COMMUNITY PARTICIPATORY APPROACHES IN THE EPIDEMIOLOGY AND CONTROL OF TRYPANOSOMOSIS IN CAMELS IN TURKANA DISTRICT, KENYA

KENNEDY MIYORO O. MOCHABO (BVM)

A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Veterinary Epidemiology and Economics.

Department of Public Health, Pharmacology and Toxicology,

Faculty of Veterinary medicine,

University of Nairobi.

DECLARATION

This thesis is my original work and has not been presented for the award of a degree in any other university.

Signature. ……..…….……..

Kennedy Miyoro O. Mochabo (BVM)

This thesis has been submitted for examination with our approval as University Supervisors:

Signature. ……..……..

Dr. P. M. Kitala (BVM, MSc, PhD)

Signature. ……..……..

Dr. P. B. Gathura (BVM, MSc, PhD)

Signature. …..……...……..

Dr. W. O. Ogara (BVM, MSc, PhD)

DEDICATION

In memory of my beloved father,

Francis Mochabo Miyoro

And his nephew,

Dr Charles Lwanga Obino

To them, I live to strive to realize their dreams and may the Grace extend His magnanimous peace to their souls.

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ABSTRACT

This thesis describes a study of the use of participatory approaches in the epidemiology and control of camel trypanosomosis (*surra*) in Turkana District of Kenya. The objectives were: 1) to evaluate the ability of the Turkana to diagnose, treat and control camel trypanosomosis; 2) to estimate the incidence of and mortality due to camel trypanosomosis in Turkana District; and 3) to assess the socio-economic impact of camel trypanosomosis on the Turkanas.

Four animal camps (*adakars*) were conveniently selected for the study. In each *adakar*, three groups of informants were selected to form a total of 12 groups for participatory exercises. Each group comprised of five to eight informants. The participatory methods used were mapping, matrices, proportional piling, trend-lines and semi-structured interviews. In addition, blood samples were collected from camels for trypanosomosis diagnosis using Latex Agglutination Test (LAT) and Polymerase Chain Reaction (PCR). At the end of the study, a stakeholders' workshop involving the Turkana pastoralists, the Intermediate Technology and Development Group (ITDG), the District Veterinary Officer (DVO) and the Veterinary Officer (VO) of the area, the chief and assistant chief, and investigators, was held.

The participatory map showed key features including forests, rivers as well as areas with wildlife (buffaloes, lions, wild cats, elephants, gazelles, foxes, jackals, warthogs, kudus, ostriches, leopards) and biting flies (camel flies, houseflies, tsetse flies, mosquitoes, ticks and lice). The important presenting signs for camel trypanosomosis mentioned were overt ventral oedema, loss of appetite, reduced milk yield, rough hair coat, abortion, low birth-weight calves, small udders, emaciation, listlessness, swollen joints, coughing, shrunken hump at terminal stages, and death within 3-5 months of infection. The post mortem lesions listed were watery and fibrous meat, lack of fat around the heart, and watery bone marrow. The informants were in good agreement on most of the signs of *surra* with Kendall's level of concordance (W) ranging from 0.675, 0.753, 0.860 to 0.885 for infertility and abortion, skin lesions, loss of hair and oedema respectively. The causes of *surra* according to the informants were stagnant water shared by livestock and elephants, rain, a riverine tree

called *esokon* (*Salvadora persica*), a shrub called *edome* (*Cordia sinensis*), a type of pasture called *epoo* (*Grewia spp*) occurring during the rainy season, and biting flies. There was good agreement (W = 0.547 to W= 0.729) between the informants on the uses of camels which included provision of milk, meat, blood, fat, and hides, payment of dowry, barter trade, payment of fines, killing to seal marriages in the absence of an ox, slaughtering to appease the ancestors, as an indicator of wealth, initiation of elders to higher levels, and slaughtering to mark burial ceremonies of elders. On the control of *surra,* the indigenous method appeared to be the most preferred and included drenching of sick animals with a variety of herbs mixed with soups from goat, wildcat, bird or donkey meat. Branding of oedematous areas on the body of affected camels was also used for treatment.

The seasonal calendar showed that most cases of *surra* occurred immediately after the rainy season as well as in the dry season. The results of proportional piling showed that almost half (49.3%) of the camel population suffered from one disease or another over the past one year with *surra* (*lotorobuo*) recording the highest (11.4%) incidence. The annual incidence of *surra* was highest in adult camels (15%) relative to calves (6.9%). This pattern was also reflected in *surra* mortalities with the rate in adults being 9.9% and in calves 5.2%. According to the results of the trend line, the levels of *surra* were highest in 1978 but declined thereafter to a stable state from 1996 to 2002. There was poor agreement between the diagnosis of *surra* by pastoralists and by LAT (kappa = 0.1875) and PCR (kappa = 0.32). However, LAT and PCR had excellent agreement (kappa = 0.75).

Based on the study findings, it is concluded that the camel plays an important role in the lives of the Turkana pastoralists and that *surra* is an important camel disease, which exerts a heavy toll in terms of morbidity and mortality. There is a need to conduct a community-based, integrated control programme of *surra* in Turkana District.

CHAPTER ONE

1.0 INTRODUCTION

Trypanosomosis is one of the most researched diseases in Africa and is known to be a major constraint to the expansion and production of livestock and their products on approximately 10 million km^2 of land, covering 37 countries (FAO, 2000; Mugalla, 2000). The economic impact of trypanosomosis is made up of direct and indirect losses from the disease (Budd, 1999). Direct losses of trypanosomosis include loss in productivity (in terms of milk, meat, manure), mortality, abortion, as well as costs of prevention and treatment. Indirect losses include loss of potential for production (i.e. the production that could be achieved if trypanosomosis did not occur). Most people associate trypanosomosis with tsetse flies (*Glossina spp*), but camel trypanosomosis is exceptional (Evans *et al*., 1995). Mostly, camels suffer from trypanosomosis caused by *Trypanosoma evansi* that is transmitted mechanically independent of tsetse flies. Camels are also affected to a lesser extent by the tsetse-transmitted trypanosome species *T. brucei* (Evans *et al*., 1995). *Trypanosoma evansi*, the parasite causing camel trypanosomosis (*surra*), is cosmopolitan wherever camels are found (Losos, 1980; Luckins, 1988). In Kenya, 95% of cases of *surra* have been attributed to *T. evansi* (Wilson *et al.,* 1981). The disease manifests itself in different forms: acute, sub-acute, chronic and inapparent (Wilson *et al*., 1983). The chronic form is the most common and is characterised by severe anaemia, general wasting, reduced milk yield, infertility, abortions and death in some animals (Olaho-Mukani *et al*., 1993).

The Turkana acquired camels about 150 years ago from the Gabbra and Rendille whom they drove out of what is now known as Turkana District (Evans *et al*., 1995). The value of the camel among individual Kenyan pastoral groups varies. The Turkana, who are originally cattle pastoralists, still value the camel as the cow (Ngeiywa, 1992) whereas the Gabbra regard the camel husbandry as a mainstay of their subsistence.

The nomadic pastoralists have successfully managed their livestock and range resources for many years using their experience and conventional wisdom acquired through generations. To date, there is a dearth of published information on trypanosomosis in Turkana District and generally on camel problems in Kenya (Ngeiywa, 1992). The annual report of the Turkana District Veterinary Office (DVO) indicates that trypanosomosis is an endemic problem. The DVO reported 169 and 455 treated cases of trypanosomosis in cattle and camels, respectively, for the year 2000 (Ministry of Agriculture and Rural Development, 2000). Camel trypanosomosis is the most widespread and probably most economically important disease of camels (Kohler-Rollefson *et al*., 2001).

The camel has a special significance in the drought-stricken and semi-arid parts of Africa and Asia. Majority of the world's 19 million camels are kept by pastoralists who depend on them for food, transport and income (Kohler-Rollefson *et al*., 2001). The camel provides milk even during drought periods and for this reason has been referred to as a 'desert dairy' (Evans *et al.*, 1995).

Community participation and the role it plays in animal health services has been reviewed by Leyland (1991). The extent to which a disease is recognised as a problem is often dependent on the efficacy of the means for diagnosing it and observing its occurrence (Whiteside, 1958). The Turkana pastoralists have been known to possess knowledge in the field of animal health (Catley and Leyland, 2001). Participatory rural appraisal (PRA) is a systematic data gathering activity carried out by a multidisciplinary team to reveal the unidentified facts about a community (Lelo *et al*., 1995). The core of PRA study includes spatial, time-related, social and technical data. Veterinarians and livestock workers have used and are presently using a variety of PRA methods to investigate animal health problems (Catley, 1999). The tools include interviewing, scoring and ranking, and visualisation such as seasonal calendars, maps, Venn diagrams and flow diagrams.

Providing veterinary services to the communities according to the western model has proven difficult due to lack of infrastructure and the veterinarians' limited experience on camels under pastoral system. In addition, most veterinarians are not adept with diagnosis and treatment of camel

diseases due to the relatively limited research on camels and also the fact that camel diseases are rarely taught in veterinary schools. Thus, participatory approach (PA) methods become necessary. Furthermore, there is extensive body of traditional knowledge or ethnoveterinary knowledge that pastoralists have been known to possess and on which they rely to diagnose or treat many diseases (Kohler-Rollefson *et al*., 2001). It is conceivable that the proper collection, collation and analysis of data from the pastoralists would enable the relevant authorities to formulate and implement policies that foster improvement in pastoral incomes as well as improve the existing livestock pastoral production systems. In order to assess the impact of trypanosomosis and ability of the Turkana pastoralists to diagnose the disease, reliable and accurate data are needed on the incidence of trypanosomosis, the methods of control, both conventional and traditional.

Given this general background, the specific objectives of the study were:

1. To evaluate the ability of the Turkana in diagnosis, treatment and control of camel trypanosomosis in Turkana District;
2. To estimate the incidence of and mortality due to camel trypanosomosis in Turkana District;
3. To assess the socio-economic impact of camel trypanosomosis on Turkana pastoralists.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The camel

The camel (*Camelus dromedarius* – one-humped camel, dromedary) is a member of the old world group of camels. The new world camels consist of the genera *Vicuna* and *Lama*. The genus *Camelus* consist *dromedarius* and *bactrinus* (two-humped) species (Ngeiywa, 1992; Schwartz and Dioli, 1992). Dromedaries are the type camelids found in Kenya (Evans *et al*., 1995).

The camel's contribution to the national economy is important. However, it is difficult to do an economic evaluation by a conventional way using parameters like cash flow analysis, gross margin calculation, because most camel products are confined within the consuming community and often traded in kind rather than cash (Schwartz and Dioli, 1992). In this dynamic world, the camel has undergone change from being a 'ship of the desert' to being a 'food security animal' and thus, there has been increased interest on matters pertaining to utilization and management of arid and semi-arid lands (ASALs) where camels are usually found. Countries such as Somalia (with the largest camel population in the world), Sudan, Ethiopia, Djibouti, Mauritania and Kenya depict the camel on their currency notes.

Camels are the most valuable species for 75% of Kenya's land area, which is ASAL and recently is degrading rapidly towards a desert (Evans *et al*., 1995). It is estimated that Kenya has between 700,000-780,000 camels that are kept mostly by the nomadic pastoralists in ASALs in the northern region of the country (Schwartz and Dioli, 1992). Camels in Kenya are kept mainly for meat, milk, blood, transportation, and for bush control in ranches. Amongst the pastoralists, camel meat is only eaten when adult male castrates are slaughtered during drought, on ceremonial occasions or when a camel dies from disease or predation (Field and Simpkin, 1985). The Turkanas use camel hides for making ropes, donkey carriers, sandals, and women skirts (Ngeiywa, 1992). In addition, camels are

also given out as bride price as well as being used as a bank, i.e., as security against drought, diseases and other natural calamities that affect smaller stock seriously (Ngeiywa, 1992).

Camels are essential in the subsistence of pastoralists, as they do not compete for food with other types of livestock due to their grazing/browsing behaviour. Camel milk has been found to have high levels of vitamin C, which is important for pastoralists. Furthermore, camels have the capability of converting poor quality and rangeland forage into milk and meat. Thus, the Government of Kenya efforts to reclaim ASALs and the establishment of ranches should be encouraged (Ngeiywa, 1992).

The Turkana were originally cattle-keepers but acquired camels through intertribal raids from their camel-keeping neighbours, Gabbra and Rendille (Evans, *et al*., 1995). The value of the camel among individual Kenyan pastoral groups varies. The Turkana pastoralists, still value the camel as some sort of cattle (Ngeiywa, 1992; Evans, *et al*., 1995) whereas the Gabbra regard camel husbandry as the mainstay of their subsistence.

2.2 Epidemiology of trypanosomosis

2.2.1 Aetiology

Trypanosomoses are caused by a protozoan parasite of the genus *Trypanosoma,* order Kinetoplastida. The parasites have characteristic organelles, a kinetoplast and a flagellum (Soulsby, 1982; FAO, 2000). Trypanosomes parasitize all classes of vertebrates: fish, amphibians, reptiles, birds and mammals (including humans). Haematophagous invertebrate vectors transmit the parasites cyclically from host to host except *Trypanosoma equiperdum,* which is transmitted venereally in equines. Naturally, trypanosomes are digenetic parasites, which require two hosts to complete their life cycle. They multiply in blood, tissues or body fluids of the host.

Trypanosomoses form a group of diseases, each of which is caused by a different pathogenic species of trypanosomes (FAO, 2000). Radostitis *et al.* (1994) have classified them as:

a) *Nagana* (African trypanosomosis) is caused by *Trypanosoma brucei, T. congolense, T. vivax and T. simiae.* They are cyclically transmitted by tsetse flies (Connor, 1994) and

mechanically by other biting flies in a range of animals (Wells, 1972; Roeder *et al.*, 1984; FAO, 2000);

b) *Surra* is caused by *T. evansi* in horses and camels and is transmitted mechanically by biting flies (Connor, 1994);

c) *Dourine* is caused by *T. equiperdum* in horses and is venereally transmitted (Hoare, 1972);

d) *Chagas* disease is caused by *T. cruzi* mainly in dogs and humans and is transmitted by bloodsucking bugs (De Raadt and Seed, 1977);

e) Trypanosomiases caused by *T. theileri* are non-pathogenic stercorarian in cattle and are transmitted mechanically (Theiler, 1903).

The trypanosomes, which cause sleeping sickness in humans and nagana in domestic animals, are of salivarian type. A light microscope can detect the different morphological variations. The bloodstream forms are trypomastigotes. From the posterior portion arises a flagellum that extends anteriorly, connected to the body by an undulating membrane, and is 8-35μm long (Hoare, 1972; Teixeira, 1987; FAO, 2000). In some species, the flagellum may extend free of attachment to the undulating membrane, beyond the anterior extremity. Within the cell, there is a kinetoplast, found at the posterior position at the base of the flagellum. The kinetoplast may be either marginal or sub-terminal. A single nucleus is located halfway along the body (FAO, 2000).

In the tsetse fly, trypomastigotes transform to epimastigotes in which the kinetoplast moves anteriorly to be adjacent to the nucleus (Ikede, 1986; FAO, 2000). These cyclical changes from trypomastigote to epimastigote and back to trypomastigote in the course of the life cycle of a trypanosome are now clear due to ultrastructural and biochemical studies. These studies have revealed the parasite's survival tactics in the bloodstream, where it faces immunological defences of the host and the digestive enzymes of the tsetse fly's gut.

Morphological differences have been used to identify the different species of trypanosomes after staining in thin blood smears with Giemsa, Leishman's or other Romanovsky stains. Apart from morphology, motility, host specificity and tsetse transmissibility have also been used for identification, but currently characterisation methods include the use of isoenzyme typing, analysis of kinetoplast DNA and DNA hybridization (Gibson, 1985; Gardiner, 1989; Masake *et al.*, 1997; Desquesnes *et al.,* 2001). *T. congolense* and *T. vivax* are monomorphic parasites and *T. brucei* polymorphic. *T. congolense* is the smallest (8-20 μm long), has no free flagellum and the kinetoplast is usually sub-terminal and marginal. *T. vivax* is medium (20-26 μm long), has a long free flagellum and often, terminal kinetoplast. *T. brucei* (23-30 μm long) has a long free flagellum, a conspicuous undulating membrane and a sub-terminal kinetoplast; sometimes there are short stumpy forms, which range from 17-22μm in length but with a well developed undulating membrane. *T. simiae* is between 12 and 24 μm in length. *T. theileri*, a stercorarian species, is non-pathogenic and the largest (up to 100 μm in length) and demonstrates a well-developed host-parasite relationship (Hoare, 1972; FAO, 2000). *T. evansi* is morphologically identical to the slender forms of the subgenus *Trypanozoon,* which include the brucei group *T. brucei brucei, T. brucei gambiense, T. brucei rhodesiense, T. evansi and T. equiperdum* (Evans *et al*., 1995; FAO, 2000).

2.2.2 History and life cycle

The first report of trypanosomosis was from India in 1880 in horses and camels caused by *Trypanosoma evansi* (Waitumbi, 1990; Connor, 1994; Evans *et al*., 1995). Balbian named the causative agent after its discoverer, Graffith Evans, who found trypanosomes in the blood of horses and camels. The local Indians had a local name for the disease – *Surra,* meaning emaciated. Several species of tsetse-transmitted trypanosomes cause African trypanosomoses in domestic animals that are collectively referred to as 'nagana', a word derived from the Zulu name 'nakane', meaning tsetse fly disease (Connor, 1994).

Trypanosomes reproduce by longitudinal binary fission both in the host and in the vector, although a sexual process seem to occur in the tsetse fly (Tait and Turner, 1990). Multiplication in host culminates in mature trypanosomes that stop dividing and are pre-adapted to the conditions in the next cyclical cycle in the tsetse fly. When the tsetse fly ingests a blood meal, the un-adapted parasites die, hence the necessity of the bloodstream trypanosomes (trypomastigotes) to change to procyclic forms (epimastigotes) (Ellie *et al*., 1999). *T. vivax* has the simplest migratory pattern limited only to the proboscis and pharynx. A complete cycle takes 5-13 days (Hoare, 1972; Gardiner, 1989).

2.2.3 Modes of transmission

Transmission is either by inoculation of parasites with saliva or by contamination of mucosa or broken skin with the vector's faecal material, voided during a blood meal. On this basis, the mammalian trypanosomes are classified into salivaria and stercoraria groups respectively (Hoare, 1972; FAO, 2000).

Two main modes of transmission have been reported which include the cyclical and the non-cyclical transmission. There are about 23 *Glossina* (tsetse flies) species involved in the cyclical transmission. They are grouped according to their preferred habitats as: forest species (*G. fusca, G. brevipalpis, G. longipennis*), riverine species (*G. palpalis, G. tachinoides, G. fuscipes*) and savannah species (*G. morsitans, G. austeni, G. pallidipes, G. swynnertoni and G. longipalpis*). The latter group pose the greatest challenge to the livestock industry and man (Jordan, 1976).

The non-cyclical transmission of trypanosomes is aided by biting flies and thus, in the absence of *Glossina,* the transmission is maintained in the ecosystem. Biting flies, such as *Tabanids* (horse flies)*, Stomoxys and Hippoboscids* (camel flies)*,* transmit trypanosomes mechanically through their mouthparts when they feed on more than one host within a short interval because the trypanosomes remain infective for only a short period (Anonymous, 1959; Roeder *et al*., 1984; Evans *et al*., 1995). *T. evansi* may be transmitted to a lesser extent by ticks of genera *Hyalomma, Dermacenter* and *Rhipicephalus* (Boid *et al.,* 1985).

Transplacental transmission has been recorded but is of less significance in the epidemiology of trypanosomosis (Ogwu and Nuru, 1981; Ikede, *et al*., 1988). Nasal and conjuctival transmission have also been reported (Stephen, 1986). Dogs may also become infected by ingestion of infected carcasses (Evans *et al*., 1995). Experimentally, trypanosomes may be transmitted by syringes using infected blood (Soulsby, 1982).

2.2.4 Pathogenesis, clinical signs and pathology

Trypanosomosis is a wasting disease, which leads to a slow progressive loss of body condition accompanied by anaemia, weakness, collapse and death (FAO, 2000). Its exact pathogenesis is not clearly understood (Losos and Chouinard, 1979; Losos, 1986). Following inoculation of metacyclic trypanosomes by the fly during feeding, there is a local skin reaction called a chancre which is more pronounced in a more susceptible host and slight or absent with some strains (Luckins and Gray, 1978; Akol and Murray, 1982; FAO, 2000). The trypanosomes change into trypomastigote form and enter the blood stream directly or through the lymphatics. Their behaviour thereafter depends on the species of trypanosome transmitted (Ikede, 1986). The parasites multiply causing parasitaemic waves with host's defences reacting (Nantulya, 1986), causing intermittent fever in the host. Three features arise including anaemia, tissue damage, and immunosuppression, which are prominent in the pathology (Urquhart, 1980; FAO, 2000). Trypanosomes can pass through the placenta and into the foetus causing abortion in pregnant cows (Ogwu *et al*., 1986).

In camels, there is reduced appetite and water intake, the hump disappears as the disease progresses, the hair coat is dull and rough with loss of hair at the tail. There is oedema under the belly visible especially in the morning, pregnant females may abort and newborn calves of infected dams usually die. There is pallor of mucous membranes of the eyes, a fluctuating temperature with initial peaks of up to 41^0 C and the urine usually has a characteristic smell (Evans *et al*., 1995; FAO, 2000; Kohler-Rollefson *et al*., 2001).

There are no pathognomonic signs of the disease in the camels and any clinical examination is of little importance for a conclusive diagnosis (FAO, 2000), but the parasites can be detected in blood 13 to 16 days after an infective fly has had a meal. The parasitaemia causes a large number of red blood cells (RBCs) to be removed from circulation by cells of the mononuclear phagocytic system (MPS) in the spleen, bone marrow, lungs and haemal lymph nodes. The removal of a large number of RBCs leads to a fall in packed red cell volume (PCV) to below 25% or even to as low as 10%. This results in anaemia and the affected animals become dull, anorexic, listless, with ocular discharges, and loss of body condition (Urquhart, 1980; Murray and Dexter, 1988; Evans *et al*., 1995; FAO, 2000). There is lymphadenopathy, pale mucous membranes, occasional diarrhoea and oedema of the throat and the underlying sub-cutaneous tissue. Semen ejaculate quality of bulls and rams is affected (Sekoni *et al.,* 1988) impacting negatively on fertility (Ikede *et al*., 1988). In females, oestrous cycles become irregular and eventually cease (Llewelyn *et al.*, 1988). A cerebral form occurs with *T. brucei* infection alone or in mixed infections with other trypanosome species (Masake *et al*., 1984; Whitelaw *et al*., 1988; Wellde *et al*., 1989). Animals become emaciated and die within 2-4 months as a result of anaemia, circulatory disturbances and myocardial damage leading to congestive heart failure (Murray *et al*., 1979). The camel may live up to four years with sub-clinical infections and some may eventually recover and eliminate the parasite (Evans *et al*., 1995). Necropsy lesions, like the clinical signs, are non-specific (FAO, 2000). However, the gross lesions that would be observed in chronic cases of *surra* include dull, dry, scaly and inelastic coat. The carcass is generally emaciated, pale and may be icteric sometimes. The lymph nodes are enlarged and oedematous on incision. There is hydrothorax, hydropericardium and ascites. In acute cases, the spleen is enlarged but in chronic cases, it is atrophic (Connor, 1994; Radostits *et al*., 1994; FAO, 2000).

2.2.5 Occurrence and prevalence

Trypanosomes are insect-borne and their occurrence depends on vector dynamics (Jordan,

1986). In Africa, 37 countries are infested with tsetse flies covering an estimated 10 million km^2 of land surface (Anonymous, 1999; FAO, 2000). Majority of camels suffer from trypanosomosis caused by *T. evansi* that is spread mechanically and independent of tsetse flies. Camels are also affected to a lesser extent by the tsetse-transmitted trypanosome species *T. brucei* (Evans *et al*., 1995). *T. evansi* parasite is cosmopolitan wherever camels are reared (Losos, 1980; Luckins, 1988). Camel trypanosomosis is endemic in most camel herds (Njiru *et al*., 2000) and 95% of camel trypanosomosis has been associated with *T. evansi* in Kenya (Wilson *et al*., 1981).

2.2.6 Risk factors

The sequel to infection with the salivarian trypanosomes is not always a disease. For a disease to result, there must be an inter-play of many factors that relate to the vectors, wild hosts, livestock and their management, the trypanosomes and the climatic conditions (Whiteside, 1958).

2.2.6.1 Host factors

In natural hosts and some domestic animals, the salivarian trypanosomes do not evoke clinical signs. This suggests that there is a host-parasite equilibrium (Mulla and Rickman, 1988). Some breeds of indigenous cattle tolerate light to moderate challenges by limiting the multiplication of trypanosomes in blood (Njogu *et al*., 1985; Murray and Dexter, 1988; Mwangi *et al.,* 1998). This phenomenon is called trypanotolerance and is both genetically and environmentally determined (Morrison *et al*., 1985; Roelants, 1986; Murray *et al*., 1990). The breeds that have been found to exhibit this phenomenon are the humpless or taurine referred to as N'Dama cattle as well as the African buffalo (Murray *et al*., 1981; Akol and Murray, 1986; Grootenhuis *et al*., 1990) and in some breeds of goats and sheep (Kanyari *et al*., 1983; Mutayoba *et al*., 1989). In East Africa, the Maasai Zebu shows reduced susceptibility, but the Orma Boran has superior tolerance (Njogu *et al*., 1985; Mwangi *et al*., 1998).

In trypanotolerant animals, it has been found that some may effect self-cure, but some individual animals may come down with the disease due to stress (Murray *et al*., 1982). Stress occurs in late pregnancy and early in lactation in animals that are more susceptible (Murray *et al*, 1981; Ogwu and Njoku, 1987). Inter-current infections (e.g. helminthosis), also stressful, may accentuate the severity of the disease. Trypanotolerance may also be reduced by low plane of nutrition (Maclennan, 1974) and when animals have to trek for long distances in search of water and pasture in the dry season. This is especially common in the nomadic pastoral communities. Age has some effect on resistance to trypanosomosis; cattle born in an infested area do not immediately succumb to infection, though they acquire trypanosomal infection when young, whereas cattle brought to such areas readily do so (Maclennan, 1974; Murray *et al.,* 1982). *Surra* affects camels of all ages with a higher incidence of disease in sub-adult camels shortly after weaning (Evans *et al.*, 1995).

2.2.6.2 Environmental factors

In the tsetse-infested tracts of Africa, populations of game have thrived for many years with the flies and trypanosomes, and have therefore established a stable host-parasite relationship (Connor, 1994). Tsetse flies caught around game reserves have been found to have higher infection rates and thus, animals grazing near game reserves or parks are at a higher risk (Whiteside, 1958). There is usually a build-up of fly vector populations (tabanids, hippoboscids, stomoxys) during the rains due to a good humid environment for breeding hence resulting in increase of new infections. Towards the end of a dry season, pastoralists usually take their animals to riverine or swampy areas, which are also favourable grounds for these flies (Evans *et al.*, 1995).

The degree of risk depends on the challenge, i.e., the number of infective tsetse/vector fly bites that an animal experiences in a given time (Rogers, 1985). But, the interaction of infective tsetse/vectors, host preference, host susceptibility and the virulence of the parasite determine the true challenge or risk.

2.2.6.3 Pathogen factors

The developmental cycle of trypanosomes in the fly varies from species of parasite. For instance, *T. vivax* has adapted very well, with a relatively simple complete cycle in a fly of five to thirteen days, compared to one of between 17 to 45 days for *T. brucei.* Thus, more flies are found infected by *T. vivax* parasite (Hoare, 1972; Maclennan, 1974; FAO, 2000). *T. evansi* has adapted to an entirely mechanical, non-cyclical mode of transmission by blood-sucking flies other than tsetse and infects a wide range of animal hosts (Connor, 1994). Mixed trypanosome infections have been found to be more prevalent since the advent of antigen-trapping enzyme immuno-assays (Nantulya *et al*., 1989). Mixed infection rates of 2.75% and 0.014% for *T. congolense*/*T. vivax* and *T. congolense*/*T. brucei,* respectively, have been observed in Kenya (Tarimo-Nesbitt *et al.*, 1999). *T. vivax* has been found to produce higher levels of parasitaemia than other species of trypanosomes (Connor, 1994).

2.2.7 Immune mechanisms

The ability of trypanosomes to manifest a prolonged infection in a susceptible host is due to their antigenic variation (Bernards, 1984). The bloodstream parasite (trypomastigote) has a dense glycoprotein coat, which is anchored to the parasite's surface membrane (Roditi and Pearson, 1990). When there is high parasitaemia, the host mounts a specific immunologic response against the bloodstream parasites producing a complement-mediated lysis of all trypanosomes of that antigenic type. At some point, some trypanosomes as few as one in 100,000 in numbers activate the gene that codes for a different protein (Nantulya, 1986). The parasites with a new coat, survive to produce another parasitaemic peak and the cycle repeats. The antigenic variation is due to the variable surface glycoproteins (VSGs) expression, which constitutes variable antigen types (VATs) Nantulya (1986). When the trypanosomes shield themselves from host defence system, it leads to a prolonged course of infection. The cycles continue until the animal succumbs or the immune mechanism catches up with the parasite and the animal recovers (Masake, 1980; FAO, 2000). This phenomenon of successive peaks of parasitaemia brings about the clinical sign of intermittent fever.

Immunosuppression has been reported in animals infected with trypanosomosis making them prone to secondary bacterial infections (Murray and Dexter, 1988). This feature occurs in both trypanosusceptible and trypanotolerant cattle, but the only distinguishing feature between them is the humoral response (Taylor *et al*., 1999).

2.3 Diagnosis

The diagnosis of trypanosomosis is basically divided into clinical, parasitological and serological. For research purposes, especially in epidemiological surveys, sensitive and specific diagnostic methods, as well as their applicability in the field, are prerequisites. In fact, the accuracy of the work will be authenticated if two or more methods that complement each other are used (FAO, 2000). The specific clinical diagnosis of trypanosomosis is difficult due to non-specific clinical signs coupled with intermittent fever and low parasitaemias (FAO, 2000). Comparisons of different methods of diagnosis have been done (Nantulya, 1990). Diagnostic procedures vary according to the tools available and the purpose of the tests (FAO, 2000).

In many tsetse-infested areas, conventional diagnostic facilities are not available, and thus clinical signs of trypanosomosis are usually used for making a tentative diagnosis. Indeed, veterinarians and farmers are known to use response to treatment as a confirmation of infection by trypanosomes (Connor, 1994). There are some traditional tests for diagnosis of *surra* that have been documented: Sand Ball Test which involves taking soil that a camel has urinated on, shaping it into a ball, letting it dry for 15 minutes and then breaking it open and smelling (if the smell is sweet, then the camel has *surra*); the other test is the Tail-hair Test, which involves pulling out hair from the tail of a camel, and if the hair comes out easily with some tissue sticking to it, then that is taken as a confirmation of *surra* (Kohler-Rollefson *et al.,* 2001).

For confirmatory diagnosis, parasitological demonstration needs to be done using blood, either capillary blood from the tip of the tail or venous blood from ear or jugular veins and lymph fluid (FAO, 2000). Cerebrospinal fluid is used in case of human sleeping sickness (Wellde *et al*., 1989).

2.3.1 Parasitological diagnosis

Parasitological methods include: microscopic examination of blood; parasite concentration techniques; and animal inoculation. The easiest and most frequently used of the three techniques is direct microscopic examination of blood, either by wet blood film method, or as stained thick and thin smears (FAO, 2000). In the wet film smear, the trypanosomes are seen either directly between blood cells or indirectly as they cause blood cells to move. Fresh lymph preparations and thin smears of lymph may also be used (FAO, 2000). These smears (thin blood and lymph) are useful for morphological identification of different trypanosomes under the light microscope (Monzon *et al*., 1990; Nantulya, 1990).

Haematocrit centrifugation, a concentration method, is one of the early techniques that has been used to detect equine trypanosomosis (Kihurani, 1995). Buffy coat (Woo technique) (Woo, 1969) has been used by either examining directly or by making a smear from a buffy coat/plasma junction (4-5 mm above the white ring in a micropipette) under a light microscope for presence of motile trypanosomes (FAO, 2000). One can also assess the degree of anaemia, by reading the packed red blood cell volume (PCV) of blood in the centrifuged tube.

The oedematous fluids from genitalia, urticarial plaques and vaginal washings have been centrifuged for use in the diagnosis of *T. equiperdum* (Hagebock, 1992).

The sub-inoculation of blood and other body fluids into susceptible experimental animals is another diagnostic technique for trypanosomosis, especially when parasitaemia is scanty (FAO, 2000).

In epidemiological studies, a parasitological diagnosis of trypanosomes in biological vectors is sometimes necessary (FAO, 2000).

2.3.2 Serological diagnosis

Serological techniques have been used in the diagnosis of trypanosomosis. They have proved particularly useful for the subgenus *Trypanozoon,* which invade and multiply in the connective tissue. They have been found good for epidemiological surveys in research (Hopkins *et al.,* 1998).

2.3.2.1 Antibody detection tests

Antibody techniques include complement fixation test (CFT) that has been used in the diagnosis of *T. equiperdum* in equines (Hagebock, 1992). Enzyme-linked immunosorbent assays (ELISA) and radioimmunoassays (RIA) have also been used (Hagebock, 1992). Indirect fluorescent antibody test (IFAT) has been used in herd diagnosis of trypanosomes (Connor, 1994). Card agglutination test for trypanosomosis (CATT), the simplest for *T. evansi,* has also been used (Nantulya, 1990; Luckins, 1992). When antibodies are detected, however, they do not distinguish between current and past infections, and also cross-reactions may occur between trypanosome species (Luckins, 1977).

2.3.2.2 Antigen detection tests

Enzyme immunoassays have been developed for the detection of antigens rather than antibodies as a means of diagnosis (Nantulya and Lindqvist, 1989). These assays detect the circulating antigens of *T. congolense, T. vivax and T. brucei* in blood of infected animals. Latex agglutination test (LAT) has also been used specifically for *T. evansi* (Nantulya, 1994).

The demonstration of trypanosome antigens is equivalent to parasitological diagnosis and thus an indicator of current infection if an animal has not been recently treated for the disease (Voller and De Savginy, 1981; Nantulya and Lindqvist, 1989).

Parasite detection techniques are generally 100% specific but their sensitivity is relatively low. Masake and Nantulya (1991) compared the sensitivity of antigen ELISA with the buffy coat technique and observed that antigen ELISA detected 94.3% and 82.5% of *T. congolense* infections in goats and

cattle, respectively. In contrast, the buffy coat technique detected only 10.9% and 19.7% of *T. congolense* infections in goats and cattle, respectively.

The ELISA technique may give false negative results even in parasitologically proven cases. This occurs in sera from acute or early phase of infection and has been observed in *T. congolense, T. vivax* and *T. brucei* infections in cattle and goats (Nantulya and Lindqvist, 1989; Masake and Nantulya, 1991). The monoclonal antibody used in antigen ELISA is directed at an internal or somatic unsecreted antigen that is only released after trypanosome lysis. Thus, in early infection, before the first parasitaemic peak, the test can give negative results due to absence or low levels of antigens in blood (Nantulya and Lindqvist, 1989; Masake and Nantulya, 1991). It is, therefore, important to combine antigen detection ELISA with the parasitological techniques for effective diagnosis of tryapanosomosis (Nantulya, 1990; Masake and Nantulya, 1991).

2.3.3 Molecular techniques

Molecular techniques are suitable for detecting parasites in the mammalian host and in the insect vector and currently are the main research tools (FAO, 2000). The principle of molecular tests is the expression of the occurrence of nucleotides, which are specific for a trypanosome subgenus, species or even a type or strain. Two main methods are used: DNA-probes and polymerase chain reaction (PCR) (FAO, 2000).

In DNA-probes, the sample to be examined is heated to separate the two strands of DNA, which are then fixed to the membrane to avoid recombining after cooling. A probe, which is a linear sequence of nucleotides prepared to correspond with a similar sequence of the parasite in the sample, is added. The probe will link (hybridise) with that part of parasite DNA and this will be detected when the probes are labelled with radioactive isotopes or enzymes for use in ELISA.

The PCR is based on the use of enzyme DNA polymerase that will amplify the sequences of DNA bases, until sufficient DNA material is produced to detectable levels. The parasite DNA is denatured by heat and two primers are used that are short sequences of nucleotides (one for each DNA

strand) complementary to a specific site on one of the two single parasite DNA strands. The primers attach to the complementary sites and the DNA polymerase then starts to reproduce the rest of each complementary sequence, which follows from that primer. Thus, the polymerase amplifies minute DNA bases when the cycle is repeated. The PCR product is then subjected to electrophoresis and the bands are detected by a special staining. The procedure is extremely sensitive and detects minute levels of parasite DNA. However, it is relatively expensive.

In order to detect trypanosomes and avoid false positive results, it is possible to combine PCR and the DNA probes technology (Gibson, 1985; Gardiner, 1989; Nantulya, 1990; Majiwa, 1998; FAO, 2000; Desquesnes *et al.,* 2001).

2.4 Treatment and prevention

There are a number of drugs available for treatment and prevention of trypanosomosis and approximately a million doses are administered annually in Africa (FAO, 2000). The drugs can be grouped as curative, prophylactic or sanative (Boyt, 1980; Raynaud *et al*., 1989). The curative drugs are homidium chloride (Novidium®), homidium bromide (Ethidium®), quinapyramine sulphate (Trypacide®, Antrycide®), diminazene aceturate (Berenil®, Veriben®), isometamidium chloride (Samorin®), suramin (Naganol®), and melarsenoxide cysteamine (Cymelarsan®). The prophylactic drugs are quinapyramine sulphate and isometamidium chloride. The latter drug becomes prophylactic only if used at a high dose (Boyt, 1980).

A sanative drug is one that has not been in use for sometime but when used will eliminate trypanosomes that are resistant to the drugs used previously. It should provide moderate prophylaxis and avoid development of resistance to the prime drug, but this has not been well implemented, leading to a multiple resistance to curative, prophylactic and sanative drugs (Whiteside, 1958; FAO, 2000).

Suramin and quinapyramine sulphate are the two drugs available for the treatment of *T. evansi* infections in camels (Evans *et al.,* 1995). Suramin is administered at a dosage rate of 12mg/kg body

weight intravenously for curative and prophylactic activity. Quinapyramine, when administered as methyl sulphate at a dosage rate of 3-5 mg/kg body weight subcutaneously is for curative purposes but as a pro-salt chloride/methyl sulphate mixture at 5-8.3 mg/kg body weight is for curative and prophylactic activity. Most drugs are either not curative such as homidium bromide, or are too toxic for camels such as diminazene aceturate.

The management and control of trypanosomosis will continue to depend on the proper usage of the few available trypanocides, especially the strategic deployment of the sanative drugs in order to reduce development of drug resistance plus the continued use of environment-friendly vector control programmes (FAO, 2000; Anene *et al*., 2001).

The present strategy of chemotherapy and chemoprophylaxis is faced with the following technical drawbacks: a limited number of drugs for use; the emergent drug resistance; cross-resistance to the present drugs; toxicity of the drugs.

2.5 Control

The institution of a programme to either control or eradicate trypanosomosis in an animal population must be based on knowledge of the extent of the disease in that population, factors associated with its occurrence, the facilities required for control, and the costs and benefits involved (Thrusfield, 1986). This is possible through disease monitoring and surveillance. In addition, surveillance is required to determine whether there are new factors affecting the occurrence of the disease.

Trypanosomosis control has been carried out in endemic countries by use of three approaches coupled with modified management: vector population control; chemoprophylaxis; and use of trypanotolerant animals (Anene *et al*., 2001). The aim of prevention is to break the vector transmission cycle in camels. The application of synthetic pyrethroids for the control of *Tabanidae* and *Muscidae* has been effective in cattle (Evans *et al*., 1995). Sheep and goats, which are often kept close to camels, act as asymptomatic carriers of *T. evansi* from where camels can get the infection (Evans *et al*., 1995).

There is no vaccine available for use due to the trypanosome antigenic variation made possible by their constant change of the glycoprotein surface coat (Radostitis *et al.*, 1994; Taylor *et al.,* 1999).

2.5.1 Vector control

The threat of animal trypanosomosis can be removed in endemic areas by elimination of the fly vectors (FAO, 1989). The tsetse control objective is to reduce the tsetse population and hence disease challenge to levels where the risk of infection is either very low, or to manageable levels with drugs, or by use of trypanotolerant livestock (Pollock, 1986a; FAO, 1989). Tsetse eradication is the complete elimination of the vectors but this can only be possible if the area to be cleared is relatively small or is isolated from other infested areas (Pollock, 1986b).

Recently, more environment-friendly methods have been devised including use of targets, traps and pour-ons. The latter method has an added advantage of reducing tick infestation (Lohr *et al*., 1991; Mwongela, 1991; Bauer *et al.,* 1992; Thomson and Wilson, 1992) through the use of synthetic pyrethroids. The new generation of pour-on insect repellents are helpful in controlling new infections (Schwartz and Dioli, 1992). The targets and traps, usually impregnated with insecticides, have been found to be effective, simple, cheap and could be constructed and maintained by local communities (Dransfield *et al*., 1991; Williams *et al.,* 1993). The shape, colour, and odour attractants, play a role in the attraction of tsetse flies to traps (FAO, 1989). Blue colour attracts tsetse, while black and ultraviolet, reflecting white, entice them to land on a device or enter the trap (FAO, 1989; Vale, 1993). Natural host odours are the most effective and include buffalo and cattle urine (Owaga, 1985; Hassanali *et al*., 1986; Dransfield *et al*., 1986; Saini, 1986). Carbon dioxide and 1-octen-3-ol, which are components of breath (Vale and Hall 1985; Dransfield *et al*., 1986; FAO, 1989), and ketones (e.g. acetone which is part of the ox odour), have also been found to be effective.

Biological control methods have also been proposed and include use of predators such as ants and wasps to feed on the tsetse pupae and adults, respectively (Pollock, 1986a). The sterile male technique is another practical approach for control of tsetse populations (Nantulya and Moloo, 1989).

In this method, large numbers of male flies are sterilised by irradiation and released into the field where they mate with virgin females. The resultant eggs are unfertile and no further development takes place (Pollock, 1986b). The method is expensive requiring a lot of capital and high technology.

The insecticides, applied to screens or targets, are environmentally acceptable alternatives to ground or aerial spraying (FAO, 1989). The more recent technique involves use of insecticide-treated animals, especially cattle as attractive living targets. However, the technique suffers from the limitation that requires animals to have a density of at least 10 cattle/km^2 and be well distributed (Bauer *et al*., 1992).

2.5.2 Use of trypanotolerant animals

The use of innate resistance of the host, a phenomenon referred to as trypanotolerance, which is both genetically and environmentally determined (Morrison *et al*., 1985; Roelants, 1986; Murray *et al*., 1990), is being exploited also in the control of trypanosomosis (FAO, 2000). The breeds that have been found to be tolerant such as the N'Dama and Orma Boran cattle are being encouraged for use in trypanosome endemic areas (Maichomo *et al*., 1999).

2.6 Socio-economic impact assessment

The economic impact of trypanosomosis is made up of direct and indirect losses from the disease. The direct losses include loss in productivity (in terms of milk, meat, manure), mortality, abortion as well as costs of prevention and treatment (FAO, 2000). The indirect losses include loss of potential for production (i.e. the production that could be achieved if trypanosomosis did not occur).

Trypanosomosis is an expensive disease to control and thus, an economic analysis (costs and benefits) become essential to show the extent of socio-economic losses due to the disease (Thrusfield, 1986). The socio-economic losses directly due to the disease include mortality, morbidity, reduced productivity, retarded growth, abortion and infertility (Finelle, 1974; Thrusfield, 1986). The costs, on the other hand, include those of detection and treatment of infected animals (veterinary services, drugs,

equipment and operating expenses), chemoprophylaxis and tsetse fly control and research (Finelle, 1974).

The socio-economic impact of tryapanosomosis control is very important in setting up priority self-sustaining control measures (Budd, 1999). Positive social impacts have been observed in community control programs in Lambwe Valley, Kenya, where trypanosomosis prevalence decreased by 84% and 60.6% in high-challenge and low-challenge areas, respectively (Barret and Okali, 1998). However, in Busia, Kenya, there was failure of a tsetse control program using targets and traps attributed to the non-incorporating of community participation in the project.

The cost evaluation of tsetse control against chemoprophylaxis has been done in cattle where it was found that the lower the stock carrying capacity and the lower the incidence of trypanosomosis, it was more economical to protect the animals by drugs rather than tsetse control (Holmes and Scott, 1982).

2.7 Community participation

Concepts of community participation began to feature in the 1970s. Cohen and Uphoff (1980) suggested that participation requires people's involvement in decision-making, programme implementation, sharing the benefits of development programmes and evaluating them. However, to date, there are varied definitions that can be subject to misinterpretations (Pretty, 1994; 1995). Pretty (1995) has given a comprehensive outline of community participation at seven levels with the underlying theme relating to balance between outsiders and local people ownership in development activities ranging from decision-making, information and resources.

Rapid rural appraisal (RRA), participatory rural appraisal (PRA) and similar terms have become common since 1980s. The methods are designed to overcome some of the limitations of the conventional survey and research methods in developing countries with the aim of increasing the involvement of local people in development activities. The PRA involves appreciation of the local knowledge and culture and includes interviews, scoring and ranking, and visualisation methods by the

local people (Catley, 1999; Catley *et al*., 2002a). The PRA is more of a facilitation rather than investigation by outsiders. In PRA, researchers become facilitators on the local analysis and ownership of information that lead to community action plans (CAPs) (Chambers, 1997). In the PRA approach, gathering data is done in group discussions, using mostly informal discussions, visual aids and observations.

Leyland (1991) has reviewed community participation and its role in animal health services. The experiences on community-based animal health approaches in Kenya have been documented (Catley, 1999). There is substantial evidence that participatory appraisal (PA) methods do generate information that precisely describes local people perceptions on animal health problems. The PA methods are relatively resource-friendly and are easily flexible according to given circumstances and information needs (Catley, 1999). In addition, there is an increasing interest by research centres to involve rural communities in the definition of research problems and identification of their solutions (Catley and Irungu, 2000). Community-based programmes look promising with regard to sustainability (Budd, 1999). Where a disease control program is not sustained, major problems such as re-infection may appear (Barret and Okali, 1998). Project end is ultimately more important than the project itself, as what continues represents the real contribution of the project, hence its sustainability (Olubai and Woodhouse, 1999). In any collective and sustained activity of the community, there is need to recognise the already existing local methods used by the community in the control of trypanosomosis (Catley and Irungu, 2000). Thus, the need to assess the local characterisation of the disease in the local names vis-à-vis the scientific disease names.

2.7.1 Participatory rural appraisal (PRA) tools

Participatory rural appraisal (PRA) is an organized data gathering procedure carried out by a multidisciplinary team to reveal the unidentified facts about a community (Lelo *et al*., 1995). Several types of field data form the core of PRA study that includes spatial, temporal, social and technical data. Veterinarians and livestock workers have used and are currently using a wide range of PRA methods

to investigate animal health problems (Catley, 1999). The methods include interviewing, scoring and ranking, and visualisation tools such as seasonal calendars, maps, Venn diagrams and flow diagrams. The PA methods, like disease matrix scoring, are good when used with conventional methods especially where the livestock keepers have a well-developed indigenous knowledge (Catley *et al*., 2002a).

The PA methods have evolved from qualitative research methods and experiences. The qualitative research data validity is based on cross-checking the data that is derived from different sources. The process is also referred to as triangulation. Also, qualitative research aims at describing and understanding problems within a specific environment rather than produce results that can be extrapolated to describe a wider population (Catley *et al*., 2002a). There is an argument by some participatory researchers regarding the validity of PA methods in that they cannot be usefully determined from a quantitative research perspective and the validity criteria objective researches (Pretty, 1994; 1995). For donors, the PA require reversals in funding patterns with more resources required as the project unfolds and new objectives and activities appear (Catley and Irungu, 2000).

Most PA methods involve interviewing skills and often follow-up questions are asked after the completion of a diagram, map or scoring tool (Catley, 1999). The semi-structured interview (SSI) has some relation to veterinary medicine in history taking and subsequent tentative diagnosis. The SSIs prompts one to have a checklist of some questions then the follow-ups (Catley and Mohammed, 1996; Catley, 1999).

For the visualisation methods, mapping has been used in animal health surveys and involves construction of a map on the ground using locally available materials (Catley, 1999). For spatial data, maps and transects are used (Lelo *et al*., 1995). For temporal data, the tools that have been employed are timelines, trend lines and seasonal calendars.

Venn diagrams have been used in more general agricultural surveys to show the institutional relationships between different players in a particular community (Catley, 1999). Ranking and scoring

methods have been used whereby informants are required to compare items or problems in pairs and decide the most important and the results presented in a matrix with a total rank calculated (Catley, 1999). The scoring methods are made more visual when a matrix is drawn on the ground with items along one axis and indicators along the other axis and counters like stones used to score. This method has been used in northern Somalia to understand associations between different types of ticks and health problems (Catley and Aden, 1996).

Another visually oriented scoring method is proportional piling (Catley, 1999). The method involves the use of a large pile of counters like stones. The counters are usually 100 that the informants are asked to distribute on different items to show the relative sizes or importance. The results from proportional piling may be presented in pie charts.

2.7.1.1 Advantages and disadvantages of participatory appraisal (PA) tools compared to conventional methods

According to Mugenda and Mugenda (1999), IIED (1994), ITDG-EA (2001) and Catley *et al*. (2002b), the following advantages and disadvantages of PA methods compared to conventional methods are implied:

The use of PA tools normally generate largely a qualitative data that are detailed, dynamic and defines local peoples' problems and solutions whereas the conventional (Traditional) methods only yield data that are chiefly quantitative and stable (data whose facts do not change). Thus, the PA methods have been qualified as a bottom-up approach compared to the top-down approach of the conventional approaches. The PA approaches are holistic in nature whereby all aspects of the phenomenon in question are studied by use of multiple methods in a process referred to as triangulation. The focus of conventional methods is usually on selected predefined variables. The community has a greater access, control, understanding and analysis of information when the PA tools are employed, but in the conventional ones, the community does not apparently own the information.

In addition, this makes the project unsustainable, because researchers are seen as ‘outsiders’ and decision-making is entirely from them. On this basis, the PA methods attempt to break the cultural barriers and researchers are seen as ‘insiders’ which in turn, lead to collection of useful information about the community, particularly, with involvement of local people in decision-making. The PA has been found to be cheaper and faster in gathering data because the data collection is simultaneous with analysis and informal tools are used compared to the conventional methods.

The qualitative data arising from use of PA tools, leads to the debated question of reliability and validity whereas the conventional methods yield quantitative data, which are assumed to be reliable and validated. Predictions and controls for qualitative data, arising from PA tools are impossible (Mugenda and Mugenda, 1999). This indicates that the participative appraisal collected data cannot be extrapolated. The use of PA methods can also be time consuming (some tools are involving). Furthermore, the minority groups based on, e.g., age, gender, wealth can be overlooked particularly when an inexperienced person conducts PA.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study area

3.1.1 Description of study area

The study was carried out in Lapur division of Turkana District in the Rift Valley Province of Kenya between February and April 2002. The district occupies the northwestern part of Kenya and covers an area of 70,000 km^2. It borders Lake Turkana to the East, Uganda to the West and Sudan and Ethiopia to the North. Turkana district is divided into 17 administrative divisions.

The district receives an annual average rainfall of 120mm and temperatures are high and fairly uniform in the range of 24 – 38^0C. The area spans agroecological zones III to VII and has a human population of approximately 447,000 people (Central Bureau of Statistics, 1999). The geographic features include low-lying open plains, mountain ranges, Lake Turkana and the river drainage patterns. The altitude of the mountain ranges is between 1500 and 1800 metres above sea level (Turkana development plan, 2002-2008). According to the records at the Turkana District Veterinary Office, there are approximately 200,000 head of cattle, over 2.5 million small ruminants and about 115,000 camels.

3.1.2 Selection of study area and sites

The northern part of the district (Lapur Division) was conveniently selected due to logistical, rough terrain and security reasons. A map of Kenya showing Turkana District and the location of the study area is shown in Figure 3.1. The study was conducted during the dry season when the animals had been driven to the hills near the Ethiopia and Sudan borders and Lapur Division was nearest. Lapur Division consists of three locations with an area estimated at 4650 km^2 and has a human population of approximately 13,700 people. The Division has four main *Adakars* (animal camps) that were used as the sampling units. The *Adakars* were identified by local administration since each *Adakar* has a leader. The leaders (*Emurons*) from every *Adakar* identified the members who formed 12

groups of informants for participatory research processes. Each A*dakar* provided three groups comprising of five to eight informants.

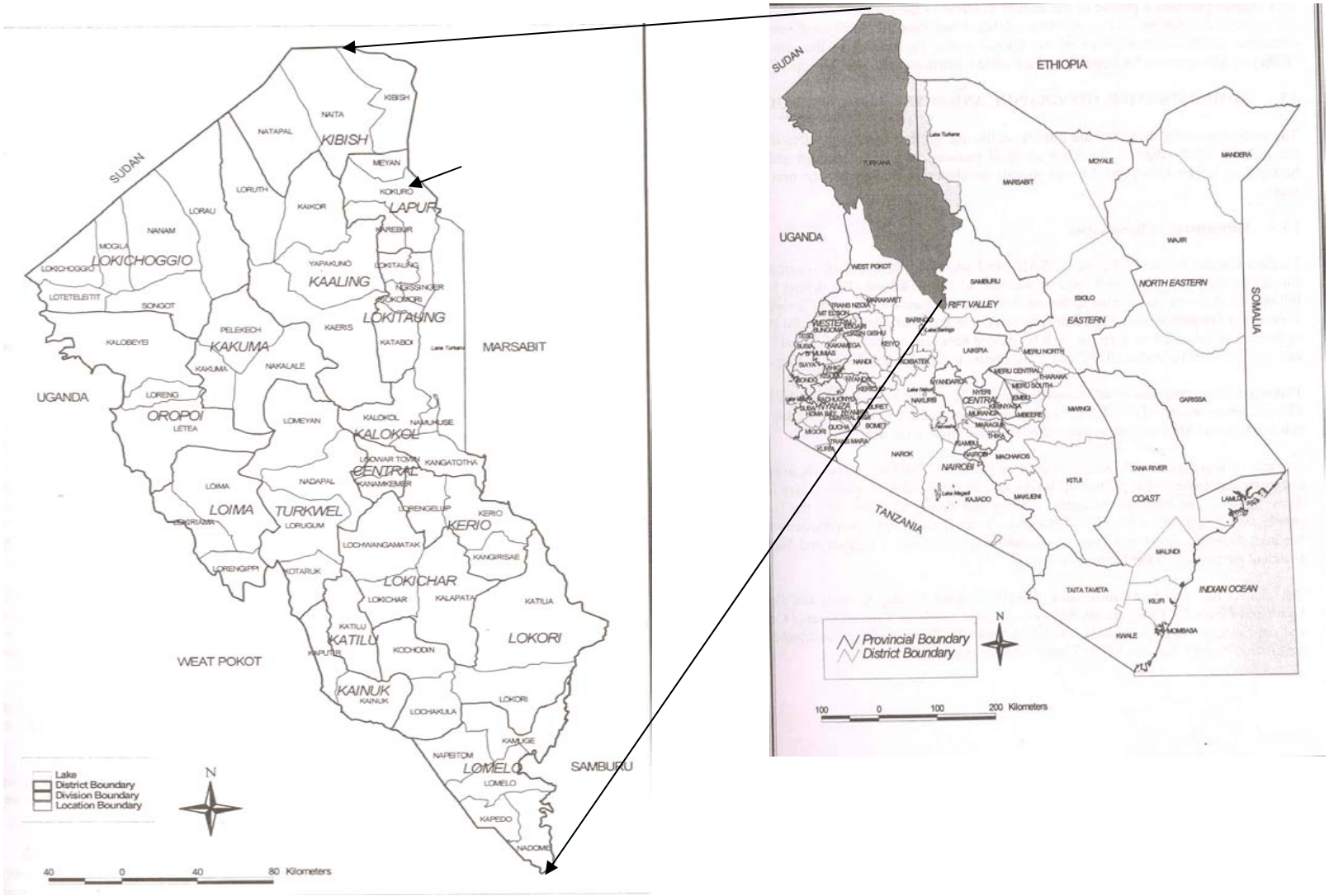

Figure 3.1: Map of Kenya showing location of the study area, Lapur Division, Turkana District, 2003.

Adapted from Turkana District Development Plan, 2002-2008

3.2 Data collection

3.2.1 Participatory rural appraisal (PRA) tools

Participatory rural appraisal (PRA) tools were used as described by Catley (1999), Catley and Irungu (2000) and Catley *et al*. (2001).

3.2.1.1 Mapping

Participatory mapping, a tool for collecting spatial data of a community (Lelo *et al*., 1995), was used to identify the geographical boundaries of the *Adakars* and included other features such as, natural resources, infrastructure, seasonal camel movements, and the distribution of flies. A group of informants sketched four maps on the ground and after triangulating the results, they were collapsed into one blueprint to represent the study area as per Catley (1999).

3.2.1.2 Matrices

3.2.1.2.1 Local perception of livestock diseases

Semi-structured interviews (SSI) were used to gain an understanding of the local perception of livestock diseases in general, and specifically on camel diseases. The groups of informants were asked to mention the most important diseases of every livestock they kept. In addition, they were asked to give the five most important diseases of camels. Through pair-wise ranking, the signs associated with the five diseases mentioned were obtained. Matrix scoring was used to obtain the local perceptions of clinical signs in the progression of the five diseases of camels. The signs were subsequently related to modern veterinary thinking. The five diseases were represented using familiar objects (e.g. bone, dung, stick, stone), which were placed along the top X-axis of the matrix while their signs (indicators) were illustrated along the Y-axis. The informants were asked to score the signs one by one according to their relative importance while maintaining 25 stones per each sign across the 5 diseases and the results triangulated. The level of agreement across the groups was determined by the method of Seigel and Castellan (1994). Plates 3.1 and 3.2 show some informants during a matrix scoring.

3.2.1.2.2 Seasonal calendars

Seasonal calendars, a time-related data source (Lelo *et al*., 1995), were used to describe the seasonal prevalence of the five important camel diseases identified in the matrix scoring. One group of elders per *Adakar* was used for this exercise. The elders were asked to divide a calendar year according to their perception. The seasons by their local names were represented by objects (e.g. dry leaf, stick or fresh leaf) on the X-axis and cards with names of the diseases written on them placed along the Y-axis. The four groups of informants were asked to score the prevalences of the diseases one by one according to the seasons and the results triangulated. The level of agreement across the groups was determined by the method of Seigel and Castellan (1994).

3.2.1.2.3 Control methods

Different control methods of *surra*, indigenous and modern, such as use of herbs, drugs, vacating an area and vector control that determined through conducting SSIs on four informant groups, were placed on the X-axis and their indicators (cost, effectiveness, ease in use and availability) on the Y-axis. The four groups of informants were asked to score the different control options against the indicators and the results triangulated. The level of concordance between the groups was determined by the method of Seigel and Castellan (1994).

3.2.1.2.4 Socio-economic data

After conducting semi-structured interviews (SSI) with the informants on the losses associated with important camel diseases, they were organised into 12 groups for purposes of matrix scoring. The method of scoring was done according Catley and Mohamed (1996). The diseases were placed on the X-axis and the indicators of economic losses (milk, meat, wool, hides, abortion, fertility, death, sale value, treatment costs, dowry, ceremonies) obtained through the SSI, on the Y-axis.

Plate 3.1: Matrix scoring by women from Lapur Division, Turkana District, 2001-2002.

Plate 3.2: Matrix scoring by men elders from Lapur Division, Turkana District, 2001-2002.

3.2.2 Proportional piling

Proportional piling was used to estimate the relative incidences and mortality of the five most important camel diseases during the past one year. Before the informants could score they were asked to classify the camels into different age-groups, i.e., adults and the young (suckling and weaners). Every informant maintained a pile of 100 stones for each age-group. First, the informant split the pile of stones into two relative to the number of camels sick and healthy during the past one year. This activity was repeated for 59 informants and provided estimates of annual incidences of the diseases. In addition, each informant was asked to remove some of the already allotted stones representing the sick camels to indicate the number that died during the past one year. This activity provided estimates of the annual mortalities due to the diseases.

3.2.3 Trend lines

Information was collected on trends of *surra* prevalences for the past 20 or so years on the key events the community thought were important. The four informant groups were prodded to remember important events in the community. This activity was used to approximate the years the events took place. They were also asked how long they have been rearing camels and when they first saw a case of *surra*. As a cut-off date, 1978 was adopted because the informants associated it with the death of an elder called Lowoton hence they called it the year of Lowoton. These events were then related to the prevalence of camel trypanosomosis. The community informants drew graphs on the ground. Two sticks were placed on the ground to represent the Y and X axes. The X-axis represented the key events over the years and on the Y-axis, the informants were asked to score using stones to show the levels of *surra*. This tool was used in combination with SSIs.

3.2.4 Semi-structured interviews (SSI)

Semi-structured interviews were employed at every stage in combination with the above tools of PRA as described by Catley (1999), Catley and Irungu (2000) and Catley *et al*. (2001). Through use of SSIs, the informant groups were specifically probed more on the disease of interest (trypanosomosis) with regard to the signs, causes, treatment and control. They were also used to

understand the community's perception and beliefs of livestock diseases. Besides conducting SSIs, there was observational estimation of livestock numbers kept in all the four participating *adakars.*

3.2.5 Collection of blood samples

Whole blood was collected from camels pre-identified by the owners as trypanosomosis cases and non-cases by a jugular venipuncture into 10ml siliconised plain vacutainers (Becton-Dickinson and company, Rutherfold, New Jersey, USA). The blood was stored overnight at room temperature for serum separation. The serum was used for trypanosomosis diagnosis using Latex Agglutination Test (LAT). In addition, the collected blood was immediately spotted onto filter paper (Appendix 5), air-dried according to Hopkins *et al.* (1998), and stored in a plastic jar with silica gel awaiting testing for trypanosomosis in the laboratory using the polymerase chain reaction (PCR).

3.3 Analysis of blood samples

3.3.1 Latex agglutination test (LAT)

In the field, LAT was done on the camel blood samples according to the method described by Nantulya (1994). In this test, a suspension of latex particles are sensitised with a monoclonal antibody against a *T. evansi* internal antigen. The specific antibody, bound to the latex particles, captures the antigen molecules in the serum. Several latex particles combine to multiple epitopes of the antigen molecule to form clusters, which can be visualised with the naked eye. Briefly, the test was conducted by placing 100µl of serum onto a special test slide. An equal volume of Suratex® reagent was placed next to the drop of serum. The two drops were mixed with a stirring rod to cover the surface area of the circle. The test slide was then tilted and rotated manually and the slide examined under a clear light for any evidence of agglutination.

3.3.2 Polymerase Chain Reaction (PCR)

Laboratory analysis of blood samples on the dried filter papers was done using polymerase chain reaction (PCR) as described by Saiki *et al.* (1988).

3.3.2.1 DNA extraction

DNA extraction from the filter papers was done with minor modifications according to Boid *et al*. (1999). Briefly, a 6 mm diameter disc was cut from the dried blood spot and placed in a 0.5 ml microcentrifuge tube with 200 µl of sterile water. The tube was incubated at 37^0 C for 30 minutes and then centrifuged at 12000 rpm for 2 minutes. The supernatant was removed and discarded. Sterile water (200 µl) was added and the tube centrifuged at 12000 rpm for one minute, and the supernatant removed and discarded. A 200 µl of Saponin lysis buffer (0.2% NaCl, 0.15% Saponin and 1 mM EDTA) was added, the sample vortexed, centrifuged for 1 minute and the supernatant discarded. Sterile water (200 µl) was added, pause-centrifuged, and the supernatant discarded. A 100 µl of water was added and the tube incubated at 100^0 C for 30 minutes. The tube was then centrifuged at 13000 rpm for 4 minutes, the supernatant transferred into a new tube and stored between -4^0 to -20^0 C if not immediately used.

3.3.2.2 Primers and PCR cycling

Oligonucleotide primers for trypanosome characterisation used were those described for subgenus *Trypanozoon* by Moser *et al.* (1989). Briefly, 50-µl reaction mixtures contained 10 mM Tris-HCl pH 8.3, 50 mM KCl, 1.5 mM $MgCl_2$, 0.01% gelatin, 200 µM of each of the four deoxynucleoside triphosphates (dNTPs), oligonucleotide primers (TBR 1&2 specific primers) at 1 mM, 10 µl of DNA template and 1.5 units of FastStart *Taq* DNA polymerase (Roche®).

The typical PCR reaction involved an initial step at 94^0 C for 1 minute to denature the template. Subsequent cycles involved a second denaturing at 94^0 for 30 seconds, annealing at 60^0 C for 45 seconds and extension at 72^0 C for 30 seconds. In total, 30 cycles were done. Elongation was continued at 72^0 C for five minutes.

A 15 µl of each amplified sample was subjected to electrophoresis using 1.5% agarose gel stained with 1 µg/ml ethidium bromide and photographed under ultraviolet illumination. A positive control (with reference DNA) and negative control (without DNA) were added for each reaction.

3.4 Data management and analysis

Survey and laboratory data were entered and stored in Microsoft Excel 2000 Software. The data were then exported to Statistical Package for Social Sciences (SPSS®) base 11 (Inc. Chicago IL., USA) for statistical analysis. The level of agreement between trypanosomosis diagnosis by pastoralists and conventional methods (LAT and PCR) was judged by the kappa statistic (Fleish, 1981). The layout for the computation of the kappa statistic is as shown in Table 3.1.

Table 3.1: 2X2 table for computing kappa statistic.

		1ST TEST		Total
		+	-	
2ND TEST	+	a	b	a+b
	-	c	d	c+d
Total		a+c	b+d	N = a + b + c + d

% Observed agreement (a+d)/n

% Expected agreement {[(a+c) X (a+b)]/n + [(b+d) X (c+d)]/n}/n

% Actual agreement beyond chance (observed – expected)

% Potential agreement beyond chance (100% - expected)

KAPPA = Actual agreement beyond chance
Potential agreement beyond chance

Kendall coefficient of concordance (W) was used to determine the level of agreement between the scores of four and 12 groups of informants using the formula (Seigel and Castellan, 1994):

$$W = \frac{\sum_{i=1}^{N} (\check{R}_i - \check{R})}{N(N^2-1)/12}$$

Where N = number of objects (or individuals) being ranked,
$\check{R}_i$ = average number of ranks assigned to the íth object or subject,
$\check{R}$ = the average (or grand mean) of the ranks assigned across all objects or subjects,
$N(N^2-1)/12$ = maximum possible sum of squared deviations, i.e. the numerator which would occur if there were perfect agreement among the rankings, and the average rankings were 1,2,…..N

3.5 Stakeholders' workshop

After a preliminary analysis of the results in the field, a summarised report was presented in a seminar to the pastoralists and other stakeholders. The seminar was held at Kokuro and those present were the members of the four *Adakars*, the Turkana District Veterinary Officer (DVO), and the Veterinary Officer (VO) of the area, the hosting NGO (ITDG), the chief and his assistant chief. The objective of the seminar was to have a forum for discussing the best options for the control of *surra.*

CHAPTER FOUR

4.0 RESULTS

4.1 Characteristics of study area

Lapur, division of Turkana District where the study was carried out is shown in Figure 3.1. Members from four *Adakars* participated in the study. The approximate numbers of livestock kept by the four *Adakars* were: cattle (950); sheep and goats (20,000); donkeys (500); and camels (200). These were rough estimates as it was not possible to get the exact numbers due to security reasons.

4.2 Participatory mapping

The collapsed map sketched by the four groups of informants is shown in Figure 4.1. The map shows natural features such as water sources, vegetation, mountains as well as services like markets and points for procurement of animal drugs. It also shows the Turkana neighbours, Toposas and Dongiros from Sudan, and Merilles from Ethiopia.

Flies were mostly found along the rivers and mountains and included camel flies (*Lolingokor*), houseflies (*Loporeit*), tsetse flies (*Lopodokongor*), mosquitoes (*Ng'isurut*), and biting flies (*Longicet*). Ticks (*Emadang'*) and lice (*Ng'ilach*) were also said to be abundant. Wild animals found within and around the study area included: buffaloes, lions, wild cats, elephants, gazelles, foxes, jackals, warthogs, kudus, ostriches and leopards.

During the dry season, livestock are moved upstream into the mountains and brought downstream into the plains during the rainy season as shown on the map.

Turkanas are pastoralists who move from place to place in search of pasture and water for their livestock and therefore *Adakars* are not constant with regard to size and location. Occasionally, due to security reasons, *Adakars* may merge or even move altogether from one area to another.

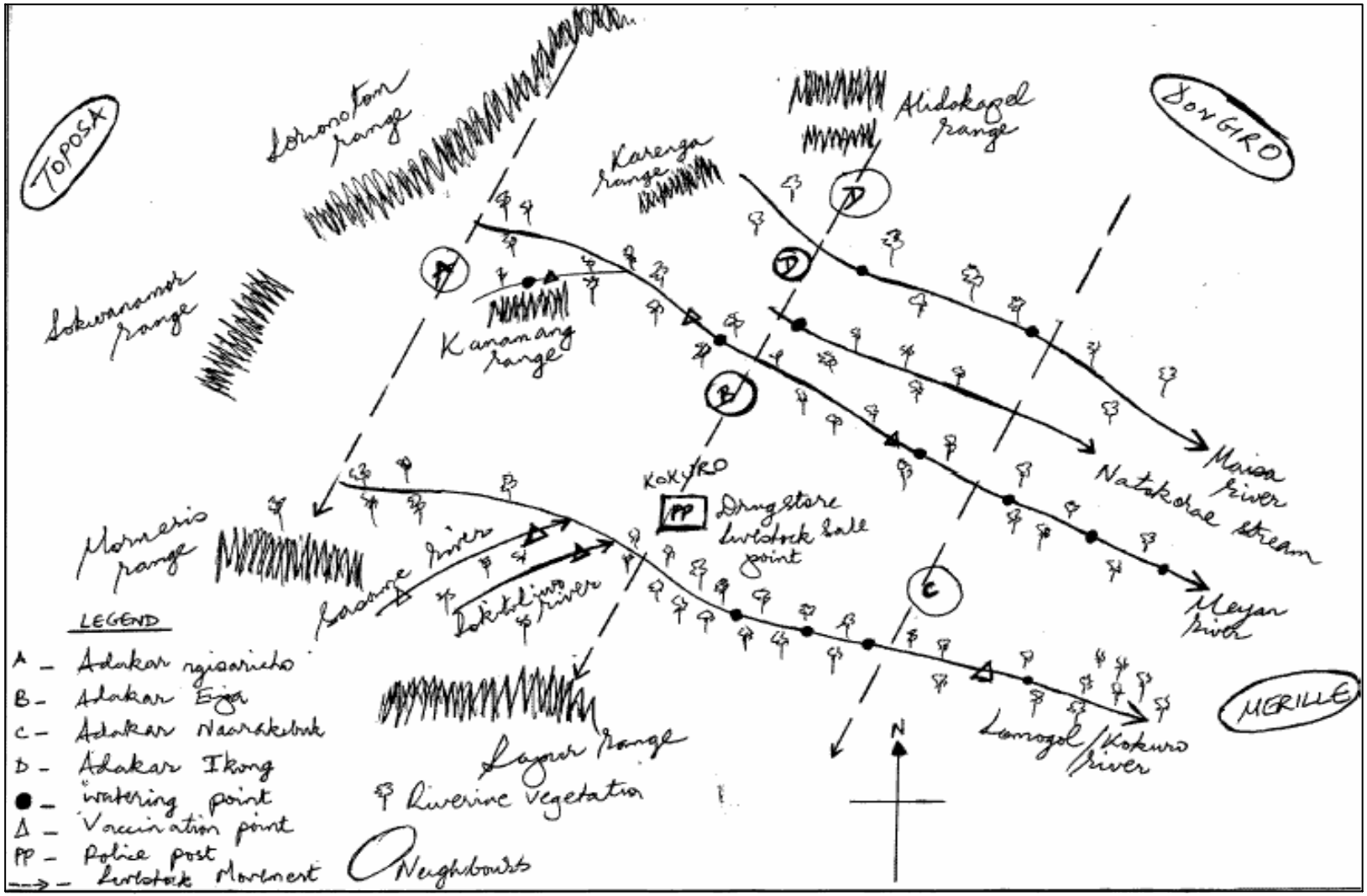

Figure 4.1: A map constructed on the ground by members of the four *Adakars* in Lapur Division, Turkana District, 2001-2002.

4.3 Matrices

4.3.1 Disease matrix

The results of the semi-structured interviews (SSIs) to determine the types of livestock kept and three most important diseases afflicting each type of livestock are summarised in Table 4.1.

Table 4.1: Types of livestock kept by the Turkana and the three important diseases affecting each type of livestock in Lapur Division, Turkana District, 2001-2002.

Type of Livestock	Diseases
Cattle	Contagious bovine pleuropneumonia (CBPP) (*Loukoi*)
	Black quarter (*Lokichuma*)
	Rinderpest (*Lokio*)
Camel	Trypanosomosis (*Lotorobuo*)
	Mange (*Ekoto*)
	Non-specific diarrhoea (*Loleewa*)
Sheep and goats	Contagious caprine pleuropneumonia CCPP (*Loukoi*)
	Pox (*Etune*)
	Orf disease or contagious ecthyma (*Ng'ibuorok*)
Donkeys	Trypanosomosis (*Lokipi*)
	Black quarter (*Lokichuma*)
	Anthrax (*Enomokere*)

After further probing on the camel diseases, the informants listed the following diseases in their order of importance: *lotorobuo* (s*urra*), *ekoto* (mange), *loleewa* (non-specific diarrhoea), *emadang'* (tick infestation), *logooroi* (haemorrhagic septicaemia), *ng'ibuorok* (orf or camel contagious ecthyma), *lowala* (camel pneumonia), *etune* (camel pox), *akiserit* (dermatomycosis), *long'okuo* (rabies), *lobusion* (abscesses) and *looketa* (mastitis).

It is worth noting that the Turkana name various livestock diseases according to the presenting signs and the species affected. A particular disease can have various names, e.g. trypanosomosis is called *Lotorobuo* in camels and *Lokipi* in cattle and donkeys. Both names mean ventral oedema, a sign of trypanosomosis in donkeys and camels.

A pair-wise comparison was used on the five most important diseases of the camel to determine the disease indicators for use in the matrix scoring (Appendix 1). *Lotorobuo* was the disease of interest while the other four were control diseases. The matrix scoring results (Appendix 1) of disease-signs are shown in Table 4.2. As shown in Table 4.2, the most important signs of *lotorobuo* were oedema, emaciation, high mortality, and infertility and abortion.

Table 4.2: Summarised matrix scoring of disease-signs in Lapur Division, Turkana District, 2001-2002.

Signs	Diseases: Lotorobuo	Emadang'	Loleewa	Ekoto	Logooroi
Skin lesions (W=0.753***)	0 (0-7)	♦♦♦♦ 3.5 (0-9)	0 (0-0)	♦♦♦♦♦♦♦♦♦♦ ♦♦♦♦♦♦♦♦ 19 (14-25)	0 (0-8)
Oedema (W=0.885***)	♦♦♦♦♦♦♦♦♦♦ ♦♦♦♦♦ 15 (10-20)	0 (0-5)	0 (0-0)	0 (0-8)	♦♦♦♦♦♦♦ 6.5 (5-11)
Loss of hair (W=0.860***)	0 (0-5)	♦♦♦♦♦♦ 5.5 (0-10)	0 (0-0)	♦♦♦♦♦♦♦♦♦♦ ♦♦♦♦♦♦♦♦ 18 (12-25)	0 (0-5)
Emaciation (W=0.420*)	♦♦♦♦♦♦♦♦♦♦ ♦♦♦ 12.5 (5-18)	♦♦ 1.5 (0-10)	♦♦ 1.5 (0-12)	♦♦♦♦♦♦ 5.5 (0-12)	0 (0-6)
High mortality (W=0.171^{ns})	♦♦♦♦♦♦ 6 (0-12)	♦♦ 2 (0-12)	♦♦♦♦♦♦ 5.5 (0-13)	♦♦♦♦♦ 4.5 (1-10)	♦♦♦♦♦ 5 (0-9)
Infertility and abortion (W=0.675**)	♦♦♦♦♦♦♦♦♦♦ ♦♦ 11.5 (4-20)	0 (0-3)	0 (0-8)	♦♦♦♦♦♦♦♦♦♦ 9.5 (0-18)	0 (0-8)

Key:

Number of informant groups = 12; W=Kendall's Coefficient of Concordance (*p<0.05; **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 the informant groups. The black dots represent the median scores (number of stones) that were used during the matrix scoring. The minimum and maximum limits are shown in parentheses.

The agreement between the 12 informant groups on the signs of diseases varied from 'non significant (ns)','weak', 'moderate' and 'good' according to the critical values of W. The level of agreement was good for skin lesions (W = 0.753), oedema (W = 0.885), loss of hair (W = 0.860), moderate for infertility and abortion (W = 0.675), weak for emaciation and not significant (W = 0.171) for the high mortality disease indicator (Table 4.2).

Additional signs of *lotorobuo* were explored through SSI. The listed signs were: loss of appetite, reduced milk yield, rough hair coat, low birth-weight calves, small udders, listlessness, swollen joints, coughing and a shrunken hump at the terminal stages. The post mortem lesions listed were watery and fibrous meat, lack of fat around the heart, and watery bone marrow.

When cross-checking the identity of flies, informants consistently called the *Hippobosca camelina* (camel fly) and other *Tabanus spp* as *lolingokor* and *ekaerorot* respectively. *Glossina spp* of flies were called *longicet*, a general name for biting flies. A few informants were able to identify *G. swynertoni* as *lopodokongor* although majority of them confused it with the common housefly (*loporeit*).

Through SSI, the following were identified by the informants as the most likely causes of *lotorobuo*: stagnant water shared by livestock and elephants, rain, a riverine tree called *esokon* (*Salvadora persica*), a shrub called *edome* (*Cordia sinensis*), a type of pasture called *epoo* (*Grewia spp*) occurring during the rainy season and biting flies.

4.3.2 Socio-economic matrix

The following uses of camels and their products by the Turkana were identified as important and included: milk (*ng'akile*), meat and blood (*akiring*' and *ng'akot*), fat (*akimet*), hides (*agijom*), payment of dowry (*akuuta*), barter trade, payment of fines, slaughtering to seal marriages in the absence of an ox, slaughtering to appease the ancestors, as an indicator of wealth, initiation of elders to higher levels and slaughtering to mark burial ceremonies of elders. On further probing, it was found that the community uses hides for making mattresses, shoes, bags, oil containers, ropes, donkey carriers, women skirts and thatching of *manyattas* especially during the rainy season. Indeed, the camel song (*edong'a*) below illustrates the importance the Turkanas attach to camels:

Vernacular	**English translation**
Nyani namanang'	Where is my milking camel?
Napetem imano ng'akile?	The one I do get milk from?
Atonia kolong' (agopia kolong')	It has long disappeared
Chorus	Tall like a giraffe (milking giraffe)
ekori lomanangit	Chorus
Iyo ikooson	Tell me where it has disappeared
Iyo lokamuran kang'	You the informed
Iyo ekeutan	You my in-law
Iyo ekewalan	You the suitor
	You the feathers bearer

From the list generated on the uses of camels and their products, six were selected and two (treatment cost, fertility and abortion) added by the investigator to make a total of eight indicators. These indicators were used against the five most important camel diseases for scoring in the disease-economic indicators matrix (Appendix 2). The summarised matrix is shown in Table 4.3.

The analysis of the matrix showed moderate to poor agreement between the informant groups (Table 4.3). There was moderate agreement between the groups for milk (W = 0.547), fat (W = 0.638), hides (W = 0.701), dowry (W = 0.635), infertility and abortion (W = 0.729). As shown in Table 4.3, the diseases with the highest scores were *lotorobuo* and *ekoto* on all indicators.

Table 4.3: Summarised matrix scoring of disease-economic indicators in Lapur Division, Turkana District, 2001-2002.

Indicators	Diseases: Lotorobuo	Emadang'	Loleewa	Ekoto	Logooroi
Milk (W=0.547**)	♦♦♦♦♦♦♦♦♦♦♦ 11 (6-16)	♦♦ 2 (0-14)	♦♦♦ 3 (0-6)	♦♦♦♦♦ 5 (0-12)	♦♦♦ 2.5 (0-6)
Meat and blood (W=0.443*)	♦♦♦♦♦♦♦♦♦♦ 10 (6-20)	♦♦♦ 3 (0-13)	♦♦♦♦ 3.5 (0-10)	♦♦♦♦♦ 5 (0-12)	♦♦♦ 2.5 (0-5)
Fat (W=0.638**)	♦♦♦♦♦♦♦♦♦♦♦ 10.5 (5-19)	♦♦ 2 (0-9)	♦♦ 1.5 (0-11)	♦♦♦♦♦♦♦ 7 (0-15)	♦♦ 2 (0-4)
Hides (W=0.701**)	♦♦♦♦♦♦♦♦♦ 8.5 (0-15)	♦ 0.5 (0-10)	0 (0-2)	♦♦♦♦♦♦♦♦♦ ♦♦♦♦♦ 14 (0-25)	0 (0-4)
Dowry (W=0.635**)	♦♦♦♦♦♦♦ 6.5 (1-10)	♦ 1 (0-5)	♦♦♦ 3 (0-8)	♦♦♦♦♦♦♦♦♦ 9 (6-17)	♦♦♦ 3 (2-9)
Infertility and abortion (W=0.729**)	♦♦♦♦♦♦♦♦♦♦ 9.5 (3-15)	♦ 0.5 (0-6)	♦♦♦ 3 (0-10)	♦♦♦♦♦♦♦♦♦ 9 (0-16)	0 (0-4)
Sale value (W=0.400*)	♦♦♦♦♦♦♦♦ 7.5 (0-10)	♦♦ 1.5 (0-10)	♦♦♦♦ 3.5 (0-7)	♦♦♦♦♦♦♦♦♦♦ 10 (0-19)	♦♦♦ 2.5 (0-11)
Cost of treatment (W=0.390*)	♦♦♦♦♦♦♦♦ 7.5 (2-13)	♦♦ 2 (0-12)	♦♦♦ 3 (0-8)	♦♦♦♦♦♦♦♦♦♦ 9.5 (3-15)	♦♦ 2 (0-13)

Key:

Number of informant groups = 12; W=Kendall's Coefficient of Concordance (*p<0.05; **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 the informant groups. The black dots represent the median scores (number of stones) that were used during the matrix scoring. The minimum and maximum limits are shown in parentheses.

4.3.3 Control methods matrix

The control methods of *lotorobuo* matrix was scored by the four groups of informants (Appendix 3) using relocation of animals, pour-on, drugs and indigenous (herbs, branding) as the control methods and effectiveness, costs, availability and ease of use of the methods as the indicators. The results are summarised in Table 4.4.

Table 4.4: Summarised matrix scoring of control methods of *surra* in Lapur Division, Turkana District, 2001-2002.

Indicators	Control methods: Relocation	Pour-on	Drug use	Indigenous
Effectiveness (W=0.534**)	♦ 0.5 (0-8)	♦ 0.5 (0-4)	♦♦♦♦♦♦♦♦♦♦ ♦♦ 12 (6-14)	♦♦♦♦♦♦ 6 (2-8)
Low financial cost (W=0.519**)	♦♦♦♦♦♦♦♦ 8 (2-10)	♦♦♦♦♦♦ 5.5 (4-10)	♦♦♦♦ 4 (3-5)	♦♦♦ 3 (2-3)
Availability (W=0.974***)	♦ 1 (0-2)	0 (0-0)	♦♦♦♦♦♦♦♦ 8 (7-9)	♦♦♦♦♦♦♦♦♦♦ ♦ 10.5 (10-13)
Ease in use (W=0.526**)	♦ 0.5 (0-2)	0 (0-8)	♦♦♦♦♦♦♦♦♦♦ ♦♦♦ 12.5 (5-16)	♦♦♦♦♦♦ 5.5 (4-8)

Key:

Number of informant groups = 4; W=Kendall's Coefficient of Concordance (*p<0.05; **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 the informant groups. The black dots represent the median scores (number of stones) that were used during the matrix scoring. The minimum and maximum limits are in parentheses.

From Table 4.4, availability as an indicator had the highest agreement (W = 0.974) among the four groups of informants. Effectiveness, financial cost and ease in use had moderate score of

agreement. The indigenous methods of control were scored highly as was the case of drugs in the control of *lotorobuo*.

Using SSI tool, the various indigenous treatment methods of *lotorobuo* were explored. The main treatment methods were the use of hot iron metal to brand the oedematous areas, and the giving of salt solution and goat urine orally. Sick animals were also reported to be given soup orally prepared from goat, wildcat, bird or donkey meat. These soups were mixed with various herbs that included: *lokitoe, kayeb, eyarabos, eusugu, emanman, erengen* roots*, lorimosha, louyogorok, etesiro, elingoi, epogai, esokon, edung, ekaye,* and *elimu*. Asked about the effectiveness of the indigenous methods, majority of the informants reported that camels usually recovered but that the disease recurred after 3-9 months of administration of the treatment.

4.3.4 Seasonal calendars

The four groups of informants divided a year into three seasons for purposes of matrix scoring (Appendix 4). The seasons were: *akiporo* (rainy season); *akamu* (dry season); and an intermediate season (*akiitiar*). *Akamu* was from January to May, *akiitiar* in the month of June and *akiporo* from July to December. Although the agreement between the informants was poor (W = 0.317) as to when *lotorobuo* occurred, the majority concurred that most cases were seen during the *akamu* season (Table 4.5). There was good agreement for *loleewa* (W=0.942), moderate agreement for *logooroi* (W=0.517) and no agreement for both *ekoto* and *emadang*' (W = 0.050 and W = 0.000, respectively).

Table 4.5: Summarised seasonal calendar on the occurrence of camel diseases in Lapur Division, Turkana District, 2001-2002.

Diseases	Turkana Seasons: Akiporo	Akiitiar	Akamu
Lotorobuo (W=0.317*)	♦♦♦♦♦ 5 (0-8)	♦♦ 1.5 (0-5)	♦♦♦♦♦♦♦♦ 7.5 (4-15)
Emadang' (W=0.000^{ns})	♦♦♦♦♦ 5 (0-8)	♦♦♦♦♦ 4.5 (4-5)	♦♦♦♦♦ 5 (3-11)
Loleewa (W=0.942***)	♦♦♦♦♦♦♦♦ ♦♦♦♦♦♦♦ 15 (8-15)	0 (0-3)	0 (0-4)
Ekoto (W=0.050^{ns})	♦♦♦♦♦♦ 6 (3-10)	♦♦♦♦ 4 (0-6)	♦♦♦♦♦ 4.5 (2-10)
Logooroi (W=0.517**)	♦♦♦♦♦♦♦♦♦ 9 (5-15)	♦♦ 1.5 (0-3)	♦♦♦♦ 3.5 (0-9)

Key:
Number of informant groups = 4; W=Kendall's Coefficient of Concordance (*p<0.05; **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 the informant groups. The black dots represent the median scores (number of stones) that were used during the matrix scoring. The minimum and maximum limits are shown in parentheses.

4.4 Proportional piling

4.4.1 Disease incidences

The informants (59 individuals) categorized camels into three age groups as: adults (*ng'ikala*), growing stock (*ng'isorok*) and suckling (*ng'itang'ikala*).

Because of the taxing nature of proportional piling, each informant was asked to place the camels into two main groups, namely, the adults and the young stock (suckling and weaners). Almost

half (49.3%) of the camels suffered from one ailment or another during the past one year (Figure 4.2) with *lotorobuo* contributing 11.4% of the cases.

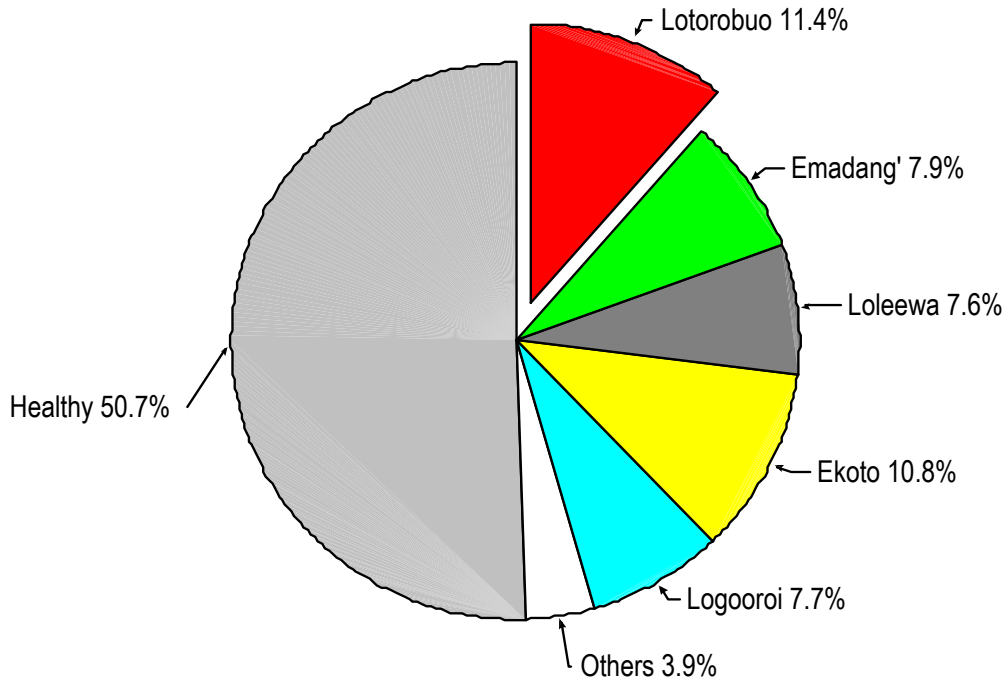

Figure 4.2: Mean annual incidences of camel diseases relative to the healthy in Lapur Division, Turkana District, 2001-2002

The mean annual incidences of the five diseases in adult and young camels are shown in Figure 4.3. Among the adult camel diseases, *lotorobuo* had the highest incidence (15.1%) while in the young group the incidence was 7%. This was an indication that the incidence of *lotorobuo* increased with age relative to the other camel diseases (Figure 4.3). This pattern was also observed with *ekoto. Emadang*' was observed more in young camels as compared to the adults (Figure 4.3).

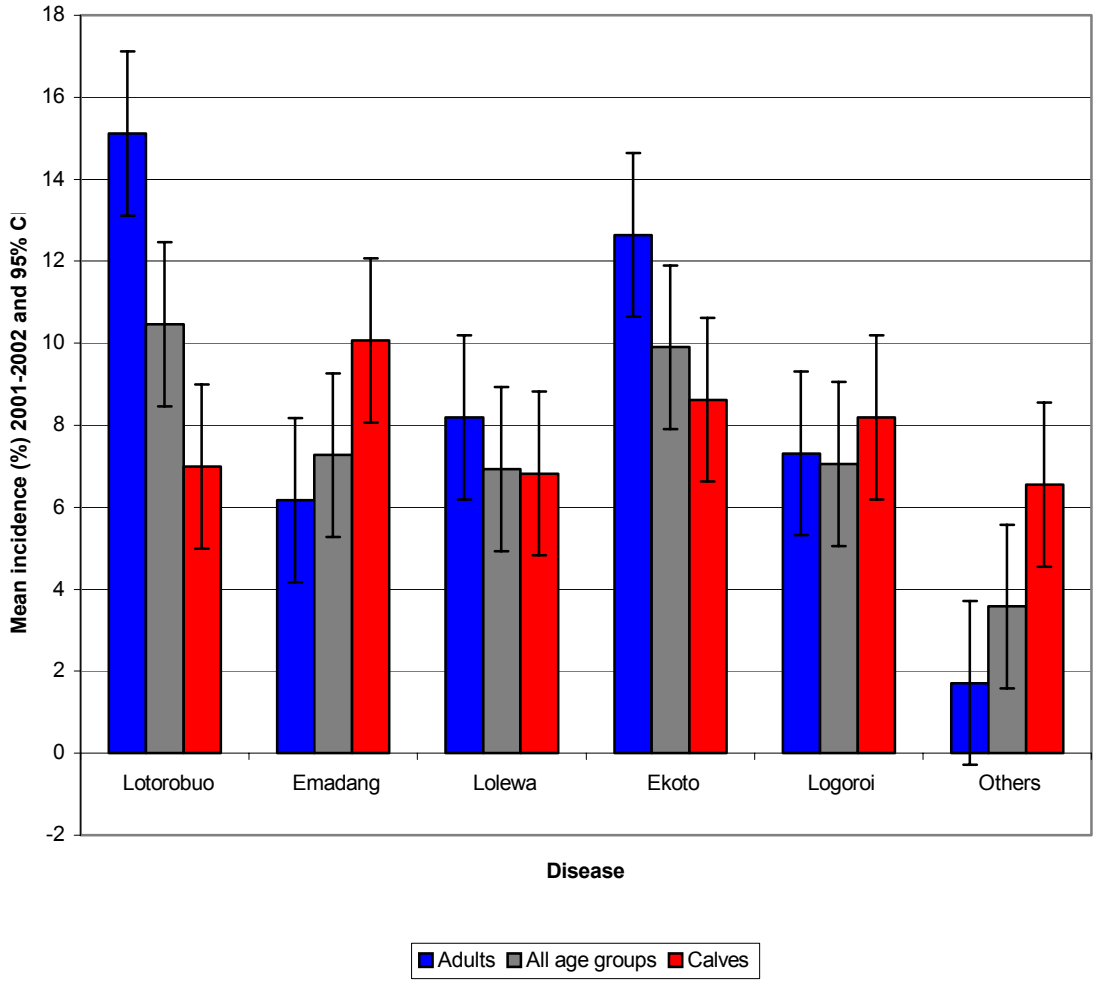

Figure 4.3: Mean annual incidences of camel diseases in Lapur Division, Turkana District, 2001-2002

4.4.2 Disease mortalities

The results of proportional piling on disease mortalities showed that 31% of camels died in the past one year with *lotorobuo* accounting for 7.8% of the fatalities (Figure 4.4). The mean annual mortalities of adult and young camels are shown in Figure 4.5. Among the adult camel diseases, *lotorobuo* had the highest mortality of 10% while in the young group the mortality was 5%. This was an indication that deaths from *lotorobuo* increased with age relative to the other camel diseases (Figure

4.5). This feature was also observed to a small extent with *ekoto* and *loleewa*. *Ekoto* and *emadang*' were leading causes of mortality in young camels.

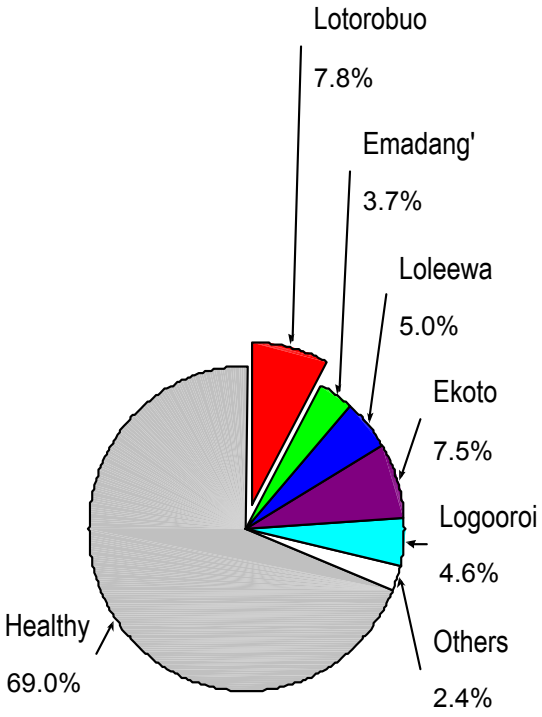

Figure 4.4: Mean annual mortalities of camels due to diseases relative to the healthy in Lapur Division, Turkana District, 2001-2002

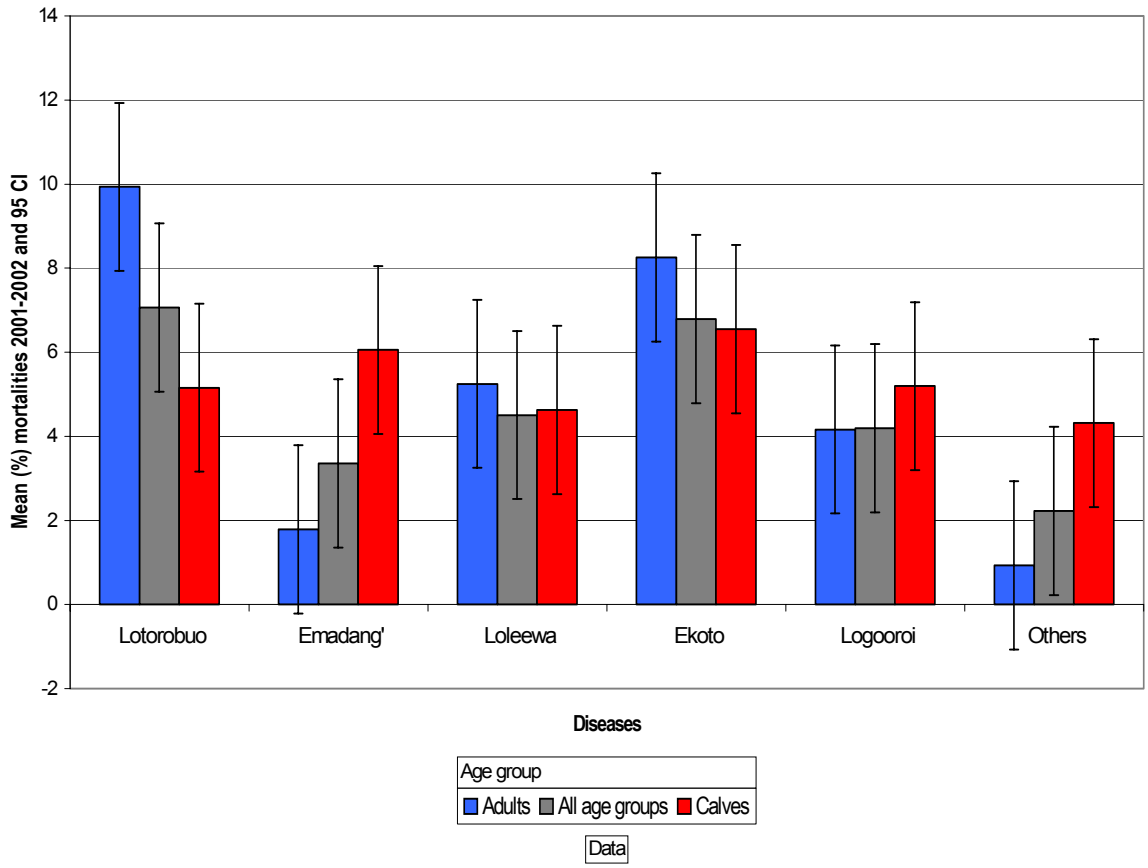

Figure 4.5: Cause-specific mean annual mortalities of camels in Lapur Division, Turkana District, 2001-2002

4.5 Trend lines

The Turkana associate different times in their history with the occurrence of extraordinary events, e.g., eclipse of the sun, famine, thunderstorms, wars, deaths of great men or women, disease outbreaks, etc. After intensive probing of the informants, the year 1978 was chosen as a cut-off point. This year was associated with the death of an elder called Lowoton. Using other events that occurred since 1978, the years the events took place were estimated. Variations in the levels of prevalence of *lotorobuo*, contagious bovine pleuropneumonia (CBPP) and veterinary drugs delivery levels (VDDL) were used along the Y-axis and years along the X-axis. There was a general decline in the level of

lotorobuo from a high of nearly 100% to a low of 15% in 2002 (Figure 4.6). From 1989, veterinary drugs delivery levels increased.

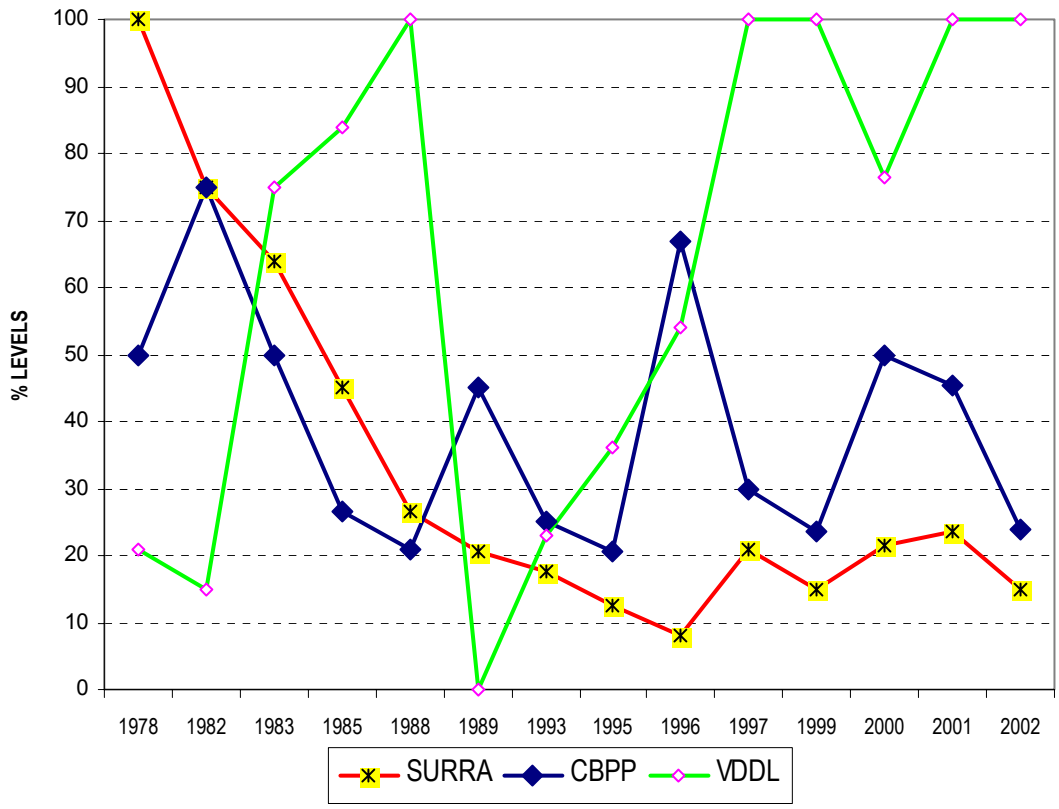

Figure 4.6: Trend lines depicting variation of *surra*, CBPP, and veterinary drugs delivery levels (VDDL) in Lapur Division, Turkana District from 1978-2002.

4.6 Diagnosis of *surra*

A total of the 32 camels were bled out of which 16 (50%) were positive for *T. evansi* on LAT. According to the pastoralists, 84.4% (27/32) of the camels presented for bleeding were diagnosed with *surra* while only 62.5% (20/32) of the corresponding blood samples were positive on PCR (Table 4.6).

Table 4.6: Diagnostic results of *surra* as determined by pastoralists and their corresponding blood results on LAT and PCR in Lapur Division, Turkana District, 2002.

Camel No.	Pastoralist diagnosis	LAT	PCR
EK01	+	+	+
EK02	+	+	+
EK03	+	+	+
EK04	+	+	+
EK05	+	-	-
EK06	+	+	+
EK07	+	+	+
EK08	+	+	+
EK09	+	+	+
EK10	+	+	+
EK11	+	-	-
EK12	+	+	+
EK13	+	-	-
EK14	-	-	-
EK15	+	-	+
EK16	+	+	+
EK17	+	-	-
EK18	+	-	+
EK19	+	+	+
EK20	+	-	-
EK21	+	-	-
EK22	+	-	-
EK23	+	+	+
EP01	+	-	+
EP02	+	-	-
EP03	+	+	+
EP04	+	-	+
EP05	+	+	+
N0I	-	-	-
N02	-	-	-
N03	-	-	-
N04	-	+	+
TOTAL POSITIVE	**27**	**16**	**20**

The PCR results on 24 of the 32 camel blood specimens and their corresponding LAT results are displayed in Figure 4.7. The 164bp in the specific band for *T. evansi* while the common band is a PCR artefact resulting from nondescript primer dimer bonding (Figure 4.7).

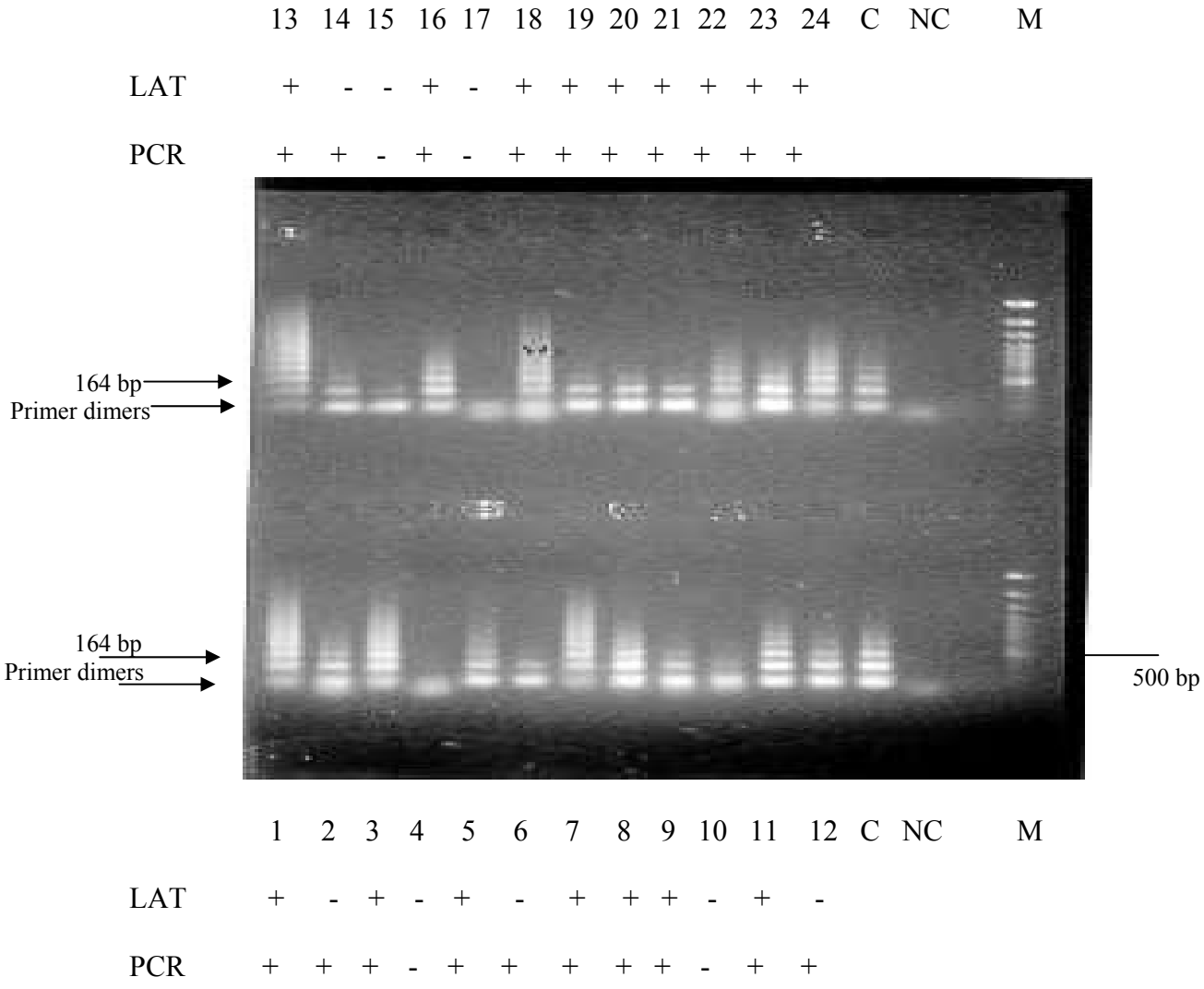

Figure 4.7: PCR results of 24 camel blood specimens presented for *surra* diagnosis and their corresponding LAT results in Lapur Division, Turkana District, 2001-2002.

Key:
C = positive control, NC = negative control and M = marker.

There was poor agreement between diagnoses as done by the pastoralists and by the LAT and PCR with a kappa statistic of 0.19 and 0.32, respectively. However, LAT and PCR had an excellent agreement (kappa of 0.75) in the diagnosis of camel trypanosomosis.

4.7 Stakeholders' workshop

During the workshop held at the end of the study, various stakeholders discussed the preliminary results. The role of the community-based animal health workers (CBAHWs) featured prominently. The pastoralists expressed their displeasure at the mediocre services they received from the CBAHWs. In addition, they felt they were being exploited by the CBAHWs, since their prices were exorbitant. However, they were willing to pay for the drugs once the role of CBAHWs was streamlined and more drug selling points established. The need for retraining of the CBAHWs with regular visits by the relevant authorities was considered a priority for better management of livestock diseases.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Participatory mapping

Participatory maps are powerful tools in the provision of spatial data on communities in a particular locality (Lelo *et al.,* 1995). The participatory map drawn by the key informants showed important features including forested areas, rivers, mountain ranges and areas where biting flies are found. It has long been recognised that the occurrence of trypanosomosis involves an inter-play of many factors that relate to disease vectors, wild hosts, livestock and their management, the trypanosomes and the climatic conditions (Whiteside, 1958). The features reported, particularly the presence of biting flies, provide ideal conditions for maintenance of *surra* in the camel population of Lapur Division. Indeed, *surra* was identified through pair-wise comparisons by the informants as one of the leading diseases of camels in the study area. In addition, these results were substantiated by the detection of *T. evansi* in the camel blood samples using LAT and PCR diagnostic techniques. The practice by pastoralists of grazing livestock along rivers and swampy areas, favourable habitats for biting flies (Evans *et al.*, 1995), may have contributed to the high prevalence of *surra.* Furthermore, the presence of a large population of sheep and goats may have acted as a reservoir, since they have been shown to harbour *T. evansi* inapparently (Evans *et al*., 1995). The donkeys could also suffer but are resistant (FAO, 2000), and could thus have served as reservoirs.

5.2 Matrices

As reported by Catley *et al.* (2002a) in their study of seasonal incidences of diseases of cattle, disease vectors and rainfall in southern Sudan, the use of matrix scoring as a tool for gathering information in pastoralist communities was found to be invaluable in this study. The key informants agreed quite well on most of the presenting signs of the important camel diseases. Indeed, most of the signs listed for *surra* were consistent with what appears in the veterinary literature (Evans *et al*., 1995; Kaufmann, 1998; FAO, 2000). In a study by Noor (1999), foul-smelling diarrhoea and sweet smell of urine of infected camels were also reported as additional signs of *surra* in Moyale District by Somali

pastoralists. In another study by Catley *et al*. (2001), loss of tail hair was also mentioned by Turkana pastoralists as a sign of *surra*. These results were an indication of an enormous wealth of knowledge Turkana pastoralists possess on livestock diseases. In addition, the informants were able to link increased cases of *surra* to a build-up of the biting fly population. It is known that biting flies play an important role in the transmission mechanisms of *surra* (Evans *et al.*, 1995; FAO, 2000). Catley and Irungu (2000) in their study of bovine trypanosomosis using participatory methods documented a similar knowledge base of livestock diseases by the Orma pastoralists of Tana River District, Kenya.

The informants mentioned and agreed very well on most of the uses of camels. It was however rather surprising that the Turkana do not use the camel as a transport animal. Camels are used extensively for transport by the Gabbra/Ariaal and Borana communities in the neighbouring district of Marsabit as well as the Somali ethnic group of Wajir and Garissa Districts (Evans *et al.,* 1995; Kaufmann, 1998). This could be attributed to the fact that Turkanas are traditionally cattle keepers and camels are a relatively new introduction. Furthermore, it was noted that the donkeys were in abundance and Turkanas prefer using them instead. It is likely that with sound educational programmes, the Turkanas would be able to use camels in more different ways than is currently the practice.

Turkana pastoralists consume camel milk, blood and meat and camel hide is used for making sandals, ropes, whips, donkey carriers, bags and women skirts and for thatching. On traditional subsistence systems in Kenya, the camel can produce between 2.2 – 4.5 litres of milk per day and their lactation period is about a year (Kaufmann, 1998). Milk is important to pastoralists in the provision of vitamin C, which they would otherwise suffer a deficiency from, since fresh fruits and vegetables are rare in arid lands (Noor, 1999).

Even though Turkana eat camel meat, it was apparent that camels are seldom slaughtered, except when marking certain occasions. Camels are usually slaughtered at an old age – mean 14.5 years – and have a long calving-to-conception interval of 22 months (Evans *et al*., 1995: Kaufmann, 1998). These factors may have worked against the use of the camel as an important source of meat.

The Turkana have not fully exploited the potential of the camel and its various products. In the neighbouring Samburu District, camels are being used as tourist attractions through camel races (Noor, 1999). There is need to introduce some of these innovations to the Turkana through educational programmes.

It is difficult to do an economic analysis in monetary terms in the pastoral camel production system since most camel products do not enter the market and most inputs are not purchased (Noor, 1999). However, given the various ways the camel is used by the Turkana, the socio-economic impact of *surra* arising from morbidity and mortality was likely to have been great.

The informants identified several bottlenecks in their efforts to control *surra.* Relocating of animals to avoid riverine habitats where biting flies thrive was not considered an option especially during the dry season. Although trypanocidal drugs were considered to be reasonably available, their use were impeded by what Turkana considered as their prohibitive prices. The price of a single dose of quinapyramine sulphate was Kshs 350.00, equivalent to the cost of an adult goat. It was therefore not entirely surprising that the preferred method of *surra* control by the Turkana was the indigenous one, which involved the application of a concoction of herbs, mixed with soup and the branding of oedematous areas on sick animals using hot iron. Although the informants were in agreement on the effectiveness of these remedies, the annual mortality (7.8%) attributed to *surra* was unacceptably high. Furthermore, it was claimed that the disease usually recurred after 3 to 9 months upon administration of these remedies. There is a need to carry out clinical trials on these remedies to assess their efficacy. The application of similar herbal concoctions in the treatment of cattle trypanosomosis has been reported among the pastoral Orma community of Tana River District (Catley and Irungu, 2000).

The seasonal calendar was used to demonstrate the temporal variations in the prevalences of camel diseases. There was poor agreement (W = 0.317) across the groups of informants as to when *surra* occurred with the highest frequency. The lack of good agreement may have been due to the few (four) informant groups (Judges) used for this exercise in comparison to twelve groups used for the other exercises. Moreover, the PA methods are still under refinement and there is no minimum number

of informant groups to achieve good agreement. However, there appeared to be a general consensus that *surra* occurred more frequently during the dry season. The upsurge of *surra* during the dry season may have been attributed to the build-up of the biting fly population after rains. In addition, during the dry season, camels are usually in a low plane of nutrition and trek for long distances in search of water and pasture. This is likely to stress the animals and subsequently trigger clinical signs of *surra* in animals which would otherwise be sub-clinically infected. A high prevalence of *surra* occurring in the dry season has also been reported in semi-arid rangelands in Kenya by Evans *et al.* (1995).

5.3 Proportional piling

This PA tool was used for the estimation of incidence and mortality of *surra* and other camel diseases. According to the informants, about a half (49.3%) of the camel population suffered from at least one disease over the past one year with *Surra* reportedly having the highest annual incidence (11.4%). The same pattern was also reflected in disease mortalities with crude mortality estimated at 31% for the previous year. *Surra* accounted for 7.8% of the mortalities with age-specific mortalities of 9.9% and 5.2% in adult camels and calves, respectively. A similar pattern of trypanosomosis has been observed in Orma cattle where the annual incidence rate was 17.9% in all age groups (Catley and Irungu, 2000). In a study of *surra* among Rendille and Gabbra communities of the neighbouring Marsabit District and the Somali communities of Wajir and Garissa Districts, Kaufmann (1998) recorded surra incidences of 25%, 8% and 26%, respectively. As noted by Catley and Irungu (2000), informants were likely to inflate the incidence of *surra* in expectation of free drugs. However, infection rates of *surra* in the range of 20% – 70% have been reported in the past (Wilson, 1984; Radostitis *et al*., 1994). The reported incidence (11.4%) due to *surra* irrespective of age of animal was within the range of 3% and 20% reported for endemic and epidemic scenarios, respectively (Wilson, 1984; Evans *et al.,* 1995). The 7.8% mortality was high as compared to what has been reported as 3% (Wilson, 1984), which would be attributed to inflated incidence pattern.

5.4 Trend lines

The trend line drawn by the informants from 1978 to March 2002 showed a general decline in *surra* prevalence levels from 1978 to 1996. Since 1996, the prevalence levels exhibited an oscillatory pattern with only minor fluctuations to what appeared to be a steady equilibrium. Although the delivery of veterinary services appeared to improve during this period of low prevalence, it is difficult to attribute the low prevalence to veterinary interventions. This argument appears to be supported by the results of the disease control matrix where informants were in agreement that the trypanocides were not regularly used due to their prohibitive costs. It is likely that the camel and the causative agent (*T. evansi*) of *surra* have established a stable relationship over time to an endemically stable state. Indeed, Njiru *et al*. (2000) have shown that *surra* occurs endemically in camel populations of Kenya. This phenomenon of endemic stability has also been reported in tick-borne diseases of cattle in some parts of central Kenya (Gitau *et al*., 2001).

5.5 Diagnosis

There was poor agreement in the diagnosis of *surra* by the pastoralists and diagnosis using the LAT and PCR techniques (0.1875 and 0.32, respectively). The two tests showed strong agreement (kappa = 0.75) in the detection of *T. evansi* in camel blood. The poor agreement between the pastoralists and the two diagnostic tests may have been due to the tendency of the camel owners to present their animals for bleeding in expectation of free trypanocides. However, on the basis of the disease-signs matrix, it was evident that the pastoralists knew *surra* quite well since they enumerated *surra* signs consistent with those found in the veterinary literature. In a different study by Noor (1999) in Moyale District, Kenya, pastoralists were able to diagnose from between 75-85% of all infected camel herds.

5.6 Stakeholders' workshop

This was the first process of feeding back the pastoralists on their information. As noted by Kaufmann (1998), the workshop stimulated dialogue between the researchers and the informants. The informants were able to freely discuss the constraints they faced in managing their livestock. The issue

of community-based animal health workers (CBAHWs) featured prominently during the discussions. The presence of the District Veterinary Officer (DVO) for Turkana District was important and had a chance to hear first-hand, the problems experienced by the pastoralists. The agreements arrived at the workshop, e.g., streamlining the services of CBAHWs and their close supervision, in addition to providing more drug-selling points, should of necessity be addressed. The workshop also provided an opportunity to the pastoralists to learn new techniques in the management of their livestock, e.g., the use of pour-ons in the control of biting fly populations.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The present study provided baseline data that can be used in the planning and implementation of a *surra* control programme in the pastoralist area of Turkana District. *Surra* is an important disease in Turkana with a reported annual incidence of 11.4%. The delivery of veterinary services in this large and arid area of Kenya is still inadequate partly due to its vastness, harsh climatic conditions and insecurity. It was evident that the Turkana pastoralists do possess an enormous wealth of knowledge on livestock diseases. *Surra* was identified as one of the leading diseases of camels through both pair-wise comparisons. This was substantiated by the detection of *T. evansi* in camel blood samples using LAT and PCR diagnostic techniques. The ability of Turkana pastoralists to diagnose camel trypanosomosis was generally good as they were able to link increased *surra* cases to biting fly population build-up. In addition, the key informants agreed quite well on most presenting signs of important camel diseases that were consistent with veterinary literature. The Turkanas were well aware of the modern treatment of camel trypanosomosis, but they preferred traditional herbal concoctions. However, the efficacy of the indigenous remedies practised by pastoralists in the control of *surra,* remains unestablished. The full potential of the camel is not yet fully exploited by the Turkana. However, the camel still plays an important role in the lives of Turkana pastoralists and thus the socio-economic impact of *surra* arising from its morbidity and mortality is likely to have been great. Despite this, it was difficult to do an economic analysis since most camel products do not enter the market. Thus, the socio-economic impact was more of a qualitative observation than through measurable indicators like milk production. The Turkana community showed a lot of interest in this study and are therefore likely to be compliant in any *surra* control programme instituted in the area.

6.2 Recommendations

Because of the negative effect of *surra* in Turkana, there is a need for operational research to compare, using field trials, the feasibility and sustainability of alternate *surra* control programmes in the district. Such programmes could include those aimed at reducing the vector populations (e.g. the use of pour-ons, traps and targets) and the use of trypanocides. The role of community-based animal health workers (CBAHWs) in enhancing delivery of animal health-care should also be assessed. Clinical trials also need to be conducted to assess the efficacy of the indigenous remedies applied by the pastoralists. The pastoralists should also be educated on ways to utilize the camel's potential for work, riding and as a pack animal. For the success of these programmes, the pastoralist's sympathy and support should be enlisted. In addition, the community should be active participants from the planning, implementing, and assessment of the programmes.

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APPENDICES

Appendix 1: Disease-signs matrices constructed by the 12 groups of informants on the ground in Lapur Division, Turkana District, 2002.

		Diseases				
Group	**Indicator**	**Lotorobuo**	**Emadang'**	**Loleewa**	**Ekoto**	**Logooroi**
1Nk H	Skin lesions	0	0	0	25	0
1Nk H	Oedema	15	0	0	0	10
1Nk H	Loss of hair					
1Nk H	Emaciation	13	0	6	0	6
1Nk H	High mortality	0	12	5	4	4
1Nk H	Infertility and abortion					
2Nk E	Skin lesions	0	0	0	25	0
2Nk E	Oedema	20	0	0	0	5
2Nk E	Loss of hair					
2Nk E	Emaciation	11	8	0	3	3
2Nk E	High mortality	3	3	11	2	6
2Nk E	Infertility and abortion					
3Nk W	Skin lesions	0	0	0	20	5
3Nk W	Oedema	20	0	0	0	5
3Nk W	Loss of hair	0	8	0	12	5
3Nk W	Emaciation	14	4	2	2	3
3Nk W	High mortality	4	3	6	10	2
3Nk W	Infertility and abortion	4	3	8	10	0
4Ng E	Skin lesions	0	3	0	14	8
4Ng E	Oedema	11	0	0	8	6
4Ng E	Loss of hair	0	0	0	25	0
4Ng E	Emaciation	10	1	1	7	6
4Ng E	High mortality	12	0	0	7	6
4Ng E	Infertility and abortion	12	0	0	5	8
5Ng W	Skin lesions	0	5	0	20	0
5Ng W	Oedema	20	0	0	0	5
5Ng W	Loss of hair	3	3	0	19	0
5Ng W	Emaciation	18	0	5	0	2
5Ng W	High mortality	8	6	6	1	4
5Ng W	Infertility and abortion	20	0	5	0	0
6Ek E	Skin lesions	0	0	0	25	0
6Ek E	Oedema	14	5	0	0	6
6Ek E	Loss of hair	0	10	0	15	0
6Ek E	Emaciation	5	10	0	10	0
6Ek E	High mortality	6	0	3	10	6
6Ek E	Infertility and abortion	10	0	0	15	0
7Ek W	Skin lesions	0	4	0	14	7

Appendix 1 continues

7Ek W	Oedema	10	4	0	0	11
7Ek W	Loss of hair	0	0	0	25	0
7Ek W	Emaciation	13	4	0	8	0
7Ek W	High mortality	8	2	2	4	9
7Ek W	Infertility and abortion	16	0	0	9	0
8Ek E	Skin lesions	0	4	0	15	6
8Ek E	Oedema	14	0	0	0	11
8Ek E	Loss of hair	0	7	0	13	5
8Ek E	Emaciation	14	0	4	7	0
8Ek E	High mortality	7	3	4	9	2
8Ek E	Infertility and abortion	9	0	0	16	0
9Ek H	Skin lesions	0	9	0	16	0
9Ek H	Oedema	16	4	0	0	5
9Ek H	Loss of hair	0	4	0	21	0
9Ek H	Emaciation	8	5	12	0	0
9Ek H	High mortality	6	2	6	3	8
9Ek H	Infertility and abortion	7	0	0	18	0
10Ep W	Skin lesions	0	4	0	21	0
10Ep W	Oedema	14	2	0	0	9
10Ep W	Loss of hair	0	3	0	22	0
10Ep W	Emaciation	11	2	0	12	0
10Ep W	High mortality	6	0	13	6	0
10Ep W	Infertility and abortion	12	0	0	13	0
11Ep E	Skin lesions	7	0	0	18	0
11Ep E	Oedema	15	0	0	0	10
11Ep E	Loss of hair	0	8	0	17	0
11Ep E	Emaciation	15	0	0	10	0
11Ep E	High mortality	11	2	4	5	3
11Ep E	Infertility and abortion	11	2	2	7	3
12Ep H	Skin lesions	0	9	0	16	0
12Ep H	Oedema	18	0	0	0	7
12Ep H	Loss of hair	5	7	0	13	0
12Ep H	Emaciation	12	0	9	4	0
12Ep H	High mortality	5	2	9	3	6
12Ep H	Infertility and abortion	17	0	0	8	0

KEY

NkH – Naraakibuk herders
NkE – Naraakibuk men elders
NkW – Naraakibuk women
NgE – Ng'isaricho men elders
NgW – Ng'isaricho women
EkE – Ikong' men elders
EkW – Ikong' women
EkH – Ikong' herders
EpE – Eipa men elders
EpH – Eipa herders
EpW – Eipa women

Appendix 2: Disease-socio-economic indicators matrices constructed by the 12 groups of informants on the ground in Lapur Division, Turkana District, 2002.

		Diseases				
Group	**Indicator**	**Lotorobuo**	**Emadang'**	**Loleewa**	**Ekoto**	**Logooroi**
1Nk E	Milk	16	9	0	0	0
1Nk E	Meat &blood	12	13	0	0	0
1Nk E	Fat	16	9	0	0	0
1Nk E	Hides	15	10	0	0	0
1Nk E	Dowry	5	5	3	9	3
1Nk E	Fertility & abortion	9	6	1	9	0
1Nk E	Sale value	10	10	5	0	0
1Nk E	Cost of treatment					
2Nk H	Milk	6	14	3	2	0
2Nk H	Meat & blood	10	3	0	12	0
2Nk H	Fat	5	3	2	15	0
2Nk H	Hides	11	0	0	10	4
2Nk H	Dowry	7	0	0	15	3
2Nk H	Fertility & abortion	9	0	0	16	0
2Nk H	Sale value	9	3	0	13	0
2Nk H	Cost of treatment					
3Nk W	Milk	13	5	4	3	0
3Nk W	Meat & blood	6	7	4	3	5
3Nk W	Fat	8	3	5	5	4
3Nk W	Hides	12	5		8	0
3Nk W	Dowry	7	3	3	8	4
3Nk W	Fertility & abortion	10	2	3	10	0
3Nk W	Sale value	0	0	6	19	0
3Nk W	Cost of treatment	5	12	4	4	0
4Ng E	Milk	11	0	0	10	4
4Ng E	Meat & blood	12	0	0	8	5
4Ng E	Fat	13	0	0	10	2
4Ng E	Hides	11	0	0	14	0
4Ng E	Dowry	6	0	0	17	2
4Ng E	Fertility & abortion	14	0	0	7	4
4Ng E	Sale value	5	5	5	5	5
4Ng E	Cost of treatment	13	0	0	12	0
5Ng W	Milk	15	2	3	3	2
5Ng W	Meat & blood	10	2	5	5	3
5Ng W	Fat	11	1	1	10	2
5Ng W	Hides	0	0	0	25	0

Appendix 2 continues

5Ng W	Dowry	10	0	3	9	3
5Ng W	Fertility & abortion	15	0	10	0	0
5Ng W	Sale value	3	2	3	14	3
5Ng W	Cost of treatment	12	0	3	8	2
6Ek E	Milk	6	0	3	12	4
6Ek E	Meat & blood	8	3	2	8	4
6Ek E	Fat	6	3	0	12	4
6Ek E	Hides	0	0	0	25	0
6Ek E	Dowry	6	1	3	9	6
6Ek E	Fertility & abortion	7	2	3	13	0
6Ek E	Sale value	8	0	0	15	2
6Ek E	Cost of treatment	4	2	1	15	3
7Ek W	Milk	11	1	3	4	6
7Ek W	Meat & blood	8	7	4	6	0
7Ek W	Fat	12	2	1	10	0
7Ek W	Hides	5	0	0	20	0
7Ek W	Dowry	8	1	8	6	2
7Ek W	Fertility & abortion	11	0	2	9	3
7Ek W	Sale value	8	2	4	10	1
7Ek W	Cost of treatment	2	2	8	10	3
8Ek H	Milk	15	0	6	4	0
8Ek H	Meat & blood	7	3	10	4	1
8Ek H	Fat	11	0	11		3
8Ek H	Hides	4	3	0	16	2
8Ek H	Dowry	1	1	5	15	3
8Ek H	Fertility & abortion	3	0	8	14	0
8Ek H	Sale value	1	0	3	10	11
8Ek H	Cost of treatment	7	2	3	13	0
9Ek W	Milk	10	2	4	6	3
9Ek W	Meat & blood	11	2	4	4	4
9Ek W	Fat	7	3	5	7	3
9Ek W	Hides	9	2	0	14	0
9Ek W	Dowry	5	1	3	14	2
9Ek W	Fertility & abortion	7	1	3	12	2
9Ek W	Sale value	8	2	2	11	2
9Ek W	Cost of treatment	8	2	3	10	2
10Ep E	Milk	8	2	4	8	3
10Ep E	Meat & blood	11	1	3	8	2
10Ep E	Fat	10	2	4	7	2
10Ep E	Hides	8	1	2	10	4

Appendix 2 continues

10Ep E	Dowry	10	1	4	7	3
10Ep E	Fertility & abortion	11	1	5	6	2
10Ep E	Sale value	10	1	3	8	3
10Ep E	Cost of treatment	9	5	2	6	3
11Ep H	Milk	12	0	3	10	0
11Ep H	Meat & blood	20	0	0	5	0
11Ep H	Fat	19	0	0	6	0
11Ep H	Hides	4	0	0	21	0
11Ep H	Dowry	1	0	6	9	9
11Ep H	Fertility & abortion	14	0	8	3	0
11Ep H	Sale value	1	0	7	9	8
11Ep H	Cost of treatment	2	1	6	3	13
12Ep W	Milk	6	3	5	6	5
12Ep W	Meat & blood	6	4	5	5	5
12Ep W	Fat	10	2	4	5	4
12Ep W	Hides	12	2	0	11	0
12Ep W	Dowry	7	2	5	7	4
12Ep W	Fertility & abortion	9	2	4	8	2
12Ep W	Sale value	7	1	6	7	4
12Ep W	Cost of treatment	11	5	0	9	0

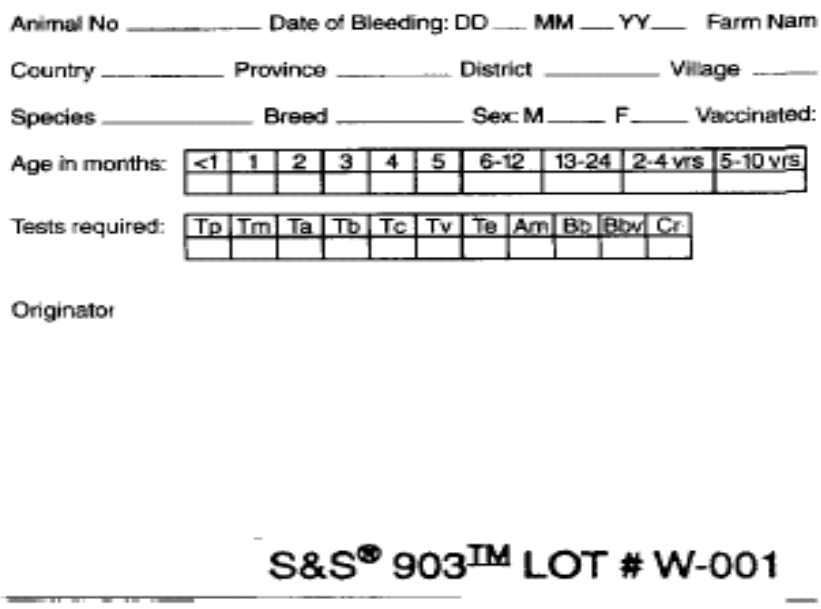
Appendix 3: Disease control matrices constructed by four groups of informants on the ground in Lapur Division, Turkana District, 2002

		Control methods			
Group	**Indicators**	**Relocation**	**Pour-on**	**Drugs**	**Indigenous**
1EkE	Cost	9	5	4	2
1EkE	Effectiveness	0	0	14	6
1EkE	Availability	0	0	7	13
1EkE	Ease	0	0	16	4
2EkW	Cost	10	4	3	3
2EkW	Effectiveness	0	0	12	8
2EkW	Availability	0	0	9	11
2EkW	Ease	0	0	12	8
3EpE	Cost	2	10	5	3
3EpE	Effectiveness	8	4	6	2
3EpE	Availability	2	0	8	10
3EpE	Ease	1	8	5	6
4EpW	Cost	7	6	4	3
4EpW	Effectiveness	1	1	12	6
4EpW	Availability	2	0	8	10
4EpW	Ease	2	0	13	5

Appendix 4: Seasonal calendar matrices constructed by 4 groups of informants on the ground in Lapur Division, Turkana District, 2002.

		Seasons		
Group	**Diseases**	**Akiporo**	**Akiitiar**	**Akamu**
Nk E	Lotorobuo	0	0	15
Nk E	Emadang'	0	4	11
Nk E	Loleewa	8	3	4
Nk E	Ekoto	3	6	6
Nk E	Logooroi	8	2	5
Ng E	Lotorobuo	4	0	11
Ng E	Emadang'	5	5	5
Ng E	Loleewa	15	0	0
Ng E	Ekoto	5	0	10
Ng E	Logooroi	8	2	5
Ek E	Lotorobuo	8	3	4
Ek E	Emadang'	8	4	3
Ek E	Loleewa	15	0	0
Ek E	Ekoto	7	5	3
Ek E	Logooroi	10	3	2
Ep E	Lotorobuo	6	5	4
Ep E	Emadang'	5	5	5
Ep E	Loleewa	15	0	0
Ep E	Ekoto	10	3	2
Ep E	Logooroi	15	0	0

Appendix 5: A filter paper used to impregnate camel blood in Lapur Division, Turkana District, 2002.


Animal No _____ Date of Bleeding: DD ___ MM ___ YY___ Farm Nam

Country _____ Province _____ District _____ Village _____

Species _____ Breed _____ Sex: M _____ F_____ Vaccinated:

Age in months:	<1	1	2	3	4	5	6-12	13-24	2-4 yrs	5-10 yrs

Tests required:	Tp	Tm	Ta	Tb	Tc	Tv	Te	Am	Bb	Bbv	Cr

Originator

S&S® 903™ LOT # W-001