

# ASSESSING THE IMPACT OF MALIGNANT CATARRHAL FEVER IN NGORONGORO DISTRICT, TANZANIA

A study commissioned by the Animal Health Programme,  
Department for International Development



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## SUMMARY

### **BACKGROUND**

*This study was commissioned by the DFID Animal Health Programme to assess the impact of malignant catarrhal fever in Ngorongoro District, Tanzania. Field studies involved a participatory rural appraisal to evaluate the impact of MCF in Maasai pastoralist communities and collection of laboratory diagnostic material from suspected clinical cases of MCF to validate reported data. Data were also compiled from consultation with specialists and reviews of published literature.*

#### Malignant Catarrhal Fever

- *Malignant catarrhal fever (MCF) is a fatal disease of cattle caused by a gammaherpesvirus transmitted from wildebeest.*
- *Wildebeest are carriers of infection but show no signs of clinical disease.*
- *Wildebeest calves excrete high levels of the MCF virus, which can be transmitted to cattle through close contact.*
- *There are currently no vaccines or treatments available to control the disease.*

#### Trends in Livestock and Human Populations in Ngorongoro District

- *Livestock play a central role in the livelihoods of the Ngorongoro Maasai, providing food, cash, insurance and a measure of social status.*
- *Within Ngorongoro District, as throughout much of Maasailand, a growing human population has become dependent on a declining livestock production base.*
- *Poor livestock production has resulted in families becoming trapped in a cycle of poverty, with many people now facing destitution.*
- *A growing dependence on grain necessitates the sale of animals to raise cash and hence a further decline in cattle numbers.*
- *Many families now have insufficient animals to meet nutritional demands and more than 50% of children are malnourished or undernourished.*

#### Trends in Wildebeest Population and Distribution in the Serengeti Ecosystem

- *Since the implementation of large-scale cattle vaccination programmes against rinderpest, wildebeest numbers in the Serengeti have increased more than five-fold from 200,000 animals to current levels of 1-1.5 million animals.*
- *The range of the wildebeest migration has expanded into areas previously used by Maasai cattle in the wet season, with increased utilisation of the Salei plains.*
- *During the wet season, the productive short-grass plains provide the energy and minerals that are required for calving and lactation in both wildebeest and cattle populations.*
- *Maasai are forced to abandon the short-grass plains at the start of the wildebeest calving season to avoid MCF.*

## **FINDINGS**

### Maasai Perceptions of Disease Burden in Ngorongoro District

- *For the participatory rural appraisal, villages were classified as to whether they were considered at high or relatively low risk from MCF according to livestock officers and district officials.*
- *In all villages MCF was ranked by Maasai among the five most important cattle diseases.*
- *Overall, East Coast Fever (ECF) was considered to be the disease of most concern to Ngorongoro pastoralists.*
- *In villages considered at high-risk of MCF, the disease was ranked second behind ECF.*
- *In lower-risk villages, MCF was ranked fourth behind ECF, bovine cerebral theileriosis (Ormilo) and contagious bovine pleuropneumonia (CBPP).*
- *Data from other studies indicate that MCF is perceived a disease of major significance elsewhere in Maasailand, including northern Tanzania and southwest Kenya.*

### Incidence of MCF in Ngorongoro District

- *In high-risk areas of Ngorongoro District, 65/76 (86%) cattle herds were affected by MCF in 2000.*
- *Adjusting for possible under-reporting of herd size, 5.6%-6.2% of cattle died from MCF in high-risk villages in 2000. The incidence of MCF in low risk villages could not be determined as a result of insufficient data on herd size.*
- *Assuming no cases from MCF in low-risk villages (which will provide a conservative estimate of disease burden), approximately 5,000-9,000 cattle deaths were caused by MCF in Ngorongoro District in 2000, with most deaths in adult animals.*
- *Localised incidence data should not be extrapolated to estimate disease burden across a wide geographic range.*

### Recognition of Disease by Pastoralists

- *Histopathological findings in nine out of ten cattle with suspected MCF were strongly suggestive of a diagnosis of MCF.*
- *The combination of clinical signs, history, and post-mortem findings allow a presumptive diagnosis of MCF to be made in all suspected cases examined in this study.*
- *Maasai owners in Ngorongoro District are able to recognise MCF with a high degree of accuracy on the basis of clinical signs and history.*
- *Clinical observations are likely to provide a relatively accurate and accessible source of epidemiological data in the absence of laboratory diagnostic confirmation.*

### Current Means of Controlling MCF

- *Maasai avoid MCF by abandoning the short-grass plains and moving cattle to highland and woodland areas during the wildebeest-calving season.*
- *Traditional medicines are used by a proportion of owners to treat MCF but are widely recognised to be ineffective.*
- *Salt provisioning is used by some Maasai in Loliondo Division to avoid moving cattle into high-risk wildebeest areas in the wet season and has reduced the MCF incidence in a few localised areas.*

### Direct Losses from MCF

- *Direct losses from MCF arise from the death, emergency sale or slaughter of affected animals.*
- *Sale or exchange of live animals incurs losses as a result of low prices obtained for MCF-affected cattle.*
- *Emergency slaughter provides meat for home consumption but supply exceeds demand during the MCF season.*
- *The unpredictable nature of MCF and the high incidence in productive adult animals makes it difficult for Maasai to develop strategies that optimise long-term herd production and commercial offtake.*

### Indirect Impacts of MCF in the Serengeti-Ngorongoro ecosystem

- *MCF has important indirect effects on the Serengeti-Ngorongoro ecosystem, with serious implications for livestock production and the environment.*
- *Increasing concentration and confinement of Maasai in the highlands and woodlands has resulted in an increased burden of vector-borne and directly-transmitted diseases.*
- *Lack of availability of salt and high-quality forage leads to a direct loss of production, with the energy demands of increased travel resulting in indirect losses in milk production and body condition.*
- *Failure to re-establish body condition at the end of the dry season results in reduced survival and fertility in the ensuing year.*
- *Confinement of cattle to the highlands contributes to problems of over-grazing, a decline in pasture quality, deforestation through increased tree-felling and uncontrolled burning, soil erosion and bush encroachment.*
- *The decline in livestock production has led to an increased demand for cultivation, a form of land-use that is incompatible with both traditional pastoralism and wildlife conservation.*

## **RECOMMENDATIONS**

### The Case for Development of a Vaccine against MCF

- *Despite widespread concern about MCF for many years, the Maasai believe the problem has been ignored by government and donors.*
- *There was extremely strong support for development of a vaccine against MCF, with several owners volunteering cattle for field trials.*
- *Introduction of a vaccine would allow more efficient grazing management and production systems.*

- *Although cattle productivity would probably increase, an explosion in cattle numbers is not expected because of the growing demand to sell animals to raise cash for grain, medicines, school fees and clothing.*
- *Any growth of fixed settlements on the short-grass plains is likely to be limited by lack of availability of dry-season water and grazing.*
- *Pilot field trials are essential to monitor potential impacts of MCF vaccination on livestock production and demographics, vegetation patterns and wildlife movement patterns.*

#### *Feasibility of MCF Vaccine Development*

- *Although early efforts to develop MCF vaccines have been unsuccessful in terms of protecting cattle, there are several feasible strategies for vaccine development that have not yet been attempted.*
- *The use of tissue-culture propagated virus directed to enhance mucosal immunity provides a relatively simple approach that may be feasible in the short term.*
- *The elucidation of the full sequence of the MCF virus genome and identification of genes involved in virulence raise the possibility of constructing recombinant vaccines or proteins in the longer-term.*
- *Small-scale pilot trials are essential before any large-scale vaccination is considered.*
- *Several research groups have expressed an interest in possible MCF vaccine studies.*

#### *Recommendations for Other Collaborative Research and Development Programmes*

- *Collaborative strategies for livestock development in Ngorongoro District would provide benefits for both pastoralists and conservation groups by reducing the demand for large-scale expansion of agriculture.*
- *A small-scale trial of salt provisioning may be a useful first step to assess the impact of reduced MCF mortality on herd productivity.*
- *Integrated studies that combine epidemiological approaches, economic analysis and land-use modelling are likely to generate valuable data that will assist decision-making by pastoralists, wildlife managers and land-use planners in Ngorongoro District.*

## Abbreviations and Terms

<b>AIHV-1</b>	Alcelaphine herpesvirus –1
<b>BQ</b>	Blackquarter
<b>CBPP</b>	Contagious bovine pleuropneumonia
<b>DANIDA</b>	Danish International Development Assistance
<b>DFID</b>	Department for International Development
<b>ECF</b>	East Coast Fever
<b>FAO</b>	Food and Agricultural Organisation
<b>FMD</b>	Foot-and-Mouth Disease
<b>FZS</b>	Frankfurt Zoological Society
<b>KARI</b>	Kenya Agricultural Research Institute
<b>MCF</b>	Malignant Catarrhal Fever
<b>NCA</b>	Ngorongoro Conservation Area
<b>NCAA</b>	Ngorongoro Conservation Area Authority
<b>NORAD</b>	Norwegian Agency for Development Co-operation
<b>NPW</b>	Natural People’s World
<b>OAU/IBAR</b>	Organisation of African Unity/ Inter African Bureau for Animal Resources
<b>OvHV-2</b>	Ovine herpesvirus -2
<b>PARC</b>	Pan African Rinderpest Campaign
<b>SA-MCF</b>	Sheep-associated malignant catarrhal fever
<b>TANAPA</b>	Tanzania National Parks
<b>WD-MCF</b>	Wildebeest-derived malignant catarrhal fever
<b>95% C.I.</b>	95% confidence interval
<b><i>Boma</i></b>	Maasai homestead consisting of a number of huts built around central holding corrals for livestock.
<b><i>Morani</i></b>	Warriors, unmarried young men usually between 15-20 years of age.
<b><i>Zindiko</i></b>	A KiSwahili term for magic spell described by several respondents as a traditional treatment for MCF.



## **Participatory Rural Appraisal**

### **Team Members**

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## INTRODUCTION

Pastoralism provides a livelihood for over 25 million people in Africa, but pastoralists are among the poorest people in the world (UNDP, 1997) and have become increasingly marginalised in national economies. In northern Tanzania, many pastoralist communities are facing a precarious existence and are struggling to retain traditional lifestyles in the face of growing poverty. Livestock play a central role in the livelihoods of the Maasai, but the productivity of Maasai livestock is uniformly low throughout the region (Field *et al.*, 1997). In Ngorongoro District in northern Tanzania, the ratio of cattle to people has declined substantially over the past 30 years, leading to a collapse in the livestock production base (Kijazi *et al.*, 1997). As a result, many families are now trapped into a declining cycle of poverty with insufficient animals in their herds to meet nutritional and income needs (McCabe *et al.*, 1997). More than 50% of families have been classified as living in poverty or acute poverty (NCAA/NPW, 1994), and more than 55% of children are now malnourished or undernourished (McCabe *et al.*, 1997).

Infectious diseases are considered a major constraint to cattle production in Ngorongoro District (Machange, 1997). The burden of livestock diseases appears to have increased over the past 20 years, with the emergence and re-emergence of several diseases, notably *Ornitho* (bovine cerebral theileriosis), East coast fever (ECF), foot-and-mouth disease (FMD) and malignant catarrhal fever (MCF) (Field *et al.*, 1997). It is widely recognised that strategies to control or prevent cattle diseases need particular attention in Ngorongoro District. Despite some improvements in the delivery of animal health services in the Ngorongoro Conservation Area in recent years (for example, through the DANIDA-funded Ngorongoro Pastoralist Project), the infrastructure remains inadequate to meet demand and most livestock owners still have very little access to veterinary care.

Pastoralists in Ngorongoro claim substantial losses from malignant catarrhal fever (MCF), but lack of quantitative data make it difficult to evaluate these claims (Machange, 1997). MCF is a fatal disease of cattle, caused by a herpes virus that can be transmitted from wildebeest to cattle. Infection is asymptomatic in wildebeest but wildebeest calves, in particular, excrete large quantities of virus that can be transmitted to cattle (Barnard *et al.*, 1994). Although MCF has been present in the area for many years, there are suggestions that the problem has increased in recent years as a result of an increase in wildebeest numbers (Sinclair, 1995).

In the absence of any treatment or preventive vaccine for MCF, the Maasai have long established strategies of avoidance of wildebeest during calving times. However, these strategies carry costs that may exacerbate the problems of livestock production and cause environmental degradation. Declining livestock productivity also has important implications on land-use patterns, with the growing demand for grain and expansion of agriculture posing a growing threat to both traditional pastoralism and wildlife conservation.

## **Aims of the Study**

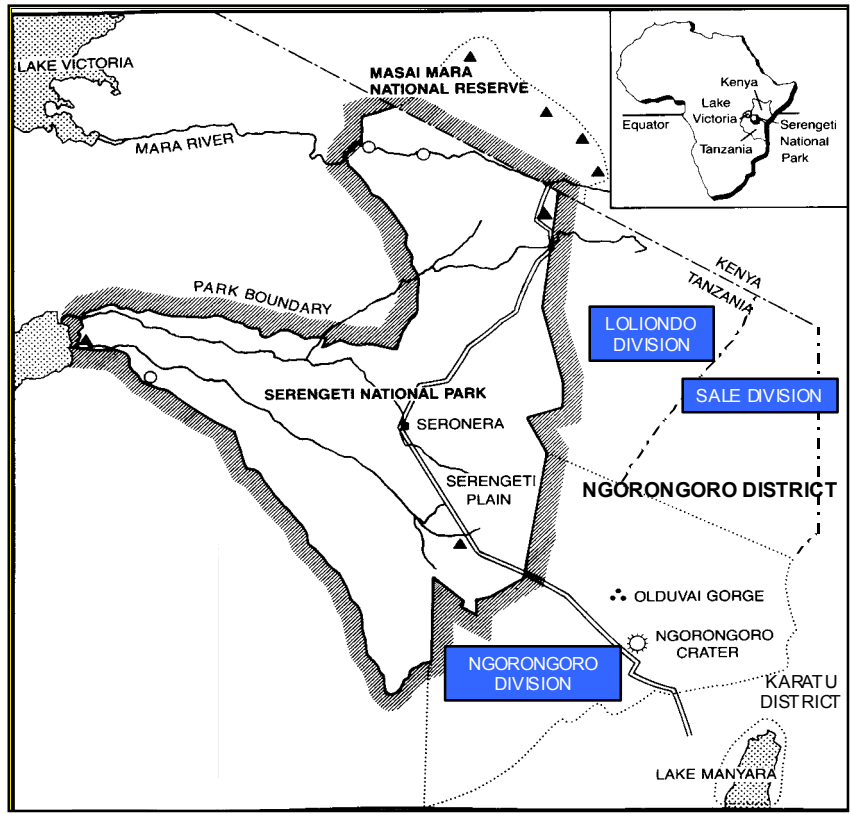
This study was undertaken to evaluate the direct and indirect impacts of MCF in the Ngorongoro District, Tanzania, and to assess the contribution of MCF to the growing problem of pastoralist poverty in the area. The principal aims of the project were:

- to characterise local perceptions of the relative importance of malignant catarrhal fever in relation to other diseases of Maasai cattle in Ngorongoro District.
- to provide data on direct and indirect losses associated with malignant catarrhal fever.
- to identify options for further action with respect to improved disease control and development of optimum land-use strategies.

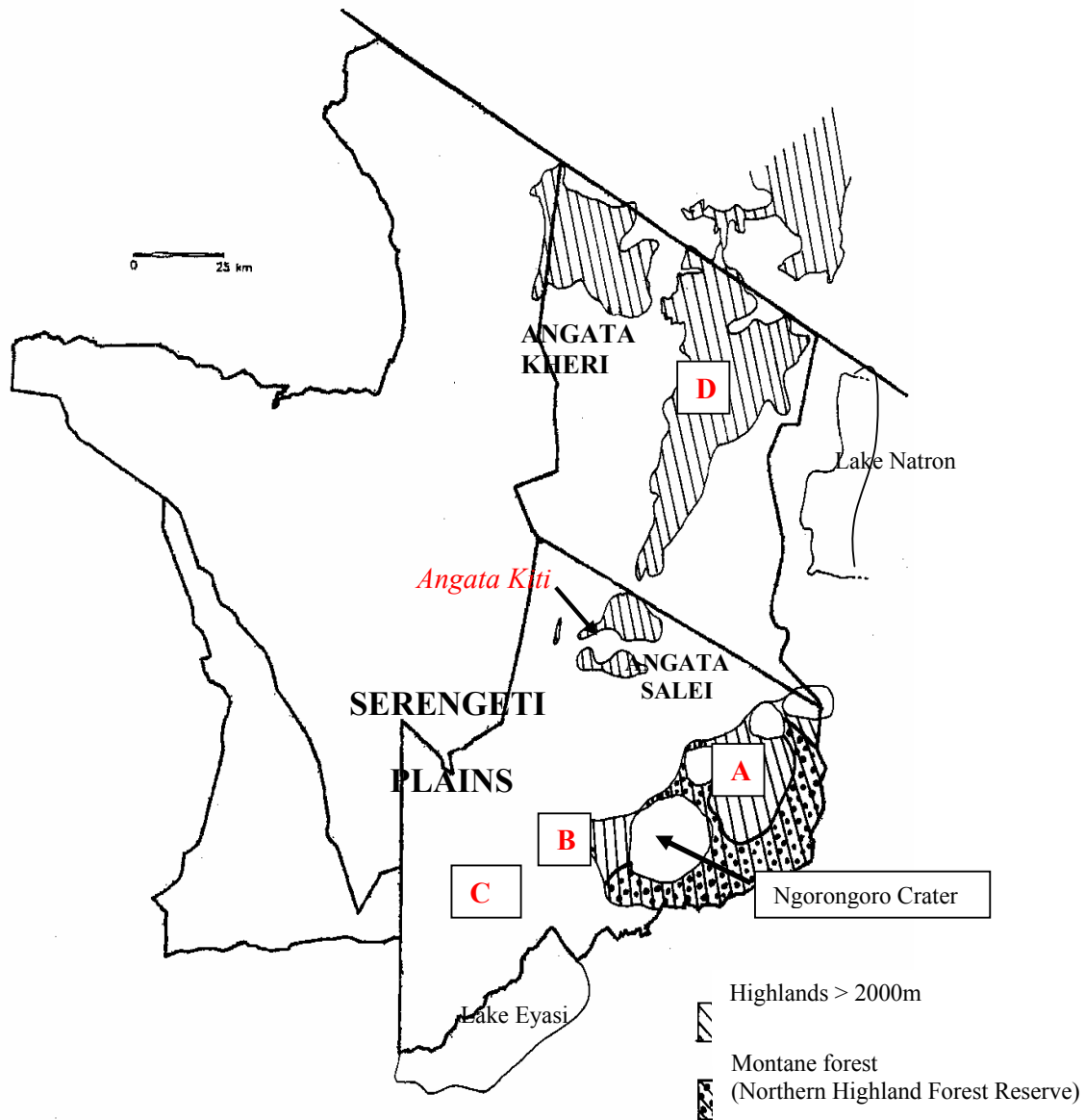
## **Ngorongoro District**

The study area comprised the Ngorongoro District in northern Tanzania, which is bordered by the Serengeti National Park to the west, the Kenya international border to the north, Monduli District to the east and Karatu District to the south (Fig. 1). The District comprises three administrative divisions, with the southern Ngorongoro division contained within the Ngorongoro Conservation Area (NCA), which is a multiple-use protected area, encompassing some 8,300 km<sup>2</sup> under the management of the parastatal Ngorongoro Conservation Area Authority (NCAA). The northern section encompasses some 9,100 km<sup>2</sup>, with the Loliondo Division bordering the Serengeti National Park and the Sale Division to the east. Loliondo Division contains the Loliondo Game Controlled Area (LGCA), a wildlife protected area, in which hunting, eco-tourism and cultivation provide a source of income other than traditional pastoralism.

Ngorongoro District has extreme habitat diversity comprising areas of subalpine pasture at 4000m, montane evergreen forest, arid thorn bush and treeless short grass plains at 1800m (Fig.2). The District incorporates a significant part of the Greater Serengeti ecosystem and is one of the few remaining areas in East Africa where Maasai are still able to pursue a traditional pastoralist lifestyle. The annual wildebeest migration of the Serengeti also utilises both the NCA and the LGCA. The short-grass plains of the NCA, and to a lesser extent Loliondo, play a vital role in the Serengeti ecosystem as the wet season grazing and calving grounds of the migratory herds. The short grasses on the plains are highly nutritious with a high mineral content that provides ideal grazing for wildebeest during calving and lactation. However a lack of permanent water means that migratory herds move away from the plains whenever rainfall becomes low or erratic. Utilisation of the short-grass plains by cattle is limited by two principal factors: first, the need to avoid MCF in the wet season and second, the absence of permanent water and grazing in the dry season. These areas thus have some of the lowest human and livestock densities in the district.



**Fig 1: Map of the Serengeti ecosystem**



**Fig 2: Map showing key features of Ngorongoro District.**

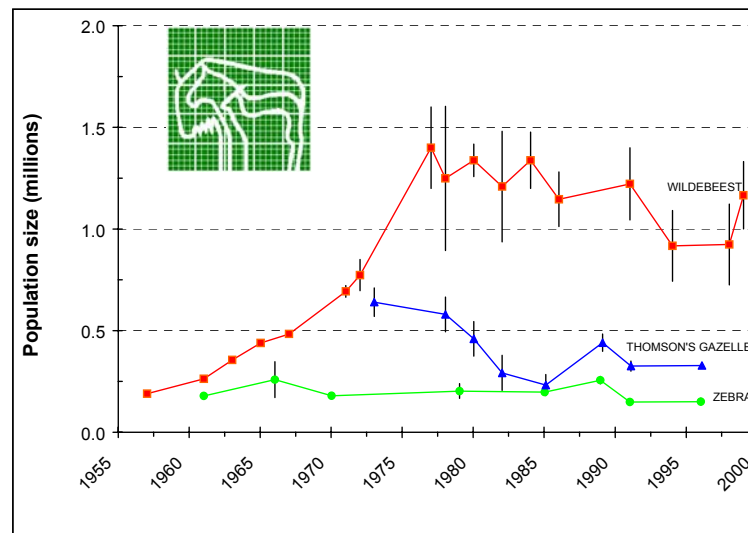
- A: Nainokanoka block (heathland)
- B: Oloroibi block (heathland)
- C: Endulen/Kakesio woodland block
- D: Loliondo highlands

Short-grass plains comprise the Serengeti plains, Angata Salei, Angata Kheri and Angata Kiti.

## The Wildebeest Migration

The Serengeti ecosystem is a World Heritage Site that is renowned as the site of the migration of vast herds of blue wildebeest (*Connochaetes taurinus*). One of the major factors affecting the wildebeest migration in the past 40 years has been the mass vaccination of cattle against rinderpest around the Serengeti. In the 1960s, cattle vaccination led to the elimination of rinderpest, not only in cattle, but also wildlife, and removed a major source of mortality for wildebeest calves. With a significant increase in calf survival, wildebeest numbers rose dramatically, from approximately 200,000 animals in 1962 to 1.3 million in 1977, when the population levelled out. Wildebeest numbers now fluctuate between 1 million and 1.5 million (Sinclair, 1995; TWCM, 1998, 2000; Fig. 3).

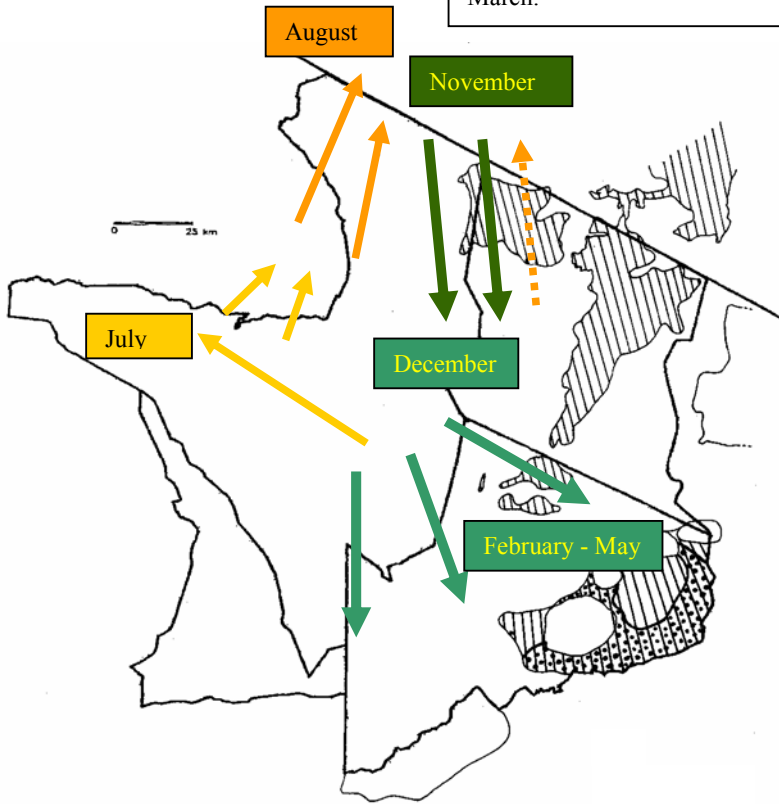
Fig. 3: Graph showing the growth of the wildebeest population when released from the limiting effects of rinderpest. The number of zebras, which are not susceptible to rinderpest, have remained roughly stable over the same period.



With the increase in wildebeest numbers, there have been several changes to the 'classic' annual migration cycle, in which wildebeest use the plains in the wet season (December – June), move northwest in late May or June and shift north into Kenya as the dry season progresses (for a detailed description, see Sinclair, 1979). As wildebeest populations have expanded, a greater number of migratory animals now utilise the Salei Plains to the east and the Angata Kheri plains to the north, with some wildebeest herds moving directly north to Kenya through the Loliondo area (Fig 4a, b). Little is still known about the impact of these changes on the incidence of livestock diseases.

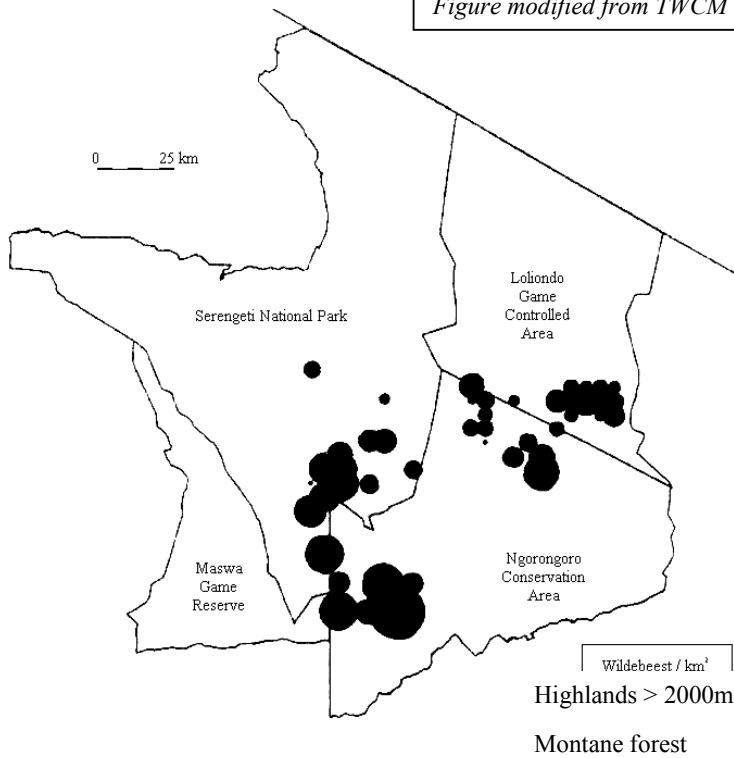
**Fig 4a. Map showing the current pattern of the annual wildebeest migration.**

The range now includes Angata Salei with some northward migration directly through the Loliondo area. Calving occurs during February and March.



**Fig 4b: Distribution of wildebeest in May 1998 determined from aerial survey data.**

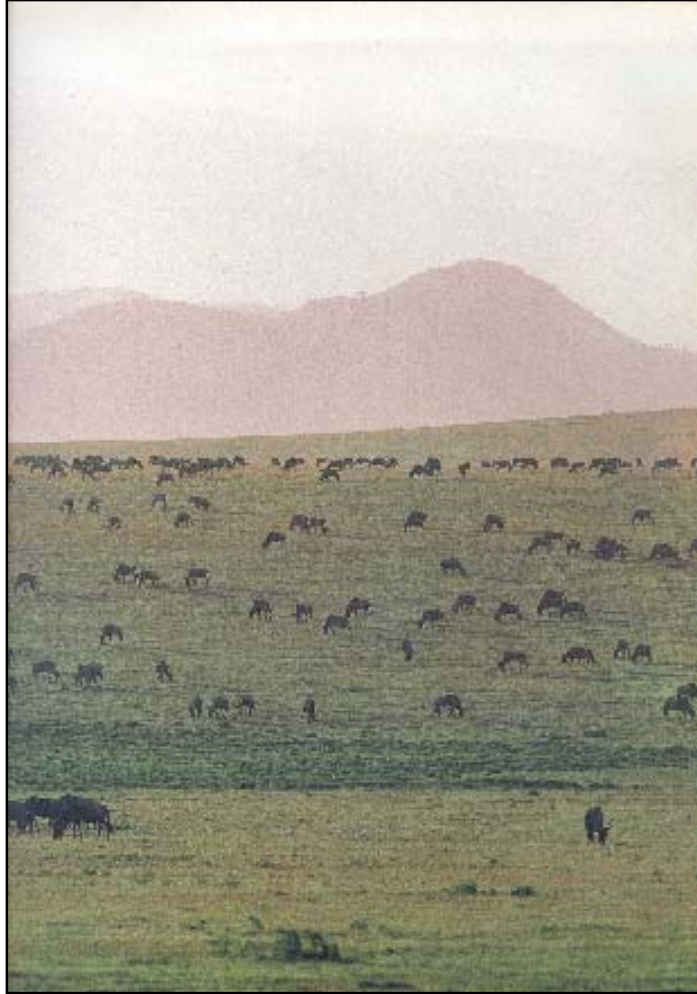
*Figure modified from TWCM (1998).*





**Fig. 5: Wildebeest on the short-grass Serengeti plains at the start of the wet season with the Ngorongoro highlands in the background.**

*Photograph: Jonathan Scott*



## Human Population

The vast majority of residents in Ngorongoro District are Maasai pastoralists, with a pastoral economy based on cattle-keeping, supplemented by raising of small stock. Traditional reports of Maasai lifestyle describe seasonal patterns of dry-season concentration in semi-permanent settlements followed by dispersal into temporary camps on the plains in the wet season. However, it is likely that these patterns have changed in the wake of the increase and expansion of the wildebeest migration. Aerial surveys conducted in 1980 (EcoSystems) and 1991 (TWCM, 1991) indicate that cattle now rarely use the short grass plains in the wet season at all.

The last national census in Tanzania was conducted in 1988 (Bureau of Statistics, 1991), and projected population estimates over a period of 13 years at the time are likely to be relatively inaccurate. However, taking the 1988 data and growth rate (3.9% per annum) at face value, projected population sizes are estimated to be 112,350 for Ngorongoro District in 2000 (Table 1). A detailed census conducted in the NCA in 1994 estimated the NCA human population to be 42,508, based on methodology adapted for migratory pastoral populations (NPW, 1994). This estimate exceeds the projected figure for 1994 of 34,000 and suggests that, in the absence of evidence for significant immigration into the NCA, baseline data in 1988 may have underestimated the true population size. However, this interpretation has been challenged, with suggestions that a link between the 1994 census and a re-stocking programme in the NCA may have led to over-reporting of human populations in 1994. Given these uncertainties, the projected figures presented in Table 1 are likely to provide only a rough approximation of the current human population size.

Table 1: Human population data for Ngorongoro District based on the 1988 National Census with projected population sizes for 2000.

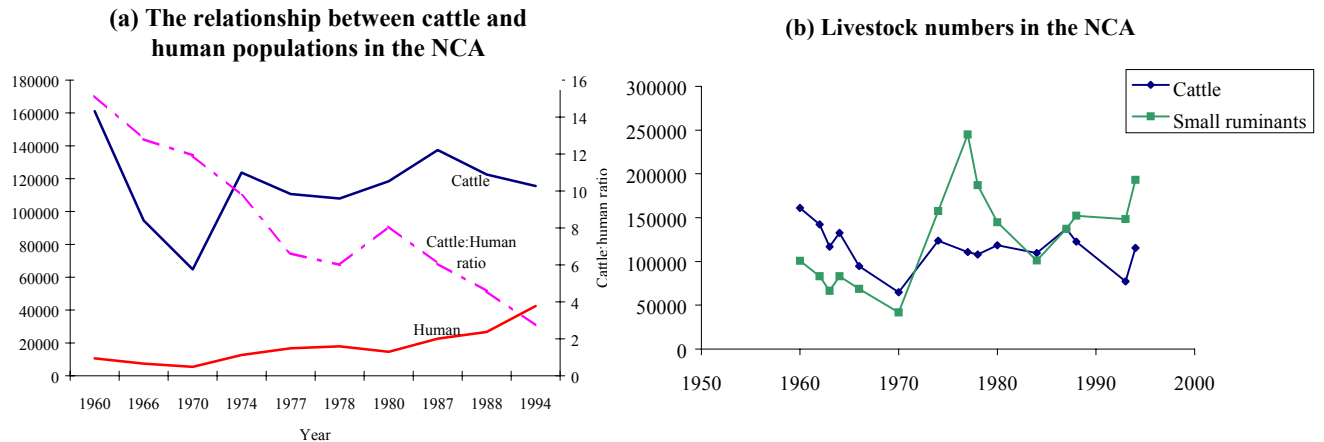
<b>Division</b>	<b>1988 national census</b>	<b>Projected population size for 2000</b> (based on annual growth of 3.9%)
Ngorongoro	26,894	42,944
Loliondo	21,657	34,582
Sale	20,556	32,824
<b>DISTRICT TOTAL</b>	<b>69,107</b>	<b>112,350</b>

## Livestock

In contrast to the dramatic increase in wildebeest numbers in the Serengeti, cattle numbers in the NCA have shown no signs of overall increase over the past 30 years (Fig. 6a). As with human population estimates, the accuracy and consistency of livestock census data is uncertain. However, there is little doubt that with the increase in human populations, the cattle:human ratio has declined steadily, falling from an estimated value of 15 cattle per capita in 1960 to 3 cattle per capita in 1994. Sheep and goat numbers have followed a rather different pattern to cattle, with a starting

population of around 100,000 in 1960, rising to an apparent peak of 187,000 in 1978 and declining to 137,000 in 1987 (Arhem, 1981, cited in Kijazi *et al.*, 1997; Perkin, 1987) (Fig 6b). MCF, which does not affect sheep and goats, has been cited as one explanation why the cattle population has not increased in line with small ruminant populations (Aikman and Cobb, 1997; Field *et al.*, 1997).

**Fig. 6: Human and livestock population trends in the NCA, 1954-1994**



### Malignant Catarrhal Fever (MCF)

Malignant catarrhal fever (MCF) is a generalised disease, affecting cattle and some other ungulates. The disease is caused by two gammaherpesviruses; alcelaphine herpesvirus –1 (AIHV-1) for which the natural hosts are the blue wildebeest (*Connochaetes taurinus*) and the black wildebeest (*C. gnou*) and ovine herpesvirus-2 (OvHV-2), for which the natural host is the sheep. Although the viruses do not cause clinical disease in their natural hosts, the disease is usually fatal in cattle and is characterised by severe clinical signs, with high fever and severe inflammation of the mucosae of the respiratory and alimentary tracts and conjunctivae, eyes and skin. These lesions are often accompanied by profuse mucopurulent nasal and ocular discharges and, in some cases, neurological signs (Selman *et al.*, 1974).

Two main epidemiological patterns of MCF exist; the wildebeest-derived form of the disease (WD-MCF) caused by AIHV-1, and the sheep-associated form (SA-MCF) caused by OvHV-2. Clinical manifestations of the disease in cattle are essentially the same for AIHV-1 and OvHV-2. In Africa, the epidemiology of MCF is closely linked with wildebeest, which are the main source of infection for cattle, although MCF cases arising from contact with sheep also occurs in East Africa (Mulei, *et al.*, 2000; G. Scott, pers. comm.).

No vaccine is currently available to protect animals against MCF and eradication is impractical as it would involve the elimination of carrier species. Control therefore relies on segregating wildebeest from susceptible animals. As infectious virus is

excreted only by the natural hosts, cattle-to-cattle transmission does not occur.

## **PARTICIPATORY RURAL APPRAISAL**

### **Timing of the Study**

The participatory rural appraisal (PRA) exercise was carried out between 26/2/01 and 6/3/01 in Loliondo and Sale Divisions and between 25/5/01 and 31/5/01 in Ngorongoro Division. These months were selected to coincide with the onset of the wildebeest calving season because a principal objective of the study was to obtain diagnostic material from suspected cases of MCF for laboratory diagnosis.

At the time of the first PRA exercise (February to March), wildebeest were observed primarily in the southeastern Serengeti plains, moving west towards the woodland areas of the Maswa Game Reserve during a relatively dry period in early March. Small herds were also observed in the Loliondo area in the Angata Kheri plains and in the Mondrosi plains near Soit Sambu village (Fig. 7).

Fig. 7: Landscape comprising mixed woodlands and plains in the Loliondo Division, looking north towards Kenya.



### **Study Villages**

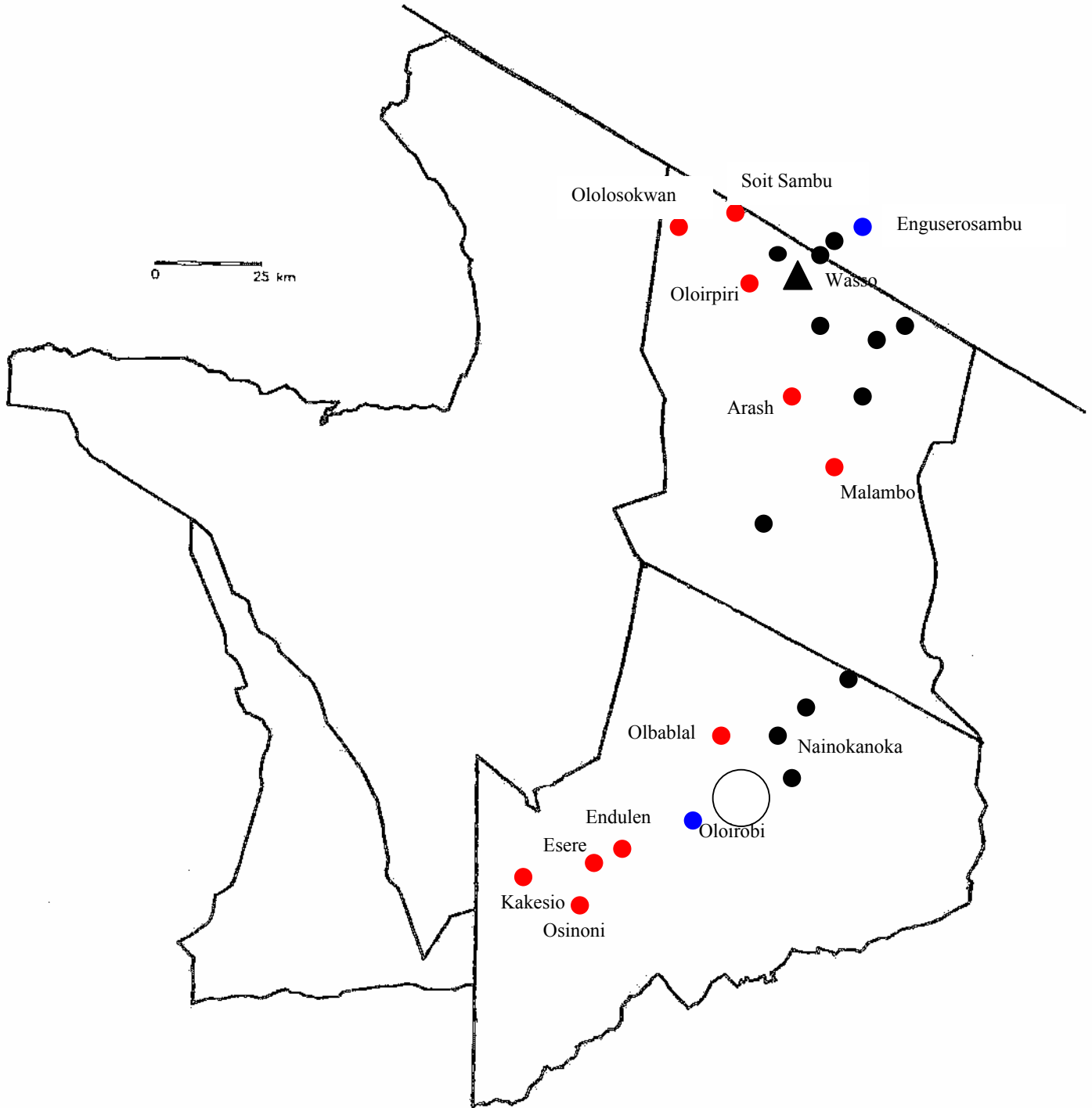
Each village within Ngorongoro District was classified by livestock officers as either a high- or low-risk area for MCF, with 17 villages in the district falling into the high-risk category and 17 falling into the low-risk category (see Appendix I). Using the village distribution of cattle from vaccination campaigns, 52% of cattle were found in high-risk villages, equivalent to an estimated 104,000-136,000 animals.

The study focussed principally in high-risk villages, in order to obtain sufficient information on the direct and indirect impacts of the disease. Two villages, which were considered to be of relatively low risk (Enguserosambu and Oloirobi), were also included in the study for comparison of perceptions and to obtain an indication of the overall disease burden in the district (Fig. 8).

**Fig. 8: Location of villages in Ngorongoro District.**

Villages visited during the PRA study are shown by the coloured circles, with high-risk villages shown in red and low-risk villages in blue.

The Ngorongoro District head office is shown by the black triangle.



## **Team Members**

The project team consisted of eight individuals, with a variety of skills encompassing veterinary knowledge, previous PRA experience, local knowledge of the area and livestock system, and fluency in the Maasai language. Group discussions and questionnaires were conducted in the Maasai language or KiSwahili, depending on the group composition. Those members of the team who did not have previous PRA experience were given training by other team members prior to the onset of the study.

## **Background Information**

Background information concerning the area, and villages of interest, was obtained from a variety of sources, including the Ngorongoro District Council, the district livestock office, village authorities, local extension officers, and previous NGO reports.

## **Initial Approach**

Before performing a PRA exercise in a village, the village chairperson was identified, the aims of the study were explained, and permission was sought to carry out the study in the village. At the time of the preliminary introduction, the emphasis was placed on evaluating perceptions about cattle diseases in general, without focussing specifically on MCF. However, as part of the PRA, the personal views of the village chairperson were sought concerning MCF and the resulting implications to the community. Facilitation of the PRA exercise, including the identification of key individuals, and organisation of group meetings was then carried out through the village chairperson.

## **Group Discussions**

Group discussions were carried out with a number of different respondents, who were selected to represent a wide cross-section of the village community. Such groups included young *morani* (responsible for supervision of cattle during grazing), village elders (with considerable experience of cattle keeping), and women (who were responsible for milking). Some group meetings were arranged in a formal manner through the village chairman, whilst others were formed on an 'ad-hoc' basis upon meeting a group of respondents by chance e.g. at grazing areas, milling machines, village *dukas* (shops).

Fig. 9: Group Discussion in Soit Sambu, Loliondo Division.



### **Semi Structured Interviews**

The team was split into two groups to carry out the work, and it was therefore felt to be important that key questions concerning MCF were asked consistently in each area. For this reason, a questionnaire was devised which comprised a series of open-ended questions covering the main areas of interest. During questionnaire administration attempts were made to maintain interviews in the form of open discussions, using the questions as prompts for further discussion, and following up interesting responses with further questions and probing.

Initial questions related to general disease perceptions and experiences, and were followed by more specific questions concerning MCF and the implications of this disease. Opinions were also sought concerning the possible impact of developing an effective vaccine against MCF, and the effects this could have on the Maasai lifestyle, particularly concerning grazing patterns during both the wet and dry season.

### **Participatory Mapping**

Participatory mapping techniques were used to establish the Maasai's perception of their area, and to highlight areas of conflict between livestock and wildlife. Participants were asked to draw a rough outline of their area, including key landmarks, either on the ground, or on large sheets of paper. They were then asked to mark the main grazing areas for cattle, both in the wet and the dry season, followed by the main migration routes and grazing areas of the wildebeest. Other key areas illustrated included watering points, and 'salting areas' for the cattle. The mapping was done as a group exercise, with one participant usually responsible for drawing the outline of the map, whilst other participants discussed and contributed to the completion of the map details (Fig. 10). It was found that these exercises often stimulated a great deal of discussion amongst participants, and the content of this



discussion was recorded where possible.

**Fig. 10: Participatory Mapping.**



### **Matrix Ranking**

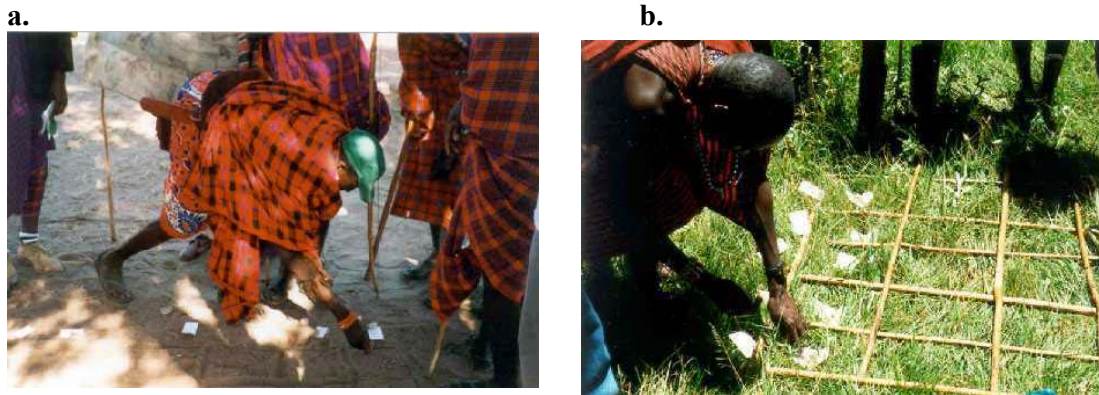
Matrix ranking was used to obtain perceptions about the relative importance of different cattle diseases within the community, and also the relationship between these diseases and different wildlife species. These exercises were performed with groups of respondents gathered around the matrix, which was either drawn on the ground (Fig 11a.), or, in the case of grassy areas, using the sticks of the Maasai themselves to form the matrix (Fig 11b.).

Group members were asked to work systematically through the matrix, choosing to work either along one row or column (e.g. choosing either one disease or wildlife species) ranking the importance of the relationship between the two factors represented by that particular cell. A maximum of ten beans were allotted to each cell of the matrix, and participants were asked to allocate an appropriate number of beans according to their ranking (effectively giving a ‘mark out of ten’ for each square of the matrix).

This methodology, using large grids drawn on the ground, and ‘proportional piling’ of beans, proved to generate an excellent visual focus for group participants which attracted a significant amount of interest and stimulated lively discussion. The size of the bean pile allocated to each square was often a matter of heated debate, and several adjustments were often made before all participants were satisfied with the final matrix. Details of the discussion, and debate, surrounding the exercise were recorded.



**Fig. 11: Participation in Matrix Ranking of Disease Burden.**



### **Data Analysis**

To provide a quantitative of disease rank, a simple scoring was adopted whereby a disease ranked most important was given a score of 5, and a disease ranked 5<sup>th</sup> given a score of 1. The sum of all respondents provided an overall score. For the matrix scoring, diseases were scored according to the proportion of beans placed in each cell of the matrix and an overall rank obtained by summing the scores of each group discussion. Non-parametric statistics were used to investigate differences between season and geographic areas.

## RESULTS AND DISCUSSION

### Background Information

The distribution of villages and participants involved in the PRA survey is shown for Loliondo and Sale Divisions in Table 2 and Ngorongoro Division in Table 3. Although few women were willing to be interviewed during the questionnaire surveys, women did contribute willingly to group discussions and did not appear to be hesitant in participating. PRA activities at the *bomas* were concentrated in the morning, to avoid missing people who left to graze livestock or attend markets. Discussions at central village locations tended to be conducted in the afternoon.

Although there was a very high degree of co-operation shown by Maasai, several respondents showed evidence of research fatigue as a result of several studies that have been conducted in the area. There was some impatience about the need for further questioning, but clear demand for action to be taken to alleviate livestock disease problems.

**Table 2. Summary of PRA Activities in Loliondo and Sale Divisions.**

Division	Village	SEMI-STRUCTURED QUESTIONNAIRES		GROUP DISCUSSIONS		
		Males	Females	Subvillage	Males	Females
Loliondo	Soit Sambu	11	0	Soit Sambu	12	2
				Soit Sambu	7	1
				Kritalo	19	0
				Mondros	0	11
				Mondros	5	2
				Endashok	10	0
Loliondo	Ololosokwan	4	0	Ololosokwan	7	0
				Ololosokwan	5	0
				Merowa Chini	0	2
Loliondo	Enguserosambu	5	0	Enguserosambu	5	7
				Endulele	2	0
Loliondo	Arash	10	3	Arash	6	3
Loliondo	Oloipiri	5	0			
Sale	Malambo	13	0	Malambo	5	0
				Malambo	10	0
<b>TOTAL</b>		<b>48</b>	<b>3</b>	<b>TOTAL</b>		

**Table 3. Summary of PRA activities in Ngorongoro Division.**

Village	SEMI-STRUCTURED QUESTIONNAIRES		GROUP DISCUSSIONS			
	Males	Females	Subvillage	Group	Males	Females
Oldonyogol	1	0	Anaiborsoit	1	5	0
Olbabal	1	0	Olbabal	2	6	0
Eserere	3	0	Olmoti	3	10	0
			Olmoti	4	3	0
Osinoni	1	0	Ngereyeni	5	5	0
			Ngereyeni	6	0	3
Ilmisigiyo			Ndorosi	7	9	3
Kakesio	7	0				
Meshele	2	1				
Ngoile	3	1				
Oloirobi	2	0				
Endulen	7	1				
<b>TOTAL</b>	<b>27</b>	<b>3</b>	<b>TOTAL</b>		<b>38</b>	<b>6</b>

### Cattle Numbers

Information from Oxfam and Ngorongoro District council headquarters indicated that the Ngorongoro cattle population comprised 200,000 – 250,000 animals, lower than the figure of 276,900 recorded during the 1984 cattle census. This is line with the opinion expressed by livestock officers and local government officials that the number of cattle has been declining throughout the district in recent years.

Records collected from the District Veterinary Office during the vaccination campaign against contagious bovine pleuropneumonia (CBPP) in 2000 provided an indication of the distribution of cattle within the district, with 25.4% of cattle in Loliondo Division, 24.8% in Sale Division and 49.8% in Ngorongoro Division. Using these figures, estimates of the cattle population are 50,800-63,500 in Loliondo Division, 49,600-62,000 in Sale Division and 99,600-124,500 in Ngorongoro Division. The figure for Ngorongoro Division was similar to that reported in the 1994 livestock census, which estimated 115,468 cattle in the NCA (NPW, 1994) and suggests that cattle numbers have remained relatively stable in the NCA over the past 10 years. However, the human population has almost certainly increased over the same period, and the cattle:human ratio in the NCA is now estimated to be between 1.7 and 2.1 cattle per person, continuing the downward trend previously reported (Kijazi *et al.*, 1997) and well below the levels needed for a sustainable pastoral economy (McCabe *et al.*, 1997). The implications of this trend are serious, with a growing dependence amongst Maasai on grain and an increasing need to sell livestock to purchase food. Offtake in cattle herds has almost certainly now reached unsustainable levels and threatens the entire pastoral system (McCabe *et al.*, 1997).

## Nutritional Status of Children

Data on the nutritional status of children were obtained by Dr. John Lukumay (District Medical Officer) from outreach clinics and during routine measles vaccination campaigns conducted between March and June 2001. From the clinics, a total of 264/3704 (7%) children under the age of 5 years weighed less than 80% the expected weight for age, indicative of malnutrition. Of these, 106 children (3%) weighed less than 60% the expected weight for age, indicative of severe malnutrition.

During measles vaccination clinics, a total of 1157 children were vaccinated of which 141 (12.2%) weighed less than 60% weight/age and 260 (22.5%) weighed less than 80% weight/age.

These results support the findings of McCabe *et al.*, 1997, in which malnutrition, assessed by weight for height, was recorded in 16-27% of children in the NCA and Loliondo, with no significant differences between zones. In this published study, over 55% of children were classified as either malnourished or undernourished.

### Summary

- *Within Ngorongoro District, as throughout much of Maasailand, a growing human population is dependent on a declining livestock production base.*
- *Poor livestock production has resulted in families becoming trapped in a cycle of poverty, with many people now facing destitution.*
- *A growing dependence on grain necessitates the sale of animals to raise cash and hence a further decline in cattle numbers.*
- *Many families now have insufficient animals to meet nutritional demands and more than 50% of children are malnourished or undernourished.*

## Perceptions of Disease Burden

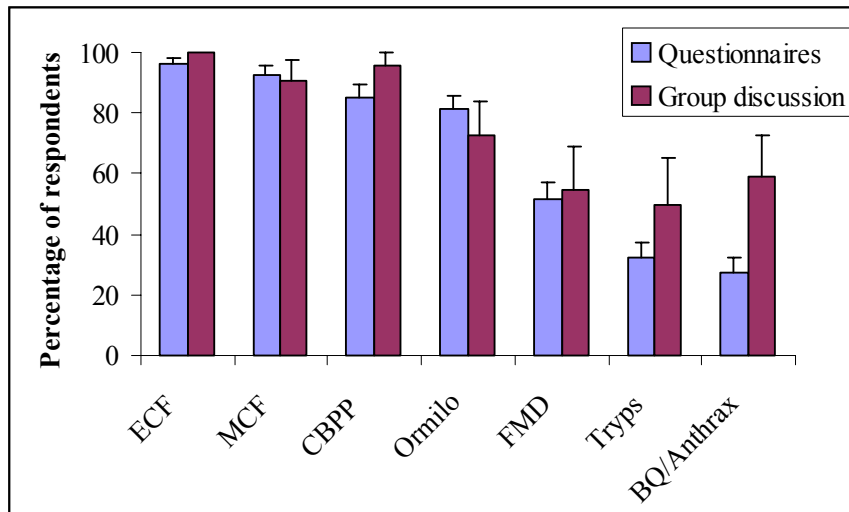
In terms of overall importance of disease, consistent results were obtained using two different methods for disease ranking. Using both approaches, East Coast Fever (ECF) was ranked the most important disease and MCF ranked second.

In answer to the question asking people to list the five diseases they considered most significant, ECF was included in the ‘top-five’ list of 78/81 (96%) questionnaire respondents and by all group participants (Fig. 12). MCF was included in 75/81 (93%) of questionnaire replies and in 20/22 (91%) of the group discussions. Other diseases considered important to the Maasai included *Ormilo*, CBPP, foot-and-mouth disease (FMD), trypanosomosis, anthrax, black-quarter (BQ) rinderpest and anaplasmosis.

*Ormilo* is the Maasai term used for bovine cerebral theileriosis, which the Maasai have long recognised as a disease entity distinct from ECF (caused by *Theileria parva*). Recent studies indicate that this premise is correct, with confirmation of *Theileria taurotragi* as a causative agent of *Ormilo* (Lynen *et al.*, 2001). As the Maasai often grouped anthrax and black-quarter as a single disease entity, the diseases are analysed as such in this study.

A brief description of diseases included in this report, together with Maasai terminology, is shown in Appendix II.

**Figure 12: Percentage of respondents listing MCF and other diseases in the category of ‘five most important diseases’.**



Using a simple 5-point scoring system and adding scores obtained during questionnaire surveys and group discussions, MCF was ranked overall the second most important disease after ECF (Table 4).

**Table 4: Index of overall importance of disease according to Maasai respondents. The index represents the sum of individual scores, with 5 given to the disease considered most important, and 1 to the disease considered least important in the ‘top-five’ list.**

	ECF	MCF	<i>Ornilo</i>	CBPP	FMD	Trypanosomosis	Anthrax /BQ	<i>Olodwa</i> *
Questionnaires	273	259	246	183	65	47	36	10
Group Discussion	45	35	32	28	5	14	12	5
<b>Overall Rank</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>5</b>	<b>7</b>	<b>8</b>
“High-risk” villages	316	280	248	192	58	57	39	10
<b>Rank</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>
“Low risk” villages	24	15	30	18	10	3	5	5
<b>Rank</b>	<b>2</b>	<b>4</b>	<b>1</b>	<b>3</b>	<b>5</b>	<b>8</b>	<b>6</b>	<b>6</b>

\* The word *Olodwa* is the traditional Maasai term for rinderpest, although some Maasai currently use the word to describe anaplasmosis (see Appendix II).

Even in relatively low-risk areas, MCF mortality was reported in several herds and the disease was perceived to be important. There are several reasons for this: (a) cattle may not leave the short-grass plains early enough in the wet season to avoid wildebeest, (b) owners still need to bring cattle onto the plains for salt provisioning (see later), (c) unusual rainfall patterns may make wildebeest movements unpredictable and herds are unable to move away in time. It is only in areas where cattle are able to stay in the highlands or on the escarpment for the whole year, such as Oloirobi (Field *et al.*, 1988; McCabe, 1993) and Nainokanoka (Machange, 1997) that MCF is not considered a serious problem.

### Problems with Disease Ranking

There are clearly a number of inherent problems in providing an overall ranking for disease significance as different diseases pose very different types of problems. Matrix scoring provided a useful visual framework for addressing this problem, allowing diseases to be ranked specifically in terms of mortality, morbidity and financial costs. A further problem encountered with overall ranking was that MCF mortality was restricted to only a few months of the year, whereas the seasonality of other major diseases was generally less marked.

### Matrix Ranking

Results of matrix ranking by group participants provided an index of disease significance specifically in terms of mortality, morbidity and financial costs (Table 5). Matrix scores represent the sum of beans placed in each cell by each of the groups

(n=9). Costs relate to the direct costs of treatment and prevention, such as purchase of antibiotics, acaricide, vaccine and local medicines

Table 5. Matrix scores from group discussions.

MATRIX SCORE	ECF	MCF	<i>Ormilo</i>	CBPP	FMD	Trypano- somosis	Anthrax/ BQ	<i>Olodwa</i>	Pneumonia
Mortality	66	<b>70</b>	40	57	5	20	6	4	3
Morbidity	<b>25</b>	20	14	19	12	18	3	-	-
Financial costs	26	12	46	<b>57</b>	5	41	3	4	4
Mortality – RANK	2	1	4	3	7	5	6	8	9
Morbidity - RANK	1	2	5	3	6	4	7		
Costs - RANK	4	5	2	1	6	3	9	7	7

In the matrix scoring, MCF was ranked the most significant disease in terms of mortality and was also ranked highly in terms of morbidity. Costs of MCF were considered to be low in comparison with other diseases because of the lack of effective treatments.

These results clearly indicate that the Maasai perceive MCF to be a disease of major significance in Ngorongoro District. Consistent with our findings, previous studies generally consider that ECF is the most serious livestock disease in the NCA, with MCF rated as a disease of major concern, together with trypanosomosis, anthrax, rinderpest and anaplasmosis (Christensen, 1990; Machange, 1997). It should be noted that in previous reports, *Ormilo* (bovine cerebral theileriosis) has often been considered a form of ECF and therefore the specific disease burden of ECF may have been overestimated.

MCF has been ranked by Maasai as a disease of major significance in other parts of East Africa. In Kenya, MCF was ranked the most important disease of cattle in Kajiado District and ranked third behind ECF and trypanosomosis in Narok (Ngotho *et al.*, 1999a). A study in northern Tanzania reporting information from Maasai ranked MCF the disease of most concern, above ECF, CBPP and trypanosomosis (Kalunda *et al.* 1982). As with our study, these results were obtained from studies focussed specifically on MCF, which may have an influence on the findings. Detailed discussion about the interpretation of reported disease data is given below (see – *Reported Incidence of MCF*).

#### Summary

- For the participatory rural appraisal, villages were classified as to whether they were considered at high or relatively low risk from MCF according to livestock officers and district officials.
- In all areas of Ngorongoro District MCF is commonly ranked by Maasai among the five most important diseases of cattle.
- Overall, East Coast Fever (ECF) was considered to be the disease of most concern to Ngorongoro pastoralists.
- In villages considered at high-risk of MCF, the disease was ranked second behind ECF.
- In lower-risk villages, MCF was ranked fourth behind ECF, *Ormilo* and CBPP.
- Data from other studies indicate that MCF is perceived a disease of major

*significance elsewhere in Maasailand, including northern Tanzania and southwest Kenya.*

### Perceptions of Disease Impact

Factors relating to the impacts of different disease were relatively consistent among respondents (Table 6). MCF was considered important principally because of cattle deaths (mentioned by 57% respondents) and because no treatment was available (36% of respondents). ECF was a concern primarily because of high calf mortality (reported to be as high as 70% per annum) and the costs of treatment. This is consistent with previous reports, in which 75% calf mortality has been attributed to ECF in Ngorongoro District (NPW, 1990).

**Table 6: Percentage of respondents citing factors that contribute to the burden of different cattle diseases in Ngorongoro District.**

Reasons why disease considered important	MCF (n=77)	ECF (n=106)	<i>Ornilo</i> (n=90)	CBPP (n=113)	FMD (n=38)	Trypanosomosis (=17)
Deaths (unspecified)	43 (57%)	30 (28%)	42 (47%)	40 (35%)	-	-
Adult mortality	-	2 (2%)	-	-	-	-
Calf mortality	-	16 (15%)	-	-	10 (26%)	-
Lost production (e.g. milk, breeding animals)	2 (3%)	6 (6%)	4 (4%)	14 (12%)	5 (13%)	2 (12%)
Treatment/vaccine costs	2 (3%)	41 (39%)	34 (38%)	47 (42%)	13 (34%)	14 (82%)
Lack of treatment	27 (36%)	-	2 (2%)	-	-	-
Sale of animals	1 (1%)	3 (2%)	1 (1%)	3 (3%)	-	-
Need to move animals	2 (3%)	-	-	-	-	-
High morbidity	-	5 (5%)	7 (8%)	9 (8%)	4 (11%)	-
Other	-	3 (3%)	-	-	6 (16%)	1 (6%)

### Direct Financial Losses

Maasai owners reported direct losses associated with MCF ranging from 50,000 to 150,000 TSh (approx. £42-£125) per case, as a result of deaths, emergency slaughter, low prices for sale of sick animals and lost milk production.

In the case of death, the animal has no value beyond the hide. Emergency slaughter provides meat for home consumption and it has been suggested that MCF does not represent a major economic problem because meat from affected cattle can be consumed. However, the availability of meat during the MCF season almost certainly exceeds demand for home consumption. While a commercial farmer could maximise the short-term cash return from such meat, the pastoralist needs to optimise output to ensure the long-term survival of the herd. The unpredictable nature of MCF-related mortality makes it difficult to plan an effective strategy for commercial offtake. Furthermore, as the disease affects mainly adult animals in Ngorongoro District (see later *-Epidemiology*), the disease has serious implications for the reproductive and productive potential of the herd. Several respondents indicated that lifetime reproductive losses were an important component of the costs of the disease, but these have not been quantified here.



In Ngorongoro District, the price for MCF-affected cattle ranged from 20,000-50,000 TSh, with several respondents indicating that a MCF-animal could be exchanged only for a single goat, which is equivalent to approximately 15,000 TSh (£12.50). In contrast, prices for healthy cattle were reported to be in the region of 130,000 TSh for a pregnant cow, 120,000 TSh for a lactating cow and 50,000 TSh for a heifer. Low prices for sale of affected cattle were also reported in a more detailed economic study of MCF in Kenya in which sick cattle taken to slaughter commanded only 20%-30% of the value of healthy animals (Ngotho *et al.*, 1999b). In the Kenyan study, direct losses through MCF deaths, emergency sales and slaughter resulted in losses to herd value of 4%-8% in low-incidence areas and 14%-24% in high-incidence areas (Ngotho *et al.*, 1999b).

Summary

- *Direct losses from MCF arise from the death, emergency sale or slaughter of affected animals.*
- *Sale or exchange of live animals incurs losses as a result of low prices obtained for MCF-affected cattle.*
- *Emergency slaughter provides meat for home consumption but supply exceeds demand during the MCF season.*
- *The unpredictable nature of MCF and the high incidence in productive adult animals makes it difficult for Maasai to develop strategies that optimise long-term herd production and commercial offtake.*

## Incidence of MCF

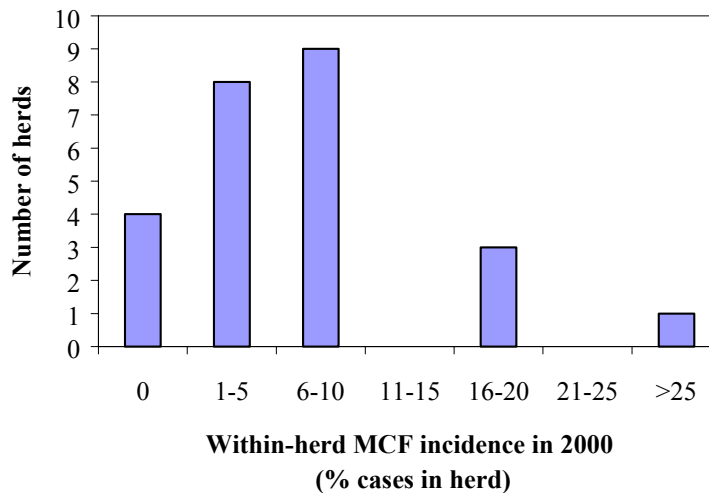
Overall 70/82 (85%) households reported at least one case of MCF in their herd in 2000. Although data were obtained from only two villages in low-risk areas, 5/6 households (83%) in low-risk villages also reported at least one MCF death in 2000.

In many cases, the incidence of disease could not be estimated because people were reluctant to indicate the number of cattle in their herds. This arises because of an understandable sensitivity about revealing the extent of family wealth and a general mistrust about the purpose of livestock research. Some villagers were suspicious that information on cattle numbers would be used by the government for taxation purposes.

It was also apparent that figures for herd size probably did not include calves less than one year of age. Reported herd sizes were therefore adjusted to include young calves: (a) using data from four locations in the NCA which reported a mean of 27.2% of the herd consisting of calves (Homewood and Rodgers, 1991) and (b) from the mean of four studies reported in Field *et al* (1997) with 19.1% of the herd consisting of calves.

Incidence data could be estimated from 21 herds (7 questionnaires, 9 group discussions), for which information was provided on both MCF cases and herd size. Removing one outlier, which was almost certainly an exaggerated case (100 deaths out of 200 animals), the within-herd incidence of MCF ranged from 0%-40% (Fig. 13). The mean incidence was determined from the total number of cases divided by the adjusted total in the 21 herds and estimated as (a) 5.6% (95% C.I. = 4.8-6.3%) allowing a herd size adjustment of 27% and (b) 6.2% (5.4-7.0%) with an adjustment of 19%.

**Fig. 13. Frequency distribution of within-herd incidence of MCF in Ngorongoro District in 2000.**

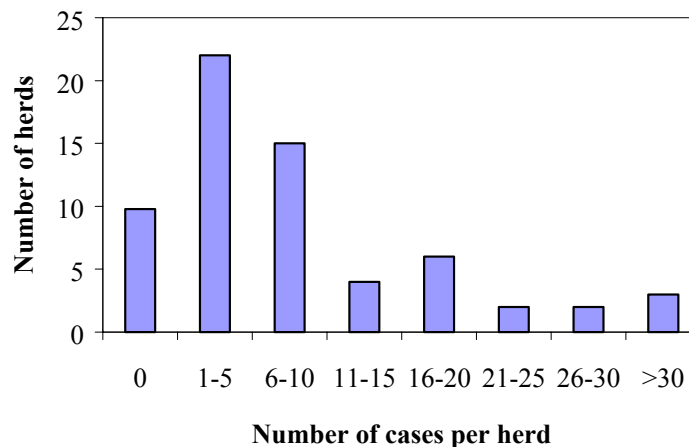


These incidence figures are broadly consistent with those reported elsewhere in East Africa. For example, losses in 1970 in Kenya were reported up to 7% in 10,000 animals from closely-observed herds (Plowright *et al.*, 1975). It should be noted that these incidence data were recorded at a time when wildebeest numbers were lower than at present. In a ranch adjacent to Manyara National Park in northern Tanzania, 200/7000 cattle (3%) died in one outbreak and annual incidences of 3%-12% have been reported elsewhere in Tanzania Maasailand (Kalunda *et al.*, 1982). Mean incidence data from a study involving five group ranches and five private ranches in Kenya were reported to range from 1%-21%, with cases reported every year between 1990 and 1998 (Ngotho *et al.*, 1999b).

### MCF Cases

Even if not providing information on herd size, respondents were generally willing to report the number of MCF deaths in their herds in 2000, with the frequency distribution of MCF deaths shown in Fig. 14. Accounting for the proportion of herds with no cases reported in 2000, and removing three outliers which exceeded 50 cases, the mean number of deaths per herd was 9.5 (95% C.I.=6.8-15.1).

**Fig 14: Frequency distribution of within-herd cases of MCF in Ngorongoro District in 2000**



### Estimating the Total Number of MCF Deaths in Ngorongoro District

Applying our adjusted incidence figures to high-risk villages, the estimated total number of MCF deaths in the year 2000 for Ngorongoro District ranged from 5,000 (using the lower incidence figure of 5.6% per annum) to 9,000 (using an upper value of 6.2%), with most deaths occurring in adult animals. This is likely to be a conservative estimate because (a) we have assumed that no MCF cases have occurred in low-risk villages in the district, whereas some mortality undoubtedly occurs, and (b) total cattle numbers estimated by the Ngorongoro District livestock office may not include calves, whereas our incidence figures have been adjusted to account for this.

## Interpretation of Case-Incidence Data

Uncertainties arise both with respect to the accuracy of reporting of herd sizes and in the number of MCF cases. Any underestimate of herd size will increase the incidence of disease and while we tried to correct for the likely under-reporting of calves, we cannot be sure that people were not deliberately under-reporting cattle numbers to avoid revealing the extent of their wealth. Livestock census data that depend on reported numbers are notoriously unreliable and detailed observations by ground or aerial counts, which were beyond the scope of this study, are likely to be necessary to obtain robust data.

Although there is no doubt that Maasai recognise the clinical signs of MCF (see later - *Diagnosis*), we cannot be certain that information given was not affected by the purpose of the study. Permission for the study had to be obtained through the Ngorongoro District Council, the Ngorongoro Conservation Area Authority and the Tanzania Wildlife Research Institute prior to the PRA, therefore information about our interest in MCF control may already have circulated within the Maasai community. During our introduction to village and household leaders, attempts were made not to focus specifically on MCF, but we cannot rule out the possibility that some respondents have exaggerated the impact of MCF in order to stimulate donor funding for disease control and prevention.

A further issue relates to annual variation in disease incidence, as this study obtained data only on deaths reported in 2000. The year 2000 was generally considered to be a high-incidence year for MCF mortality because an extended dry period resulted in unpredictable wildebeest movements with extension of the migration into livestock grazing areas.

Although our data are consistent with other studies, care must also be taken in the interpretation of published data, which may be representative of disease only on a local scale. Incidence data may only be published from major outbreaks or from high-incidence areas. Extrapolation of localised incidence data to much wider populations is probably not meaningful and likely to exaggerate the burden of disease.

### Summary

- *In high-risk areas of Ngorongoro District, 65/76 (86%) cattle herds were affected by MCF in 2000.*
- *Adjusting for possible under-reporting of herd size, 5.6%-6.2% of cattle died from MCF in high-risk villages in 2000.*
- *Assuming no cases of MCF in low-risk villages (which will provide a conservative estimate of MCF deaths), approximately 5,000-9,000 cattle deaths were caused by MCF in Ngorongoro District in 2000.*
- *Incidence data should be treated with caution due to likely inaccuracies in reporting herd sizes and possible exaggeration of MCF cases. Localised incidence data should not be extrapolated to estimate disease burden across a wide geographic range.*

## **The Impact of WD-MCF Elsewhere**

Wildebeest have a wide distribution throughout Tanzania and it is likely that MCF occurs in many parts of the country. However, cases are rarely reported to veterinary authorities and official incidence data difficult to obtain (Kalunda *et al.*, 1982 ). The disease is considered to be a constraint to cattle grazing in the Simanjiro plains of Tanzania (Bourn and Blench, 1999) and has also been reported in Monduli District. However, a decline in both wildebeest numbers and in the extent of wildebeest movements in the dispersal areas around Tarangire National Park (TWCM, 1999) probably means the disease has relatively less impact than in Ngorongoro district.

Within Kenya, wildebeest are limited mainly to the southwest of the country and the areas at greatest risk from MCF are those adjacent to the Maasai Mara Game Reserve and Amboseli National Park in Narok and Kajiado Districts. In these areas, incidence rates ranging from 1%-21% have been reported on several group ranches and private ranches, with cases documented every year (Ngotho *et al.*, 1999b). In some of the private group ranches, economic losses from MCF were compensated by the benefits accrued from wildlife through tourism. However, smaller ranches and smallholders were sporadically incurring substantial losses that could not be compensated (Annie McLeod, pers. comm).

Elsewhere in Africa, WD-MCF occurs sporadically, but has been reported with increasing frequency in South Africa as a result of the growth in game farming. Substantial losses have been reported recently in the north-western Transvaal, with incidences as high as 34% in farms adjacent to game reserves (Barnard *et al.*, 1994).

## Diagnosis and Recognition of MCF

In all the group discussions and in 80/81 (99%) questionnaires, MCF was well-known as a cattle disease. Only one respondent, a young man of 18 years who lived in the Ngorongoro Highlands, had not heard of the disease, although he later showed some knowledge of transmission.

### Incubation period

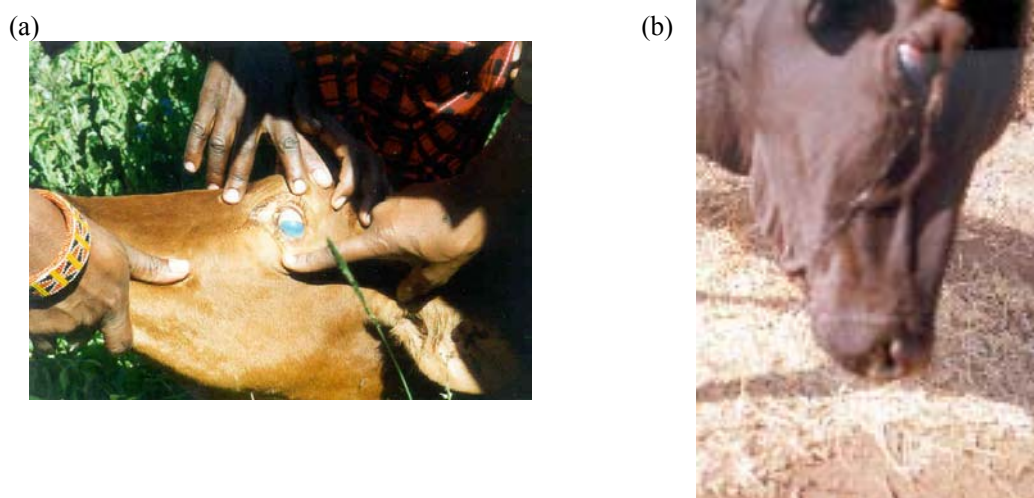
Out of 81 respondents, 22% recognised an incubation period as part of the disease cycle, describing it as the time needed for the disease agent to mature within the infected animal's body and the reason for the occurrence of cases 1-2 months after exposure to wildebeest calves.

### Duration of clinical disease

For cattle that died, owners reported a range of 1-30 days between first observation of clinical signs and death of the animal. Cattle usually die within 4-5 days of obvious clinical signs developing, although a more prolonged course of disease up to 21 days has also been recorded (Barnard *et al.*, 1994).

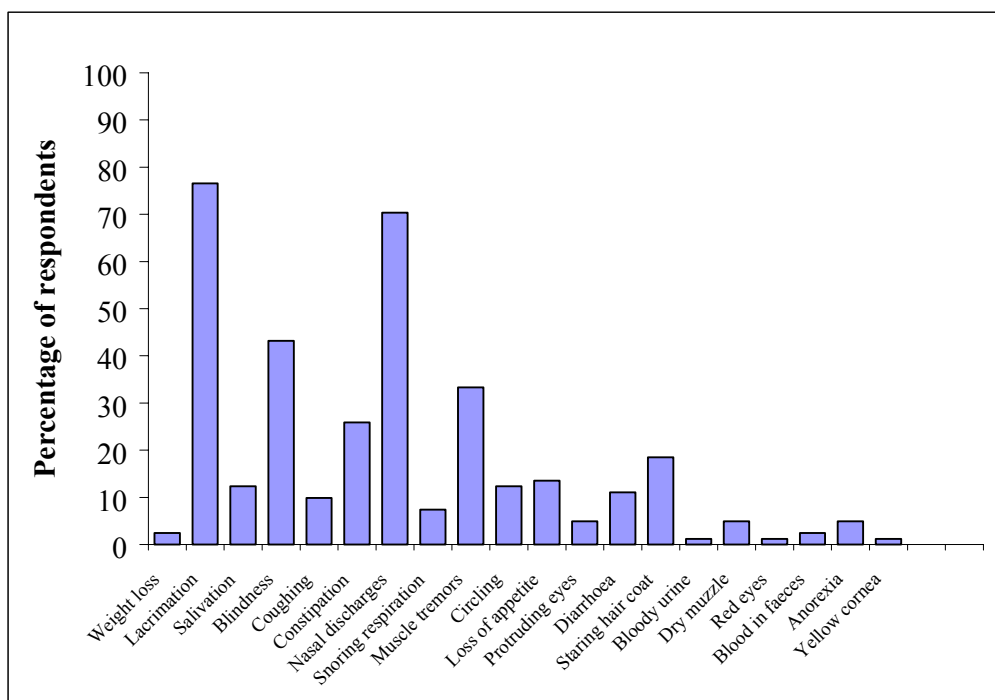
### Clinical Signs

The most common signs associated with MCF were ocular lesions (reported by 86% of respondents), followed by nasal discharges (70%), blindness (43%) muscle tremors (32%), constipation (26%) and circling (12%) (Fig. 16). Out of 27 respondents reporting muscle tremors, 9 (33%) specified tremors of the hump or shoulder muscles. There was no significant difference in the frequency of clinical signs reported between Loliondo and Ngorongoro ( $\chi^2 = 12.1$ , d.f. = 11,  $p > 0.05$ ). The clinical signs observed earliest in the course of the disease included ocular lesions (83%), nasal discharges (17%), muscle tremors (33%) and anorexia (17%).



**Fig. 15: Clinical signs of lacrimation, conjunctivitis and corneal opacity observed in two suspected cases of MCF observed during the PRA (a) from Soit Sambu and (b) from Olbalbal.**

**Fig. 16: Clinical Signs of MCF Reported by Maasai**



The clinical signs described by Maasai owners were similar to published features of typical MCF cases, consistent with reports of ocular and nasal lesions appearing early in the disease and becoming more profuse and mucopurulent as the disease progresses. There were no reports of enlarged lymph nodes in the PRA survey, even though generalized lymphadenopathy is reported as a clinical sign (Plowright, 1986), occasionally occurring before the onset of pyrexia (Pierson *et al.*, 1979). However, examination of cattle by livestock officers revealed generalized lymphadenopathy in 2/10 cases of suspected MCF brought for slaughter in the months following the PRA.

Muscle tremors, a manifestation of meningo-encephalitis, were frequently reported in this survey, with muscle groups of the shoulder, hump and back most commonly affected. Circling was the only other neurological sign reported. Consistent with published reports, constipation was a common feature of the disease in this area, occurring early and persisting throughout the course of the disease. Diarrhoea was reported very infrequently.

The features described by Maasai were typical of the acute ‘head-and-eye’ form of the disease. In the peracute form of the disease, clinical signs may be minimal and go unrecognized. Other manifestations of MCF reported in the literature, such as dermatitis, diarrhoea and dysentery, were not widely recognised in this study. However, these signs are more often associated with SA-MCF and rarely with WD-MCF (Barnard *et al.*, 1994).

### **Post-Mortem Signs**

The most common post-mortem sign reported by Maasai was the finding of hair in the

omasum, abomasum or small intestine (95%). One respondent (4%) reported dirty, red material in the intestine, consistent with epithelial necrosis and erosions.

In the two months following the PRA, post-mortem samples were collected by livestock officers from ten suspected cases of MCF, three from the Loliondo area and seven from the Ngorongoro area (Table 7). Post-mortem findings recorded in eight carcasses included hepatomegaly (7), generalized lymphadenopathy (4), kidney infarcts (2), pneumonic lesions (2), and abomasal erosions (1). Hydatid cysts were recorded in the liver and lung of one carcass. All cattle brought for slaughter with suspected MCF signs were adult animals > 2 years of age.

There was a discrepancy between the reports of Maasai respondents, who consistently recorded hair in the gastrointestinal tract, and reports of published literature and livestock/veterinary officers, who do not record this finding. Livestock officers may not consider hair in the omasum or abomasum a significant abnormality worth reporting. In contrast, Maasai may assume that it is important on the basis of suspected routes of virus transmission through ingestion of wildebeest hair (see later-*Epidemiology*). It is possible that cattle grazing on the plains at the time when wildebeest calves moult (about 3 months of age) ingest large quantities of hair from the pasture. Hence, any animal that has been grazing on the plains and dies may have hair in the intestinal tract, whatever the cause of death. The association between ingestion of wildebeest hair and MCF may thus arise only because mortality of adult cattle from non-MCF causes at this time of year is relatively low.

### **Recovery from Disease**

There were no reports of any animals having recovered from MCF in either the questionnaire survey or the group discussions. However, in most cases, Maasai opted to slaughter cattle once clinical signs of the disease became apparent. Although the outcome of MCF is usually fatal, recovery or mild disease has been reported in some animals infected with the alcelaphine herpes virus-1. Under experimental conditions, mild disease with recovery has been recorded in 6% of infected cattle (Plowright, 1968; Kalunda *et al.*, 1981). However, the frequency and distribution of recovered cases under natural conditions is still unknown. To date, serological studies in East Africa have failed to produce evidence of subclinical infection in 'normal' cattle (Rossiter *et al.*, 1980)

#### Summary

- *The clinical manifestations of wildebeest-associated MCF described by Maasai, both women and men, were consistent across study areas.*
- *Clinical signs reported by Maasai were very similar to those described in the published literature for WD-MCF.*
- *Where MCF occurs, the 'head-and-eye' form of the disease is well-recognised as a clinical entity.*
- *As the disease is known to be fatal, most owners opted to slaughter affected animals once clinical signs of the disease become obvious.*



**Table 7: Table showing details of suspected MCF cases from which samples were collected for histopathological examination.**  
*Histopathological analyses were carried out by Dr. Alex Schock, Moredun Research Institute.*

ID No.	Village	Age (yrs)	Clinical signs	Gross post-mortem signs	Histopathological changes	Final diagnosis with regard to MCF
W01	Oloipiri	4	Lacrimation, blindness, nasal discharge, nostrils blocked, breathing with difficulty.	Swollen liver, pneumonia	Severe lymphoid hyperplasia and vasculitis in kidney, liver, lung, urinary bladder and brain.	Consistent
W02	Oldonyowas	7	Ocular and nasal discharges, dry and cracking muzzle, breathing with difficulty.	Liver enlargement, slight pulmonary oedema and enlarge/oedematous lymph nodes	Moderate lymphoid hyperplasia and vasculitis in kidney, liver, urinary bladder and brain Spongy change in white matter and nephrosis.	Supportive, but prominent underlying pathology
L01	Loliondo	6	Ocular and mucopurulent nasal discharges, difficulty breathing, fever (40° C).	Liver enlargement, grey spots in kidney	Moderate lymphoid hyperplasia and vasculitis in kidney, urinary bladder and liver.	Consistent
1	Esere	5	Lacrimation, blindness, nasal discharge, difficulty breathing.	Kidney infarcts, enlarged liver	Severe lymphoid hyperplasia and vasculitis in urinary bladder, kidney and liver.	Consistent
2	Endulen	3	Lacrimation, blindness, nasal discharge, difficulty breathing.	Kidney infarcts, hydatid cysts in lungs and liver	Moderate lymphoid hyperplasia and vasculitis in brain, kidney, urinary bladder, liver, lymph nodes and spleen.	Consistent
3	Endulen	4	Ocular and nasal discharge, dull and off feed.	Not recorded	Mild lymphoid hyperplasia and vasculitis in brain, lymph nodes, kidney and spleen	Inconclusive
4	Endulen	5	Lacrimation and nasal discharge.	Not recorded	Very mild lymphoid hyperplasia and vasculitis in brain, kidney and spleen.	Supportive, but insufficient material
I	Ngoile	Adult	Lacrimation, rough hair, muscle tremors, anorexia, nasal discharge.	Hepatomegaly, lymphadenopathy	Moderate to severe lymphoid hyperplasia and vasculitis in urinary bladder, pharynx, pylorus, lymph nodes, kidney, liver, brain and spleen. Nephrosis.	Supportive, but prominent underlying pathology
II	Meshele	5	Generalized lymphadenopathy, lacrimation, staring coat, anorexia.	Dry omasum, generalized lymphadenopathy, hepatomegaly	Moderate to severe lymphoid hyperplasia in the kidney, lung, brain, urinary bladder, pylorus and lymph node.	Consistent
III	Ngoile	2	Swollen lymph nodes, lacrimation, nasal discharge, staring coat, diarrhoea.	Hepatomegaly, lymphadenopathy, jaundice in small intestine, erosion in abomasal wall	Moderate lymphoid hyperplasia and vasculitis in the kidney.	Strongly suggestive

## Histopathological Diagnosis

Tissue samples, including kidney, urinary bladder, brain, liver, lung, lymph nodes and spleen were submitted for histopathological examination from 10 adult cattle on the basis of clinical suspicion of MCF by Maasai owners. The age, village of origin and clinical signs are shown in Table 7, together with the gross post-mortem findings and histopathology results.

The principal histopathological findings were (a) infiltration or accumulation of lymphocytes into sub-epithelial tissues (particularly marked in the bladder), (b) hyperplasia of lymphoblasts in T-cell areas of lymph nodes and spleen, (c) arteritis with lymphocyte infiltration in the wall of vessels and perivascular spaces (most prominent in the brain, meninges, kidney and lung). These findings are typical of MCF lesions in cattle (Plowright, 1986; Barnard *et al.*, 1994; Reid and van Vuuren, in press) and thought to be associated with activation of autoaggressive T-lymphocytes follow virus infection (Liggit *et al.*, 1978; Schock and Reid, 1996). Severe renal tubular nephrosis was observed in two cases, suggesting that these animals may also have been exposed to a toxic insult.

In all cases, histopathological findings were supportive of a diagnosis of MCF. However the severity of lesions and the organs affected varied and, in one case, lesions were too non-specific to confirm a diagnosis on the basis of histopathology alone. The major differential diagnosis which has to be considered would be East Cost Fever (ECF). However, as a result of endemic stability in this area, ECF affects mainly calves and adult mortality is relatively low. We consider that the combination of clinical signs (lacrimation and nasal discharge), age (6 years) and histopathology make MCF a more likely diagnosis than ECF in this animal.

Conclusive diagnosis of MCF infection in these cattle would require either isolation of virus or demonstration of specific antibody in the serum. Isolation of virus requires storage of samples at  $-70^{\circ}\text{C}$ , which was not logistically possible in this study. Although collection and storage of serum samples may have been feasible under field conditions, serology is of limited value in the diagnosis of WD-MCF as only a small proportion of cattle develop humoral responses late in the course of the disease (Barnard *et al.*, 1994). In an outbreak of MCF in northern Tanzania in 1976, for example, neutralizing antibody titres could not be demonstrated in any of 14 sick cattle (Kalunda *et al.*, 1982)

Although the differential diagnosis for MCF includes several infectious and non-infectious disease, including rinderpest, bovine virus diarrhoea, vesicular disease and ingestion of caustic substances (Sewell and Brocklesby, 1990), the Maasai are able to recognise the disease with a high degree of accuracy.

### Summary

- *Histopathological findings in nine out of ten cattle with suspected MCF were strongly suggestive of a diagnosis of MCF.*
- *The combination of clinical signs, history, and post-mortem findings allow a presumptive diagnosis of MCF to be made in all suspected cases examined in this study.*
- *Maasai owners in Ngorongoro District are able to recognise MCF with a high degree of accuracy on the basis of clinical signs and history.*
- *Clinical observations are likely to provide a relatively accurate and accessible source of epidemiological data in the absence of laboratory diagnostic confirmation.*

### **Action Taken in Clinical Cases**

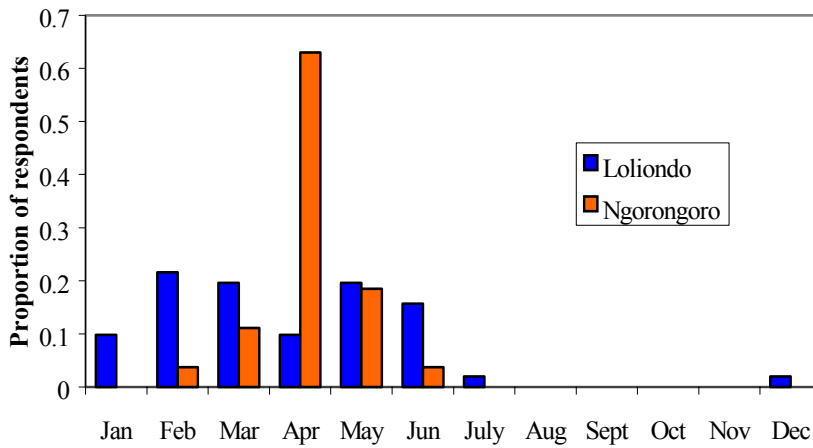
In clinical cases of MCF, 71/76 (93%) respondents indicated that the animals would be slaughtered, 21% of respondents would try to sell the animals live (or exchange with goats), 9% would leave the animals to die and 1% would attempt some form of traditional treatment. Most respondents reported that they would slaughter or sell the animals as early as possible, once it became obvious that the disease was MCF. However, the relatively high proportion (38%) of households reporting deaths as the actual outcome of cases in 2000, suggests that many animals died before the decision is made to slaughter. Indeed, during the PRA, the decision was made to delay the slaughter of two animals with early signs consistent with MCF (Fig. 15) until the owners were more certain of the diagnosis. Another factor contributing to the delay in slaughter is that Maasai do not store meat. Therefore, if two or more animals are concurrently affected by MCF, the most moribund animal would be slaughtered first and the others either exchanged for goats or sheep, or given palliative treatment until slaughter some days subsequently.

All respondents and participants in the group discussions indicated they would eat the meat of animals that had died from MCF, or been slaughtered. The meat was preferred if the animal had been slaughtered early in the course of the disease. 50/74 (81%) of respondents indicated that they would be able to sell the meat, but only at low prices. Meat would generally be consumed by the family, friends and visitors.

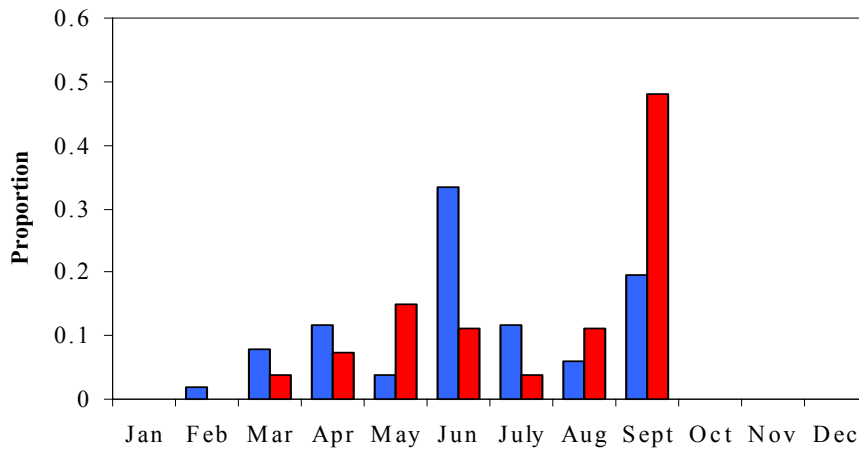
**Seasonality**

There was a clear seasonality in the pattern of MCF cases with 97% of respondents reporting the first cases between January and June, and 91% respondents reporting the last cases between April and September (Fig. 17a, b). However there were significant differences between Loliondo and Ngorongoro Divisions, with disease appearing earlier in Loliondo and having a flatter distribution ( $\chi^2 = 14.8$ , d.f.=2,  $p < 0.001$ ). In contrast, the disease in Ngorongoro showed a more clearly defined season, with a peak onset in April and a peak of final cases in September.

**Fig 17a: Timing of onset of MCF cases in Ngorongoro District**



**Fig 17b: Timing of the end of the MCF season.**



In South Africa, two peaks in disease incidence are seen; one in January to May (following the wildebeest calving season in December to February), and a second, in which the incidence is higher, from September to November (when the wildebeest calves are nine to 11 months old). The latter period coincides with the weaning period of the wildebeest calves, but the source of infection remains unclear.

### Age Classes

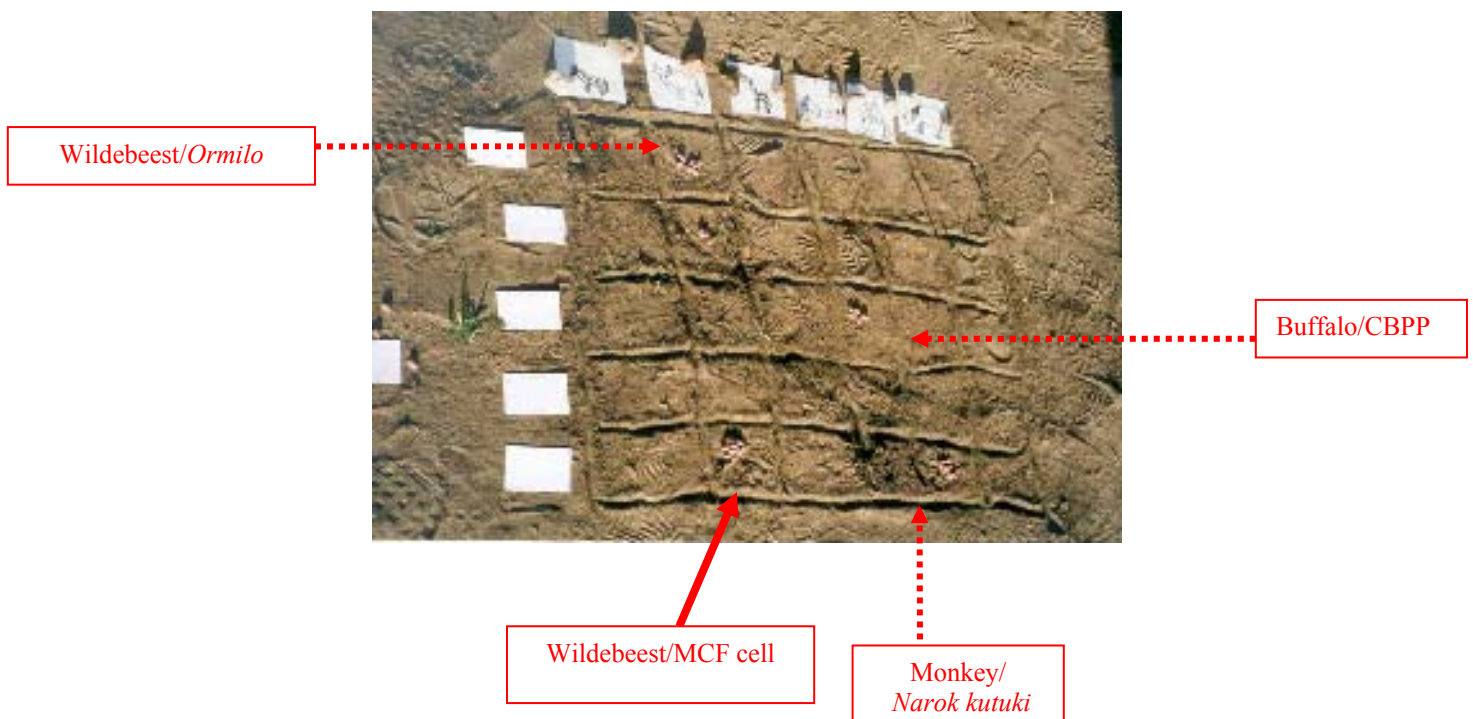
It was recognised that all age classes of cattle could be affected by MCF, but 36% of respondents indicated that the disease occurred predominantly in adults, with five respondents indicating that the disease affected mainly adult females. Although all age classes are susceptible to MCF, other studies have also demonstrated a higher incidence in adults, particularly in periparturient females (Barnard *et al.*, 1989). An explanation given for the low incidence in calves in this study was that calves tended to stay near the boma and did not spend as much time as adults in the wildebeest grazing areas.

### Transmission

The Maasai term for MCF, *Emoyian oo engati*, means ‘disease of wildebeest’. It was therefore not surprising that the association between MCF and wildebeest was clearly recognised by all 81 questionnaire respondents, all group participants and was consistently highlighted during the matrix ranking exercises. Participants attributed the seasonality of the disease to wildebeest calving.

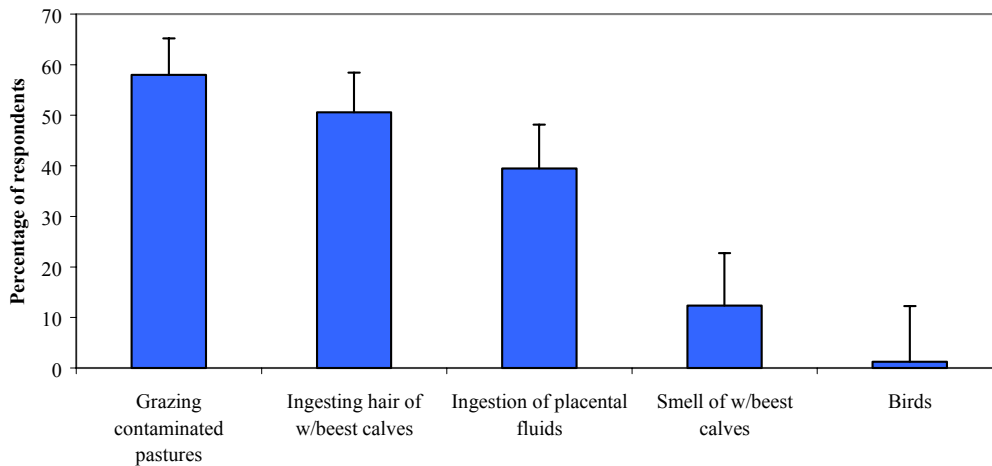
**Fig. 18: Matrix showing wildlife associations with cattle diseases. Images of wildlife species are on the horizontal axis and the disease names, in the Maasai language, along the vertical axis.**

(*Narok kutuki* is reported as a fatal disease of cattle and small ruminants with clinical signs very similar to MCF spread by monkeys – for further details of this disease and other disease associations with wildlife see Appendix II).



Several routes of transmission from wildebeest to cattle were identified, which relate principally to (a) ingestion of pasture or water contaminated with afterbirth materials, (b) ingestion of hair from wildebeest calves (coinciding with the time that calves moult at 3-4 months of age) and (c) the smell of calves or afterbirth (Fig. 19).

Fig. 19. Routes of Transmission of MCF identified by Maasai Respondents.



None of the respondents in the questionnaire survey thought that cattle-to-cattle transmission occurred, nor that the disease affected livestock other than cattle. Several owners described a similar fatal disease of sheep and goats, called *Emoyian Oong'oilin*, which is spread from Thomson's gazelle and causes reddening of the eyes and protrusion of the eyeball.

Although the Maasai are firm in their beliefs about MCF transmission from placenta, foetal membranes, foetal fluid or calf hair, studies have consistently failed to isolate virus from any of the tissues (Plowright, 1964; Rossiter *et al.*, 1983). Transmission of the virus among wildebeest is extremely efficient. All calves become infected within the first few months of age (Plowright, 1967) and excrete high levels of cell-free virus in oculo-nasal secretions during the first 3-4 months of life (Mushi *et al.*, 1981). The respiratory tract has thus been suggested as the most likely route of transmission. Rather than acting as the principal source of infection, wildebeest foetal membranes, fluids and hair (which is shed at 3-4 months of age) may provide visual markers for areas of pasture which are heavily contaminated with MCF virus from oculo-nasal secretion of wildebeest calves (Rossiter *et al.*, 1983).

Transmission from wildebeest to cattle has also been documented over considerable distances, with one outbreak in South Africa reported in cattle separated from wildebeest by up to 800 metres (Barnard 1990, Barnard and Van-De-Pypekamp 1988). Despite speculation about the possibility of spread by arthropod vectors, it is more likely that natural spread is generally, if not exclusively, by aerosol with the apparent anomalies explained by prolonged incubation periods occurring in some animals (Reid and van Vuuren, in press).

**Fig 20. Wildebeest cow with new-born calf. Foetal membranes and fluid may provide visual markers for areas contaminated with MCF virus from oculo-nasal secretion of calves.**

*Photograph: Jonathan Scott*



The cell-free virus excreted by wildebeest calves is probably rapidly inactivated when exposed to direct sunlight under field conditions (Rossiter *et al.*, 1983). It is suggested that pastures with nursery herds are therefore likely to be heavily contaminated with virus in the early part of the day and that the risk of infection may be reduced by delaying the start of grazing until the middle of the day (Rossiter *et al.*, 1983). Support for this view was provided by one Maasai elder who claimed that the practice of late grazing reduced the risk of disease. However, other Maasai beliefs are contradictory. For example, the view that infection risk is reduced following heavy rainfall is not consistent with rapid inactivation of the MCF virus in sunlight.

### **Trends in Disease Incidence**

An almost equal number of respondents perceived an increase in disease incidence over the past 20 years (51%) as those reporting no increase (49%). Those reporting a rise in disease incidence attributed this to an increase in wildebeest numbers and expansion of the population into livestock grazing areas, consistent with earlier reports (McCabe, 1994; Bourn and Blench, 1999). A decrease in rainfall was also given as a possible explanation for a growing disease problem. Indeed, low or unpredictable rainfall was cited as a principal factor causing year-to-year variation and was cited as the cause of the high MCF mortality in 2000.

Where respondents reported no increase in disease incidence, a greater awareness of the disease was given as the main explanation, with people becoming more efficient at moving livestock away from wildebeest during the calving season.

## Control Methods

Almost all participants recognized the importance of avoiding the wildebeest calving areas and where this was not reported, it was probably not considered as a method of control *per se*. Of 73 respondents, 36% used traditional medicines, describing a practice in which cattle were confined in a boma and powder sprinkled over their backs. Several people described treatment in terms of *zindikio*, meaning a magic spell, rather than as a specific medicine. Many people recognized that traditional treatments were not effective and complained about being cheated by traditional healers, as well as their low levels of knowledge. The cost of traditional treatment ranged from 500 TSh to 5,000 TSh per animal.

Only six respondents reported chasing away wildebeest or erecting thorn fences to prevent incursions into livestock grazing areas, although it is possible that these have been under-reported as they are not permitted in the NCA. One respondent sent young boys out to the plains to check for signs of onset of calving. Two respondents confined their cattle to avoid contact with wildebeest.

### *Summary*

- *Maasai avoid MCF by moving cattle to highland and woodland areas during the wildebeest-calving season.*
- *Traditional medicines are used by a proportion of owners to treat MCF but are widely recognised to be ineffective and considered relatively expensive.*

## IMPACTS OF MCF AVOIDANCE

### Perception of Problems Caused by MCF Avoidance

When asked as an open question, the main problems associated with disease control were reported to be an increase in other diseases (62%), shortage of pasture and salt (28%) and land-use conflicts (28%). Other reported problems included deception by local healers and/or lack of efficacy of local treatments (18%), increased predation (10%), environmental problems, such as soil erosion and tree-felling (5%) and increased risk of cattle rustling (3%).

### Increase in Disease Burden

In response to specific questions relating to problems associated with disease avoidance, 55/67 (82%) respondents reported an increased incidence of other infectious diseases as a result of confinement and concentration of cattle in highland areas. An increased burden of infectious diseases (which included a higher incidence of disease and increased treatment costs) was reported for both tick-borne diseases, including ECF (n=36) and *Ormilo* (n=25), and directly-transmitted diseases, such as CBPP (n=17) and FMD (n=11). An increased incidence of trypanosomiasis was reported as an indirect effect of MCF



during group discussions in Soit Sambu and Ololosokwan and is consistent with reports from Narok, Kenya, in which avoidance of wildebeest forced cattle into tsetse-infested areas ( Ngotho *et al.*, 199b)

### **Availability of Salt, Pasture and Water**

Specific questions were asked to highlight the implications of disease avoidance in terms of reduced grazing quality. Restricted grazing patterns were reported to affect the accessibility of resources in the wet season, with 47/76 (62%) respondents reporting difficulties in finding adequate pasture, 50% facing problems obtaining salt and 46% having problems with water availability.

A lack of high-quality grazing at the end of the dry season has previously been emphasised as one of the most important consequences of MCF in Ngorongoro District and may have a much greater impact than is immediately apparent (Homewood *et al.*, 1987). The high energy and mineral content of the short-grass plains contribute to successful lactation of cattle, as well as to wildebeest, improving the survival of both calves and adult females. Furthermore, the high productivity of short-stem grasses allows cattle to re-establish body condition at the end of the dry season, which is thought to be a critical factor for ensuring cattle survival and fertility in the subsequent year (Swift, 1983).

In some areas, such as Soit Sambu and Malambo in the LGCA, the lack of salt in woodland pastures necessitated movement of cattle to wildebeest calving areas, such as Angata Kheri, and salting trips posed the main risk of exposure to MCF in these areas. The fact that reproductive and production losses arising from salt deficiency were considered a greater problem than MCF mortality emphasises the crucial role of salt in the diet. Clinical signs of salt-deficiency were well recognised by Maasai and reported as a dull, staring coat, hypersalivation, excessive ground licking and a loss of production.

**Fig. 21: Herd in Ololosokwan village showing a high prevalence of trypanosomosis. An increased disease burden results from the need to restrict wet-season grazing to tsetse-infested habitats in order to avoid wildebeest.**



Provisioning of salt may offer a partial solution to the MCF problem in these localities. One *moran* from Soit Sambu had opted to avoid Angata Kheri completely, purchasing salt blocks from Narok in Kenya instead. As a result, his cattle had suffered no cases of MCF in the previous year. However, many respondents indicated that they would be reluctant to replace naturally-acquired salt with commercial salt blocks, that they considered less effective. In the absence of a vaccine, one approach to reduce the risk of MCF would be to set up a system of collection and distribution of *Olchoibor* salt to local herd owners.

In other areas, particularly in Ngorongoro, salt provisioning was not considered to be a major issue, and even if salt were to be provided, Maasai indicated that they would still be at risk from MCF, because they are forced into high-risk areas in search of grazing.

**Fig. 22: Maasai are forced to abandon the short-grass plains during the wet season to avoid MCF and are increasingly confined to the highlands and woodlands, with adverse consequences for both cattle productivity and the environment.**

*Photograph: Roland Frommann*



## *Environmental Impacts*

There was widespread concern about the environmental impacts arising from the concentration of people and cattle in the highlands, with soil erosion reported as a problem by 33% of respondents (n=39), overgrazing by 31%, and tree-felling for fuel and boma construction by 62%.

The increase in the human population within the NCA and adjacent areas has led to a rapid increase in the demand for wood and local supplies outside the NCA have been completely exhausted (Misana, 1997). Although the major part of firewood used by pastoralists consists of dead wood, there is evidence of an increase in tree-cutting to provide fuelwood and building poles and tree-felling is now thought to be an important cause of deforestation in the Northern Highland Forest Reserve (Misana, 1997). A second consequence of increased grazing pressure in the highlands has been the growing use of fire to clear grazing land in the forest, which has been cited as a major cause of damage to forests and forest regeneration (Struhsaker *et al.*, 1997; Misana, 1997). Although fire damage has been documented in published literature, this was not mentioned by any of the respondents in our study, presumably because such activities are illegal in the forest reserve. Deforestation is a major environmental concern in the NCA as the forest ecosystem serves as both a regional water catchment area and important source of biodiversity (Kijazi, 1997).

Maasai concerns about over-grazing in the highlands mirror those expressed in several ecological studies, which have documented adverse changes to vegetation as a result of over-grazing with expansion of unpalatable montane tussock grasses, such as *Eleusine* and *Pennisetum spp* (Homewood *et al.*, 1987). The indirect losses to cattle from poor-quality forage are difficult to quantify, but may be substantial. Inadequate burning also tends to favour the establishment of unpalatable grasses (Branagan, 1974) and the Maasai consider that a curtailment of fire in the NCA may be an important factor (Misana, 1997). Introduction of controlled burning management may facilitate pasture improvement and help alleviate some of the impacts of over-grazing in highland areas, but despite recommendations in the NCA General Management Plan (NCAA, 1996), a controlled-burning programme has still to be implemented.

Reduced utilisation of the short-grass plains may also be a contributory factor to the problem of bush encroachment, which has expanded over 6.5% of the NCA and is particularly severe in the transition zone between highlands and plains and on the short-grass plains (Misana, 1997). Problems with soil erosion have also been documented as a result of over-grazing in the highlands, with gullied livestock tracks on the north-west highland slopes and advance of *Eleusine jaegeri* both signs of overuse (Aikman and Cobb, 1997).

Energy costs of long-distance travel and the consequent restriction on feeding time are the main factors affecting milk production in Maasai cattle (Homewood *et al.*, 1997). Any increase in trekking times for salt, water or grazing arising as a result of MCF avoidance can be considered indirect impacts of the disease that will adversely affect milk production.

### **Increasing Demand for Cultivation**

As a result of reduced availability of productive pasture and high levels of livestock disease, livestock production has failed to keep pace with the growth in the human population leading to a growing dependence on grain. The increased demand for cultivation has already generated considerable friction

between Maasai and the NCAA, leading to a lifting on the ban on cultivation in 1992 (NCAA, 1992 cited in Perkin and Thompson, 1997). However, there are concerns that increasing cultivation may result in disruption of wildlife migration routes, particularly on the western slopes of the Ngorongoro crater (Perkin, 1995). This issue is discussed further below (see - MCF and wildlife conservation).

**Fig. 23: A decline in livestock production has led to an increased demand for grain with expansion of cultivation occurring throughout Ngorongoro District.**



*Photograph: Roland Frommann*

### Summary

- *MCF has important indirect effects on the Serengeti-Ngorongoro ecosystem, with serious implications for livestock production and the environment.*
- *Increasing concentration and confinement of Maasai in the highlands and woodlands has resulted in an increased burden of vector-borne and directly-transmitted diseases.*
- *Lack of availability of salt and high-quality forage results in a direct loss of production, with the energy demands of increased travel leading to indirect losses in milk production and body condition.*
- *Confinement of cattle to the highlands contributes to problems of over-grazing, a decline in pasture quality, deforestation, through increased tree-felling and uncontrolled burning, soil erosion and bush encroachment.*
- *The decline in livestock production has led to an increased demand for cultivation, a form of land-use that is incompatible with both traditional pastoralism and wildlife conservation.*

## PERCEPTIONS OF MCF VACCINE DEVELOPMENT

There was extremely strong support for the development and use of a vaccine against MCF. Of 81 respondents in the questionnaire survey, 79 (98%) said they would use a vaccine, if available. Of those willing to use a vaccine, 66% had no concerns about its use and 13% specified that trials for safety and efficacy would have to be undertaken before they would consider immunisation of their cattle. In group discussions, most owners indicated a willingness to pay for MCF vaccines should they prove to be effective. The fact that several owners volunteered animals for field trials provided an indication of the strength of support for vaccine development. In one village, it was suggested that each household would be willing to contribute at least five animals for vaccine trials.

Despite this support, there was some scepticism about the likelihood of vaccines becoming available and the time required for their development. People frequently expressed the view that their concerns about MCF had been totally ignored by government and donors over many years and felt resentment that there had been no research initiated on methods for MCF control.

## CONSEQUENCES OF MCF CONTROL

There is no doubt that control of MCF would result in an increase in survival of adult animals, with a direct improvement in herd productivity. It is also likely that, by permitting wet-season grazing on the short-grass plains, a vaccine against MCF would also reduce mortality and morbidity from other diseases and enhance survival and fertility through access to high-quality grazing at a critical time of year. Adverse environmental impacts associated with concentration of people and cattle in the highlands, which include overgrazing, erosion and tree-felling, might also be mitigated.

### Grazing Competition

Several concerns have been raised about potentially harmful impacts of MCF control, for example, that increased pressure on the short-grass plains might lead to overgrazing, degradation of water quality, and growth of permanent settlements. Indeed, during an interview with the NCAA, the view was expressed that MCF might be 'a blessing in disguise', indicative perhaps of NCAA policies which have, in the past, tended to favour wildlife conservation above pastoral development. However, a consensus was apparent among the ecologists consulted that grazing was not a limiting factor on the short-grass plains in the wet season and that the presence of 100,000 cattle on the plains from February to May would probably not result in significant impacts to either vegetation or wildlife. It should be noted that a number of ecologists expressed conflicting views and considered that the impact on wildlife would be severely detrimental. For example, competition for water was cited as a possible factor that might restrict the utilisation of the short-grass plains by wildebeest.

A land-use model, Savanna, developed at Colorado State University has been used to explore land-use scenarios in the NCA and assist in decision-making in the area (Boone *et al.*, in press). Two scenarios are of particular interest here. First, model outputs indicated that increased access of cattle to the plains during the wet season would allow the NCA to support 20,000 more cattle after 15 years. In this scenario, the condition indices of goats and sheep were reduced as a result of increased grazing competition with cattle on the plains, indicating that there may be a trade-off in production between small ruminants and cattle. A second scenario, which modelled an increase in adult survival of 5% (as



would be expected with elimination of MCF mortality) left an additional 7,000 cattle available for sale in the NCA alone.

### **Cattle Population Growth**

One concern expressed by conservationists has been that the reduction in MCF-related mortality may lead to a rise in cattle numbers, which might further increase land-use pressure in the district. Despite the importance of cattle as a measure of status and wealth in pastoralist society, current trends suggest that Maasai are now more likely to sell 'excess' animals that are produced or survive as a result of MCF control. For most herds, the growing demand for cash income to pay for grain, medicines, and school fees is likely to necessitate sustained commercial offtake. There is also a growing realisation of the need to improve the quality of livestock, not merely the quantity. One owner in Soit Sambu, for example, placed a limit of 200 cattle for his herd, and sold any animals exceeding this limit. Thus, although cattle numbers may increase slightly, a cattle population explosion is unlikely to occur in Ngorongoro District, even if MCF is controlled.

### **Growth of Permanent Settlements on the Short-grass Plains**

It became apparent during discussions that some families (36% respondents) would consider settling permanently on the short-grass plains if a MCF vaccine were available. It is likely that lack of dry-season water and grazing would limit the growth of fixed settlements in these areas. However, the risk remains that increased utilisation of the short-grass plains might stimulate demand for development of permanent water sources, which has the potential to cause serious adverse environmental impacts (Sinclair, and Fryxell, 1985).

The consensus of opinion was that the use of a MCF vaccine would prolong the duration of grazing on the short-grass plains, allowing utilisation of the area during the most productive months of the year, but would not lead to substantial shifts in Maasai communities. Families with cultivation plots were particularly reluctant to move to an area where agriculture was not possible. Others cited security concerns and the increased risk of cattle raiding as reasons for not moving permanently to the plains.

**Fig. 24: The lack of permanent water and dry-season grazing would probably limit development of permanent settlements on the short-grass plains.**



### **Problems Associated with Changes in Grazing Patterns**

All respondents indicated that the introduction of a MCF vaccine would result in changes to the grazing pattern, with improvements to the efficiency of grazing management. Few problems were anticipated as a result of these changes, although over-grazing was mentioned by one respondent and another expressed concerns about a rise in immigration from Kenya.

### **Land-use Conflicts**

All respondents indicated that traditional approaches would be adopted to tackle potential land-use conflicts, with decisions made by community leaders and Maasai elders. In pastoralist societies, access to grazing lands is maintained through traditional systems of age-sets and kinship, and legal patterns can be difficult to trace. One respondent informed us that traditional leaders effectively make bye-laws to determine access to grazing lands and to protect the environment, with elders having the power to discipline “grazing defaulters”. Traditional decision-making probably provides an effective mechanism for appropriate and flexible utilisation of rangelands (Homewood *et al.*, 1987).

### **Monitoring**

There is a compelling case to be made for development of a vaccine against MCF in order to improve pastoral livelihoods in rangelands of Tanzania. However, the introduction of a vaccine has potentially far-ranging repercussions on environmentally-sensitive areas, such as the Serengeti, and it is crucial that the impact of any vaccination programme is closely monitored to evaluate changes in livestock demography, cattle and small ruminant production, disease incidence, vegetation patterns, human settlements and immigration, as well as the numbers and distribution of wildlife.

### Summary

- *Despite widespread concern about MCF for many years, the Maasai believe the problem has been ignored by government and donors.*
- *There was extremely strong support for development of a vaccine against MCF, with several owners volunteering cattle for field trials.*
- *Introduction of a vaccine would allow more efficient grazing management and production systems.*
- *Although cattle productivity would probably increase, an explosion in cattle numbers is not expected because of the growing demand to sell animals to raise cash for grain, medicines, school fees and clothing.*
- *Any growth of fixed settlements on the short-grass plains is likely to be limited by lack of availability of dry-season water and grazing.*
- *Pilot field trials are essential to monitor potential impacts of MCF vaccination on livestock production and demographics, vegetation patterns and wildlife movement patterns.*



## FEASIBILITY OF VACCINE DEVELOPMENT

It has generally been considered that, on global scale, the incidence and economic impact of MCF has not been high enough to justify development of a vaccine. However, in East Africa, there is clear evidence for social, economic and environmental costs of the disease and MCF appears to be a growing problem in parts of southern Africa. Any advances in knowledge about vaccination for AIHV-1 will also have a wider relevance for the control of MCF throughout the world, as well as providing considerable comparative interest for the control of other herpesvirus infections, many of which are important to livestock and human health. There may thus be scope for developing public-private partnerships for MCF vaccine development, which will address the specific need for MCF control in Maasai communities, as well as having a wider application in the control of MCF and other herpesvirus infections elsewhere.

Although early vaccine studies using both attenuated and inactivated vaccines have largely been unsuccessful (Plowright, 1968; Reid and Rowe, 1973; Plowright, *et al.*, 1975), there appears to be no *a priori* reason to expect that development of a MCF vaccine could not be achieved. Immunity to MCF is possible and occurs in the rare cases where cattle recover from the disease (Plowright, 1990). In the past, inactivated vaccines have been developed that induced high levels of neutralizing antibody in cattle. However, none have conferred resistance to parenteral challenge (Plowright, 1968; Plowright, 1975). In rabbit models, Rossiter (1982) found that several inoculations of fixed or living culture cells expressing viral antigens on their membranes, when combined with Freund's adjuvant, immunized rabbits against challenge with virulent cell-free suspensions. However, there have been no successful challenge trials in cattle. Consideration also needs to be given to development of a suitable challenge model, as cell suspensions may not be an appropriate system for infection under natural conditions, where transmission is thought to occur mainly by aerosol spread of cell-free virus.

Two broad approaches to MCF vaccine development are likely to be feasible. First it may be possible to manipulate the host immune response to stimulate T-lymphocyte responses and/or high levels of neutralising antibody. For example, the use of tissue-culture propagated virus that could stimulate high levels of neutralizing antibody at mucosal surfaces (e.g. by inclusion of cholera toxin as an adjuvant and through nasal immunisation) may prevent virus uptake in exposed cattle. This is a relatively simple approach that offers a feasible strategy for vaccine development in the short term. The second main approach, which would require a longer development phase, is through recombinant technology to design vaccines that allow expression of specific pathogen genes against which the host needs to be protected. Recent advances in knowledge about the molecular biology of AHV-1 have opened the way for development of recombinant vaccines. For example, recent studies have elucidated the full sequence of the genome (Ensser *et al.*, 1997) and identified genes involved in virulence (Handley *et al.*, 1995), which raises the possibility of constructing recombinant proteins and vaccines

Prior to the development of any vaccine for use in East Africa, consideration should be given to potential concerns relating to the use of live and recombinant vaccines. Despite a long history of mass cattle vaccination programmes, e.g. against rinderpest, vaccination is a particularly sensitive issue in the Serengeti/Ngorongoro ecosystem, partly because any pathogenicity to non-target species could have far-reaching implications for the valuable wildlife resources of the area. Indeed, concern about the potential pathogenicity of live MCF vaccines for wildlife was one of the major issues raised during discussions with the NCAA.

As discussed above, the introduction of a MCF vaccine has potentially far-ranging repercussions and it is crucial that the impact of any vaccination programme is closely monitored. Small-scale pilot trials are an essential first stage to evaluate potential impacts on disease incidence, ranging patterns and demographic characteristics of livestock and wildlife.

## Research Groups

The following research groups have an interest in possible MCF vaccine development studies:

- Moredun Research Institute, U.K. (Dr. H. Reid)
- University of Edinburgh, U.K. (Prof. A. Nash, Dr. R. Dalziel)
- Intervet, U.K. (Dr. S. Chalmers, Dr. W. Baxendale)
- Kenya Agricultural Research Institute, National Veterinary Research Centre, Maguga, Kenya
- Sokoine University of Agriculture (field trials)

### Summary

- *Although early attempts to develop MCF vaccines have been unsuccessful in protecting cattle against challenge infection, there are several feasible strategies for vaccine development that have not yet been attempted.*
- *The use of tissue-culture propagated virus directed to enhance mucosal immunity provides a relatively simple approach that may be feasible in the short-term.*
- *The elucidation of the full sequence of the MCF virus genome and identification of genes involved in virulence raise the possibility of constructing recombinant proteins and vaccines in the longer-term.*
- *Small-scale pilot trials are essential before any large-scale vaccination is considered.*
- *Several research groups have expressed an interest in possible MCF vaccine studies.*

## OTHER CONTROL OPTIONS

### **Salt Provision**

Provisioning of salt may provide a partial solution to alleviating the MCF risk in certain areas of Loliondo and Sale Division, but would not improve the situation in Ngorongoro Division. Even with salt provisioning, lack of access to high-quality pastures and problems associated with concentration of cattle and people in the highland and woodland areas will continue to pose a significant constraint to cattle productivity.

### **Zoning**

Contained within the general management plan for the NCA are recommendations to identify priority areas for livestock development and pastoralism, wildlife management, tourism, forestry and archaeology (NCAA, 1996). Zones for pastoralist development focus on areas with relatively large permanent settlements in the highlands, such as Nainokanoka and Oloirobi. Without methods to control MCF, strategies to extend utilisation of the short-grass are extremely limited. Currently the only

suggestion included in the NCA General Management Plan relates to improved security measures to reduce the risk of cattle raiding, which restricts grazing on the plains, particularly in the southeast.

The option of fencing zoned areas has not been raised at all within the management plan for NCA of the integrated development plan for Ngorongoro District. This is indicative of the fact that separation of wildlife and livestock by game-fences is widely held to be an unacceptable form of land-zoning incompatible with the aesthetic, cultural and conservation goals of the Serengeti and Ngorongoro, which are designated World Heritage Sites. Fencing is likely to have catastrophic consequences on the wildebeest migration, limiting access to areas that are critical for survival when resources are scarce. Similarly, fences would pose significant constraints to traditional pastoralism. In contrast, development of a MCF vaccine would facilitate the co-existence of wildlife and livestock and support the re-establishment of transhumance in Ngorongoro.

Fences may also not provide a completely effective means of controlling MCF. It has been reported that in areas where fencing of rangelands has occurred and migration of wildebeest is restricted, MCF has become less of a problem (Bourn and Blench, 1999). However, studies in southern Africa indicate that cattle separated from wildebeest by either a game-proof fence or by distances of at least 100m sustained a higher incidence of disease than those that shared the same grazing and watering points as wildebeest (Barnard *et al.*, 1989). MCF was only prevented in cattle when wildebeest and cattle were separated by 1,000 m or more.

## **MCF AND WILDLIFE CONSERVATION**

The NCA, which includes the Ngorongoro Crater, is renowned throughout the world for its spectacular wildlife and Loliondo has perhaps the best wildlife resource outside of Tanzania's National Parks and game reserves. However, inequalities in distribution of wildlife-related income have long been a concern in the area. Throughout East Africa, cost-benefit analyses have shown that it is the Maasai who bear the opportunity costs for protecting the wildlife resources in rangeland areas, effectively providing hidden subsidies for 'cheap' conservation (Norton-Griffiths, 1996).

With the continued deterioration of the livestock production base, food security for pastoralists can only be assured with increasing reliance upon cultivation, a form of land-use which poses a much more profound threat to wildlife than any arising from pastoralism. In Loliondo Division, in particular, there is intense pressure to open up land for arable agriculture (Parkipuny, 1997). To prevent expansion of agriculture, as has occurred throughout much of Kenya Maasailand, it is entirely in the interests of conservation to combine forces with pastoralists to develop strategies that promote livestock production. The recent establishment of Wildlife Management Areas (WMA) adjacent to the Serengeti National Park provides an opportunity for developing combined strategies of wildlife conservation and livestock production in the Loliondo Area (CDC/FZS, 1997). Pastoralism and wildlife-compatible forms of land-use are likely to be sustained area only if revenues can be generated above a critical threshold of \$400/km<sup>2</sup> that is required to compete with agriculture (CDC/FZS, 1997). Control of MCF is likely to be an important factor in the equation, favouring a strategy of sustained wildlife and livestock co-existence.

## RECOMMENDATIONS FOR EPIDEMIOLOGICAL RESEARCH

In addition to research into MCF vaccines, epidemiological studies could provide a valuable contribution to addressing animal disease and land-use problems in Ngorongoro District. The lack of quantitative epidemiological data on the impact of livestock diseases has been a major factor hampering livestock development initiatives in Ngorongoro. Although this problem has long been recognised (Field *et al.*, 1988), only limited studies have been conducted in Ngorongoro District over the past 15 years. A veterinary research programme has recently been initiated by Sokoine University of Agriculture, Tanzania, with support from NORAD, and specific epidemiological studies conducted on tick-borne diseases (Integrated Tick and Tick-Borne Disease Study) and zoonotic infections (e.g. DFID-funded studies on rabies and brucellosis). However, still lacking are longitudinal studies generating case-incidence data that will permit quantification of the relative impacts of different diseases on livestock production, pastoralist poverty, and wildlife health.

A study to investigate the impact of salt provisioning in Loliondo Division may provide a useful first intervention trial, which may reduce the incidence of MCF in some parts of the district, as well as providing quantitative data on the effects of reduced MCF mortality on herd productivity. Modelling approaches, for example using the Savanna programme, are also likely to provide a powerful tool for exploring the impact of MCF control measures, including vaccination, and to assess the relative importance of different factors in determining demographic and environmental change.

Collaborative studies that combine epidemiological approaches, economic analysis and land-use modelling are likely to generate particularly valuable data that will assist decision-making by pastoralists, wildlife managers and land-use planners in Ngorongoro District.

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## APPENDIX I

### Demographic Data

Village	Division	Ward	Perceived Category of Risk for MCF	Estimated Human Population (Ward Totals) <sup>∞</sup>	Percentage of total cattle in the district*
Loliondo	Loliondo	Orgosorok	Low		2.50
Sakala	Loliondo	Orgosorok	Low		1.67
Olorien	Loliondo	Orgosorok	High		4.61
Enguserosambu	Loliondo	Orgosorok	High	14,539	3.89
Arash	Loliondo	Arash	High		4.72
Loosito	Loliondo	Arash	High	9,364	2.44
Soit Sambu	Loliondo	Soit Sambu	High		2.22
Oloipiri	Loliondo	Soit Sambu	High		1.12
Ololosokwan	Loliondo	Soit Sambu	High	10,679	2.22
Malambo	Sale	Malambo	High		5.02
Piyaya	Sale	Malambo	High	9,605	3.61
Pinyinyi	Sale	Pinyinyi	High		0.97
Engaresero	Sale	Pinyinyi	High	5,590	2.21
Oldonyosambu	Sale	Oldonyosambu	Low	3,308	2.68
Sale	Sale	Sale	Low	3,537	2.27
Digodigo	Sale	Digodigo	Low		1.77
Kisangiro	Sale	Digodigo	Low		1.19
Samunge	Sale	Digodigo	Low		2.52
Mugholo	Sale	Digodigo	Low		1.51
Yasi/Mdito	Sale	Digodigo	Low	10,783	1.03
Endulen	Ngorongoro	Endulen	High		5.83
Esere	Ngorongoro	Endulen	High	8,326	3.49
Kakesio	Ngorongoro	Kakesio	High		1.29
Osinoni	Ngorongoro	Kakesio	High		1.92
Meshele	Ngorongoro	Kakesio	High	3,002	3.96
Oloirobi	Ngorongoro	Ngorongoro	Low		2.60
Emisigiyo	Ngorongoro	Ngorongoro	Low	12,283	4.07
Naiyobi	Ngorongoro	Olbalbal	Low		5.50
Ngoile	Ngorongoro	Olbalbal	High		2.76
Kapeyiro	Ngorongoro	Naiyobi	Low		2.23
Nainokanoka	Ngorongoro	Nainokanoka	Low		2.01
Alaililai	Ngorongoro	Nainokanoka	Low		8.13
Butali	Ngorongoro	Nainokanoka	Low		3.22
Irkeepus	Ngorongoro	Nainokanoka	Low	19,334	2.83
<b>TOTAL</b>				<b>100,351</b>	

<sup>∞</sup> Human population size estimated from government census data (1988) projected at a growth rate of 3.9% per annum (Bureau of Statistics, 1991).

\* Distribution of cattle determined from vaccination records held at the District Veterinary Office.

## APPENDIX II

### **Brief Notes on Cattle Diseases Discussed in the Participatory Rural Appraisal Including Associations with Wildlife**

(Maasai terms for each disease are given in parentheses)

#### **Anaplasmosis**

Anaplasmosis is a tick-borne disease of cattle, caused by the rickettsia *Anaplasma marginale*, which has a wide distribution throughout the world. It is characterised by initial high fever and progressive anaemia. Post-mortem findings include yellow discolouration of internal organs, enlargement of the spleen and distension of the gall bladder with thick brownish-green bile. Some confusion arose in this study about the definition of the Maasai term, *Olodwa*, which is traditionally used to describe rinderpest, but in some households was apparently also used to describe an anaplasmosis-like disease with bile staining.

#### **Anthrax (*Emboru*)**

A fatal disease affecting domestic and wild animals, caused by the bacterium, *Bacillus anthracis*. Anthrax can affect a wide range of game animals and sporadic outbreaks has caused high mortality in impala, zebra and elephants in the Serengeti National Park and Tarangire National Park (TANAPA, 1999). The epidemiology of the disease, particularly in wildlife, is still poorly understood in East Africa. In this study, the disease was not perceived by Maasai to be associated with wildlife. Vaccines are available to control the disease but vaccination occurs only sporadically in Ngorongoro District.

#### **Blackquarter**

Blackquarter is an important cause of cattle death in tropical areas and is caused by the bacterium *Clostridium chauvoei*. The disease has an acute course and animals are often found dead, which can make the disease difficult to distinguish from anthrax. The Maasai tend to use a single term to encompass both anthrax and blackquarter, and in this study, they have been analysed as a single disease entity.

#### **Bovine Cerebral Theileriosis (*Ormilo*)**

Bovine cerebral theileriosis is a fatal tick-borne disease of cattle characterized by nervous signs, which has emerged over the past two decades as an important disease of cattle in the Arusha and Tanga regions of Northern Tanzania. Recent molecular studies have identified *Theileria taurotragi* as a causal agent of the disease (Lynen *et al.*, 2000). Studies are underway to elucidate the epidemiology of the disease in Tanzania Maasailand. Matrix-ranking in this study indicated that some Maasai perceived an association between *Ormilo* wildebeest and buffalo.

### **Contagious Bovine Pleuropneumonia (*Orkipie*)**

A disease of cattle caused by the bacterium *Mycoplasma mycoides*. Symptoms include pneumonia, accelerated respiration, coughing, anorexia and a rough coat. Until recently confined to the north of Kenya, the disease is now increasing in many parts of east Africa. Mortality rates are high in herds with no previous exposure and severe outbreaks have been documented in recent years in Loliondo Division. Control strategies are now being introduced and coordinated through the OAU/IBAR Pan-African Control of Epizootics (PACE).

Although CBPP occurs in areas where wildlife and cattle co-exist, there has been no conclusive evidence for wildlife involvement in the epidemiology of the disease. During a recent outbreak, post-mortem signs typical of CBPP were observed in buffalo on the borders of the Serengeti National Park (Mr. Miran, pers. comm), but the disease was not confirmed. In the matrix-ranking exercise, Maasai consistently identified a link between CBPP and buffalo. Further research may be warranted to explore the possibility of infection and transmission in buffalo.

### **East Coast Fever (*Oltikana*)**

A serious and widespread tick-borne disease caused by the parasite *Theileria parva* (*parva*), which poses a severe constraint to cattle production in east Africa. Tick control, vaccination and chemotherapy are the three main methods in the control of East Coast fever. With the deterioration in facilities for dipping cattle in Ngorongoro and an increase in the cost of acaricides, there has been an increasing reliance on chemotherapy for treatment. Effective methods of vaccination have been introduced recently in Ngorongoro District through the Integrated Tick and Tick-Borne Disease Project, Arusha (Lieve Lynen, pers. comm) and a disease control method involving natural infection and treatment has been investigated as part of a VetAid Project in Simanjiro District (Chris Daborn, pers. comm).

ECF is a cause of high calf mortality in Ngorongoro District, but as a result of endemic stability, mortality in older cattle is relatively low. Although buffalo are known to be reservoirs of Corridor Disease, caused by *T. parva* (*lawrencei*), the role of buffalo in transmission of ECF to cattle in Ngorongoro is thought to be minimal (Machange, 1997). In the PRA study, ECF was associated with buffalo by one Maasai group.

### **Foot-and-Mouth Disease (*Orkerobe*)**

A highly infectious and rapid-spreading viral disease of domestic and wild ungulates. It is widespread in Tanzania and has been recorded in Ngorongoro District for many years. African buffalo are a natural reservoir for the SAT types of the FMD virus and it is assumed, but never demonstrated, that buffalo populations in East Africa are a potential source of infection for cattle. A recent outbreak of clinical disease was reported in wildebeest in the Serengeti National Park (TANAPA, 2000). In this study, pastoralists associated the disease with both buffalo and wildebeest.

### **Rinderpest (*Olodwa*)**

A highly contagious virus that is a major threat to cattle and wildlife populations in Kenya and many other African countries. Large-scale vaccination of cattle in northern Tanzania introduced in the 1950s has resulted in successful control of the disease in cattle and wildlife for much of the past 40 years, indicating that cattle were the reservoirs of infection. The recent re-appearance of rinderpest in northern Tanzania caused widespread alarm, but intensive efforts by PARC with the assistance of Tanzania National Parks (TANAPA) appear to have contained the disease. In this study, Maasai perceived a weak association between rinderpest and wildebeest, buffalo and eland.

### **Trypanosomosis (*Ndorobo*)**

A disease of man and domestic animals caused by species of the protozoan parasite, *Trypanosoma*. Infection is transmitted by tsetse flies. Trypanosomes infect a wide range of wildlife species, many of which are natural hosts for the parasite and show no clinical signs of disease. In cattle in Ngorongoro, trypanosomosis is usually seen as a chronic debilitating disease characterised by loss of body weight, lethargy, enlargement of superficial lymph nodes and anaemia. Generally, pastoralists in this study did not attribute infection in cattle with transmission from wildlife, but considered that movements of elephants and buffalo may contribute to an increased disease incidence by attracting large numbers of tsetse flies into an area.

### **Other Diseases Described by Maasai during the PRA**

- Emoyian Oong'oilin* A fatal disease of small ruminants transmitted from Thomson's gazelle causing lacrimation, reddening and protrusion of eyes. Possibly infectious keratoconjunctivitis.
- Narok kutuki* A fatal disease spread by monkeys, possibly through faeces, to cattle, sheep and goats. Clinical signs are similar to MCF but Maasai additionally report a lymphadenopathy. Disease incidence varies seasonally. The disease was reported only by the Loita and Purko clans in the north of Ngorongoro District.
- Osingiri* A disease caused by water toxicity as a result of fish being crushed by cattle feet, described by Maasai in Soit Sambu and Ololosokwan in Loliondo Division.
- Engayonkwenye* A disease reported by one respondent in Arash causing jaundice with paleness in internal organs.
- Ormoko* A disease in cattle causing lymphadenopathy and tumour-like lesions.