A PARTICIPATORY EPIDEMIOLOGIC STUDY OF CONTAGIOUS BOVINE PLEUROPNEUMONIA IN LAPUR DIVISION TURKANA DISTRICT, KENYA

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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This thesis has been submitted for examination with our approval as University supervisors.

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DEDICATION

Dedicated to all my teachers

ABSTRACT

A participatory study of the epidemiology of contagious bovine pleuropneumonia (CBPP) (*loukoi)* was carried out in Lapur Division of Turkana District in four grazing groups (*Adakars*) namely, Narakibuk, Ng'isaricho, Ikong and Eipa *Adakars.* The study was carried out with four specific objectives: 1) to determine the capacity of livestock keepers to diagnose CBPP; 2) to estimate the morbidity and mortality rates in cattle due to CBPP; 3) to assess the socio-economic impact of CBPP relative to other important diseases; and 4) to identify the best-bet options for improving CBPP control.

A participatory appraisal research methodology was used in the data collection process in March and April 2002. A serological survey was incorporated to test the CBPP status of the animals. Semi-structured interviews, matrix scoring, proportional piling and trend-lines were carried out with informants who included elders, women and young men/herders. Rinderpest (*lokio*), anthrax (*enomokere*), CBPP (*loukoi*), rabies (*long'okuo*) and ear infection (*lokit*) among others were the list important or priority cattle diseases generated by informants. *Lokio, enomokere, long'okuo* and *lokit* were the 'controls' while *loukoi* was the disease of interest.

Analysis of matrix scoring of clinical signs and post-mortem lesions against diseases demonstrated good agreement between the 12 informant groups (Kendall's coefficient of concordance (W) values between 0.680 to 1.000). The livestock keepers associated lacrimation, diarrhoea and salivation with *lokio* by assigning more scores to these clinical signs. Madness or aggressiveness was associated with *long'okuo* and *lokit.*

Herders associated swollen lymph node (unilateral on the head region) and sudden death with *lokit* and *enomokere* respectively. During matrix scoring exercise, livestock keepers associated *loukoi* with coughing, dyspnoea, yellow fluid in the chest cavity and lungs adhering to the chest cavity, which are the signs and lesions inexperienced professional will look for to make a presumptive diagnosis if the case in question is CBPP or not. However, results of the laboratory CFT, field CFT and the owner diagnosis for the last six months when compared using Kappa statistic, showed the following: There was fair to good agreement between field CFT and laboratory CFT - Kappa value 0.615 (0.333 to 0.897 at 95% CI), poor agreement between laboratory CFT and owner historical diagnosis based on clinical signs for the last six months - Kappa value 0.179 (-0.115 to 0.473 at 95% CI) and poor agreement between field CFT and owner historical diagnosis for the last six months - Kappa value 0.196 (-0.096 to 0.488 at 95% CI).

It is important to note that the results of owner historical diagnosis of *loukoi* were likely to be biased for two reasons: 1) The livestock keepers expectations of assistance in drugs and vaccines provision because examined animals if found sick were treated and this could have prompted them to present animals that were not necessary sick and 2) Livestock keepers recall bias, as the results were retrospective in nature. The author's assessment of cattle presented by livestock keepers for clinical examination for CBPP status were not showing any clinical signs of CBPP (Appendix xiv). The owners' opinion of cattle thought to have suffered from *loukoi* from previous six months were not suffering from *loukoi* during March and April 2002 (Appendix xiv) indicating a perfect/excellent agreement beyond chance (Kappa = 1.000) between the veterinarian and livestock owners. In conclusion it is the writer's opinion based on narratives of clinical signs and post mortem lesions of *loukoi*, analysis of matrix scoring of clinical signs and postmortem lesions against diseases and believes on transmission of the same disease, that the capability of livestock keepers to diagnose *loukoi* is good. It is only the laboratory tests, which can redefine CBPP status of suspected cases where a 'gold standard test' is absent.

According to the perceptions of livestock keepers the annual morbidity rate due to *loukoi* was estimated at 12.1% (10.59 to 13.6% at 95% CI), using proportional piling methodology with 57 herds/informants in the year 2001-2002. The annual mortality rate due to *loukoi* was also estimated at 8.1% (6.9 to 9.3% at 95% CI) year 2001-2002.

Livestock keepers ranked *loukoi* second to *lokio* in terms of diseases that cause both social and economic losses. *Long'okuo, enomokere* and *lokit* were ranked third, fourth and fifth respectively. Analysis of losses versus diseases demonstrated good agreement between the 12 informant groups (Kendall's coefficient of concordance (W) values between 0.474 to 0.764) for indicators like milk, meat, fat, dowry and hides among others. However the results showed weak agreement between the 12 informant groups (W value of 0.179) for the indicator 'sale value' which was not significant according to the critical values $p<0.05$). The assessment of losses was carried out using indicators which pastoralists could understand in their local language i.e. milk, meat, blood, dowry, calves, and hides among others.

Good agreement was evident among the six informant groups concerning the associations of prevention and control methods of *loukoi* and the indicators i.e. low

financial cost, effectiveness, user friendliness, group action and individual action (W Values of 0.459 to 0.861). In general informants agreed on vaccination as the best option in the prevention of *loukoi* by assigning most scores. 'Community-enforced quarantine' and peace were ranked second and third respectively as other important prevention methods. Modern drugs and traditional herbal remedies were ranked almost as equal methods in terms of frequency of use in the control of *loukoi*. Trend-lines of *loukoi*, veterinary drugs and vaccines delivery 'levels' from 1978 to 2002 demonstrated that pastoralists perceive *loukoi* as an endemic disease in the study area.

The results of this study demonstrated that participatory appraisal was a useful, practical and valid research methodology, especially in a pastoral setting where there are very limited facilities, poor infrastructure and alarming levels of illiteracy.

CHAPTER 1

1.0 INTRODUCTION

Turkana District is located in the northern part of the Rift Valley Province of Kenya. The district borders Uganda (West), Sudan (North), Ethiopia (Northeast), West Pokot District (Southwest), Baringo District (South), Samburu District (Southeast) and Lake Turkana (beyond which is Marsabit District) on the East. The district is divided into 17 administrative divisions, 56 locations and 158 sub-locations. The population of Turkana District was estimated at 450,860 people, in 1999 occupying an area of 77,000 sq. km., with a density of one person per 7 sq. km. (Central Bureau of Statistics, 2001).

The district is an arid and semi arid land (ASAL); 97% of the district falls under arid and the very arid agro-climatic zones (V and VI) (Pratt and Gwynne 1977). About three percent (zones III and IV) of the district's landmass, can be regarded as suitable for rain fed cultivation (Turkana District Development Plan, 1997-2001). The lowest rainfall is recorded in the central plains around Lodwar, with an annual rainfall of 120mm, while the highest rainfall is experienced in the northwest area around Lokichoggio, which averages 430mm. The rainfall pattern is irregular and unreliable. The temperatures are extremely high (daily average range of 24-38°C). There is relatively little vegetation cover to stabilize the soils and so they are easily eroded. Only a small part of the district's soils may have potential for irrigated agriculture. There is a wide range of vegetation within the district; (from barren land to evergreen forest), the most abundant type is deciduous annual grassland (with scattered dwarf shrubs, shrubs and trees)(Herlocker *et al.*, (1994).

The people of Turkana practice nomadic pastoralism and livestock is the main source of livelihood. However, they practice some form of crop agriculture along the riverbeds where sorghum is grown. Gulliver (1951) noted that livestock is not just a means of livelihood for the Turkana people but also part of the mechanism of ritual and mystic affairs. Livestock are the very core of life to all the people, involved in their labour, happiness, worry and disasters. With the failure of rain, livestock productivity declines slowly at first and thereafter, more rapidly. As livestock deaths increase and households break up, old people and children are the first to grow sickly and serious hunger sets in (Bush, 1995).

The livestock population of Turkana District was estimated at 175,000 cattle, 2.4 million sheep and goats, 137,000 camels and 32,000 donkeys (Ministry of Agriculture & Rural Development (MA&RD), 2000). Prolonged and severe drought in the year 2000 left many animals dead mainly due to starvation. Contagious bovine pleuro-pneumonia (CBPP), contagious caprine pleuro-pneumonia (CCPP) and trypanosomosis (in cattle and camels) are endemic in the district (MA&RD, 2000). Pastoralists do appreciate alternative (modern) disease control strategies through prophylaxis (e.g. vaccinations) or treatment. They do, however, resent having such interventions at times when their animals are stressed, as happens during drought (African Technology Development Link, 2001). Wanyoike (1999) reported that vaccination coverage for CBPP in Turkana District has been poor (0-40%, between 1989-1998). A suspected outbreak of CBPP was reported at Lokiriama in Loima Division bordering Uganda in March 2000 (African Technology Development Link, 2001). Nevertheless, 667 animals were diagnosed as suspected CBPP cases and treated in Lokichar, Kakuma, Lokichoggio and Alale by Community–Based Animal Health Workers (CBAHWs)(Intermediate Technology Development Group, 2000).

Gathuma (2000) in a recent rapid rural appraisal in Turkana District reported that the community identified insecurity, lack of water for irrigation, lack of sorghum seeds, inadequate human health, inadequate animal health and lack of schools as their main problems. Regarding animal health issues, the community singled out CCPP and CBPP as the major livestock disease constraints in the district. Contagious bovine pleuropneumonia quarantine has been in force in Turkana District since 1966. This means that cattle from the district are only allowed to move to Nairobi/Kiambu for immediate slaughter, thus restricting the market outlets (African Technology Development Link, 2001). According to African Technology Development Link (2001), Turkana District report, the community has suggested the creation of awareness among pastoralists and livestock traders on methods of disease transmission/spread and control measures particularly on CBPP. The same consultants reported that the areas, which are at great risk of CBPP, appear to be Kibish, Lokichoggio, Oropoi, Kakuma and Loima divisions since they are located along the international borders. The MA&RD (2000) report clearly stated that there was no vaccination against CBPP during the year 2000.

In recent years, CBPP has moved from endemic areas to reinvade new areas from which it had previously been eradicated (FAO, 1997a). In addition to these newly infected areas even the endemic areas, have been experiencing new outbreaks of CBPP (FAO, 1997a). In Kenya, about 70% of cattle are found in ASALs (Ministry of Agriculture Livestock Development & Marketing, 1994). Meat, milk and blood are important sources of protein from animals that are raised under the pastoralist production system in the ASALs and it is in these areas that CBPP is thought to be endemic (Masiga and Domenech, 1995).

Mariner (2001), has proposed that participatory epidemiology and disease modelling can be used as a means of studying the dynamics of CBPP in endemic pastoral settings and develop more practical control strategies. To date, some progress has been made in the understanding of the dynamics of selected diseases in the pastoral setting through participatory epidemiologic studies. Examples of such studies exist for rinderpest (Mariner and Flanagan, 1996), trypanosomosis (Catley and Irungu, 2000) and mixed parasitism (Catley *et al.*, 2001). Contagious bovine pleuropneumonia (CBPP), Foot and mouth disease (FMD) and vector-borne diseases are of higher priority to livestock owners on day-to-day basis. These diseases, especially CBPP, warrant study with methods appropriate to the realities of the pastoral setting (Mariner, 2001).

This study encouraged community participation such as interactive participation (co-learning) and self-mobilisation (collective action). This was thought most likely to result in sustained benefits for livestock keepers.

The broad objective of the study was to describe CBPP, using participatory appraisal methods and recommend more appropriate strategies for its control. The specific objectives of this study were:

1) To determine the capacity of livestock keepers to diagnose CBPP;
2) To estimate the morbidity and mortality rates in cattle due to CBPP;
3) To assess the socio-economic impact of CBPP relative to other important diseases;
4) To identify the best-bet options for improving CBPP control.

CHAPTER 2

2.0 GENERAL LITERATURE REVIEW

Contagious bovine pleuropneumonia is endemic in many pastoral areas of Kenya including Turkana, West Pokot, Marsabit, Mandera, Isiolo, Wajir, Garissa, Tana River and Lamu districts (Wanyoike, 1999). Contagious bovine pleuropneumonia is the second most important trans-boundary livestock disease (after rinderpest) in eastern and southern Africa and a major threat to cattle raising in Africa (FAO, 1997b). In 1993, 23 African countries, including Kenya, were reported as having had CBPP outbreaks (Masiga and Domenech, 1995).

The incidence of CBPP is increasing in Africa (Nawathe, 1992; Sylla *et al*., 1995), where it remains a threat to food security. The spread of CBPP is predominantly associated with cattle movements and this makes its control difficult in Africa (Masiga and Domenech, 1995). Provost *et al*. (1987) noted that the traditional nomadic husbandry favoured the spread of the disease. The use of antibiotics and traditional medicines makes the problem more complex and serious. It is believed that the use of antibiotics and traditional medicines leads to generation of high proportion of 'lungers' (chronic carriers with sequestration in the lungs) in the herd and that these can later spread infection to susceptible cattle. This may be true but in most countries in which CBPP occurs antibiotic therapy is a fact of life (Guadagnini *et al*. 1991, Mlengeya, 1995, Bolske *et al*. 1995 and FAO 2002).

Immunity conferred by vaccines is short lived up to 8 months (Abdalla, 1975), 12 months (Dyson and Smith, 1975) and 2 years (Masiga and Domenech, 1995).

Following vaccination, some animals contract CBPP as a direct vaccination effect or as a reactivation of latent cases while others elicit unacceptable adverse reactions (Provost *et al.*, 1987). Carriers are difficult to detect, as the Office International des Epizooties (OIE) recommended test, Complement fixation test (CFT), has low sensitivity in detecting chronic carriers. Besides, CFT is cumbersome and time consuming, requiring well-trained personnel to carry out the test (Bashiruddin *et al.*, 1994; Provost *et al.*, 1987). Polymerase chain reaction (PCR) is a powerful tool, which can identify *Mycoplasma mycoides* subspecies *mycoides* Sc. in clinical material, obtained from disease outbreaks with in two days and can detect chronic cases (carriers) of CBPP with small amounts of organisms in nasal mucous, pleural fluid and pulmonary tissue (Bashiruddin *et al.*, 1994, Hoetzel, *et al.*, 1996). Clinically, CBPP is difficult to diagnose such that it is often ignored or misdiagnosed as simply a respiratory disease or some other disease (Blancou, 1996).

There is poor vaccination coverage in endemic and high-risk areas in Africa due to high costs and nomadic movements (Egwu *et al.*, 1996). FAO (1997b) has cited inadequate disease reporting by farmers and sometimes slow or inadequate action from field veterinarians and private practitioners, and the absence of early warning systems, to have made the problem worse. Masiga *et al.* (1996) have alluded at lack of data on the economic impact of CBPP as one of the reasons why the disease cannot be eradicated from Africa.

Continuing civil strive in some African countries and drought have had a significant impact on the spread of CBPP due to problems in control of cattle movements (Egwu *et al.*, 1996). Masiga and Domenech (1994) noted the inherent difficulties in controlling cattle movements, particularly in sub-Saharan Africa, and the complications of applying quarantine and slaughter policies.

2.1 Contagious bovine pleuropneumonia in Kenya

It is not known when the disease was introduced in Kenya although some sources (Davies, 1991) state that after its arrival in South Africa from Europe, CBPP spread into East Africa through the Boer settlers who trekked their cattle to the Kenya highlands around the turn of the 20^{th} century. Others believe it may have been present in pre-colonial times and cite Thompson's description of a cattle disease resembling CBPP in Maasai cattle in the 1880s in East Africa (Davies, 1991). African Technology Development Link (2001) reported that the prevalence of CBPP in the 10 Arid Lands Resources Management Project (ALRMP) districts appeared to be low as only sporadic cases were reported in some of the districts (the prevalence of CBPP is not known in ASALS of Kenya). Annual vaccinations against CBPP (carried out together with rinderpest vaccination) have no doubt contributed to the low prevalence. However, in the border districts, especially in Mandera, Turkana and West Pokot, there is evidence that CBPP was a major threat to the cattle industry. Serological results for CBPP of cattle screened before sale tend to support that evidence and call for proper epidemiological assessment of the disease in the country (African Technology Development Link, 2001).

2.2 The aetiological agent of CBPP

The *Mycoplasma* causing CBPP belongs to the class Mollicutes, order Mycoplasmatales, family Mycoplasmataceae, genus Mycoplasma and species *Mycoplasma mycoides* subspecies *mycoides* small colony variant (*MmmSc*) (Nicholas and Bashiruddin, 1995).

2.3 Clinical manifestation of CBPP

There is considerable variation in the degree of severity of clinical signs seen in cattle affected by CBPP, ranging from hyper-acute, through acute to chronic and sub-clinical forms. Respiratory distress and coughing, evident on stimulation of resting animals, are the main signs of CBPP (Scudamore, 1995). The incubation period of the natural disease may range from 5-207 days (Martel *et al.,* 1983). The disease is characterised by fibrinous interstitial pneumonia, pericaditis and pleurisy, with a morbidity of up to 70% and a mortality of approximately 60% (TerLaak, 1992; Provost *et al.*, 1987; Hall, 1977). There is also swelling, oedema and haemorrhages of thoracic lymph nodes (Scanziani *et al.*, 1997).

2.3.1 Hyper-acute form

This form occurs at the onset of an outbreak and death may be the only observation. In some cases, the animal may die after one to three days, with no signs of pneumonia. Death may result from asphyxia, toxaemia or heart attack (Masiga *et al.*, 1996).

2.3.2 Acute form

This form has a course of five to seven days. The early stages of the disease are indistinguishable from any severe pneumonia with pleurisy (Scudamore, 1995). The animals are listless with a staring, dull coat and they also look emaciated due to anorexia (Seifert, 1996).

2.3.3 Sub-acute and chronic forms

The sub-acute form occurs in 40-50% of the animals. Up to 25% of these cattle become chronic carriers, which are referred to as "lungers" and are believed to play a role in initiating new outbreaks when they are moved into susceptible herds (Radostitis *et al.*, 2000). This proportion is probably higher in Europe where there is far more widespread use of anti-microbials (Nicholas and Palmer, 1994). Antibiotics and anti-inflammatory drugs may be used to mask clinical signs and accelerate the formation of chronic lesions (Guadagnini *et al.* 1991). Symptoms may be limited to a slight cough only noticeable when animals are exercised, to intermittent fever and chronic emaciation (Blancou, 1996). Regeneration of the lesions may occur after several weeks and full recovery is exceptional while sequestered lesions and pleural adhesions remain. On the other hand Masiga *et al.* (1996) believe that after 36 months the lung lesion may get sterile and, depending on its size, there might be complete healing. Classical respiratory signs may be evident in calves, localisation in the limb joints of calves by the causative agent and arthritis usually predominate. Complications accompanying the disease may also include valvular endocarditis and myocarditis (Martel *et al.*, 1983).

2.4 Diagnosis of CBPP

2.4.1 Clinical diagnosis

Clinical diagnosis of CBPP is not particularly difficult in the acute form, but it can be difficult in sub-acute forms and completely impossible for chronic carriers (Lefevre, 1994). Furthermore, the use of anti-microbial or anti-inflammatory drugs can mask the clinical expression of the disease (Egwu *et al.*, 1996).

2.4.2 Post-mortem diagnosis

At post-mortem or at the abattoir, the lesions are very characteristic when acute exudative forms or chronic forms are present. Post-mortem diagnosis is therefore relatively easy, particularly within a relevant epidemiological context. However, subacute forms here again pose problems as the lesions can be confused with those of pasteurellosis or East coast fever (Lefevre, 1994). In carrying out a clinical and post mortem diagnosis, it is necessary to differentiate CBPP from other diseases, which may present similar clinical signs or lesions (FAO, 1997a) e.g. bacterial or viral broncho-pneumonia, Hemorrhagic septicaemia, Rinderpest, tuberculosis, East coast fever, foreign body pericaditis among others. Laboratory diagnosis is indispensable whenever CBPP is suspected (Lefevre, 1994).

2.4.3 Culture

The isolation of *MmmSc* from infected animals is essential for successful diagnosis of CBPP. While there are few exceptions, the growth of laboratory adapted *MmmSc* strains and detection of strains by culture, frequently underestimates the levels of infection (Miles, 1992). This is due to a number of factors; that include, relatively poor survival of *Mycoplasma* during transport, the poor adaptation of fresh isolates to in-vitro culture and to widespread use of antibiotics, which severely reduce the number of viable organisms in the samples. Isolation of *MmmSc* is followed by the identification of the pathogen through examination of its biochemical properties with serological confirmation, by growth inhibition and/or immunofluorescence tests with monospecific conjugates (Freundt *et al.*, 1979).

2.4.4 Serology

Among the diseases investigated in veterinary medicine, CBPP is one researched a lot through serology (Gourlay, 1983, Perreau, 1975). Numerous serological tests have been described over the last century. These tests include the slide agglutination

(Priestley, 1951), complement fixation (CFT) (Campbell and Turner 1953), agar gel precipitation (Gourlay, 1965), passive heamagglutination (PHA) (Chima and Onoviran, 1982) and polymerase chain reaction (PCR) (Bashiruddin *et al.*, 1994, Hoetzel, *et al.*, 1996).

2.4.4.1 Compliment fixation test (CFT)

The Campbell and Turner (1953) CFT is the recommended procedure by the OIE (OIE, 1996). Antibodies are detectable as from about 10 days after the onset of the disease and during the subsequent few months. In countries where vaccination is practised, a presumptive diagnosis of CBPP cannot be made, because the CFT can yield positive results for 3-6 months after vaccination (Hudson, 1971). The limitations of CFT are well known. With a specificity of 99.5%, the CFT can detect nearly all sick animals with acute lesions, (OIE, 2000). However as the process of sequestration takes place, the CFT becomes less sensitive (sensitivity 70%) and can fail to detect up 30% of the cases. In addition, therapeutic interventions and improperly conducted prophylactic operations (partial slaughter) may increase the number of false-negative reactions. However, for groups of animals (herd epidemiological unit) the CFT is capable of detecting practically 100% of infected groups (OIE, 2000). Despite the high specificity of the CFT, false-positive results can occur (less than 0.5%) of which an important cause is serological cross-reactions with other *mycoplasmas*, particularly other members of *Mycoplasma mycoides* cluster (OIE, 2000). The validity of the results has to be confirmed by post mortem and bacteriological examination, and serological tests on blood taken at the time of slaughter (OIE, 2000).

2.4.4.2 Enzyme-linked immunosorbent assay (ELISA)

ELISAs are inherently sensitive and are already being used for the diagnosis of CBPP. Enzyme-linked immunosorbent assay detects all antibodies to CBPP where the antigen consists of a lysate of *MmmSc*. Enzyme-linked immunosorbent assay can detect chronic cases due to the high sensitivity of the test, which is capable of detecting even traces of antibodies (Provost *et al.*, 1987).

In extensive evaluation of cattle using ELISA with a sonicated antigen, Onoviran and Robinson-Taylor (1979) and Le Goff (1986) showed clear distinction between infected and uninfected cattle. The agreement between the CFT and the competitive ELISA in a sero-prevalence study and in a vaccination trial in Ethiopia has been rated as good to excellent (Kappa=0.78) (Takele, 1998). According to Le Goff and Thiaucourt (1998), the two tests correlate well with relative specificity and sensitivity of more than 90%.

2.5 The epidemiology of CBPP

2.5.1 Modes of infection

The disease is transmitted by direct contact, and over small distances by the coughing animal, emitting droplets from the mucous membrane of pharynx, trachea and bronchi and from saliva or even micro-droplets of urine transported by an air current (Masiga *et al.*, 1972).

2.5.2 Species and breeds affected by CBPP

Under natural conditions, CBPP primarily affects cattle; rare natural cases have been observed in buffalo, yak, bison reindeer and antelopes (Radostitis *et al.*, 2000). *Bos taurus* and *Bos indicus* are equally susceptible (Masiga and Windsor, 1974 and 1975; Masiga *et al.*, 1996). Some breeds of Zebu such as Somba, the breed of coastal Benin, and the small Cote d'Ivoire breed, are resistant to naturally occurring CBPP. The Maasai breed of Tanzanian cattle is equally resistant, and 80-85% of them recover without treatment, whereas the European breeds and their crosses are more susceptible (Provost *et al.*, 1987, Seifert, 1996).

2.5.3 Age affected by CBPP

Provost *et al.* (1987) stated that calves up to six months of age respond poorly to inoculation of virulent pleural fluid, developing no more than slight, transient oedema and that numerous cases of poly-arthritis develop as a consequence. To this may be added cases of coronary valvular disease and myocarditis, encountered among calves less than three months old. At a later stage heifers respond weakly to vaccination but nevertheless become more resistant to experimental infection than adult cows.

2.5.4 Seasonal dynamics for CBPP

Season seems to play a role in stimulating infection, particularly the rainy season, when animals are exposed to cold weather (Provost *et al.*, 1987). Sudden changes of weather have been cited by Dennis (1986), as important factors in the spread of the disease and these may be more important than stable temperature and humidity, to which the animal may adapt. These changes may affect both the potential pathogen and the host

2.6 Economics of CBPP

Contagious bovine pleuro-pneumonia is economically the most important cattle disease in Africa, causing greater losses in cattle than any other trans boundary disease, including rinderpest (OIE, 1995). The direct losses, according to Mlengeya (1995), are attributed to mortality, vaccination campaign costs, disease surveillance and research programmes. Other direct and indirect losses are mainly due to the chronic nature of the disease and include loss of weight and decrease in working ability, reduced milk yield, delayed marketing, and reduced fertility, losses due to quarantine and consequent reduced cattle trade. In Kenya, the current cost of CBPP control to the Government, (both vaccinations and sero-surveillance) in the Arid Lands Resources Management Project (ALRMP) districts, was estimated to be about KShs.8.1 million annually (African Technology Development Link, 2001). However saving this would make at risk of infecting cattle population in the south with CBPP as they get exposed to the cattle from the north. At national level Kshs.19.2 billion annually was the estimated minimum annual loss that is prevented from the current system of CBPP control (African Technology Development Link, 2001).

2.7 Community participatory epidemiology and research

Community participation involves a balanced control of decision-making process, information and resources between outsiders and the community, with more involved types of participation, calling for local people to take ownership of development activities.

Plowright (1998) suggested that nomadic cattle owners can give uninitiated professionals a firm diagnosis of rinderpest and even passaged mild strains in recovered animals purposely to immunise their stock. Pastoralists can describe very well the disease entities afflicting their livestock. These descriptions often correspond with western notions but are profoundly richer (Akabwai *et al.*, 1994). Livestock owner interviews have been used in combination with serology during an assessment of the prevalence of bovine brucellosis and CBPP in Kongor Rural Council, southern

Sudan (McDermott *et al.*, 1987). Akabwai *et al.* (1994) have noted the indigenous veterinary skills, knowledge and good memory of the Turkana herdsmen. According to Mariner (1999), livestock owners should no longer be seen as an inert substrate upon which development is to be practised, since they are active participants who can bring important intellectual contributions to development.

Veterinarians and livestock workers have used and are currently using a wide range of participatory appraisal (PA) methods to investigate animal health topics. These methods include various scoring and ranking tools, and visualisation tools such as seasonal calendars, maps, Venn diagrams and flow diagrams (Cornwall, 1992; Waters-Bayer and Bayer, 1994; Catley, 1997).

2.7.1 Interviewing methods

Interviewing methods have widely been used during participatory surveys. Not only are they useful in their own right, but also they are often considered to be important components of other methods (Pretty *et al.*, 1995). Most, if not all, other PA methods involved interviewing skills and it was the follow-up questions asked after the completion of a diagram, map or scoring tool which provides the most insightful information.

2.8 Modelling for CBPP

Some authors consider modelling to be very important for veterinary epidemiology (De Jong, 1995) while others criticise the use of modelling (Stille and Gersten, 1978; Bart *et al.*, 1983). This criticism is partly due to the naive promotion of 'realistic' simulation models. The criticism may also be due to a lack of understanding by the critics how models can be useful as scientific theories (De Jong, 1995). Mathematical modelling is valuable for the study of complex phenomena, like the population dynamics of infectious agents, because models show how separate measurements can be seen as a manifestation of the same underlying processes. To build models that can act as connecting theories, careful model building is very important (De Jong, 1995). The gain of modelling is not the resulting model, but instead the insight into the population dynamics of infectious agents that is obtained in the process of model building and the model analysis on the one hand, and interpreting experimental and observational data on the other.

A central concept is that of basic reproductive rate of the infection R_0 (Anderson and May, 1991). The basic reproductive number (R_0) can be defined as number of secondary cases that arise from one infectious index case in a totally susceptible population. It is a key concept in measuring the transmissibility of an infectious agent in a population and has important consequences in regard to the dynamics of epidemics and endemism. In endemic population with low or no vaccination cover the value of R_0 can be calculated from the population that is susceptible to infection (Anderson, 1992). If the proportion of the susceptible is termed x then; $R_0 = 1/x$. A CBPP model can be developed that incorporates estimates of R_0 from serological data.

African Technology Development Link (2001) have modelled CBPP using a model adapted from the International Animal Health Code (OIE, 1998), used in the calculation of the so-called "unrestricted risk estimator". The unrestricted risk estimator (R) is basically an estimate of the risk of infection of healthy animals in the disease free region with a particular disease as the animals (i.e. livestock in this case) move freely from a disease endemic region into the non-endemic or disease free region.

CHAPTER 3

3.0 MATERIALS AND METHODS

3.1 Location of the study area

The study was carried out in Turkana District which lies between longitudes 34^0 0` and $36^0$ 40` East and between latitudes 10^0 30` and $5^0$ 30` North (Fig.1). It has an estimated total area of 77,000 sq km (the largest district in Kenya), which is 42 % of the total area of the Rift Valley Province. The district has 17 divisions and 97% of the area falls under arid and the very arid agro-climatic zones (V and VI) while about 3% (zones III and IV) of the district can be regarded as suitable for rain fed cultivation (Pratt and Gwynne, 1977). Most of the nomadic pastoralists keep the Zebu breed of cattle. Harsh climate, sparse and erratic rainfall conditions and recurrent droughts lead to widespread losses of livestock, destitution, starvation and death of people.

3.2 Selection of study sites

The study was carried out in March and April 2002 in Lapur Division in the northern part of the district (Fig.1). The division borders Kibish Division to the north, shares an international border with Ethiopia to the east, and Lokitaug Division to the south. The population of Lapur Division was estimated at 13,764 people, in 2001 occupying an area of 4652 sq. km., with a density of one person per 3 sq. km. (Turkana Development Plan, 2002-2008). The division receives a median annual rainfall of 200 to 300mm. The landforms comprises of mountains, hills, uplands, footslopes and piedmont plains. The vegetation type varies from deciduous bushland to deciduous shrubland.

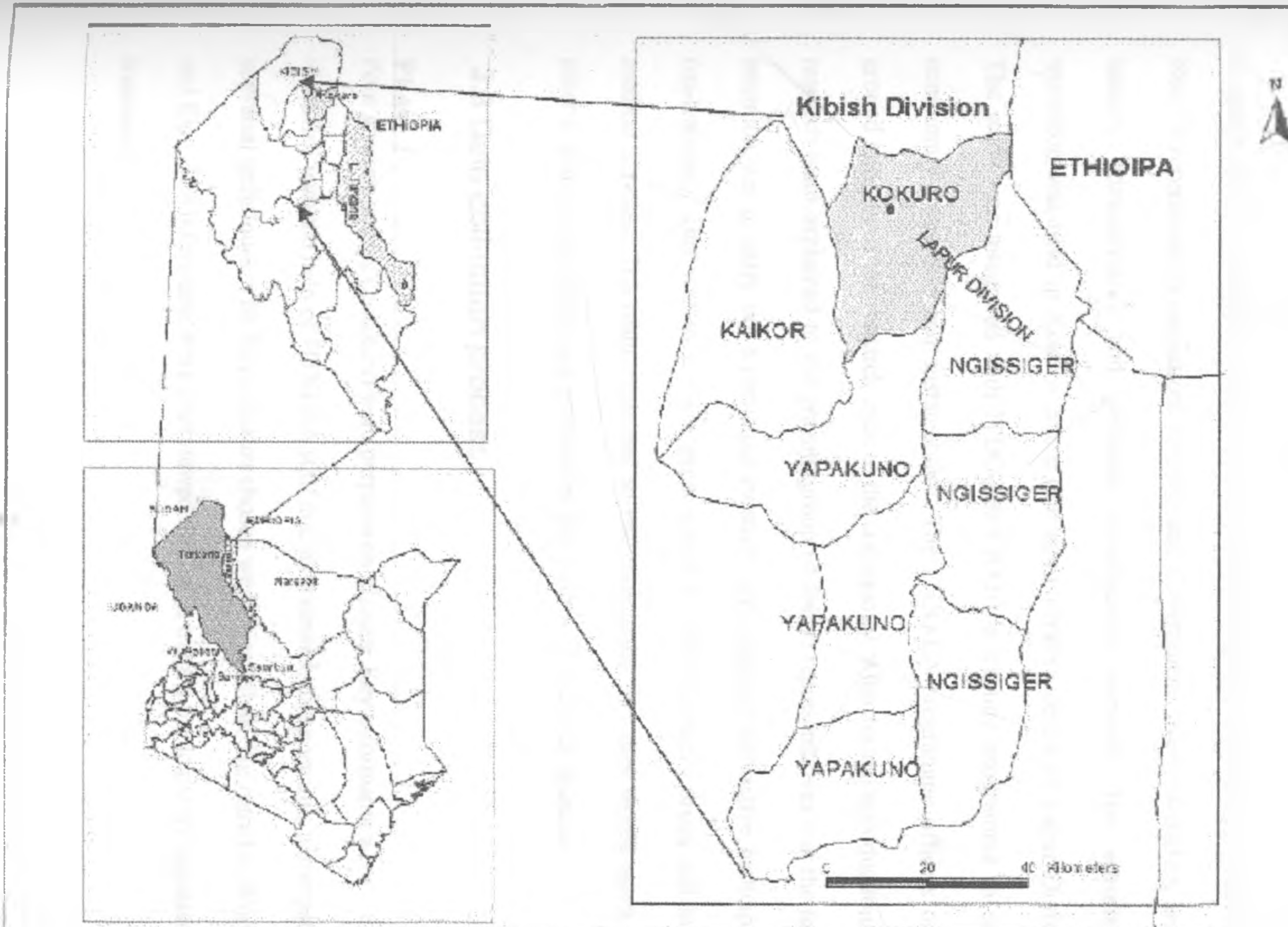

Figure 1: Maps showing the location of the study area, Lapur Division of Turkana District

Permissible forage biomass off-take is extremely low relative to total biomass production, with approximately 5% and 16% for the herb and shrub layer respectively (Herlocker *et al.*, 1994). Logistics, distances, facilities, migration patterns of the people and cattle, and insecurity influenced the location, design and execution of this study.

A sensitisation workshop was held where livestock keepers, veterinary personnel from Non-Governmental Organisations (NGOs) and Government, livestock-traders, women leaders, administrators and principal investigators attended. The sensitisation workshop was held in Kokuro centre (the administrative centre of Lapur Division). The study was integrated with ITDG-EA CBAHWs training programme to ensure community ownership and sustainability. The ITDG-EA programme officers on the ground introduced the research team to the community. After formal introductions, the research team explained to the grazing group (*Adakar*) representatives that the team's intention was to carry out a participatory study and expected interactive participation (co-learning). This was to prevent expectations of free veterinary drugs and human medical services. The team explained to the community that they would assist each other in learning the diagnosis, prevention and control of livestock diseases.

3.3 Data collection process

Phase I

Four grazing groups (*Adakars*) were purposively chosen. Key informants were identified with the help of ITDG-EA staff and interviewed, using various participatory appraisal techniques. The four *Adakars* chosen were; Narakibuk, Ng'isaricho, Ikong and Eipa. The informants were interviewed through a trained participatory appraisal translator.

Using participatory appraisal methods, adapted from Catley and Mohammed (1996), Catley and Irungu (2000) and Catley *et al.* (2001), the following activities were carried out:

3.3.1 Activity one: Participatory mapping

Livestock keepers chose a suitable sitting site where there was adequate shelter, either on a dry riverbed or under the 'tree of men' (a tree where men discuss issues during day time). Participatory mapping was carried out to define geographical boundaries of grazing groups (*Adakars*), herd mobility and movement patterns. A clean piece of open ground was selected. Mapping was done using locally available materials such as sticks and stones, by a group of informants comprising between 5-15 people. Herders were asked to produce a picture showing geographical boundaries of the grazing group (*Adakar*). The boundaries included the furthest places where they go to graze their animals. Herders were asked to describe cattle movements during the past year. They were asked to draw on the ground the main grazing areas and watering points they had moved to during the past year. The landmarks included market centres, rivers, wells, vaccination sites, sale points, plains, hills and ranges. The above method was also used to establish community structure and contact levels between sub-groups. One map per *Adakar* was developed (total, n=4).

3.3.2 Activity two: Matrix scoring to describe livestock keepers' perceptions of CBPP relative to other diseases

A semi-structured interview was first carried out to identify key informants (people who are knowledgeable in livestock diseases). An informant group comprised 5-8 participants who were elders, young men (herders) and women grouped in separate groups. Local names of diseases were listed. Clinical signs, causes (associations) and post mortem lesions as described by livestock keepers were used to develop a notion in veterinary medicine typology of cattle diseases versus Turkana typology of cattle diseases. Semi-structured interviews were carried out with key informants to identify local perceptions and beliefs on major cattle diseases concerning disease transmission.

A pair-wise comparison of diseases was carried out to generate a list of indicators (clinical signs and post mortem lesions which differentiate pairs of diseases). The author explained to livestock keepers that they were going to discuss in detail only five diseases they ranked to be important cattle diseases. Locally available materials such as bones, spent gun cartridges, sticks, leaves and dry cow-dung among others, represented the five priority diseases of cattle. These objects were placed on the x-axis and clinical signs and post mortem lesions written on cards, which were placed on the y-axis.

Contagious bovine pleuropneumonia (*loukoi*) was always the disease of interest to the author among the important or priority cattle diseases listed by livestock keepers. Rinderpest (*lokio*), anthrax (*enomokere*), ear infection (*lokit*) and rabies (*long'okuo*) were the controls since they comprised the list of other important cattle diseases and remained in the matrix so as to achieve a standard matrix. Livestock keepers used pebbles/stones to do the signs/lesions against diseases matrix scoring exercise. Twenty-five stones/pebbles were used in the diseases versus sign/post-mortem lesion matrix scoring exercise (Plate 1 and 2). Lines were drawn to delineate the matrixes on the ground. This exercise was repeated for all important clinical signs and lesions at slaughter. This exercise was repeated with at least two groups of informants per *Adakar* (total n=12).

Plate 1: Matrix scoring exercise with informants (a group of elders) of Lapur Division Turkana District (March/April 2002)

Plate 2: Matrix scoring exercise with informants (a group of women) of Lapur Division Turkana District (March/April 2002)

3.3.3 Activity three: Seasonal calendars

Seasonal calendars were used to describe the occurrence of priority cattle diseases in one calendar year. With no reference to any particular year, semi-structured interviews were used to describe Turkana seasons and lunar months in the Turkana language. Probing and triangulation were used to establish if Turkana months coincided with the Gregorian calendar. Turkana seasons represented by objects were placed on the x-axis. Diseases, written on cards, were placed on the y-axis. Fifteen stones were used in the scoring exercise of seasons versus cattle diseases. Elders comprised the key informants since they were the key decision makers in *Adakars*. This exercise was repeated in four *Adakars* with one key group of elders (n=4).

3.3.4 Activity four: Proportional piling

Proportional piling was used to describe local perceptions of morbidity and mortality rates due to CBPP in different age groups of cattle. Ten to twenty informants were chosen from each *Adakar*. Using semi-structured interviews Turkana pastoralists were asked to categorise their cattle into two groups; (1) calves and (2) adult stock. The proportional piling method was repeated with each of the two age groups and involved the following stages:

1.Using a pile of 100 stones/pebbles to depict each age group, the stones were divided to show the proportion/'pattern' of 'sick cattle during the last year' and 'healthy cattle during the same year by one livestock keeper. A year was defined as previous 12 months from March and April 2002.

2.The informant/livestock keeper then subdivided the pile of stones representing 'sick cattle' to show the proportions of cattle suffering from *lokio, loukoi, enomokere, lokit, long'okuo* and 'other diseases'.

3.Using the respective piles of stones representing 'sick cattle' from the above diseases the informant/livestock keeper was asked to show the proportion of those cattle, which died and survived from these same diseases listed above. This method was then repeated in different *Adakars* and up to a total of 57 informants participated in this exercise.

3.3.5 Activity five: Assessment of socio-economic impact of *loukoi* relative to other diseases

Semi-structured interviews were used to develop a list of products and uses of cattle. The 5 priority diseases namely, *lokio, loukoi, enomokere, lokit* and *long'okuo* were listed on the x-axis. Socio-economic losses/indicators, which were equivalent to the products or uses of cattle, were listed on the y-axis. Pair-wise comparisons of diseases were carried out to generate a list of losses/indicators. Locally available materials such as bones, spent cartridges, sticks, leaves and dry cow-dung, represented the five priority diseases of cattle. *Lokio, lokit, enomokere* and *long'okuo* were the controls. These objects were placed on the x-axis and then a corresponding socio-economic indicator was scored accordingly with the 25 pebbles provided. Lines were drawn to delineate the matrices on the ground. This activity was repeated with at least 3 groups of informants per *Adakar* (total n=12).

3.3.6 Activity six: Collection of blood samples

Full case history and clinical signs of 40 cases suspected of *loukoi* from 5 livestock keepers (total n=40) were recorded. A thorough clinical examination of the cases identified by livestock keepers was carried out. Thereafter, blood samples were collected from these 40 animals using plain vacutainers. The clots were allowed to separate from the sera in the open field under shade. The vacutainers were later transferred to a kerosene-powered refrigerator and stored overnight at 0-4^{0}C. After 12 hours the formed sera were carefully decanted into plain cryovials (Greiner® Bio-one Corp. Germany) and again stored in the refrigerator. The clots were discarded. The harvested sera were transported in the same refrigerator to Lodwar town and immediately stored in a deep freezer at-20^{0}C. Sera were later transported in a cool box, with dry ice, to Nairobi.

3.3.7 Activity seven: Determination of local preferences for preventing or treating *loukoi*

Semi-structured interviews were carried out to determine local preferences for preventing or treating *loukoi*. Different prevention and control methods were listed by livestock keepers, for example; vaccination using conventional vaccines, isolation of sick cattle/'community-enforced quarantine', slaughter of sick cattle, peace (prohibition of cattle rustling), use of modern drugs and herbal remedies. The indicators, which were used to rank the prevention or control options, included; effectiveness, low financial cost, user-friendliness, requires group action and individual acts alone. Each indicator was mentioned against control or treatment options and a score given accordingly. Where more stones were placed, it meant the method was the most preferred; where the least number of stones were placed, it meant the method was least preferred. This activity was repeated in different cattle camps with six informant groups comprising 5-8 members. In all the above data gathering activities, the following methods were used to check the validity of information:

1. Prolonged engagement of various groups of people in order to build trust and rapport.
2. Use of triangulation to cross-check information.
3. Participant checking methodologies.
4. Peer or colleague checking methods in order to expose the investigator to probing questions.
5. Expression and analysis of difference in participants to ensure equal representation of informants. The investigator ensured there were differences according to gender, age and class of informants.

3.3.8 Activity eight: Establishment of trend-lines for *loukoi,* veterinary drugs and vaccines delivery levels

A three day-stakeholders' workshop was convened where livestock keepers, veterinary personnel from NGOs and Government, livestock-traders, women leaders, administrators, principal investigators, and supervisors attended. During the stakeholders' workshop, the livestock keepers' representatives developed trend-lines for *loukoi*, Surra and veterinary service provision from year 1978 to the year 2002. Using semi-structured interviews a checklist was developed of important events/years in the lives of the livestock keepers. Triangulation was carried out to establish a concurrence of the mentioned events with calendar years from one of the indigenous literate chiefs. Years or events were put on the x-axis and levels of diseases and veterinary services availability were plotted on the y-axis, using approximately one metre stick. Plotting of points on the 'graph' was done using locally available objects. During the stakeholders workshop preliminary findings were presented and verified to the community representatives.

Phase II

3.4 Laboratory analysis of blood samples

3.4.1 Field Complement fixation test (Screening test procedure)

In the Central Veterinary Laboratories (CVL) at Kabete Field Compliment Fixation Test (CFT) was carried out according to the technique described by Huddart (1963).

In summary, fresh Sheep red blood cells (SRBC) were obtained and stored in 50% Alsever solution (Appendix XV) at + 4°C for two days. Before use the SRBC were washed thrice in normal saline (one volume of sheep red blood cells in 9 volumes of normal saline) at 1764g for five minutes.

Test sera were diluted 1:10, one drop of sera to nine drops of normal saline using a large dropper into a set of tubes. A known positive serum (Arc-Ovi South Africa) and a known negative serum (Arc-Ovi South Africa) were included as the controls. After dispensing each sample the dropper was washed thoroughly in several changes of normal saline. To inactivate the complement, test sera were incubated at 56°C for 30 minutes. Test sera were dispensed into U bottomed polystyrene CFT plates (Greiner® bio-one Corp. Germany).

Diluted antigen (Kenya Agricultural Research Institute (KARI) Muguga) was added at 1:60 as the working titre; followed by diluted Guinea pig complement (Central Veterinary Laboratories (CVL) Kabete) at 1:50 as the working titre.

The plate was incubated at 37 °C for 30 minutes. Sensitisation of sheep red blood cells was carried out using Rabbit haemolytic serum (Central Veterinary Laboratories (CVL) Kabete) to make a haemolytic system. Sensitised sheep red blood cells were added into the wells. The plate was incubated at 37 °C for 30 minutes and shaken at intervals of 10,20 and 25 minutes.

After completion of incubations the plate was removed from the water bath and tapped gently then it was set aside for 10-15 minutes and then read against a white background and degree of complement fixation assessed.

3.4.2 Laboratory Complement Fixation test

The sera were retested using the laboratory CFT, otherwise known as micromethod CFT, a standard operating procedure described by Le Goff and Thiaucourt (1995), which is an adaptation of the original method by Campell and Turner (1953).

In summary:

Reactives

The antigen (CIRAD-EMVT PATHOTROP-reference laboratory for CBPP, France) was used at dilution of two units per 25µl.

The test sera were tested at three dilutions: 1/10,1/20,1/40 at volumes of 25µl.

The reference serum CFT-CBPP (positive control) No. 99029 (CIRAD-EMVT France) was tested at doubling dilutions ranging from 1/10 to 1/1280.

The reference serum Arc-Ovi CBPP (negative control) (Arc-Ovi South Africa) was included among the reactives.

The Guinea Pig Complement reference: 72122 (BioMériux 69280 Marcy I'Etoile, France) was titrated and diluted to give a final concentration of 2.5 units at 25µl.

Fresh Sheep red blood cells (SRBC) were obtained and stored in 50% Alsever solution (Appendix XV). These fresh SRBC were kept at + 4°C for two days. Before use they were washed thrice in Veronal with calcium and magnesium (VCM) reference: 72171(BioMériux France)(Appendix XVI) by one volume of SRBC for nine volumes of VCM at 3136g for five minutes.

Haemolytic system containing 3% sheep red blood cell and six haemolytic doses 50% per 25µl was constituted. The haemolytic system was obtained by mixing equal volumes of the 6% suspension of SRBC with the diluted haemolytic serum Reference: 72202 Rabbit haemolytic serum (BioMériux 69280 Marcy I'Etoile, France).

Methodology

Sera, including the positive and negative control, were decomplemented at 56°C for 30 minutes in a water bath.

Titration protocol

A 1/100 dilution of the Guinea Pig complement was prepared in VCM. Then the following dilutions were made in 96 wells of U-bottom Polystyrene microplates (Greiner® bio-one Corp. Germany), all volumes are in µl.

Well No	1	2	3	4	5	6	7	8	9
1/100 Complement	10	15	20	25	30	35	40	45	50
VCM	40	35	30	25	20	15	10	5	0
Antigen (2U)	25	25	25	25	25	25	25	25	25

Mixing was carried out by flipping the plate gently and then placed at 37°C for 30 minutes, a haemolytic system was added as follows:

Haemolytic system	25	25	25	25	25	25	25	25	25

The plate was put on the plate agitator (Insel Hamble Ltd England) and incubated at 37°C with constant agitation for 30 minutes.

The following table gave the final dilution of the complement and well no. six (1:28) showed complete haemolysis.

Well No	1	2	3	4	5	6	7	8	9
Dilution	1/100	1/66	1/50	1/40	1/33	1/28	1/25	1/22	1/20

Distribution of sera and serum control

A one tenth dilution of each serum to be tested was prepared by transferring 20 μl of serum into 180 μl of VCM.

Twenty-five μl of VCM were distributed into the wells of rows A, C, D.

Twenty-five μl of diluted sera (1/10) were distributed into wells of rows A, B, C.

Good homogenisation was ensured in the wells of row C with a multi-channel pipette set at 25 μl and 25 μl was transferred into wells of row D. Good homogenisation was ensured by in and out suction and 25 μl was discarded.

Distribution of the reactives

Twenty five μl of diluted antigen was added into wells of rows B, C,D.

Twenty five μl of diluted complement into all the wells of rows A, B,C,D.

Reaction controls

For each set of reaction, four controls were included:

1) A known positive serum that was tested in various dilutions ranging from 1/10 to 1/1280
2) A known negative serum that was tested in various dilutions ranging from 1/10 to 1/1280
3) An antigen control:

Serum 0, Antigen 25 μl, Complement 25 μl, VCM 25 μl

4) Four Complement controls			
Serum 0	Antigen 0	Complement 25 µl	VCM50 µl
Serum 0	Antigen 0	Complement (1/2) 25 µl	VCM50 µl
Serum 0	Antigen 0	Complement (1/4) 25 µl	VCM50 µl
Serum 0	Antigen 0	Complement (1/8)25 µl	VCM50 µl

5) An haemolytic system control:			
Serum 0	Antigen 0	Complement 0	VCM 75 µl

First incubation

All plates were incubated at 37°C for 30 minutes. The plates were covered to prevent evaporation. While this incubation was going on the haemolytic system was prepared by mixing equal volumes of 6% SRBC and the 1/700 dilution of haemolytic serum.

Second incubation

Twenty-five µl of haemolytic system was added in every well and the plates were covered and incubated at 37°C for 30 minutes, with constant shaking.

Validation and interpreting results

1) Positive serum control: the inhibition of haemolysis occurred up to the expected dilution 1/28.
2) Antigen control: There was complete haemolysis.
3) Complement controls: There was complete haemolysis in the first two wells (pure and 1/2), partial haemolysis in the third well (1/4), traces of haemolysis in fourth well (1/8).
4) Haemolytic system control: There was no haemolysis.

Anticomplementarity control: There was complete haemolysis in this well

The degree of haemolysis observed for each serum dilution varied from 0 to +++, from no inhibition of haemolysis to a complete inhibition of haemolysis.

3.5 Data handling and analysis

Activity one: The participatory map drawn on the ground by livestock keepers was drawn by hand on A4 plain paper. This map was scanned using Scanjet® 5200 scanner (Hewlett Packard Corporation USA) and stored as pdf file in Adobe Acrobat Reader 5.0 (Adobe systems incorporated USA).

Activities two, three, five and seven resulted to standardised matrixes on the ground which were transferred into a note book as tables and other recorded notes. The quantitative data in form of tables were entered in Microsoft Excel® 2000 (Microsoft corporation USA) as spreadsheets. Data were saved as Microsoft Excel 4.0 worksheet in separate files. Data were imported from Microsoft Excel® to SPSS® version 11, 2001(SPSS® Inc. USA). Medians and range (maximum and minimum values were computed in SPSS® using the descriptive statistics menu. Levels of agreement between informants were computed using Kendall's Coefficient of Concordance (W) in SPSS® by the Non-parametric tests; K-related samples menu. According to critical values for W provided by Siegel and Castellan (1994) and assuming ranking of objects by judges (groups of informants), agreement between informant groups was categorized as 'weak', 'moderate' and 'good'. Agreement was termed weak, moderate, and good if W-values were less than 0.26, between 0.26 and 0.38 ($p<0.05$) and greater than 0.38 ($p<0.01$ to 0.001), respectively.

Data from activity four on proportional piling data were entered from a notebook into Microsoft Excel® and saved as Microsoft Excel 4.0 worksheets. Disease morbidity and mortality data were stored in Microsoft Excel® as separate files. Data were imported from Microsoft Excel® to SPSS®. Descriptive statistics were computed in SPSS®. Using the graphs – pie charts menu, pie charts were created and later edited in

SPSS® viewer window. Using the pivot tables and chart report menu, bar graphs and error bar graphs were created with the aid of chart wizard syntax in Microsoft Excel®.

Activity six: Case histories, clinical signs and laboratory results data were transferred from a note book to Microsoft Excel®. Data were saved as Microsoft Excel 4.0 worksheet as a single file. Data were then imported from Microsoft Excel® to SPSS®. Using the descriptive statistics-crosstabs menu, cross tabulations were created and Kappa statistics were computed in SPSS®. According to critical values provided by SPSS® Base10.0 applications guide (1999), values of Kappa greater than 0.75 indicated excellent agreement beyond chance; values between the 0.40 to 0.75 indicated fair to good and values below 0.40 indicated poor agreement.

Activity eight: Trend-line 'graphs' from the ground were drawn by hand on A4 paper. Using a 30-centimetre ruler, points on the graph were determined and transferred into Microsoft Excel®. Using the chart wizard option graphs were created to give trend-lines of CBPP (*loukoi*), veterinary drugs and vaccines delivery levels.

CHAPTER 4

4.0 RESULTS

4.1 Introduction

This chapter describes the results of the participatory epidemiologic study of CBPP (*loukoi*) in Lapur Division of Turkana District carried out between March and April 2002. The results give a community map, matrix scoring of diseases versus clinical signs and post mortem lesions, summarised notes from semi-structured interviews, matrix scoring of cattle diseases versus Turkana seasons, comparisons of laboratory results versus clinical case histories, proportional piling estimates of morbidity and mortality rates of diseases, matrix scoring of diseases versus losses, matrix scoring of prevention and control methods of *loukoi* versus indicators and finally trend-lines of *loukoi*, veterinary drugs and vaccines delivery levels.

4.2 Results of the various participatory appraisal activities

4.2.1 Description of the community map

Participatory appraisal techniques generated a community map, from the four *Adakars* namely, Narakibuk, Ng'isaricho, Ikong and Eipa.

The community map (Fig.2) shows the neighbours to be the Merilles, Toposas and Dong'iros. These neighbours are the 'enemies' of the Turkana and 'restocking' or cattle rustling is a common practice among the communities.

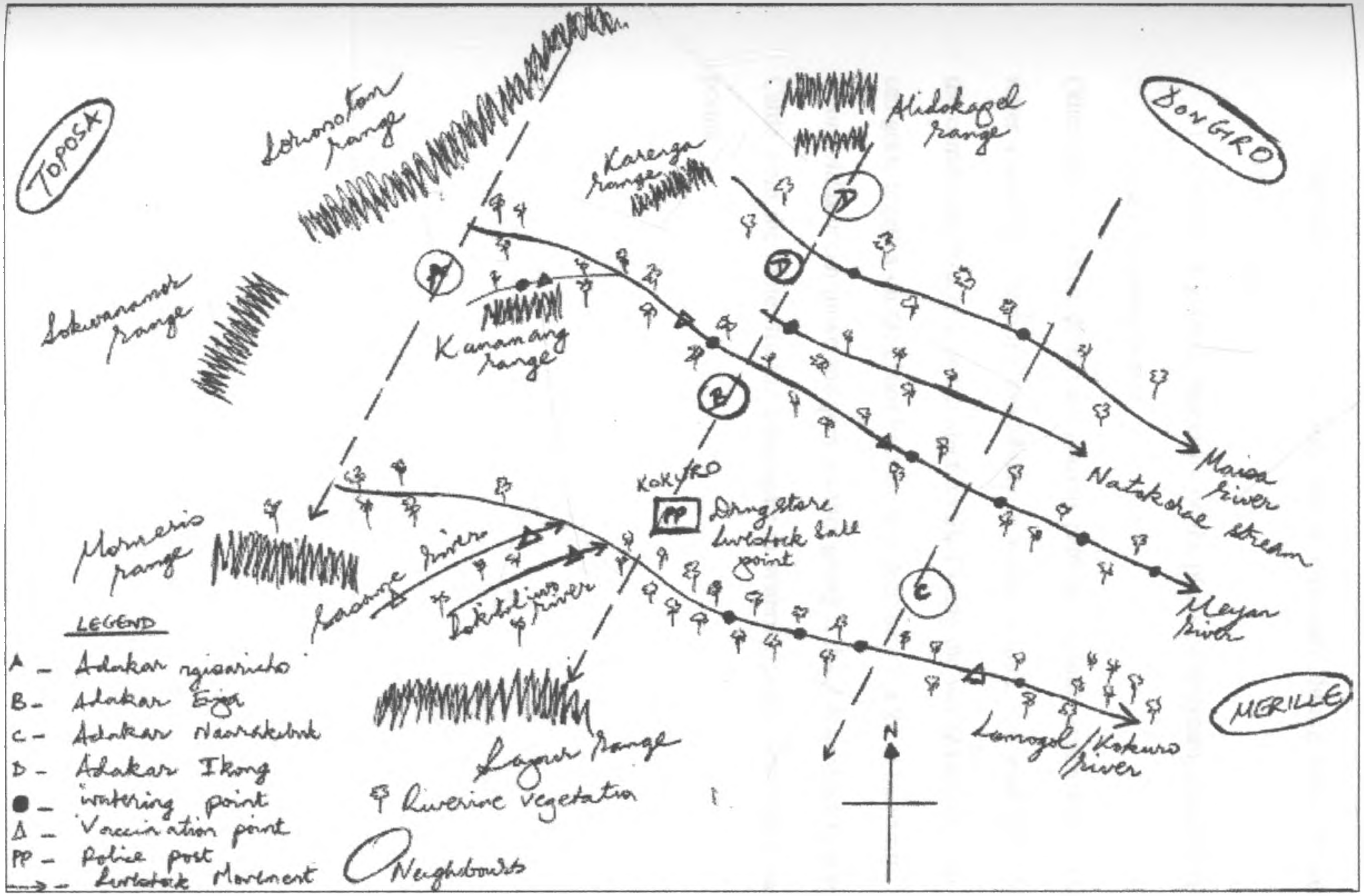

Figure 2: Map of Narakibuk, Ng'isaricho and Eipa *Adakars* of Lapur Division, Turkana District (March/April 2002)

Concerning the grazing patterns the community has 3 options;

1) Dry season grazing along the river-lines where there is a lot of pasture despite the threat of Merille livestock rustlers on the eastern side.

2) Dry season grazing on the mountains especially Lorionotom ranges where the community feels it is more secure especially during times of well-known livestock raids.

3) Wet season grazing, especially on the plains or upstream along the river lines, close to watering points.

Other factors, which determine grazing patterns, include: leadership, security, and water availability. Security, availability of water, pasture, and leadership determines the community structure and contact levels. During the wet season the four *Adakars* can graze together on the plains because they feel there is a lot of insecurity. Members of one *Adakar* can move and join another group if the *Adakar* leaders accept them. Cattle from the same *Adakar* congregate in watering points, kraals and vaccination points.

4.2.2 Matrix scoring to describe livestock keepers' perceptions of CBPP relative to other diseases

Semi-structured interviews were used to develop a list of cattle diseases, their clinical signs, post mortem lesions and associations of diseases (Appendix I). Turkana cattle disease names were translated into English/scientific names and associations with other factors as outlined in Table 1.

Table 1: Turkana names of cattle diseases and corresponding English/scientific names

Turkana names	Associations	English/scientific names
Logoroi	Associated with swelling of the neck	Hemorrhagic septicaemia
Enomokere	Associated with cutaneous form of anthrax in humans	Anthrax
Loukoi	Associated with the lungs	Contagious bovine pleuropneumonia
Lokichuma	*Akichuma* – pain caused by infection	Black-quarter
Long'okuo	Associated with dogs	Rabies
Lojala	*Jala* –drooling saliva	Foot and mouth disease
Eyala	Protracted weakness and malaise	Chronic foot and mouth disease
Ekitowo	Associated with sickness and recovery in 2 to 3 days	Ephemeral fever
**Lokio*	Associated with 'tearing'	Rinderpest*
lokit	Associated with ticks	Ear infection
Ekichodunu	Associated with limping	Foot rot

**Lokio* in Turkana language means '*tearing*'/lacrimation, there are other diseases with the same clinical signs as *lokio* e.g. *long'oripoko* (undifferentiated diarrhoea).

Figure 3 shows a summarised matrix scoring of diseases versus clinical signs and post mortem lesions. Analysis of disease signs and post-mortem lesions versus diseases demonstrated good agreement between the 12 informant groups (Kendall's coefficient of concordance (W) values between 0.680 to 1.000). The livestock keepers associated lacrimation, diarrhoea and salivation with rinderpest (*lokio*) by assigning more scores to these disease signs. Madness or aggressiveness was associated with rabies (*long'okuo*) and ear infection (*lokit*). Herders associated swollen lymph nodes (unilateral on the head region) and sudden death with ear infection (*lokit*) and anthrax (*enomokere*) respectively. Livestock keepers associated CBPP (*loukoi*) with coughing, dyspnoea, yellow fluid in the chest cavity and lungs adhering to the chest cavity. Herders did not associate coughing, dyspnoea, yellow fluid in the chest cavity and lungs adhering to the chest cavity with any of the control diseases. Taking notes from livestock keepers about typical cases of *loukoi* they revealed that the lungs of acute cases have many colours (marbling of the lungs) and described with a lot of clarity the sequence of signs of typical cases of *loukoi*. However they did not mention the swelling of joints (polyarthritis) in calves. On further probing they argued that the only important clinical sign they see in calves is coughing. They refuted the assertion that sick calves due to *loukoi* can be lame and develop actual swelling of joints.

Diseases

Clinical signs/PM lesions	*Lokio*	*Long'okuo*	*Lokat*	*Enomokere*	*Loukoi*
Lacrimation (W=0.890***)	25(10-25)	0(0-4)	0(0-7)	0(0-0)	0(0-5)
Diarrhoea (W=1.000***)	25(25-25)	0(0-0)	0(0-0)	0(0-0)	0(0-0)
Cough (W=0.956***)	0(0-2)	0(0-0)	0(0-0)	0(0-0)	25(23-25)
'Sudden death' (W=0.906***)	0(0-3)	0(0-0)	0(0-0)	25(16-25)	0(0-9)
Salivation (W=0.714***)	19(7-25)	1(0-11)	0(0-3)	0(0-6)	0(0-10)
Lungs adhering to the chest cavity (W=0.956***)	0(0-0)	0(0-0)	0(0-6)	0(0-0)	25(19-25)
Yellow fluid in chest cavity (W=0.936***)	0(0-0)	0(0-5)	0(0-8)	0(0-0)	25(12-25)
Madness or wildness (W=0.680***)	0(0-19)	19.50(0-25)	5(0-10)	0(0-6)	0(0-0)
Dyspnoea (W=0.774***)	0(0-9)	0(0-5)	0(0-7)	0(0-12)	22.5(13-25)
Swollen lymph nodes (W=0.901***)	0(0-8)	0(0-0)	25(10-25)	0(0-11)	0(0-0)

Figure 3: Summarised matrix scoring of diseases versus clinical signs and post mortem lesions

Number of informant groups=12; W = Kendall's Coefficient of Concordance (***p<0.001). W values vary from 0 to 1.0; the higher the value the higher the level of agreement between informants. The black dots represent the median scores (number of stones) that were used during the matrix scoring. The minimum and the maximum values or the range are shown in the parentheses.

4.2.3 Livestock keepers' perceptions and beliefs concerning transmission of important cattle diseases

Livestock keepers associated the transmission of CBPP (*loukoi*) with the entry of a sick or suspect cow in their herds, gathering of cattle at watering points and vaccination sites. Peace is advocated as a control method of transmission of *loukoi.* However the livestock keepers attributed the transmission of this disease to exchange of cattle during conflict resolution meetings. Livestock keepers acknowledged that raided cattle pose a real threat of infecting their healthy herds.

The community strongly associated rabies (*long'okuo*) with dogs. They described scenarios of sick dogs roving long distances biting people and livestock. Turkana pastoralists agreed that dogs, jackals, foxes and other small carnivores are the sources of this disease. Members of Narakibuk *Adakar* narrated to the author an incident where the disease killed a member of the Eipa *Adakar*.

Although the people did not know the real cause of anthrax (*enomokere,*) they attributed the malady to contact with meat, hides and other products of infected carcasses. *Enomokere* was strongly associated with the cutaneous form of anthrax. When narrating the signs and lesions of anthrax, they repeatedly pointed to scars on heads and lips. They argued that infected meat is wholesome if cooked properly. However they cautioned that blood from infected animals is highly dreaded because if taken it can be fatal.

Concerning the transmission of ear infection (*lokit*) the informants concurred that the disease is associated with ticks (*emadang*). They listed the following favoured control and treatment options; hot iron branding, hand pulling of ticks, use of acaricides and avoidance of tick-infested areas. Further probing revealed that the livestock keepers believe that ticks are attracted to the ears. On encounter with a clinical case of *lokit* in a goat, the author concluded that *lokit* is as sequalae to tick bites causing wounds in the ear, which becomes infected, the ear swells and an abscess forms which the pastoralists reported can be fatal. Occasionally the affected animal becomes wild/aggressive.

Some pastoralists believe flies (*loporiet*) transmit rinderpest (*lokio*). Nevertheless they associated the disease with wild animals namely gazelles, kudus, warthogs and buffaloes. The informants described how the fly moved from sick wild animals to healthy domesticated animals, including human beings! The community explained with a lot of clarity how at any given time they noted wild animals dying from the disease; they feared that their cattle would be the next victims. However, together with these associations and beliefs, some pastoralists believe that some diseases especially in lactating herds are caused by witchcraft from known witches and jealous neighbours!

4.2.4 Seasonal calendars

To understand the association of seasons with priority diseases, Turkana seasons and months were listed and translated in corresponding Gregorian months (Table 2).

Table 2: Turkana seasons, months versus Gregorian months

Seasons	Turkana months	Gregorian months
	Lomaruk	January
	Titima	February
Rain season (*akiporo*)	*Yelyel*	March
	Lochoto	April
	Losuban	May
Inter-phase (*akiitiar*)	*Lotiak*	June
	Lolong'u	July
	Lopoh	August
Dry season (*akamu*)	*Lorara*	September
	Lomuk	October
	Lokwang	November
	Loduge	December

Tukana pastoralists traditionally divide their year into two main seasons i.e. dry season (*akamu*), rainy season (*akiporo*) and an inter-phase (*akiitiar*). The results from the four seasonal calendars are summarised in Fig. 4. Moderate to good agreement was evident among the four informant groups concerning the association of seasons and diseases, *loukoi* and *long'okuo*. In general, according to the perceptions of the livestock keepers, *lokit, loukoi, enomokere* and *lokio* peaked in both seasons (*akamu* and *akiporo*). However, the prevalence of the four diseases reduced in the inter-phase season (*akiitiar*). Weak agreement between informant groups was obtained for *lokit, lokio* and *enomokere* (W=0.205, 0.017 and 0.188) respectively. During the semi-structured interview sessions, the herders concurred that all the five priority diseases were prevalent throughout the year or all the seasons. The Turkana pastoralists argued that due to drastic adverse climatic change, the *akamu* season can be prolonged to three years and the *akiporo* season reduced to less than a month, hence a protracted drought.

Turkana seasons

Diseases	Dry season/*Akamu* (July-Dec.)	Inter-phase/*Akiitiar* (June)	Rain season/*Akiporo* (Jan.-May)
Lokit (W=0.205)	●●● ●●● 6(0-9)	●●● 3(0-5)	●●● ●● 5(3-15)
Loukoi (W=0.438**)	●●● ●●●● 7(3-10)	●● ●● 3.5(0-50	●●● ●● 5(4-8)
Lokio (W=0.017)	●●● ●● 5(3-13)	●● ●● 3.5(1-9)	●● ●● 4(0-9)
Enomokere (W=0.188)	●●● ●●● 6(0-9)	●●● 3(2-5)	●●● ●●● 6(3-11)
Long'okuo (W=0.317*)	●●● ●●● 6(0-15)	●● 1.5(0-5)	●●●● ●●●● 7.5(0-10)

Figure 4: Matrix scoring of cattle diseases versus Turkana seasons

Summarised seasonal calendar for cattle diseases in Narakibuk, Ng'isaricho, Ikong and Eipa *Adakars* (grazing groups) in Lapur Division, Turkana district, N=4; W = Kendall's coefficient of concordance (*$p<0.05$; **$p<0.01$). The black dots represent the median scores (number of stones) that were used in the construction of the seasonal calendar (many stones = strong positive association). The minimum and the maximum values or the range are shown in the parentheses.

4.2.5 Comparisons of laboratory results and case histories of CBPP (*loukoi*)

Field CFT and Laboratory CFT classified sera as either negative (90%) or positive (10%) for CBPP antibodies (Appendix XIV). The positives or negatives were recorded as counts (observed and expected counts)(Table 3).

Table 3: Cross-tabulation of field CFT by micromethod/laboratory CFT

FIELD CFT		MICROMETHOD CFT Negative	Positive	Total
Negative	Observed count	32	4	36
	Expected count	28.8	7.2	36.0
Positive	Observed count	0	4	4
	Expected Count	3.2	.8	4.0
	Total observed count	32	8	40
	Total expected count	32.0	8.0	40.0

The value of Kappa was 0.615, (Table 4) indicating fair to good agreement between the laboratory CFT and field CFT tests for CBPP antibodies. The *t* statistic for testing that the measure is 0 was 4.22 with an approximate significance less than 0.0005. The Asymptotic standard error was used to construct a confidence interval for the point estimate (Kappa); that is, a 95% interval for kappa extends from 0.333 to 0.897

Table 4: Kappa-symmetric measures between field CFT and laboratory CFT

	Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of agreement Kappa	.615	.168	4.216	.000
N of Valid Cases	40			

Key
[a] -Not assuming the null hypothesis.
[b]-Using the asymptotic standard error assuming the null hypothesis.

Livestock keepers complained that their cattle suffered from *loukoi* during the last dry season. This was inferred to mean that cattle were sick approximately from the month of September 2001. This information was triangulated with the area chief's information and confirmed that there was an outbreak of *loukoi* during that time. It was observed that no cattle had overt clinical signs of CBPP in all the contact herds. However livestock keepers expressed fears that the disease was still prevalent in the inaccessible rugged mountainous ranges of Lorionotom (Figure 2). Herders in unison clearly stated that their cattle were not suffering from *loukoi* during the time this study was carried out. Clinical examination of all cattle presented for bleeding revealed that all the cattle had no obvious signs of CBPP (Appendix XIV). Nevertheless, other diseases and conditions of no epidemic importance were encountered namely foot-rot (*Ekichodunu*) and black-quarter (*lokichuma*). Livestock keepers were requested to present cattle, which they suspected to have suffered from *loukoi* during the past 6 months for examination and bleeding. Table 5 and 7 shows the cross tabulations of laboratory CFT, Field CFT and the owner historical diagnosis in the last six months.

Table 5: Cross-tabulation of micromethod CFT (laboratory CFT) by owner diagnosis in the last 6 months

OWNER HISTORICAL DIAGNOSIS IN THE LAST 6 MONTHS

LABORATORY CFT		Negative	Positive	Total
Negative	Observed count	26	6	32
	Expected count	24.8	7.2	32.0
Positive	Observed count	5	3	8
	Expected count	6.2	1.8	8.0
	Total observed count	31	9	40
	Total expected count	31.0	9.0	40.0

The Kappa measure of agreement computed between the laboratory CFT and owner/livestock keeper diagnosis of *loukoi* was 0.179. It was justified to conclude that there was poor agreement beyond chance between the laboratory CFT and owner historical diagnosis of *loukoi* (Table 6). The *t* statistic for testing that the measure is 0 was 1.136 which was not significant as it was below the critical level $P<0.05$,α *value* of 0.05 at 95% CI.

Table 6: Kappa-symmetric measure between laboratory CFT and owner diagnosis in the last 6 months

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of agreement	Kappa	.179	.175	1.136	.256
N of Valid Cases		40			

Key

[a]-Not assuming the null hypothesis.

[b]-Using the asymptotic standard error assuming the null hypothesis.

There was no significant difference in the results of computed Kappa value between the field CFT and the owner historical diagnosis of *loukoi* and the results of the Kappa value computed between laboratory CFT and owner historical diagnosis, (values of 0.196 and 0.179 respectively) (Tables 6 and 8). Both Kappa values illustrated poor agreement between laboratory diagnostic tests and owner diagnosis of *loukoi*.

Table 7: Cross-tabulation of field CFT by owner diagnosis from the last 6 months

OWNER HISTORICAL DIAGNOSIS IN THE LAST 6 MONTHS

FIELD CFT			Negative	Positive	Total
	Negative	Observed count	29	7	36
		Expected count	27.9	8.1	36.0
	Positive	Observed count	2	2	4
		Expected Count	3.1	.9	4.0
		Total observed count	31	9	40
		Total expected count	31.0	9.0	40.0

Table 8: Kappa-symmetric measure between field CFT and owner diagnosis in the last 6 months

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of agreement	Kappa	.196	.174	1.388	.165
N of Valid Cases		40			

Key

[a]-Not assuming the null hypothesis.

[b]-Using the asymptotic standard error assuming the null hypothesis.

Finally, the author's assessment of cattle presented for clinical examination is that there were no clinical cases of CBPP at that moment in time. The owners' opinion of suspect *loukoi* cases of the previous six months were not active clinical cases of *loukoi* in that moment in time (during March to April 2002) (Appendix XVII) indicating a perfect/excellent agreement beyond chance (Kappa = 1.000) between the veterinarian and livestock keepers. The veterinarian and livestock owners used only clinical signs as 'diagnostic test' for CBPP (*loukoi*).

4.3 Estimation of morbidity and mortality rates in cattle due to CBPP (*loukoi*)

From a management point of view Turkana pastoralists traditionally divide their cattle into two groups; calves and adult cattle. Calves graze around the homestead while adult cattle can graze many kilometers away from the temporary home. Calves are cattle, which are suckling, while adult stock comprise of all growing stock (young bulls and heifers), lactating cows and adult bulls. Livestock keepers believe that lactating herds are vulnerable to diseases because of witchcraft from jealous neighbours.

4.3.1 Estimation of the morbidity rate due to CBPP (*loukoi*)

The mean morbidity rate due to *loukoi* in adult cattle in the year 2001 – 2002 was 14.6% according to the perceptions of 57 livestock keepers (Fig.5).

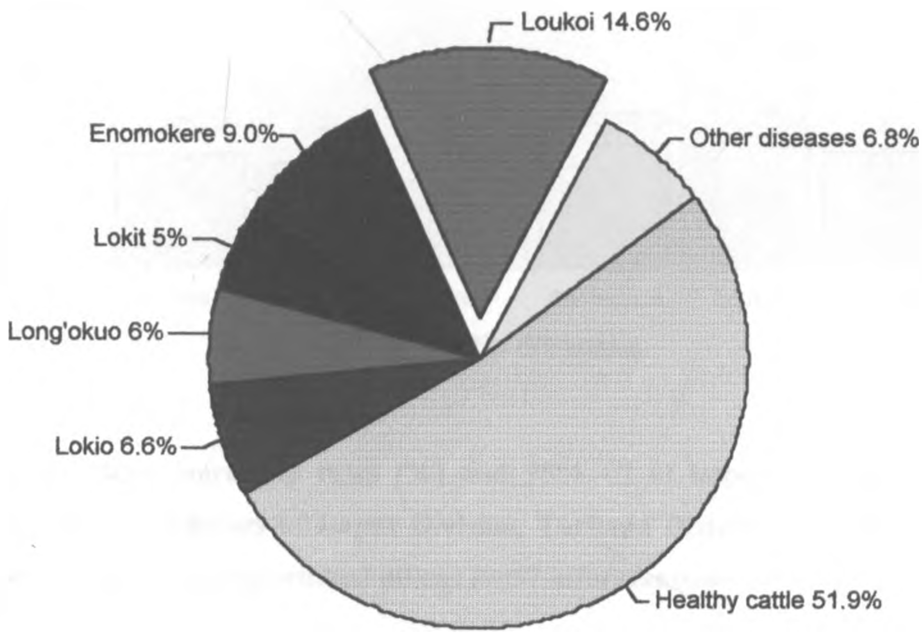

Figure 5: Mean morbidity rates (%) of important adult cattle diseases relative to healthy cattle in four *Adakars* of Lapur Division, Turkana District: year 2001-2002 (Estimates based on proportional piling; N=57 informants/herds)

Among the four 'control diseases' *lokit* had the lowest morbidity (5%) and *enomkere* had the highest mean morbidity (9.0%). Approximately 51.9% of the adult cattle herds were healthy in the year 2001-2002.

The mean morbidity rates of *lokio, long'okuo, lokit, enomokere, loukoi* and 'other diseases' as (point estimates) and their 95% confidence intervals in adult cattle in the year 2001-2002 are displayed as bar graphs and error bar graphs respectively in Fig. 6.

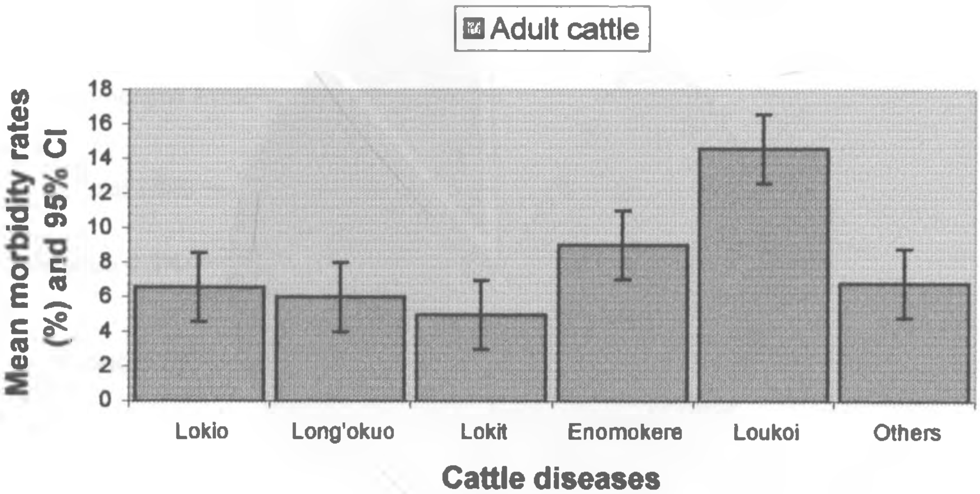

Figure 6: Mean morbidity rates (%) and 95% CI of important adult cattle diseases in four *Adakars* of Lapur Division, Turkana District: year 2001-2002 (Estimates based on proportional piling; N=57 informants/herds)

Morbidity due to *loukoi* accounted for 10.7% of calf diseases in the year 2001-2002 (Fig. 7). This was slightly lower than cases of *loukoi* in the same year in adult cattle (14.6%; Fig. 5). Among the 'control diseases' livestock keepers demonstrated during the proportional piling exercise that, the morbidity due to 'other diseases' in calves was the highest (9.3%), but a low morbidity rate due to *lokit* (3.9%) was reported. According to the perception of the informants, calf herds were slightly healthier (57.9%) than adult cattle herds (51.9%).

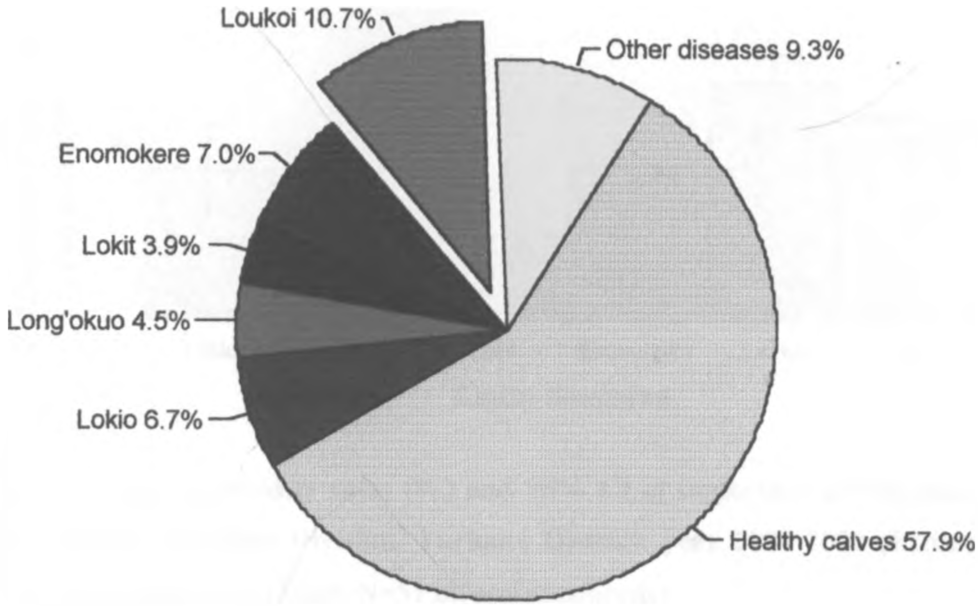

Figure 7: Mean morbidity rates (%) of important calf diseases relative to healthy calves in four *Adakars* of Lapur Division, Turkana District: year 2001-2002 (Estimates based on proportional piling; N=51 informants/herds)

The mean morbidity rates of important calf disease (point estimates) and 95% confidence intervals of these estimates are illustrated by bar graphs and error bar graphs respectively, in Fig. 8. Morbidity rates due to *lokio, enomokere, loukoi* and 'other diseases' were higher compared to the morbidity rates due to *long'okuo* and *lokit* in the year 2001-2002.

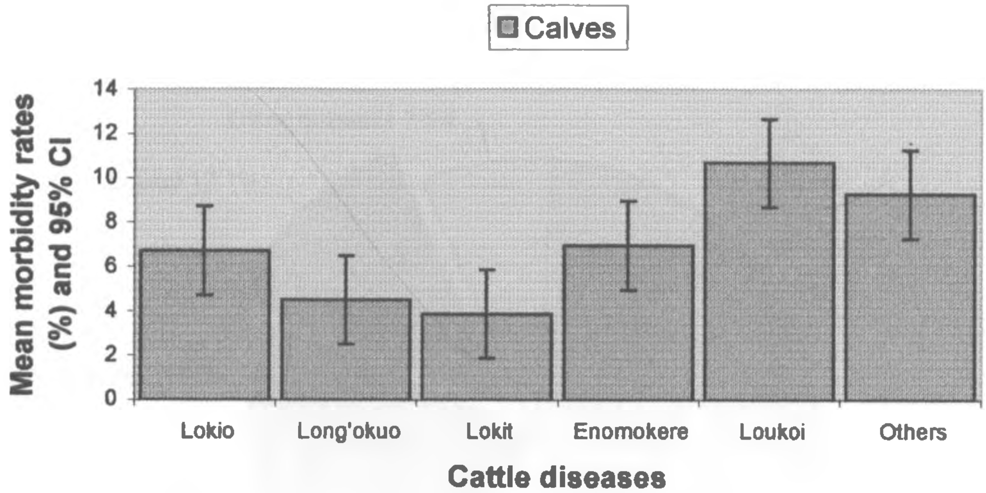

Figure 8: Mean morbidity rates (%) and 95% CI of important calf diseases in four *Adakars* of Lapur Division, Turkana District: year 2001-2002 (Estimates based on proportional piling; N=51 informants/herds)

The mean morbidity rate due to *loukoi* in all age groups of cattle was estimated at 12.1% in the year 2001-2002 (Fig. 9). Informants demonstrated that the morbidity rate due to *lokit* (4.2%) in all age groups was the lowest. These results show that tick borne diseases are of lower priority to livestock keepers compared to epidemics of international importance like *loukoi* (12.1%) and *lokio* (6.3%). *Enomokere* and 'other diseases' in all age groups of cattle accounted for 15.2% of the disease cases.

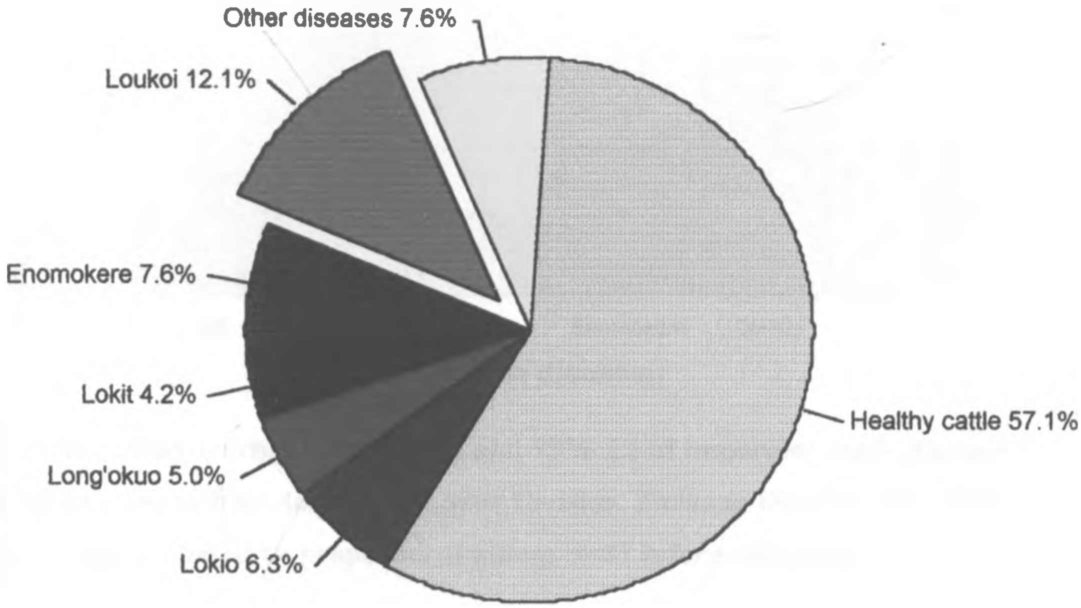

Figure 9: Mean morbidity rates (%) of important cattle diseases relative to healthy cattle, (all age groups) in four *Adakars* of Lapur Division, Turkana District: year 2001-2002 (Estimates based on proportional piling; N=57 informants/herds)

The mean morbidity rates due to important cattle diseases, (point estimates) in all age groups in the year 2001-2002 and their 95% confidence intervals are displayed in Fig. 10. *Enomokere, loukoi* and 'other diseases' show a comparatively higher morbidity than *lokio, long'okuo* and *lokit.*

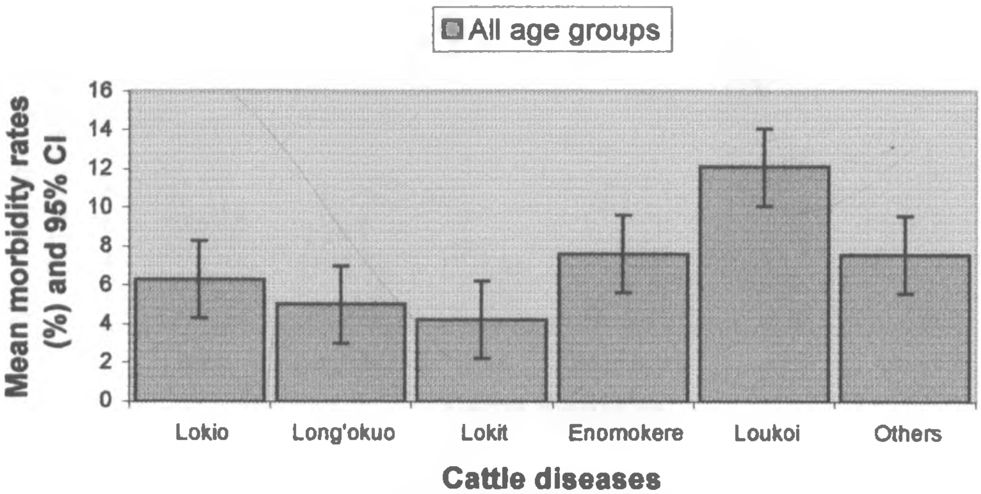

Figure 10: Mean morbidity rates (%) and 95% CI of important cattle diseases (all age groups) in four *Adakars* of Lapur Division, Turkana District: year 2001-2002 (Estimates based on proportional piling; N=57 informants/herds)

According to the results of proportional piling, the morbidity rate due to *lokio* was almost the same in both age groups (adult cattle 6.6% and calves 6.7 %; Fig. 11). The livestock keepers perceptions regarding the morbidity due to *long'okuo, lokit, enomokere*, and *loukoi* decreased with decreasing age (*long'okuo:* adults 6%, calves 4.5%); (*lokit:* adults 5%, calves 3.9%); (*enomokere:* adults 9%, calves 7%) and (*loukoi:* adults 14.6%, calves 10.7%). The results of proportional piling on morbidity rates of 'other diseases' in adult cattle and calves illustrate that the morbidity rates decreased with increasing age (calves 9.3%, adult cattle 6.8%). The results show that calves are more susceptible to 'other diseases' than adult cattle.

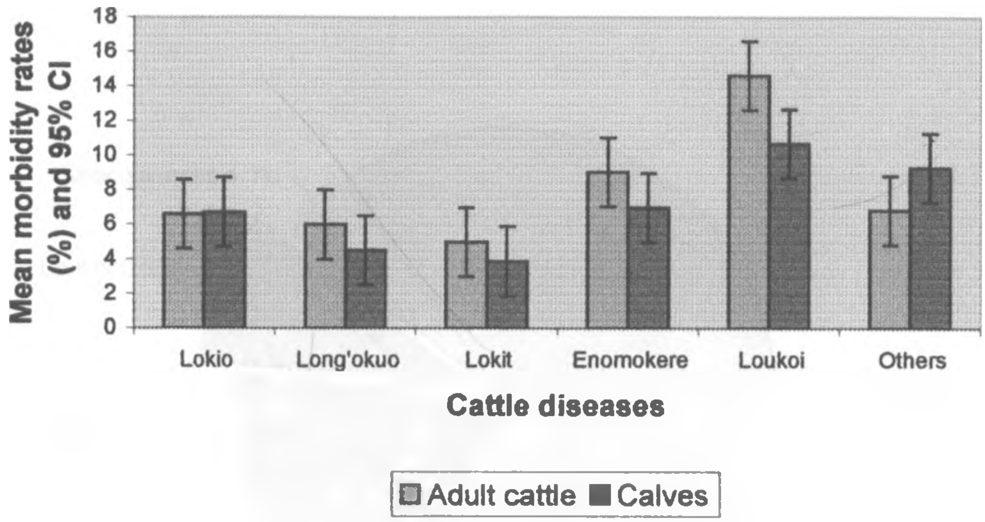

Figure 11: Mean morbidity rates (%) and 95%CI of important cattle diseases (calves and adult cattle) in four *Adakars* of Lapur Division, Turkana District: year 2001-2002 (Estimates based on proportional piling; N=51 informants/herds)

4.3.2 Estimation of mortality rate due to CBPP (*loukoi*)

Mortality due to *loukoi* (9.3%) in adult cattle was the highest in the year 2001-2002 (Fig. 12) followed by *enomokere* (5.7%), *long'okuo* (5.0%), *lokio* (4.6%), other diseases (4.1%), and *lokit* (2.8%). Livestock keepers reported that they lost 31.2% of adult cattle due to diseases in their herds.

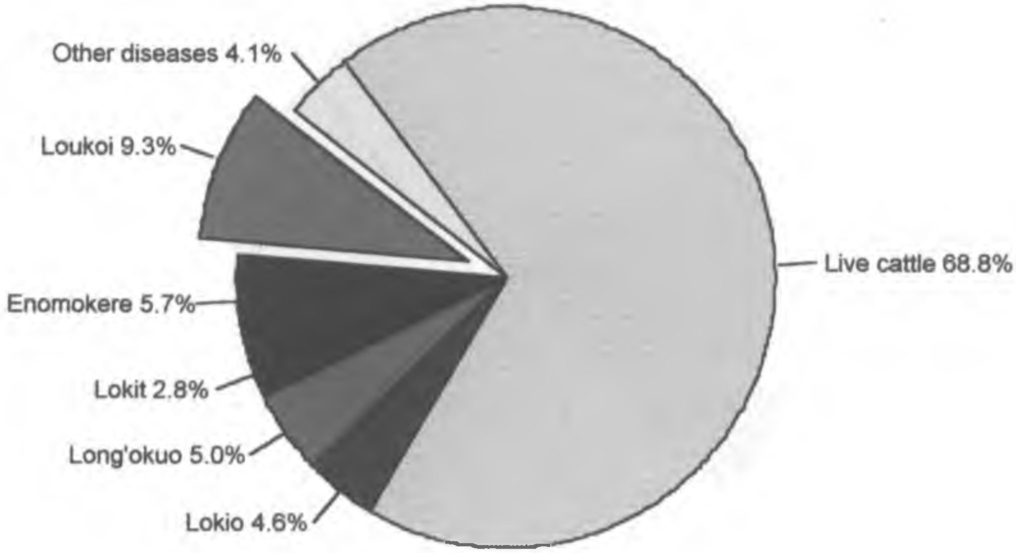

Figure 12: Mean mortality rates (%) due to important adult cattle diseases relative to live adult cattle in four *Adakars* of Lapur Division, Turkana District: year 2001-2002 (Estimates based on proportional piling; N=57 informants/herds)

Mortality due to *loukoi* (6.8%) in calves was the highest in the year 2001-2002 (Fig. 13) followed by 'other diseases' (5.8%), *lokio* (4.7%), *enomokere* (4.2%), *long'okuo* (3.8%), and *lokit* (2.3%). Livestock keepers reported that they lost 27.5% of calves due to diseases. This is likely to impact negatively on the size and productivity of their herds.

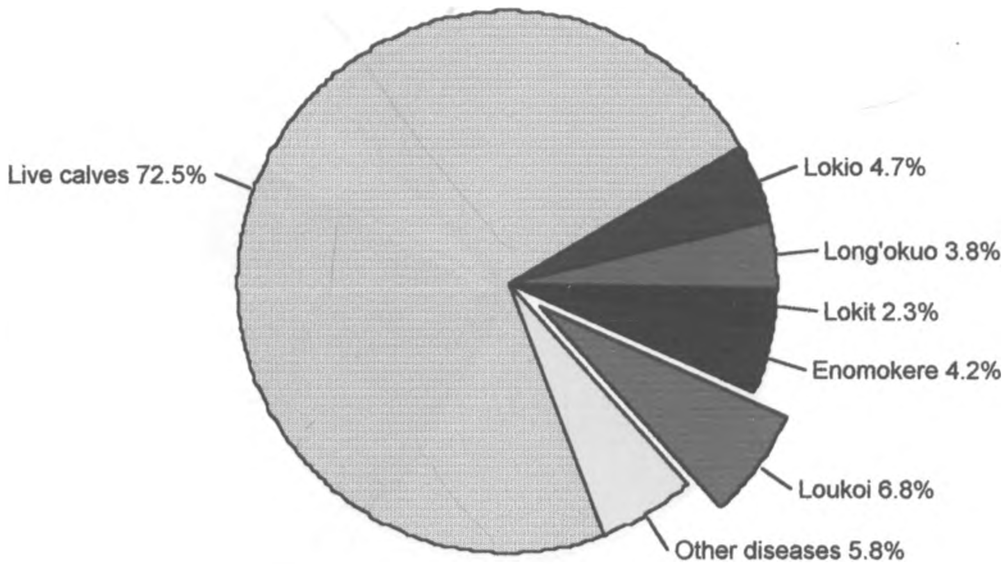

Figure 13: Mean mortality rates (%) due to priority calf diseases relative to live calves in four *Adakars* of Lapur Division, Turkana District: year 2001-2002 (Estimates based on proportional piling; N=51 informants/herds)

Mortality rate due to *loukoi* in all age groups of cattle was the highest (8.1%), followed by 'other diseases' (5.1%), *enomokere* (5.0%), *lokio* (4.6%), *long'okuo* (4.5%) and *lokit* (2.4%)(Fig. 14). Approximately 30% of all cattle (all age groups) in 51 herds were reported to have died due to diseases in the year 2001-2002.

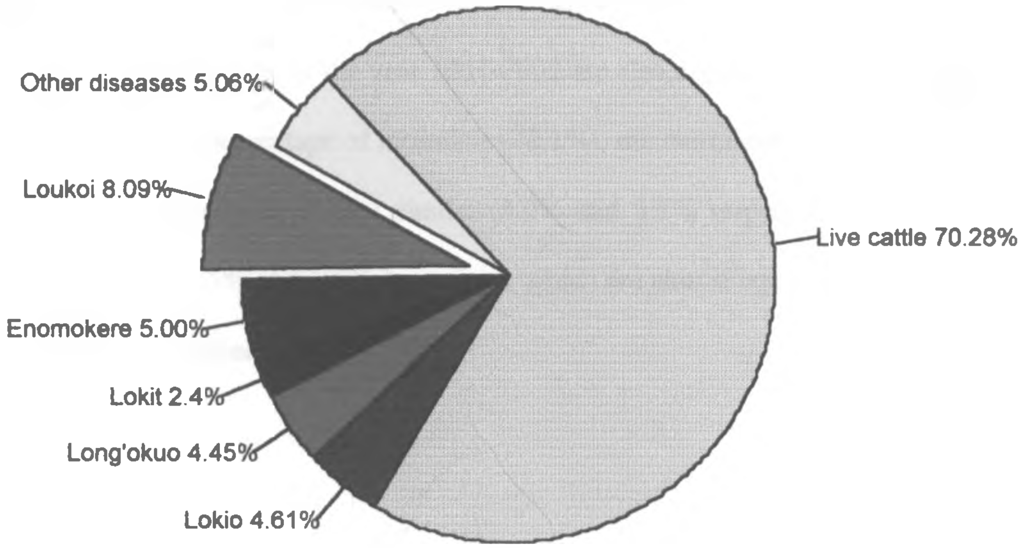

Figure 14: Mean mortality rates (%) due to important cattle diseases relative to live cattle, all age groups in four *Adakars* of Lapur Division, Turkana District: year 2001-2002 (Estimates based on proportional piling; N=51 informants/herds)

Approximately 29.6% of all cattle (all age groups) in 51 herds were reported to have died due to diseases in the year 2001-2002. The results of proportional piling indicated that, the mortality rate due to *lokio* was similar in both age groups (adult cattle 4.6% and calves 4.7 %; Fig. 15). The livestock keepers perceptions on the mortality rates of *long'okuo*, *lokit*, *enomokere*, and *loukoi* decreased with decreasing age (*long'okuo:* adults 5.0%, calves 3.8%); (*lokit:* adults 2.8%, calves 2.3%); (*enomokere:* adults 5.7%, calves 4.2%) and (*loukoi:* adults 9.3%, calves 6.8%). The results of proportional piling on mortality rates of 'other diseases' in adult cattle and calves illustrate that the mortality rates decreased with increasing age (calves 5.8%, adult cattle 4.1%). The results show that calves are more susceptible to 'other diseases' than adult cattle.

Mean mortality rates (%) and their 95% confidence intervals, due to important cattle diseases in all age groups in the year 2001-2002 are also displayed in Fig. 15. *Loukoi* caused the highest percentage of mortalities (8.1%), the mortalities due to *enomokere* and 'other diseases' were almost similar (5.0% and 5.1% respectively). *Long'okuo* and *lokio* caused 4.5% and 4.6% mortalities, which are almost equal. *Lokit* caused the least proportion of deaths (2.4%).

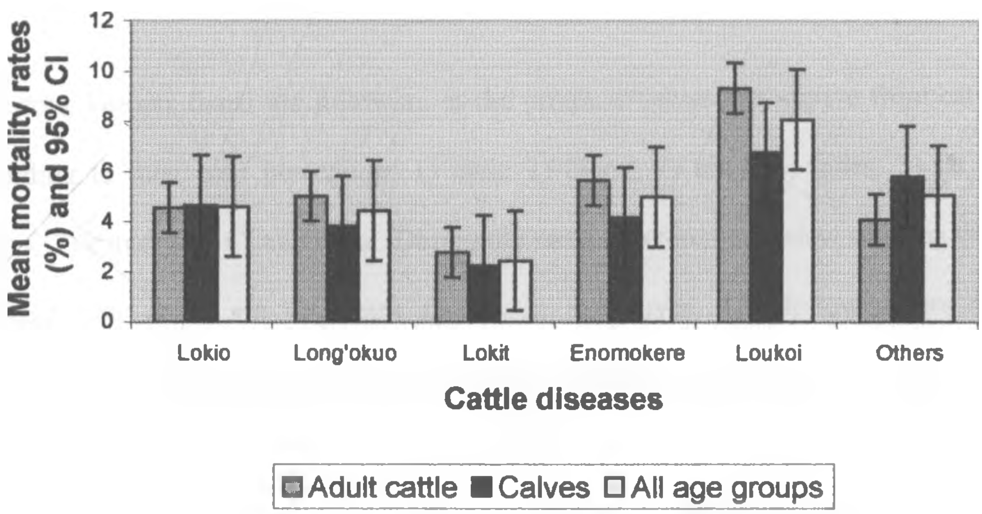

Figure 15: Mean mortality rates (%) and 95% CI due to important cattle diseases in adult cattle, calves and all age groups in four *Adakars* of Lapur Division, Turkana District: year 2001-2002 (Estimates based on proportional piling; N=51 informants/herds)

4.4 Assessment of socio-economic impact of CBPP (*loukoi*) relative to other diseases

Pastoralists who own large herds of cattle were reported to be respected members of the society and were regarded as wealthy. Cattle are important in rituals like appeasing of ancestors and burial ceremonies of prominent members of the community. Cattle are traditionally sourced from raids/cattle rustling, dowry, gifts from friends, inherited, fines and purchases using money or barter trade, using goats. Pastoralists are known to compose praise songs to their bulls during their traditional dances (*endong'a*). Pastoralists have great sentimental attachment to cattle. They can fight to death defending their cattle from enemies. Cattle are ranked second to human life!

Livestock keepers listed the following as the products/values they derive from cattle according to their own perception: 1) milk, 2) blood, 3) meat, 4) hides, 5) fat 6) dowry, 7) calves and 8) sale value. During the semi-structured interview sessions they narrated how cattle are important species in their lives. The following are the livestock keepers' perceptions of socio-economic losses and importance of cattle.

Cows provide larger quantities of milk as compared to sheep and goats. Milk is a major item of diet in the community and diseases like *loukoi, lokit, long'okuo* and *lokio* causes reduction in milk yield of lactating cows. However, cows suffering from *enomokere* there is no apparent milk loss because they die suddenly. Livestock keepers claimed that cows suffering from *loukoi* produce watery milk.

Livestock keepers reported that sick and dying cattle from the above mentioned diseases have a salvage value. Meat from cattle dying of *lokio* is tasteless and decomposes very fast; hence most of the meat is discarded. Meat and blood from cattle suffering or dying from *long'okuo* are wholesome. Pastoralists simply gun down any belligerent/wild animal; therefore the loss is minimal. Describing the loss they incur in *lokit* cases they explained that they throw away the whole head. Regarding cases of *enomokere*, it is only blood, which is not 'eaten!' Concerning *loukoi* they explained that they throw away the affected lungs and heart. In serious cases of *loukoi* they trim away all surrounding meat.

Livestock keepers utilize fat in both meat and milk. They lose more fat in *lokio* cases compared to other diseases. However they also lose some fat in *loukoi* cases as animals are markedly emaciated and the fat becomes gelatinous.

Informants explained that sick cattle or those dying from *loukoi*, *long'okuo, lokit* and *lokio* are not accepted in payment of dowry. Nevertheless, cattle suffering from *enomokere* can be accepted since it is difficult to know that they are sick before they die. Hides of cattle have the following uses: making of whips, ropes, clothing for women, fabrication of donkey bags for transport, used as beddings, roofing material in provision of shelter and making of shoes, oil containers and bags. Hides of cattle dying from *lokio* are poor in quality as they are hard and very light. In this aspect they make poor beddings. Hides of cattle dying from *long'okuo, lokit* and *loukoi* are of good quality. However hides of cattle dying of *enomokere* are of very poor quality, as they cause the cutaneous form of anthrax (*enomokere*) in human beings. Informants showed many scars on their bodies they thought were caused by the illness.

To livestock keepers, fertility meant many calves, which directly affected herd size. Lowered fertility due to abortions adversely affected livestock keepers' wealth base.

Lokio and *loukoi* caused many deaths in calves, therefore high losses to livestock keepers. Livestock keepers reported that they occasionally attempt to treat *lokio* and *loukoi* in cattle. However, they have been disappointed as a high proportion of *lokio* cases fail to recover and therefore opted for vaccination. Drugs for treatment of clinical cases of *loukoi* are available in the drug stores and therefore livestock owners exchanged goats for drugs, hence cost of treatment of *loukoi* was regarded as highest. The sale value of cattle dying/suffering from *lokio, long'okuo, lokit, enomokere* and *loukoi* varied from one livestock keeper to another as this depended on bargaining ability of the seller. Barter trade is practiced. The following are some of the exchange values in diseased cases; *Long'okuo*–seven goats, *Lokit*–three goats, *Loukoi, Enomokere* and *Lokio*–one goat for each case. The standard exchange value is 11 goats for a normal bull that is equivalent to one camel or one donkey. A cow is highly valued i.e. one cow is exchanged for 20 goats. Sometimes a cow is exchanged for a female camel or a donkey.

After the semi-structured interviews matrix-scoring exercise was carried out. Figure 16 shows a summarized matrix scoring of diseases versus losses. Analysis of disease losses versus diseases demonstrated good agreement between the 12 informant groups (Kendall's coefficient of concordance (W) values between 0.474 to 0.764). However the results showed weak agreement between the 12 informant groups, W value of 0.179, for the indicator 'sale value' and the five diseases, which was not significant. Livestock keepers associated higher losses in milk production due to *lokio, long'okuo, lokit* and *loukoi* by assigning more scores to these diseases. However, they did not associate loss of milk with *enomokere* as they argued that the affected cows die suddenly so there is no apparent loss of milk. They also attributed loss of blood and meat to *lokio* and *loukoi* by assigning more scores to these diseases. They did not associate loss of blood and meat with *long'okuo* as they asserted that they simply gunned down such cases and the meat and blood were consumed. They associated very limited losses in meat and blood with *lokit* and *enomokere* because they lost only the head and blood respectively. They associated the highest loss in fat with *lokio* and a minimal loss to *loukoi*.

The Turkana pastoralists felt a major loss of hides due to *enomokere*. However, minimal losses of hides were associated with *lokio* and *loukoi*. Turkana pastoralists felt that they lost many calves due to abortions and infertility and associated these losses with *lokio, enomokere* and *loukoi*. Informants did not associate losses in calves with *long'okuo* and *lokit*. Informants associated high cost of treatment with *loukoi* compared with *lokio* as they argued that vaccination against *lokio* was free of charge and treatment for *loukoi* necessitated purchase of modern drugs. They failed to associate treatment of *long'okuo, lokit* and *enomokere* with high cost of treatment, as treatment for these diseases is not attempted using modern drugs.

Finally, livestock keepers ranked *loukoi* second to *lokio* in causing both social and economic losses as shown in Fig. 16. *Long'okuo, enomokere* and *lokit* followed, in that order, in causing losses in cattle and their products. The ranking was in concert with the median scores of all indicators/losses in Fig. 16.

Diseases

Losses	*Lokio*	*Long'okuo*	*Lokit*	*Enomokere*	*Loukoi*
Milk (W=0.474**)	10(3-15)	6(0-13)	3(0-7)	0(0-4)	4.5(0-12)
Meat/blood (W=0.671***)	11.5(7-23)	0(0-9)	2.5(0-7)	1(0-7)	4.5(2-9)
Fat/meat & milk (W=0.506***)	14(10-23)	1(0-14)	0(0-5)	0(0-13)	2(0-11)
Dowry (W=0.524***)	6(1-12)	6(1-10)	3.5(0-6)	0(0-4)	7(2-14)
Hides (W=0.513***)	4(0-25)	0(0-5)	0(0-5)	12(0-25)	2(0-13)
Calves (W=0.496**)	9(5-25)	0(0-6)	0(0-10)	4(0-8)	6(0-11)
Cost of treatment (W=0.764***)	6(0-13)	0(0-1)	0(0-3)	0(0-9)	17(10-25)
Sale value (W=0.179^ns)	6(2-12)	6(1-12)	3(1-7)	2.5(0-8)	4(1-11)

Figure 16: Summarised matrix scoring of diseases versus losses

Number of informant groups=12; W = Kendall's Coefficient of Concordance (**$p<0.01$, ***$p<0.001$and ns= not significant). W values vary from 0 to 1.0; the higher the value the higher the level of agreement between informants. The black dots represent the median scores (number of stones) that were used during the matrix scoring. The minimum and the maximum values or the range are shown in the parentheses.

4.5 Identification of best-bet options for improving CBPP (*loukoi*) control

Livestock keepers demonstrated keen interest in prevention, control and treatment of *loukoi*. Over time the community has evolved a quarantine system here referred to as 'community-enforced quarantine'. The community-enforced quarantine operates under the following conditions;

1) No sharing of watering points and grazing areas with infected herds.

2) Exclusion/segregation of livestock keepers with cattle with *loukoi* to the Lorionotom ranges.

3) Raided cattle, which are suspect cases, are put under quarantine or observation for 2 ½ months.

4) Before raided cattle are grouped with owners' herd, one animal is slaughtered and if lesions suggesting *loukoi* are observed the necessary precautions are taken.

The community and her development partners have institutionalised prohibition of cattle rustling through down-to-earth conflict resolution projects. The community acknowledges peace is a useful tool in the prevention and control of *loukoi*. The community supports vaccination as a useful weapon in the fight against *loukoi*. After the semi-structured interviews exposition, matrix-scoring exercise resulted in six prevention and control matrixes (Appendix XIII) that were summarised into matrix scoring of prevention and control methods versus the indicators in Fig. 17. Good agreement was evident among the 6 informant groups concerning prevention and control methods and the indicators - low financial cost, effectiveness, user friendliness, group action and individual action (W Values of 0.459 to 0.861). In general, informants agreed on vaccination as the best option in the prevention of *loukoi* by assigning most scores. Community-enforced quarantine and peace were ranked second and third respectively, as other important prevention methods. Modern drugs and traditional herbal remedies were ranked almost as equal methods of control of *loukoi*. Slaughter as a method of control of *loukoi* was the least favoured by informant groups. Further probing elucidated that livestock keepers used *emus* (*Euphorbia glochidiata*) Pax as one of the major herbal remedies. Informants agreed that community-enforced quarantine was a no-nonsense prevention strategy of *loukoi* in a community where laws, order and respect for leadership are highly regarded values. Informants demonstrated good understanding of the indicators - group action and individual action in the prevention, control and treatment strategies of *loukoi* by assigning high scores where these strategies applied.

Prevention and control methods of *loukoi*

Indicators	Vaccination	Community quarantine	Peace	Slaughter	Modern drugs	Traditional herbs
Low financial cost (W=0.815***)	●●●●● ●●●●● 10(6-19)	●●● ●●● 6(4 - 9)	●●● ●●● 6(4 - 8)	●● 1.5(0-6)	0(0-2)	●● ●● 4(2-6)
Effectiveness (W=0.730***)	●●●●● ●●●●● 10(7-24)	●●●● ●●● 7(0-10)	●●● 2.5(0-5)	● 1(0-2)	●●● ●● 4.5(1-6)	●● ●● 3.5(2-6)
User friendliness (W=0.459**)	●●●●● ●●●● 9(0-19)	●●● ●● 5(0-9)	●●● 2.5(0-9)	● 1(0-4)	●●● ●● 4.5(1-9)	●●● ●● 5(4-9)
Group action (W=0.861***)	●●●●● ●●●●● 10(7-16)	●●●● ●●●● 7.5(6-12)	●●●● ●●●● 8(5-10)	0(0-2)	●● 2(0-4)	● 0.5(0-3)
Individual action (W=0.761***)	0(0-3)	0(0-2)	0(0)	●●●●● ●●●● 8.5(0-12)	●●●●● ●●●● 8.5(0-13)	●●●●●● ●●●●● 10.5(7-15)

Figure 17: Summarised matrix scoring of prevention and control methods versus indicators

Number of informant groups =6; W = Kendall's Coefficient of Concordance (**p<0.01; ***p<0.001). W values vary from 0 to 1.0; the higher the value the higher the level of agreement between informants. The black dots represent the median scores (number of stones) that were used during the matrix scoring. The minimum and the maximum values or the range are shown in the parentheses.

4.6 Trend-line of CBPP (*loukoi*), veterinary drugs and vaccines delivery levels

Community representatives described trend lines of *loukoi* and veterinary drugs and vaccines delivery levels during a stakeholders' workshop (Fig. 18). Table 9 gives a summary of the Turkana years or important events from 1978 to 2002.

In 1978, vaccinations of cattle against *loukoi*, *lokichuma* and *lokio* were carried out. Vaccination crushes were constructed at Kaeris, Kokuro, and Todonyang. According to the perception of informants 50% levels of *loukoi* and low availability of vaccines was reported. In 1982 ('year of floods'), pastoralists claimed that levels of *loukoi* increased due to abundant grass and availability of water. Vaccines were available but only few areas were covered due to poor accessibility of most areas by road. In 1983 *loukoi* levels dropped due to availability of drugs and vaccines from the Kenya Government.

In 1985, there was a further decrease in the levels of *loukoi* due to continued increase in the supply of vaccines and drugs. Levels of drugs and vaccines peaked in 1988 while the levels of *loukoi* hit the lowest levels ever. A severe drought occurred in 1989, resulting in many animals' deaths; an outbreak of *loukoi* occurred. Drugs and vaccines were not available in 1989.

In 1993, 1995,1996 and 1997 there was a steady increase in supply and availability of vaccines and drugs supplied by hawkers, ITDG-EA and the Government of Kenya. However in 1996 there was a *loukoi* outbreak, which livestock keepers attributed to mixing of raided Merille cattle with their cattle.

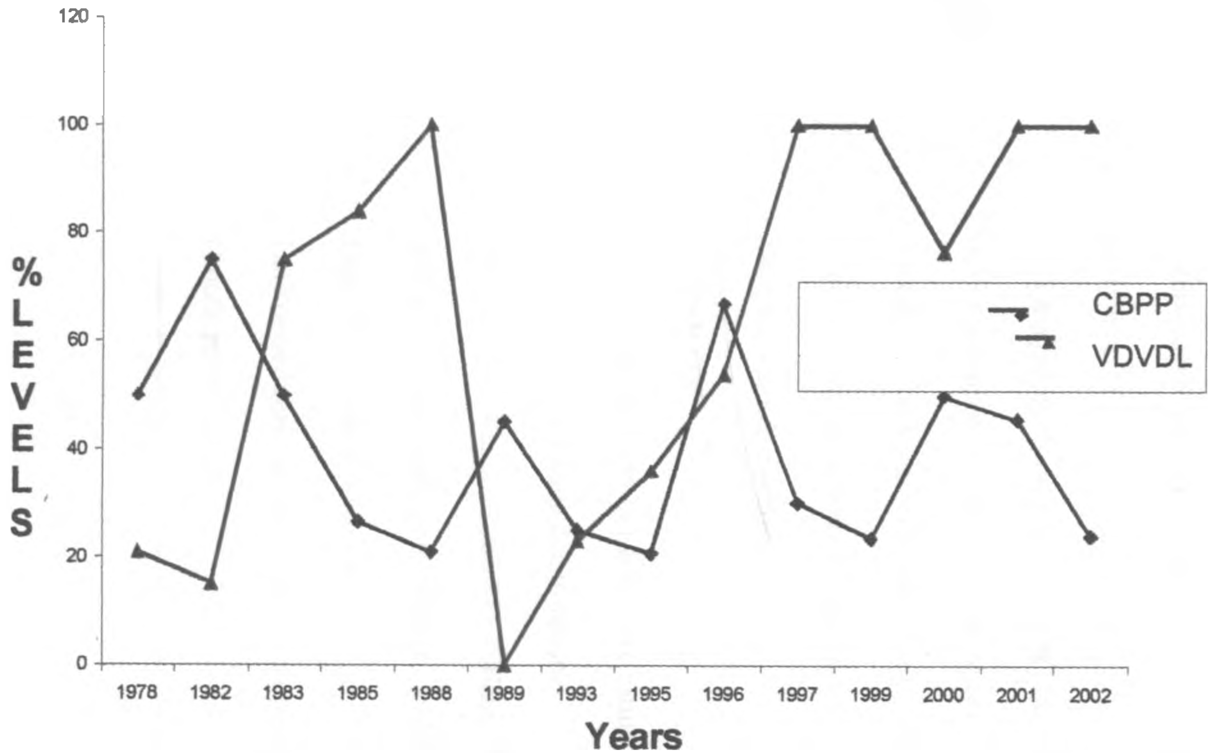

Figure 18: Trend-lines of CBPP (*loukoi*), Veterinary drugs and Vaccines delivery levels (VDVDL)

Table 9: Turkana years/events and corresponding calendar years

Turkana year	Event/important activity in the community	Calendar year
Ekaru a Lowoton	Lowoton killed by Merille and Jomo Kenyatta died	1978
Ekaru a ngakalel	Devastating floods killed people and livestock	1982
Ekaru ang'ikeny	Season of many birds during a raid at Kaikor	1983
Ekaru a Aadongiroit	Turkana were around Kibish while they killed Adongiro woman while at peace with Dongiros	1985
Ekaru Anagiligil	A Government of Kenya helicopter at Kibish assisted Turkanas repulse the Toposas	1988
Ekaru lokwakoyo	A very severe drought (white dry bones scattered every where)	1989
Ekaru angimoyo	Turkana raided Toposa livestock at Matamba (running caused sloughing of feet soles)	1993
Ekaru aakolong	Vaccination of livestock carried out by ITDG-E.A	1995
Ekaru a ngide Kakelai	Some girls were killed by enemies (Toposa and Dongiros) at Kakelai area	1996
Ekaru a kampain	Election year	1997
Ekaru Aageech	Livestock keepers from Lapur were eating very small fish from lake Turkana due to famine	1999
Ekaru ekitala	The senseless massacre year (45 Turkana children and women were killed near Kokuro by Merille)	2000
Ekaru Apuyere	Ekoyen was killed at Ngachuro	2001
———	Loukoi outbreak was reported at Kalopotikol (Southern Sudan)	2002

From 1996 to 1999 a decline in levels of *loukoi* was reported. This was attributed to a steady supply of drugs and vaccines. From 1999 to 2001, although drugs were available from hawkers and ITDG-EA, the government failed to vaccinate cattle; as a result there was a 'mild' *loukoi* outbreak in the year 2001.

Livestock keepers managed to control the disease through increased use of modern veterinary drugs. During the study period (year 2002) there was a report of a *loukoi* outbreak in Kalopotikol (southern Sudan). In conclusion livestock keepers described in their own language the trend of *loukoi* over the years from 1978 to date.

CHAPTER 5

5.0 DISCUSSION

This study has demonstrated that participatory appraisal methods can be used in the epidemiologic study of CBPP in a pastoral setting. Although livestock keepers are not professionals in animal health in their own right they cannot be ignored because their intellectual capacity concerning livestock is deeply rich. Livestock keepers, especially pastoralists, have husbanded and lived with cattle for many centuries developing a system of recognition of patterns of diseases. McDermott *et al.* (1987), working in southern Sudan with Dinka agro-pastoralists compared the opinions of livestock keepers with serological findings and noted the agreement between owner diagnosis and presence of CBPP antibodies in some age groups of cattle. In Maasailand it was the herders who first suggested that wildebeest were associated with epidemiology of malignant catarrhal fever (Barnard *et al.*, 1994). Similarly Akabwai *et al.* (1994) have noted the indigenous veterinary skills, knowledge and good memory of the Turkana herdsmen.

Participatory mapping activity set the right atmosphere for participatory learning. Participatory mapping became the stimulus to livestock keepers as they felt that they owned information and were very enthusiastic to divulge this information. Participatory mapping is a popular participatory appraisal method in animal health surveys and usually involves the construction of maps on the ground using locally available materials (Catley, 1999). Participatory mapping was used to determine the movement patterns of the livestock keepers and livestock grazing cycles and initiated a discussion on the link between mobility and Turkana seasons. Hadrill and Yusuf

(1994) and Mearns *et al.* (1994) have used maps to demonstrate livestock mobility and grazing patterns.

Kendall's coefficient of concordance (W) is a non-parametric test measuring the association between set of ranks assigned to objects by judges (or in this study, groups of judges) and computes a W value between 0 and 1. A high or significant W value means that the judges are ranking the objects using a similar standard. The test is particularly useful for determining interjudge reliability (Seigel and Castellan, 1994).

Analysis of diseases signs and post-mortem lesions versus diseases demonstrated good agreement between the 12 informant groups (Kendall's coefficient of concordance (W) values between 0.680 to 1.000). Catley *et al.* (2001), working in southern Sudan using the same research methodology (participatory appraisal) in an almost similar ecosystem, produced similar results. The high agreement between informant groups indicated that the matrix scoring is repeatable and hence reliable. Semi-structured interviews were valuable for crosschecking scores and proved to be goldmines in information clarification. Pastoralists are very confident people when describing animal diseases in their own language. In situations where one scorer disagreed with the others, one member of the informant group challenged the scores allocated to that particular sign after a lengthy explanation why he/she was challenging the scores. Use of 'control diseases' provided unbiased scoring as the author had not disclosed the disease of interest to the informants. Description of diseases like *lokio, long'okuo, lokit, enomokere* and *loukoi* fitted descriptions of rinderpest, rabies, ear infection, anthrax and CBPP respectively, in modern veterinary medicine. Descriptions of *loukoi* by informants in particular were similar to descriptions in standard veterinary medicine textbooks. Although Seifert (1996), Martel *et al.* (1983) and Provost *et al.* (1987) include polyarthritis as one of the signs in calves, informants failed to include this important sign. Professionals do not expect pastoralists to be veterinarians to know all clinical signs in cattle diseases. However this study demonstrated beyond doubt that the pastoralists know what to look for in suspect *loukoi* cases (the post mortem lesions are eye-openers). This position is similar to the summary guidelines provided by the FAO field manual of recognition of CBPP (FAO, 1997a). Turkana pastoralists use the same criteria as veterinarians in the field, with no laboratory facilities, for confirmation of their diagnosis.

Livestock keepers associated *loukoi* with coughing, dyspnoea, yellow fluid in the chest cavity and lungs adhering to the chest cavity. These are the signs and lesions an uninitiated professional will look for to make a tentative diagnosis of CBPP. Bonnett (1990), explaining the diagnostic process, equates diagnosis with a problem-solving process, that is, it involves these actions: define the problem, collect, analyze and synthesize data and make a decision. Similarly, pastoralists do hold discussions about diseases afflicting their livestock, where to graze and water them. They analyze on a daily basis which cow is not eating, is coughing or has entered the herd. On a daily basis they observe and check which animals are missing. This research has evolved a preliminary Turkana typology of cattle diseases (Chapter 4, Table 1). This goes a long way in the diagnostic process, as defining the problem is one of the key steps in the diagnostic process (Sackett *et al.*, 1985; Bonnett, 1990). Descriptions of *lokit, long'okuo, enomokere* and *loukoi* transmission notions by livestock keepers were almost similar to disease transmission mechanisms accepted by veterinarians. Livestock keepers associated the transmission of *lokio* with flies and wildlife, including African buffaloes, eland, kudu, wildebeest, various antelopes, bush-pigs, warthogs and giraffes among others), wildlife are known hosts of rinderpest (FAO, 1999). *Loukoi* was associated with entry of a sick/suspect cow into a healthy herd. This notion concurs with the fact that 'lungers' are known to disseminate the illness (Provost *et al.*, 1987, Coetzer *et al.*, 1994, Radostitis *et al.*, 1994). The same reasons apply to why pastoralists do take caution on the event of 'restocking' (raiding) their herds as elucidated in the community-enforced quarantine concept.

Informants associated *long'okuo* with dogs, jackals, foxes and other small carnivores. This is a realistic perception. Githaiga *et al.* (1997), Kitala *et al.* (2000) and Courtin *et al.* (2000) have noted that dogs and small carnivores transmit rabies to domestic animals and man. *Lokit* was associated with tick bites; the author encountered a typical case of *lokit* during the study. *Enomokere* was associated with the cutanenous form of anthrax in humans and sudden death in cattle. Informants were observed who pointed to scars on the head, hands, fingers and lips as they described *enomokere*. These are the same descriptions of cutaneous form of anthrax by Centres for Disease Control and Prevention, (CDC) (Nov. 2001). Although the author did not expect livestock keepers to associate the transmission of these diseases with micro-organisms, it can be concluded that the knowledge of informants about disease transmission is good. Moderate to good agreement was evident among the four informant groups concerning the association of seasons with diseases, (*loukoi* and *long'okuo*) by Kendall's Coefficient of Concordance (W) values 0.438 and 0.317 respectively. Livestock keepers associated *loukoi* with the dry season (*akamu*) by assigning this season more scores (median score) compared to others. This is a realistic thinking because during the dry season cattle do congregate at watering points and are likely to be stressed due to scarcity of pastures. However, Provost *et al.* (1987) have noted how the rainy season plays a role in stimulating infection, particularly when the animals are exposed to cold showers. Catley *et al.* (2002), working in the Dinka area of southern Sudan, reported a W value of 0.41when agro-pastoralists ranked CBPP in association with four Dinka seasons. The W values were almost similar, although the studies were done with different communities.

Turkana pastoralists were concerned about gathering of animals at watering points during the dry season, which they argued caused further dissemination of the disease. They also mentioned that during drought, their cattle are stressed and are likely to contract the disease. All these arguments are valid according to Egwu *et al.* (1996) and the African Technology Development Link, (2001). Herders in concert clearly stated that their cattle were not suffering from *loukoi* during the time we carried out this study. It was not possible to compare the laboratory tests results to any available 'gold standard test'. However, according to Sackett *et al.* (1985), and Martin and Bonnett (1987), where we are unable to compare the results of a test to a gold standard or we wish to compare the level of agreement between two clinicians diagnoses (inter-operator agreement) this can be accomplished through the use of Kappa statistic. There was poor agreement between the laboratory tests results and owner historical diagnosis of *loukoi* for the previous six months.

It is important to note that the results of owner historical diagnosis of *loukoi* are likely to be biased for two reasons: 1) The livestock keepers expectations of assistance in drugs and vaccines provision because examined animals if found sick were treated and this could have prompted them to present animals that were not necessary sick and 2) Livestock keepers recall bias, as the results were retrospective in nature. There was poor agreement between the laboratory tests and owner historical diagnosis because the owner historical diagnosis used overt clinical signs, which are evident at the onset of disease, while laboratory tests used the presence of circulating antibodies. The author's opinion concerning CBPP status on the cattle clinically examined and the owners' assessment of *loukoi* cases was the same (negative) at that moment in time (March and April 2002) indicating a perfect/excellent agreement beyond chance (Kappa = 1.000). The livestock keepers and the veterinarian used the same criteria (clinical signs) in deciding a case diagnosis is *loukoi* or not (for all cattle presented for examination).

According to the perceptions of the informants, *lokio* was interpreted as rinderpest. However, *lokio* could mean all other diseases that present signs similar to rinderpest. Nevertheless clinical signs of rinderpest may be similar to those seen in other diseases which fever, oculonasal discharges, stomatitis and or diarrhea may be prominent features. These diseases include foot and mouth disease, bovine viral diarrhea, infectious bovine rhinotracheitis, some forms of malignant catarrhal fever, vesicular stomatitis, salmonellosis, paratuberculosis, pest des petits ruminants and necrobacilosis among others. According to the FAO (1999) all the diseases listed above are important differentials of rinderpest where the disease has not been confirmed by a reference laboratory. This view is further supported by what the author observed in the field; some pastoralists referred to lacrimation or 'tearing' as *lokio* in cattle considered not to be rinderpest cases. Rinderpest is among the diseases highly feared by Turkana livestock keepers, one clinical sign observed raises a lot of fear and speculation.

In conclusion; this study has demonstrated that the diagnostic capacity of livestock keepers cannot be ignored.

The level of susceptibility of animals in a given herd varies considerably between individuals. Although CBPP morbidity is about 70% and mortality is about 60%, (Hall, 1977; Provost *et al.*, 1987; TerLaak, 1992), up to 60% of cattle in some herds may be resistant (Coetzer *et al.*, 1994). Survivors in an outbreak have a significant degree of immunity. Estimates of morbidity and mortality rates due to *loukoi* in all age groups of cattle in the year 2001-2002 were 12.1% (10.6 to 13.6% at 95% CI) and 8.1%(6.9 to 9.3% at 95% CI) respectively. Catley and Irungu (2000), working with Orma pastoralists of Tana River District using a similar research methodology, reported a morbidity of 11.9% in the year 2000, in a district where the disease is reported to be endemic. However, Laval (1999) carried out a retrospective study, using questionnaires, and reported annual morbidity and mortality rates of 30.2% and 12.5% respectively in areas where the disease is endemic in Ethiopia.

Contagious bovine pleuropneumonia was ranked by the livestock keepers second to rinderpest in terms of causing social and economic losses. African Technology Development Link (2001) consultants explored the available options for CBPP control, costs and benefits and allocated monetary values in the Arid Lands Resource Management Project areas. This study demonstrated that social and economic losses can be assessed by using indicators, which can be understood and stated in the local language of livestock keepers (for example, milk, meat, blood and dowry among others). These indicators are very crucial to the survival of the community as regards food security. However, this does not relegate the national and international importance of CBPP in cattle trade. McDermott *et al.* (1999) noted that in the pastoral sector, estimates of livestock numbers and different direct and indirect losses due to epidemic diseases are difficult to obtain. Therefore economic assessment tools are focused on decisions to invest in control programmes.

Informants agreed on vaccination as the best option in the prevention of *loukoi* by assigning most scores. Similarly professionals do concur that vaccination is the only realistic method of choice for CBPP control in endemic zones in Africa (Provost, 1994; Egwu *et al.*, 1996; Tulasne *et al.*, 1996). Community-enforced quarantine and peace (prohibition of livestock rustling) were ranked second and third respectively as other important prevention methods. FAO (2002) stipulates that quarantine is the first line of defence against CBPP and other trans boundary diseases. Any sick cattle should be held apart from the other cattle (i.e. self quarantine), which supports the view that the most important resource in the prevention of CBPP (or any other livestock disease) is the informed animal owner or manager (FAO 2002). Peace (prohibition of livestock rustling) between the Turkana pastoralists and their neighbouring communities is important tool in the prevention of CBPP as it controls illegal movement of cattle across the international boundaries of Ethiopia, Kenya and Sudan. Radostits *et al.* (2000) cites social and civil disturbances as one of the constraints, which interfere with effective disease control, cattle may be stolen and sold far from point of origin. Modern drugs and traditional herbal remedies were ranked almost as equal methods in of control of *loukoi* in terms of frequency of use. However, chemotherapeutic treatment of actual cases of CBPP is discouraged in both Europe and Africa by the OIE (OIE, 1995). This is because antibiotic treatment causes clinical signs that are often very mild thus complicating clinical diagnosis of cases (Bolske *et al.*, 1995). Epidemics of the disease may be exacerbated by the use of antimicribials, which reduce the effects of clinical disease while creating chronic carriers as the antimicrobials may not eliminate the causal agent especially the chronic cases with sequestrae (Radostits *et al.*, 2000). Slaughter was the least favoured by informant groups as a method of control of *loukoi*. Slaughter of suspect cases is quite an unpopular method of control of *loukoi* among these pastoralists. Masiga and Domenech (1994) have stated that, even with an elaborate compensation policy, it is difficult to convince livestock keepers to slaughter affected cattle. Wanyoike (1999) has also affirmed that the slaughter strategy is often impractical in developing countries under the present economic conditions where compensation is not feasible. The community has evolved 'community-enforced quarantine' and 'peace' (prohibition of livestock rustling) as prevention methods of *loukoi*, which are equivalent to methods advocated by professionals (Kane, 1975; Egwu *et al.*, 1996). These methods are similar to early warning systems, developed by the community and her development partner, ITDG-EA which indicate the decrease in numbers of four livestock groups, (cattle, camels, donkeys and shoats) cattle and camels are the first to be affected by drought, diseases and raids, while shoats and donkeys are least affected, the so called the 'four leg-idiom' by livestock keepers (ITDG-EA, 2001). These methods should be supported by other development agencies that advocate food security for Turkana pastoralists.

Trend-lines of *loukoi,* veterinary drugs and vaccines delivery levels which are similar to time trend graphs (Thrusfield, 1995) demonstrated that pastoralists could state in their own language (their perceptions) that CBPP remains endemic in the district despite all the prevention and control efforts. Other stakeholders do hold similar perception (MA&RD, 2001; African Technology Development Link, 2001).

CHAPTER 6

6.0 CONLUSIONS AND RECOMMEDATIONS

6.1 Conclusions

The following conclusions can be made from this study:

1. Epidemiological studies of livestock diseases in pastoral settings where there are limited facilities, poor infrastructure, insecurity and alarming levels of illiteracy can be carried out using participatory appraisal methodologies.
2. The capability of Turkana livestock keepers to diagnose CBPP (*loukoi*) is good, especially will be found at early stages of the disease – a diagnosis based on clinical signs and post mortem lesions.
3. According to the perception of livestock keepers' *loukoi* was the most important disease with annual morbidity and mortality rate of 12.1% and 8.1% respectively in the year 2001 – 2002. However, it was ranked second to *lokio* in terms of causing both social and economic losses in cattle.
4. *Loukoi* continues to cause social and economic losses in cattle in terms of milk, meat, blood, hides and dowry among others, indicators that are crucial to the livelihood of pastoral people.
5. Vaccination, supported by other methods defined by the community as 'community-enforced quarantine' and peace, is an effective tool in the prevention and control of *loukoi*.
6. Trend-lines of *loukoi*, veterinary drugs and vaccines 'levels' from 1978 to 2002 demonstrated that Turkana pastoralists do perceive *loukoi* as an endemic disease despite all the prevention and control efforts.

6.2 Recommendations

1. Community-based animal health workers (CBAHWs), who are livestock keepers themselves, should be allocated part of surveillance work of livestock diseases due to their indigenous knowledge of livestock diseases in remote pastoral areas.
2. Community-evolved methods of prevention of *loukoi* like 'community-enforced quarantine' and peace should be supported and integrated in the already existing early warning systems.
3. Further investigations on the typology of livestock diseases within and between related pastoral communities should be conducted with a view of describing the same diseases in already established CBAHWs training programmes.
4. Vaccinations of cattle by the government and other development partners should be integrated with CBAHWs activities whereby the CBAHWs would mobilise and sensitise the community and report to interested agencies the best time to carry out the vaccinations in order to achieve a high vaccination coverage.

7.0 REFERENCES

Abdalla, A.E. (1975). A report on contagious bovine pleuropneumonia diagnosis, control and eradication in the Sudan. Bulletin, Office International des Epizooties(**84**), 413-419.

African Technology Development Link (2001). Consultancy report on the livestock health quarantine measures. Arid Lands Resource Management Project (ALRMP) 2001. TECHLINK International.

Akabwai, D.M.O., Mariner, J.C., Toyang, J., Berhani, A., Sali Django and Osire, T. (1994). Ethno-veterinary Knowledge: A basis for community–based animal health work in pastoral areas. The Kenya veterinarian, **18**(2): 520.

Anderson, R.M. and May, R.M. (1991). Immunization and herd immunity. Lancet **335**: 641-646.

Anderson, R.M. (1992). The concept of herd immunity and the design of community based immunization programmes. Vaccine. **10**: 928-935.

Bart, K.J., Orenstein, W.A., Hinman, A.R. and Amler, R.W. (1983). Measles and models. International Journal of Epidemiology. **12**: 263-266.

Barnard, B.J.H., Van der Lugt, J.J. and Mushi, E.Z. (1994). Malignant catarrhal fever. In Infectious Diseases of Livestock: with special reference to southern Africa. Coetzer, J.A.W., Thomson, G.R. and Tustin, R.C. (Eds). Oxford University Press, New York. Pp946-957.

Bashiruddin, J.B., Nicholas, R.A.J., Santini, F.G., Woodward, M.J. and Taylor, T.K. (1994). Use of polymerase chain reaction to detect Mycoplasma DNA in cattle with contagious bovine pleuropneumonia. Veterinary Record. **134**: 240-241.

Blancou, J. (1996). Early methods of surveillance and control of contagious bovine pleuropneumonia. Revue Scientifique et Technique. Office International des Epizooties. **15**(4): 1263-1282.

Bolske, G., Msami, H.M., Gunnarson, A., Kapaga, A.M. and Loomu, P.M. (1995). Contagious bovine pleuropneumonia in northern Tanzania: Culture, confirmation and serological studies. Tropical Animal Health and Production. **27**: 193-201.

Bonnett, B.N. (1990). Interpretation of diagnostic tests: Skills for practice and research. Proceeding of the 9th annual meeting International Society for Theriogenology. Ontario, Canada. 13th-15th November 1990 Pp 56-70.

Bush, J. (1995). The role of food aid in drought and recovery: Oxfam's North Turkana (Kenya) Drought Relief Programme, 1992-1994. Disasters, **19**(3): 247-352.

Campbell, A.D. and Turner, A.W. (1953). Studies on Contagious bovine pleuropneumonia of cattle. IV. An improved complement fixation test. Australian Veterinary Journal. **29**: 154-163.

Catley, A. (1997). Adapting participatory appraisal (PA) for the Veterinary Epidemiologist: PA tools for the use in livestock disease data collection. Proceedings of the Society for Veterinary Epidemiology and Preventive Medicine, Chester, UK April 1997. Pp 246-257.

Catley, A. (1999). Methods on the move .A review of veterinary uses of participatory approaches and methods focusing on experiences in dry land Africa. Sustainable Agriculture and Rural Livelihoods Programme. 3 Endsleigh Street London WC1H 0DD, UK. Pp65.

Catley, A. and Irungu, P. (2000). Participatory research on bovine trypanasomosis in Orma cattle, Tana River District, Kenya. Preliminary findings and identifications of best-bet interventions. International Institute for Environment and Development/Kenya Trypanasomiasis Research Institute.

Catley, A. and Mohammed, A.A. (1996). The use of livestock-disease scoring by a primary animal health programme in Somaliland. Preventive Veterinary Medicine. **28**: 175-186.

Catley, A., Okoth, S., Osman, J., Fison, T., Njiru, Z., Mwangi, J., Jones, B.A. and Leyland, T.J. (2001). Participatory diagnosis of a chronic wasting disease in southern Sudan. Preventive Veterinary Medicine. **51**:161-181.

Catley, A., Osman, J., Mawien, C., Jones, B.A. and Leyland, T.J. (2002). Participatory analysis of seasonal incidences of diseases of cattle, diseases vectors and rainfall in southern Sudan. Preventive Veterinary Medicine. **53**:275-284.

Central Bureau of Statistics (2001). 1999 Population and Housing Census, counting our people for development vol.1. Ministry of Finance and Planning, January, 2001. Republic of Kenya.

Centres for Disease Control and Prevention, (CDC)(Nov, 2001). Update: Investigation of Bioterrorism-related anthrax and interim guidelines for clinical evaluation of persons with possible anthrax, November 2001. MMWR 2001; **50**: 942-948.

Chima, J.C. and Onoviran, O. (1982). A passive haemmaglutination test for detection of antibodies against *Mycoplasma mycoides* subsp. *mycoides* using glutaraldehyde-fixed sheep erythrocytes. Veterinary Microbiology. **7**: 343-349.

Coetzer, J.A.W., Thompson, G.R., and Tustin, R.C. (1994). Contagious Bovine Pleuropneumonia. In: Infectious Diseases of Livestock with special reference to southern Africa. Oxford University Press. Cape Town, Oxford, New York. Pp1485-1494.

Cornwall, A. (1992). Participatory Rural Appraisal (PRA) for Livestock Issues. London School of Hygiene and Tropical Medicine, unpublished notes.

Courtin, F., Carpenter, T.E., Paskin, R.D. and Chomel, B.B. (2000). Temporal patterns of domestic and wildlife rabies in central Namibia stock-ranching area, (1986-1996). Preventive Veterinary Medicine **43**: 13-28.

Davies, G. (1991). Contagious bovine pleuropneumonia. What every veterinarian ought to know. State Veterinary Journal. **1**: 9-11.

De Jong, M.C.M. (1995). Mathematical modelling in veterinary epidemiology: Why model building is important. Preventive Veterinary Medicine. **25**: 183-193.

Dennis, M.J. (1986). The effects of temperature and humidity on some animal diseases – A review. British Veterinary Journal. **142**:472-485.

Dyson, S.H., Smith, G.R. (1975). The virulence of vaccine strains of *Mycoplasma mycoides* subsp. *mycoides* small colony variant (*MmmSc*) recovered from inoculated cattle. Research Veterinary Science18 (**1**), 115-116.

Egwu, G.O., Nicholas, R.A.J., Ameh, J.A. and Bashiruddin, J.B. (1996). Contagious bovine pleuropneumonia; An update. Veterinary Bulletin. **9**: 875-888.

Food and Agriculture Organisation (FAO) (1997a). Recognising CBPP: A field manual for Recognition. Rome; Food and Agriculture Organisation of the United Nations. Pp1-28.

Food and Agriculture Organisation (FAO) (1997b). Prevention and control of trans-boundary diseases. Report of the Expert Consultation on the Emergency Prevention System (EMPRES) for Trans-boundary Animal and Plant Diseases (Livestock Disease Programme) including the Blueprint for Global Rinderpest Eradication Rome 24th-26th July, 1996 Rome; Food and Agriculture Organisation of United Nations, Pp85-103.

Food and Agriculture Organisation (FAO) (1999). Manual on the preparation of rinderpest contingency plans. FAO Animal Health Manual No 7. Rome; Food and Agriculture Organisation of United Nations 1999, Pp1-34.

Food and Agriculture Organisation (FAO) (2002). Preparation of CBPP contingency plans. FAO animal Health Manual No 14. Rome; Food and Agriculture Organisation of United Nations 2002, Pp1-76.

Freundt, E.A., Erno, H. and Lemke, R.M. (1979). Identification of Mycoplasmas. In Methods in Microbiology. Vol. 13. Bergan, T., Norris J.R. (eds.): Academic Press London UK Pp377-434.

Gathuma, J.M. (2000). Rapid appraisal for Turkana District. Agro-Ecosystem Health Project (AESH) report 2000.

Githaiga, J.K., McDermott, J.J. and Ogara, W.O. (1997). Rabies surveillance in wildlife populations at the wildlife domestic–animal interface: A case study in Kibwezi, Kenya. Proceedings of the Fourth Meeting of the Southern and Eastern African Rabies Group. Nairobi, Kenya 4-6 March 1997, Pp104-110.

Gourlay, R.N. (1965). Comparison between some diagnostic tests for contagious bovine pleuropneumonia. Journal of Comparative Pathology. **75**: 97-109.

Gourlay, R.N. (1983). Serological tests for the diagnosis of contagious bovine pleuropneumonia and other infections with *Mycoplasma mycoides* subsp. *mycoides*. A seminar in the CEC programme of coordination of research on animal pathology. 16^{th}–17^{th} June. Brussels: Pp27-32.

Guadagnini, P.F., Simone, F., Panina, G.F., Gaffuri, A., Bugnetti, M., Finazzi, M., Mandelli, G., Sironi, G., Belloli, A. and Desmone, F. (1991). Contagious bovine pleuropneumonia. A review with field observations. Selezione.Veterinaria. **32** (1): 3-31.

Gulliver, P.H. (1951). A preliminary Survey of Turkana. A report compiled for the Government of Kenya. University of Cape Town, School of African Studies, New series No.26 (reprinted 1963).

Hadrill, D. and Yusuf, H. (1994). Mapping of seasonal migrations in the Sanaag region of Somaliland. Rapid Rural Appraisal (RRA) Notes, **20:** 106-112.

Hall, H.T.B. (1977). Diseases and Parasites of Livestock in the Tropics (Longman Group Ltd, London). Pp 94-96.

Herlocker, D., Shaabani, B.S., and Wilkes, S. (1994). Range Management Handbook of Kenya Vol II, 9. Turkana District. Ministry of Agriculture Livestock Development and Marketing/Deutsche Gesellschaft für Technische Zusammenarbeit. Republic of Kenya.

Hoetzel, H., Sachse, K. and Pfützner, H. (1996). A polymerase chain reaction (PCR) scheme for differentiation of organisms belonging to *Mycoplasma mycoides* cluster. Veterinary microbiology. **49**, 31-43.

Hudson, J.R. (1971). Contagious Bovine Pleuropneumonia. FAO Agricultural studies, No.86. Rome: Food and Agriculture Organisation of the United Nations.

Huddart, J.E. (1963). A field modification of the complement fixation test for contagious bovine pleuropneumonia. Rome: FAO, Animal Health Branch Monograph No. 6. Food and Agriculture Organisation of the United Nations.

Intermediate Technology Development Group-Eastern Africa (ITDG-EA) (2000). Proceedings of the 19th Decentralised Animal Health Workshop. Intermediate Technology Development Group (E.A) in collaboration with OAU/IBAR and SNV.

Intermediate Technology Development Group-Eastern Africa (ITDG-EA) (2001). The role of community-based animal health care in rural development, ITDG-EA's experiences. ITDG-EA 2001 182 Pp.

Kane, K.W.S. (1975). The control of contagious bovine pleuropneumonia in Kenya. Bulletin. Office International des Epizooties, **84**: 421-428.

Kitala, P.M., McDermott, J.J., Kyule, M.N. and Gathuma, J.M.(2000). Community-based active surveillance for rabies in Machakos District Kenya. Preventive Veterinary Medicine. **44**: 73-85.

Laval, G. (1999). Cost analysis of contagious bovine pleuropneumonia (CBPP) in Ethiopia. A dissertation for Master of Science (M.Sc) in analysis of methods of Health systems 1999. Claude Bernard University (Lyon I) France.

Le Goff, C. (1986). Immuno-enzyme technique applied to the serological diagnosis of contagious bovine pleuropneumonia: A preliminary note. Revue d Elevage et deMédecine. Véterinaire desPays Tropicaux. **39**: 171-173.

Le Goff, C. and Thiaucourt, F. (1995). Micromethod Complement Fixation Test for Contagious bovine pleuropneumonia standard operating procedure. Centre de cooperation Internationale Rescherche Agronomique Irle Developpement-Departement d'Élevage et de Médicine Vétérinaire (CIRAD-EMVT), Technical document. Version 2.1. Cedex1, France. 24th August 1995.

Le Goff, C. and Thiaucourt, F. (1998). A competitive ELISA for the specific diagnosis of contagious bovine pleuropneumonia (CBPP). Veterinary Microbiology. **60**: 179-191.

Lefevre, P.C. (1994). Foot and mouth disease, African Horse Sickness and Contagious bovine pleuropneumonia. OIE Scientific conference, Gaborone, Botswana 20th –23rd April 1994. Summaries and conclusions. Paris, France: Office international des Epizooties. Pp59-60.

Mariner, C.J. (1999). Participatory epidemiology: Methods for the collection of Action-Oriented Epidemiological Intelligence. Draft Document prepared for FAO. Vet work UK, Musselburgh and RDP Livestock Services B.V. Zeist.

Mariner, C.J. (2001). A report of consultancy to assist in the development of a rinderpest eradication strategy in the West and East Nile ecosystems OAU/IBAR. RDP Livestock Services B.V.

Mariner, C.J. and Flanagan, F. (1996). Epidemiological Intelligence on the Incidence of Rinderpest in Somalia and North Eastern Kenya. Rome. Food and Agriculture Organization.

Martel, J.L., Perrin, M., Belli, P. and Froget, F.J. (1983). The clinical aspects of contagious bovine pleuropneumonia. In: Hall, S.A.(ed): The diagnosis of Contagious bovine pleuropneumonia and other infections with *Mycoplasma mycoides* subsp. *mycoides*. Luxembourg: C.E.C Publications (EUR 8654). Pp 4-7.

Martin, S.W. and Bonnett, B. (1987). Clinical epidemiology. Canadian Veterinary Journal; **28**: 318-325.

Masiga, W.N. and Domenech, J. (1994). Foot and Mouth disease, African Horse Sickness and Contagious bovine pleuropneumonia. OIE Scientific conference, Gaborone, Botswana 20th –23rd April 1994. Summaries and conclusions. Paris, France: Office International des Epizooties. Pp55-56.

Masiga, W.N. and Domenech, J. (1995). Overview and epidemiology of CBPP in Africa. Revue Scientifique et Technique. Office International des Epizooties. **14** (3): 611-620.

Masiga, W.N., Domenech, J. and Windsor, R.S. (1996). Manifestation and epidemiology of CBPP in Africa. Revue Scientifique et Technique. Office International des Epizooties. **15** (4): 1282-1382.

Masiga, W.N. and Windsor, R.S. (1974). Susceptibility to contagious bovine pleuropneumonia. Veterinary Record. **95**: 87.

Masiga, W.N. and Windsor, R.S. (1975). Immunity to contagious bovine pleuropneumonia. Veterinary Record. **97**: 350-351.

Masiga, W.N., Windsor, R.S. and Read, W.C.S. (1972). A new mode of spread of contagious bovine pleuropneumonia? Veterinary Record. **90**: 247-248.

McDermott, J.J., Deng, K.A., Jayatileka, T.N. and El Jack, M.A. (1987). A cross-sectional cattle disease survey in Kongor Rural Council, Southern Sudan Prevalence Estimates and Age, Sex and Breed Associations for Brucellosis and Contagious Bovine Pleuropneumonia. Preventive Veterinary Medicine. **5**: 111-123.

McDermott, J.J., Randolph, T.F. and Staal, S.J. (1999). The economics of optimal health and productivity in smallholder livestock systems in developing countries. Revue Scientifique et Technique. Office International des Epizooties. **18**(2): 399-424.

Mearns, R., Shombodon, D., Narangerel, G., Tuul, U., Enkhamgalan, A., Myagmrzhav, B., Bayanjargal, B. and Bekhsuren, B. (1994). Natural resource mapping and seasonal variations and stresses in Mongolia. Rapid Rural Appraisal (RRA) Notes, **20**: 95-105.

Miles, R.J. (1992). Cell nutrition and growth. In: Maniloff. (ed): Mycoplasmas molecular biology and pathogenesis. Washington DC: American Society for Microbiology. Pp23-40.

Ministry of Agriculture, Livestock Development & Marketing (MALD&M) (1994). Livestock Division Annual Report, 1994.

Ministry of Agriculture & Rural Development (MA&RD) (2000). Turkana District Annual Report 2000. Department of Veterinary Services. Republic of Kenya.

Ministry of Agriculture & Rural Development (MA&RD) (2001). Turkana District Annual Report 2001. Department of Veterinary Services. Republic of Kenya.

Mlengeya, T.D.K. (1995). Current status of contagious bovine pleuropneumonia (CBPP) in Tanzania. A paper presented at the National Conference of the Tanzanian Veterinary Medical Association, Arusha 15th May Pp.1-11.

Nawathe, D.R. (1992). Resurgence of contagious bovine pleuropneumonia in Nigeria. Revue Scientifique et Technique. Office International des Epizooties. **11**: 799-804.

Nicholas, R.A.J. and Bashiruddin, J.B. (1995). *Mycoplasma mycoides* subsp.*mycoides* (small colony variant): the agent of contagious bovine pleuropneumonia and a member of the "*Mycoplasma mycoides* cluster". Journal of Comparative Pathology. **13**: 1-27.

Nicholas, R.A.J. and Palmer, N. (1994). Contagious bovine pleuropneumonia in Europe. State Veterinary Journal. **4**: 14-16.

Office International des Epizooties (OIE) (1995). Meeting of the FMD and other Epizootics Commision.16th-20th January, Paris: Office International des Epizooties.

Office International des Epizooties (OIE)(1996). CBPP diagnostic technique. Manual of standards for diagnostic tests and vaccines. Paris: Office International des Epizooties. Pp 47-56.

Office International des Epizooties (OIE) (1998). Recommended Standards for Epidemiological Surveillance Systems for CBPP. In: The International Animal Health Code.

Office International des Epizooties (OIE) (2000). Contagious Bovine pleuropneumonia. In: Manual for standards for diagnostic tests and vaccines 2000. Office International des Epizooties, World organisation for Animal Health. Paris, France Pp123-133.

Onoviran, O. and Robinson-Taylor, D. (1979). Detection of antibodies against *Mycoplasma mycoides* subsp. *mycoides* small colony in cattle by an indirect ELISA. Veterinary Research. **105** (8): 165-166.

Perreau, P. (1975). Le diagnostic serologique de la péripneumoniae. Progrés techniques actuels. Bulletin. Office International des Epizooties. **84**: 349-358.

Plowright, W. (1998). Professional Commitment to the Success of the Global Rinderpest Eradication Campaign. Technical Consultation on the Global Rinderpest Eradication Programme, 28th-30th September 1998, FAO Rome.

Pratt, D.J.G. and Gwynne, M.D. (1977). Rangeland management and ecology in East Africa. Robert E. Krieger Publishing Co. Inc. New York USA. Pp40-50.

Pretty, J., Guijt, I., Thompson, J. and Scoones, I. (1995). Participatory Learning and Action: A Trainers Guide. Sustainable Agriculture Programme, International Institute for Environment and Development. London.

Priestley, F.W. (1951). A slide flocculation test for the diagnosis of contagious bovine pleuropneumonia. Veterinary Record. **63**: 427-429.

Provost, A., Perreau, P., Breard, A., Le Goff, C., Martel, J.L. and Cottew, G.S. (1987). Contagious bovine pleuropneumonia. Revue Scientifique et Technique. Office International des Epizooties. **6** (1): 565-679.

Radostits, O.M., Blood, D.C. and Gay, C.C., (1994). Contagious bovine pleuropneumonia: in Veterinary Medicine, 8th edition. Bailliere Tindall. London, Pp910-913.

Radostits, O.M., Blood, D.C., Gay, C.C. and Hinchcliff, K.W. (2000). Contagious bovine pleuropneumonia: in Veterinary Medicine, 9th edition. W.B Saunders Harcourt publishers Ltd 2000. Harcourt place 32Jamestown Road. London UK Pp999-1004.

Sackett, D.L., Haynes, R.B. and Tugwell, P. (1985). Clinical epidemiology: A basic science for clinical medicine. Little, Brown and company, Boston/Toronto.

Scanziani, E., Paltrinieri, S., Boldini, M., Grieco, V., Monaci, C., Giusti, A.M. and Mandelli, G. (1997). Histological and immunohistochemical findings in the thoracic lymph nodes with CBPP. Journal of Comparative Pathology. **117**(2): 127-136.

Scudamore, J.M. (1995). Contagious bovine pleuropneumonia. State Veterinary Journal. **5**:13-16.

Seigel, S. and Castellan, N.J. (1994). Nonparametric statistics for the Behavioural Sciences. Second edition. McGraw-Hill, New York. Pp 399.

Seifert, H.S.H. (1996). Tropical Animal Health. London. Drorecht Kluwer Academic. Pp 332-343.

SPSS® Base10.0 applications guide (1999). In: Using crosstabs to obtain crosstabulations and measures of association. The Kappa measure of agreement for an RxR Table. SPSS Inc. 233 South Wacker drive. Chicago USA. Pp 63-86.

Stille, W.T. and Gersten, J.C. (1978). Tautology in epidemic models. Journal of Infectious Diseases. **138**: 99-101.

Sylla, D., Litamoi, J. and Rweyemamu, M.M. (1995). Vaccination strategies for contagious bovine pleuropneumonia in Africa. Revue Scientifique et Technique. Office International des Epizooties. **14**(3): 577-592.

Takele, G. (1998). Epidemiological survey of CBPP in Awi and Western Gojjam zones of Amhara Region and comparison of CFT and competitive ELISA for the diagnosis of CBPP. Berlin; Freie Universitat, Faculty of Veterinary Medicine, MSc thesis.

TerLaak, E.A. (1992). Contagious bovine pleuropneumonia: A review; Veterinary Quarterly **14**: 104-110.

Thrusfield, M. (1995). Describing disease occurrence in: Veterinary epidemiology. 2nd edition 1995. Blackwell science Ltd. London. Pp483.

Tulasne, J.J., Litamoi, J.K., Morein, B., Dedieu, L., Palya, V.J., Yami, M., Izzeldin, A., Sylla, D. and Bensaid, A. (1996). CBPP vaccines: Actual situation and need for improvements. Scientific Review of the OIE 1996 on Animal Mycoplasmoses. Paris: Office International des Epizooties. Pp1373-1396.

Turkana District Development Plan (1997-2001). Office of the Vice President and Ministry of Planning and National Development. Republic of Kenya.

Turkana District Development Plan (2002-2008). Office of the Vice President and Ministry of Planning and National Development. Republic of Kenya.

Wanyoike, S.W. (1999). Assessment and mapping of Contagious Bovine Pleuropneumonia in Kenya. Past and present. A masters thesis in tropical veterinary epidemiology, Freie University, Berlin.

Waters–Bayer, A. and Bayer, W. (1994). Planning with pastoralists: PRA and more. A review of methods focussed on Africa. Deutsche Gesselschaft für Technische Zusammenrbeit (GTZ), Eschborn.

APPENDICES

Appendix I: Clinical signs, post mortem lesions and associations of cattle diseases by Turkana livestock keepers

	Diseases											
Signs/lesions	*Lokit*	*Logoroi*	*Enomokere*	*Loukoi*	*Lokichuma*	*Long'okuo*	*Lojala*	*Eyala*	*Ekitowo*	*Ekichodunu*	*Lokio*	*Ediit*
Diarrhoea	-	-	-	-	-	-	-	-	-	-	Yes	-
Cough	-	-	-	Yes	-	-	-	-	-	-	-	-
Associated with ticks	Yes	-	-	-	-	-	-	-	-	-	-	-
Abscess in chest/skin	-	-	-	Yes	-	-	-	-	-	Yes	-	-
Adhesion of lungs	-	-	-	Yes	-	-	-	-	-	-	-	-
Sudden death	-	-	Yes	-	Yes	-	-	-	-	-	-	-
Swollen lymph node	Yes	-	-	-	-	-	-	-	-	-	-	-
No clotting of blood	-	-	Yes	-	-	-	-	-	-	-	-	-
Swollen joints	-	-	-	-	-	-	-	Yes	-	-	-	-
Meat with foul smell	-	-	-	-	Yes	-	-	-	-	-	Yes	-
Rapid breathing	-	-	-	Yes	Yes	-	-	Yes	-	-		-
Seeks shelter	-	-	-	Yes	Yes	-	-	Yes	-	-	Yes	
High mortality	-	Yes	Yes	Yes	Yes	Yes	-	-	-	-	Yes	Yes
Low mortality	Yes	-	-	-	-	-	Yes	Yes	Yes	Yes	-	-
Madness/wildness	Yes	-	-	-	-	Yes	-	-	-	-	-	-
Lameness	-	-	-	-	Yes	-	Yes	Yes	Yes	Yes	-	-
Emaciation	-	-	-	Yes	-	-	Yes	Yes	-	-	-	Yes
Gelatinisation of fat	-	-	-	-	-	-	-	-	-	-	Yes	Yes
Zoonosis	-	-	Yes	-	-	Yes	-	-	-	-	-	-
Swollen neck	-	Yes	-	-	-	-	-	-	-	-	-	-
Loss of tail/skin hair	-	-	-	-	-	-	-	-	-	-	-	-
Ropy salivation	-	Yes	-	-	-	Yes	Yes	Yes	-	-	Yes	-
Over growth of hair	-	-	-	-	-	-	-	Yes	-	-	-	-
3 days & recovery	-	-	-	-	-	-	-	-	Yes	-	-	-
Associated with sick cow	-	-	-	-	-	-	-	Yes	-	-	-	-
Associated with wild life	Yes	-	-	-	-	-	-	-	-	-	Yes	-
Associated with grass, water	-	Yes	Yes	-	-	-	-	-	-	Yes	-	-
Cause not known	Yes	-	-	-	-	-	-	-	Yes	Yes	Yes	-

Appendix II: 12 matrixes of diseases versus clinical signs and post mortem lesions

Group	Indicator	*Lokio*	*Long'okuo*	*Lokit*	*Enomokere*	*Loukoi*	Source *Adakar*
1	Lacrimation/'tearing'	21	4	0	0	0	Narakibuk Elders
1	Diarrhoea	25	0	0	0	0	Narakibuk Elders
1	Cough	2	0	0	0	23	Narakibuk Elders
1	Sudden death	0	0	0	25	0	Narakibuk Elders
1	Salivation	20	5	0	0	0	Narakibuk Elders
1	Adhesion of lungs to chest cavity	0	0	0	0	25	Narakibuk Elders
1	Yellow fluid in the chest cavity	0	0	0	0	25	Narakibuk Elders
1	Madness/wildness	0	19	6	0	0	Narakibuk Elders
1	Dyspnoea	0	0	0	0	25	Narakibuk Elders
1	Swollen lymph node	0	0	25	0	0	Narakibuk Elders
2	Lacrimation/'tearing'	25	0	0	0	0	Narakibuk Herders
2	Diarrhoea	25	0	0	0	0	Narakibuk Herders
2	Cough	0	0	0	0	25	Narakibuk Herders
2	Sudden death	0	0	0	25	0	Narakibuk Herders
2	Salivation	16	9	0	0	0	Narakibuk Herders
2	Adhesion of lungs to chest cavity	0	0	0	0	25	Narakibuk Herders
2	Yellow fluid in the chest cavity	0	0	0	0	25	Narakibuk Herders
2	Madness/wildness	0	25	0	0	0	Narakibuk Herders
2	Dyspnoea	0	0	0	12	13	Narakibuk Herders
2	Swollen lymph node	0	0	25	0	0	Narakibuk Herders
3	Lacrimation/'tearing"	10	3	7	0	5	Narakibuk women
3	Diarrhoea	25	0	0	0	0	Narakibuk women
3	Cough	0	0	0	0	25	Narakibuk women
3	Sudden death	0	0	0	16	9	Narakibuk women
3	Salivation	7	3	3	6	6	Narakibuk women
3	Adhesion of lungs to chest cavity	0	0	6	0	19	Narakibuk women
3	Yellow fluid in the chest cavity	0	5	8	0	12	Narakibuk women
3	Madness/wildness	0	15	10	0	0	Narakibuk women
3	Dyspnoea	0	0	0	12	13	Narakibuk women
3	Swollen lymph node	8	0	10	7	0	Narakibuk women
4	Lacrimation/'tearing'	25	0	0	0	0	Ng'isaricho Elders
4	Diarrhoea	25	0	0	0	0	Ng'isaricho Elders
4	Cough	0	0	0	0	25	Ng'isaricho Elders
4	Sudden death	0	0	0	25	0	Ng'isaricho Elders
4	Salivation	16	2	0	0	7	Ng'isaricho Elders
4	Adhesion of lungs to chest cavity	0	0	0	0	25	Ng'isaricho Elders
4	Yellow fluid in the chest cavity	0	0	0	0	25	Ng'isaricho Elders
4	Madness/wildness	0	18	7	0	0	Ng'isaricho Elders
4	Dyspnoea	0	0	0	0	25	Ng'isaricho Elders
4	Swollen lymph node	0	0	25	0	0	Ng'isaricho Elders
5	Lacrimation/'tearing'	25	0	0	0	0	Ng'isaricho women
5	Diarrhoea	25	0	0	0	0	Ng'isaricho women
5	Cough	0	0	0	0	25	Ng'isaricho women
5	Sudden death	0	0	0	25	0	Ng'isaricho women
5	Salivation	10	11	0	0	4	Ng'isaricho women
5	Adhesion of lungs to chest cavity	0	0	0	0	25	Ng'isaricho women

Appendix II continues

5	Yellow fluid in the chest cavity	0	0	0	0	25	Ng'isaricho women
5	Madness/wildness	19		0	6	0	Ng'isaricho women
5	Dyspnoea	0	5	0	0	20	Ng'isaricho women
5	Swollen lymph node	0	0	25	0	0	Ng'isaricho women
6	Lacrimation/'tearing'	25	0	0	0	0	Ikong Elders
6	Diarrhoea	25	0	0	0	0	Ikong Elders
6	Cough	0	0	0	0	25	Ikong Elders
6	Sudden death	0	0	0	25	0	Ikong Elders
6	Salivation	25	0	0	0	0	Ikong Elders
6	Adhesion of lungs to chest cavity	0	0	0	0	25	Ikong Elders
6	Yellow fluid in the chest cavity	0	0	0	0	25	Ikong Elders
6	Madness/wildness	0	16	9	0	0	Ikong Elders
6	Dyspnoea	5	0	0	0	20	Ikong Elders
6	Swollen lymph node	0	0	25	0	0	Ikong Elders
7	Lacrimation/'tearing'	25	0	0	0	0	Ikong women
7	Diarrhoea	25	0	0	0	0	Ikong women
7	Cough	0	0	0	0	25	Ikong women
7	Sudden death	0	0	0	25	0	Ikong women
7	Salivation	15	0	0	0	10	Ikong women
7	Adhesion of lungs to chest cavity	0	0	0	0	25	Ikong women
7	Yellow fluid in the chest cavity	0	0	0	0	25	Ikong women
7	Madness/wildness	0	15	10	0	0	Ikong women
7	Dyspnoea	9	0	0	0	16	Ikong women
7	Swollen lymph node	0	0	25	0	0	Ikong women
8	Lacrimation/'tearing'	25	0	0	0	0	Ikong Elders
8	Diarrhoea	25	0	0	0	0	Ikong Elders
8	Cough	0	0	0	0	25	Ikong Elders
8	Sudden death	3	0	0	17	5	Ikong Elders
8	Salivation	25	0	0	0	0	Ikong Elders
8	Adhesion of lungs to chest cavity	0	0	0	0	25	Ikong Elders
8	Yellow fluid in the chest cavity	0	0	0	0	25	Ikong Elders
8	Madness/wildness	0	20	5	0	0	Ikong Elders
8	Dyspnoea	0	0	0	0	25	Ikong Elders
8	Swollen lymph node	0	0	25	0	0	Ikong Elders
9	Lacrimation/'tearing'	25	0	0	0	0	Ikong women
9	Diarrhoea	25	0	0	0	0	Ikong women
9	Cough	0	0	0	0	25	Ikong women
9	Sudden death	0	0	0	25	0	Ikong women
9	Salivation	25	0	0	0	0	Ikong women
9	Adhesion of lungs to chest cavity	0	0	0	0	25	Ikong women
9	Yellow fluid in the chest cavity	0	0	0	0	25	Ikong women
9	Madness/wildness	0	25	0	0	0	Ikong women
9	Dyspnoea	0	0	0	0	25	Ikong women
9	Swollen lymph node	0	0	14	11	0	Ikong women
10	Lacrimation/'tearing'	25	0	0	0	0	Eipa Elders
10	Diarrhoea	25	0	0	0	0	Eipa Elders
10	Cough	0	0	0	0	25	Eipa Elders
10	Sudden death	0	0	0	25	0	Eipa Elders

Appendix II continues

10	Salivation	18	7	0	0	0	Eipa Elders
10	Adhesion of lungs to chest cavity	0	0	0	0	25	Eipa Elders
10	Yellow fluid in the chest cavity	0	0	0	0	25	Eipa Elders
10	Madness/wildness	0	25	0	0	0	Eipa Elders
10	Dyspnoea	0	0	7	0	18	Eipa Elders
10	Swollen lymph node	0	0	25	0	0	Eipa Elders
11	Lacrimation/'tearing'	25	0	0	0	0	Eipa Women
11	Diarrhoea	25	0	0	0	0	Eipa Women
11	Cough	0	0	0	0	25	Eipa Women
11	Sudden death	0	0	0	25	0	Eipa Women
11	Salivation	25	0	0	0	0	Eipa Women
11	Adhesion of lungs to chest cavity	0	0	0	0	25	Eipa Women
11	Yellow fluid in the chest cavity	0	0	0	0	25	Eipa Women
11	Madness/wildness	0	20	5	0	0	Eipa Women
11	Dyspnoea	0	0	0	0	25	Eipa Women
11	Swollen lymph node	0	0	25	0	0	Eipa Women
12	Lacrimation/'tearing'	25	0	0	0	0	Eipa Herders
12	Diarrhoea	25	0	0	0	0	Eipa Herders
12	Cough	0	0	0	0	25	Eipa Herders
12	Sudden death	0	0	0	25	0	Eipa Herders
12	Salivation	20	0	0	0	5	Eipa Herders
12	Adhesion of lungs to chest cavity	0	0	0	0	25	Eipa Herders
12	Yellow fluid in the chest cavity	0	0	0	0	25	Eipa Herders
12	Madness/wildness	0	23	2	0	0	Eipa Herders
12	Dyspnoea	0	0	0	0	25	Eipa Herders
12	Swollen lymph node	0	0	25	0	0	Eipa Herders

Appendix III: Descriptive statistics of morbidity rates of important adult cattle diseases relative to healthy adult cattle in four *Adakars* of Lapur Division Turkana District, year 2001-2002

		Lokio	*Long'okuo*	*Lokit*	*Enomokere*	*Loukoi*	Others	Healthy cattle
N	Valid	57	57	57	57	57	57	57
	Missing	1	1	1	1	1	1	1
Mean		6.59	6.00	4.98	9.04	14.63	6.82	51.93
Std. Error of Mean		.784	.454	.433	.632	.963	.834	2.164
Std. Deviation		5.92	3.43	3.27	4.78	7.27	6.30	16.34
Variance		35.07	11.750	10.70	22.82	52.92	39.61	266.85

Appendix IV: Descriptive statistics of estimated morbidity rates of important calf diseases relative to healthy calves in four *Adakars* of Lapur Division Turkana District, year 2001-2002

		Lokio	*Long'okuo*	*Lokit*	*Enomokere*	*Loukoi*	Others	Healthy calves
N	Valid	51	51	51	51	51	51	51
	Missing	7	7	7	7	7	7	7
Mean		6.73	4.51	3.88	6.98	10.70	9.29	57.90
Std. Error of Mean		1.06	.547	.475	.728	.929	1.148	2.413
Std. Deviation		7.59	3.90	3.39	5.20	6.63	8.20	17.24
Variance		57.64	15.25	11.50	27.02	44.01	67.25	297.17

Appendix V: Descriptive statistics of estimated morbidity rates of important cattle diseases relative to healthy cattle, all age groups in four *Adakars* of Lapur Division Turkana District, year 2001-2002

		Lokio	*Long'okuo*	*Lokit*	*Enomokere*	*Loukoi*	Other Diseases	Healthy cattle
N	Valid	57	57	57	57	57	57	57
	Missing	1	1	1	1	1	1	1
Mean		6.30	5.01	4.22	7.64	12.10	7.57	57.13
Std. Error of Mean		.730	.427	.343	.576	772	.784	2.079
Std. Deviation		5.51	3.22	2.59	4.35	5.82	5.92	15.69
Variance		30.40	10.40	6.72	18.93	33.98	35.04	246.45

Appendix VI: Descriptive statistics of estimated mortalities due to important adult cattle diseases relative to live adult cattle, in four *Adakars* of Lapur Division Turkana District, year 2001-2002

		Lokio	*Long'okuo*	*Lokit*	*Enomokere*	*Loukoi*	Other diseases	Live adult cattle
N	Valid	57	57	57	57	57	57	57
	Missing	0	0	0	0	0	0	0
Mean		4.56	5.03	2.78	5.66	9.33	4.10	68.75
Std. Error of Mean		.621	.432	.299	.522	.710	.543	1.808
Std. Deviation		4.694	3.262	2.25	3.947	5.366	4.104	13.652
Variance		22.03	10.64	5.09	15.58	28.79	16.84	186.40

Appendix VII: Descriptive statistics of estimated mortalities due to important calf diseases relative to live calves in four *Adakars* of Lapur Division Turkana District, year 2001-2002

		Lokio	*Long'okuo*	*Lokit*	*Enomokere*	*Loukoi*	Other diseases	Live calves
N	Valid	51	51	51	51	51	51	51
	Missing	6	6	6	6	6	6	6
Mean		4.67	3.84	2.25	4.18	6.76	5.82	72.47
Std. Error of Mean		.906	.505	.347	.484	.741	.820	2.136
Std. Deviation		6.47	3.60	2.48	3.46	5.29	5.86	15.26
Variance		41.90	13.01	6.15	11.95	28.02	34.34	232.85

Appendix VIII: Descriptive statistics of estimated mortalities % due to important cattle diseases relative to live cattle, all age groups in four *Adakars* of Lapur Division Turkana District, year 2001-2002

		Lokio	*Long'okuo*	*Lokit*	*Enomokere*	*Loukoi*	Other diseases	Live cattle
N	Valid	51	51	51	51	51	51	51
	Missing	6	6	6	6	6	6	6
Mean		4.60	4.45	2.46	5.00	8.08	5.05	70.28
Std. Error of Mean		.645	.444	.271	461	.611	.584	1.842
Std. Deviation		4.61	3.17	1.938	3.29	4.36	4.17	13.15
Variance		21.25	10.06	3.75	10.84	19.04	17.41	173.13

Appendix IX: Proportional piling with 57 informants/herds, morbidity scores in adult cattle and calves

Herd number	Adults *lokio*	Adults *long'okuo*	Adults *lokit*	Adults *enomokere*	Adults *loukoi*	Adults-other diseases	Calves *lokio*	Calves *long'okuo*	Calves *lokit*	Calves *enomokere*	Calves *loukoi*	Calves 'other diseases'
1	11	4	2	16	19	13	14	3	3	18	15	12
2	5	2	0	3	5	2	16	3	0	18	22	4
3	3	1	2	15	28	7	3	1	4	6	7	1
4	10	6	9	9	25	6	14	3	6	7	19	6
5	11	3	2	5	17	2	13	6	2	6	18	5
6	5	3	4	12	15	0	7	6	6	8	12	0
7	8	7	6	11	14	0	8	8	4	9	10	0
8	8	5	5	6	11	7	8	3	3	4	7	5
9	10	3	3	12	14	7	7	5	7	8	13	7
10	7	6	6	5	13	8	6	3	5	5	9	9
11	0	5	7	8	12	2	2	4	4	9	22	1
12	0	0	0	8	14	8	0	0	0	0	0	34
13	0	4	3	5	6	1	0	5	0	0	7	12
14	0	8	6	23	29	27	0	4	2	11	8	4
15	0	2	1	6	7	0	0	0	3	0	0	11
16	0	2	1	4	19	7	0	0	0	0	0	17
17	0	6	0	5	11	7	0	0	0	0	12	0
18	0	10	2	6	10	5	0	0	0	0	4	9
19	0	7	3	0	12	5	0	0	0	4	8	14
20	0	0	13	9	19	20	0	0	0	0	16	23
21	0	4	0	6	26	17	0	0	0	0	10	20
22	0	8	9	12	16	12	0	6	5	9	15	8
23	0	0	3	7	7	4	0	0	0	0	0	15
24	0	2	2	2	5	3	0	0	0	0	3	4
25	0	8	7	13	25	22	37	0	13	0	29	17
26	10	9	11	14	14	10	0	10	9	11	11	14
27	0	9	0	9	7	12	0	7	0	14	15	17
28	0	0	0	0	44	24	0	0	0	0	20	15

29	0	0	0	20	31	18	0	0	10	14	0	15
30	13	9	3	7	16	4	13	10	5	7	14	7
31	11	7	2	4	21	3	12	12	3	6	15	3
32	8	7	6	9	15	5	9	8	7	8	11	7
33	9	12	10	10	15	7	31	3	2	11	0	20
34	14	8	6	14	12	13	14	5	10	14	8	8
35	12	7	9	11	12	5	6	3	4	7	7	2
36	6	11	8	10	14	9	9	10	9	13	12	9
37	13	10	6	21	14	8	6	8	7	11	16	8
38	5	6	6	8	10	6	8	6	11	9	14	11
39	14	7	6	14	14	10	7	7	6	10	8	11
40	5	7	7	5	10	9	6	8	4	9	13	6
41	7	7	5	4	17	6	5	3	4	9	11	6
42	5	9	5	12	20	10	6	7	6	9	12	4
43	5	4	5	14	12	0	8	9	8	10	15	0
44	18	5	10	8	4	0	0	0	0	0	0	39
45	11	9	11	9	14	0	12	7	0	9	13	13
46	5	1	4	10	15	0	6	3	3	6	8	2
47	10	8	6	5	14	4	6	6	3	4	9	11
48	18	10	7	6	14	0	14	9	5	17	19	0
49	24	6	6	15	8	0	7	2	5	7	4	8
50	7	12	3	14	16	0	8	15	5	13	19	0
51	20	13	5	9	9	0	15	12	5	6	6	0
52	12	10	10	10	14	8						
53	9	9	9	8	13	6						
54	6	3	6	4	4	4						
55	6	9	5	7	11	6						
56	5	4	6	8	15	7						
57	10	8	5	8	6	3						

Appendix X: Proportional piling with 57 informants/herds, scores of mortalities due to diseases in adult cattle and calves

Herd	Adults *lokio*	Adults *long'okuo*	Adults *lokit*	Adults *enomokere*	Adults *loukoi*	Adults 'other disease'	Live Adult cattle	Calves *lokio*	Calves *long'okuo*	Calves *lokit*	Calves *enomokere*	Calves *loukoi*	Calves 'other diseases'	Live Calves
1	6	2	0	11	11	9	62	10	1	1	14	10	8	56
2	2	1	0	2	2	1	92	8	1	0	7	15	2	67
3	2	0	1	8	16	4	68	2	1	3	4	5	1	84
4	4	3	3	5	10	2	72	6	1	3	3	9	3	75
5	5	1	2	2	7	2	79	9	2	2	3	6	3	75
6	2	1	1	3	5	0	87	1	2	1	2	4	0	90
7	3	4	1	7	3	0	85	4	2	1	3	3	0	87
8	5	5	1	4	7	5	78	8	3	1	2	5	4	77
9	7	3	1	9	9	4	74	6	5	3	6	10	4	66
10	3	6	2	1	8	4	79	4	3	2	3	5	4	79
11	0	4	4	6	8	1	77	1	3	2	5	17	1	71
12	0	0	0	3	5	0	92	0	0	0	0	0	5	95
13	0	3	2	3	6	0	86	0	5	0	0	7	5	83
14	0	5	4	23	25	13	30	0	3	1	7	4	4	81
15	0	2	1	6	7	0	84	0	0	1	0	0	4	95
16	0	2	0	3	15	4	76	0	0	0	0	0	12	88
17	0	6	0	3	5	3	83	0	0	0	0	6	0	94
18	0	10	1	3	7	3	76	0	0	0	0	3	9	88
19	0	7	2	0	5	5	81	0	0	0	2	4	8	86
20	0	0	8	4	10	13	65	0	0	0	0	6	15	79
21	0	4	0	2	6	11	77	0	0	0	0	3	10	87
22	0	8	4	6	9	7	59	0	6	3	5	10	5	71
23	0	0	0	2	3	1	94	0	0	0	0	0	5	95
24	0	2	1	1	2	1	93	0	0	0	0	1	2	97
25	0	3	4	9	21	17	46	35	0	10	0	28	15	12
26	7	9	9	11	10	6	42	0	10	6	7	6	10	61
27	0	9	0	6	5	7	62	0	7	0	10	11	12	60
28	0	0	0	0	27	16	52	0	0	0	0	14	10	76

Appendix X continues

29	0	0	0	12	23	11	46
30	13	9	3	2	7	2	65
31	11	7	2	5	12	3	63
32	5	7	3	5	9	4	68
33	8	9	7	6	10	4	56
34	12	8	5	11	8	7	57
35	8	7	7	8	7	4	58
36	4	11	5	6	11	7	57
37	8	10	3	13	12	7	49
38	4	6	4	3	8	5	70
39	9	7	4	8	11	6	62
40	3	7	2	2	5	5	63
41	6	6	4	3	13	4	62
42	4	5	3	9	16	7	57
43	2	3	3	10	8	0	67
44	16	5	6	7	3	0	61
45	8	9	7	6	10	0	53
46	3	1	2	7	14	0	70
47	9	6	3	4	11	4	58
48	18	10	5	4	8	0	64
49	15	5	3	7	4	0	75
50	6	10	1	11	11	0	65
51	14	10	2	5	5	0	76
52	9	5	6	7	11	4	64
53	6	3	5	3	11	2	70
54	2	2	4	2	2	1	89
55	2	8	2	5	10	2	73
56	3	3	2	3	13	4	75
57	6	8	4	6	5	2	75

0	0	7	8	0	8	77
5	10	5	5	4	2	69
10	12	2	3	10	2	61
6	8	3	5	6	4	68
27	2	0	7	0	17	47
12	5	9	9	5	4	56
4	3	2	3	4	1	83
4	10	6	9	10	8	53
5	8	4	9	12	7	55
3	6	8	5	11	6	61
4	7	4	7	6	7	65
3	8	1	3	5	3	77
4	2	3	7	9	5	70
3	5	4	5	8	3	72
5	5	4	6	8	0	72
0	0	0	0	0	34	66
9	7	0	7	12	10	55
4	8	1	3	6	2	76
6	5	3	2	7	9	68
9	9	2	11	15	0	54
4	2	3	6	3	4	78
6	10	2	7	10	0	65
11	9	2	3	2	0	73

Appendix XI: 12 Matrixes of socio–economic losses versus disease scores

Group	Indicator	*Lokio*	*long'okuo*	*Lokit*	*Enomokere*	*Loukoi*	Source
1	Milk	12	13	0	0	0	Narakibuk Elders
1	Meat/blood	23	0	0	0	2	Narakibuk Elders
1	Fat/milk/meat	15	10	0	0	0	Narakibuk Elders
1	Dowry	6	8	0	0	11	Narakibuk Elders
1	Hides	25	0	0	0	0	Narakibuk Elders
1	Calves/Abortion	20	5	0	0	0	Narakibuk Elders
1	Cost treatment						Narakibuk Elders
1	Sale value						Narakibuk Elders
2	Milk	13	12	0	0	0	Narakibuk Herders
2	Meat/blood	9	8	0	0	8	Narakibuk Herders
2	Fat/milk/meat	11	14	0	0	0	Narakibuk Herders
2	Dowry	12	7	0	0	6	Narakibuk Herders
2	Hides	5	5	5	5	5	Narakibuk Herders
2	Calves/Abortion						Narakibuk Herders
2	Cost treatment	6	0	0	0	19	Narakibuk Herders
2	Sale value	4	10	2	8	1	Narakibuk Herders
3	Milk	15	2	5	0	3	Ng'isarichoElders
3	Meat/blood	21	0	0	0	4	Ng'isarichoElders
3	Fat/milk/meat	14	7	4	0	0	Ng'isarichoElders
3	Dowry	6	6	6	0	7	Ng'isarichoElders
3	Hides	0	0	0	25	0	Ng'isarichoElders
3	Calves/Abortion	6	0	6	4	9	Ng'isarichoElders
3	Cost treatment	0	0	0	9	16	Ng'isarichoElders
3	Sale value	3	12	3	4	3	Ng'isarichoElders
4	Milk	11	1	2	0	11	Ng'isaricho Women
4	Meat/blood	12	0	6	3	4	Ng'isaricho Women
4	Fat/milk/meat	12	0	0	13	0	Ng'isaricho Women
4	Dowry	5	8	6	2	4	Ng'isaricho Women
4	Hides	0	0	0	25	0	Ng'isaricho Women
4	Calves/Abortion	5	6	4	4	6	Ng'isaricho Women
4	Cost treatment	0	0	0	0	25	Ng'isaricho Women
4	Sale value	2	10	7	3	3	Ng'isaricho Women
5	Milk	5	2	3	4	11	Ikong Elders
5	Meat/blood	11	0	3	4	7	Ikong Elders
5	Fat/milk/meat	15	0	0	0	10	Ikong Elders
5	Dowry	11	7	4	1	2	Ikong Elders
5	Hides	4	4	3	10	4	Ikong Elders
5	Calves/Abortion	8	0	0	7	10	Ikong Elders
5	Cost treatment	10	1	1	3	10	Ikong Elders
5	Sale value	9	5	7	3	1	Ikong Elders
6	Milk	3	11	7	2	2	Ikong Women
6	Meat/blood	9	0	3	7	6	Ikong Women
6	Fat/milk/meat	11	1	5	1	6	Ikong Women
6	Dowry	1	4	2	4	14	Ikong Women
6	Hides	3	0	3	12	7	Ikong Women
6	Calves/Abortion	9	0	0	5	11	Ikong Women
6	Cost treatment	8	0	0	0	17	Ikong Women
6	Sale value	11	8	3	2	1	Ikong Women
7	Milk	10	1	2	0	12	Ikong Elders
7	Meat/blood	12	4	1	1	7	Ikong Elders

7	Fat/milk/meat	18	1	2	0	4	Ikong Elders
7	Dowry	9	1	1	0	14	Ikong Elders
7	Hides	4	0	0	21	0	Ikong Elders
7	Calves/Abortion	24	0	0	1	0	Ikong Elders
7	Cost treatment	5	0	1	0	19	Ikong Elders
7	Sale value						Ikong Elders
8	Milk	10	0	3	0	12	Ikong Women
8	Meat/blood	7	0	4	5	9	Ikong Women
8	Fat/milk/meat	10	0	0	4	11	Ikong Women
8	Dowry	5	5	5	5	5	Ikong Women
8	Hides	0	0	0	12	13	Ikong Women
8	Calves/Abortion	9	0	0	8	8	Ikong Women
8	Cost treatment	0	0	0	0	25	Ikong Women
8	Sale value	5	5	5	5	5	Ikong Women
9	Milk	7	6	6	0	6	Eipa Elders
9	Meat/blood	11	1	7	2	4	Eipa Elders
9	Fat/milk/meat	14	0	4	0	7	Eipa Elders
9	Dowry	7	5	3	0	10	Eipa Elders
9	Hides	5	3	5	8	4	Eipa Elders
9	Calves/Abortion	25	0	0	0	0	Eipa Elders
9	Cost treatment	10	0	3	0	12	Eipa Elders
9	Sale value	5	6	4	1	9	Eipa Elders
10	Milk	6	6	3	4	6	Eipa Women
10	Meat/blood	10	9	2	1	3	Eipa Women
10	Fat/milk/meat	11	11	0	1	2	Eipa Women
10	Dowry	4	10	3	1	7	Eipa Women
10	Hides	4	0	0	14	7	Eipa Women
10	Calves/Abortion	9	0	0	6	10	Eipa Women
10	Cost treatment	0	0	0	0	25	Eipa Women
10	Sale value	8	6	3	0	8	Eipa Women
11	Milk	11	9	2	0	3	Eipa Herders
11	Meat/blood	19	0	3	1	2	Eipa Herders
11	Fat/milk/meat	23	0	0	0	2	Eipa Herders
11	Dowry	9	4	5	0	7	Eipa Herders
11	Hides	0	0	0	25	0	Eipa Herders
11	Calves/Abortion	21	0	0	0	4	Eipa Herders
11	Cost treatment	13	0	0	0	12	Eipa Herders
11	Sale value	7	4	3	0	11	Eipa Herders
12	Milk	10	7	7	0	1	Eipa Herders
12	Meat/blood	15	2	2	1	5	Eipa Herders
12	Fat/milk/meat	19	2	2	0	2	Eipa Herders
12	Dowry	6	6	6	0	7	Eipa Herders
12	Hides	20	0	0	5	0	Eipa Herders
12	Calves/Abortion	11	0	10	0	4	Eipa Herders
12	Cost treatment	12	0	0	0	13	Eipa Herders
12	Sale value	12	1	1	1	10	Eipa Herders

Appendix XII: 4 matrixes of Turkana seasons versus cattle disease scores

Group Indicator	*Akamu*/Dry season	*Akiitiar*/Interphase	*Akiporo*/Rain season	Source
1 *lokit*	0	0	15	Narakibuk Elders
1 *loukoi*	8	3	4	Narakibuk Elders
1 *lokio*	13	1	1	Narakibuk Elders
1 *enomokere*	5	2	8	Narakibuk Elders
1 *long'okuo*	0	5	10	Narakibuk Elders
2 *lokit*	9	1	5	Ng'isaricho Elders
2 *loukoi*	10	0	5	Ng'isaricho Elders
2 *lokio*	4	2	9	Ng'isaricho Elders
2 *enomokere*	9	2	4	Ng'isaricho Elders
2 *long'okuo*	15	0	0	Ng'isaricho Elders
3 *lokit*	5	5	5	Ikong Elders
3 *loukoi*	6	4	5	Ikong Elders
3 *lokio*	6	9	0	Ikong Elders
3 *enomokere*	7	5	3	Ikong Elders
3 *long'okuo*	5	0	10	Ikong Elders
4 *lokit*	7	5	3	Eipa Elders
4 *loukoi*	3	4	8	Eipa Elders
4 *lokio*	3	5	7	Eipa Elders
4 *enomokere*	0	4	11	Eipa Elders
4 *long'okuo*	7	3	5	Eipa Elders

Appendix XIII: 6 matrixes of prevention and control methods versus the indicators

Group no	Source	Indicator	Vaccination	Community quarantine	Peace	Slaughter	Modern drugs	Traditional herbs
1	Narakibuk E	Low financial cost	12	6	8	1	1	2
1	Narakibuk E	Effectiveness	15	8	0	0	1	6
1	Narakibuk E	User-friendliness	15	9	0	0	1	5
1	Narakibuk E	Group action	11	12	6	0	1	0
1	Narakibuk E	Individual action	3	2	0	7	8	10
2	Ng'isaricho E	Low financial cost	11	9	6	0	0	4
2	Ng'isaricho E	Effectiveness	10	10	0	2	5	3
2	Ng'isaricho E	User-friendliness	9	2	9	2	4	4
2	Ng'isaricho E	Group action	7	8	8	2	4	1
2	Ng'isaricho E	Individual action	0	0	0	10	13	7
3	Ikong W	Low financial cost	6	6	6	6	0	6
3	Ikong W	Effectiveness	10	5	5	2	4	4
3	Ikong W	User-friendliness	6	4	3	4	8	5
3	Ikong W	Group action	8	6	8	2	3	3
3	Ikong W	Individual action	0	0	0	12	9	9
4	Ikong E	Low financial cost	19	4	4	1	0	2
4	Ikong E	Effectiveness	24	0	0	0	4	2
4	Ikong E	User-friendliness	19	0	2	0	5	4
4	Ikong E	Group action	16	7	5	0	1	1
4	Ikong E	Individual action	0	0	0	6	13	11
5	Eipa W	Low financial cost	6	6	5	5	2	6
5	Eipa W	Effectiveness	9	7	5	0	5	4
5	Eipa W	User-friendliness	9	6	7	0	3	5
5	Eipa W	Group action	9	7	10	0	4	0
5	Eipa W	Individual action	0	0	0	15	0	15
6	Eipa H	Low financial cost	9	9	6	2	0	4
6	Eipa H	Effectiveness	7	7	5	2	6	3
6	Eipa H	User-friendliness	0	8	0	4	9	9
6	Eipa H	Group action	12	8	10	0	0	0
6	Eipa H	Individual action	0	0	0	11	8	11

KEY
E=ELDERS
W=WOMEN
H=HERDERS

Appendix XIV: Laboratory results, clinical case history and Vet. examination results

Well	Description	FCFT	Owner Dx now	LCFT	Owner dx 6months	Temp. °C	Demeanor	Vet dx now	Other owner dx
1	EP9FA	Negative	Negative	Negative	Negative	38	bright	Negative	normal
2	EP30FA	Negative	Negative	Negative	Negative	38	bright	Negative	normal
3	EP18FA	Negative	Negative	Negative	Positive	38.5	bright	Negative	normal
4	EP23FA	Negative	Negative	Negative	Negative	37.9	bright	Negative	normal
5	K4FC	Negative	Negative	Negative	Negative	38.2	bright	Negative	normal
6	EP25FA	Negative	Negative	Negative	Negative	38.5	bright	Negative	normal
7	EP24FA	Negative	Negative	Positive	Negative	38	bright	Negative	normal
8	EP14FA	Negative	Negative	Negative	Negative	37.5	bright	Negative	normal
9	EP4FA	Negative	Negative	Negative	Negative	38	bright	Negative	normal
10	EP22FA	Negative	Negative	Negative	Positive	37.9	bright	Negative	normal
11	EP28FA	Negative	Negative	Positive	Negative	38.5	bright	Negative	normal
12	EP10FA	Negative	Negative	Negative	Negative	38.9	bright	Negative	normal
13	EP2FA	Negative	Negative	Positive	Positive	38.3	bright	Negative	normal
14	EP17FA	Negative	Negative	Negative	Positive	37.4	bright	Negative	normal
15	EP13FC	Negative	Negative	Negative	Negative	38	bright	Negative	normal
16	EP8FA	Positive	Negative	Positive	Positive	37.8	bright	Negative	normal
17	EP34FA	Negative	Negative	Negative	Positive	38.5	limping	Negative	*lokichuma*
18	EP19MA	Negative	Negative	Negative	Negative	38.4	bright	Negative	normal
19	EP12FA	Negative	Negative	Negative	Negative	38.8	bright	Negative	normal
20	EP3FA	Negative	Negative	Negative	Negative	38	bright	Negative	normal
21	EP6FA	Negative	Negative	Negative	Negative	38.2	bright	Negative	normal
22	EP21	Negative	Negative	Negative	Positive	38	bright	Negative	normal
23	EP32FC	Positive	Negative	Positive	Negative	38.2	limping	Negative	*lokichuma*
24	K3FA	Negative	Negative	Negative	Negative	38.1	bright	Negative	normal
25	EP11FA	Negative	Negative	Negative	Negative	38.5	bright	Negative	normal
26	EP20FA	Positive	Negative	Positive	Positive	38.1	bright	Negative	normal
27	EP16FA	Negative	Negative	Negative	Negative	38	bright	Negative	normal
28	EP26FA	Negative	Negative	Negative	Negative	38.2	bright	Negative	normal
29	EP1FA	Negative	Negative	Negative	Negative	38	bright	Negative	normal
30	K2MC	Negative	Negative	Negative	Negative	38.6	bright	Negative	normal
31	EP29FA	Negative	Negative	Negative	Negative	38.3	bright	Negative	normal
32	EP5FA	Negative	Negative	Negative	Positive	38	bright	Negative	normal
33	EP33H	Positive	Negative	Positive	Negative	38.5	limping	Negative	normal
34	K5MW	Negative	Negative	Negative	Negative	38.7	bright	Negative	normal
35	K6FA	Negative	Negative	Negative	Negative	38.9	dull	Negative	*ekichodonu*
36	K1MC	Negative	Negative	Positive	Negative	38.3	bright	Negative	normal
37	EP15FA	Negative	Negative	Negative	Negative	38.1	bright	Negative	normal
38	EP27FA	Negative	Negative	Negative	Negative	38.1	bright	Negative	normal
39	EP7FA	Negative	Negative	Negative	Negative	37.4	bright	Negative	normal
40	EP31FA	Negative	Negative	Negative	Negative	38.2	limping	Negative	*lokichuma*

Key dx =diagnosis, FCFT=field CFT, LCFT=lab CFT

Appendix XV: Alsever solution

Glucose...8.66g

Sodium chloride...4.18g

Sodium citrate...8.00g

Citric acid...0.55g

Distilled water...1000ml

This solution was sterilized by filtration and kept at 4 °C

Appendix XVI: Veronal with calcium and magnesium (VCM)

Sodium chloride...8.50g

Diethylmalonylurea (Barbital)..................................0.575g

Diethylmalonylurea, Sodium salt..............................0.185g

Calcium chloride (anhydrous)...................................0.028g

Magnesium chloride ($6H_2O$)...................................0.168g

Distilled water PH:7.2...1000ml

Once prepared this solution was kept at 4°C. (Ref; BioMerieux France:72171)