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EX ANTE IMPACT ASSESSMENT OF DISEASE CONTROL TECHNOLOGIES : THE CASE OF VECTOR-BORNE INFECTIONS IN AFRICA

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Afin d'évaluer les mérites de différentes options de recherche, dans le domaine du contrôle des maladies animales, aussi bien en terme de productivité que de transfert de technologies, nous assistons à une demande croissante d'analyse ex ante de l'impact. Ceci nécessite une modélisation prédictive des effets des technologies sur différents indicateurs pré-définis, de type biologique, économique et environnemental. C'est le cas de l'Institut International de Recherche Animale (ILRI) où de nouvelles technologies sont développées, comme les vaccins, les animaux génétiquement résistants et les stratégies intégrées d'amélioration du contrôle des infections des ruminants des tropiques contre les hémo-parasites.

L'analyse ex ante est décrite. Dans le premier des 3 exemples, les effets épidémiologiques de différentes stratégies de lutte contre la cowdriose (maladie transmise par les tiques, infection à Cowdria) en particulier l'utilisation d'un nouveau vaccin inactivé en cours de développement, ont été évalués grâce à un modèle dynamique d'infection. Le modèle a été utilisé pour étudier la manière dont les vaccins affectent l'évolution et la dynamique d'infection dans différents systèmes de production, ainsi que pour aider à contrôler le développement des tiques et l'application de protocoles vaccinaux.

Dans le second exemple, un modèle de calcul a été développé en vue de déterminer l'intérêt économique de nouveaux vaccins contre la thélériose (infection à Theileria) dans différents systèmes de production africains et le marché potentiel de ces vaccins.

Dans le troisième exemple, des systèmes d'information géographique (GIS) ont été utilisés pour prédire l'impact du contrôle de la trypanosomose sur l'environnement. En effet, cette maladie transmise par la mouche tsé-tsé, limite voire exclut la production de bétail dans plusieurs pays d'Afrique sub-saharienne, tandis que les avantages et les bénéfices de la productivité liés à son contrôle sont prévus, les impacts potentiels sur l'environnement sont encore peu connus.

INTRODUCTION

The International Livestock Research Institute (ILRI) conducts research on strategic issues that constrain livestock productivity of resource-poor households, with a focus as smallholder crop-livestock systems. The institute conducts research in the areas of ruminant genetics, ruminant health, feed resources, crop-livestock systems and strengthening national agricultural systems of the developing world. Although previously concerned principally with Africa, the Institute now has a global mandate and is initiating research in Asia and Latin America. With such a broad mandate and geographical coverage, it is imperative that the institute develops a strategic focus, undertaking research on issues that are demonstrated to be of high priority, and ensuring research products reach its clients and beneficiaries. As a result, there has been an increasing demand for *ex ante* impact assessment in two areas. The first is to predict the potential returns to research in different subjects, so contributing to priority setting for livestock research. The second, the subject of this paper, is to predict the impact of the products of current research, in order that continued investment in such research can be justified, and that such research products achieve their optimal impact on livestock productivity. In the area of animal health research, ILRI focuses on haemoparasitic infections of ruminants, in particular the tick-borne infections and the trypanosomoses. *Ex ante* impact assessment of new technologies to control these diseases has become an important area of research itself (Perry, 1996). Three examples of impact assessment are presented in this paper, describing studies to evaluate the impact of diseases and their control on biological, economic and environmental indicators.

CASE 1 : PREDICTING THE INFECTION DYNAMICS OF HEARTWATER

Heartwater, caused by *Cowdria ruminantium* and transmitted ticks of the genus*Amblyomma,* is responsible for significant losses in cattle, sheep and goats. In Zimbabwe, the site of a USAID supported University of Florida/Southern African Development Community heartwater research project, losses have been controlled in the past by the use of acaricides applied at high frequency. In recent years, there has been some relaxation of the intensity of acaricide use, which along with other factors, such as animal movement, has resulted in the spread of the ticks to areas previously heartwater free (Norval *et al.*, 1994). The infection has different impacts on livestock productivity depending on the natural region, the systems of livestock production and the efficacy of control measures. To quantify the epidemiological and economic impacts of heartwater on productivity, a series

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of cross-sectional and longitudinal studies were set up to characterise the epidemiological status on the basis of geographical zone (northern, central and southern), production system (commercial or communal) and efficacy of tick control measures (Perry *et al.*, 1997). A summary of the estimated proportions of cattle in each epidemiological state is shown in Table I.

Table I
Estimated distribution of epidemiological states under current heartwater control programme

Geographical Zone	Production System	Heartwater free	Unstable, high incidence	Unstable, low Incidence	Stable
Northern	Commercial	100%	0	0	0
	Communal	100%	0	0	0
Central	Commercial	10%	10%	75%	5%
	Communal	10%	10%	5%	75%
Southern	Commercial	0	10%	60%	30%
	Communal	0	5%	5%	90%

A model of *C. ruminantium* infection dynamics, which predicts the incidence and case fatality of heartwater was developed (O'Callaghan *et al.*, 1997). Model parameters were quantified from field and experimental studies. The model was then used to predict the production losses from heartwater for each of the states illustrated in Table 1. Subsequently, an evaluation of how the proportion of cattle in each category might change over a 10 year period was made (Table II), assuming the deployment of the vaccine currently under development (Mahan *et al.*, 1995). The heartwater model again predicted production losses which were used to evaluate the economic impact of the heartwater vaccine (Perry *et al.*, 1997).

Table II
Estimated distribution of epidemiological states under optimal deployment of heartwater vaccine

Geographical Zone	Production System	Heartwater free	Unstable, high incidence	Unstable, low incidence	Stable
Northern	Commercial	0	10%	80%	10%
	Communal	0	10%	5%	85%
Central	Commercial	0	10%	80%	10%
	Communal	0	10%	5%	85%
Southern	Commercial	0	10%	40%	50%
	Communal	0	5%	5%	90%

CASE 2 : PREDICTING THE ECONOMIC IMPACT OF NEW THEILERIOSIS VACCINES

Theileriosis, caused by *Theileria parva* and and transmitted by the tick *Rhipicephalus appendiculatus* causes severe economic losses to the cattle industries of eastern and southern Africa (Mukhebi *et al.*, 1992). ILRI is conducting research to develop a safe and effective vaccine to control the disease. Recently, trials have demonstrated the efficacy of an experimental vaccine based on a 67 kiloDalton antigen (Nene *et al.*, 1996) . A study was carried out to determine the economic impact of such a vaccine in four target countries and estimate the number of doses required over a 10 year period (Williams *et al.*, in preparation). Secondary data on livestock populations at risk, livestock production economics, theileriosis occurrence and current control measures were assembled for Kenya, Uganda, Tanzania and Zimbabwe. Vaccination protocols were proposed for different production systems based on current knowledge of the performance of the vaccine. It was assumed that vaccination would cost US$5 per dose and be accompanied by a 50% reduction in acaricide use. Vaccine adoption rates were developed for different production systems, based on the economic viability of the system, and the theileriosis risk, and increased from 5-60% over 10 years. Data were analysed using a disease impact and control assessment model (DICAM) developed by Smeding (1996), a revised version of a spreadsheet model originally developed by Mukhebi *et al.* (1992). A summary of the results is presented in Table III.

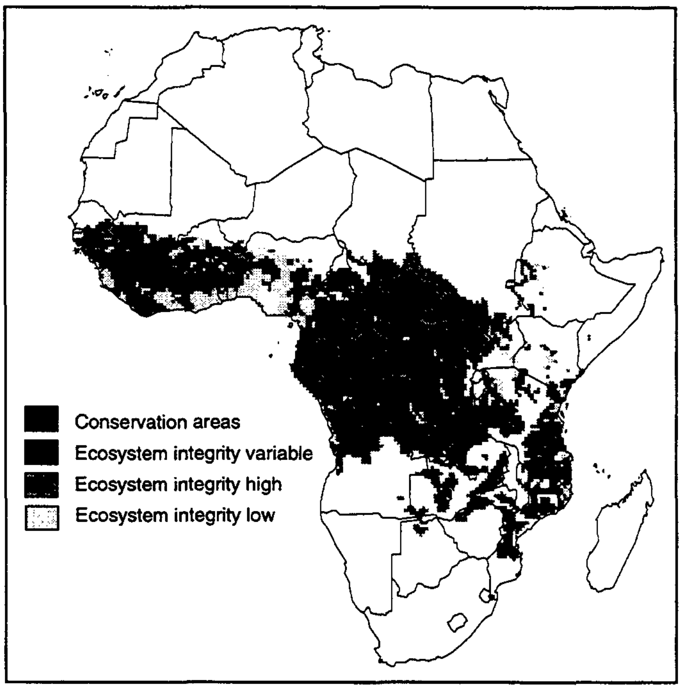
Table III
Impact of Theileriosis control in four countries of eastern and southern Africa

Country	Cattle population	Cattle population under theileriosis risk (%)	Estimated *average annual vaccine requirements of 1st generation p67 vaccine (doses)	Estimated benefit: cost ratio	Estimated net present value over 10 years (US$ millions)
Kenya	12,920,000	5,977,000 (46%)	3,447,000	3:1	777
Tanzania	13,618,000	4,147,000 (31%)	3,064,000	3:1	122
Uganda	5,100,000	4,223,000 (83%)	3,271,000	3:1	82
Zimbabwe	5,406,000	1,765,000 (33%)	1,117,000	3:1	832

This study has demonstrated the economic viability of a vaccination strategy using a recombinant p67 antigen vaccine in the 4 case study countries, and has provided estimates of the market for such a vaccine.

CASE 3 : PREDICTING THE ENVIRONMENTAL IMPACTS OF TRYPANOSOMOSIS CONTROL

Trypanosomosis is widely distributed in the world. The tsetse fly, which transmits African animal trypanosomosis, reportedly infests 10 million sq. kms. in 37 countries. It has been argued that trypanosomosis is the major constraint to the development of animal agriculture in Africa. However, it has also been suggested that the successful control of the disease could unleash an expansion of cultivation and livestock populations which could threaten the natural resources of the continent. Few studies of the environmental impacts of trypanosomiasis control have been undertaken to evaluate these hypotheses. As part of a series of studies by ILRI and its partners, a continental simulation model was developed, using geographical information systems (GIS) to determine where the impacts of trypanosomosis control might be high (Reid & Ellis, 1995). The model evaluated where trypanosomosis control might have significant negative effects on ecosystem integrity. A series of georeferenced databases on key variables was assembled in a GIS. These included distributions of tsetse fly, cattle, human population density and conservation areas. A data overlay procedure was applied and areas were classified according to a series of assumptions. These were: 1) tsetse control in areas designated for conservation (such as game parks) will cause significant negative impacts on ecosystem integrity if human use is not strictly controlled; 2) where human density is very low ($<1/km^2$), integrity is very high; 3) where human density is low ($1-5/km^2$), integrity is high; 4) where human use is low to moderate ($6-50/km^2$), land use intensity may or may not be high, depending upon many factors, and ecosystem integrity will likely vary from one site to another; 5) where human density is $>50/km^2$, ecosystem integrity is likely to be low. Areas within the tsetse fly distribution were thus classified as to their ecosystem integrity, and this classification was displayed geographically (Figure 1). Clearly, tsetse control should not be conducted in conservation areas unless strong conservation laws are in place and enforced. Furthermore, tsetse control should not be applied where population density is $5/km^2$ or less. In contrast, it is considered that tsetse control could likely be freely used where population density exceeds $50/km^2$, It is likely that ecosystem integrity is already low in these areas due to high human populations, and trypanosomosis control could lead to significant increases in agricultural productivity. The most difficult areas are those of intermediate human density, where further information on crop use intensity, agricultural potential and conservation value will be required before the environmental impact can be predicted.



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