ILRAD REPORTS
JANUARY 1990

Published by the International Laboratory for Research on Animal Diseases

Volume **8** Number **1**

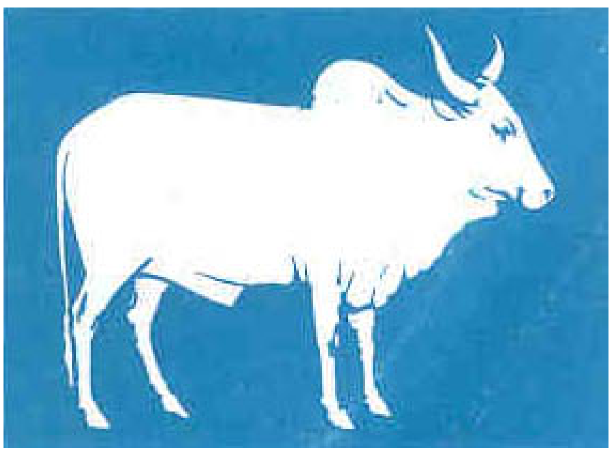
Assessing the impact of better control of livestock diseases in Africa

Despite almost a century of veterinary service and research in Africa, disease remains a major constraint to livestock production on the continent. The widespread prevalence of infectious diseases is due to a variety of circumstances. The African climate and habitat, for example, are ideal for many disease agents and their vectors. In many parts of the continent, it is difficult and at times impossible to impose quarantine, or to restrict movement of livestock; and the uncontrolled movement helps spread diseases. Slaughter policies, used extensively in other parts of the world to control livestock infection; are not feasible in most places in Africa, where the destruction of animals would also destroy the livelihood of peasant farmers whose government could not afford to pay compensation. Finally, the introduction of livestock from Europe, North America and Australia to improve the productivity of local stock by crossbreeding has exacerbated disease control problems because most of the introduced breeds are highly susceptible to Africa's endemic diseases, especially those transmitted by ticks.

ILRAD is strongly committed to developing immunological methods to control two of Africa's most devastating livestock diseases: theileriosis, better known as East Coast fever, and trypanosomiasis (called sleeping sickness in people). The possible development of vaccines against these diseases offers the prospect of controlling them with relatively inexpensive and environmentally sound methods the same way that we now control through vaccination such important diseases as rabies and lumpy skin diseases in animals, and measles and polio in humans.

Even the availability of a highly effective vaccine, however, does not guarantee the widespread control of a disease in Africa. This was well illustrated in the pan-African rinderpest eradication campaign of the late 1960s and early 1970s, during which vaccination conducted on an unprecedented scale brought the disease under control. The campaign was a success, but the follow-up was a failure. To maintain levels of herd immunity to rinderpest, each new generation of animals must be vaccinated at a particular age. The funds and logistical support needed to plan and conduct annual calf vaccinations were beyond the resources of many small veterinary services and the disease soon spread back through the continent, reaching by the 1980s the same levels that existed before the campaign started.

With Africa's burgeoning human population and decreasing agricultural output per capita, the resources needed to implement and maintain widespread animal disease control are becoming scarcer every year as these funds are stretched to help solve the many other problems facing the African agricultural industries. To make the most efficient use of the increasingly scarce resources, disease control programs must be tailored to the needs of particular communities and to high-priority cattle populations to ensure their efficacy, acceptance and sustainability.



In 1987, ILRAD established an Epidemiology and Socioeconomics Program to address the factors likely to enhance or impair disease control practices in Africa so as to avert failures in the future use of vaccines developed at ILRAD and elsewhere. The Program has three main objectives: (1) to identify the epidemiological, socioeconomic and environmental constraints to effective immunological control of livestock diseases, particularly tick-borne diseases, under diverse circumstances, (2) to predict the likely epidemiological, economic and environmental outcomes of improving control of the diseases in given areas, and (3) to suggest control strategies and alternatives appropriate to the needs of particular groups of cattle keepers and mixed farmers, as well as the needs of individual governments.

Members of the Epidemiology and Socioeconomics Program collaborate in their work, particularly in the collection and analyses of data, with scientists and disease control officers in other international and national organizations, such as the International Livestock Centre for Africa (ILCA), Addis Ababa; the Kenya Agricultural Research Institute (KARI); extension services of the Kenya Ministries of Agriculture and Livestock Development; the United Nations Environment Programme (Nairobi); and the Zimbabwe Department of Veterinary Services. At the same time, scientists from national agricultural research institutes are being trained to use the methodologies developed at ILRAD so that research and control organizations throughout the continent may conduct parallel assessments of the epidemiology and socioeconomics of livestock disease control.

Determining the risk of ECF and the impact of implementing new control strategies

The tick-transmitted parasite *Theileria parva* causes three major cattle diseases—East Coast fever, Corridor disease and January disease—in 11 countries of eastern, central and southern Africa. In 1986, these countries together carried an estimated 61 million cattle, or 35% of Africa's total population. Stock farming plays a vital role in the region's agricultural sector, where domestic animals serve a variety of economic and social functions. Cattle, for example, are an important source of such diverse essentials as cash, food, draught power, manure and fuel, and also provide economic security and social status.

Although the economic losses to cattle producers caused by East Coast fever (ECF), the most important of the theilerial diseases, have not yet been systematically quantified, the disease is known to cause high mortality in cattle, especially in exotic (*Bos taurus*) breeds and crosses of exotic and indigenous (*Bos indicus)* breeds raised for dairy and beef production. The mortality rate caused by ECF can reach 100% in herds of exotic cattle introduced in an endemic area, and even in indigenous animals the rate can be as high as 30% in endemic areas. Also at risk are animals of all breeds that have poor nutrition or that are subject to intensive but intermittent tick control. Furthermore, most animals that do recover from ECF show substantial losses in milk yield and live weight gain.

Smallholder farmers spend considerable amounts of time and money on controlling ECF by regularly dipping, or spraying their cattle with acaricides to kill the tick vector and by treating infected cattle with chemotherapeutic drugs. Dairy farmers in one area of Kenya spent an average of US$8.50 (in present value terms) per animal on acaricidal application in 1986 alone. Governmental expenditures on maintaining dipping services and conducting research into the disease are also high. The government of Zimbabwe, for example, spent US$9 million (current value) in one financial year (1988/89) on the control of ticks and tick-borne diseases alone; this amounted to over 50% of the budget for all veterinary services in the country that year. East Coast fever also causes indirect losses, due, for example, to exclusion of highly productive exotic and grade cattle from much of the endemic region and to environmental pollution and degradation caused by regular acaricide use and walking cattle to dips.

In most areas, control of ECF and other tick-borne diseases depends on controlling ticks with acaricides. This method is increasingly unreliable, however. National governments have trouble keeping acaricides in stock because they are expensive and must be bought with scarce foreign currency. Dips are often poorly managed and maintained by ill-equipped veterinary services, water needed to operate dips may be scarce and cattle may be moved illegally from areas where dipping is practised to areas where it is not. A further, important biological problem of this control method is that some tick species are developing resistance to frequently used acaricides.

Although chemotherapeutic drugs exist for treating cattle infected with *T. parva*, these drugs must be administered at an early stage in the development of the disease in order to be effective. Early diagnosis depends on efficient veterinary services, which are scarce in many rural areas. In addition, curative drugs are expensive and not widely available. Effective treatment for ECF is thus beyond the reach of most of Africa's livestock producers.

Because of the problems in using dipping and drug treatment to control ECF and other tick-borne diseases, alternative control strategies based on immunization are now being more widely considered. The only practical way to immunize cattle against ECF at present is to infect cattle with live sporozoite forms of the parasite and simultaneously treat the animals with an antibiotic or theilericidal drug to reduce the severity of the resulting infection, while still allowing an immune response to develop. This method, known as 'infection-and-treatment', has been refined over several years by researchers at KARI, with support from the Food and Agriculture Organization, and at ILRAD. The method has been used effectively to immunize cattle against ECF in field trials conducted in several countries, and the governments of some of these countries plan to use the infection-and-treatment immunization method more extensively in the near future.

The risk to livestock of ECF varies considerably from area to area, depending on such variables as the climate and vegetation, which determine differences in the seasonality, abundance and infectivity of the tick vector; differences in the cattle types regarding susceptibility both to the tick and to the parasite; and differences in management systems, which in turn determine which ECF control methods are used. Because ECF risk varies considerably from one area to another, the need for immunological control and the choice of control strategy will also vary.

Therefore, before embarking on widespread implementation of immunological control, the disease risk in target areas must be identified so that control programs may be tailored to specific places and production systems, and thus be as cost-effective as possible. To determine the level of ECF risk in a given area and the best control strategy or strategies to implement, the following basic questions need to be answered.

- What are the types and numbers of cattle?
- What cattle management systems are in use (i.e., how are cattle fed and watered and how do their movement patterns affect their contact with ticks)?
- What ecological and economic niches do cattle fill and what incentives and resources do cattle keepers have to improve productivity?
- What is the nutritional status of cattle; if improvement is needed, what opportunities exist for accomplishing this?
- How serious a constraint to productivity and farm income are the cattle diseases present?
- What strains of *T. parva* (the parasite that causes ECF) and *R. appendiculatus* (the parasite's tick vector) exist, how are the populations distributed and how prevalent are the strains?
- What is the incidence, severity and case fatality of clinical ECF?
- How effectively do control strategies already in use for ECF meet the needs of the farmers?
- What are the estimated economic costs and benefits of controlling ECF by immunological means rather than by dipping or spraying?

Field studies in Kenya

Members of the Epidemiology and Socioeconomics Program are engaged in field studies aimed at finding effective strategies for controlling ECF by the infection-and-treatment immunization method and assessing the impact of such control in two districts of Kenya: Kilifi and Uasin Gishu. In this work, Program members are collaborating with scientists from KARI and with Kenya-based staff from ILCA. The Kilifi and Uasin Gishu projects grew out of work conducted by scientists at Kenya's National Veterinary Research Centre (NVRC), Muguga, who undertook a series of immunization trials on parastatal and commercial ranches and dairies to assess the efficacy of an infection-and-treatment protocol that relies on a Kenyan stock of *T. parva* called Marikebuni. Results of these trials demonstrated that infection and treatment using the Marikebuni stock effectively controls ECF in many areas of Kenya.

The controlled conditions of the NVRC trials, although necessary for the demonstration of biological efficacy, did not reflect the socioeconomic or epidemiological complexity of Kenya's livestock sector. Therefore, before extending immunization to cattle on smallholder farms, detailed pilot studies were conducted to determine the conditions under which the method should be assayed and to obtain baseline data on disease, productivity and socioeconomic conditions against which the results could be measured. KARI staff selected Kilifi and Uasin Gishu districts as initial foci for smallholder trials and encouraged staff of the Epidemiology and Socioeconomics Program to collaborate on preliminary studies in these districts.

Kaloleni Division, Kilifi District

Kaloleni Division is located in Kilifi District, in Kenya's subhumid coastal strip. Annual rainfall in the division ranges from 700 to 1200 mm across three distinct agroecological zones: a high-potential, high-rainfall area, designated the 'coconut/cassava zone'; a transitional; moderate-rainfall, 'cashew nut/cassava zone'; and a dry, 'livestock/millet zone'. Theileriosis is endemic throughout Kaloleni Division, but tick habitability and livestock production systems vary markedly across the division's three zones. Consequently, the need for immunological control, as well as its costs and benefits, must be calculated for different areas.

As a first step in this process, two baseline surveys were carried out in Kaloleni in 1989. The first was a socioeconomic study conducted by KARI and ILCA staff, in which more than 1800 farmers were questioned about livestock and crop production on their farms. The second was a cattle census in which all cattle in Kaloleni Division were counted and the age, sex and breed distributions were plotted. One of the most important production features identified in these studies is the small size of most Kaloleni farms, especially in the coconut/cassava and cashew/cassava zones, where the average farm consists of less than two hectares. Another important feature is the small proportion of Kaloleni farmers, about 8% overall, that keep cattle.

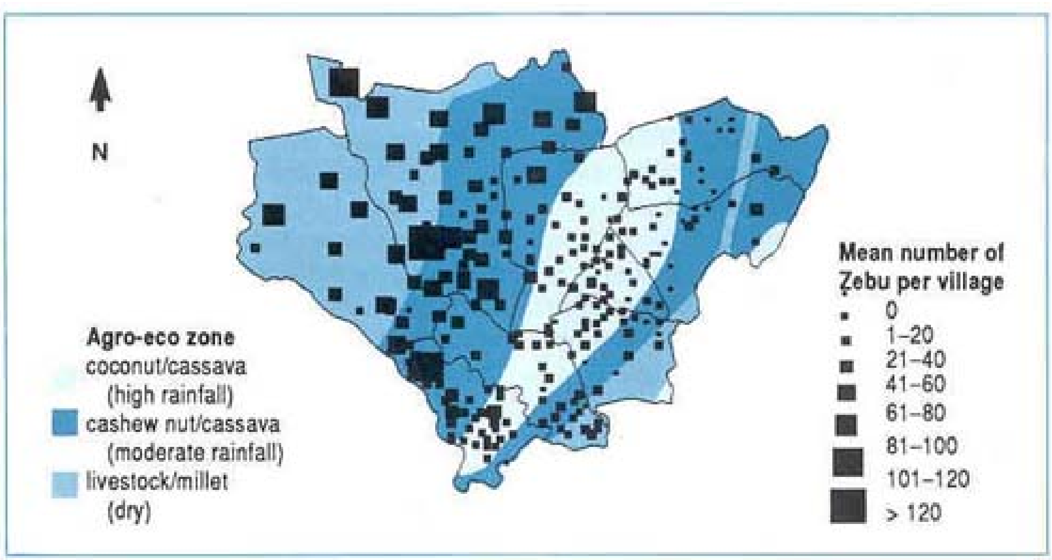


FIGURE 1. *Map illustrating the strong association between the size of indigenous, Zebu herds and the potential of the land In Kaloleni Division, in Kenya.*

The census results indicate that indigenous Zebu cattle dominate Kaloleni's modest livestock sector: 57,000 Zebu animals are kept on 1500 farms, giving a mean Zebu herd size of 39 head. Large Zebu herds are a prominent feature of the dry, livestock/millet zone (Figure 1), where the percentage of farmers that keep cattle is high and where free-range grazing systems prevail.

Just 2% of Kaloleni farmers keep 'grade' cattle, which show evidence of genetic improvement by their cross-breeding with *Bos taurus* or improved Zebu animals. A total of 889 grade cattle on 157 farms were counted in the division, yielding a mean grade herd size of about 6 head. Grade cattle are concentrated in the coconut/cassava and cashew/cassava zones, where herds are generally small. In these zones, 15% of the grade stock are managed under what are called 'zero' and 'semi-zero' grazing systems, in which cattle are permanently or usually confined in a shed or paddock, where they are watered and fed.

It is important to consider breed characteristics and management practices when determining the level of theileriosis risk in an area. Under free-range grazing systems, for example, grade cattle face a much higher risk of infection with *T. parva* than indigenous cattle. Studies such as those described above are therefore essential to making sound decisions about the need and relative advantage of immunological control in different places. A simple 'risk matrix' for theileriosis in Kaloleni Division (which could be translated into a 'risk map') needs to account not only for spatial and seasonal variations in abundance of the parasite vector, but also for such factors as the distribution of grade stock and the patterns of grazing and watering, which strongly influence the exposure of animals to ticks and disease.

Serological surveys carried out jointly by ILCA, ILRAD and KARI staff in late 1989 offer more precise evidence of the ways in which exposure to *T. parva* varies in Kaloleni Division. Antibody prevalence tests—which enable researchers to calculate the prevalence of livestock exposure to *T. parva* according to area and the age and sex of livestock—are particularly important in determining which cattle populations would benefit from immunization. Environmental as well as cattle census, breed and production data obtained in earlier surveys together provide an analytical framework with which to assess these results.

Seventy-three percent of cattle tested in Kaloleni Division carry antibodies to *T. parva;* the presence of antibodies indicates that these animals have at some earlier time been infected by the parasite. This high prevalence rate demonstrates widespread ECF endemicity in the division and furthermore is evidence that attempts to control theileriosis through the application of acaricides have not prevented most Kaloleni. cattle from being exposed to the parasite. A high proportion of Kaloleni cattle have probably thus survived exposure to theileriosis.

The high overall prevalence of antibodies to *T. parva* in the division, however, conceals marked differences in the prevalence rates, which vary according to the zone; the cattle type, age and sex; and the management system used. Closer analyses of the antibody prevalence rates and census data reveal a complex disease epidemiology that may call for strategic immunization. For example, in the dry, livestock/millet zone, antibody prevalence rates in the Zebu population are consistently high, whereas the rates in the population of grade cattle vary according to the age of the animal. Among the relatively few grade cattle raised in this zone, the prevalence rate in animals under 1.5 years old was 29%. The rate rose to 53% in animals 1.5–3 years old and to 63% in animals over 3 years old.

The evidence of differences in age-specific exposure among grade cattle suggests that these cattle tend to become infected over a period of several months in early life, during which time considerable mortality occurs, leaving a depleted but generally immune adult population. The high antibody prevalence rates in all adult animals in this division, and the associated widespread immunity to ECF, may have developed in Kaloleni at the expense of high, periodic mortality, especially in calves. Mortality studies are being carried out to test these hypotheses.

Results of analyses of data obtained so far in the surveys conducted in Kaloleni

Division suggest that productivity in the dryland zone can be increased in a cost-effective way through immunization of calves. In the coconut/cassava and cashew/cassava zones, the data show not only that calves are the most susceptible group, but also that there is a decline over time in antibody levels among adult grade cattle kept under zero grazing management. In these zones, therefore, strategic immunization may be beneficial for adult grade livestock maintained under zero grazing as well as for calves.

Two other studies have been undertaken in Kaloleni Division by the Epidemiology and Socioeconomics Program as part of a broad effort to determine ways to introduce new, sustainable disease-control technology and to measure its impact. In a comprehensive ethnoveterinary study completed recently, 158 cattle keepers covering all of the division's ten administrative locations were interviewed about how they perceive, classify and respond to livestock diseases. The survey disclosed indigenous names of 144 cattle diseases or syndromes.

The reported diseases were broken down by area and animal population subgroup. Each disease was then characterized by the type, age and sex of the affected cattle; the geoclimatic environment in which the disease occurred; the progression of clinical symptoms; effects of the disease on production; what the livestock owner judged to be the cause of the disease; preventive strategies employed; traditional and modern therapies available for treating affected animals; how effective the livestock owner judged each of these therapies to be; and details of recent cases of the disease.

Among the findings of this study pertinent to attempts to improve theileriosis control are the widespread use of four local names for ECF, as well as a well-known descriptor for the disease when it occurs in calves; descriptions of traditional curative practices; distinct geographical patterns of use of and access to modern veterinary treatment; and the inability of many farmers—including those who regularly use methods of tick control—to associate clinical signs of theileriosis with the presence of ticks. This information on local disease vocabulary and ethnoetiology will help improve communication between Kaloteni farmers and veterinary extension workers who will implement ECF control through the infection-and-treatment method.

To assess the potential and actual economic impact of implementing immunological control in a region, baseline economic data must be obtained from that region against which changes in disease control practice can be measured. The ILRAD team has therefore conducted another study in which it identified the most important farm enterprises in Kaloleni Division (farms on which no cattle were kept were included in the survey) and selected sample farms for in-depth economic assessments before implementing an immunization strategy.

The team is now determining the relationship between agricultural inputs, especially those required for livestock production, and profitability.

This study includes an assessment of animal health costs and the role of livestock in household economies of various types. The data obtained will be entered in computer models of farm income and expenditure, livestock herd dynamics, and the economic costs and benefits of introducing new methods of controlling theileriosis, including immunization by the infection-and-treatment method.

Uasin Gishu District

Uasin Gishu District, lying on a 1680to 1980-m plateau in Kenya's Rift Valley Province, contrasts sharply with Kaloleni Division, near the Kenya coast. Representative of highland environments in much of eastern Africa, Uasin Gishu is a major wheat and livestock-producing region. The district carries an estimated 100,000 head of cattle, most of which are crossbreeds kept for milk production.

The initial characterization exercise conducted in this district by staff from the Epidemiology and Socioeconomics Program differed somewhat from that conducted at the coast. From May to June 1989, agricultural and livestock extension agents in the district were interviewed about the farm and livestock enterprises in each of 634 land registration units that have existed in the district since before Kenya's Independence, in 1963. Data obtained in this survey were entered in a computer and displayed and analysed with a geographic information system (GIS) (see chapter on GIS).

The map in Figure 2, produced with a GIS, shows the average farm size in each of Uasin Gishu's land registration units. Data on environment, crops, cattle types, cattle management systems, land tenure and many other variables were also fed into the GIS. The maps produced from these databases are enabling the research workers to analyse geographically the factors that impinge on the livestock economy, disease epidemiology and disease control in the district. This information has also been used to select a representative sample of land registration units on which to conduct more detailed epidemiological, socioeconomic and environmental studies.

Results of these studies will help research workers and control personnel to determine which control strategies will be most cost-effective in different parts of the district. If in some places control by infection-and-treatment is called for, the ILRAD team will monitor the health and productivity of both immunized and non-immunized cattle, as well as the socioeconomic impact on the farm and regional economy of controlling ECF by this immunization method.

Impact of tick and tick-borne disease control in Zimbabwe

Tick-borne diseases have long been a major constraint to livestock production in Zimbabwe, where a government-supported tick-borne disease control program has been in operation since 1914. Control is based on regular application of acaricides to cattle. In what is known as the Communal Land sector of the country, the cost of this acaricide program is borne entirely by the government.

The Zimbabwe acaricide program is one of the most efficient national tick-borne disease control programs in Africa. In spite of this, however, the Zimbabwe Department of Veterinary Services is now reassessing its tick-borne disease control strategies in light of several facts. The dipping program requires acaricides that must be purchased from other countries with scarce foreign exchange. The Department currently spends about 50% of its annual budget on dipping services, much of the money being used to buy acaricides. The dipping program is also heavily dependent on an extensive government infrastructure needed for the construction and maintenance of cattle dips. The risk of livestock becoming infected with *T. parva* is now low in the Communal Lands, where overgrazing has destroyed much of the habitat required for the survival and development of the parasite vector, *R. appendiculatus.* Several new immunization procedures for the control of tick-borne diseases are available or are under development, one or more of which may lead to use of less expensive and more sustainable disease-control methods in the country.

Keeping livestock tick-free by means of. dipping makes animals highly susceptible to tick-borne diseases. If the program is interrupted, high mortality occurs. This happened during Zimbabwe's War of Independence (1973–1980), during which almost a million cattle died of tick-borne diseases due to a breakdown in the country's dipping services. However, results of serological surveys showed that this breakdown was also responsible for the subsequent development of enzootic stability to some of the tick-borne diseases in livestock herds in much of the country, and that natural challenge with pathogens had produced high levels of herd immunity to the tick-borne diseases anaplasmosis and babesiosis. However, a reintensification of dipping following independence has again rendered much of the country's cattle population susceptible to tick-borne diseases.

In collaboration with workers in the Zimbabwe Department of Veterinary Services, members of ILRAD's Epidemiology and Socioeconomics Program are comparing the impact of controlling ticks and tick-borne diseases in Zimbabwe by use of national control programs already in place and by use of new, alternative strategies. Two control strategies have been proposed *(Report to the Director of Veterinary Services, Zimbabwe,* by Perry, Mukhebi, Norval and Barrett, 1990).

One strategy, designated 'reduced dipping', consists of reducing the frequency of dipping to once a fortnight in the summer months and to once a month for the rest of the year. Because acaricides in present use are highly effective and most Zimbabwe stock farmers comply with government dipping regulations, the scientists predict that use of the reduced dipping strategy will save the Zimbabwe Government considerable amounts of money while causing no increase in the incidence of tick-borne diseases.

The other strategy, called 'strategic dipping', is designed to permit natural challenge by ticks at a level sufficient to maintain herd immunity. Using this strategy, some cattle would have to be immunized against some tick-borne diseases during a transition phase between regular acaricide application and the development of widespread immunity due to natural challenge.

Researchers in Zimbabwe and ILRAD are assessing which cattle populations in the country would most benefit from each control strategy. With the aid of a geographic information system, they are also predicting the likely epidemiological, production and socioeconomic consequences of implementing each strategy.

Early this year, staff from ILRAD and the Zimbabwe Veterinary Department completed a preliminary assessment for the Director of Veterinary Services outlining the feasibility of implementing each alternative strategy in Zimbabwe and the areas in which further research needs to be conducted. The assessment includes an estimate of the financial consequences of using the alternative strategies over a 20-year period. The team concluded that use of reduced or strategic dipping would be more cost-effective than the intensive dipping now in practice in the country. Assuming that the introduction of the alternative strategies will cause no significant changes in disease risk, the team estimated that the alternative strategies would save the Zimbabwe Veterinary Department US$3.8–5.6 million per year in present-value terms. Applying reduced dipping, it was estimated, would reduce the cost of control by 46%, from US$1.25 to $0.68 per animal per year; applying strategic dipping would reduce the control cost by 68%, from US$1.25 to $0.41 per animal per year.

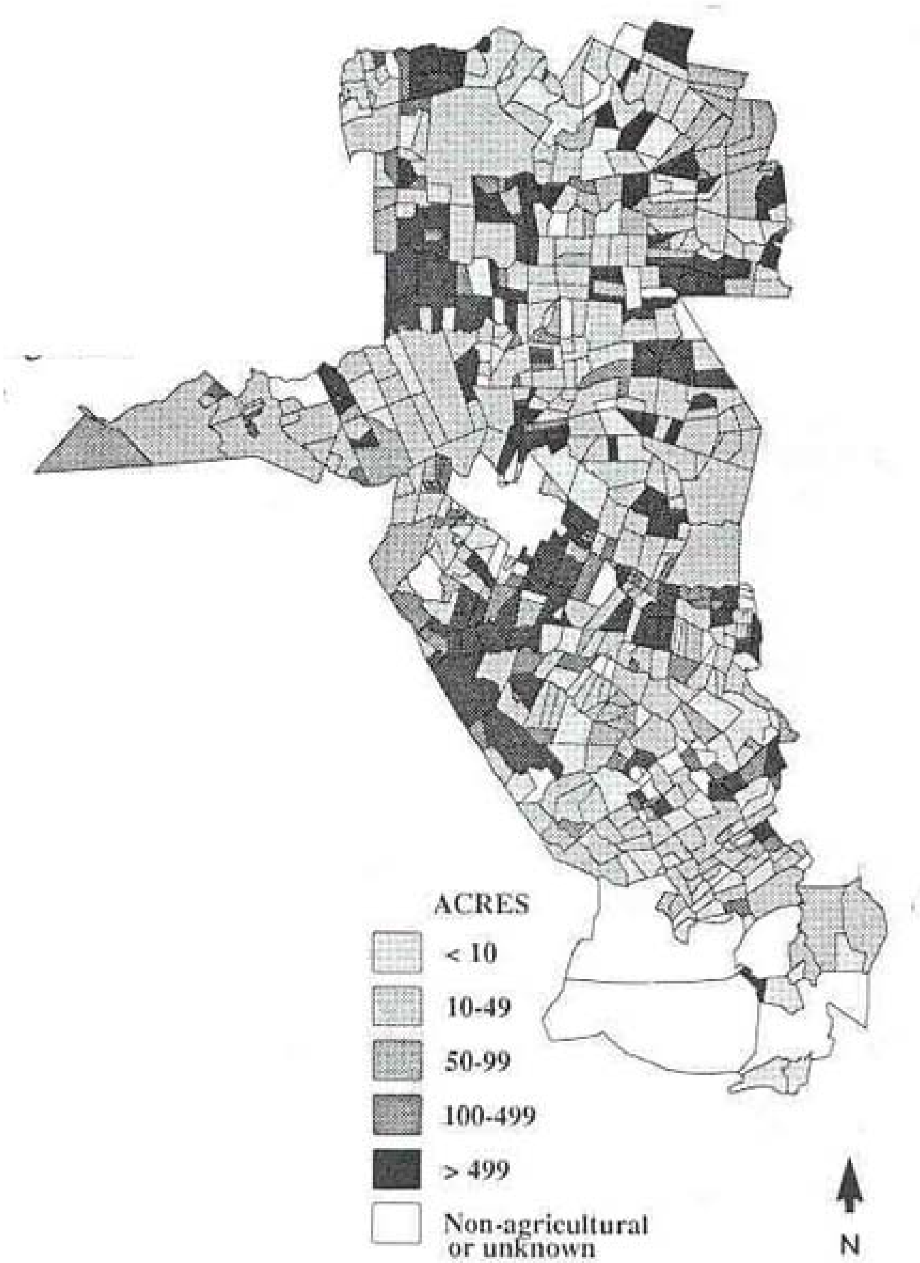


FIGURE 2. *Map showing the average farm size in each land registration unit in Uasin Gishu District, Kenya. Farm size as well as production data have been entered in a computer geographic information system to facilitate analyses of the variables in livestock production in different areas.*

As a first step in a final appraisal of the sustainability, environmental soundness and economic benefits of using the alternative strategies, staff members of the Zimbabwe Department of Veterinary Services are now testing assumptions made in the preliminary assessment, such as that implementing the alternative strategies will not change the incidences of tick-borne diseases. The ILRAD team is evaluating benefits other than the relative cheapness of the alternative strategies and making more precise estimations of the costs of such factors as local vaccine production and vaccine delivery.

Extrapolating the predicted impact of disease control from one area to another

Due to the great diversity of both vector-borne diseases and the circumstances in which the diseases occur in Africa, the epidemiology of these diseases varies greatly from place to place. Thus, although site-specific studies at the division, district or country level, such as those described above, are necessary to obtain specific epidemiological data and details of the circumstances in which a livestock disease occurs, extrapolation of the results of these studies to other areas will be valid only if those other areas share the particular set of circumstances—including the farming systems; the social, economic and natural environments; and the disease epidemiology —that pertain to the original, specific, study sites. Key variables must therefore be identified in the site-specific studies that will be used to characterize the impact of disease control at the farm, division, district and country levels. These characterizations will then be used to develop methods with which to apply a particular set of circumstances to other areas of Africa. Program staff members will then be able to develop computer models that will accurately predict the livestock production levels and the behaviour of livestock diseases under different management systems and control regimes and in different areas and circumstances.

Further Reading

Single copies of reprints may be requested from the ILRAD Library. Please mention the ILRAD publication number given in brackets at the end of each reference.

LESSARD, P. (1988). Geographic information systems in tick-borne disease epidemiology. *The Kenya Veterinarian* 12: 9–11 (723).

LESSARD, P., L'EPLATTENIER, R., NORVAL, R.A.I., KUNDERT, K., DOLAN, T.T., CROZE, H., WALKER, J.B., IRVIN, A.D. and PERRY, B.D. 1990. Geographic information systems for studying the epidemiology of cattle diseases caused by *Theileria parva.The Veterinary Report* 126: 255–262 (792).

MUKHEBL A.W, WAITHANGA, J., PERRY, B.D., IRVIN, A.D. and MORZARIA, S.P (1989). Financial analysis of East Coast fever control strategies on beef production under farm conditions. *The Veterinary Record* 125: 456–459 (717).

PERRY, B.D., LESSARD, P, NORVAL, R.A.I., KUNDERT, K. and KRUSKA, R. (1990). Climate, vegetation and the distribution of *Rhipicephalus appendiculatus* in Africa. *Parasitology Today* 6: 4 (802).

PERRY, B.D., MUKHEBI, A.W, NORVAL, R.A.I. and BARRETT, J.C. (1990). *Report to the Director of Veterinary Services: A Preliminary Assessment of Current and Alternative Tick and Tick-Borne Disease Control Strategies in Zimbabwe.* ILRAD Report. Nairobi: International Laboratory for Research on Animal Diseases, 41 pp. (photocopy).

The following papers appear in:
DOLAN, TT., ed. (1989). *Theileriosis in Eastern, Central and Southern Africa: Proceedings of a Workshop on East Coast Fever Immunization, Held in Lilongwe, Malawi, 20–22 September* 1988. Nairobi: International Laboratory for Research on Animal Diseases, 191 pp. (873).

MORZARIA, S.P A systematic approach to East Coast fever immunization in the Kilifi District of the Kenya coast, pp. 46–52 (875).

MUKHEBI, A.W., MORZARIA, S.P and PERRY, B.D. Economics of an East Coast fever immunization trial at the Kenya coast, pp. 60–61 (876).

MUKHEBI, A.W, MORZARIA, S.P, PERRY, B.D., DOLAN, T.T. and NORVAL, R.A.I. Production and delivery costs of the infection-and-treatment vaccine against East