed that the higher retail milk prices that followed liberalisation had not translated into proportionately higher farm-gate prices, due to the continued market dominance of KCC. The policy changes had removed only about 20–30% of the negative price effects induced by KCC's monopoly. By 1995, farm-gate milk prices in the main milk-producing areas had risen, implying increased competitiveness in the milk market, but most of the increase had occurred as a result of increased activity in the informal raw milk market, not through entry into the market by co-operatives or private-sector processors. Indeed, by 1998, some co-operatives were no longer functional, as they could not compete with the high prices paid to farmers by informal traders. Analysis by ILRI and its partners has shown that the strength of the informal market lies in its ability to deliver milk at low cost to poor urban consumers.

Research on milk price formation and market performance in the smallholder dairying sector continues in Kenya, Tanzania and Ghana, with the twin aims of improving efficiency and milk safety.

Sources: Staal and Shapiro (1994); Owango et al. (1998); Morton et al. (1999).

The third pillar of policy making required to ensure that poor producers benefit from the Livestock Revolution is the creation of public goods and services. Governments need to promote or invest in a range of services to support their livestock sectors, including research, extension, veterinary and artificial insemination services. Among the goods in which investment is needed are productivity-increasing technology, which we'll discuss later, and infrastructure such as roads and marketing facilities.

Garth Holloway, visiting scientist with ILRI's Livestock Policy Analysis Programme, has analysed the variables that affect farmers' decisions on whether or not to participate in the expanding milk

'The worst thing that well-motivated agencies can do is to prevent public investment that could facilitate sustainable and market-oriented production by smallholders. That will not stop the Livestock Revolution, but it will make it less equitable and less sustainable.'—2020 study report.

market of Ethiopia's central highland plateau. He and his colleagues have found that setting up a co-operative, while it helps, is not enough. 'Physical distance isn't the only factor affecting farmers' decisions,' he explains. 'Farmers must also cover the necessary "psychological" distance, plucking up the courage to enter the market. Those who were better educated were more willing to take the plunge, as also were those who had had prolonged contact with the extension service.'

Extension services in Africa are often depicted as demoralised and ineffective, so it is heartening to find them playing a strong role in this case. 'Extensionists here are trusted and respected by farmers,' says Abebe Misgina, an ILRI economist with many years experience in central Ethiopia. 'Some farmers even build them a house, so that they can live next door.' According to Abebe, extension staff in Ethiopia are recruited within the communities they serve, so are not seen by farmers as outsiders. They are also comparatively well educated and better paid than in some countries. And the government has recently put in place a system for monitoring and evaluating their performance, ensuring that they are highly motivated to do their best for farmers. 'The message to policy makers is clear,' comments Ehui. 'It is possible to build a strong and effective extension service in Africa. And such services can contribute greatly to the uptake of new livestock technology.'

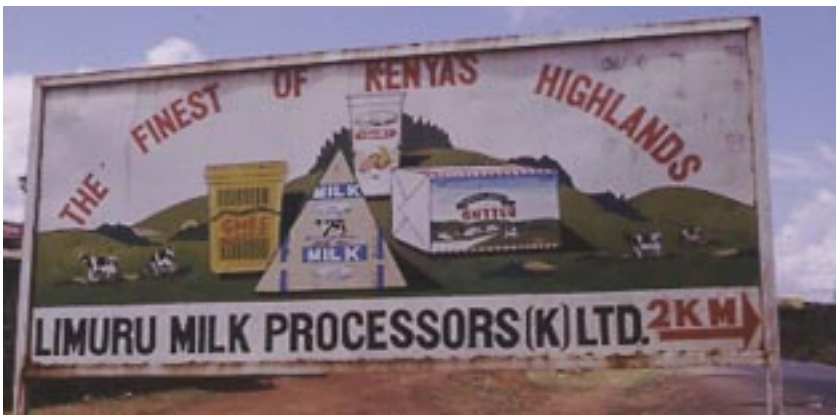
One of the most effective public goods for promoting market participation is the building of roads to link remote rural areas to city markets. Road building in humid areas has often received a bad press because of its association with immigration and deforestation, as has occurred in the Amazon. But several studies have shown that in fact building roads can help to protect the environment, as the opportunity to switch to more market-oriented, tree-based production systems enables subsistence crop farmers to stop mining the

resource base. Most tree-based systems are compatible with livestock production. Roads linking producers to markets are also needed in the drier areas, where livestock are often the main, sometimes the only, source of both subsistence and cash. In West Africa, for example, roads linking the dry livestock-producing areas of the north to the densely populated humid coastal zone to the south could be the single most important intervention needed to boost the incomes of poor pastoral people.

The fourth and last 'policy pillar' identified in the 2020 report is the need to promote the necessary regulatory institutions to deal with the environmental and public health issues raised by the Livestock Revolution. Cash-strapped governments in developing countries will find this difficult, especially at a time when many of them are being urged to cut public expenditure. The report points out that the best payoff to investments can be achieved by targeting regulatory efforts to those parts of the livestock economy where problems are most likely to arise. For instance, meat hygiene needs to be better enforced in China, while the management of grazing deserves attention in West Africa. Moreover, acting now to prevent problems from arising will be cheaper than trying to mop up after disaster has struck. As trade in livestock products grows, the costs of regulatory failures on the public health side will escalate particularly rapidly. This is an area in which developing countries can learn from the mistakes made in the developed world, where Britain's 1980s epidemic of mad-cow disease ended up costing the country its entire beef export market in the second half of the 1990s.

ILRI and its partners are conducting research on the regulatory institutions needed to enable poor producers to compete effectively in the growing market for livestock products. Amos Omore,

'An ounce of prevention may eliminate the need for a pound of cure.' —2020 study.



veterinarian with the Market-Oriented Smallholder Dairy Research Project, is investigating the public health aspects of traditional milk marketing in Kenya, Tanzania and Ghana. Here as in many other developing countries, smallholders entering the dairy market often sell raw milk direct to consumers, obtaining a higher price for it than when they sell to parastatals, co-operatives or private processors, which pasteurise the product. Practices both on the farm and in the market-place, where milk is more likely to be handled in a calabash or a plastic jerry can than in a sterilised aluminium container, may pose risks to consumers' health, mainly from microbial contamination. But some practices may be riskier than others and it may be possible to educate producers and traders to make their product safer. 'Quantifying the risks will help policy makers decide whether to police this sector or to support it,' says Omore.

Rising to the productivity challenge

Unlike the supply-driven Green Revolution in crops, which was made possible by technology that raised farmers' yields and lowered prices to consumers, the Livestock Revolution has so far been largely demand-driven. But that seems likely to change in the future. As the returns to livestock production rise, so also will producers' willingness to invest in productivity-increasing technology. 'Now that the market is growing, research can really make a difference,' says Ehui. It's important that it should do so: past increases in production have come mainly from increasing animal numbers, placing the natural resource base under strain.

'Technological progress…will be central to the positive outcome of the Livestock Revolution.'—2020 study.

Because most livestock producers are poor, public-sector research has an especially important part to play in the short to medium term. As the 2020 study points out, productivity-increasing technology in the rapidly growing poultry and pig sectors is developed by commercial enterprises that can afford their own research, so it seems sensible for ILRI to continue to focus its efforts primarily on ruminant species, the productivity of which has been growing more slowly. The two most promising technological pathways to increased ruminant productivity for poor producers are improving the quantity and quality of feed available and controlling animal diseases. ILRI and its partners conduct a

great deal of research on and around both these themes, so we'll restrict ourselves here to a few examples of work that has shown particular promise in 1999.

To generate a surplus for market, poor producers need simple technologies that they can adopt at low risk, without investing large amounts of scarce cash or overtaxing their family members with too much extra work. A statement of the obvious perhaps, yet it is astonishing how much research of the past failed to meet these basic conditions. Not surprisingly, many poor producers have expressed scepticism about the ability of research to benefit them. But over the past decade, growing numbers of them have begun changing their minds. One of the reasons is a sea change in the way research itself is conducted. More and more researchers have discarded the top-down approaches of the past in favour of a participatory approach in which they treat producers as equal partners in planning, implementing and evaluating experiments. One of the hallmarks of this approach is the attempt to involve whole communities in the research process, making sure that vulnerable groups get a voice and are not disadvantaged by innovations that suit others.

'First, when an extension agent explained the project to me, I was among those farmers who opposed the idea. Later, when I understood that the project really could improve our living standards, I changed my mind and decided to participate.'— Tadesse Etisso, participating farmer in the Smallholder Dairy Development Project, Ethiopia.

The adoption of a participatory approach has been accompanied by other positive changes in the research paradigm. Researchers no longer seek merely to increase productivity in the short term but also to protect and enhance the natural resource base, so that long-term productivity is assured. And their institutes no longer work in isolation or with a few like-minded research partners but with a broader range of organisations whose different points of view and different areas of expertise contribute to an integrated research and development (R&D) process. In the Andean region of Latin America, ILRI is a member of a consortium of institutions conducting this new kind of research, with results that show every promise of improving the livelihoods of poor livestock producers (Box 5).

Much can be gained by using the new participatory approach to drive the agenda of laboratory research—so often criticised as divorced from poor producers' needs in the past. This is what is happening in another important area of ILRI's research, the improvement of crop residues as animal feeds.

Box 5: New thinking in research: The work of CONDESAN

At 3914 metres, Lake Titicaca in Peru is the world's highest lake. Life for the farmers in the hills around its shores is hard. Few crops grow here and livestock, especially cattle and alpaca, are vital to incomes.

With night-time temperatures dipping below –10°C, frost is a major killer of the young calves raised for beef or dairy production and left exposed to the elements on the pastures they graze. The productivity of those that survive is low, as the calves spend much of their energy just keeping warm, slowing down their daily weight gain. However, a growing number of livestock producers are now achieving better results thanks to the introduction of a rudimentary shelter to house their calves at night. The tent-like shelter, which consists of a simple wooden frame covered by plastic sheeting, improves weight gains by 20% in local animals and by 53% in improved breeds.

Recently, Lake Titicaca has been invaded by a noxious weed, the water lentil. Like its Asian cousin the water hyacinth, water lentil (*Lemna* sp) flourishes on the excessive nutrients draining into the lake from agriculture, industry and housing. It spreads rapidly over the lake surface, choking the passage of boats and killing off fish. Left to its own devices, water lentil threatens to destroy the lakeside economy altogether. But farmers are finding they can help get rid of the weed by feeding it to livestock. The harvested plant is first rid of its high water content by drying it on simple wooden frames, a quick and easy operation at this high altitude. The wilted weed makes an ideal protein-rich supplement for fattening sheep, leading to a 72% weight gain over sheep fed the traditional diet.

These are just two of the innovative ideas under research and development by an innovative organisation: the Consorcio para el Desarollo Sostenible de la Ecoregión Andina (CONDESAN). Convened by ILRI's sister institute in the CGIAR, the Centro Internacional de la Papa (CIP), CONDESAN is a powerful alliance of research institutes, extension services, universities, private-sector companies and non-governmental organisations (NGOs) working to improve rural livelihoods in some of the poorest countries of Latin America, those of the Andes. Among the consortium's other achievements are the development of a bio-economic model to assist alpaca producers in selecting animals for wool production, and the launching of a micro-credit scheme for resource-poor farmers, based on a revolving fund. The credit scheme has achieved repayment rates of 92%—unusually high for Latin America.

CONDESAN's reputation for innovative R&D rests on several unusual organisational features. As an ecoregional consortium, it combines the skills of a wider range of partners than those normally participating in a conventional network. Its members share the costs of research as well as its benefits, ensuring their full commitment to the agreed agenda, and adopt an entrepreneurial approach in which research is firmly tied to development. A unique feature is the *mesa de concertacion* or round table, a local-level mechanism for planning activities and co-ordinating their implementation. Chaired by district mayors, the *mesas* ensure strong ownership of all the consortium's initiatives by local communities. CONDESAN was recently singled out for praise by the Technical Advisory Committee (TAC) of the CGIAR as a model for effective natural resource management research.

ILRI joined CONDESAN in 1995. Besides providing livestock-related inputs to ongoing activities, it has a part to play in raising the profile of livestock on the R&D agenda—an important task in a region where livestock are often thought of as an enterprise for wealthy large-scale farmers only. The Institute may also help spread the successful CONDESAN model to other regions of the world where it could prove applicable, including the Himalayas in Asia and the highlands of sub-Saharan Africa.

Source: CONDESAN (1999).

Larger amounts of better quality crop residues are vital in making meat and milk production more profitable for resource-poor farmers while simultaneously lowering the prices of these commodities so that poor consumers also benefit. Most resource-poor farmers already regard the cereal crops they grow as dual-purpose—for animal feed as well as human food. Farmers in the semi-arid tropics, for example, value the residues of pearl millet and sorghum almost as much as the grain. Surveys in India have shown that sales of these residues to peri-urban livestock producers can generate up to 50% of farm income from cropping in the more rural areas. As cropping expands at the expense of rangeland for grazing, farmers' dependence on crop residues will increase still further.

The residues of most of the world's important grain crops are fibrous, with a low feed value for livestock. Research to improve feed value has a long history, but has so far met with little success. Much of the effort has gone into chemical treatments that have been little adopted by farmers. In the 1980s, ILRI joined forces with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in a new approach based on genetic enhancement. Considerable progress has since been made in understanding both farmers' criteria for the selection of dual-purpose varieties and the genetic basis of good feed value (Box 6).

ILRI's recent External Programme and Management Review (EPMR) noted that the Institute was well placed to usher in the new 'genomics era' of livestock research. In livestock as in crops, researchers will increasingly seek to raise productivity by identifying and applying genetic solutions to the constraints facing small-scale producers. Besides raising productivity these solutions should bring substantial environmental and human health benefits, in that they will allow the use of chemicals to be reduced or even avoided altogether.

Many of the world's poorest livestock producers live in stressful environments, where pests and diseases are a constant challenge and high-quality feed is often scarce because of drought, poor soils or other resource constraints. The traditional livestock breeds

Box 6: From participatory rural analysis to quantitative trait loci

Most cereal crop breeders still concentrate on improving grain yield and quality for human consumption. The ICRISAT–ILRI research is demonstrating the need for a shift in emphasis to reflect the dual purpose of these crops—and the considerable impact that could result from such a shift.

Conducted mainly at ICRISAT's Sahelian Center in Niger, the first phase of the research led to the discovery of several traits indicating fodder value, including the 'stay-green' trait in sorghum and the 'brown midrib' and 'trichome-less' traits in pearl millet. These discoveries encouraged the two centres to intensify their efforts through further research based at ICRISAT's headquarters in India. This second phase is conducted in collaboration with Indian national programmes and specialised institutes in the UK, the USA and Australia.

The partners' first task was to find out what plant traits are actually associated with feed quality in pearl millet and sorghum by farmers. They conducted a participatory rural analysis (PRA) covering 13 villages in 11 districts of India, using techniques such as focus group discussions and variety matrix ranking to explore farmers' perceptions. Farmers' top priorities in both crops were grain and fodder yield, in the amounts needed to feed their families and animals respectively. Fodder quality came a close third, indicating that farmers are well aware of the link between feed value and animal productivity. Farmers said they would not be prepared to sacrifice grain yield to improve fodder quality. But they also said that grain yield would have to increase substantially before they would accept any loss in fodder yield or quality. The farmers pointed to two key indicators of fodder quality: soft stems and sweet taste of stems and foliage.

These and other traits are now being investigated in the laboratory. Scientists at the John Innes Centre (JIC) and the Institute of Grassland and Environmental Research (IGER) in the UK have crossed two pearl millet hybrids, one bred purely for grain and the other a recognised dual-purpose variety. The residues of the progeny are being analysed for their dry matter content and *in vitro* production of fermentation gas—two important indicators of digestibility. The scientists then use genetic marker technology to identify quantitative trait loci (QTLs)—the segments of DNA responsible for specific traits. The long-term aim is to link information on traits for fodder quality with other important traits, such as drought tolerance and resistance to downy mildew. Ultimately, a map of the pearl millet genome will be developed.

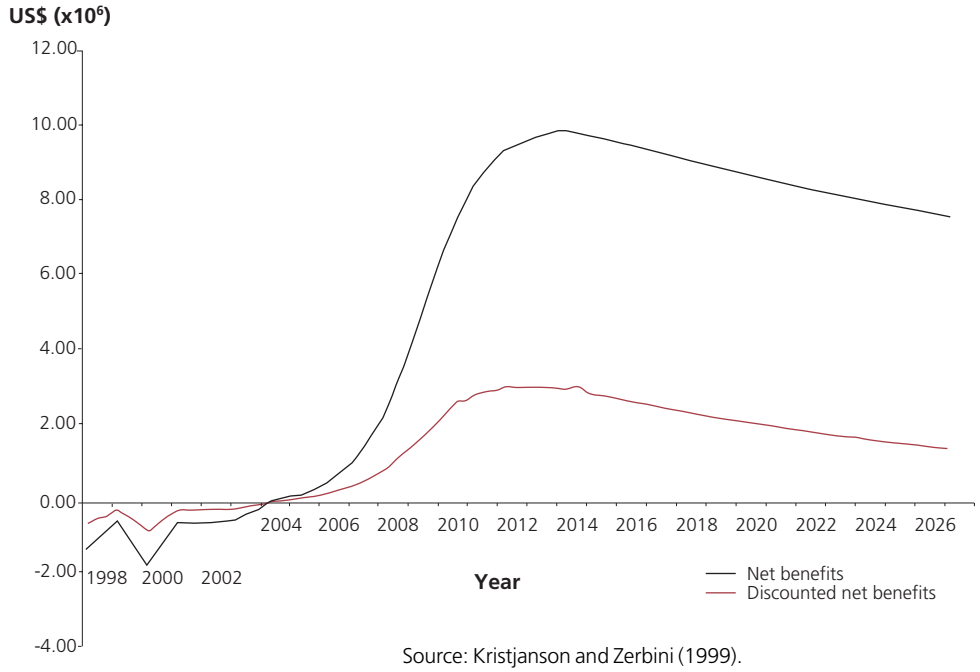
This laboratory research has already yielded useful results. Digestibility in the different progeny ranges widely, suggesting considerable potential for identifying genotypes with superior feed quality. The scientists have found 11 QTLs for different traits, one of which has proved statistically significant for digestibility. The indications are that it will be possible to increase stover yield and quality at the same time.

The *ex ante* impact study conducted by ILRI shows that, if successful, this research will have a substantial impact (Figure 4). The study predicts that a 1% increase in stover digestibility—the lowest level thought likely by plant breeders and nutritionists—will lead to a 6–8% increase in the production of milk and meat. In India alone this increase will be worth around US$ 42 million at the most cautiously estimated level of adoption and up to US$ 208 million if adoption is more widespread. Returns will be even higher if farmers in Africa and Latin America benefit as well, and higher still if crop production also rises in response to increased amounts of better quality manure and more efficient animal traction.

The ICRISAT–ILRI collaboration demonstrates the value of underpinning strategic research in the laboratory with participatory research to ensure a strong emphasis on users' needs. It also shows how partnerships in which each institute contributes according to its comparative advantage can enhance the efficiency of research and increase its potential for impact.

Sources: Kristjanson and Zerbini (1999); Swindale (1999); Zerbini and Hash (1999).

Figure 4. Predicted net annual benefits from genetic research to improve the feed value of sorghum and pearl millet residues.



Source: Kristjanson and Zerbini (1999).

raised here harbour valuable genes that protect them against these stresses. The techniques of modern biotechnology allow these genes to be identified and transferred into a more productive background. This makes it vital to ensure that indigenous breeds are conserved. Just like crop landraces, the 'unimproved' livestock breeds raised by pastoralists and smallholders are under threat of genetic erosion. A recent ILRI study has shown that 22 of Africa's indigenous cattle breeds have become extinct over the past century and that a third of the 145 or so breeds that remain are endangered. ILRI is a partner in several projects whose results demonstrate the value of research to conserve and use Africa's indigenous livestock biodiversity (Box 7). These projects use marker technology to pursue and apply knowledge that could not have been obtained at all a decade ago.

Box 7: 'There's cash in them there genes': East Africa's Red Maasai sheep

Internal parasites, including helminths, are one of the most serious health constraints to the increased productivity of sheep and goats in sub-Saharan Africa. The control methods available at present consist of anthelmintic drugs, which are expensive and lead to the build-up of parasite resistance, and controlled grazing, which is impractical in most pastoral and smallholder settings. Genetic resistance, if it can be found and used in selection and breeding programmes, offers a better way forward.

The indigenous Red Maasai sheep of East Africa have long been thought to be resistant to helminths, but the evidence was largely anecdotal or based on inconclusive results. In 1991, ILRI and its partners launched a study near Mombasa, on the coast of Kenya, to answer the question once and for all. The study compared the resistance and productivity of Red Maasai and Dorper sheep, the Dorper being an improved breed originally imported from South Africa and now popular with Kenyan farmers.

The results confirmed that Red Maasai are indeed resistant. On two indicators that together provide a reasonably reliable picture of resistance—faecal egg counts (FEC) and packed cell volume (PCV)—Red Maasai ewes and lambs performed significantly better than Dorpers (Figure 5). They also had dramatically lower mortality rates, leading to much faster flock growth. The number of 1-year-old sheep available for sale in the Red Maasai flock was three times higher than in the Dorper flock (Table 5).

The research demonstrated that keeping Red Maasai has a clear economic advantage for producers. In response, FAO has supported the establishment of a pilot scheme to breed rams for distribution to farmers in Kenya's coastal zone.

The next stage in the research is to understand the genetic basis of resistance. ILRI's scientists have crossed Red Maasai and Dorper sheep, then back-crossed the male progeny to both Red Maasai and Dorper ewes to produce double back-cross lambs. These lambs are being evaluated for their resistance, which is then being correlated with the presence of key genetic markers to identify quantitative trait loci (QTLs). If the QTLs can be established with reasonable confidence, it should prove possible to breed resistance into a more productive genetic background. In the longer term, the genes themselves may be pinpointed, providing a possible basis for the development of a vaccine or a new drug in addition to opportunities for genetic modification and other applications.

Source: Baker (1998).

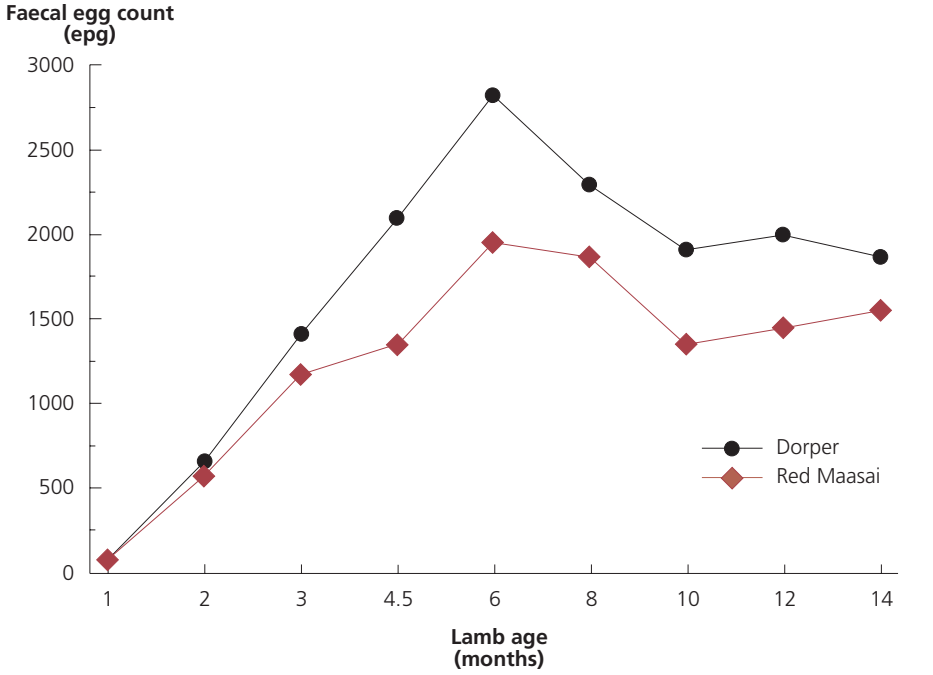
Table 5. Productivity of Dorper and Red Maasai sheep under helminth challenge, coastal Kenya.

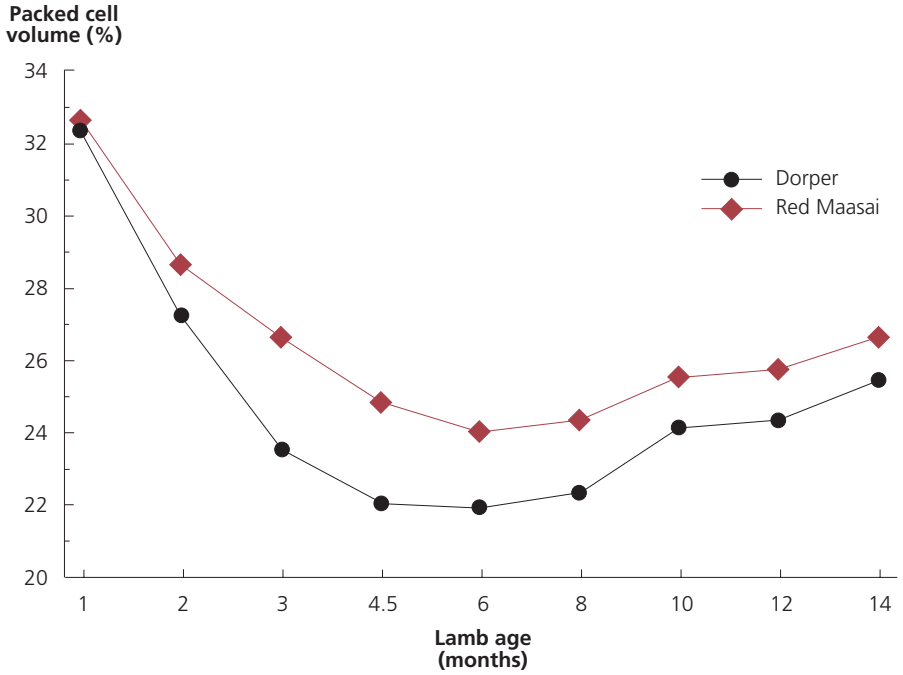
Trait	Dorper	Red Maasai
No. of ewes mated	853	457
Ewe live weight (kg)	30	26
Ewes lambing/ewes mated (%)	66.4	75.1
Prolificacy (%) (lambs born/ewes lambing)	102.0	101.9
Lamb mortality (%)	66	28
Yearling live weight (kg)	19.7	18.4
Offtake (1 year):*		
No. of sheep	11	35
Total live weight (kg)	217	644

* Offtake based on a 100-ewe flock with a 20% female replacement rate and all male and non-replacement females alive at 1 year of age making up the offtake. The Dorper flock is not sustainable at this replacement rate in this environment.

Source: Baker (1998).

Figure 5. Mean faecal egg counts and packed cell volume in Red Maasai and Dorper lambs, coastal Kenya.





Source: Baker (1998).

New directions in health research

In 1997, the dissemination of crossbred dairy cows in the central Ethiopian highlands under the FINNIDA project came to an abrupt halt. Imports of the animals from neighbouring Kenya were banned because veterinarians could not guarantee that the animals were free of a serious disease, East Coast fever, and that the ticks that transmit the disease would not survive the quarantine period at the frontier. The potential cost of introducing the disease into Ethiopia was thought to be far greater than that of the lost opportunity for dairy development caused by lack of the animals.

The episode is a potent illustration of the importance of the animal health issues raised by the Livestock Revolution. As livestock become a global business, the increased movement of animals across frontiers could lead to the more rapid spread of such 'diseases of trade'. In addition, the rising concentrations of animals in and around cities will increase the risk of large-scale epidemics of contagious diseases, including those that can jump the species barrier from animals to human beings. And the intensification of animal husbandry will alter the kinds of disease that are likely to evolve and to be transmitted. Even the change from grazing to stall feeding, already well advanced, brings new risks.

In response to the changing disease situation, ILRI and its partners are reassessing their priorities in animal health research. For ILRI, the reassessment is part of a continuous process of review aimed at ensuring the effectiveness and relevance of its activities in this field. The review process has already led to several shifts in the Institute's research agenda, which will continue to evolve in the opening years of the new century.

At foundation in 1994, ILRI inherited the programme of its predecessor in animal health research, the International Laboratory for Research on Animal Diseases (ILRAD). This programme focussed mainly on the development of vaccines against two major diseases in Africa, East Coast fever and trypanosomosis. ILRI has continued this long-term work, in which exciting advances have recently been made (Boxes 8 and 9). However, ILRI is acutely aware of the need for impact in the shorter term. For this reason, the programme has launched new activities to improve the efficacy of existing control measures. The two major aims of these activities are to improve the delivery of the existing

live vaccine against East Coast fever and to prolong the efficacy of the drugs to control trypanosomosis, which show signs of becoming ineffective owing to resistance in the parasite.

This increased emphasis on impact is closely associated with a second shift in ILRI's health programme: from basic research designed to increase knowledge—necessary in the early stages of research—to a more practical focus on the development of products based on that knowledge, including decision support systems, vaccines and diagnostic kits. To some extent this shift has occurred naturally as the programme has evolved. But it was given further impetus by a series of stakeholder workshops held in 1996 and an

Box 8: Towards a user-friendly vaccine against East Coast fever

The parasite *Theileria parva* is a single-cell protozoan organism belonging to the same family as the *Plasmodium* genus that causes malaria. Transmitted to cattle by biting ticks, it causes a cancer-like division of cells that quickly kills host animals. Known as East Coast fever, the disease is restricted to East and Central Africa, where it has caused devastating epidemics, especially among exotic breeds.

Research on East Coast fever began when scientists observed that survivors of epidemics had powerful acquired immunity, suggesting that the development of a vaccine was possible. In the 1970s, a live vaccine became available, but this is difficult to apply under African conditions (see below) and must be used in conjunction with an expensive antibiotic, tetracycline. The development of a cheaper and more user-friendly treatment, in the form of a 'dead' vaccine containing fractions of the parasite (a subunit vaccine), became a priority of ILRAD on foundation.

The study of immune responses led to the discovery, on the surface coat of the parasite, of a protein called p67 which acts as an antigen, inducing the production of antibodies when injected into animals. Having identified the gene that expresses p67, the scientists produced the protein in the laboratory and began testing it as a candidate subunit vaccine.

The results showed that p67 conferred 60% protection—not enough for use in the field. The aim now is to identify other proteins that can be combined with p67 to create what is known as a multi-valent vaccine. Comprising more than one component of the parasite, such a vaccine should bring immunity levels up to 90% or more.

The scientists are investigating a specific source of these additional proteins. When they enter the blood stream of host animals, *T. parva* parasites colonise white blood cells, where they multiply to become a large intra-cellular multi-nucleate body called a schizont. The agents directly responsible for cell division, schizonts secrete proteins which migrate to the surface of the blood cell, where they modify the cell-surface proteins unique to individual animals. The animal's immune system then sees these modified proteins as foreign, and starts to kill the cells on which they are located. ILRI scientists are currently attempting to identify these schizont antigens, so that they can be added to p67 to improve the candidate vaccine.

Box 9: Trypanosomosis: The prospects improve

Trypanosomosis is probably the single greatest health constraint to increased livestock productivity in sub-Saharan Africa and is also gaining ground in parts of Asia and Latin America. The disease is caused by trypanosomes—minute, single-cell parasites that enter the blood stream of mammals through the saliva of tsetse or other species of biting flies. There they secrete and feed on blood proteins as they multiply, causing anaemia, lowered productivity and, in many cases, death.

In contrast to East Coast fever, scientists had until recently found no clear evidence of acquired immunity to trypanosomosis. A further factor complicating vaccine development is that the trypanosome constantly changes its surface coat, allowing it to evade any immune response made by its host. These major obstacles have led some scientists and investors to doubt whether a vaccine is feasible. However, progress over the past few years has improved the prospects markedly.

The two best places to look for acquired immunity are Africa's trypanotolerant domestic livestock and wildlife. Both groups have been the object of intensive research by ILRI and its partners.

Studies of the trypanotolerant N'dama cattle of West Africa pointed to a cysteine protease called congopain as a potential candidate for vaccine development. Present in all trypanosomes, cysteine or papain proteases are enzymes that break down host blood proteins and are thought to be the cause of anaemia. Congopain is the name coined for the enzyme specific to *Trypanosoma congolense*, a species of trypanosome responsible for a widespread and severe form of the disease. Laboratory research conducted in collaboration with the animal production and veterinary medicine programme of France's Centre de coopération internationale en recherche agronomique pour le développement (CIRAD) has shown that vaccinating susceptible cattle with congopain can make them behave more like their trypanotolerant relatives when challenged by infected tsetse flies. The vaccine does not prevent infection, but vaccinated animals remain productive while non-vaccinated controls do not.

In contrast to trypanotolerant cattle, African wildlife species were thought to have an innate resistance mechanism for controlling trypanosome infections. Scientists at ILRI and the University of Massachusetts have characterised this mechanism in Cape buffalo and found that it cannot account for the extended control of infection displayed by these animals. The mechanism is short-lived, conferring immunity for only 10–15 days. Parasites persist in the blood stream after this time but do not grow or multiply, indicating the presence of some other factor that is able to suppress them. The scientists have now established that these animals are able to target an immune response against trypanosome receptors located in the flagellar pocket of the trypanosome. Trypanosome receptors are proteins on the surface of the parasite that bind the nutrients it needs to survive and grow. The flagellar pocket is a surface depression close to where the flagellum or 'tail' of the parasite, which it uses to swim through the blood stream, projects from its body. Unlike other coat proteins, the receptors in this area do not constantly change, suggesting that they could form the basis of a vaccine. Collaborative research with the Free University of Brussels, Belgium, the University of Massachusetts, USA, and the University of Victoria, Canada, has confirmed that this is so.

The challenge now is to incorporate the protective antigens identified through the work on Cape buffalo into a multi-valent vaccine that will reduce infection, then to combine this vaccine with the congopain vaccine developed through the work on trypanotolerant cattle. The result could be the world's first effective vaccine against a disease that currently deprives many millions of poor people of the benefits of livestock production.

external review commissioned by ILRI later that year. These recommended reduced investment in basic research, accompanied by restructuring to promote a multidisciplinary problem-solving approach. Both recommendations have been implemented.

East Coast fever and trypanosomosis are likely to remain important priorities for ILRI, since success now seems much nearer than it did a few years ago and progress in these diseases will contribute to the control of related diseases globally. But the change from an African to a global mandate that came with ILRI's foundation requires consideration of other priority diseases in Asia and Latin America. ILRI has already agreed in principle to conduct research on other diseases; the question is, which ones?

'We plan a global exercise to evaluate the current and future impact of different diseases, so as to determine whether and how ILRI can contribute,' says programme leader Subhash Morzaria. 'The Livestock Revolution will be a major factor influencing our thinking.'

There's no shortage of candidate diseases queuing to join the research agenda. Most are so-called 'orphan diseases' on which the profit-oriented private sector is unwilling to work. 'Commercial companies tend not to put money into diseases that affect poor livestock producers, as they know these people can't afford to pay high prices for inputs,' says Morzaria. 'Our first step must be to put a hard figure on the economic damage caused by each disease. Then we need to consider the question of feasibility—does a vaccine look possible and, if so, could it be delivered to users? Lastly, we'll need to look at our comparative advantage in conducting the necessary research. In some cases we could play a catalytic role, while national or regional institutes take the lead. In others, we could do much of the work ourselves.'

Like the diseases themselves, approaches to disease control are also evolving—a further factor that affects ILRI's future research agenda. 'The concept now is one of integrated disease control,' Morzaria explains. Essentially this means the use of a combination of methods, including improved management practices in addition to drugs, vaccines and diagnostic tools. 'We've realised that no single method is adequate by itself.'

Vaccines retain pride of place in the new paradigm. Their power as a control tool stems from the fact that, as they are applied, the number of immune individuals in a population rises to the point at which the disease can no longer be easily transmitted, opening up the possibility of eradication. Vaccine development has brought enormous benefits to the livestock sector in the developed world and there have been success stories in the developing countries too. In 1999 Dr Walter Plowright became the first veterinarian to win the World Food Prize for his contribution to the development

of a vaccine against rinderpest over a quarter of a century ago, while working for the East African Veterinary Research Organisation. An economic analysis conducted by ILRI and the Organization of African Unity/Inter-African Bureau for Animal Resources (OAU/IBAR) has shown the high economic returns attributable to the use of this and other vaccines. In the case of zoonotic diseases, the benefits extend to human as well as animal health. However, there is increasing recognition that the immunity conferred by vaccines can break down under heavy disease challenge, just as it can with drugs. And in the developing countries, the delivery of vaccines to users has emerged as a critical issue. Live vaccines, which have to be kept frozen up to the point of use, are expensive and difficult to deliver in regions such as sub-Saharan Africa, with the result that subunit vaccines, which use a component of the causative agent to stimulate the production of antibodies, are now widely regarded as a better bet. Technologies such as freeze drying vaccines or simply keeping them on ice are also a possible way forward. While vaccine development for tropical animal diseases is likely to remain a public-sector responsibility, it will be necessary to entice a hitherto reluctant private sector into vaccine dissemination if users are to be reached in sufficient numbers.

ILRI will make increasing use of information technology to support animal health research. Geographic information systems (GIS) offer opportunities to improve the planning and evaluation

of disease control strategies, helping to concentrate scarce resources in the areas where they can make the most impact. Bioinformatics is a powerful new tool for identifying the genetic components of the next generation of vaccines, drugs and diagnostic tools. 'This is a tremendously important area in which we plan to build our capacity,' says Morzaria.

In sum, ILRI's research on East Coast fever and trypanosomosis has endowed it with a critical mass of expertise and facilities. The Institute has already achieved much in the field of animal health research. Resources will be deployed even more effectively in the future, to ensure that the Livestock Revolution serves the needs of poor producers and consumers worldwide.

A future for Zufaan

Making the Livestock Revolution work for the poor is, as we have seen, a complex challenge requiring a mix of policy, institutional and technological interventions. Assuming that challenge is met, how will Zufaan Assefaw be farming 20 years from now?

Rural Ethiopia is very conservative and some things in Zufaan's life will probably unfold much as they did for her mother. If she stays in the countryside she could well marry another farmer, and it's a safe bet that on that day there will be much traditional merry-making. But once she has a farming family of her own she may well look back on her youth in wonder that her parents' farm remained so traditional—in many respects a half-way house between the past and the future.

Instead of raising a mix of food crops and livestock, as her parents did, Zufaan's future farm is likely to be far more specialised, perhaps deriving all of its income from the sale of animals and their products or from the growing of forages. It will use more inputs and will be more closely linked to expanding urban markets, possibly even to an export market, via a prosperous co-operative or contracting business. It will probably be larger than today's average smallholding, as less successful neighbouring farmers are bought out and leave the land to search for work in the cities.

Like other members of tomorrow's farming generation, Zufaan and her husband will expect to get more out of life than their parents did. And, if all goes well, they will have the higher incomes to fulfil those expectations, at least in part. They will stand a good

'Failing to act risks throwing away one of the few dynamic economic trends that can be used to improve the lives of poor rural people in developing countries.'—2020 study.

'The Panel believes that ILRI has enormous potential to increase human well-being in the tropical world.'—EPMR report.

chance of succeeding in their farming venture, because their better education will motivate them to get access to information—about markets, the use of inputs and so on—that their parents never dreamed would be relevant, let alone accessible. And if they work hard, they will be able to put that information to good use. After meeting their family's basic needs in food, clothing and shelter, they will invest in the technology and equipment that can improve their lives and livelihoods still further. In the corner of the farm kitchen there may be a television, perhaps even a phone and a computer with access to the Internet. Outside, in the yard, there could be a tractor and a car or pick-up truck belonging to the farm. And if the family can save enough money, they may invest some of it in a small shop or a taxi business in a neighbouring town. Almost certainly, Zufaan and her husband will seek to invest in more education for their children than they received themselves.

These are humble enough aspirations—no greater than those of millions of small farming households around the world as the 21st century dawns. Their realisation, however, depends crucially on a 'benign' Livestock Revolution—one that allows the rural poor to participate. ILRI and its partners are dedicated to securing that outcome.

Sources

Baker R.L. 1998. Genetic resistance to endoparasites in sheep and goats: A review of genetic resistance to gastro-intestinal nematode parasites in sheep and goats in the tropics and evidence for resistance in some sheep and goat breeds in subhumid coastal Kenya. *Animal Genetic Resources Information* 24: 13–30.

CAST (Council for Agricultural Science and Technology). 1999. *Animal Agriculture and Global Food Supply*. Task Force Report No. 135. Ames, Indiana, USA.

CONDESAN (Consortio para el Desarollo sostenible de la Ecoregión Andina). 1999. *Investigación y Desarollo para los Andes*. Lima, Peru.

Delgado C., Rosegrant M., Steinfeld H., Ehui S. and Courbois C. 1999. *Livestock to 2020: The Next Food Revolution*. Food, Agriculture and the Environment Discussion Paper No. 28. International Food Policy Research Institute (IFPRI), Washington DC, USA.

Freeman H.A., Jabbar M.A. and Ehui S. 1998. *The Role of Credit in the Uptake and Productivity of Improved Dairy Technologies in Sub-Saharan Africa*. Livestock Policy Analysis Brief No. 10. ILRI, Nairobi, Kenya.

Haider J., Shapiro B.I., Tsegaye Demissie and Alemu Gebre Wold. 1998. The impact of crossbred cows on the nutritional and health status of women and children in Holetta *woreda*, Ethiopia. Paper presented at a conference held at ILRI, Addis Ababa, Ethiopia.

Kristjanson P.M. and Zerbini E. 1999. *Genetic Enhancement of Sorghum and Millet Residues Fed to Ruminants: An Ex-ante Assessment of Returns to Research*. ILRI Impact Assessment Series No. 3. ILRI, Nairobi, Kenya.

Morton J., Coulter J., Miheso V., Staal S., Kenyanjui M. and Tallontire A. 1999. *Provision of Agricultural Services through Co-operatives and Self-help Groups in the Dairy Sector of Kenya*. Research Report, Natural Resources Institute (NRI), Chatham, UK.

Owango M., Staal S., Kenyanjui M., Lukuyu B., Njubi D. and Thorpe W. 1998. Dairy co-operatives and policy reform in Kenya: Effects of livestock service and milk market liberalisation. *Food Policy 23* (2): 173–185.

Staal S., Delgado C. and Nicholson C. 1998. Smallholder Dairying under Transaction Costs in East Africa. Livestock Policy Analysis Brief No. 6. ILRI, Nairobi, Kenya.

Staal S.J. and Shapiro B.I. 1998. *The Effects of Price Liberalisation on Kenyan Peri-urban Dairying*. Livestock Policy Analysis Brief No. 15. ILRI, Nairobi, Kenya.

Shapiro B.I., Haider J., Alemu Gebre Wold and Abebe Misgina. 1998. The intra-household economic and nutritional impacts of market-oriented dairy production: Evidence from the Ethiopian highlands. Paper presented at a conference held at ILRI, Addis Ababa, Ethiopia.

Swindale L.D. 1999. ILRI, ICRISAT, NARS and Farmers: Partnerships to Exploit Crop–livestock Synergies in Africa and Asia. Presentation at International Centers Week, October 1999, Washington DC, USA.

Zerbini E. and Hash C.T. 1999. Progress report: Development and Use of Molecular Genetic Markers for Enhancing the Feeding Value of Cereal Crop Residues for Ruminants: Pearl Millet. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India.

ILRI programme areas in 1999

Biosciences Programme

Ruminant genetics

Characterisation, conservation and use of animal genetic resources

Development of disease-resistant livestock

Ruminant health

Molecular basis of pathogenesis and disease resistance

Immunology and vaccine development

Improving livestock productivity through development of subunit vaccines

Development and application of diagnostic tools in disease control and surveillance

Epidemiology and disease control

Ruminant feed resources

Feed utilisation improvement for enhancing livestock productivity

Rumen microbiology for feed utilisation enhancement

Conservation and characterisation of forage genetic resources

Sustainable Production Systems Programme

Systems analysis and impact assessment

Increasing returns to livestock research through systems analysis and impact assessment

Livestock policy analysis

Policy analysis for improving productivity and sustainability of crop–livestock systems

Crop–livestock systems research

Improving crop–livestock systems and sustainability in the highlands of sub-Saharan Africa and Asia

Improving productivity and sustainability in crop–livestock systems of subhumid Asia and sub-Saharan Africa

Improving productivity and sustainability of crop–livestock systems in semi-arid sub-Saharan Africa and Asia

Improving productivity and sustainability of crop–livestock systems in fragile environments in the Latin America and Caribbean region

Improving productivity and sustainability of crop–livestock systems in West Asia–North Africa

Improving livestock productivity under disease risk

Improving productivity and sustainability of smallholder dairy systems

CGIAR System-wide Livestock Programme

Strengthening Partnerships with National Agricultural Research Systems Programme

Capacity development for strengthening national agricultural research systems

Publications by ILRI staff in 1999

ILRI technical publications

Delgado C., Rosegrant M., Steinfeld H., Ehui S. and Courbois C. 1999. *Livestock to 2020: The Next Food Revolution*. IFPRI Food, Agriculture, and the Environment Discussion Paper 28. IFPRI (International Food Policy Research Institute), Washington DC, USA/ FAO (Food and Agriculture Organization of the United Nations), Rome, Italy/ILRI (International Livestock Research Institute), Nairobi, Kenya. 72 pp.

Elbasha E., Thornton P.K. and Tarawali G. 1999. *An Ex-post Economic Assessment of Planted Forages in West Africa*. ILRI Impact Assessment Series 2. ILRI (International Livestock Research Institute), Nairobi, Kenya. 61 pp.

Falvey L. and Chantalakhana C. (eds). 1999. *Smallholder Dairying in the Tropics*. ILRI (International Livestock Research Institute), Nairobi, Kenya. 447 pp.

Kristjanson P.M. and Zerbini E. 1999. *Genetic Enhancement of Sorghum and Millet Residues Fed to Ruminants: An Ex-ante Assessment of Returns to Research*. ILRI Impact Assessment Series 3. ILRI (International Livestock Research Institute), Nairobi, Kenya. 44 pp.

Kristjanson P., Rowlands J., Swallow B., Kruska R., de Leeuw P. and Nagda S. 1999. *Using the Economic Surplus Model to Measure Potential Returns to International Livestock Research: The Case of Trypanosomosis Vaccine Research*. ILRI Impact Assessment Series 4. ILRI (International Livestock Research Institute), Nairobi, Kenya. 36 pp.

Nicholson C.F., Thornton P.K., Mohammed L., Muinga R.W., Mwamachi D.M., Elbasha E.H., Staal S.J. and Thorpe W. 1999. *Smallholder Dairy Technology in Coastal Kenya: An Adoption and Impact Study*. ILRI Impact Assessment Series 5. ILRI (International Livestock Research Institute), Nairobi, Kenya. 59 pp.

Pengelly B.C., Maass B.L. and Hanson J. 1999. Lablab purpureus: *A Photographic Record of Lablab Collections*. ATFGRC-CSIRO, Brisbane, Australia/ILRI (International Livestock Research Institute), Addis Ababa, Ethiopia. 266 pp.

Tarawali S.A., Peters M. and Schultze-Kraft R. 1999. *Forage Legumes for Sustainable Agriculture and Livestock Production in Subhumid West Africa*. ILRI Project Report. ILRI (International Livestock Research Institute), Nairobi, Kenya. 118 pp.

Papers in peer reviewed journals

Achenef M., Marcos T., Feseha G., Hibret A. and Tembely S. 1999. *Coenurus cerebralis* infection in Ethiopian highland sheep: Incidence and observations on pathogenesis and clinical signs. *Tropical Animal Health and Production (UK)* 31(1):15–24.

Ayantunde A.A., Hiernaux P., Fernandez-Rivera S., van Keulev H. and Udo H.M.J. 1999. Selective grazing by cattle on spatially and seasonally heterogenous rangeland in the Sahel. *Journal of Arid Environments (UK)* 42(4):261–279.

Baker R.L. 1999. Genetics of resistance to endoparasites and ectoparasites. *International Journal of Parasitology (UK)* 29(1):73–75.

Baker R.L., Mwamachi D.M., Audho J.O., Aduda E.O. and Thorpe W. 1999. Genetic resistance to gastro-intestinal nematode parasites in Red Maasai, Dorper and Red Maasai x Dorper ewes in the sub-humid tropics. *Animal Science (UK)* 69(pt. 2):335–344.

Bauer B., Amsler-Delafosse S., Kabore I. and Kamuanga M. 1999. Improvement of cattle productivity through rapid alleviation of African animal trypanosomiasis by integrated disease management practices in the agropastoral zone of Yale, Burkina Faso. *Tropical Animal Health and Production (UK)* 31(2):89–102.

Boulter N., Brown D., Wilkie G., Williamson S., Kirvar E., Knight P., Glass E., Campbell J., Morzaria S., Nene V., Musoke T., d'Oliveira C., Gubbels M., Jongejan F. and Hall R. 1999. Evaluation of recombinant sporozoite antigen SPAG-1 as a vaccine candidate against *Theileria annulata* by the use of different delivery systems. *Tropical Medicine and International Health* 4(9):A71–A77.

Buza J. and Naessens J. 1999. Trypanosome non-specific IgM antibodies detected in serum of *Trypanosoma congolense*-infected cattle are polyreactive. *Veterinary Immunology and Immunopathology (the Netherlands)* 69(1):1–9.

Chamboko T., Mukhebi A.W., Callaghan C.J.O., Peter T.F., Kruska R.L., Medley G.F., Mahan S.M. and Perry B.D. 1999. The control of heartwater on large-scale commercial and smallholder farms in Zimbabwe. *Preventive Veterinary Medicine (the Netherlands)* 39:191–210.

Coppock D.L. and Sovani S. 1999. Is supplementation justified to compensate pastoral calves for milk restriction? *Journal of Range Management (USA)* 52(3):208–217.

Dada S.A.O., Adeneye J.A., Akinsoyinu A.O., Smith J.W. and Dashiell K.E. 1999. Performance of sheep fed soybean stover and cassava crumb based diets. *Small Ruminant Research (the Netherlands)* 31(3):229–238.

Daubenberger C.A., Taracha E.L.N., Gaidulis L., Davis W.C. and McKeever D.J. 1999. Bovine γδ T-cell responses to the intracellular parasite *Theileria parva*. *Infection and Immunity* 67:2241–2249.

Davison H.C., Thrusfield M.V., Muharsini S., Husein A., Partoutomo S., Rae P.F., Masake R. and Luckins A.G. 1999. Evaluation of antigen detection and antibody detection tests for *Trypanosoma evansi* infections of buffaloes in Indonesia. *Epidemiology and Infection (UK)* 123:149–155.

Devendra C. 1999. Goats: Challenges for increased productivity and improved livelihoods. *Outlook on Agriculture* 28:215–226.

Devendra C. 1999. The relevance and implications of livestock–tree interactions in agroforestry systems in developing countries. *Annals of Arid Zone* 39:397–411.

Ebong C., Byenkya S.G. and Ndikumana J. 1999. Effects of substituting *Calliandra* leaf meal for soybean meal on intake, digestibility, growth and feed efficiency in goats. *Journal of Applied Animal Research (India)* 16(2):211–216.

Ellis S.A. and Ballingal K.T. 1999. Cattle MHC: Evolution in action? *Immunological Reviews (Denmark)* 167:159–168.

Fall A., Diack A., Diaite A., Seye M. and d'Ieteren G.D.M. 1999. Tsetse challenge, trypanosome and helminth infection in relation to productivity of village N'dama cattle in Senegal. *Veterinary Parasitology (the Netherlands)* 81:235–247.

Fufa Dawo and Zerbini E. 1999. Post-partum reproductive function of F_1 crossbred cows under smallholder management conditions in central highlands of Ethiopia. *Journal of the Ethiopian Veterinary Association* 3(1):17–33.

Gavian S. and Ehui S. 1999. Measuring the production efficiency of alternative land tenure contracts in a mixed crop–livestock system in Ethiopia. *Agricultural Economics (USA)* 20(1):37–49.

Gelhaus A., Hanotte O., Horstmann R.D. and Teale A.J. 1999. Linkage mapping of the bovine lysosomal alphamannosidase (MANB) gene. *Animal Genetics (UK)* 30:225–244.

Geysen D., Bishop R., Skilton R., Dolan T. and Morzaria S. 1999. Molecular epidemiology of *Theileria parva* in the field. *Tropical Medicine and International Health* 4(9):21–27.

Gitau G.K., Perry B.D. and McDermott J.J. 1999. The incidence, calf morbidity and mortality due to *Theileria parva* infections in smallholder dairy farms in Murang'a District, Kenya. *Preventive Veterinary Medicine (the Netherlands)* 39:65–79.

Goldammer T., Brunner R.M., Kang'a S., Hanotte O. and Schwerin M. 1999. Generation of a bovine BAC pool for chromosome region BTA7q14-22 correlated to the trait trypanotolerance. Proceedings of an International Symposium on Candidate Genes for Animal Health, Rostock, Germany, 25–27 August 1999. *Archiv für Tierzucht (Archives of Animal Breeding), Special Issue* 42:150–152.

Gu Y., Gettinby G., McKendrick I., Murray M., Peregrine A.S. and Revie C. 1999. Development of a decision support system for trypanocidal drug control of bovine trypanosomosis in Africa. *Veterinary Parasitology* 87(1):9–23.

Haque I. and Lupwayi N.Z. 1999. Landform and phosphorus effects on nitrogen fixed by annual clovers and its contribution to succeeding cereals in the Ethiopian highlands. *Australian Journal of Agricultural Research* 50(8):1393–1398.

Haque I., Lupwayi N.Z. and Ssali H. 1999. Agronomic effectiveness of unacidulated and partially acidulated Minjingu rock phosphates on *Stylosanthes guianensis*. *Tropical Grasslands* 33(3):159–164.

Haque I., Lupwayi N.Z. and Ssali H. 1999. Agronomic evaluation of unacidulated and partially acidulated Minjingu and Chilembwe phosphate rocks for clover production in Ethiopia. *European Journal of Agronomy* 10:37–47.

Hiernaux P. and Gérard B. 1999. The influence of vegetation pattern on the productivity, diversity and stability of vegetation: The case of 'brousse tigrée' in the Sahel. *Acta Oecologica* 20(3):147–158.

Hiernaux P., Bielders C.L., Valentin C., Bationo A. and Fernandez-Rivera S. 1999. Effects of livestock grazing on physical and chemical properties of sandy soil in Sahelian rangelands. *Journal of Arid Environments* 41(3):231–245.

van Hooft W.F., Hanotte O., Wenink P.W., Groen A.F., Sugimoto Y., Prins H.H.T. and Teale A. 1999. Applicability of bovine microsatellite markers for population genetic studies on African buffalo *(Syncerus caffer)*. *Animal Genetics (UK)* 30:214–220.

Hope J.C., Werling R.A., Collins R.A., Mertens B. and Howard C. 1999. FLT-3 Ligand, in combination with bovine GM-CSF and IL-4, promotes the growth of bovine bone marrow-derived dendritic cells. *Scandinavian Journal of Immunology* 51:60–66.

d'Hughes A.J. and Tarawali S.A. 1999. Viruses of herbacious legumes in the moist savannah of West Africa. *Tropical Science (UK)* 39(2):70–76.

Ikpe F.N., Powell J.M., Isirimah N.O., Wahua T.A.T. and Godigha E.M. 1999. Effects of primary tillage and soil amendment practices on pearl millet yield and nutrient uptake in the Sahel of West Africa. *Experimental Agriculture (UK)* 35(4):437–448.

Iraqi F. and Teale A. 1999. Polymorphisms in the Tnfa gene of different inbred mouse strains. *Immunogenetics (Germany)* 49:242–245.

Iraqi F., Marteen S. and Teale A. 1999. TNF-a expression in trypanosomiasis resistant and susceptible mouse strains during infection with *Trypanosoma congolense*. Proceedings of the International Symposium on Candidate

Genes for Animal Health, Rostock, Germany, 25–27 August 1999. *Archiv für Tierzucht (Archives of Animal Breeding) Special Issue* 42:119–122.

Jabbar M.A., Swallow B.M. and Rege J.E.O. 1999. Incorporation of farmer knowledge and preferences in designing breeding policy and conservation strategy for domestic animals. *Outlook on Agriculture* 28(4):239–243.

Janoo R., Musoke A., Wells C. and Bishop R. 1999. A Rab1 homologue with a novel isoprenylation signal provides insight into the secretory pathway of *Theileria parva*. *Molecular and Biochemical Parasitology* 102:131–143.

Jones P.G. and Thornton P.K. 1999. Linking a third-order Markov rainfall model to interpolated climate surfaces. *Agricultural and Forest Meteorology* 97(3):213–231.

Kahsay Berhe, Tothill J.C. and Mohamed-Saleem M.A. 1999. Response of different *Sesbania* accessions to phosphorus application and fodder quality of *S. sesban* under acid soil conditions. *Ethiopian Journal of Natural Resources* 1(1):57–75.

Kariuki J.N., Gitau G.K., Gachuiri C.K., Tamminga S., Irungu K.R.G. and Muia J.M. 1999. Effect of maturity on the mineral content of Napier grass (*Pennisetum purpureum*). *Tropical Science (UK)* 39(1):56–61.

Kariuki J.N., Gitau G.K., Gachuiri C.K., Tamminga S. and Muia J.M.K. 1999. Effect of supplementing Napier grass with desmodium and lucerne on DM, CP and NDF intake and weight gains in dairy heifers. *Livestock Production Science (the Netherlands)* 60(1):81–88.

Kariuki J.N., Tamminga S., Gitau G.K., Gachuiri C.K. and Muia J.M.K. 1999. Performance of Sahiwal and Friesian heifers fed on Napier grass supplemented with graded levels of lucerne. *South African Journal of Animal Science* 29(1):1–10.

Kassa T., Wirtu G. and Tegegne A. 1999. Survey of mastitis in dairy herds in the Ethiopian central highlands. *SINET: Ethiopian Journal of Science* 22(2):291–301.

Kassie M., Jabbar M.A. and Kassa B. 1999. An analysis of the implications of forage legumes and a cereal-based cropping system for sustainable agriculture in Ethiopia: A linear programming approach. *Science, Technology and Development* 16(3):32–50.

Khalili H., Kuusela E., Saarisalo E. and Suvitie M. 1999. Use of rapeseed and pea grain protein supplements for organic milk production. *Agricultural and Food Science in Finland* 8(3):239–252.

Kristjanson P.M., Swallow B.M., Rowlands G.J., Kruska R.L. and de Leeuw P.N. 1999. Measuring the costs of African animal trypanosomosis, the potential benefits of control and returns to research. *Agricultural Systems (UK)* 59(1):79–98.

Kurtu M.Y., Tawah C.L., Rege J.E.O., Nega Alemayehu and Mesfin Shibre. 1999. Lactation performance of purebred Arsi cows and Friesian x Arsi crosses under pre-partum and post-partum supplementary feeding regimes. *Animal Science (UK)* 68(4):625–633.

Larbi A., Adekunle I.O., Awojide A. and Akinlade J. 1999. Identifying *Chamaecrista rotundifolia* accessions and *Centrosema* species for bridging seasonal feed gaps in smallholder mixed farms in the West African derived savanna. *Tropical Grasslands (Australia)* 33(2):91–97.

Larbi A., Dung D.D., Olorunju P.E., Smith J.W., Tanko R.J., Muhammad I.R. and Adekunle I.O. 1999. Groundnut (*Arachis hypogaea*) for food and fodder in crop–livestock systems: Forage and seed yields, chemical composition and rumen degradation of leaf and stem fractions of 38 cultivars. *Animal Feed Science and Technology (the Netherlands)* 77(1–2):33–47.

Lebbie S.H.B. and Ramsay K. 1999. A perspective on conservation and

management of small ruminant genetic resources in sub-Saharan Africa. *Small Ruminant Research (the Netherlands)* 34(3):231–247.

Li-Pun H. and Maass B.L. 1999. The role of international livestock research in addressing human needs and protecting the environment. (Role de la recherche internationale sur l'élevage dans la satisfaction des besoins humains et la protection de l'environnement). *Agriculture and Rural Development (Germany), Agriculture et Développement Rural* 6(1):58–61.

Lupwayi N.Z. and Haque I. 1999. *Leucaena* hedgerow intercropping and cattle manure application in the Ethiopian highlands, 1: Decomposition and nutrient release. *Biology and Fertility of Soils (Germany)* 28:182–195.

Lupwayi N.Z. and Haque I. 1999. *Leucaena* hedgerow intercropping and cattle manure application in the Ethiopian highlands, 3: Nutrient balances. *Biology and Fertility of Soils (Germany)* 28:204–211.

Lupwayi N.Z., Haque I., Saka A.R. and Siaw D.E.K.A. 1999. *Leucaena* hedgerow intercropping and cattle manure application in the Ethiopian highlands, 2: Maize yields and nutrient uptake. *Biology and Fertility of Soils (Germany)* 28:196–203.

Martinez T.A., Meltzer M.I., Perry B.D., Burridge M.J. and Mahan S.M. 1999. The effect of subclinical experimental *Cowdria ruminantium* infection in ewes on the growth and milk consumption of pre-weaning lambs. *Preventive Veterinary Medicine (the Netherlands)* 41:105–118.

Martinez T.A., Meltzer M.I., Perry B.D., Burridge M.J. and Mahan S.M. 1999. The effect of subclinical experimental *Cowdria ruminantium* infection on the health and reproductive performance of breeding ewes. *Preventive Veterinary Medicine (the Netherlands)* 41:89–103.

McDermott J.J., Randolph T.F. and Staal S.J. 1999. The economics of optimal health and productivity in smallholder livestock systems in developing countries. *Revue Scientifique et Technique de l'OIE (OIE Scientific and Technical Review, France)* 18(2):399–424.

McKeever D.J. and Rege J.E.O. 1999. Vaccines and diagnostic tools for animal health: The influence of biotechnology. *Livestock Production Science (the Netherlands)* 59(2–3):257–264.

McKeever D.J., Taracha E.L.N., Morrison A.J., Musoke A.J. and Morzaria S.P. 1999. Protective immune mechanisms against *Theileria parva*: Evolution of vaccine development strategies. *Parasitology Today (UK)* 15(7):263–267.

Menale Kassie, Jabbar M.A., Belay Kassa and Mohammed-Saleem M.A. 1999. Benefits of integration of cereals and forage legumes with and without crossbred cows in mixed farms: An *ex-ante* analysis for highland Ethiopia. *Journal of Sustainable Agriculture (USA)* 14(1):31–48.

Mertens B., Taylor K., Muriuki C. and Rocchi M. 1999. Cytokine mRNA profiles in trypanotolerant and trypanosusceptible cattle infected with the protozoan parasite *Trypanosoma congolense*: Protective role for interleukin-4. *Journal of Interferon and Cytokine Research* 19(1):59–65.

Minjauw B., Rushton J., James A.D. and Upton M. 1999. Financial analysis of East Coast fever control strategies in traditionally managed Sanga cattle in Central Province of Zambia. *Preventive Veterinary Medicine (the Netherlands)* 38:34–45.

Moloo S.K., Karia F.W. and Okumu I.O. 1999. Membrane feeding *Glossina morsitans centralis* on livestock blood and its effect on the tsetse susceptibility to pathogenic trypanosome infections. *Medical and Veterinary Entomology* 13(1):110–113.

Moloo S.K., Orinda G.O., Sabwa C.L., Minja S.H. and Masake R.A. 1999. Study on the sequential tsetse-transmitted *Trypanosoma*

congolense, *T. brucei brucei* and *T. vivax* infections to African buffalo, eland, waterbuck, N'Dama and Boran cattle. *Veterinary Parasitology (the Netherlands)* 80:197–213.

Mommens G., Peelman L.J., van Zeveren A., d'Ieteren G. and Wissocq N. 1999. Microsatellite variation between an African and five European taurine breeds results in a geographical phylogenetic tree with a bison outgroup. *Zeitschrift für Tierzüchtung und Züchtungsbiologie (Journal of Animal Breeding and Genetics, Germany)* 116(5):325–330.

Morty R.E., Authie E., Troeberg L., Lonsdale-Eccles J.D. and Coetzer T.H.T. 1999. Purification and characterisation of a typsin-like serine oligo peptidase from *Trypanosoma congolense*. *Molecular and Biochemical Parasitology* 102:144–155.

Mukhebi A.W., Chamboko T., O'Callaghan C.J., Peter T.F., Kruska R.L., Medley G.F., Mahan S.M. and Perry B.D. 1999. An assessment of the economic impact of heart-water (*Cowdria ruminantium* infection) and its control in Zimbabwe. *Preventive Veterinary Medicine (the Netherlands)* 39:173–189.

Mulenga A., Sugimoto C., Sako C., Ohashi K., Musoke A., Shubash M. and Onuma M. 1999. Molecular characterization of *Haemaphysalis longicornis* tick salivary gland-associated 29-kilodalton protein and its effect as a vaccine against tick infestation in rabbits. *Infection and Immunity (USA)* 67(4):1652–1658.

Nene V., Gobright E., Bishop R., Morzaria S. and Musoke A. 1999. Linear peptide specificity of antibody responses to p67 and sequence diversity of sporozoite neutralising epitopes: Implications for a *Theileria parva* vaccine. *Infection and Immunity* 67:1261–1266.

Nijman I.J., Bradley D.G., Hanotte O., Otsen M. and Lenstra J.A. 1999. Satellite DNA polymorphisms and AFLPs correlate with *Bos indicus-taurus* hybridization. *Animal Genetics (UK)* 30:265–273.

Nilsson P.H., Kang'a S., Rottengatter K., Suebeck U., Iraqi F., Mwakaya J., Mwangi D., Womack J.E., Goldammer T., Schwerin M., Bradley D., Agaba M., Sugimoto K., Gelhaus A., Horstmann R., Teale A., Kemp S. and Hanotte O. 1999. Radiation hybrid maps of candidate trypanotolerance regions in cattle. In: Proceedings of an International Symposium on Candidate Genes for Animal Health, Rostock, Germany, 25–27 August 1999. *Archiv für Tierzucht (Archives of Animal Breeding), Special Issue* 42:123–125.

Nsahlai I.V., Umunna N.N. and Osuji P.O. 1999. Influence of feeding sheep on oilseed cake following the consumption of tanniferous feeds. *Livestock Production Science (the Netherlands)* 60(1):59–69.

Nsahlai I.V., Bryant M.J. and Umunna N.N. 1999. Utilization of barley straw by steers: Effects of replacing urea with protein, source of protein and quantity of rumen degradable nitrogen on straw degradation, liquid and particle passage rates and intake. *Journal of Applied Animal Research (India)* 16(2):129–146.

O'Callaghan C.J., Medley G.F., Peter T.F., Mahan S.M. and Perry B.D. 1999. Predicting the effect of vaccination on the transmission dynamics of heartwater (*Cowdria ruminantium*) infection. *Preventive Veterinary Medicine* 2(1):17–38.

Odenyo A.A., Bishop R., Asefa G., Wells C. and Osuji P.O. 1999. Isolation and characterisation of anaerobic cellulose-degrading bacteria from East African porcupine (*Hystrix cristata*). *Anaerobe* 5(2):93–100.

Odenyo A.A., McSweeney C.S., Palmer B., Negassa D. and Osuji P.O. 1999. *In vitro* screening of rumen fluid samples from indigenous African ruminants provides for rumen fluid with superior capacities to digest tannin-rich fodders. *Australian Journal of Agricultural Research* 50(7):1147–1157.

Odenyo A.A., Osuji P.O. and Negassa D. 1999. Microbial evaluation of fodder tree leaves as ruminant feed. *Asian-Australasian Journal of Animal Sciences (Korea)* 12(5):708–714.

Ogore P.B., Baker R.L., Kenyanjui M. and Thorpe W. 1999. Assessment of natural ixodid tick infestations in sheep. *Small Ruminant Research (the Netherlands)* 33(2):103–107.

Okello-Onen J., Tukahirwa E.M., Perry B.D., Rowlands G.J., Nagda S.M., Musisi G., Bode E., Heironen R., Mwaji W. and Opuda-Asibo J. 1999. Population dynamics of ticks on indigenous cattle in a pastoral dry to semi-arid rangeland zone of Uganda. *Experimental and Applied Acarology (the Netherlands)* 23:79–88.

Omiti J.M., Parton K.A., Sinden J.A. and Ehui S.K. 1999. Monitoring changes in land-use practices following agrarian de-collectivisation in Ethiopia. *Agriculture, Ecosystems and Environment (the Netherlands)* 72:111–118.

Omore A.O., McDermott J.J., Arimi S.M. and Kyule M.N. 1999. Impact of mastitis control measures on milk production and mastitis indicators in smallholder dairy farms in Kiambu District, Kenya. *Tropical Animal Health and Production (UK)* 31(6):347–361.

Park S.D.E., Adomefa K., Dao B., Hanotte O., Kemp S.J., Sow R., Teale A.J. and Bradley D.G. 1999. Application of population genetic analysis of linked, mapped microsatellites to the identification of loci under selection for disease resistance. In: Proceedings of an International Symposium on Candidate Genes for Animal Health, Rostock, Germany, 25–27 August 1999. *Archiv für Tierzucht (Archives of Animal Breeding), Special Issue* 42:97–99.

Pearson R.A., Zerbini E. and Lawrence P.R. 1999. Recent advances in research on draught ruminants. *Animal Science (UK)* 68(1):1–17.

Perry B.D. and Randolph T.F. 1999. Improving the assessment of the economic impact of parasitic diseases and of their control in production animals. *Veterinary Parasitology* 84:145–168.

Perry B.D., Kalpravidh W., Coleman P.G., Horst H.S., McDermott J.J., Randolph T.F. and Glesson L.J. 1999. The economic impact of foot-and-mouth disease and its control in South-East Asia: A preliminary assessment with special reference to Thailand. *Revue Scientifique et Technique d l'OIE (OIE Scientific and Technical Review, France)* 18(2):478–497.

Peter T.F., Bryson N.J., Perry B.D., O'Callaghan C.J., Medley G.F., Mlambo G., Horak I.G., Burridge M.J. and Mahan S.M. 1999. *Cowdria ruminantium* infection in an African nature reserve. *Veterinary Record* 145:304–307.

Peter T.F., Anderson E.C., Burridge M.J., Perry B.D. and Mahan S.M. 1999. Susceptibility and carrier status of impala, sable and tsessebe for *Cowdria ruminantium* infection (heartwater). *Journal of Parasitology* 85:31–35.

Peters M., Tarawali S.A., Schultze-Kraft R., Smith J.W. and Musa A. 1999. Performance of legume mixtures under small-plot periodic grazing. *Journal of Agronomy and Crop Science (Germany)* 182:25–35.

Powell J.M., Ikpe F.N. and Somda Z.C. 1999. Crop yield and the fate of nitrogen and phosphorus following application of plant material and feces to soil. *Nutrient Cycling in Agroecosystems (the Netherlands)* 54(3):215–226.

Rege J.E.O. 1999. The state of African cattle genetic resources, 1: Classification framework and identification of threatened and extinct breeds. *FAO/UNEP Animal Genetic Resources Information Bulletin* 25:1–25.

Rekwote P.I., Oyedipe E.O., Mukasa-Mugerwa E., Sekoni V.O., Akinpelumi O.P. and Anyam A.A. 1999. Fertility in zebu cattle

(*Bos indicus*) after prostaglandin administration and artificial insemination. *Veterinary Journal (UK)* 158(1):53–58.

Rowlands G.J., Woudyalew Mulatu, Leak S.G.A., Nagda S.M. and d'Ieteren G.D.M. 1999. Estimating the effects of tsetse control on livestock productivity: A case study in southwest Ethiopia. *Tropical Animal Health and Production (UK)* 31(5):279–294.

Rushton J., Thornton P.K. and Otte M.J. 1999. Methods of economic impact assessment. *Revue Scientifique et Technique d l'OIE (OIE Scientific and Technical Review, France)* 18(2):315–342.

Saarisalo E.M., Odenyo A.A. and Osuji P.O. 1999. Inoculation with adapted microbes versus addition of polyethylene glycol as methods to alleviate toxicity of *Acacia angustissima* leaves in sheep. *Journal of Agricultural Science* 133:445–454.

Shaw M.K. 1999. *Theileria parva*: Sporozoite entry into bovine lymphocytes is not dependent on the parasite cytoskeleton. *Experimental Parasitology (USA)* 92(1):24–31.

Suliman H.B., Logan-Henfrey L., Majiwa P.A.O., Ole-Moiyoi O.K. and Feldman B.F. 1999. Analysis of erythropoietin and erythropoietin receptor genes expression in cattle during acute infection with *Trypanosoma congolense*. *Experimental Haematology (USA)* 27:37–45.

Tambi N.E. 1999. Co-integration and error-correction modelling of agricultural export supply in Cameroon. *Agricultural Economics (USA)* 20(1):57–67.

Tambi N.E., Maina O.W., Mukhebi A.W. and Randolph T.F. 1999. Economic impact assessment of rinderpest control in Africa. *Revue Scientifique et Technique d l'OIE (OIE Scientific and Technical Review, France)* 18(2):458–477.

Tambi N.E., Mukhebi W.A., Maina W.O. and Solomon H-M. 1999. Probit analysis of livestock producers' demand for private veterinary services in the high-potential agricultural areas of Kenya. *Agricultural Systems (UK)* 59(2):163–176.

Taylor K. and Mertens B. 1999. Bovine trypanosomosis and immunosuppression. *Memorias do Instituto Oswaldo Cruz* 94:239–244.

Teale A., Agaba M., Clapcott S.T., Gelhaus A., Haley C.H., Hanotte O., Horstmann R., Iraqi F., Kemp S.T., Nilsson P., Schwerin M., Sekikawa K., Soller M., Sugimoto Y. and Womack J. 1999. Resistance to trypanosomosis: Of markers, genes and mechanisms. In: Proceedings of an International Symposium on Candidate Genes for Animal Health, Rostock, Germany, 25–27 August 1999. *Archiv für Tierzucht (Archives of Animal Breeding), Special Issue* 42:36–41.

Tedla A., Mamo T., Klaij M.C. and Diedhiou M.L. 1999. Effects of cropping system, seed bed management and fertility interactions on biomass of crops grown on a Vertisol in the central highlands of Ethiopia. *Journal of Agronomy and Crop Science (Germany)* 183:205–211.

Teferedegne B., McIntosh F., Osuji P.O., Odenyo A., Wallace R.J. and Newbold C.J. 1999. Influence of foliage from different accessions of the sub-tropical leguminous tree, *Sesbania sesban*, on ruminal protozoa in Ethiopian and Scottish sheep. *Animal Feed Science and Technology (the Netherlands)* 78(1–2):11–20.

Totte P., Nyanjui J., Bensaid A. and McKeever D. 1999. Bovine CD4sup (+) T-cell lines reactive with soluble and membrane antigens of *Cowdria ruminantium*. *Veterinary Immunology and Immunopathology* 70(3/4): 269–276.

Totte P., Bensaid A., Mahan S.M., Martinez D. and McKeever D.J. 1999. Immune responses to *Cowdria ruminantium* infections. *Parasitology Today (UK)* 15(7):286–290.

Williams T.O. 1999. Factors influencing manure application by farmers in semi-arid West Africa. *Nutrient Cycling in Agroecosystems (the Netherlands)* 55(1):15–22.

van de Wouw M., Hanson J. and Luethi S. 1999. Morphological and agronomic characterisation of a collection of Napier grass (*Pennisetum purpureum*) and *P. purpureum x P. glaucum*. *Tropical Grasslands* 33(3):150–158.

van de Wouw M., Hanson J. and Nokoe S. 1999. Observation strategies for morphological characterisation of forages. *Genetic Resources and Crop Evolution* 46(1):63–71.

Zerbini E. and Alemu Gebre Wold. 1999. Effect of work applied at different stages of lactation on milk production, reproduction and liveweight change of F_1 crossbred dairy cows used for draught. *Animal Science (UK)* 69(3):473–480.

Zerbini E., Sharma A. and Rattunde H.F.W. 1999. Fermentation kinetics of stems of sorghum and millet genotypes. *Animal Feed Science and Technology (the Netherlands)* 81(1–2):17–34.

Books and chapters from books

Chin H.F. and Hanson J. 1999. Seed quality: Seed storage. In: Loch D.S. and Ferguson J. (eds), *Forage Seed Production, vol. 2: Tropical and Subtropical Species*. CAB International, Wallingford, UK. pp. 303–315.

Devendra C. 1999. Dairying in integrated farming systems. In: Falvey L. and Chantalakhana C. (eds), *Smallholder Dairying in the Tropics*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 277–288.

Hacker B. and Hanson J. 1999. Crop growth and development: Reproduction. In: Loch D.S. and Ferguson J. (eds), *Forage Seed Production, vol. 2: Tropical and Subtropical Species*. CAB International, Wallingford, UK. pp. 93–111.

d'Ieteren G., Authié E., Wissocq N. and Murray M. 1999. Exploitation of resistance to trypanosomes. In: Axford R.F.E., Bishop S.C., Nicholas F.W. and Owen J.B. (eds), *Breeding for Disease Resistance in Farm Animals*. Second edition. CAB International, Wallingford, UK. pp. 195–216.

de Leeuw P.N., Omore A., Staal S. and Thorpe W. 1999. Dairy production systems in the tropics. In: Falvey L. and Chantalakhana C. (eds), *Smallholder Dairying in the Tropics*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 19–44.

Nicholson C.F., Thornton P.K., Mohamed L., Muinga R.F., Mwamachi D. M., Elbasha E.H., Staal S.J. and Thorpe W. 1999. Smallholder dairy technology in coastal Kenya. In: Sechrest L., Stewart M. and Stickle T. (eds), *A Synthesis of Findings Concerning CGIAR Case Studies on the Adoption of Technological Innovations*. IAEG Secretariat, FAO (Food and Agriculture Organization of the United Nations), Rome, Italy. pp. 65–79.

Pender J., Place F. and Ehui S. 1999. *Strategies for Sustainable Agricultural Development in the East African Highlands*. EPTD Discussion Paper 41. EPTD (Environmental Production Technology Division), IFPRI (International Food Policy Research Institute), Washington DC, USA. 86 pp.

Smith J.W. and Naazie A. 1999. Role of ruminant livestock in soil fertility management in sub-Saharan Africa. In: Lal R. (ed), *Soil Quality and Agricultural Sustainability*. Ann Arbor Press, Chelsea, Michigan, USA. pp. 214–222.

Thornton P.K., Booltink H.W.G. and Stoorvogel J.J. 1999. Spatial analysis. In: Hoogenboom G., Wilkens P.W. and Tsuji G.Y. (eds), *DSSAT Version 3*, vol. 4. University of Hawaii Press, Honolulu, USA. pp. 37–110.

Zerbini E. and Alemu Gebre Wold. 1999. Feeding dairy cows for draught. In: Falvey L. and Chantalakhana C. (eds), *Smallholder*

Dairying in the Tropics. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 133–156.

ILRI training resources

Bruns E., Hiwot Berhane and Solomon Zewdie. 1999. *LIMS: Livestock Information Management System: Introductory Guide*. ILRI (International Livestock Research Institute), Nairobi, Kenya. Various pages.

Ibrahim H. 1999. *Feed Resources for Ruminant Livestock*. ILRI Slide Series 1. ILRI (International Livestock Research Institute), Nairobi, Kenya. 36 pp.

Ibrahim H. 1999. *Using Cattle for Draft Power and Transport*. ILRI Slide Series 2. ILRI (International Livestock Research Institute), Nairobi, Kenya. 29 pp.

Ibrahim H., Tembely S. and Roger F. 1999. *Diseases of Economic Importance in Small Ruminants in Sub-Saharan Africa*. ILRI Slide Series 3. ILRI (International Livestock Research Institute), Nairobi, Kenya. 37 pp.

Metz T. and Michael D. Asfaw. 1999. *LIMS: Livestock Information Management System: Database for Livestock Performance Data, Version 1.2*. ILRI (International Livestock Research Institute), Nairobi, Kenya. Various pages.

ILRI institutional publications

ILRI (International Livestock Research Institute). 1999. *Annual Programme Meeting Report, Addis Ababa, Ethiopia, 20–24 September 1999*. ILRI, Nairobi, Kenya. Various pages.

ILRI (International Livestock Research Institute). 1999. *ILRI Annual Progress Reports 1998*. ILRI, Nairobi, Kenya. 266 pp.

ILRI (International Livestock Research Institute). 1999. *ILRI Annual Workplans 1999*. ILRI, Nairobi, Kenya. 159 pp.

ILRI (International Livestock Research Institute). 1999. *ILRI 1998: Elevage et gestion des ressources naturelles*. ILRI, Nairobi, Kenya. 58 pp.

ILRI (International Livestock Research Institute). 1999. *ILRI 1998: Linking Livestock and Natural Resource Management*. ILRI, Nairobi, Kenya. 58 pp.

ILRI (International Livestock Research Institute). 1999. *Medium-term Plan 2000–2002: Improving the Productivity of Smallholder Livestock Systems and Protecting the Natural Resources that Support them*. ILRI, Nairobi, Kenya. 60 pp.

ILRI (International Livestock Research Institute). 1999. *Strategic Planning Process, 1999: Focus Group Workshops' Reports*. ILRI, Nairobi, Kenya. 138 pp.

Proceedings

ILRI (International Livestock Research Institute). 1999. *Proceedings of the Planning Workshop on the Crop–animal Systems Project, IRRI, Los Baños, the Philippines, 1–4 June 1999*. ILRI (International Livestock Research Institute), Nairobi, Kenya. 117 pp.

Morzaria S. and Williamson S. (eds). 1999. *Live Vaccines for* Theileria parva*: Deployment in Eastern, Central and Southern Africa: Proceedings of an FAO/OAU-IBAR/ILRI Workshop, held at ILRI, Nairobi, Kenya, 10–12 March 1997*. ILRI (International Livestock Research Institute), Nairobi, Kenya. 157 pp.

Musisi F.L. and Dolan T.T. (eds). 1999. *Tick and Tick-borne Disease Control in Eastern, Central and Southern Africa, 1991–1994: Proceedings of a Joint OAU, FAO and ILRAD Workshop held in Lilongwe, Malawi, 25–28 April 1994*.

ILRI (International Livestock Research Institute), Nairobi, Kenya. 150 pp.

Rege J.E.O. (ed). 1999. *Economic Valuation of Animal Genetic Resources: Proceedings of an FAO/ILRI Workshop held at FAO Headquarters, Rome, Italy, 15–17 March 1999*. ILRI (International Livestock Research Institute), Nairobi, Kenya. 72 pp.

Thomson E.F., von Kaufmann R., Li-Pun H., Treacher T. and van Houten H. (eds). 1999. *Global Agenda for Livestock Research: Proceedings of a Consultation on Setting Livestock Research Priorities in West Asia and North Africa (WANA) Region, ICARDA, Aleppo, Syria, 12–16 November 1997*. ILRI (International Livestock Research Institute), Nairobi, Kenya. 163 pp.

Thornton P.K. and Odero A.N. (eds). 1999. *Ecoregional Research at ILRI: Proceedings of a Workshop, ILRI, Addis Ababa, Ethiopia, 5–8 October 1998*. ILRI (International Livestock Research Institute), Nairobi, Kenya. 197 pp.

Papers in proceedings

Agyemang K. and Smith J.W. 1999. Counting the cost and benefits of implementing multi-country collaborative research projects: The case of the inland valley peri-urban dairy project in West Africa. In: Smith O.B. (ed), *Urban Agriculture in West Africa: Contributing to Food Security and Urbanisation: Proceedings of a Workshop, Ouagadougou, Burkina Faso, 15–18 June 1998*. IDRC (International Development Research Centre), Ottawa, Canada/CTA (Technical Centre for Agricultural and Rural Cooperation), Wageningen, the Netherlands. pp. 169–182.

Ayantunde A.A., Fernandez-Rivera A., Hiernaux P., van Keulen H. and Udo H.M.J. 1999. Forage intake and feeding behaviour of day and/or night grazing cattle in Sahelian rangelands. In: van der Heide D., Huisman E.A., Kanis E., Osse J.W.M. and Verstegen M.W.A. (eds), *Regulation of Feed Intake: Proceedings of the Fifth Zodiac Symposium, Wageningen, the Netherlands, 22–24 April 1999*. CAB International, Wallingford, UK. pp. 197–202.

Berkvens D.L., Young A.S. and Pegram R.G. 1999. Collaborative research on behavioural diapause in adult *Rhipicephalus appendiculatus* populations. In: Musisi F.L. and Dolan T.T. (eds), *Tick and Tick-borne Disease Control in Eastern, Central and Southern Africa, 1991–1994: Proceedings of a Joint OAU, FAO and ILRAD Workshop held in Lilongwe, Malawi, 25–28 April 1994*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 74–80.

Bishop R., Nene V., Spooner P., Mbogo S., Kariuki D., Payne R. and Morzaria S. 1999. Application of molecular tools in support of deployment of *Theileria parva* live vaccines. In: Morzaria S. and Williamson S. (eds), *Live Vaccines for* Theileria parva*: Deployment in Eastern, Central and Southern Africa: Proceedings of an FAO/OAU-IBAR/ILRI Workshop, held at ILRI, Nairobi, Kenya, 10–12 March 1997*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 66–69.

Booltink H.W.G. and Thornton P.K. 1999. System prototyping and simulation modelling in mixed farming systems. In: Thornton P.K. and Odero A.N. (eds), *Ecoregional Research at ILRI: Proceedings of a Workshop, ILRI, Addis Ababa, Ethiopia, 5–8 October 1998*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 135–145.

Devendra C. 1999. Feed resources in Asia: Efficiency of use and implications for animal production systems. In: Singhal K.K. and Rai S.N. (eds), *Proceedings of the 9th Animal Nutrition Conference, Hyderabad, India.* Animal Nutrition Society of India ICAR (Indian Council of Agricultural Research), New Delhi, India. pp. 1–19.

Devendra C. 1999. Selection and overview of benchmark sites in participating countries.

In: *Proceedings of the Planning Workshop on the Crop–animal Systems Project, IRRI, Los Baños, the Philippines, 1–4 June 1999*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 20–22.

Ehui S. 1999. The green impact of livestock-based nutrient management. In: *Soil Fertility Initiative for Sub-Saharan Africa: Proceedings of the SFI/FAO Consultation, Rome, Italy, 19–20 November 1998*. FAO World Soil Resources Reports 85. FAO (Food and Agriculture Organization of the United Nations), Rome, Italy. pp. 38–41.

Fernandez-Rivera S., Hiernaux P. and Williams T. 1999. Increasing the productivity and sustainability of crop–livestock systems in semi-arid West Africa: Research approaches and methods. In: Thornton P.K. and Odero A.N. (eds), *Ecoregional Research at ILRI: Proceedings of a Workshop, ILRI, Addis Ababa, Ethiopia, 5–8 October 1998*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 49–57.

Gardiner A.J. and Reid R.S. 1999. Effects of land-use change after tsetse control on biological diversity in northwestern Zimbabwe. In: *Proceedings of the 24th Meeting of the International Scientific Council for Trypanosomiasis Research and Control, Maputo, Mozambique, 29 September–3 October 1997*. OAU/STRC, Nairobi, Kenya. pp. 543–554.

Hiernaux P. and Fernandez-Rivera S. 1999. Grazing rotation in annual dominated rangelands in the Sahel. In: Eldridge D. and Freudenberger D. (eds), *People and Rangelands: Building the Future: Proceedings of the 6th International Rangeland Congress, Aitkenvale, Queensland, Australia, 18–23 July 1999*, vol. 1. International Rangeland Congress Inc., Aitkenvale, Australia. pp. 513–514.

Hiernaux P., Ayantunde A., de Leeuw P.N., Fernandez-Rivera S., Sangare M. and Schlecht E. 1999. Foraging efficiency, stocking rates, grazing pressure and livestock weight changes in the Sahel. In: Eldridge D. and Freudenberger D. (eds), *People and Rangelands: Building the Future: Proceedings of the 6th International Rangeland Congress, Aitkenvale, Queensland, Australia, 18–23 July 1999*, vol. 1. International Rangeland Congress Inc., Aitkenvale, Australia. pp. 511–512.

Hoogenboom G., Wilkens P.W., Thornton P.K., Jones J.W. and Hunt L.A. 1999. Advances in the development and application of DSSAT. In: Donatelli M., Stockle C., Villalobos F. and Mir J.M.V. (eds), *Proceedings of an International Symposium on Modelling Cropping Systems, Lleida, Spain, 21–23 June 1999*. Division of Agroclimatology and Agronomic Modelling, European Society of Agronomy. pp. 201–202.

d'Ieteren G., Wissocq N., Trail J.C.M., Nantulya V. and Masake R. 1999. Parasite control and assessment of trypanotolerance. In: *Proceedings of the 24th Meeting of the International Scientific Council for Trypanosomiasis Research and Control, Maputo, Mozambique, 29 September–3 October 1997*. OAU/STRC, Nairobi, Kenya. pp. 301–305.

Irvin A.D., Tebele N. and de Castro J.J. 1999. Report of discussions on impact assessment and vaccine breakdown. In: Musisi F.L. and Dolan T.T. (eds), *Tick and Tick-borne Disease Control in Eastern, Central and Southern Africa, 1991–1994: Proceedings of a Joint OAU, FAO and ILRAD Workshop held in Lilongwe, Malawi, 25–28 April 1994*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 98–100.

Kahsay Berhe, Berhanu Gebre Medhin, Ehui S. and Mohamed-Saleem M.A. 1999. Development needs of pastoral production systems in Ethiopia: Lessons learnt from ILRI's research in some pastoral areas of Ethiopia. In: Mitiku Haile, Tegegne Teka, Alemayehu Azeze, Dress Tsegaye and Merha Zerabruk (eds), *Challenges and Opportunities for Research and Development in Pastoral and Agro-pastoral Areas of Ethiopia: Proceedings of the DHP/Ethiopia National Workshop, Mekele, Ethiopia, 16–18 December 1998*. Mekele

University College, Ethiopia/DHP (Dryland Husbandry Project), Ethiopia. pp. 90–105.

Koundande D., Iraqi F., van Arendonk J. and Teale A. 1999. Marker-assisted introgression of multiple unlinked QTLs: Experimental design and consequences. In: *Proceedings of the Workshop, From Jay Lush to Genomics: Visions for Animal Breeding and Genetics, 16–18 May 1999*. Iowa State University, Iowa, USA. p. 171.

Lapar L.A. 1999. Crop–animal systems research in Southeast Asia: Data collection for benchmark site characterization. In: *Proceedings of the Planning Workshop on the Crop–animal Systems Project, IRRI, Los Baños, the Philippines, 1–4 June 1999*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 16–19.

Lawrence J.A. and Young A.S. 1999. Report on incorporation of vaccination in integrated tick and tick-borne disease control in the region. In: Musisi F.L. and Dolan T.T. (eds), *Tick and Tick-borne Disease Control in Eastern, Central and Southern Africa, 1991–1994: Proceedings of a Joint OAU, FAO and ILRAD Workshop held in Lilongwe, Malawi, 25–28 April 1994*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 127–129.

de Leeuw P.N., Hiernaux P. and Miheso V.M. 1999. Grazing pressure in sub-Saharan Africa: An historical perspective. In: Eldridge D. and Freudenberger D. (eds), *People and Rangelands: Building the Future: Proceedings of the 6th International Rangeland Congress, Aitkenvale, Queensland, Australia, 18–23 July 1999*, vol. 1. International Rangeland Congress Inc., Aitkenvale, Australia. pp. 551–553.

León-Velarde C. and Quiroz R. 1999. Crop–livestock systems research in the Andean region: Ecoregional approach, methods and procedures. In: Thornton P.K. and Odero A.N. (eds), *Ecoregional Research at ILRI: Proceedings of a Workshop, ILRI, Addis Ababa, Ethiopia, 5–8 October 1998*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 27–41.

Li-Pun H. 1999. The external environment: Implications for ILRI's systems research. In: *Proceedings of the Planning Workshop on the Crop–animal Systems Project, IRRI, Los Baños, the Philippines, 1–4 June 1999*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 3–8.

Li-Pun H. 1999. Globalisation of ILRI: Rationale and activities out of Africa. In: Thomson E.F., von Kaufmann R., Li-Pun H., Treacher T. and van Houten H. (eds), *Global Agenda for Livestock Research: Proceedings of a Consultation on Setting Livestock Research Priorities in West Asia and North Africa (WANA) Region, Aleppo, Syria, 12–16 November 1997*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 11–16.

Li-Pun H. 1999. Improvement of crop–animal systems in rainfed areas: Introductory remarks. In: *Proceedings of the Planning Workshop on the Crop–animal Systems Project, IRRI, Los Baños, the Philippines, 1–4 June 1999*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 1–2.

Li-Pun H., Jabbar M. and Thornton P. 1999. Ecoregional research at ILRI: Background. In: Thornton P.K. and Odero A.N. (eds), *Ecoregional Research at ILRI: Proceedings of a Workshop, ILRI, Addis Ababa, Ethiopia, 5–8 October 1998*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 1–15.

McKeever D. 1999. Multi-component subunit vaccines against *Theileria parva*. In: Morzaria S. and Williamson S. (eds), *Live Vaccines for* Theileria parva*: Deployment in Eastern, Central and Southern Africa. Proceedings of an FAO/OAU-IBAR/ILRI Workshop, held at ILRI, Nairobi, Kenya, 10–12 March 1997*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 131–132.

Mohamed-Saleem M.A. 1999. ILRI's research in the highlands ecoregion. In: Thornton P.K.

and Odero A.N. (eds), *Ecoregional Research at ILRI: Proceedings of a Workshop, ILRI, Addis Ababa, Ethiopia, 5–8 October 1998*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 17–25.

Morzaria S., Spooner P., Bishop R. and Mwaura S. 1999. The preparation of a composite stabilate for immunisation against East Coast fever. In: Morzaria S. and Williamson S. (eds), *Live Vaccines for* Theileria parva: *Deployment in Eastern, Central and Southern Africa: Proceedings of an FAO/OAU-IBAR/ ILRI Workshop, held at ILRI, Nairobi, Kenya, 10–12 March 1997*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 56–61.

Mugalla C., Swallow B.M. and Kamuanga M. 1999. The effects of trypanosomosis risk on farmers' livestock portfolios: Evidence from The Gambia. In: *Proceedings of the 24th Meeting of the International Scientific Council for Trypanosomiasis Research and Control, Maputo, Mozambique, 29 September–3 October 1997*. OAU/STRC, Nairobi, Kenya. pp. 472–473.

Mukhebi A. and Williams T. 1999. Estimating demand for theileriosis vaccines. In: Morzaria S. and Williamson S. (eds), *Live Vaccines for* Theileria parva*: Deployment in Eastern, Central and Southern Africa: Proceedings of an FAO/OAU-IBAR/ILRI Workshop, held at ILRI, Nairobi, Kenya, 10–12 March 1997*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 110–113.

Musoke A., Morzaria S. and Nene V. 1999. Sub-unit vaccines for the control of *Theileria parva*. In: Morzaria S. and Williamson S. (eds), *Live Vaccines for* Theileria parva*: Deployment in Eastern, Central and Southern Africa: Proceedings of an FAO/OAU-IBAR/ ILRI Workshop, held at ILRI, Nairobi, Kenya, 10–12 March 1997*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 125–130.

Okello O.O., Kruska R.L. and Reid R.S. 1999. Use of GIS to analyse the impacts of controlling trypanosomosis. In: *Proceedings of the 24th Meeting of the International Scientific Council for Trypanosomiasis Research and Control, Maputo, Mozambique, 29 September–3 October 1997*. OAU/STRC, Nairobi, Kenya. p. 587.

Pezo D. 1999. Methodologies for site characterization in crop–animal systems research with an ecoregional approach. In: *Proceedings of the Planning Workshop on the Crop–animal Systems Project, IRRI, Los Baños, the Philippines, 1–4 June 1999*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 9–15.

Rege J.E.O. 1999. Characterisation and conservation of animal genetic resources: What is it about? In: Rege J.E.O. (ed), *Economic Valuation of Animal Genetic Resources: Proceedings of an FAO/ILRI Workshop held at FAO Headquarters, Rome, Italy, 15–17 March 1999*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 21–24.

Rege J.E.O. 1999. Economic valuation of farm animal genetic resources. In: Rege J.E.O. (ed), *Economic Valuation of Animal Genetic Resources: Proceedings of an FAO/ILRI Workshop held at FAO Headquarters, Rome, Italy, 15–17 March 1999*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 25–27.

Reid R.S. 1999. Impacts of controlling trypanosomosis on land use and the environment: State of our knowledge and future directions. In: *Proceedings of the 24th Meeting of the International Scientific Council for Trypanosomiasis Research and Control, Maputo, Mozambique, 29 September–3 October 1997*. OAU/STRC, Nairobi, Kenya. pp. 500–514.

Reid R.S., Kruska R.L. and Thornton P.K. 1999. Will human population growth and land-use change control tsetse during our lifetimes? In: *Proceedings of the 24th Meeting of the International Scientific Council for Trypanosomiasis Research and Control,*

Maputo, Mozambique, 29 September–3 October 1997. OAU/STRC, Nairobi, Kenya. pp. 563–577.

Rowlands G.J., Nagda S.M., Leak S.G.A., Mulatu W., d'Ieteren G. and Peregrine A.S. 1999. Epidemiological analyses of trypanocidal drug resistance in zebu cattle in Ghibe, southwest Ethiopia. In: *Proceedings of the 24th Meeting of the International Scientific Council for Trypanosomiasis Research and Control, Maputo, Mozambique, 29 September–3 October 1997*. OAU/STRC, Nairobi, Kenya. pp. 406–407.

Sanda I., Romney D., Tanner J., Thorne P. and Leaver J.D. 1999. Effect of abrupt and frequent changes in forage quality on digestibility and performance of crossbred cattle offered Napier grass (*Pennisetum purpureum*) and barley straw. In: *Proceedings of the British Society of Animal Science, Scarborough, UK, March 1999*. British Society of Animal Science, Penicuik, Midlothian, UK. p. 88.

Smith J. 1999. Ecoregional research in sub-humid West Africa. In: Thornton P.K. and Odero A.N. (eds), *Ecoregional Research at ILRI: Proceedings of a Workshop, ILRI, Addis Ababa, Ethiopia, 5–8 October 1998*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 59–68.

Tarawali S.A., Rege J.E.O, Hanotte O. and Hanson J. 1999. DNA markers for forage and livestock improvement. In: Crouch J.H. and Tenkouano A. (eds), *DNA Marker-assisted Improvement of the Staple Crops of Sub-Saharan Africa: Proceedings of the Workshop on DNA Markers, IITA, Ibadan, Nigeria, 21–22 August 1996*. CTA (Technical Centre for Agricultural and Rural Cooperation)/IITA (International Institute of Tropical Agriculture), Ibadan, Nigeria. pp. 107–112.

Teferedegne B., Osuji P.O., Odenyo A., Wallace R.J. and Newbold C.J. 1999. Effect of defaunation on utilisation of poor-quality tropical feed by sheep. In: *Proceedings of the British Society of Animal Science, Scarborough, UK, March 1999*. British Society of Animal Science, Penicuik, Midlothian, UK. p. 113.

Thorpe W. 1999. ILRI's smallholder dairy systems research: Experiences and lessons from collaborative R&D in eastern Africa. In: Thornton P.K. and Odero A.N. (eds), *Ecoregional Research at ILRI: Proceedings of a Workshop, ILRI, Addis Ababa, Ethiopia, 5–8 October 1998*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 69–82.

Wangila J., Swallow B.M., Tesfaemichael N., Okello O. and Kruska R. 1999. Factors affecting farmer demand and pour-on treatments in Ethiopia. In: *Proceedings of the 24th Meeting of the International Scientific Council for Trypanosomiasis Research and Control, Maputo, Mozambique, 29 September–3 October 1997*. OAU/STRC, Nairobi, Kenya. pp. 490–497.

Wells C.W., Awino E. and McKeever D. 1999. *Theileria parva* sporozoite invasion and development within bovine dendritic cells. In: *Proceedings of the Microscopical Society of Southern Africa, Orange Free State, Bloemfontein, South Africa, 1–3 December 1999*, vol. 29. Microscopic Society of Southern Africa. 61pp.

Williams T.O., Hiernaux P. and Fernandez-Rivera S. Crop–livestock systems in sub-Saharan Africa: Determinants and intensification pathways. In: *Proceedings of an International Symposium on Property Rights, Risk and Livestock Development, Feldafing, Germany, 27–30 September 1998*. ILRI (International Livestock Research Institute), Nairobi, Kenya/IFPRI (International Food Policy Research Institute), Washington DC, USA. (in press).

Wissocq N., d'Ieteren G., Trail J.C.M., Masake R., Nantulya B. and Monsengo B. 1999. Trypanosome antigen test to characterise infection status in N'Dama cattle. In: *Proceedings of the 24th Meeting of the International Scientific Council for Trypanosomiasis Research and Control, Maputo,*

Mozambique, 29 September–3 October 1997. OAU/STRC, Nairobi, Kenya. pp. 310–314.

Wissocq N., d'Ieteren G., Trail J.C.M. and Monsengo B. 1999. Ability to acquire resistance to trypanosome infections and growth of N'Dama cattle. In: *Proceedings of the 24th Meeting of the International Scientific Council for Trypanosomiasis Research and Control, Maputo, Mozambique, 29 September–3 October 1997*. OAU/STRC, Nairobi, Kenya. pp. 306–309.

Woudyalew M., Swallow B.M., Rowlands G.J., Leak S.G.A., d'Ieteren G. and Nagda S.M. 1999. Economic benefits to farmers of six years of application of an insecticidal 'pour-on' to control tsetse in Ghibe, Southwest Ethiopia. In: *Proceedings of the 24th Meeting of the International Scientific Council for Trypanosom-iasis Research and Control, Maputo, Mozambique, 29 September–3 October 1997*. OAU/STRC, Nairobi, Kenya. pp. 578–586.

Zerbini E. 1999. Existing and proposed ecoregional research in South Asia. In: Thornton P.K. and Odero A.N. (eds), *Ecoregional Research at ILRI: Proceedings of a Workshop, ILRI, Addis Ababa, Ethiopia, 5–8 October 1998*. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 43–48.

Papers in non-refereed journals

Tarawali S. 1999. Farmers acclaim integrated approach. *International Agricultural Development (UK)* 19(2):12–13.

Programme documents

Fitsum Hagos, Pender J. and Nega Gebreselassie. 1999. *Land Degradation in the Highlands of Tigray and Strategies for Sustainable Land Management*. ILRI Socioeconomic and Policy Research Working Paper 25. Livestock Policy Analysis Programme. ILRI (International Livestock Research Institute), Addis Ababa, Ethiopia. 73 pp.

Theses

Abiola O.B. 1999. *Interactions between Body Condition, Parity and Liveweight on Fertility of Artificially-inseminated Cattle Following Oestrus Synchronization*. MSc thesis, Department of Veterinary Surgery and Reproduction, Faculty of Veterinary Medicine, University of Ibadan, Ibadan, Nigeria. 135 pp.

Aynalem Haile. 1999. *Effects of Breed and Protein Supplementation on Development of Resistance to Gastrointestinal Parasites in Sheep*. MSc thesis, School of Graduate Studies, Alemaya University of Agriculture, Harar, Ethiopia. 110 pp.

Enyew Negussie. 1999. *Body Composition and Body Reserves in Indigenous Ethiopian Fat-tailed Sheep Breeds*. PhD thesis, Institute of Animal Breeding, Technical University of Munich, Weihenstephan, Germany. 169 pp.

Frese M. 1999. *Cross-site and Cross-location on-farm Investigation of the Epidemiology of Mastitis in Market-oriented Urban/periurban Production Systems in the Regions of Addis Ababa and Debre Zeit, Ethiopia*. Post-graduate diploma, Department of Veterinary Medicine and Epidemiology, Freie Universität Berlin, Berlin, Germany. 55 pp.

Girma G/Mariam. 1999. *The Breeding System of* Sesbania sesban *(L.) Merr. (Leguminosae)*. MSc thesis, School of Graduate Studies, Addis Ababa University, Addis Ababa, Ethiopia. 95 pp.

Girma Getachew. 1999. *Tannins in Tropical Multipurpose Tree Species: Localisation and Quantification of Tannins Using Histochemical Approaches and the Effect of Tannins on* in vitro *Rumen Fermentation*. PhD thesis, Institute for Animal Production in the Tropics and Subtropics, Hohenheim University, Stuttgart, Germany. 186 pp.

Laval G. 1999. *Cost Analysis of Contagious Bovine Pleuropneumonia (CBPP) in Ethiopia.* MSc thesis, Claude Bernard University, Lyon 1, France/ILRI (International Livestock Research Institute), Addis Ababa, Ethiopia/ CIRAD–EMVT (Centre de coopération internationale en recherche agronomique pour le développement-Département d'élevage et de médecine vétérinaire), Montpellier, France. 43 pp.

Solomon Desta. 1999. *Diversification of Livestock Assets for Risk Management in the Borana Pastoral System of Southern Ethiopia.* PhD thesis, Utah State University, Utah, USA. 159 pp.

Tona G.O. 1999. *Effect of* Lablab purpureus, *Cotton Seed Cake, Brewer's Spent Grain and Cowpea Fodder on the Lactation of Bunaji Cows Fed a Basal Diet of* Panicum maximum. PhD thesis, Department of Animal Science, Ibadan University, Ibadan, Nigeria. 280 pp.

Yitaye Alemayehu. 1999. *A Study on Livestock Production Systems, Feed Resources and Feed Allocation Practices in Three Peasant Associations of the Awassa Woreda, Southern Ethiopia.* MSc thesis, School of Graduate Studies, Alemaya University of Agriculture, Harar, Ethiopia. 98 pp.

Yoseph Mekasha. 1999. *Impact of Feed Resources on Productive and Reproductive Performance of Dairy Cows in the Urban and Peri-urban Dairy Production System in the Addis Ababa Milk Shed and Evaluation of Non-conventional Feed Resources Using Sheep.* MSc thesis, School of Graduate Studies, Alemaya University of Agriculture, Harar, Ethiopia. 197 pp.

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Officers

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Mr R. Bruce Scott	Director of Administration/ Secretary to the Board

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Left the ILRI Board in 1999

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ILRI staff in 1999

Directorate General

Hank Fitzhugh, *director general*
Joan Abila, *assistant to directorate general*
Ralph von Kaufmann, *director of external relations*
Helen Leitch, *manager, funding support systems*
Susan MacMillan, *head, public awareness*
Maria Mulindi, *assistant to the director general*
Peter Werehire, *webmaster/donor materials assistant*

Biosciences Programme

Anthony Irvin,* *programme director*

Kenya

Leyden Baker, *quantitative geneticist* [pc]
Keith Ballingall, *molecular immunologist*
Richard Bishop, *molecular parasitologist*
Alain Boulangé,[1] *immunologist* [vs]
Elizabeth Carpenter, *cellular immunologist* [pd]
Francis Chuma, *research technologist*
Paul Coleman, *epidemiologist* [pd]
Lynne Elson,* *immunologist* [pd]
Henry Gathuo, *research technologist*
Olivier Hanotte, *molecular biologist*
Chris Hinson, *laboratory manager*
Yoshikazu Honda, *molecular immunologist*
Fuad Iraqi, *molecular geneticist*
Woo-Seong Jeong,[2]* *veterinarian* [vs]
John Kabata, *research technologist*
Joseph Katende, *protozoologist diagnostician*
David Kennedy, *veterinarian*
Henry Kiara, *research officer*
Michael Kibe,[3]* *molecular biologist* [vs]
Bob King, *head of experimental animal units*
Hiroshi Kitani,[4] *cell biologist* [vs]
Nelson Kuria, *research technologist*
Marjan Leneman,[5†] *veterinary epidemiologist and social economist* [avs]
Winnie Luseno,* *research technologist*
Emma Mace,* *molecular biologist* [pd]
Niall MacHugh, *cellular immunologist*
Phelix Majiwa, *molecular biologist*
Jackson Makau, *research technologist*
Ian Maudlin,[6]* *entomologist* [vs]
John Mburu, *research technologist*
John McDermott, *epidemiologist*
Declan McKeever,* *immunologist* [pc]
Francis McOdimba, *research technologist*
Bea Mertens,[7] *immunologist* [vs]
Bruno Minjauw,* *epidemiologist* [pd]
Subhash Morzaria, *molecular parasitologist* [pc]
Peter Mucheru, *research technologist*
John Mugambi, *helminthologist* [pd]
Cecilia Muriuki, *research technologist*
Noel Murphy, *molecular geneticist* [pc]
Tony Musoke, *immunologist* [pc]
David Muteti, *research technologist*
Anthony Muthiani, *research technologist*
Joel Mwakaya, *research technologist*
Duncan Mwangi,[8] *cellular immunologist* [vs]
Jan Naessens,[7] *immunologist* [vs]
Sonal Nagda, *data analyst*
David Ndegwa, *research technologist*
Vish Nene, *molecular biologist*
Daniel Ngugi, *research technologist*
James Ngugi, *research technologist*
Philomeen Nilsson, *molecular geneticist* [vs]
Catherine Nkonge, *immunologist*
Peter Nyangweso,* *research technologist*
John Nyanjui, *research technologist*
Chris O'Callaghan,[9]* *epidemiologist* [vs]
Tom Olyhoek,[10]* *molecular biologist*
Beatrice Omusiro,[†] *research technologist*
Julius Osaso, *research technologist*
Elias Owino, *research technologist*
Roger Pelle, *molecular biologist*
Brian Perry, *epidemiologist* [pc]
Tom Randolph, *agricultural economist*
John Rowlands, *biometrician*
Rosemary Saya, *research technologist*
Rob Skilton, *molecular parasitologist*
Paul Spooner, *tissue culturist*
Emmanuel Tambi, *agricultural economist*
Evans Taracha, *immunologist*
Kathy Taylor, *cellular immunologist* [pc]
Toyohiko Urakawa,[11†] *molecular biologist*
John Wambugu, *research technologist*
Delia Wasawo, *research technologist*

Sue Welburn,[12]* *molecular biologist* [vs]
Clive Wells, *head of electron microscopy services*
Jon Wilkes,* *cell membrane physiologist*

Ethiopia
Abate Tedla, *research officer*
Abebe Tessema, *research technologist*
Abraham Bekele, *head, computer services*
Asfaw Yemegnuhal, *research technologist*
Janet Edeme, *phytopathologist* [pd]
Gemechu Degefa, *research technologist*
Jean Hanson, *plant geneticist* [pc]
Brigitte Maass,* *geneticist*
Ntombizakhe Mpofu,[13†] *animal breeding, genetics* [vs]
Agnes Odenyo, *rumen nutritionist*
Paschal Osuji, *rumen nutritionist* [pc]
Edward Rege, *animal geneticist* [pc]
Eeva Saarisalo,* *rumen nutritionist* [vs]

India
Ercole Zerbini, *animal scientist*

Philippines
Douglas Gray, *animal scientist* [pl]

Production Systems Programme

Hugo Li-Pun, *programme director* [pc]

Kenya
Guy d'Ieteren, *animal scientist* [pc]
Tineke de Wolff,[5†] *geographer* [avs]
Mario Herrero,[†] *livestock modeller*
Kimani Kamau,[†] *research technologist*
Patti Kristjanson, *agricultural economist*
Russ Kruska, *geographic information systems specialist*
Laban MacOpiyo,[†] *research technologist*
Crispin Matere,[†] *data analyst*
Joseph Matere,[†] *research technologist*
Nancy McCarthy, *agricultural economist* [pd]
Liston Njoroge, *research technologist*
David Njubi, *senior computer programmer*
Andrew Odero, *research technologist*
Onyango Okello, *research technologist*
Steven Omamo,[†] *agricultural economist*
Amos Omore, *research officer*
Tom Ouna,[†] *research technologist*
Robin Reid, *landscape ecologist*
Tim Robinson,[†] *decision support modeller*
Deborah Romney,[†] ruminant nutritionist
Arlene Rutherford, *SPS economist*
Beatrice Salasya,[†] *research officer*
Robert Sanford,[14†] *ecologist* [vs]
Steve Staal, *agricultural economist*
Jon Tanner,* *animal nutritionist*
Philip Thornton, *agricultural economist* [pc]
William Thorpe, *animal scientist* [pc]
Christa Utiger, *animal nutritionist*

Ethiopia
Abiye Astatke, *research officer*
Mohamed Ahmed, *agricultural economist* [pd]
Azage Tegegne, *animal scientist*
Berhanu Gebremedhin, *agricultural economist* [pd]
Pascal Bonnet,[1†] *agricultural economist* [vs]
Giulia Conchedda ,[15†] *remote sensing/GIS specialist* [avs]
Mamadou Diedhiou, *biometrician*
Jeroen Dijkman, *animal scientist* [vs]
Simeon Ehui, *agricultural economist* [pc]
Enyew Negussie,[†] *research officer*
Girma Tadesse, *research officer*
Mohammed Jabbar, *agricultural economist*
Joan Kagwanja,* *agricultural economist* [pd]
Kahsay Berhe, *research technologist*
Nega Gebreselassie,* *research technologist*
Chris Robinson, *laboratory manager*
Mohamed Saleem, *agronomist* [pc]
Barry Shapiro,* *agricultural economist*
Shiferaw Bekele,[16]* *agricultural economist* [vs]
Jimmy Smith, *animal scientist* [pc]
Victor Umunna,* *animal scientist/station manager (Debre Zeit)* ***(deceased)***
Woudyalew Mulatu, *research officer*
Zerihun Tadesse, *applied biometrician*

Burkina-Faso
J.B. Mulumba Kamuanga, *agricultural economist*

Nigeria
Kwaku Agyemang,* *animal production scientist*
Asmoah Larbi, *forage agronomist*
Shirley Tarawali,[17] *agronomist*

Niger (ICRISAT Sahelian Center)
Salvador Fernandez-Rivera, *animal scientist* [pc/tl]
Pierre Hiernaux, *ecologist*
Ben Spycher,[18†] *econometric analyst* [avs]
Timothy Williams, *agricultural economist*

Malaysia
Canagasaby Devendra, *animal nutritionist*

Peru
Carlos Leon-Velarde,[19] *animal production systems specialist*

Philippines
Danilo Pezo,† *animal nutritionist*

Colombia
Federico Holmann,[20] *agricultural economist*

Strengthening Partnerships with National Agricultural Research Systems

Michael Smalley, *programme director* pc

Kenya
Rob Eley, *education officer*
Dave Elsworth, *head of graphics unit*
Grace Kamau,† *librarian*
Sahr Lebbie, *co-ordinator, SADC animal agriculture research network (S-AARNET)*
Jean Ndikumana, *co-ordinator, ASARECA animal agriculture research network (A-AARNET)*

Ethiopia
Sourou Adoutan, *French translator/editor*
Ali Ahmed,† *senior typesetter/designer*
Azeb Abraham, *librarian*
Normand Demers, *head of information services*
Elizabeth Getachew, *assistant to the programme director*
Mohammed El-Habib Ibrahim, *training materials specialist*
Mulugeta Bayeh, *assistant editor*
Paul Neate,* *head of publications*
Anne Nyamu, *science writer/editor*
Wondowossen Girma, *head of print shop*

Administration

Hugh Murphy,* *director of administration*
Bruce Scott,† *director of administration*

Kenya
William Anyika, *head of engineering*
Getachew Engida,† *chief financial officer*
George Kanza, *chief accountant*
David Kinyanjui, *chief security officer*
Sylvester Kisonzo, *computer software officer*
James Magondu, *head of fluorescence-activated cell sorter services*
Faith Matee, *purchasing officer*
Gacheru Migwi,* *chief personnel officer*
Ian Moore, *head of information technology services*
Margaret Morehouse, *human resources manager*
Wangari Mwangi,† *human resources officer*
Charles Ndungi, *deputy head of engineering/ transport manager*
John Ngatti, *stores superintendent*
Onesmus Nthiwa, *chief accountant*
Atieno Ouko-Onyonyi, *project accountant*
Janepher Owino, *housing officer*
Jacob Quaye, *head of administration*
Christine Thuranira, *assistant to the director of administration*
Veronica Waiyaki, *human resources officer*

Ethiopia
Antonio Silla, *internal auditor*
Belayhun Wondimu, *chief accountant*
Emmanuel Tesfamariam, *budget and procurement officer*
Franco Leone, *physical plant manager*
Michael Tamrat,† *medical officer*
Negussie Abraham, *supervisor, general accounts*
Revathi Rao,* *manager, catering, housing and security*
Aguibou Tall, *head of administration*
Tibebe Gebreamlak, *national liaison officer*
Tilahun Tadesse,† *chief personnel officer*

Footnotes to staff list

* Left in 1999
† Joined in 1999
pc Project Co-ordinator
pl Project Leader
tl Team Leader
pd Post Doctoral Scientist
vs Visiting Scientist
avs Associate Visiting Scientist

[1] Seconded by CIRAD-EMVT (Centre de Coopération internationale en recherche agronomique pour le dévéloppement-Elevage et médicine vétérinaire des pays tropicaux (Centre for International Cooperation in Agronomic Research and Development-Animal Husbandry and Veterinary Medicine in Tropical Countries), France

[2] Salary paid by the Rural Development Administration (RDA), Korea

[3] Seconded by Hokkaido University, Japan

[4] Seconded by JIRCAS (Japan International Research Centre for Agricultural Sciences)/ Government of Japan

[5] Seconded Associate Scientist under APO (Associate Profession Officers) Scheme through the Government of the Netherlands

[6] Seconded by the University of Glasgow, UK

[7] Seconded by VVOB (Vlaamse Veringung Voor Ontwikkelingssamenwerking en Technische Bijstand), Belgium

[8] Seconded by USAID (United States Agency for International Development) and the University of Florida, USA

[9] Seconded by the University of Warwick, UK

[10] Seconded by the Institute for Animal Science and Health (ID-DLO), the Netherlands

[11] Salary paid by the Government of Japan

[12] Seconded by the University of Glasgow, UK

[13] Funded by SIDA (Swedish International Development Agency), Sweden

[14] Seconded by the University of Denver Colorado, USA

[15] Seconded and financed by the Ministry of Foreign Affairs, Italy

[16] Seconded by the Agricultural University of Norway

[17] 50% joint appointment with IITA (International Institute of Tropical Agriculture)

[18] Seconded and financed by SDC (Swiss Development Corporation), Switzerland

[19] 50% joint appointment with CIP (Centro Internacional de la Papa)

[20] 50% joint appointment with CIAT (Centro Internacional de Agricultura Tropical)

Graduate fellows at ILRI in 1999

Name/ Nationality	University/ Institute of Registration	Degree	Project Title	Location	Date of Departure
Zerihun Ademe, Ethiopian	Free University of Berlin, Germany	PhD	Epidemiology of bovine mastitis in large-scale urban and peri-urban and smallholder dairy production systems in Ethiopia	Ethiopia	1999
Fredrick Atieno, Kenyan	Nairobi, Kenya	MSc	Effects of land-use changes on plant species diversity and vegetation structure in Kenyan rangelands: A case study of Kajiado District	Kenya	1999
Isobelle Baltenweck, French	Auvergne, France	PhD	Patterns of intensification in smallholder dairying: Spatial analysis of determinants of change	Kenya	2000
Mody Barry, Ivorian	Oklahoma, USA	PhD	Urban livestock production systems and food security in the "Zone Dense" of Khorogo (Northern Côte d'Ivoire)	Côte d'Ivoire	2001
Bockline Bebe, Kenyan	Wageningen, Netherlands	PhD	Herd dynamics of smallholder dairy production in the Kenya highlands	Kenya	2002
Maira Bholla, Kenyan	Brunel, UK	MPhil	Studies on the mating incompatibilities in populations of tsetse flies (*Glossina* spp)	Kenya	1999
Wame Boitumelo, Botswanan	Guelph, Canada	PhD	Nutritive evaluation of forage legumes	Ethiopia	1999
Anthea Broadhead, British	Liverpool, UK	PhD	Positional cloning of trypanotolerance quantitative trait loci	Kenya	2000
Shauna BurnSilver, American	Colorado State, USA	PhD	Land use change and wildlife conservation in Kajiado District, Kenya as part of the integrated modelling and assessment programme in East Africa	Kenya	2002
Sebastian Chenyambuga, Tanzanian	Sokoine, Tanzania	PhD	Genetic characterisation of East African goat populations	Kenya	2000

Graduate fellows (continued)

Name/ Nationality	University/ Institute of Registration	Degree	Project Title	Location	Date of Departure
Boukader Diarra, Malian	Cheikh Anta Diop, Senegal	PhD	Characterisation of drug resistance in trypanosomes in West Africa	Kenya	2001
Ewnetu Ermias, Ethiopian	Alemaya, Ethiopia	MSc	Prediction of body fat in fat-tailed sheep using tritiated water, body and tail measurements and feed conversion efficiency	Ethiopia	1999
Mathias Frese, German	Free University of Berlin, Germany	PhD	A longitudinal study of incidence and prevalence of bovine mastitis in large-scale and smallholder production systems in urban and peri-urban regions of Addis Ababa, Ethiopia	Ethiopia	1999
Sisay Gezehegne, Ethiopian	Swedish Agricultural University, Sweden	PhD	Characterisation of indigenous Ethiopian cattle using phenotypic traits, protein polymorphisms and microsatellite markers	Ethiopia	2003
John Githiori, Kenyan	Swedish Agricultural University, Sweden	PhD	Anthelmintic properties of ethnoveterinary preparations used by smallholder farmers to treat internal parasites of their livestock	Kenya	2002
Bridgette Gnoumou, Burkinabé	Wisconsin, USA	PhD	Cattle and manure management strategies to increase soil fertility in western Niger	Niger	1999
Ida Katerina Hindrichsen, Danish	Royal Veterinary and Agricultural University, Denmark	MSc	Microbial protein supply capacity of poor-quality roughages supplemented with different fodder trees	Ethiopia	1999
Misrak Kebede, Ethiopian	Addis Ababa, Ethiopia	MSc	Isolation and characterisation of bacteria tolerant to toxic compounds in an extract fraction from *Acacia angustissima* leaves, from free-ranging indigenous animals	Ethiopia	2000
Simon Kang'a, Kenyan	Jomo Kenyatta, Kenya	PhD	Development and application of genetic markers linked to bovine trypanotolerance genes	Kenya	2001

Graduate fellows (continued)

Name/ Nationality	University/ Institute of Registration	Degree	Project Title	Location	Date of Departure
Samuel Khamadi, Kenyan	Nairobi, Kenya	MSc	Isolation and characterisation of a gene for the T-lymphocyte triggering factor (TLTF) from *Trypanosoma congolense*	Kenya	1999
Victor Konde, Zambian	Brunel, UK	PhD	Molecular genetic aspects of isometamedium resistance in *Trypanosoma* (*Nannomonas*) *congolense*	Kenya	2000
Tesfaye Kumsa, Ethiopian	Copenhagen, Denmark	PhD	On-farm use of multi-purpose crossbred cows: Implications for herd productivity, food security and environmental sustainability in the crop–livestock mixed highland production systems of Ethiopia	Ethiopia	2001
Carl Larsen, Danish	Copenhagen, Denmark	PhD	Adoption of dairy/draught technology in a smallholder mixed crop–livestock farming system: A case study from Ethiopia	Ethiopia	1999
Géraud Laval, French	CIRAD-EMVT, France	PhD	Cost/benefit analysis of contagious bovine pleuropneumonia (CBPP) control strategies in traditional livestock farming systems of Ethiopia	Ethiopia	2002
Jon Lekasi, Kenyan	Coventry, UK	PhD	Management of livestock excreta for enhanced nutrient cycling efficiency on intensive smallholder farms in the East and Central African highlands	Kenya	1999
Ben Lukuyu, Kenyan	Greenwich, UK	MPhil	Evaluation and improvement of feeding strategies for optimising feed intake in crop–livestock systems	Kenya	2000
Yar Martor, Liberian	Nairobi, Kenya	MSc	Positional cloning of trypanosomosis resistance QTL Tirl in mice	Kenya	1999
Amos Mbugua, Kenyan	Nairobi, Kenya	MSc	Analysis of receptors in the flagellar pocket of *Trypanosoma congolense*	Kenya	2000

Graduate fellows (continued)

Name/ Nationality	University/ Institute of Registration	Degree	Project Title	Location	Date of Departure
Yoseph Mekasha, Ethiopian	Alemaya, Ethiopia	MSc	Impact of feed resources on reproductive performance of dairy cows in peri-urban dairy production systems in the Addis Ababa dairy shed and evaluation of non-conventional feed resources using sheep	Ethiopia	1999
Solomon Melaku, Ethiopian	Humboldt, Germany	PhD	Supplementation of selected multi-purpose trees to Ethiopian highland sheep maintained on a basal diet of teff straw (*Eragrostis tef*): Effects on rumen fibre degradation, rumen and blood metabolites, live weight gain and reproductive parameters	Ethiopia	1999
Laurence Micout, French	CIRAD-EMVT, France	DESS	Immunisation of cattle with congopain	Kenya	1999
Noelina Mjombah, Kenyan	Nairobi, Kenya	MSc	Isolation and characterisation of genes encoding potential vaccine and diagnostic antigens of *Theileria lestoquardi*	Kenya	1999
Anne Muigai, Kenyan	Jomo Kenyatta, Kenya	PhD	Genetic diversity of sheep populations in sub-Saharan Africa	Kenya	2001
Wellington Mulinge, Kenyan	Nairobi, Kenya	PhD	Identifying the determinants of competitiveness in intensifying dairy production	Kenya	2000
Susan Musembi, Kenyan	Nairobi, Kenya	MSc	Complement analysis of *Theileria parva* secretion signal proteins	Kenya	1999
David Mwangi, Kenyan	Wye, UK	PhD	Factors affecting the growth and persistency of companion legumes for cut-and-carry Napier grass	Kenya	1999
William Mwangi, Kenyan	Nairobi, Kenya	MSc	Characterisation of polymorphism in the genes encoding cattle FC gamma receptors (CD16/CD32/CD64): Implications for vaccine development and genetic diversity	Kenya	1999

Graduate fellows (continued)

Name/ Nationality	University/ Institute of Registration	Degree	Project Title	Location	Date of Departure
Leah Ndungu, Kenyan	Pretoria, South Africa	PhD	The socio-economic, infra-structural and policy effects on the demand for, and delivery of, the p67 *T. parva* vaccine in small-scale, large-scale and pastoralist zones of Kenya	Kenya	2000
Margaret Ngigi,	Nairobi, Kenya	PhD	The effects of transaction costs on market participation of smallholder Kenyan dairy farmers	Kenya	1999
Margaret Okomo, Kenyan	Wageningen, Netherlands	PhD	Mapping quantitative trait loci controlling genetic resistance to helminthiasis in the Red Maasai sheep of Kenya	Kenya	2002
Ben Okumu, Kenyan	Manchester, UK	PhD	Bio-economic modelling analysis of watershed conservation in the Ethiopian highlands	Ethiopia	1999
Deo Olila, Ugandan	Nairobi, Kenya	PhD	Molecular epidemiology of trypanosomiasis with particular emphasis on drug-resistant phenotypes in Mukono District, Uganda	Kenya	1999
Fredrick Onyango, Kenyan	Nairobi, Kenya	MSc	T-cell responses in cattle immunised with recombinant p67	Kenya	2000
Denis Ouedraogo, Burkinabé	Ouagadougou, Burkina Faso	PhD	Socio-economic analysis of animal health management practices and factors affecting the development of drug resistance in cattle: The case of Kenedougou Province, Burkina Faso	Burkina Faso	2001
Karin Rottengatter, German	Hamburg, Germany	PhD	Development and application of genetic markers linked to bovine trypanotolerance genes	Kenya	1999
Roberto Rovere, Italian	Wageningen, Netherlands	PhD	Livestock economics in low-cost farming systems	Niger	1999
Mamadou Sangare, Malian	Prince Leopold Institute, Belgium	PhD	Optimising the use of feed sources for feeding livestock and recycling nutrients	Niger	1999

Graduate fellows (continued)

Name/ Nationality	University/ Institute of Registration	Degree	Project Title	Location	Date of Departure
Dekster Savadye, Zimbabwean	Zimbabwe, Zimbabwe	PhD	Sequencing and mapping of *Theileria parva* schizont DNAs and the establishment of a sequence data base	Kenya	1999
Dekha Sheikh, Kenyan	Missouri, USA	PhD	Methods to assess the impacts of livestock technologies on household welfare	Kenya	1999
Zewdu Sisay, Ethiopian	Brunel, UK	PhD	Managing the rumen ecosystem to improve the utilisation of thornless acacias	Ethiopia	2003
Malenie de Souza, Kenyan	Nairobi, Kenya	MSc	Analysis of two putative candidate genes for isometamidium resistance in *Trypanosoma congolense*	Kenya	1999
Florence Tangka, Cameroonian	Florida, USA	PhD	The food security impacts of dairying with crossbred cows	Ethiopia	2000
Lilian Waibochi, Kenyan	Nairobi, Kenya	MSc	Analysis of polymorphisms in the gene encoding the bovine CD45 molecule	Kenya	1999
Jeff Worden, American	Colorado State, USA	PhD	Land use change and wildlife conservation in Kajiado District, Kenya as part of the integrated modelling and assessment programme in East Africa	Kenya	2002

ILRI's investors in 1999

Unrestricted contributions

Australia
Austria
Belgium
Brazil
Canada
China, People's Republic
Denmark
Finland
France
Germany
India
Japan
Netherlands
Norway
Sweden
Switzerland
United States of America
World Bank

Targeted contributions

African Development Bank
Asian Development Bank
Australia
Belgium
Canada
European Union
Finland
Food and Agriculture Organization of the United Nations
Ford Foundation
France
Germany
International Development Research Centre
International Fund for Agricultural Development
Ireland
Italy
Japan
Kenya
Korea
Luxembourg
Netherlands
Norway
Rockefeller Foundation
South Africa
Spain
Sweden
Switzerland
United Kingdom
United States of America
World Bank

Subgrants from CGIAR inter-centre initiatives

African Highlands Initiative
Desert Margins Programme
System-wide Genetic Resources Programme

Non-CGIAR organisations contracting ILRI

African Wildlife Foundation
Colorado State University
Common Fund for Commodities
Global Livestock Collaborative Research Support Program
Organization of African Unity/Inter-African Bureau for Animal Resources
Texas A&M University
University of Nottingham
Utah State University
World Health Organisation

Financial summary

INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE
STATEMENT OF ACTIVITIES
for the year ended 31 December 1999
(US$ '000)

Revenue	1999			1998
	Unrestricted	Restricted	Total	Total
Grants	13,869	12,649	26,518	24,068
Other revenue	1,453	0	1,453	1,369
Total revenue	**15,322**	**12,649**	**27,971**	**25,437**
Operating expenses				
Research programmes	6,366	10,276	16,642	18,486
Conferences and training	381	804	1,185	1,552
Information services	911	102	1,013	1,007
General administration and operations	3,023	1,260	4,283	3,502
Board and management	1,109	207	1,316	1,040
Depreciation of fixed assets	2,070	0	2,070	2,132
Total operating expenses	**13,860**	**12,649**	**26,509**	**27,719**
Surplus/(Deficit) for the year			**1,462**	**(2,282)**

INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE
STATEMENT OF FINANCIAL POSITION
at 31 December 1999
(US$ '000)

Current assets	**1999**	**1998**
Bank and cash balance	16,185	12,363
Accounts receivable	725	1,310
Receivable from donors	3,456	4,691
Inventories	1,154	1,216
Deposits and prepayments	720	485
Total current assets	22,240	20,065
Fixed assets and investment in subsidiary		
Property, plant and equipment	18,197	18,550
Investment in subsidiary	1,816	1,816
Total fixed assets and investment in subsidiary	20,013	20,366
Total assets	**42,253**	**40,431**
Liabilities		
Accounts payable and accruals	4,069	5,184
Staff provisions	1,354	1,892
Payable to donors	5,141	3,110
Funds in-trust	356	315
Total liabilities	10,920	10,501
Fund balances		
Capital invested in fixed assets and in subsidiary	20,013	20,366
Operating fund	5,425	3,963
Capital fund	5,895	5,601
Total fund balances	31,333	29,930
Total liabilities and fund balances	**42,253**	**40,431**

INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE
1999 DONOR FUNDING
(US$ '000)

Donor	Unrestricted	Restricted	Total 1999 income
Australia	191	358	549
Austria	175		175
African Development Bank		278	278
African Highlands Initiative		3	3
African Wildlife Foundation		22	22
Asian Development Bank		299	299
Belgium	121	704	825
Brazil	6		6
Canada	742	29	771
China, People's Republic	20		20
Common Fund for Commodities (CFC)		17	17
Denmark	609		609
European Union		140	140
Food and Agriculture Organization (FAO)		33	33
Finland	355	47	402
France	276	153	429
Ford Foundation		1,000	1,000
Germany	763	1,367	2,130
IDRC		393	393
IFAD		1,142	1,142
India	38		38
Institute for Molecular Cell Biology, Africa (IIMC)		21	21
Ireland		389	389
Italy		385	385
Japan	441	1,224	1,665
Kenya		250	250
Korea		20	20
Luxembourg		18	18
Netherlands	199	92	291
Norway	1,144	156	1,300
OAU/IBAR		39	39
Office international d'épizooties (OIE)		23	23
Rockefeller Foundation		70	70
IPGRI/SINGER		12	12
Spain		50	50
Sweden	837	12	849
Switzerland	1,097	593	1,690
South Africa		70	70
United Kingdom		2,251	2,251
USAID	2,925	607	3,532
University of Nottingham		4	4
World Health Organization (WHO)		26	26
World Bank	3,930	352	4,282
Total grants	13,869	12,649	26,518

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