Use of participatory epidemiology in studies of the persistence of lineage 2 rinderpest virus in East Africa

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In 1994, rinderpest virus of African lineage 2 was detected in East Africa after an apparent absence of more than 30 years. In 1996, a disease search, based on participatory epidemiological techniques supplemented by serological and virological analyses, was undertaken in southern Somalia and northeastern Kenya to collate past and current epidemiological information about rinderpest-compatible disease events, and to test the hypothesis that African lineage 2 rinderpest virus persists in populations of transhumant cattle in the Somali ethnic areas. The findings in Afmadu in Lower Juba led the search for rinderpest to the communities in the Barardera area and then on to the Kenya/Somalia border areas between Mandera and El Wak. The herders had a specific knowledge of the clinical signs of rinderpest and provided detailed and accurate descriptions of cases. They differentiated between classical acute rinderpest and a milder syndrome characterised by an ocular discharge and diarrhoea, few oral lesions, corneal opacity and occasional mortality. The studies provided evidence for the endemic occurrence of rinderpest back to at least 1981, with a periodicity of five years in the incidence of the disease. After a period of high mortality in 1992 to 1993, around Afmadu, herders reported a milder disease, with occasional increases in mortality, from other areas of Lower Juba and the Gedo Region. Reports by herders of a rinderpest-compatible disease in the El Wak area were pursued until active cases were located and rinderpest was confirmed.

Molecular characterisation of rinderpest viruses distinguishes three viral lineages of clear epidemiological significance—a single Asian lineage and two distinct African lineages (Barrett and others 1998). From the limited material archived in the past 40 years, lineage 1 (Africa) appears to have been generally restricted to eastern Africa. However, representatives of this clade spread from the Sudan into eastern Nigeria and were present in Egypt in the early 1980s, during the last great African rinderpest pandemic. In contrast, lineage 2 (Africa) was formerly widespread in West and eastern Africa, and was represented by viruses from Nigeria in 1958 and by surviving strains of viruses circulating in Tanzania and Kenya in the 1950s and 1960s (T. Barrett, personal communication). Notable members of this group are RB74, isolated from cattle in northern Tanzania in 1960 (Plowright 1963) and RGK1, isolated from a reticulated giraffe in north-east Kenya in 1962 (Liess and Plowright 1964). In the late 1970s and early 1980s the virus that spread eastwards from Mauritania and Mali to western Nigeria was probably lineage 2, whereas lineage 1 viruses crossed from Sudan to eastern Nigeria. Together they were responsible for the rinderpest pandemic that engulfed most of sub-Saharan Africa at that time (Nawathe and Lamorde 1983).

From the 1960s to the 1990s, all the rinderpest viruses retained from outbreaks in eastern Africa belonged to lineage 1, including those isolated in Ethiopia in the early 1990s. Virus of lineage 2 was not recognised again until 1994 and subsequently, when it was detected causing epidemiologically linked outbreaks of rinderpest in wildlife, primarily buffaloes, lesser kudu and eland, and in and around Tsavo and Nairobi National Parks in southern Kenya (Barrett and others 1998, Kock and others 1999).

African lineages of rinderpest virus can cause high mortality in certain wildlife species (primarily buffalo, lesser kudu and eland) and in cattle, but there is substantial evidence, going back to the early 1900s, for the existence of strains which either cause less severe disease or possibly even cause no clinical signs in cattle (Robson and others 1959, Plowright 1963, 1998, Branagan and Hammond 1965, Taylor and Watson 1967). Although the phenomenon of lower virulence for cattle is not restricted to lineage 2 viruses it has been most clearly demonstrated for viruses of the clade in East Africa, as in the case of lineage 2 rinderpest virus isolated from an eland in Nairobi National Park, Kenya, in 1996 (C. Dunn, cited by Barrett and others 1998). In the early 1960s there were several outbreaks of rinderpest in the area north and east of the Tana River in eastern Kenya (Stewart 1964)—an area which yielded the RGK1 lineage 2 virus from a giraffe in 1962, a virus fully virulent for cattle. However, rinderpest has not been confirmed in north-eastern Kenya since then, although a retrospective analysis indicates that there is sufficient historical, clinical and serological evidence to suggest that outbreaks of what could have been rinderpest of varying severity did occur in the livestock of ethnic Somali herders. As a result, the authors postulated that the African lineage 2 rinderpest virus might have survived in Somali herders’ cattle as a pathogen of lower virulence for cattle, but occasionally causing severe, fatal epidemics in wildlife—a hypothesis which identified cattle as the reservoir host and wildlife as indicator hosts.

The mechanisms that allowed lineage 2 viruses to escape detection in eastern Africa for more than 30 years need to be investigated in the context of the effort to eradicate rinderpest from Africa—the Pan African Rinderpest Campaign (PARC) and its successor the Pan African Programme for the Control of Epizootics (PACE)—executed by the Organization of African Unity’s Inter-African Bureau for Animal Resources, with European Community funding. This paper describes the application of participatory disease search methods, based on established participatory rural appraisal (PRA) techniques (McCracken and others 1988), in combination with strategic laboratory diagnostic support, to clarifying the epidemiology of lineage 2 rinderpest in eastern Africa. The objective of the study was to collate historical and current epidemiological information about rinderpest-compatible disease events, in order to test the hypothesis that lineage 2 rinderpest virus persisted during that period in populations of transhumant cattle in the Somali ethnic areas of eastern Africa. A rinderpest-compatible disease event is one in which the herd develops clinical and epidemiological signs consistent with rinderpest, either the severe classical disease or milder forms.
**Virological techniques**

**Rinderpest virus detection** Swabs were tested by the agar gel immunodiffusion test (AGIDT) at the Kenya Agricultural Research Institute, National Veterinary Research Laboratory, Muguga, Kenya (the Muguga Laboratory).

**Rinderpest serology** The cattle sera collected in 1992 were screened at the Muguga Laboratory in a microtitre virus neutralisation test (VNT) (Mariner and others 1990) at a final dilution of 1/20 and positive samples were titrated in a two-fold dilution series. Goat sera from 1996 were tested at the World Reference Laboratory for Rinderpest by a competitive ELISA. All the tests were carried out as described by Anderson and others (1996).  

**RESULTS**

The open-ended interviews conducted by the ICRC began with the identification of the respondent and a general question about animal health problems in his cattle. In order to avoid bias, rinderpest was not mentioned until the subject was introduced by the respondents. Whenever a respondent introduced the subject of rinderpest he was asked to describe the disease, and if he could not describe it accurately, the report was eliminated. The accounts were analysed for specificity and internal consistency, and cross-checked with other independent reports. Only specific reports which gave dates and locations, and indicated contact herds by name or community, were used. Vague statements that were not supported by specific accounts of contacts with affected animals and clinical descriptions were discarded.

Reports that met the above criteria were divided into four categories: (i) a first-hand report from a herder concerning morbidity or mortality due to rinderpest in his own herd; (ii) a first-hand report of clinical cases observed by a veterinarian or veterinary assistant; (iii) a report of cases directly observed by a cattle herder; and (iv) a second-hand report or hearsay from veterinarians, herders, public officials or elders who did not actually see the disease. This category was used to assist the team in selecting locations for further study, but the information was not used in the construction of maps and timelines.

The interviewers found that cattle herders in the Lower Juba locations of Afmadu and Kolbio consistently reported rinderpest to be a major cause of mortality at the time of the interviews. Serum samples were collected from 83, 10- to 24-month-old calves from herds recently affected by rinderpest. The herders reported that the calves had not been vaccinated against rinderpest and no rinderpest vaccination markings were evident. The VNT results are shown in Table 1; 23 of the 83 calves were seropositive for rinderpest. They came from four locations: Afmadu, Kogani, Tapa and Badhaade.

**Sampling for diagnostic confirmation**

Serum samples were collected from cattle at sites in Lower Juba during the 1992 investigation. In 1996, when mild rinderpest-compatible field cases were encountered at Fino, Hashino, Alunga and Warengara, ocular and nasal swabs were also collected from the cattle. In addition, serum samples were collected from 80 goats in communities near the outbreaks, but not in direct contact with affected cattle.
Aframdu, the site with a seroprevalence of 45 per cent, is more than 125 km from the Somali-Kenyan border (Fig 1). The relationship between the herders’ reports and positive serology is shown in Table 2. The positive predictive value of the herders’ reports of rinderpest ranged between 31 and 60 per cent, being higher the shorter the time that had elapsed since the reported outbreak; however, this trend was not statistically significant. The aggregate positive predictive value of the herders’ reports was 39 per cent.

### The 1996 disease search

#### General findings

The search began at Afmadu in the Lower Juba region which was the site of the most extensive rinderpest-compatible event known to have occurred in cattle in the region. Tracing the outbreak forward and backward in time from Afmadu led the search to the communities in the Bardera area and border areas between Mandera and El Wak – all Somali ethnic areas. The sites of interviews are shown in a sketch map of the Ethiopia, Kenya and Somalia border area (Fig 1). The individual reports in categories (i) to (iii) were tabulated and mapped to build a general view of the past and recent incidence of rinderpest in the region. Building an agreed temporal and spatial view was a major component of the triangulation process, in that the construction of maps, tables and timelines made it easy to determine whether the reports were consistent or contradictory. The annual rinderpest reports from 1980 to 1996 are shown in Table 3 for the three areas Afmadu-Marere, Bardera and Mandera-El Wak, and the periodicity of the reports is illustrated in Fig 2. Table 3 shows the numbers of respondents that accurately described rinderpest and gave internally consistent accounts of having personally observed severe rinderpest, mild rinderpest or a rinderpest-like disease (a rinderpest-compatible event) in each year. The ARMA model rejected the null hypothesis that the aggregate timeline represented white noise (P<0·01) and found that the disease occurred in an approximately five-year cycle (Fig 2).

In total, 194 adult cattle herders, officials and veterinary staff were interviewed in 66 interviews, giving an average of 2·9 respondents per interview. Individuals often reported several events or an incident spanning several years, but 16 did not report any occurrence of rinderpest. Fifteen of these were in three interview groups in the Bardera area and the other was a man in his early twenties interviewed with his father near Mandera. As these 16 did not make a report, they were not requested to describe rinderpest and it was not known whether they could describe the disease. In the Afmadu-Marere group there were 12 interviews; 46 respondents were interviewed at 10 of them which were held in the area immediately surrounding Afmadu, and three respondents were interviewed at two interviews conducted at Mareere on the Juba River about 90 km to the east of Afmadu. In the Mandera-El Wak group there were 37 interviews; 97 respondents were interviewed at places where El Wak was the closest major town, and seven respondents were interviewed at five interviews held at places closer to Mandera, along both sides of the Kenya-Somalia border.

Almost all the livestock herders and other key informants, regardless of their age, could describe rinderpest accurately. Only two respondents who gave reports of rinderpest-compatible events gave contradictory or inaccurate descriptions of the disease. Of 66 interview groups, 65 (98·4 per cent) gave accurate descriptions of rinderpest. The clinical signs mentioned in order of precedence were an ocular discharge, diarrhoea, death, oral lesions, and in some cases skin lesions. Young animals were much more likely to be affected. The most popular local name in Somali was ‘shifow’, which refers to the ocular discharge. Other names that specifically refer to rinderpest were ‘madobeye’ (Somali) and ‘daadi’ (Gurreh). Non-specific Somali terms associated with rinderpest signs were ‘el waren’ and ‘hardik’ that refer to ‘a poke in the eye’ and ‘bloody diarrhoea’, respectively.

#### Afmadu-Marere area

The descriptions of rinderpest at Afmadu, and of classical, historic disease in other areas included death as a key component. In the Afmadu area, 46 respondents stated that rinderpest had been a cause of high mortality in 1992. Thirty-four of them stated that cases began to appear in December 1991 and one reported that the outbreak persisted into early 1994. They all stated that rinderpest was not causing problems at the time of the interviews in February 1996. The reports stated that the disease was travelling from the west to the east and was introduced through contact with cattle of the Mohamet Zubir clan coming from the west as a result of an extensive drought. Subsequently, three interviews were conducted at Mareere on the Juba River. The respondents stated that they were aware of the rinderpest between Liboi and Afmadu, but that the disease had not
reached their communities. The last outbreak of rinderpest mentioned at Marere was in 1987.

Bardera area There were first-hand reports of relatively recent rinderpest-compatible events in the El Wak area. Transhumant informants interviewed along the Juba river stated that they had encountered rinderpest of moderate mortality at a well (Fafadun) in the direction of El Wak and in grazing areas to the west and north of it in Somalia in the years 1994 and 1995. Eight former veterinary staff members, seven representing Bardera and one representing El Wak, were interviewed at Bardera as a group. They had been assigned to various parts of Somalia before the civil disturbances of 1990. Seven of them expressed the opinion that rinderpest had been present in Somalia in recent years, but the eighth stated categorically that classical severe rinderpest had last occurred in Somalia in 1974. When the seven respondents were asked to substantiate their view, two gave first-hand reports (category ii) of having observed rinderpest directly, the first in the Badhaade and Huluaqa area in the extreme south in 1985, and the other at El Wak in 1994/95.

Sedentary and nomadic cattle herders along the Juba River 20 km to the north and south of Bardera gave first-hand reports of rinderpest for the years 1986, 1981 and 1974. These reports cross-checked with others from the area and previous reports obtained at Afmadu. There were no first-hand reports of active or recent disease relating to the Bardera area itself.

Three first-hand reports (two category i and one category ii) of recent rinderpest-compatible events that occurred in the El Wak area, and which cross-checked, were received during interviews conducted in the Bardera area. Other detailed described outbreaks of severe rinderpest in the El Wak area were received from herders and from the governor of El Wak, Somalia.

Mandera-El Wak area At Mandera and in its vicinity, an extensive outbreak of rinderpest with high mortality was reported to have occurred between 1981 and 1983. All the Mandera respondents who were of a mature age in 1981/83 described outbreaks of severe rinderpest.

In both the Bardera and the Mandera-El Wak areas, descriptions of a recent disease syndrome highlighted diarrhoea and an ocular discharge. Some livestock herders referred to this disease as ‘shifow’ (rinderpest) whereas others categorised the problem as ‘el waren’ or ‘hardik’. When this issue was questioned at El Wak and the nearby towns of Garsal and Warengara, the consensus view of elders, local veterinary personnel and livestock herders was that the present disease might be rinderpest (‘shifow’, ‘madobeye’ or ‘daadi’). However, because it did not kill the affected animals, they found it difficult to make a definitive statement. Some respondents described the disease in their own language as ‘mild rinderpest’ or ‘rinderpest-like’.

As the search was carried south on both sides of the border reports were received of the recent occurrence of mild cases of rinderpest (‘shifow’ or ‘madobeye’) or other rinderpest-compatible disease (‘el waren’ or ‘hardik’). At Fino, Kenya (N 3°22′58″, E 41°19′11″) on April 14, 1996, livestock herders reported an ocular discharge and diarrhoea in young calves less than one year old. Of three calves examined, all three had marked epiphora, one had a unilateral corneal opacity, one had diarrhoea and one had slight oral erosions. Four more cases were encountered later at Hashino, a grazing area about 10 km distant (N 3°27′19″, E 41°09′11″). All four had epiphora (Fig 3), three of them had oral erosions or ophthalmic lesions on the muzzle, lips and medial canthus, and one had bloody diarrhoea. Ocular swabs from one of the animals at Fino and one of those at Hashino were positive for rinderpest antigen in the AGIDT.

Subsequently, animals were observed with marked ocular discharges, unilateral corneal opacity, sporadic oral erosions, and diarrhoea in youngstock and occasional adult animals, in one herd at Lalay, two at Fino, two at Alunga (N 3°02′37″, E 41°02′98″) and two herds at Warengara (N 3°24′49″, E 41°00′56″). The distribution of the clinically affected herds is shown in Fig 1.

**DISCUSSION**

The identification of the cause of the epidemic of rinderpest in wildlife in Tsavo National Park in 1994 as African lineage 2 rinderpest virus indicated that the source was not linked to known foci of rinderpest persistence, and emphasised the need for a specific search for rinderpest disease to define the origin of the virus. This search needed a reappraisal of all the clinical events that could be suggestive of rinderpest, especially the mild form. The results presented here represent the initial findings of a continuing investigation. The extensive and repeated reports of mild disease in cattle, with occasional moderate to severe epidemic flare-ups, linked to supporting
FIG 3: Epiphora in an otherwise clinically normal calf infected with rinderpest virus

serology and antigen detection indicates that the Somali ethnic areas visited have contributed to the maintenance of rinderpest throughout at least the 1980s and 1990s. The more severe waves of disease, such as that at Afmadu in 1992, appear to have been associated with periods of stress and increased mobility due to drought. As no viral genetic material was isolated, it cannot be stated that the virus is of the same lineage as that which caused the serious outbreaks in wildlife in Kenya. However, the apparently endemic nature of the mild, sometimes moderate, rinderpest in southern Somali livestock, combined with the occurrence of more readily detectable epidemics in wildlife should guide rinderpest control strategies in East Africa.

In the present study there were clusters of rinderpest-compatible events at four main periods and in two main areas. These were 1981/83, 1985/88 and 1991/93 in the Afmadu area, and 1991/96 in the El Wak area. No reports were received from the areas visited for the year 1984, and 1985 was mentioned only by one respondent. The year 1988 was mentioned by two independent groups of respondents at one location: Garsal, Somalia, near Bardera. The focus of activity shifted from these southern areas in 1985/87 to the more northerly area around El Wak in 1986/88. The peak year for reports from both the Afmadu and El Wak respondents was 1987, as opposed to 1986 in Bardera. The ARIMA time-series model first determines whether there is a significant pattern over time and then determines the periodicity of the pattern. It then corrects for the periodicity detected, and examines the data for long-term trends such as an increase or decrease in prevalence. Assuming that the conditions remain essentially unchanged, the model can be used to predict future values in the data series on the basis of the previous pattern. The time-series analysis revealed a highly significant aggregate pattern of reports with an approximate periodicity of five years, indicating that waves of rinderpest can be expected to occur with this periodicity, provided that background epidemiological factors such as partial or sporadic coverage by vaccination and climatic conditions remain unchanged. The statistical significance of the pattern of the rinderpest time-line and the pattern’s conformity to basic epidemiological concepts indicates that the herders were providing genuine descriptions of actual disease events.

That the 1991/93 cluster of events in the Lower Juba (Afmadu) area was truly rinderpest is supported by the prevalence of antibodies in unvaccinated young cattle. No animals had been vaccinated in this region of Somalia for two years before the samples were collected, owing to the severe civil disturbances. Residual maternal immunity is unlikely to have accounted for more than a small fraction of the seropositive animals, because the youngest animals sampled were 10 months old and the titres ranged up to 1/512. On the basis of contemporary herders’ reports and serological evidence, an aggressive rinderpest vaccination campaign was undertaken by the humanitarian relief effort in Somalia in 1993/94, after which the respondents at Afmadu reported no further rinderpest-compatible events.

The trail of events that led to the 1991/96 cluster of reports in the El Wak area was pursued until active cases for laboratory diagnosis were located. Informants from as far away as Bardera indicated that the area north of El Wak was a focus of active rinderpest, and laboratory confirmation of rinderpest in two affected herds substantiated the herders’ reports. The fact that all the 80 goats were seronegative is of no significance because small ruminants do not appear to be good sentinels for mild rinderpest in cattle. The results agree with the results of serosurveillance in northern Tanzania in 1997 where less than 2 per cent of 1627 goats were seropositive whereas 15 per cent of 1261 cattle in the same villages had seroconverted to the field infection (Taylor and others 2002).

The results of the present study are fully applicable only to the areas that the study team visited. Although the respondents gave some information about other areas where they had grazed or about herders with whom they had had contact, the evidential link is too weak to draw conclusions. However, the information suggested that there was a broader area of non-stable endemicity and provided ‘leads’ for further epidemiological research and investigation. The rinderpest detected at Fino and Hashino was not the end of the trail. Further field studies should be carried out in adjacent areas, particularly to the south and between the Juba and Shebelle Rivers.

This study was conducted to help to formulate eradication strategies, and it is therefore important to relate the information obtained to other published and unpublished rinderpest disease events of epidemiological significance. At the outset of Joint Project 15, a previous international rinderpest eradication effort, Atang and Plowright (1969) observed that three confirmed outbreaks of rinderpest had occurred in eastern and north-eastern provinces of Kenya in 1967 and that the disease was ‘more or less continuously present’. Since then, the published record occasionally depicts rinderpest ‘footprints’ in the region. Before the 1994 Kenyan Tsavo outbreak, the last confirmed case of rinderpest in eastern Kenya had been in an eland in Kinna, Eastern Province in 1973 (Rossiter and others 1982). The same paper presented evidence of rinderpest antibody in 35 of 425 samples of serum collected from Kenyan wildlife during the 1970s, and suggested that the undetected circulation of virus was the most plausible explanation. Wafula and others (1982) reported that seven of 28 waterbuck and four of 10 impala from the Nakuru and Naivasha area of the central Rift Valley of Kenya were seropositive, and that seven of 55 oryx from Galana in eastern Kenya were seropositive. The paper does not give information about the age of the animals or collection dates, but postulates that there may have been an unrecognised morbillivirus circulating in the region. Frequent but limited vaccination programmes limit the value of cattle serology in the detection of the virus in the Somali ethnic areas of Kenya.

A major epizootic of rinderpest occurred in 1981/83 in northern Tanzania (Rossiter and others 1983). The source of this outbreak has never been satisfactorily defined. Kenya has been suggested as the source (Nyangye and others 1985), but it is necessary to rule out the occult persistence of virus in Tanzania during the period leading up to the 1981/83 outbreak (Nyangye and others 1985). Extensive serological evidence of the circulation of rinderpest virus in populations of small ruminants and buffalo in northern Tanzania during the
mid and late 1980s was reported by Anderson and others (1990).

Corresponding to the 1981/83 cluster of events in eastern Africa, there were reports from Oman in April 1983 to the Office International des Epizooties (OIE) concerning the arrival of a dhow from Somalia with eight clinical cases of rinderpest aboard, one of which died (OIE 1983a) and these reports were followed by reports from the mid-1980s on the mainland (OIE 1983b, S. Routledge, personal communication). Anecdotal reports which cannot now be substantiated suggest that there were two later instances (in 1988 and 1992) of clinically affected cattle arriving in the Yemeni ports of Hodeidah and Aden, purportedly originating from eastern Africa (M. Al Qadassi, personal communication), and initi- ating local outbreaks. It is perhaps significant that in this study rinderpest-compatible events were detected in both these years, and particularly in 1992. The most recent episode of rinderpest in trade cattle was reported through the Gulf Cooperation Council in 1998 and involved the refusal of entry to Dubai (UAE) of clinically affected cattle described as originating from Kismayo (Roeder 1998). Rinderpest viruses originating from the Arabian Peninsula are poorly represented in the archive, but none of the five, not even the two from Yemen isolated in 1981 and 1995, was of African lineage.

The authors know of no published data from Somalia between the last reported outbreak in 1974 and the present. Government archives are almost certainly no longer available, and for the more northerly Somali communities in Ethiopia and Somalia, information is very limited. However, all the available evidence suggests that rinderpest virus has not circulated there for many years. In this study, the respondents clearly identified the Ogaden as a source of infection in 1981, but the north was not mentioned. The authors do not possess data from the mid-1980s. The studies made by Catley and Mohammed (1995, 1996) in the Sanaag region of Somalia, references to rinderpest were strictly historical. One of the present authors (J. C. M.) made a survey in the Berbera and Hargeisa areas of Somalia in January 1993 and found no evidence of active or recent rinderpest. In the last five years, the PARC has made a number of local serological studies, collecting thousands of samples in the Ethiopian Ogaden around Harer and as far south as Gode. These have been uniformly negative (A. Gopilo, personal communication) as have the results of rinderpest surveillance activities in southern Ethiopia (A. Gopilo, G. van’t Klooster, personal communication). It therefore seems probable that these areas did not contribute to the rinderpest reservoir at that time.

The importance of the Somali cattle population in the maintenance of lineage 2 virus was discussed by Barrett and others (1998). Atang and Plowright (1969) divided rinderpest in East Africa into epidemiologically distinct northern and southern foci. The northern focus was characterised by a highly fatal disease caused by a virus of the RGT1 strain (Plowright 1982) which causes about 60 per cent mortality (Liess and Plowright 1964); it was isolated during an epidemic in the Tana River area (Stewart 1964). The southern focus involved both cattle and wildlife but was characterised by a mild disease in cattle with transitory diarrhoea and mouth lesions detected only with difficulty; the RBT1 strain was said to be representative of the southern focus. Both the RBT1 strain and RGT1 strain are now known to be members of lineage 2 and this is further evidence of the variable pathogenicity of the virus. With respect to the mild forms of rinderpest, Atang and Plowright (1969) stated that it is hardly likely that such a benign and immunising disease would be reported by the stockkeepers; it would have to be searched for by persistent and careful observers.

Disease surveillance and the design of animal health interventions is increasingly supported by the collection of animal health information through participatory appraisals (Inter- national Institute for Environment and Development 1994, Catley 1999, Marinier and Paskin 2000). Southern Somali respondents, some as young as 15 years old, gave detailed and accurate descriptions of rinderpest, having developed this knowledge through first-hand experience. The clinical term ‘shifow’ in its strictest usage was compatible with classical virulent rinderpest and included death as part of the description. The association of the syndrome including an ocular discharge and occasional or transitory oral lesions and diarrhoea with ‘shifow’, combined with some individuals’ reluctance to draw definitive conclusions, indicated a sophisticated and prudent approach to clinical diagnosis. There was a relationship between herders’ reports of rinderpest collected in 1992 and the serological findings on the associated sera. The positive predictive value of herders’ reports in this endemic setting indicates that they are epidemiologically important tools for the detection of rinderpest. The positive predictive value for the aggregated data suggests that in the Somali setting five reports of rinderpest from independent but epidemiologically related sources are diagnostic of rinderpest 90 per cent of the time (P=1–[0·61]5). To put these values in perspective, standard clinical case definitions for pertussis used by physicians have a positive predictive value of about 70 per cent (Patriarca and others 1988).

Unilateral corneal opacity in cattle was associated with the clinical syndrome detected in Mandera. Corneal opacity was also observed in affected cattle during investigations of the outbreak of rinderpest in Tanzania in 1997, and ocular lesions have been observed recently in African buffalo calves in Kenya (Kock and others 1999, Rossiter 2000). However, no causal relationship has been established, and it is therefore not known whether the corneal opacity represents a primary rinderpest lesion or is the result of a secondary infection, possibly an exacerbation of an intercurrent infection (Scott 1964). It has long been known that rinderpest can cause bilateral corneal opacity and blindness as prominent clinical signs in kudus and giraffes, but it has been stated categorically not to occur in cattle (Plowright 1982). It would seem prudent to include corneal opacity in the case description of rinderpest for surveillance programmes in East Africa until more definitive information is available: at worst, it would slightly increase the size of the suspicious category.

The severity of disease and the pathogenicity of specific viral strains in individual species observed during natural outbreaks and experimental infections are variable characteristics (Plowright 1963, Branagan and Hammond 1965, Anderson and others 1990). Furthermore, the rinderpest virus does not spread between susceptible species in all field outbreaks (Taylor and Watson 1967). These observations suggest that there are partial barriers to its transmission between susceptible species, and that a combination of circumstances is required for at least some rinderpest strains to spread between cattle and wildlife or between wildlife species. As a result, field outbreaks of rinderpest vary in severity and often involve only a subset of the susceptible species.

Given the progress in the worldwide eradication of rinderpest, it is essential that rinderpest surveillance techniques should be sensitive enough to detect all the foci involved in the circulation of rinderpest virus, whether or not they are accompanied by severe clinical disease. It is becoming clear that remote and marginalised pastoral communities have served as the final reservoirs of rinderpest in Africa (Mariner 1996). Owing to its high cost, the lack of access and slow transport, there is scarcity of laboratory-based data on the epidemiology of rinderpest in remote areas. As a result, traditional laboratory data do not give an adequate account of the epidemiological picture and may be misinterpreted. The results of this study illustrate the significant contribution that participatory epidemiology, supported by laboratory testing, can make to the clarification of rinderpest epidemiology, by
providing epidemiological information to bridge the gaps between events detected by more conventional means.

To be effective in the final stages of the disease’s eradica-
tion rinderpest surveillance must be sensitive, specific and
timely. The surveillance system should incorporate tech-
niques to meet these three requirements. Methods of search-
ing for the disease are needed that detect a high percentage of rinderpest-compatible events (stomatitis-enteritis out-
breaks) for further investigation (Mariner and others 1998).
The participatory epidemiological approach is a powerful and
efficient field technique that warrants adoption by the Global
Rinderpest Eradication Programme to complement the conven-
tional surveillance methods.

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