The Epidemiology and Control of East Coast fever and other Vector-borne Diseases: Perceptions of the Pastoral Communities in Northern Rift Valley Province, Kenya

Alexander Kipruto Kipronoh
(Bachelor of Veterinary Medicine, University of Nairobi)

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Department of Public Health, Pharmacology and Toxicology
Faculty of Veterinary Medicine

University of Nairobi

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DECLARATION

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

Alexander Kipruto Kipronoh, (B.V.M.)

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

1. Prof. J.M Gathuma (B.V.Sc., M.Sc., Ph.D.)

   Signature..Date 11/2/2009..............

2. Dr. H.K. Kiara (B.V.M., M.Sc., Ph.D.)

   Signature..Date 11th February 2009..............

3. Dr. P.M. Kitala (B.V.M., M.Sc., Ph.D.)

   Signature..Date 11/02/09..............

DEDICATION

To my beloved wife Sarah and our wonderful children Timothy and Iryn,
For their prayers and patience during the challenging moments of this study

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ACRONYMS

AAU	Association of African Universities
AEZ	Agro-Ecological zone
ASAL	Arid and Semi Arid Lands
ASL	Above Sea Level
CAHW	Community Animal Health Worker
CBPP	Contagious Bovine Pleuro-Pneumonia
DDP	District Development Plan
DVO	District Veterinary Officer
ECF	East Coast fever
ELISA	Enzyme-Linked Immuno-sorbent Assay
EVK	Existing Veterinary Knowledge
EWS	Early Warning System
FAO	Food and Agricultural Organization of the United Nation
IFAT	Indirect Fluorescent Antibody test
IFAD	International Fund for Agriculture Development
ICTTBD	Integrated Control of Ticks and Tick Borne Diseases
ILRI	International Livestock Research Institute
ITM	Infection and Treatment Method
KARI	Kenya Agricultural Research Institute
LSD	Lumpy skin disease
PA	Participatory Appraisal
PCR	Polymerase Chain Reaction
PE	Participatory Epidemiology
RA	Rapid Appraisal
SSI	Semi-Structured Interview
TBD	Tick-Borne Disease
VBD	Vector-borne Disease

ABSTRACT

A participatory epidemiological study was conducted among the Pokot and Tugen communities in Northern Rift Valley, Kenya, to assess the status of tick-borne infections and obtain livestock keepers' perceptions of how the diseases impact on livelihoods in pastoral and agro-pastoral production systems. In addition a serological survey was carried out to assess antibody prevalence of priority vector-borne diseases namely ECF, Anaplasmosis and Babesiosis, as perceived by the livestock keepers and serum samples were collected from 190 animals of all age groups. Only calves over 4 months of age were sampled to avoid confusion with passively transferred colostral antibodies. Thick and thin blood smears were prepared from the marginal ear vein of all the animals bled. Lymph node biopsy smears were also collected from animals suspected to be sick based on symptoms of disease for microscopic examination. Whole body tick counts were carried out on cattle selected for sampling and tick samples were collected for identification and assessment of infection prevalence.

The choice of these communities to participate in the exercise was based on their economic dependence on livestock, cultural beliefs and practices and the nature of their ecological setting, typical for pastoral and agro-pastoral production systems. The objectives of the study were 1) to study the pattern of East Coast fever and the distribution of the vector tick in pastoral areas of the Northern Rift Valley; 2) to estimate the incidence and mortality of ECF and other important vector-borne diseases; 3) to estimate the sero-prevalence of East Coast fever and other vector-borne diseases; and 4)

to assess factors influencing the sero-prevalence of ECF and other vector-borne diseases and control practices by the pastoral livestock keepers.

The study was conducted in 22 Pokot and 22 Tugen manyattas/villages in different sub-locations that were purposely selected on the basis of accessibility and security. Group discussions and Key-informant interviews were organised through the local leaders while others were held without prior arrangement. Some of the data collection methods used included, proportional piling, seasonal calendars, participatory mapping, disease impact matrix scoring and focused group discussions alongside key informant interviews. Semi structured interviews were used for probing and clarification of results from the exercises. A total of 658 livestock keepers were interviewed in 22 village meetings each in West Pokot and Baringo districts over a period of two months. Eleven of the villages were predominantly pastoral (where 175 livestock keepers were interviewed), while the remaining 483 livestock keepers were interviewed in 33 villages in agro-pastoral production system.

The most important livelihood sources were reported to be livestock keeping, crop farming, small scale business and bee keeping. Households in both communities depended largely on livestock as the major source of livelihood. The enterprise was ranked as a priority in both study districts by 95.5 %; 21/22 and 90.9%; 20/22 of the groups in West Pokot and Baringo districts respectively. The main species of livestock kept were cattle, goats, sheep and poultry in order of preference. Donkeys and camels were ranked fifth and sixth positions in importance respectively. Crop farming was ranked as the second most important livelihood activity after livestock by both communities mainly as a supplement of household economy.

All the households in pastoral divisions kept the zebu cattle as their main breed. On the other hand, 83.9% of the households in agro-pastoral divisions had zebu crossbreds while the remaining 16.1% kept pure-bred zebu. Grazing was purely on communal pasture in pastoral divisions whereas in agro-pastoral areas, grazing was mainly in individual land holdings (85.7% of the respondents) with communal grazing being practiced by only 14.3% of the respondents. In both production systems, water for livestock was mainly from streams and rivers (for 80.1% of the herds) with the remaining 19.9% getting water from other sources including communal boreholes, dams and piped water sources. More than 85% of the households in both systems practiced tick control with frequencies varying from weekly regimes to only at the sight of ticks on animals

Major constraints affecting livestock keeping were reportedly livestock diseases, shortage of feed, lack of water/distant watering points, insecurity, wildlife menace and poor markets. Livestock diseases were ranked as the main constraint in pastoral areas whereas shortage of animal feed was considered to be of major importance in agro-pastoral areas. Vector-borne diseases particularly tick-borne (ECF and heartwater) and trypanosomosis (transmitted by tsetse flies) were the main examples of diseases noted to seriously limit livestock production in these areas. East Coast fever was scored as the most important disease across the study areas based on the results from proportional piling. The disease was given the highest relative mean score of 42.2 by all the groups in pastoral areas and 47.4 by 92% of the groups in agro-pastoral areas). This was followed by trypanosomosis with a relative mean score of 23.8 and 25.5 by 80% and 92% of groups in pastoral and agro-pastoral areas, respectively. Mean Incidence of ECF was higher in calves up to 2 years and was estimated at 37.9% compared to 17.7% and 19.4% for weaners and adults respectively. Mortality due to ECF was 23% for calves and approximately 10% for both adults and weaners.

Results from various group discussions demonstrated good agreement among informants with Kendalls' coefficient of concordance (W) values ranging between 0.43 and 0.60 ($p < 0.05$ – $p < 0.01$). In all the groups, impact of ECF was found to be the highest. Ticks were perceived to be present in high numbers during the wet season and the inter-phase. Equally, high cattle losses resulting from ECF were reported to occur during the wet season. This underscored the role seasons, which may be the source of tick infestation and subsequent disease outbreaks.

The sero-prevalence for *T.parva A. marginale* and *B. bigemina* determined by ELISA were 25.8, 53.2 and 53.7, respectively. The prevalence estimates for *A. marginale* and *B.bigemina* were significantly higher in pastoral than agro-pastoral production systems ($p = 0.002$ and 0.001 respectively). They were also significantly different in cattle grazed in communal pastures and those in private paddocks ($p = 0.001$). However, no significant difference was observed for antibody prevalence for *T. parva* between the two grazing management systems.

There was evidence from the study that herd disease control was mostly in the hands of livestock keepers and majority (67%) of them carried out animal drug administration on their own with very few of them seeking expert consultation.

Based on the findings from this study and given the role played by livestock to livelihoods in these areas, the economic importance of ECF and other TBDs and the livestock keepers' knowledge of the diseases, there is need for stakeholders in the livestock industry, to reconsider developing control options that are supportive of the production systems. This calls for the establishment and/or strengthening of their collaborative network in an effort to come up with alternative control strategies of ECF and other VBDs including the option of immunization, Integrated Control of Ticks and Tick-borne Diseases (ICTTBD) and introducing mobile veterinary clinics with the aim of developing better ways of delivering the technologies to the marginalised pastoral communities.

CHAPTER ONE: INTRODUCTION

In Kenya, arid and semi-arid lands (ASALs) cover an area of about 466,000 km^2 and account for more than 70% of the country's total land area with a population of about 5.8 million people (Government of Kenya, 2003). Low, erratic and unpredictable rainfall that varies in time and space characterise these areas. Annual rainfall ranges between 125 to 500 mm in the arid districts, and between 400 to 1250 mm in the semi-arid districts (Jaetzold and Schmidt, 1983). Many of the districts in Rift Valley Province are classified as ASAL and are predominantly occupied by pastoral and agro-pastoral groups whose economic mainstay is livestock production. Currently, the ASALs account for 50% of Kenya's livestock, 3% of agricultural output, and 7% of commercial output (Aboud *et al.*, 2004).

Livestock production in the ASALs is often the only livelihood activity of the rural poor. Besides its intrinsic value, livestock provides a stream of food and income and it is the only option for food security. Despite its importance, livestock production and ownership in these areas is at risk from a variety of constraints including a range of animal diseases, poor husbandry practices, inadequate nutrition and lack of reliable markets for livestock and their products. Animal diseases play a major role in limiting livestock production resulting in increased morbidity and mortality rates and directly or indirectly affecting productivity. Among the important diseases of cattle, tick-borne diseases (TBDs) are a major constraint especially in the areas where cattle are kept under the open grazing, a system known to increase the spread of ticks among cattle herds (Rubaire Akiiki *et al.*, 2004).

Ticks are responsible for losses caused by their direct effects on animal hides and skins, injection of toxins, and/or by the transmission of diseases that cause substantial mortalities, loss of production in sick and recovering cattle, high cost of control measures and exclusion of improved breeds from endemic areas (Young *et al.,* 1988; Mbassa *et a*l., 1994).

Of the tick-borne diseases, theileriosis (East Coast fever), anaplasmosis, babesiosis and cowdriosis are the most important and widespread (Otim, 2000). East Coast fever (ECF), the main focus of this study, is caused by *Theileria parva* and transmitted trans-stadially by the brown ear tick *Rhipicephalus appendiculatus*. The disease is the major cause of calf deaths among East African indigenous cattle, with mortality rates of 40–80% reported in Maasai pastoralist herds (Homewood *et a*l., 1987; Di Giulio *et al*., 2003) and thus, threatens livestock farming in this production system.

In Kenya, out of the estimated 13.5 million heads of cattle, 52.8% of the population is found in *R. appendiculatus* infested areas and up to 80% are thought to be at risk of contracting ECF (Dolan and Young, 1981). Poor understanding of the dynamics of ECF has resulted in poor disease management policies among the pastoralists and low reporting of the disease to the animal health service providers during outbreaks. There is evidence that the disease is increasing in importance. For instance, the Pokot have reported it as a relatively new disease which occasionally overshadows the major trans-boundary livestock diseases, including Rinderpest and other epidemic animal diseases (Contagious Bovine Pleuro-pneumonia, Foot-and-Mouth Disease, Rift Valley Fever, and Lumpy Skin Disease) (Ngotho *et al*., 1999).

Knowledge of the distribution of the vector and prevalence of the disease is crucial in assessing the extent of the disease and its potential impact on production in a particular system and therefore, in planning of control strategies (Norval *et al.*, 1985; Lessard *et al.*, 1990; Gitau *et al.*, 1997; Maloo *et al.*, 2001a). This study seeks to provide better understanding of ECF, its impact at herd level and features related to transmission dynamics in traditional herds in marginal pastoral systems. The information is important in the development of improved ECF control strategies.

1.1. Overall objective

The overall objective of the study was to assess the epidemiological states of tick-borne infections in the ASAL regions of Northern Rift Valley and livestock keepers' perception of the impacts of the diseases on livelihoods in pastoral and agro-pastoral production systems.

1.2. Specific objectives

The specific objectives were:

1. To study the pattern of East Coast fever and the distribution of the vector tick in pastoral areas of Baringo and West Pokot districts of the Northern Rift Valley.
2. To estimate the incidence and mortality of East Coast fever and other important vector-borne diseases.
3. To estimate the sero-prevalence of East Coast fever and other important vector-borne diseases viz Anaplasmosis and Babesiosis.
4. To assess factors influencing the sero-prevalence of ECF and other vector-borne diseases and control practices by the pastoral livestock keepers.

1.3. Justification of the study

Tick populations in marginal areas are likely to fluctuate according to seasonal and climatic variations. These highly variable and unpredictable spatial and temporal fluctuations mean continual shifts in tick vector population densities and dynamics, and concomitant disease risk (Katherine *et al.,* 2005).

Norval and Perry (1990) have predicted the extensions of distribution of *R. appendiculatus* into dry areas during years of above average rainfall and subsequent disappearance when conditions become unfavourable. The above predictions concur with predictions by scientists at ILRI-Kenya (IFAD, 2000, Unpublished), which indicates that the vector is likely to be present in some foci which have favourable micro-climates in marginal areas. Thus, the pattern of disease occurrence is expected to be sporadic because of marginal suitability of the vector and hence interference with endemic stability. Endemic stability occurs in situations where most cattle acquire immunity to tick-borne diseases as a result of early exposure of calves to vector ticks and have few or no clinical disease manifestation (Norval *et al.*, 1992). In marginal areas, some animals have little or no chance to develop natural immunity due to this variability in vector density, distribution and disease occurrence to induce and maintain stability resulting in high mortality due to *T. parva* infection (Norval *et al.*, 1992; Perry and Young, 1995; Billiouw *et al.*, 1999; Gitau *et al.,* 2000).

The districts of Isiolo, Samburu, Laikipia, Baringo, Marakwet, West Pokot and Turkana fall within the northern limits of the distribution of *R. appendiculatus* in Kenya (IFAD, 2000). Although the region is on the margins of the habitats suitable for ticks, ECF outbreak occur, probably related to communal grazing systems and mixing of the herds during migrations in search of animal feed and water during periods of drought.

Currently, there is a desire to control ECF in Kenya and other East and Central African countries using the infection-and-treatment method (ITM) of immunization. This has arisen from the failure of current control method of intensive acaricide application due to, among other reasons, high cost, lack of infrastructure and development of resistance by ticks to the chemicals (Perry and Young, 1995). There are also efforts to develop recombinant vaccines against ECF. These types of studies are necessary to provide epidemiological data for pastoral production systems in the ASAL on which to base recommendations for appropriate strategies for controlling TBDs. Currently, this information is scanty or unavailable and therefore, any proposed control methods based on this information are unlikely to succeed.

CHAPTER TWO: LITERATURE REVIEW

2.1. History of East Coast fever

East Coast Fever was not recognized before 1901 according to early classical writings (Young *et al.*, 1981). It is thought that *T. parva* evolved with the African buffalo *(Syncerus caffer)* in East Africa and became adapted to successive groups of cattle introduced into Eastern Africa (Irvin *et al.*, 1981). The first recognition of theileria parasites dates back to 1898 when Richard Koch recorded the parasite in blood of cattle while investigating the disease in East Africa. On the strength of it, Stephens and Christophers (1903) proposed the name *Piroplasma Kochi*, a name which perhaps unfairly was superseded by Theiler's *Piroplasma parvum* (Theiler,1904), and subsequently changed to *Theileria parva* by Bettencourt *et al.* (1907).

East Coast fever was first reported in Kenya after 1904, in a herd of cattle brought from the Kilimanjaro area to Nairobi, but was probably present long before that date in the Lake Victoria Basin and the Coastal regions (Norval *et al.*, 1992). The disease broke out in Uasin Gishu District after the First World War probably due to the introduction of susceptible European cattle and movement of indigenous cattle from 'native reserve' areas such as Nandi and Elgeyo - Marakwet districts which were endemic to ECF (Kyule, 1989 and Mining, 1992. Other reports indicate that the occurrence and spread of theileriosis to other parts of Kenya very much reflected the dynamics of colonization by European settlers at the time by moving cattle from disease - free areas into endemic areas. In Central Kenya (Machakos, Kitui, Kiambu and Naivasha) for example, cases of theileriosis increased as ox-transport became a popular mode of transport between 1901 and 1910 (Anon, 1910). In various parts of the country, ECF severely thwarted the early development of beef and dairy ranches, the object of many early settlers. Huxley (1935), in her biography of Lord Delamere, states that he lost nearly all of his young stock raised on the farm to ECF and was forced out of Elementaita area to further down the Rift Valley (Norval *et al.,* 1992).

2.2. Species of *Theileria*

A number of theileria species that infect cattle have been recognized in Africa including *T. parva, T. annulata, T. mutans, T. taurotragi and T. velifera* (Norval *et al.,* 1992). The speciation of *T. parva* has been a 'maze of synonyms and hamonyms' (Dolan, 1989). It was proposed a sub-speciation of *T. parva* into *T. parva parva* for parasites causing classical ECF, *T. parva bovis* for those causing January disease in Zimbabwe and *T. parva lawrencei* for those causing Corridor disease (Lawrence, 1979; Uilenberg *et al.*, 1982). This trinomial nomenclature was based on the distinct forms of theileriosis and was adopted for convenience rather than taxonomic reasons (Uilenberg, 1981). It was based on the fact that the three diseases could be differentiated by their distinct clinical syndromes and therefore assumed they were caused by sub-species of the parasite. Thus the type of classification of *T. parva* had no biological validity and has since been abandoned (Anon, 1989). The three parasites cannot be distinguished morphologically or serologically and have the same field vector (Conrad *et al.,* 1987). It was recommended *that T. parva* be described based on their host species of origin as either cattle or buffalo derived parasites (Anon, 1989). This system of nomenclature will be adopted in this study.

2.3. Geographical distribution of East Coast fever

The distribution of East Coast fever is restricted to parts of the African continent suitable for the main field vector, *R. appendiculatus.* The vector is found at altitudes ranging from just above sea level to 2000 m, with annual total rainfall between 500 and 2000 mm (Walker *et al.,* 2000). The disease has been reported in Burundi, Kenya, Malawi, Mozambique, Rwanda, Sudan, Tanzania, Uganda, Zaire, Zambia and Zimbabwe (Norval *et al.*, 1992; Walker *et al.*, 2000). However, its impact varies considerably within these countries due to differing virulence of *Theileria parva* strains, differences in abundance and infectivity of the vector tick, presence of other tick vectors and differences in susceptibility to the tick and the parasite of the cattle breeds and types present. Mathematical models have been applied to map out the potential distribution of the tick vector for ECF and to study the epidemiology of the disease (Perry *et al.,* 1990; Lessard *et al.,* 1990). Perry *et al.* (1990) applied the climate matching model (CLIMEX) (Sutherst and Maywald, 1985) to map the likely environmental suitability of *R. appendiculatus* based on climatic factors.

Studies in Kenya have demonstrated that the prevalence of *T. parva* infections and the reported ECF morbidity, mortality and case-fatality can vary significantly by zones and grazing system and the highest tick challenge is recorded in the lowland zones, followed by midland and upland zones (Perry and Young, 1995; Deem *et al,.* 1993; Gitau *et al.,* 1997; O'Callaghan, 1998; Gitau *et al.*, 2000). Climatically, the lowlands are more suitable for *R. appendiculatus* than the midlands and uplands (Mathysse and Colbo, 1987) (Figure 2.1). The distribution of the vector tick *R. appendiculatus* correlates closely with the highest concentration of both indigenous and exotic cattle (Kariuki, 1988). These differences have important implications for both the impact and control of ECF.

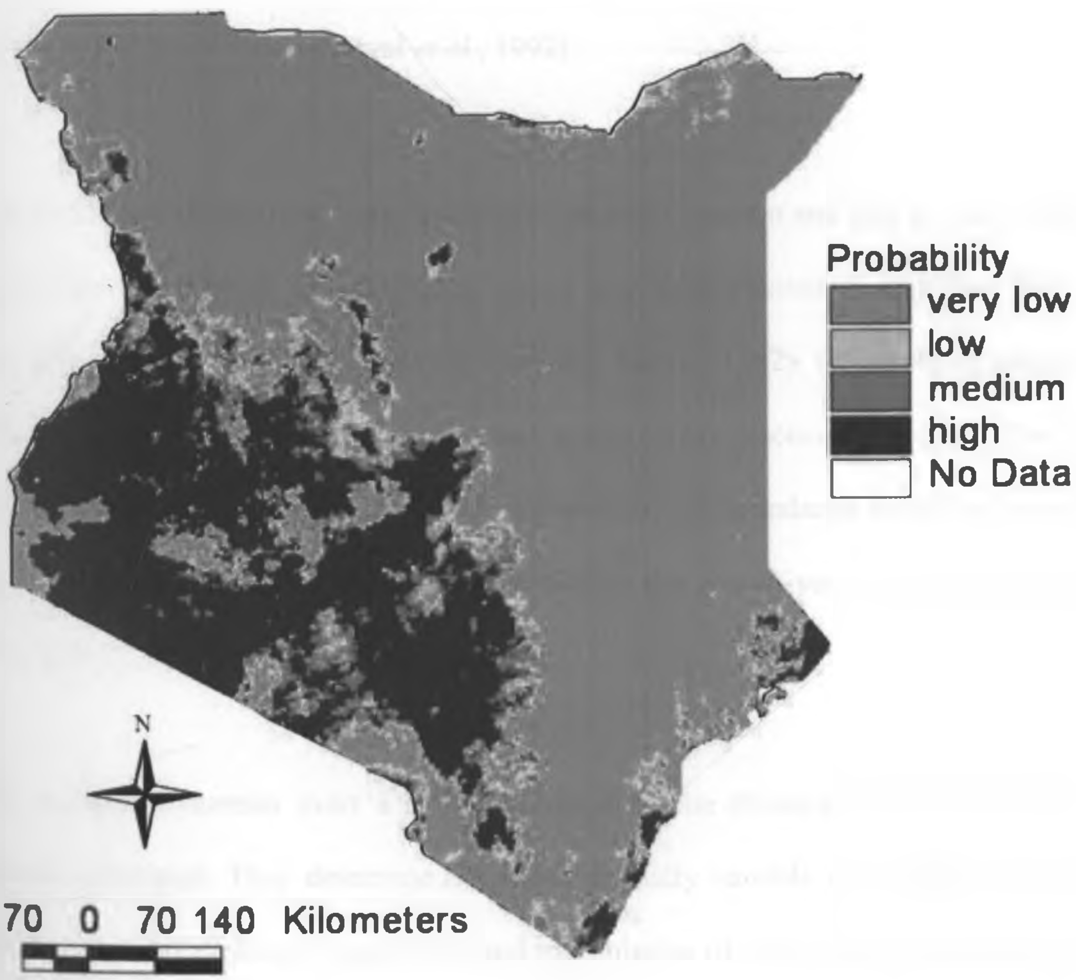


Figure 2.1: Map showing East Coast fever risk areas in Kenya.

Source; Avia–GIS Consulting Series R&D, 2003 - 2004

2.4. Epidemiologic patterns of East Coast fever

2.4.1. Vector dynamics

The survival of a population of ticks depends on the presence of hosts suitable for feeding by adults. These hosts are limited in variety than the hosts on which larvae and nymphs of three-host-ticks can survive. A population model for the tick has been developed for explanations of spatial variation in the risk of infection (Medley *et al.*, 1993). Adult tick activity invariably peaks during the wet seasons and is associated with the highest ECF incidence (Norval *et al.*, 1992).

Tick abundance is known to vary temporally (season to season and year to year) and by space (between habitats and ecological zones) due to interaction of numerous factors, such as host diversity and climate (Lightfoot and Norval, 1982), the levels of resistance of hosts, presence of control measures and management practices that affect the host behaviour (Punyua and Hassan, 1992). Fluctuations in tick abundance as well as temporal patterns of *T. parva* transmission are influenced by the year-to-year variation in rainfall (Norval *et al.*, 1992; Billiouw *et al.*, 1999).

Tick seasonal dynamics exert a major influence on the dynamics of transmission of theileria pathogens. They determine not only seasonally variable vector-host ratios, but also the time-delay between acquisition and transmission of pathogens by successive tick life-stages, which have a significant impact on the transmission potential through its effect on vector survival probabilities (Randolph and Rogers, 1997). Ticks can remain infected on the pasture for up to 2 years depending on the climatic conditions and the stage of development. Adults survive longer than nymphs and larvae (Norval *et al.*, 1992). The spread of the infection is mainly through cattle movement, such as migration in search of pasture and water, vaccination campaigns and use of communal cattle dips which is a characteristic of the pastoral communities in marginal areas (Billiouw *et al.*, 1999).

2.4.2. Host dynamics

The primary host of *T. parva* is the African buffalo (*Syncercus caffer*) in which the parasite typically does not cause any disease but acts as reservoir of *T. parva* infection. *Theileria parva* exhibits a very narrow tick and mammalian host range, and there is no laboratory animal model susceptible to infection with the parasite (Bishop *et al.,* 2004). The Indian water buffalo (*Bulbalis bulbalis*) is as susceptible to *T. parva* infection as cattle. It has been proved that water bucks (*Kobus* spp.) are also reservoirs (Norval *et al.*, 1992). Organisms isolated from African buffalo, on repeated passage in cattle, result in a parasite that produces disease characteristics indistinguishable from those associated with classical ECF (Norval *et al.*, 1992). Hence, the organism causing ECF is assumed to be a cattle-adapted form of the buffalo parasite causing Corridor disease in cattle.

Intermingling of cattle with wild African buffalo in the presence of *R. appendiculatus* ticks often leads to outbreaks of buffalo-derived *T. parva* in cattle and high mortality rate (Norval *et al.,* 1985, Urquhart *et al.,* 1996). Indigenous cattle such as the Small East African Zebu reared in ECF endemic areas of tropical Africa are known to show a high degree of resistance and exhibit some tolerance to *T. parva* infection (Norval *et al.*, 1992, Latif *et al.,* 1995). Introduced cattle, whether of a taurine, Zebu, or Sanga breeds, are much more susceptible to theileriosis and often suffer high mortality, irrespective of age or breed, unless rigid vector control is observed (Jain, 1993).

2.4.3. Transmission of East Coast fever

Rhipicephalus appendiculatus is the main field vector of ECF in East Africa, but in southern Africa other field vectors such as *R. zambeziensis* in drier areas of southern Africa and *R. duttoni* in Angola transmit the disease (Bishop *et al*., 2004). East Coast fever is not maintained in the absence of these field vectors. Transmission is trans-stadial, in that larval or nymphal instars of the tick acquire infections from a blood-meal, and then transmit to a new host, after moulting. Nymphal instars feeding shortly after moulting have a better vectorial competence than older ticks (Billiouw *et al.,* 1999). Clinical cases are the main source of infection, with the carrier population merely acting as a reservoir of the infectious parasite (Billiouw *et al*., 2002). Trans-ovarial transmission of theileria has not been proved, unlike the related protozoan *Babesia* transmitted by the one host tick *Boophilus* (Norval *et al.,* 1992).

The transmission dynamics and epidemiology of ECF vary in different areas of eastern, central and southern Africa, according to a complex interplay of factors, including the level of tick control, cattle genotype, management regimes, proximity of a wildlife reservoir of disease and the interaction of tick and parasite populations with differing genetic composition. Normally, for transmission to occur, infected ticks need to feed for several days to enable sporozoites to mature and be emitted through the saliva of the feeding tick (Short and Norval, 1981). Transmission of the infection by the tick does not usually begin until 2 days after attachment to the host (Young and Leitch, 1981). However, Young *et al.* (1979; 1984; 1987) and Ochanda *et al.* (1988) have shown that exposure of adult *R. appendiculatus* to high temperatures (26°C and 37°C) prior to feeding stimulates the maturation of *T. parva* parasites in the salivary glands to mature sporozoites. The authors conclude that adult ticks exposed to high temperatures in the field transmit infection to cattle more rapidly than would otherwise occur. This might reduce the efficiency of acaricide control of ECF and should be considered in the design of control strategies and the selection of acaricides in marginal areas in which the disease occurs.

2.5. Economic impact of East Coast fever

East Coast fever remains one of the most important cattle diseases in terms of economic losses estimated at US$ 168 million in 1989 (Mukhebi *et al.*, 1992) and restriction of livestock development in eastern, central and southern Africa (Norval *et al.,* 1992). The disease causes up to a million deaths annually in Kenya, Tanzania and Uganda. Mortality approaches 100% in taurine cattle and crossbreds of taurine and indigenous cattle developed for improved productivity (Morzaria *et al.,* 1988). In contrast, mortality in indigenous cattle in endemic areas can be low, although calf growth is severely impaired during the course of the disease and over the recovery period (Moll *et al.,* 1984). Loss of an animal or reduction of its productivity can, in turn, affect more than one type of capital asset (Minjau and McLeod, 2003).

The cost of tick control programmes and treatment of clinical cases is a major burden to the farmer and the country's economy. In Kenya, annual costs of controlling ticks vary from Kenya Shillings (Kshs. 40 to Kshs. 170 per animal (Mukhebi *et al.,* 1992). Onchoke (1993) estimated that the loss due to ECF (morbidity, mortality, etc.) was approximately Kenya shillings (Ksh.) 1.1 billion in Uasin Gishu District, Kenya in 1992.

Although direct and indirect losses attributed to ECF are one of the main sources of economic losses in cattle, very little information is available to accurately quantify the actual losses. Other studies show that the losses due to ECF could be substantial although the methods used assume uniform distribution of the disease in a region and also rely on passively derived data. A study done in Kenya highlands (O'Callaghan *et al.,* 1998) indicated that high production losses due to ECF are not universal but vary by agro-ecological zones (AEZs), grazing system and other factors. This requires refining of TBD control programmes based on good epidemiological data in priority (target) production systems.

2.6. Diagnosis of East Coast fever

2.6.1. Clinical signs and pathological findings

The main clinical findings include fever, enlarged superficial lymph nodes, depression and anorexia. In later stages, there is nasal and ocular discharge, coughing, dyspnoea due to pulmonary oedema and diarrhoea with bloody faeces occur (Bruce *et al.*, 1910; Shannon, 1977; Omuse, 1978; Kiptoon *et al.,* 1983; Norval *et al.*, 1992; Kambarage, 1995; Maloo *et al.*, 2001a; Radostitts *et al.*, 2000; Magona, 2004). Emaciation, weakness and recumbence are observed in 7 to 10 days of infection and may lead to death (Radostitts *et al.*, 2000). A nervous form of the disease, known as cerebral theileriosis, may also develop in cattle (Van Rensburg, 1976; van Amstel, 1982; Saville, 2002) and is characterized by ataxia, depression, circling, head pressing, profuse salivation, hyperaesthesia, blindness, nystagmus, proprioceptive deficits and aggressiveness. Observation of mucus membranes of animals affected by ECF reveals numerous echymotic and pin point petechial hemorrhages in older animals. On the other hand, there are fewer echimotic hemorrhages in calves (Kiptoon *et al.,* 1983).

When the disease is fatal, the animal becomes recumbent and develops opisthotonus, tonic clonic seizures and coma (Saville, 2002). In susceptible animals and in epidemic situations, mortality levels may reach 90%. Post-mortem lesions observed are pulmonary oedema, splenic enlargement, and froth in the trachea, lymph node enlargement, haemorrhages in internal organs, abomasal erosions and the presence of parasitized lymphocytes and lympho-proliferative infiltrations in visceral tissues. Animals that recover remain carriers, but have a strong immunity to homologous challenge.

2.6.2. Diagnostic procedures

The diagnosis of ECF is usually based on the epidemiology of the disease, clinical signs and demonstration of piroplasms and multinuclear micro and macro-schizonts in blood and lymph node biopsy smears, respectively (Morrison and McKeever, 1998). However, the use of clinical diagnosis alone may not be a true indicator of ECF, particularly in ECF-endemic areas in which the detection of parasites not only indicates an active infection but may also indicate either a slow proliferation of macro-schizont-infected lymphocytes or a carrier state of the animal (Maritim *et al.,* 1998). In addition, it is also difficult in case of mixed infections with other tick-borne diseases (Norval *et al.,* 1992). Body temperature monitoring in animals whose body temperature is above 39.5°C and preparation of lymph node biopsies and blood smears has been recommended as a useful method for early detection of ECF and prompt treatment in an outbreak situation (Minjau *et al.*, 1998).

A number of serological tests are available for diagnosis of *Theileria* species. The indirect fluorescent antibody test (IFA) is the most widely used test for detection of both schizont and piroplasm antibodies in serum of infected animals (Goddeeris *et al.,* 1982). The IFA test is sensitive, fairly specific, and usually easy to perform. However, because of the problems of cross-reactivity among some *Theileria* species, the test has limitations for large-scale surveys in areas where these species overlap. An enzyme–linked immunosorbent assay (ELISA), using recombinant polymorphic immunodominant molecule isolated from *T. parva* (Toye *et al.,* 1996), has demonstrated sensitivity and specificity of between 94% and 98% using experimental and field data (Katende *et al.,* 1998). In addition, molecular diagnostic tests, particularly those based on the polymerase chain reaction (PCR) and reverse line blot hybridisation, are proving to be powerful tools for characterising parasite polymorphisms, defining population genetics and generating epidemiological data. The PCR has been useful in the diagnosis of ECF, because of its greater sensitivity and specificity over conventional techniques (Bishop *et al.*, 1992). The PCR technique using primers from *T. parva* Tpr repetitive sequences has been used successfully for detection and characterization of *Theileria* parasites of several stocks in blood of carrier cattle (Bishop *et al,* 1992) and in the quantification and identification of parasite stocks in blood and tick vectors for epidemiological diagnosis (Stiller, 1992; Watt *et al.,* 1998)

2.7. Control of East Coast fever

2.7.1. Chemotherapy

Early attempts in chemotherapy of ECF, centered on the use of tetracyclines (Neits, 1953; Brocklesby and Bailey, 1962). These have suppressive effect on early schizogony in cattle which have been found useful in the 'Infection and Treatment Method' of immunization (ITM) but of limited value in treatment of clinical cases. The first compound shown to be effective in curing ECF was the hydroxynaphthoquinone menoctone (McHardy *et al.,* 1976) but its commercial use was impossible on account of difficult manufacture and therefore prohibitively high cost and toxicity. Synthesis of a large number of other hydroxynaphthoquinones (Boehm *et al.,* 1981) produced the simpler compound parvaquone marketed as Clexon™ Its ability to cure ECF was demonstrated by McHardy (1979). A third hydroxynaphthoquinone, buparvaquone marketed as Butalex™ (Schering-Plough Animal Health) was curative at lower dosages than parvaquone in a comparative study in cattle artificially infected with *T. parva.* There are currently three effective drugs for the treatment of ECF: parvaquone (Clexon), buparvaquone (Butalex), and halofuginone lactate (Terit). Each of these drugs has been introduced to the market within the last 15 years (Norval *et al.*, 1992)

Clinical cases of theileriosis need to be promptly identified because, to be effective, treatment must be applied early in the course of the disease (Dolan *et al.*, 1984; Chema *et al.*, 1986). Higher cure rates are achieved if treatment is carried out early enough to limit the development of the schizont stage of the parasite and subsequent damage to the immune system. Late diagnosis of ECF has been associated with poor success rates for all treatments and regimes (Norval *et al,* 1992).

2.7.2. Vector control

Vector control is based on the intensive use of acaricides to control the vector, *R. appendiculatus,* by preventing contact with hosts. The acaricide breaks the life cycle and reduces vector population through killing of the vector. In pastoral production systems, this has been made possible through the use of plunge dips, hand spraying and pour-on formulations as common methods of acaricide application. The method has proved effective and affordable by resource poor farmers in the case of communal plunge dips. The major disadvantage of this otherwise effective control method is the ability of ticks to develop resistance to acaricides influenced in part by lack of strict and effective monitoring strategy leading to inadequate concentration of acaricide in dips and hand-sprays (FAO, 1984). Furthermore, since the government withdrawal from maintaining the supply of acaricides in communal dips, they have been characterized by irregular application of acaricides in dip tanks. Other limitations include high costs of acaricides (Kariuki, 1990) and concerns relating to the contamination of the environment (Mbogo *et al.*, 1996).

2.7.3. Immunization

The drawbacks in the above control strategies have resulted in attempts to develop alternative methods of ECF control. Currently, immunization by the ITM described by Radley *et al* (1975) is the only effective method of conferring immunity to cattle herds. The approach is based on the inoculation of cattle with a potentially lethal dose of cryo-preserved *Theileria* parasites and simultaneously treating them with a therapeutic dose of long-acting oxytetracyclines to control the division of the schizonts and their host cells to minimize the clinical response. The procedure is reported to be feasible and viable (Mukhebi *et al.,* 1992) and widely applied in East and Central Africa (Musisi *et al.,* 1994; Musisi and Lawrence, 1995; Mbassa and Silayo, 1995). Its recent introduction in limited pastoral areas has seen a drastic reduction in calf mortality and is likely to enhance endemic stability (Uilenberg, 1999). Current Research by scientists at ILRI is focused on developing a prototype vaccine for ECF that is based on the major surface protein of the infective sporozoite stage of the parasite (Bishop *et al*, 2003)

Over the years, a number of well-characterised *T. parva* stocks have been identified as candidate immunizing stocks. The Serengeti-transformed, Kiambu 5, and Muguga stocks have been combined to produce a mixture referred to as the 'Muguga cocktail' (MC) that provides wide protection and has been used effectively in Tanzania, Uganda, Zambia, Malawi and recently in Kenya (Minjau and McLeod, 2003). The ITM used to be very costly in the sense that there were costs involved in monitoring immunized cattle, purchase of long-acting tetracyclines and drugs used to treat reactors following immunization and the maintenance of a cold-chain delivery system, which is not always available in pastoral production systems. Recently, these costs have been reduced by adopting the use of higher dose of oxy-tetracycline which has virtually eliminated reactors (Di Giulio *et al.*, 2003) Thus, good epidemiological data on ECF in these areas and control strategies integrated in the production system remains the most favourable choice for the future.

2.7.4. Integrated Control of Ticks and Tick Borne diseases

The concept of Integrated Control of Ticks and Tick Borne Diseases (ICTTBD) include methods directed towards both parasite and vector control. The ICTTBD knowledge utilizes a combination of complementary methods that are sustainable and economically viable, rather than a single method (De Castro, 1997). The objective is to minimize disease occurrence and transmission by controlling tick numbers and tick-borne diseases economically and in an environmentally sustainable manner. Available methods which could be combined for control include strategic acaricide application, use of economic threshold, biological control of ticks, quarantine and control of livestock movement, grazing management and pasture spelling, the use of host resistance to ticks and TBDs, immunization and chemotherapy (Norval *et a*l., 1992).

The most consistent feature of integrated tick control programs is a reduction in frequency of acaricide use: something that has been advocated often for indigenous cattle in smallholder systems due to the apparent poor financial return on intensive tick control (Pegram and Chizyuka, 1990; Okello-Onen et al., 1998; Mattioli *et al.*, 1998; Chamboko *et al.*, 1999). However, although these workers have concluded that current, intensive control methods are often uneconomic, there are very few published examples of long-term integrated control programs that have been implemented successfully that could support their views. A pre-requisite for successful implementation of ICTTBD is an improved understanding of TBD epidemiology and control which is the focus of this study.

2.7.5. Participatory Epidemiology

Participatory Epidemiology is an emerging field based on epidemiological techniques using participatory methods to collect epidemiological data by the widely accepted methods of rapid appraisal (RA) and participatory appraisal (PA) useful for harvesting qualitative epidemiological data within the context of community observations, existing veterinary knowledge and traditional oral history and enables the community to describe disease syndromes in their own definitions using the local language and knowledge of local perceptions of disease patterns and causal associations (Catley, 1999; 2005). This, together with the use of simple diagrams and every-day objects to represent disease symptoms and risk factors, allows the active participation of informants regardless of their educational background.

The technique has been described as useful and a reliable method for encouraging farmer participation during constraint diagnostic process (Sutherland *et al.,* 1999; Catley and Irungu, 2000; Mochabo *et al.*, 2005; Eregae *et a*l., 2003; Kaitho *et al.*, 2003; Bedelian *et al.,* 2006). The approach is particularly useful in investigating animal health problems in highly mobile herds in remote and insecure pastoral settings with poor infrastructural network and high levels of illiteracy where conventional veterinary investigations and epidemiological methods are constrained by the severe operational and resource limitations (De Leew *et al.*, 1995; Catley, 1999), which characterize the study areas selected for this study.

CHAPTER THREE: MATERIALS AND METHODS

3.1. Introduction

The study was carried out between November, 2006 and January, 2007 in purposively selected divisions of Baringo and West Pokot districts in Northern Rift Valley. The original idea was to study all the districts in the region, including; Isiolo, Samburu, Laikipia, Baringo, Marakwet, West Pokot and Turkana, which fall within the northern limits of the distribution of *R. appendiculatus* but this was not possible. West Pokot and Baringo districts were selected as representative because of logistic reasons. The study districts were stratified into Upper mid-land (UM) and the lowland zones (L) based on the classification by Jaetzold and Schmidt (1983). The upper mid-land zone has settled households and is suitable for small-holder dairying. It receives average annual rainfall (700 – 950 mm). In this zone, livestock keepers have both pure-bred and cross-bred dairy cattle. The lowland zone receives low to average annual rainfall (500 - 700 mm) and is suitable for pastoral type of livestock production with indigenous breeds of cattle including the Small East African Zebu, Boran, Sahiwal and their crosses.

3.2. Characterization of the study areas

Three administrative divisions in West Pokot District (Kacheliba, Kongelai and Chepareria) and two administrative divisions in Baringo District (Salawa and Barwessa) were purposively selected for the study based on their accessibility (Figures 3.2 and 3.3). Kacheliba and Kongelai divisions were representative of the pastoral production system in the lowland while Chepareria, Salawa and Barwessa divisions provided strata of contrasting agro-pastoral livelihood in the upper mid-land zone (Appendices 1 & 2). The study was conducted in 22 Pokot and 22 Tugen villages in different sub-locations that were selected on the basis of accessibility and security. Appendix 3 indicates the number of Manyattas/villages involved in the study and a summary of the exercises conducted in the different group meetings. In West Pokot, most villages were accessible by road although some were a security risk from the Karamojong and Siabey communities for villages along the Kenya-Uganda border and those bordering the neighbouring Turkana District.

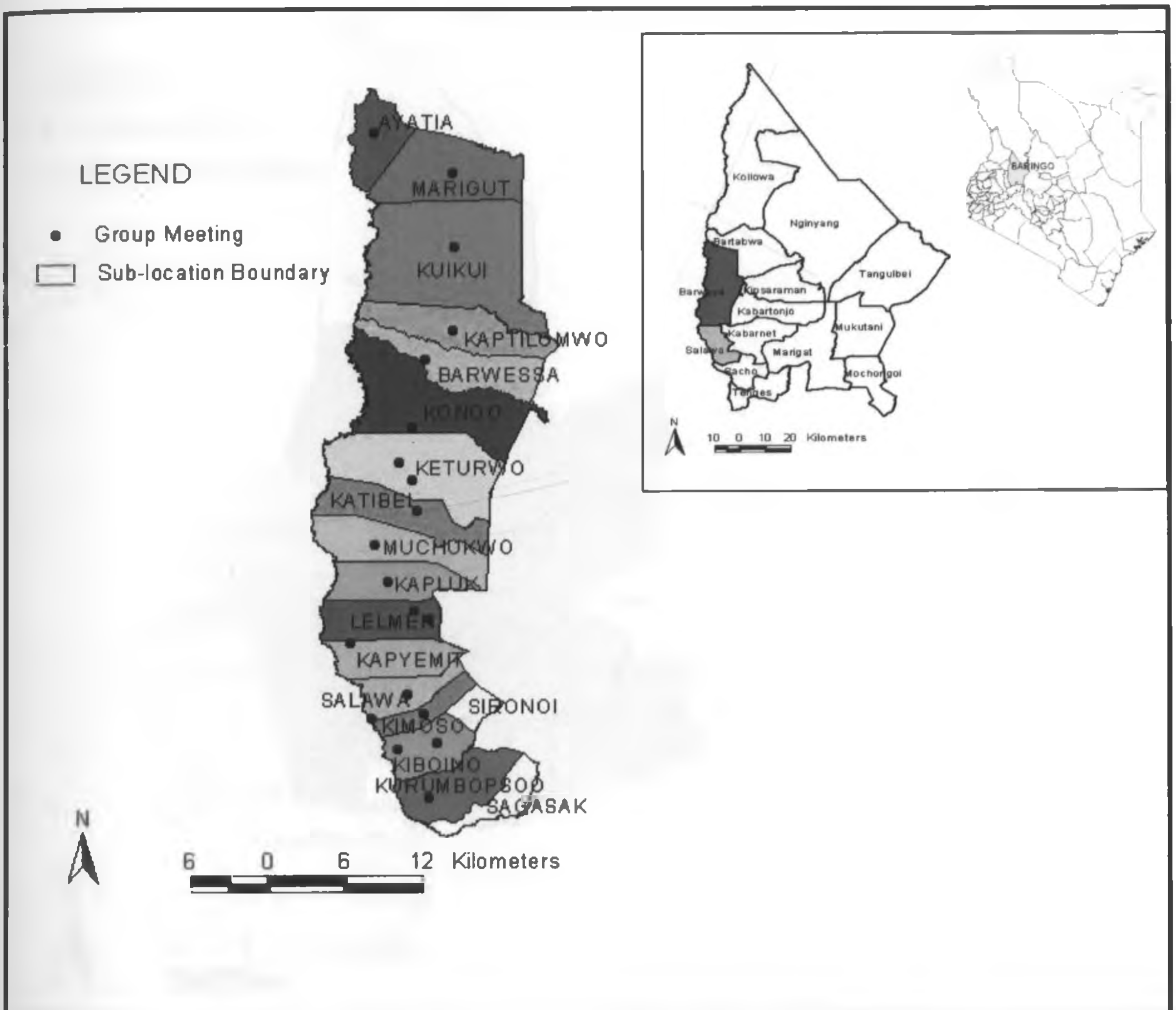


Figure 3.2: Map showing sub-locations where the group meetings were held in Salawa and Barwessa divisions of Baringo District, 2006.

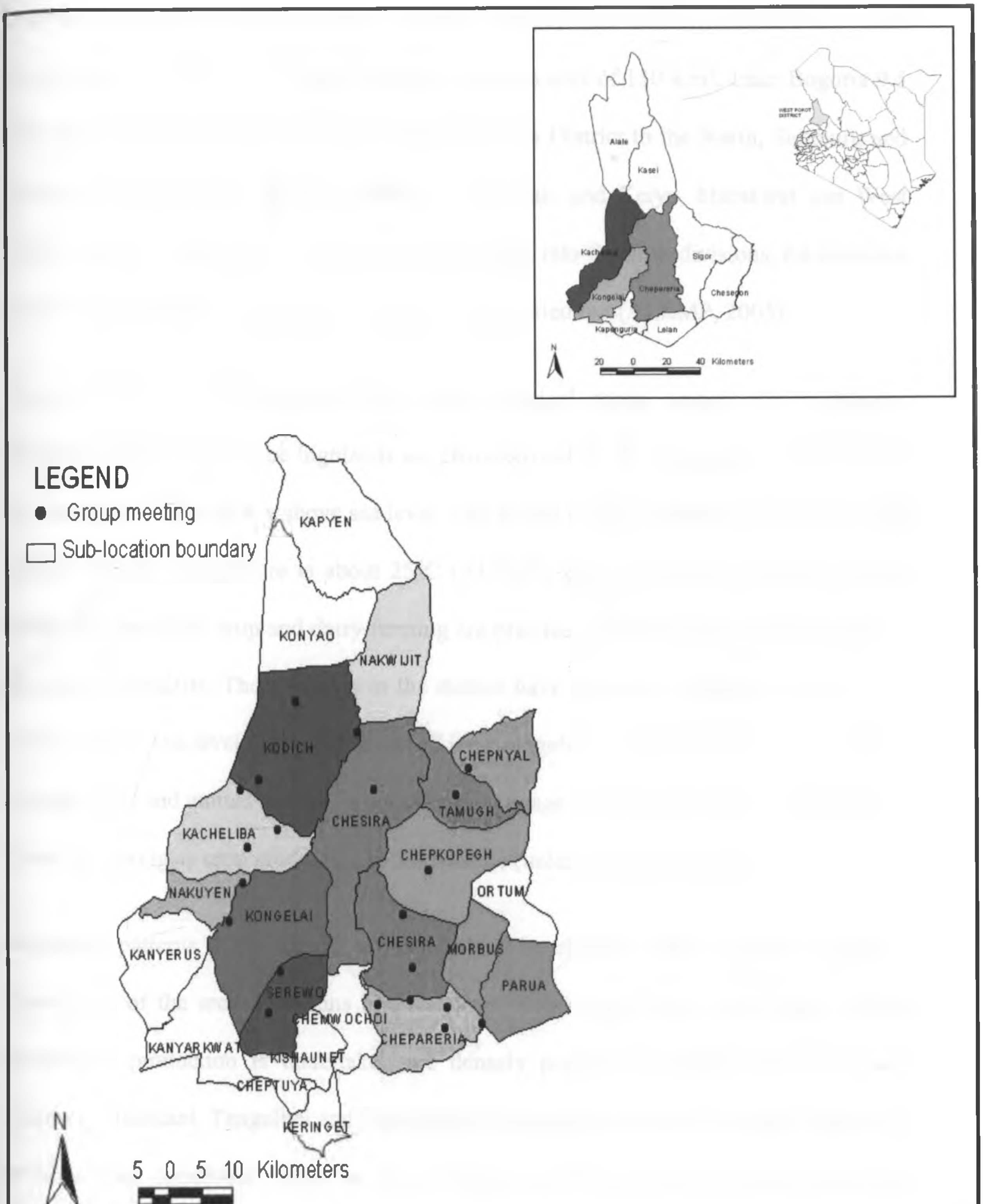


Figure 3.3: Map showing sub locations where the group meetings were held in Kacheliba, Chepareria and Kongelai divisions of West Pokot District, 2006.

3.2.1. Baringo District

Baringo District covers approximately an area of 8,655 Km^2 of which about 140.5. Km^2 is covered by water surface. Lake Baringo covers an area of 130 Km^2, Lake Bogoria 9.5 km^2 and Lake Kamnarok 1 Km^2. It borders Turkana District to the North, Samburu and Laikipia districts to the East, Koibatek to the South, and Keiyo, Marakwet and West Pokot districts to the West. The district was divided into fourteen divisions, 64 locations and 170 sub-locations at the time o the study was carried out (ALRMP, 2005).

Baringo District is divided into three agro-ecological zones, namely, the highlands, midlands and lowlands. The highlands are characterized by the Tugen hills which rise to an average of 2,000 meters above sea level. The annual average rainfall is 1,200 mm, and annual average temperature is about 25°C (ALRMP, 2005). The soils in this zone are fertile and therefore, crop and dairy farming are practised. The midlands are inhabited by the agro-pastoralists. The lowlands in the district have an average altitude of about 700 meters above sea-level (asl) and most of it is rangelands. Temperatures in this zone average 32°C and annual rainfall is 600 mm on average. The main activity in this zone is livestock rearing as crop production is not feasible (unless under irrigation).

Settlement patterns in the district are determined by climatic conditions and economic opportunity of the area. Divisions like Kabarnet, Kabartonjo, Sacho and Tenges where agricultural production is undertaken are densely populated; whereas, divisions like Kollowa, Mukutani, Tangulbei and Nginyang are sparsely populated because of the harsh environmental conditions where no crop production is feasible and the main source of livelihood is pastoralism.

3.2.2. West Pokot District

West Pokot is one of the 18 districts that form Rift Valley Province in 2006. It is situated in the North Rift and borders Uganda in the West, Trans Nzoia and Marakwet districts to the South, Baringo and Turkana districts to the east and north, respectively. The district covers an area of about 9,064 Km^2 stretching a distance of 132 Km from North to South (ALRMP, 2005). The district is divided into ten administrative divisions, 58 locations and 188 sub locations. There are three main livelihood zones in the district, with the pastoral zone supporting 45% of the total population, while the agro-pastoral and mixed farming economy zones support 29% and 26%, respectively (ALRMP, 2005).

The district has a bimodal type of rainfall. Long rains fall between April and August while the short rains fall between the month of October and February. There is, however, great variation in the amount of rainfall received in the district. The lowlands receive 600 mm while the highlands receive 1,600 mm (60% reliable) (ALRMP, 2005). The district similarly experiences great variation in temperature. Areas below 1,750 m above sea level (asl) have high temperatures ranging between 15^0C and 30^0C. The high temperature areas also experience high evaporation, which make them less favorable for production of crops. Temperature and evaporation decreases with the increase in altitude. High altitude areas above 1,750m above the sea level experience moderate temperatures and enjoy high rainfall and low evaporation. These areas are suitable for both agricultural and livestock production.

3.3. Study design

3.3.1. Introduction

The approach taken in this study was participatory epidemiology (PE) targeting livestock keepers and key informants combined with serological survey. It relies on observation, existing veterinary knowledge of traditional livestock owners notably disease symptom recognition, severity and treatment of different livestock diseases, and oral history from the local communities in combination with conventional veterinary investigation and epidemiological approaches (Thrusfield, 2005). Participatory Epidemiology is based on the principle of flexibility with the use of iterative analysis and triangulation which is the technique of cross-checking information gained from several intentionally different perspectives to build a picture of the issues under investigation (Etter *et al.* 2006).

3.3.2. Selection of study sites

A rapid appraisal (RA) in the form of an expert consultative meeting which preceded the study was held at KARI, RRC-Perkerra and attended by the veterinary personnel in the study districts as well as representatives of the departments of veterinary services. Reports on the status of ticks and tick-borne diseases, acaricide use and resistance problems in the districts were presented. Tick-borne diseases were reported as an important constraint to cattle production particularly in pastoral areas due to the migratory nature of livestock keepers which is associated with introduction of vectors to otherwise un-infected areas. Agro-ecological zones (AEZs), the major determinants of livestock production system and suitability of the tick vector, and consequently level of disease risk, were some of the criteria used in selection of study areas (O'Callaghan, 1998; Maloo et al., 2001).

3.3.3. Training of research assistants

Nine research assistants were trained by an instructor from ILRI who had experience in PE methods. The training was carried out for 5 days in order to prepare them to assist in data collection. The candidates selected were from the study districts and had at least an O-level (secondarycertificate. In addition, they were conversant with local languages, *Kalenjin* (*Tugen and Pokot*), the main dialects in the study districts. The training focused mainly on familiarization with the research topic, objectives and expected outputs, participatory epidemiological methods including proportional piling, seasonal calendars, disease impact matrix and participatory mapping. They were also trained on the development of an interview check list and the recording system for the verbal responses during the interviews. The training participants were also trained on use of geographic positioning system (GPS). Training included coding, recording and storing GPS data.

3.3.4. Evaluation of research assistants

After the inductive training, pre-testing of the PE skills learned by the research assistants was conducted in two divisions in Baringo District. The aim was to assess the ability of the trainees to apply the skills learned during the training in sourcing information from livestock keepers and familiarise themselves with the techniques of collecting, compiling and summarising of PE data. The feedback and comments from this field exposure provided the opportunity to correct mistakes encountered for better undertaking of PE exercises.

3.3.5. Participatory Epidemiology

Participatory appraisal (PA) was conducted with different groups of livestock keepers and key informants in 44 villages of the 2 districts over a period of two months. Eleven of the villages were predominantly pastoral while 33 were agro-pastoral (Appendix 3). A full list of all the villages in the study divisions were obtained from the divisional veterinary offices in the study districts for determination of the sampling frame. The interviews were conducted by the participatory appraisal teams comprising of a facilitator, a translator and a recorder. Group discussions and Key-informant interviews were organised in selected villages through the local leaders while others were held without prior arrangement. In total, 658 livestock keepers comprising of 480 men and 178 women participated in the discussions (Appendix 3).

3.3.6. Participatory appraisal tools used

The participatory appraisal tools used were adapted from the methods described by Catley and Mohammed (1996), Catley and Irungu (2000) and Catley *et al.* (2002). They included the following: proportional piling for information on livestock species owned, income and other benefits from livestock, morbidity and mortality due to ECF, as well as population/age groups at risk; Seasonal calendars provided information on seasonal variations of the disease, vectors ticks and livestock-wildlife interactions. Disease incidence scoring was used for estimation of relative morbidity and mortality due to ECF; mobility maps for understanding the grazing patterns of the herd and thus contact with neighboring herds and other possible associations as perceived by the livestock keepers;

disease impact matrix scoring for assessing impacts of the disease on livelihoods and the various control methods employed by the livestock keepers (Appendix 3).

3.3.6.1. *Semi structured interviews (SSIs)*

Semi-structured interviews (SSIs) were used at every stage of participatory appraisal exercises. The interviews were conducted in the local language (by a translator) through a guided conversation with the livestock keepers in which only topics pre-determined in a check list were discussed using open ended questions (Appendix 4). To ensure an in-depth exploration of topics in the interview process, probing was used to ask supplementary questions to clarify responses and provide a better understanding of the community perspectives and experiences on issues of interest or importance to them. They were used to generate background information regarding the main livelihood sources for livestock keepers, species of livestock kept, constraints to livestock production and detailed description of major diseases affecting cattle in the region.

3.3.6.2. *Proportional piling, ranking and scoring*

Proportional piling was used in combination with ranking and scoring exercises to generate information on livestock species kept, income and other benefits from livestock, identify important cattle diseases and estimate disease incidences as well as morbidity and mortality patterns in various cattle age groups. A simple ranking exercise was employed when discussing the general sources of livelihood, preferred livestock types/species and constraints encountered in livestock husbandry with the most salient of the above being ranked highest. The facilitators asked the livestock keepers to list important cattle diseases in the area and provide descriptions of clinical signs and post mortem findings, the local name for the disease and local views on epidemiology, treatment and control. These descriptions were used to establish the likely English translation of the disease based on the text book descriptions (Appendix 5). Sketches and cartoons of animals showing symptoms depicting the diseases listed and in some cases parasites associated with a given disease were made on pieces of cards for use as 'labels' during the exercises to confirm the disease under discussion. The drawings were done jointly by the facilitator and the livestock keepers to ensure that they understood the meaning to facilitate active participation of all members of the community without isolation in the discussion process. During the proportional piling exercise the informants were given 100 counters (beans) and asked to share those according to the importance of the diseases listed based on their severity or frequency of occurrence. The exercise was conducted in thirteen groups of 140 informants.

3.3.6.3. Disease impact matrix scoring

The method was used to score benefits derived from cattle as perceived by the livestock keepers and how the major diseases mentioned affected the benefits. The matrix scoring method was adapted from a disease scoring method in a previous participatory disease investigation (Catley and Mohammed, 1996) and involved a two stage proportional piling. The first stage required the informants to score benefits derived from cattle listed during SSIs according to the way the community values them. This was done using 100 counters. The second stage involved ranking of the effect of the various cattle diseases on the benefits by sub-dividing the scores assigned to each benefit to indicate how the diseases affected the various benefits. The exercise was conducted with a total of 155 informants in eleven groups. The matrix was constructed on the ground with sketches of animals showing the diseases placed along the x-axis and the cards with sketches of benefits placed along the y-axis of the matrix. The informants were given time to discuss and convince one another on reasons for making the scores. Probing was used to cross check the results and generate more discussions on the diseases.

3.3.6.4. Seasonal calendar

Seasonal calendars were used to describe the livestock keepers' perception of temporal variation in livestock diseases and populations of the tick vectors. First, the groups were asked to name seasons occurring in their areas and assign months when they occur in their local languages. A horizontal time line was drawn on the ground to represent a full calendar year and the informants were asked to divide it to represent the months and seasons according to their definitions. Diagrams and sketches to represent main features of the season were made on cards as previously discussed to ensure that all informants recognised seasons and major events to be used in the exercise. These features included rainfall, ECF, tick vectors and events like livestock movement and interaction with wild life. These were introduced one at a time to the calendar. The informants were given 20 counters to place in each month in a row to show the seasonal occurrence of each item under investigation. Thus the calendar was built row by row on the ground. This exercise was conducted in five groups involving 70 informants. The calendar was then 'interviewed' using open ended questions to understand the community perceptions of the association of the disease with the items under investigation.

3.3.6.5. *Participatory mapping*

Mapping was used to obtain an overview of the area from livestock keepers and information regarding their livestock movements, grazing patterns and interactions with neighboring herds, disease and vector risk areas. The sketches were made on sheets of paper with guidelines from the facilitator on features to be included in defining the map such as geographical boundaries of the community, major roads, rivers, foot paths and other major land marks. The activity was conducted as a group exercise with one of the group members responsible for providing the outline while the rest of the participants contributed details for completing the map. Participatory mapping was conducted by five groups in the study districts.

3.3.6.6. *Key informant interviews*

Key informant interviews were held with individuals with specialist knowledge of cattle diseases and other areas of livestock production. Interviews were held with the District and Divisional Veterinary Officers (DVOs) in both districts. Also at the market places, livestock traders and drug sellers were interviewed on different diseases noticed on animals brought to the markets and livestock keepers' types and reasons for buying drugs, respectively. A total of 10 key informant interviews were conducted.

3.3.7. Serological survey

In the second phase of the study, sera from cattle were collected for assessment of antibody levels. The serological survey was carried out for assessment of priority VBDs namely, ECF, Anaplasmosis and Babesiosis, as perceived by the livestock keepers. Blood samples for sera preparation were collected from randomly selected animals in herds from areas where participatory appraisal was previously held. The herds were identified through a transect walk covering a distance of about 7 kilometers on average and Sampling by proportion was used to select animals for bleeding. Twenty percent of the animals in each herd were selected for bleeding (by assigning random numbers).

A total of 190 animals of all age groups were bled in 56 herds involved in the survey. Only calves over 4 months of age were sampled to avoid confusion with passively transferred colostral antibodies. Owners were required to respond to a simple questionnaire to capture baseline information pertaining to their households and herds (Appendix 6). Blood was collected from animals by jugular veni-puncture in vacutainer tubes and stored in cool boxes while in the field and later left overnight for serum separation. Sera were obtained by carefully decanting the top most clear portion into a sterile vial. The samples were then delivered in ice boxes to the nearest DVO laboratory for storage at -20°C. The sera were later transferred to ILRI laboratory, Nairobi Campus for serological analyses.

3.3.8. Preparation of blood and Lymph-node smears

Thick and thin blood smears were prepared from the marginal ear vein of all the animals bled. Lymph node biopsy smears were also collected from animals suspected to be sick based on symptoms of disease for microscopic examination. The slides were air-dried and fixed in methanol for 5 minutes and kept in slide boxes. In the laboratory, the slides were stained with 10% Giemsa solution for 30 minutes and examined for presence of

Trypanosoma, Theileria, Anaplasma and Babesia haemo-parasites under the oil immersion objective.

3.3.9. Collection and examination of ticks

Whole body tick counts were carried out on cattle selected for sampling and tick samples were collected for identification and assessment of infection prevalence. This was done by picking them from hosts, using entomological forceps (Horak, 1982). Partially fed and unfed ticks were placed in 30 ml universal bottles with cotton wool dampened with sterile water while the engorged ticks were placed in 70% alcohol. The bottles were placed in a cool box maintained by ice packs for dispatch to the laboratory for processing. Tick species, sex and state of feeding of female ticks were determined. Specimens of *R. appendiculatus* ticks were dissected and their salivary glands removed and examined under dissecting microscope. Tick infections were determined through direct microscopy after staining the salivary glands with Schiff's (Fuelgen's) reagent to identify infected acini and subsequent estimation of infected acini by counting as described by Buscher and Otim (1986).

3.3.10. Laboratory sample analysis

Antibodies against three tick-borne parasites were detected in sera using the enzyme-linked immunoassay assay (ELISA) according to Katende *et al.* (1998). The results were expressed as percent positivity (PP) according to Wright *et al.* (1993). Percent positivity = (optic density of test serum/optic density of strong positive) x100. For *T. parva*, a sample was considered positive if the PP value was 20 or above; while for *A. marginale* and *B. bigemina*, the cut-off PP value was 15.

3.4. Data Handling and Analyses

The data collected were transferred from field notebooks to a database, collated and stored in Microsoft excel. Data derived from PE exercises were exported to SPSS system for windows Version 12.0.1. Analyses of household data, variables on animal husbandry and management practices, perceptions of the importance of different diseases and disease management were undertaken using descriptive statistical procedures involving frequencies, means and median score estimation.

Agreement between informant groups was assessed using Kendall's coefficient of concordance (W) (SPSS, 1999). This non-parametric test measures the association between sets of ranks assigned to objects by judges (or in this study, groups of judges) and computes a W value between 0 and 1. Agreements were categorized as 'weak' if Kendall's coefficient of concordance (W) values were less than 0.26, 'moderate' for values between 0.26 and 0.38; ($p < 0:05$) and 'good' for values greater than 0.38; ($p < 0:01$ to <0.001) respectively, according to critical values for W provided by Siegel and Castellan (1994).

Generalised linear model (GLM) was used to identify risk factors for *T. parva, A. marginale* and *B.bigemina* sero-prevalence using antibody prevalence data as the outcome variables against the potential risk factors (dependent variables). The type of production system, division, grazing management, tick control practice and frequency, acaricide mixing, method of application and veterinary service provider were used as fixed effects. Analyses were done in Stata release 8.2 for Windows (Stata Corporation, Texas, USA and SPSS software version 12.1, SPSS Inc., Chicago, IL, USA). A dichotomous response variable was created from the absolute percentage positive (PP-values) and coded as positive (1) or negative (0) using a fixed cut off of 15 for *A. marginale* and *B. bigemina*, and 20 for *T. parva*. Chi-square statistics were used to relate the disease prevalences (independent variable) with predictor variables at different levels.

A univariate logististic regression procedure was used to test the significance of the difference in the sero-prevalence between the categories of independent variables given above separately. All variables with univariate likelihood ratio test $p \leq 0.2$ were carried forward to create a multivariate regression model. Logistic regression analysis was performed to investigate the association between the sero-prevalence of the tick-borne diseases and the selected independent variables with a logistic link function. The logistic regression models were fit with all the variables for each of the three diseases, separately. All independent variables were included in the robust model. Both the main effects and their positive interaction terms were included in the model but those satisfying a $p < 0.1$ significance level were retained in the final model. A backward elimination approach was used to judge important variables to be retained in the final model with non-significant main effects being removed and previously removed main effects assessed for re-inclusion at each step (Hosmer and Lemeshow, 1989). Finally factors with $p < 0.05$ were taken as significant factors from the model.

To check for multi-collinearity between factors in the final model, bi-variate correlations for factor variables were examined. In addition, the stability of the model was checked by systematic removal of variables. Three methods of goodness-of-fit tests were applied: Hosmer & Lemeshow, Pearson and Deviance tests.

CHAPTER FOUR: RESULTS

4.1. Description of the farming systems

The overwhelming majority of the households (96.4%; 54/56) were farmers, with the remaining proportion of the respondents earning their livelihoods from employment. Land tenure was purely communal in pastoral divisions while the agro-pastoral divisions had a mixture of communal (75%; 42/56) and private land ownership (25%; 14/56). Household land sizes ranged between 5-15 acres. In pastoral areas, land was purely used for grazing since the climatic conditions prevailing in most of the areas could not allow for crop production (Plate 4.1).

Plate 4.1: A landscape common in pastoral areas of Baringo district.

4.2. Livelihood sources

The most important livelihood sources were reported to be livestock keeping, crop farming, small scale businesses and bee keeping. Households in both communities depended largely on livestock as the major source of livelihood. The enterprise was ranked as a priority in both study districts by 95.5 % (21/22) and 90.9% (20/22) of the groups in West Pokot and Baringo districts, respectively (Table 4.1). The main species of livestock kept were cattle, goats, sheep and poultry, in order of preference. Donkeys and camels were ranked fifth and sixth positions in importance, respectively. Crop farming was ranked as the second most important livelihood activity after livestock by both communities mainly as a supplement of household economy.

The major food crops included maize, sorghum, millet and beans. Small scale business was also reported to be an important livelihood activity and was ranked third in importance by both pastoral and agro-pastoral groups. Business mainly involved buying and selling of livestock as well as trading in livestock products such as milk and meat. The purpose for trade was to purchase cereals and obtaining cash for paying school fees, buying of livestock inputs especially drugs and other household expenses. Bee-keeping was an important activity in the agro-pastoral areas only.

Table 4.1: Prioritization of sources of livelihoods in pastoral and agro-pastoral areas of West Pokot and Baringo districts from the PE study (n=41), 2006.

	Pokot (n = 26)		Tugen (n =15)	
Livelihood source	Ranking	Frequency (%)	Ranking	Frequency (%)
Cattle keeping	1	25 (96.2)	1	14 (93.3)
Crop farming	2	24 (92.3)	2	14 (93.3)
Small scale business	3	19 (73.1)	3	9 (60.0)
Bee-keeping	4	7 (26.9)	4	4 (26.7)

4.3. Cattle production and management

All the households in pastoral divisions kept the zebu cattle as their main breed. On the other hand, 83.9% (47/56) of the households in agro-pastoral divisions had zebu crossbreds while the remaining 16.1% (9/56) kept zebu breeds. Grazing was purely on communal pasture in pastoral divisions whereas in agro-pastoral areas, grazing was mainly in individual land holdings (by 85.7% (48/56) of the respondents)) with communal grazing being practiced by only 14.3% (8/56) of the respondents. In both production systems, water for livestock was mainly from streams and rivers (for 80.1% (45/56) of the herds) with the remaining 19.9% (11/56) getting water from other sources including communal boreholes, dams and piped water sources. More than 85% (48/56)) of the households in both systems practiced tick control. Frequencies varied from weekly regimes, to only at the sight of ticks on animals (Table 4.2).

Table 4.2: Acaricide application frequency in West Pokot district as determined in the household survey, December, 2006 – January 2007.

Frequency of application	Number of respondents	%
once weekly	9	17.9
once fortnightly	29	48.2
once every 3 weeks	1	1.8
once a month	10	19.6
others (depending on tick load)	7	12.5

The main methods of acaricide application included spraying using hand held spray devices (43.6%) (24/56), hand washing using a piece of cloth material (30.9%) (17/56) and communal plunge dips by 10.7% (6/56) of the households (Plate 4.2). Only 19% (11/56) of the households were using the acaricide at the manufacturers' recommended mixing specifications. The remaining 81% (45/56) were using it at either over-strength or under-strength concentrations based on the acaricide mixing regimes reported.

4.4. Perceptions of constraints affecting livestock production.

Major constraints affecting livestock keeping were reportedly; livestock diseases; shortage of feed; lack of water/distant watering points; insecurity; wildlife menace and poor markets (Table 4.3). Livestock diseases were ranked as the main constraint in pastoral areas whereas shortage of animal feed was considered to be of major importance in agro-pastoral areas. Vector-borne diseases particularly tick-borne (ECF and heartwater) and trypanosomosis (transmitted by tsetse flies) were the main examples of diseases noted to seriously limit livestock production in these areas. Very few dipping facilities were reported to be operational in most of the areas in both districts (Plate 4.2).

Plate 4.2: An abandoned community plunge dip in Barwessa Division, Baringo District.

Table 4.3: Ranking of constraints affecting livestock production in pastoral and agro-pastoral areas of Northern Rift Valley, 2006.

	Pastoral	Agro-pastoral
Livestock diseases	1	2
Shortage of feed	2	1
Lack of water	4	3
Insecurity/cattle rustling	5	5
Wildlife	6	7
Ticks	3	4
Poor markets	7	6

4.4.1. Scoring of important cattle diseases

The results of proportional piling exercise of cattle diseases listed and scored by the livestock keepers during the interviews are summarised in Plate 4.3 and Figure 4.4. Among cattle diseases, East Coast fever, trypanosomosis, heartwater, CBPP and LSD were consistently scored as the 5 most important diseases across the study groups. East Coast fever was scored as the most important disease across the study areas and given the highest relative mean score of 42.2 by all the groups in pastoral areas and 47.4 by 92%; 20/22 of the groups in agro-pastoral areas followed by trypanosomosis with a relative mean score of 23.8 and 25.5 by 80%; 18/22 and 92%; 20/22 of groups in pastoral and agro-pastoral areas, respectively. Overall, more diseases were reported in agro-pastoral than in pastoral areas although the perception of importance of the main diseases was similar across the strata.

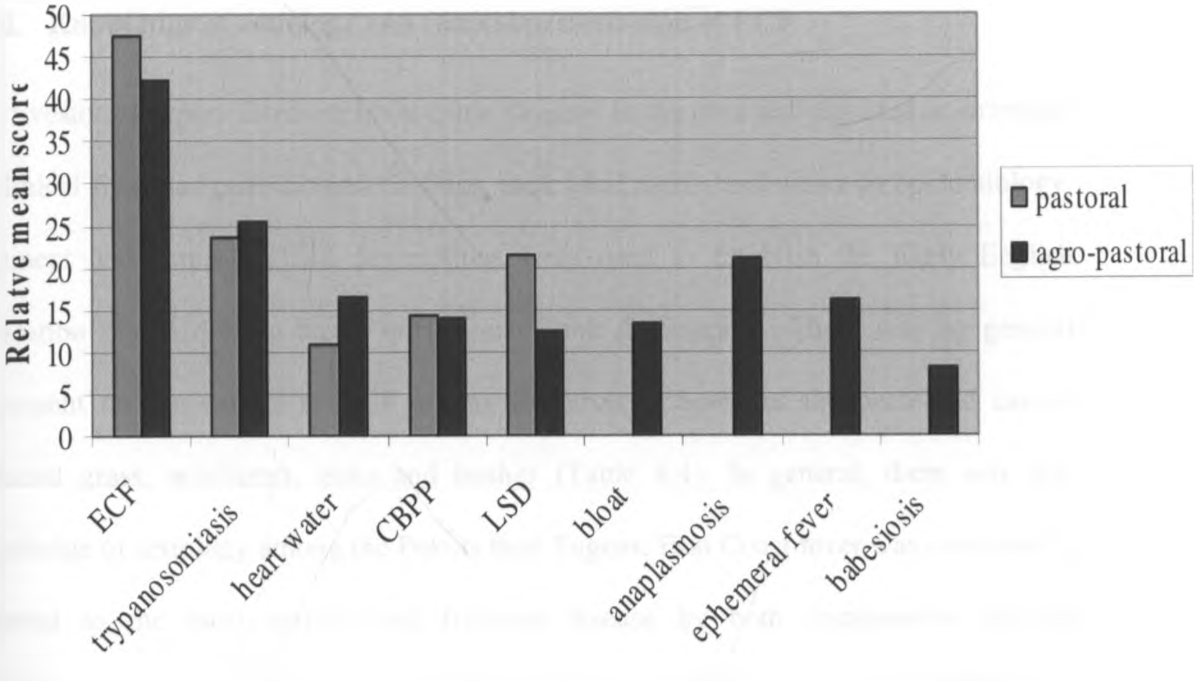


Figure 4.4: Important cattle diseases determined by proportional piling exercise in different group meetings in West Pokot and Baringo districts (n =17 groups)

Plate 4.3: Participants during a proportional piling exercise in West Pokot

4.4.2. Knowledge of aetiology and clinical presentation of ECF

The livestock keepers listed common cattle diseases in the area and provided descriptions of clinical signs and post-mortem findings, their local names and views on epidemiology, treatment and control. These descriptions were used to establish the likely English translation of the disease based on the text book descriptions. There was no general agreement on the causes of ECF among the groups. Some of the perceived causes included grass, witchcraft, ticks and bushes (Table 4.4). In general, there was less knowledge of aetiology among the Pokots than Tugens. East Coast fever was consistently reported as the most serious and frequent disease by both communities present throughout the year. The disease (locally known as *lokit* (or *yit)* by the Pokot and *cheptigon* by the Tugen community) was associated with swollen lymphnodes, deep cough, anorexia, lachrimation, nasal discharge and bloody diarrhoea as common signs across the pastoral communities involved in the study (Plate 4.4).

Plate 4.4: A livestock keeper points out at some of the key findings in a suspected case of East Coast fever in Chepareria Division, West Pokot District, 2006.

Livestock keepers were able to give a differential diagnosis of ECF with trypanosomosis which was also seen as a common cattle disease but was seasonal in occurrence. The disease, locally known as *plis* by the Pokot and *esse* by the Tugen community, had distinct pathognomonic clinical presentations that could not be confused with those of ECF. These included progressive emaciation, abortion in pregnant animals, offensive smell and loss of hair from the tail switch. The carcass from animals dying of the disease was "watery" with very little blood unlike that of ECF. Trypanosomosis was commonly associated with bushes and in particular tsetsefly (locally known as *Tabirwak* by the Pokot and *Soisoiyon* by the Tugen communities) as the main vector of disease.

Table 4.4: Reported causes of ECF among the Pokot community in West Pokot District and Tugen community in Baringo District, 2006.

Aetiology	***Pokot* (n =22)**		***Tugen* (n = 22)**	
	n	**(%)**	**n**	**(%)**
Ticks	10	45.6	17	77.3
Tsetsefly	0	0.0	1	4.5
Grass	6	27.3	1	4.5
Soil	2	9.1	0	0.0
Climate	0	0.0	1	4.5
Unknown	4	18.2	1	4.5

4.4.3. Estimated incidence of ECF and other cattle diseases

The informants categorised cattle into three age groups according to their traditional system as shown in Table 4.5 and estimated disease incidence in these age categories. The results of disease relative incidence scoring exercises are summarised in Figure 4.5.

East Coast fever was the most commonly reported disease in all age categories followed by trypanosomosis, ephemeral fever and babesiosis. Mean Incidence of ECF was higher in calves up to 2 years and was estimated at 37.9% compared to 17.7% and 19.4% for

4.4.4. Estimated mortality due to ECF on affected animals

The estimated mortality rates for the affected animals are shown in Figure 4.6. Mortality due to ECF was 23% for calves and 9% and 11% for adults and weaners, respectively. According to the participants, the high mortality seen in calves was due to difficulties encountered during diagnosis of early phases of disease in this age group and hence treatment is usually delayed and/or incorrect.

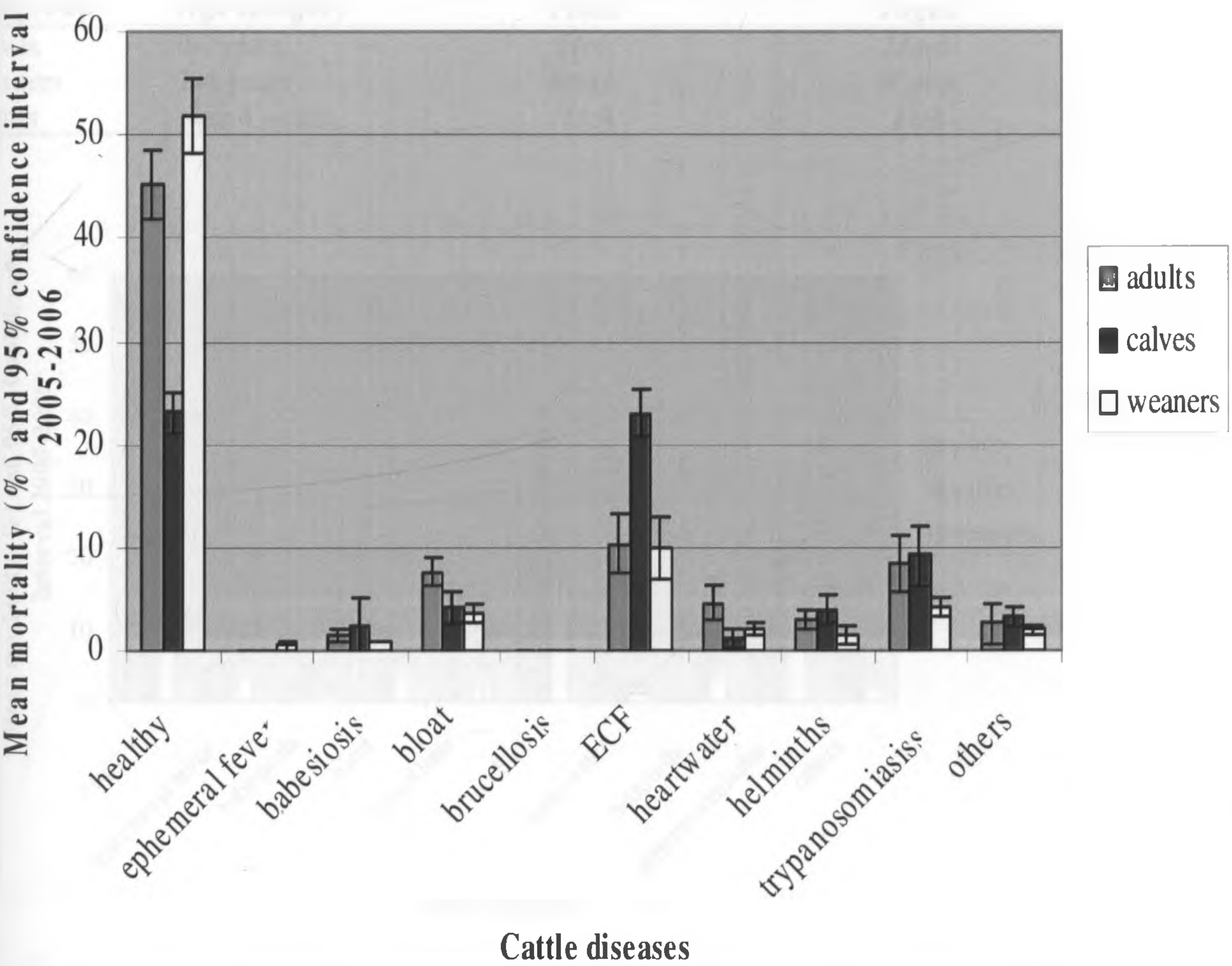


Figure 4.6: Estimated mean mortality (with 95% confidence limits) of the affected animals from various cattle diseases in agro-pastoral production system in Northern Rift Valley during the year 2005-2006.

weaners and adults, respectively. Calves were more susceptible to ECF than weaners and adults although morbidity was slightly higher in adults than weaners. The other diseases were reported to be less common among the age categories. Brucellosis, bloat and heartwater were mainly reported in adults, whereas helminths were reported to be common in calves.

Table 4.5: Categories of cattle age groups common among the *Pokot* and *Tugen* pastoralists in Northern Rift Vallley.

		Local name	
Age group	**Age category**	***Pokot***	***Tugen***
Calves	0-2years	*Mow*	*Moek*
Weaners	2-4 years	*Muser*	*Kiptoi*
Adults	over 4 years	*Tich*	*Tich*

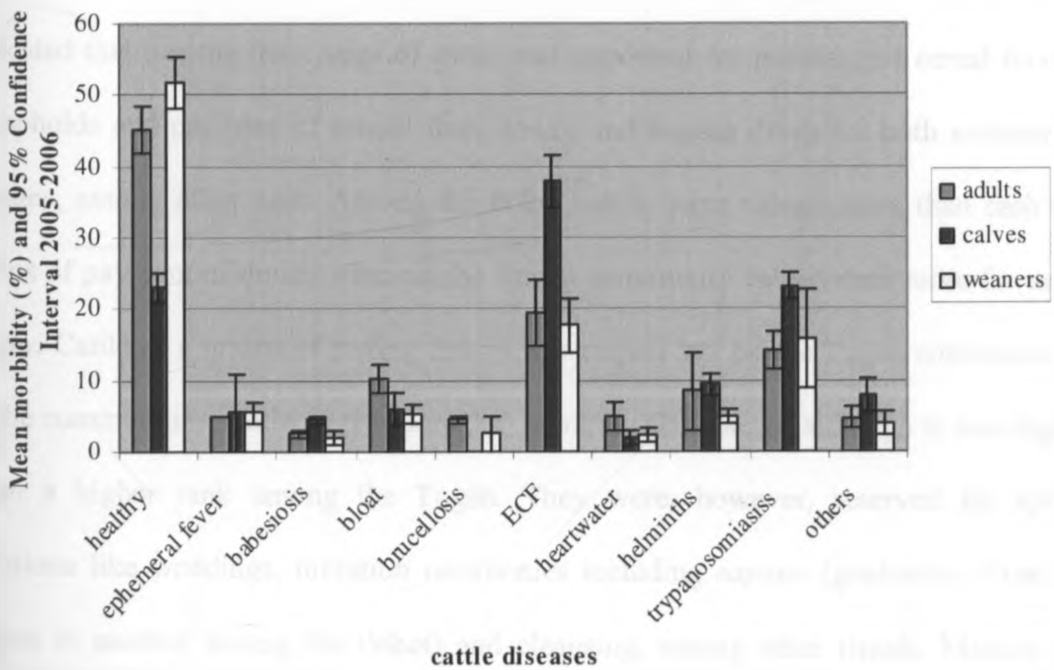


Figure 4.5: Mean morbidity (with 95% confidence limits) from various cattle diseases as perceived by the *Pokot* and *Tugen* pastoralists in agro-pastoral production system in Northern Rift Valley during the year 2005-2006.

The mean mortality due to trypanosomosis for all age groups was 9%. The participants perceived this low mortality to be due to the widely available drugs for treatment of the disease. Mortality of animals affected by bloat was reported only during the wet season when animals graze on lush pasture and was particularly a problem with the adults. Heatwater, ephemeral fever, babesiosis and brucellosis were less common and hence the low mortality associated with the occurrence of the diseases in the herds. Helminths were less likely to result in mortality although there were deaths due to poor body condition and occurrence of opportunistic infections.

4.4.5. Community Perception of impact of ECF relative to other cattle diseases

Benefits derived from cattle were ranked in order of importance as shown in Table 4.6 and Plate 4.5. In most households, milk was ranked high because it was a source of food for all members of the family especially for children and the aged. Many participants indicated that income from sales of cattle was important for purchase of cereal food for households and payment of school fees, dowry and buying drugs for both animals and humans, among other uses. Among the Pokot, cattle were valued more than cash as a means of payment of dowry whereas the Tugen community valued cash more for use as dowry. Cattle as a means of paying dowry was ranked last by the Tugen community. In all the communities, cattle were reported to be rarely slaughtered although it was slightly given a higher rank among the Tugen. They were, however, reserved for special occasions like weddings, initiation ceremonies including *sapana* (graduation from one age-set to another among the Pokot) and cleansing, among other rituals. Manure was reportedly used by some households for crop farming but this was not a major activity in the region. Hides were not reported to be a major benefit derived from cattle in all the communities although it was ranked slightly high among the Tugen.

Table 4.6: Scoring of the relative importance of benefits from cattle derived from 5 village meetings in West Pokot and Baringo districts, 2006.

	West Pokot			**Baringo**			
	Lokwapuo	Chepnyal	Total	Sach Ang'wan	Marigut	Chesongo	Total
Milk	45	30	75	39	33	38	110
Dowry	23	23	46	-	11	-	11
Cash	20	16	36	30	26	26	82
Meat	1	17	18	12	15	19	46
Manure	11	7	18	11	6	10	27
Hides	-	7	7	8	9	7	24

Figure 4.7 shows the community perception of the weighted impact of each disease on different benefits obtained from cattle. The higher the total scores assigned to a particular disease, the greater the impact of that disease. ECF frequently featured in all the matrices completed and highly affected all the cattle derived benefits indicating a higher relative importance of the disease.

The impact of ECF on milk was greatly felt by most of the livestock keepers as a result of deaths of adults and calves (10% and 23%, respectively) and subsequent reduction in milk production besides negative effects on herd growth. However, the effect on hides was the least as most of the households salvaged them for domestic use as well as for sale. Besides, meat was also salvaged for home consumption and some were offered for sale, hence the relatively low effect of ECF attributed to meat. Income from sale of cattle and cattle products was shown to reduce significantly as a result of outbreak of the disease thus lowering purchasing power of households.

The effect of the disease on dowry was because of mortality resulting in fewer animals remaining in the herd. Except for trypanosomosis, the other diseases were reported to be either seasonal or rare in occurrence and their individual effects on cattle benefits were of little importance compared to those of ECF. A summary of the matrix of losses resulting from cattle diseases is presented in Figure 4.8.

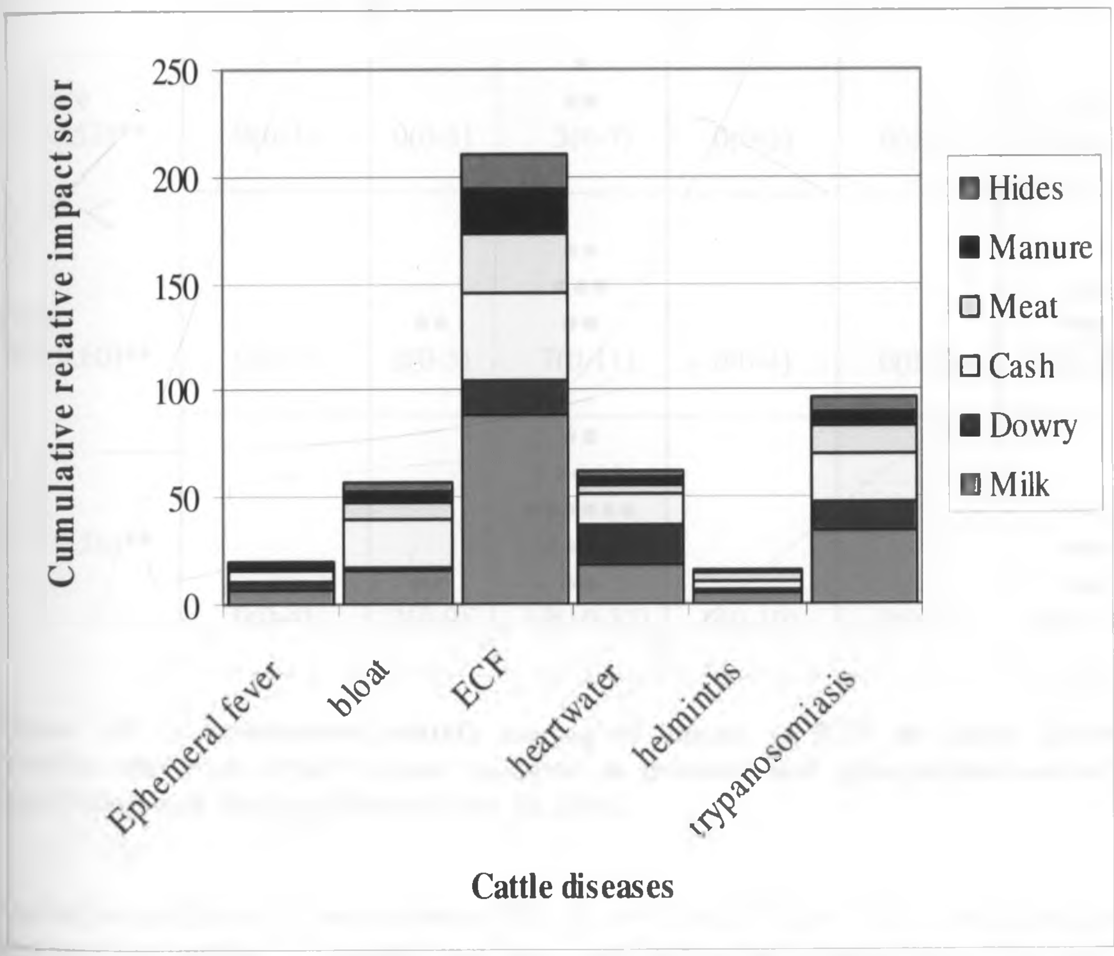


Figure 4.7: Cumulative relative impact of ECF on cattle derived benefits determined by 7 village meetings in West Pokot and Baringo districts, 2006.

Benefits	Diseases					
	Ephemeral fever	Bloat	ECF	Heartwater	Helminths	Trypano-somosis
Cash (W= 0.43)**	0(0-4)	● ●● 3(0-16)	●● ●●●● ●● 8(4-25)	0(0-9)	0(0-5)	● ●●● ● 5(0-13
Dowry (W= 0.45)**	0(0-3)	0(0-2)	●● ●● 4(0-9)	0(0-11)	0(0-2)	●● 2(0-5)
Hides (W= 0.60)**	0(0)	0(0-6)	●● 2(0-4)	0(0-2)	0(0-1)	0(0-3)
Manure (W=0.52)**	0(0-3)	0(0-3)	● ●● 3(0-7)	0(0-3)	0(0-1)	● 1(0-3)
Meat (W= 0.60)**	0(0-1)	●● 2(0-5)	●● ●●● ●● 7(0-11)	0(0-4)	0(0-3)	●● ●● 4(0-7)
Milk (W= 0.58)**	0(0-4)	●● 2(0-9)	●● ●●●●● ●●●●●● ●●●● ●● 19(10-32)	0(0-10)	0(0-5)	● ●●● ●● 6(0-11)

Figure 4.8: A summarised matrix scoring of impact of ECF on cattle derived benefits relative to other diseases common in pastoral and agro-pastoral areas of West Pokot and Baringo districts (n = 7), 2006.

Kendall's coefficient of concordance (W), (* p < 0:05; ** p < 0:01). The black dots represent the number of counters that were used during the construction of the matrix Numbers are medians (minimum and maximum values are shown in parentheses).

The seven informant groups were in good agreement ($p < 0.05$) on all the losses attributed to the cattle diseases with Kendall's coefficient of concordance (W) values ranging from 0.43 to 0.60.

Plate 4.5: Participants completing an impact scoring matrix exercise at one of the study sites in Baringo District, 2006.

4.4.6. Seasonal incidence of ECF

Figure 4.9 and Plate 4.6 shows a summary of seasonal calendars constructed for occurrences of ECF and factors associated with the disease in cattle. The results indicated that ECF occurred mostly during the wet season and less so in the interphase. During this season, the vector ticks are most abundant. However, the disease was not associated with migration which usually occurs during the dry season when vectors are less abundant.

	Seasons		
Indicators	Wet	Inter-phase	Dry
Rainfall (proportion of total annual rainfall) (W = 0.55)*	●● ●●●●● ●●●● ●● 13(11-15)	● ●●● ● 5(2-7)	●● 2 2(0-3)
Ticks (*singor/kerbes*) (W = 0.31)	● ●●● ● 5(0-16)	● ●● 3(2-10)	● 1(1-14)
ECF *(lokit/cheptigon)* (W = 0.52)*	●●● ●●●● ●●● 10(4-15)	● ●●● ●● 6(2-10)	● 1(1-14)
Migration (W = 0.98)**	0(0-0)	0(0-4)	●● ●●●●● ●●●●●● ●●●●● ●● 20(16-20)

Figure 4.9: A summarised seasonal calendar of ECF and factors associated with it's occurrence in West Pokot and Baringo districts of the Northern Rift Valley, Kenya (n = 5), 2005-2006

Kendall's coefficient of concordance (W), (* p < 0:05; ** p < 0:01). The black dots represent the number of counters that were used during the construction of the seasonal calendars (many counters represents a strong positive association). Numbers are medians (minimum and maximum values are shown in parentheses).

There was moderate to good agreement on the seasonality of ECF and its risk factors among different groups with W values ranging between 0.31 and 0.98 ($p < 0{:}05 - p < 0.01$).

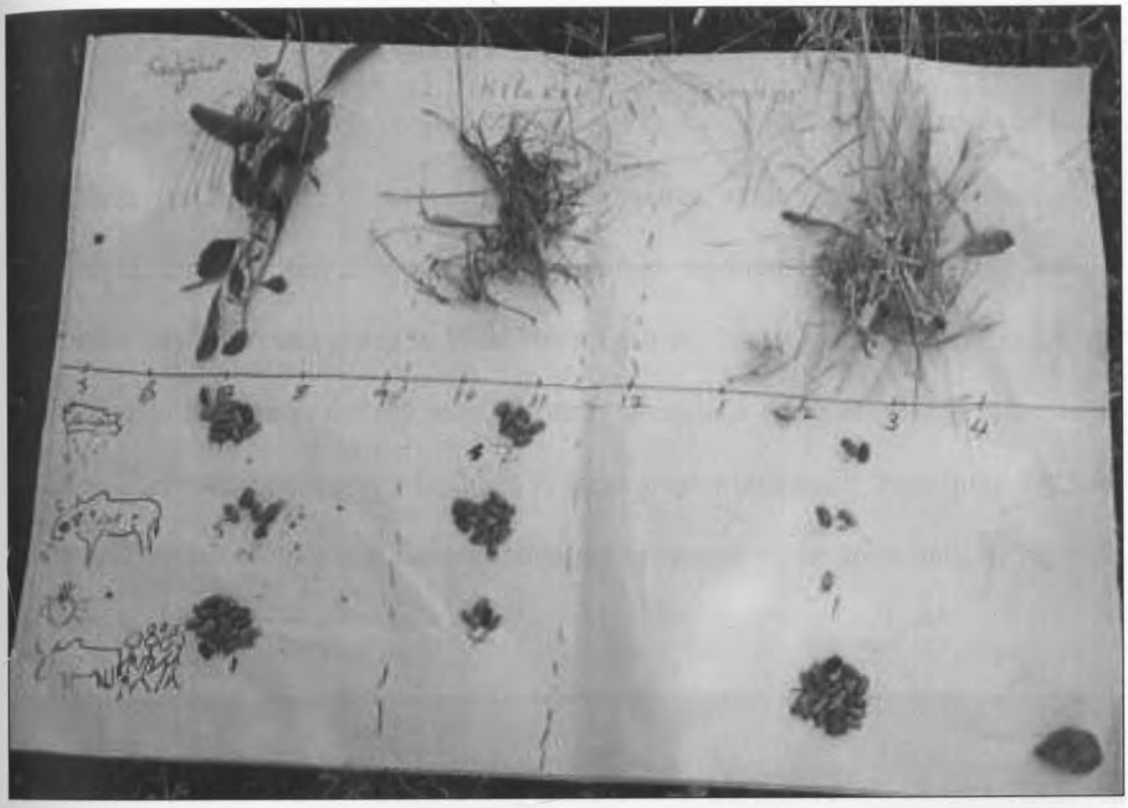


Plate 4.6: A seasonal calendar showing seasons and their association with ticks, ECF, rainfall and migration as developed by livestock keepers in Chepareria Division, West Pokot District, 2006.

4.4.7. Participatory Mapping of ECF risk areas

An example of a sketch of a village map developed during the study is presented in Plate 4.7. The mapping exercises indicated that the grazing areas were also the same areas where ticks occured. The informants reported lack of dipping facilities in most of the areas and where dips were available, most of them were no longer in use. In Chepareria for example, the informants reported that out of the 16 dips in the division, only 8 of them were operational.

Patterns of migration by the different communities were also shown in the maps. During drought, *Tugen* herds mainly crossed Kerio River to the neighbouring districts of Keiyo and Marakwet, a distance of between 10-20 kilometres, while *Pokot* herds moved as far as Uganda, approximately 160 kilometres, a journey reported to take up to four days by one of the key informant group in West Pokot District. Most participants reported tick infestation to be high in the dry season grazing areas as a result of mixing of herds. In addition, there were no dipping facilities in these areas which made them quite risky for cattle grazing but the herders had no option but to remain in the areas until the drought period lapsed.

Plate 4.7: Participatory village map of Serewo village in Kongelai division of West Pokot District, 2006.

4.4.8. Treatment options for ECF and other tick-borne diseases

Nearly all livestock keepers (96.4% (54/56) used commercial drugs for treatment of tick-borne diseases. Only 3.6% reportedly relied on existing veterinary knowledge (EVK), using various traditional practices such as burning of lymph nodes and herbal concoctions for treatment. Veterinary drugs were obtained locally from open air markets and veterinary shops (Plate 4.8). Drug administration was mainly done by livestock keepers themselves (67.3%) (38/56) with varying degrees of success, while veterinary staff (private practitioners and government staff) and community based animal health workers (CAHW) were consulted by 23.6% (13/56) and 6.1% (3/56), respectively.

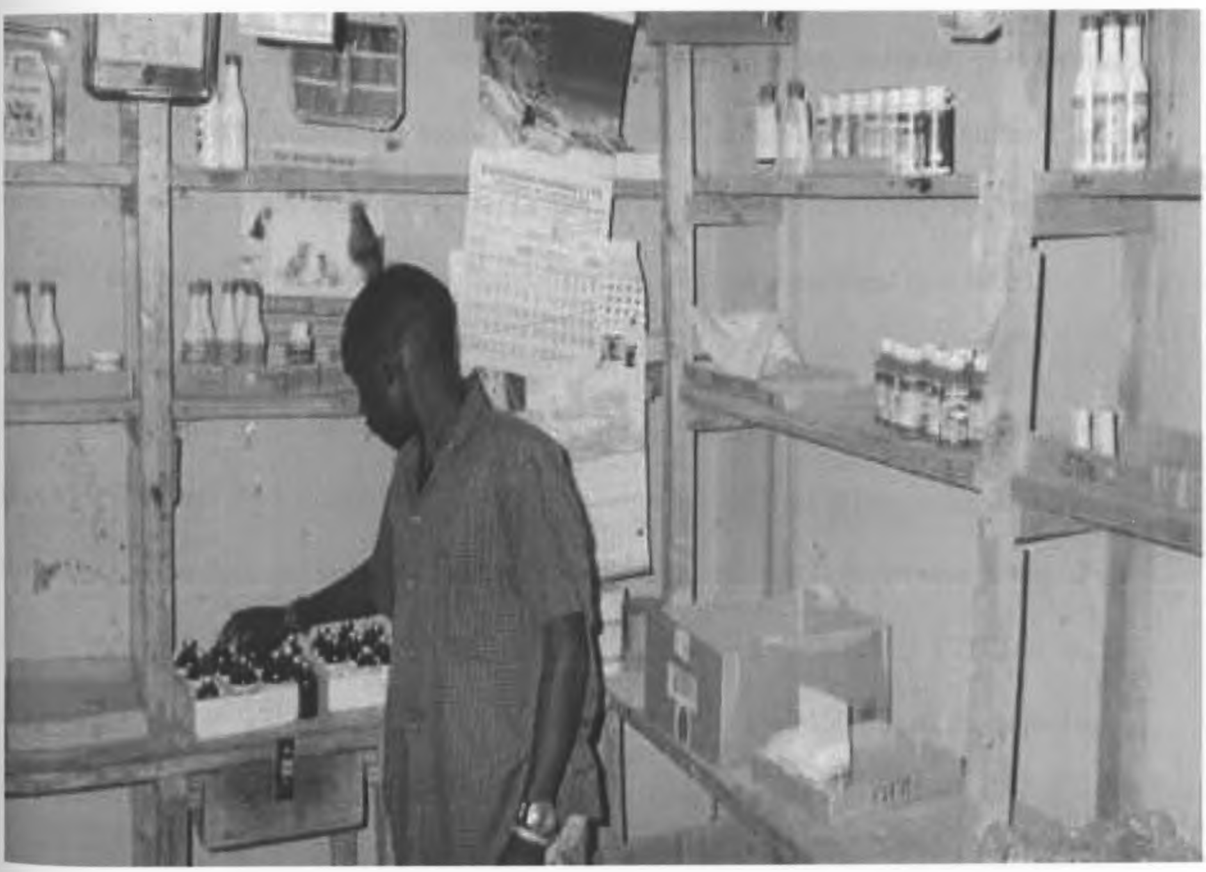


Plate 4.8: A veterinary shop in one of the study sites in Kongelai Division, West Pokot District.

4.5. Serology

The mean antibody prevalence for the major tick-borne disease by production system grazing management and age categories in cattle in the district is shown in Figures 4.10, 4.11 and 4.12. The sero-prevalence for *T. parva A. marginale* and *B. bigemina* determined by ELISA were 25.8, 53.2 and 53.7, respectively. The prevalence estimates for *A. marginale* and *B.bigemina* were significantly higher in pastoral than agro-pastoral production systems and in the different grazing managements ($p = 0.002$ and 0.001 respectively) as indicated in Figure 4.10 and 4.11. However, no significant difference was observed for antibody prevalence for *T. parva* between the two grazing management systems.

Animals in pastoral areas (mainly under communal pastures) had antibody prevalence of more than 60% for antibodies against A. *marginale* and *B. bigemina* while *T. parva* prevalence was slightly higher (14.7%) in animals in agro-pastoral compared to 11.1% in pastoral production system although the difference was not significant ($p > 0.05$).

Mixed infections were detected in 42.6% (81/190) of the samples. Nearly half of the mixed infections had double (32.6%) while about 10% had triple infections. Single infections were detected in 57.4% (109/190) of the samples. *T. parva* was detected as a single infection in only 3.7% (7/190) samples, *A. marginale* in 14.2 (27/190) and *B. bigemina* in 13.2% (25/190) of the samples. A total of 21.1% (40/190) of the samples did not show significant titres and thus were negative for any parasites via ELISA.

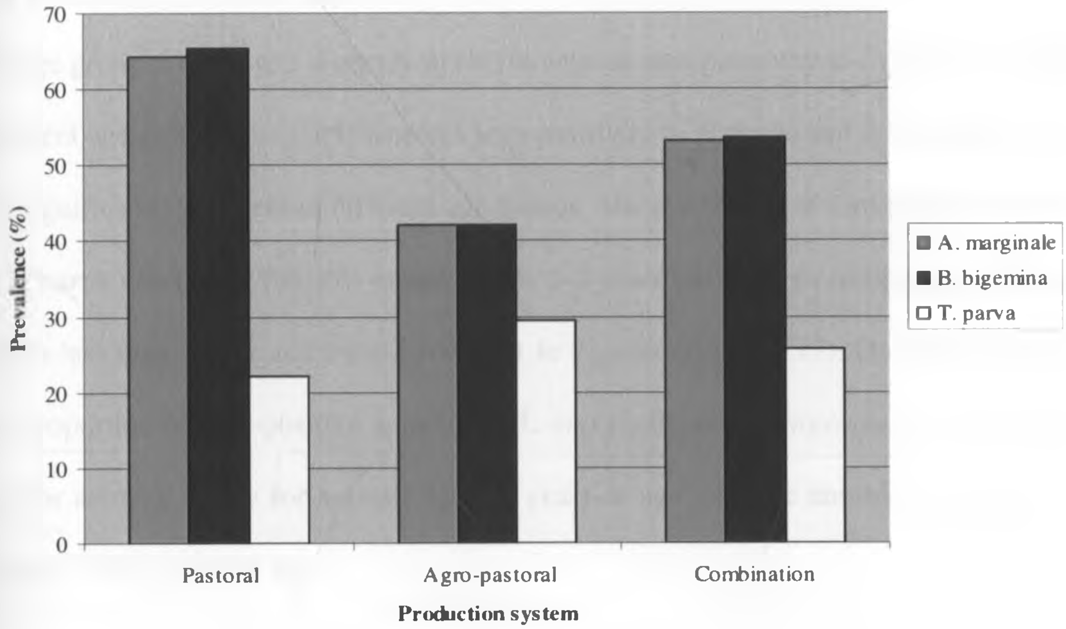


Figure 4.10: Prevalence of antibodies by ELISA against *T. parva*, *A. marginale* and *B. bigemina* in different production systems in West Pokot District, 2006.

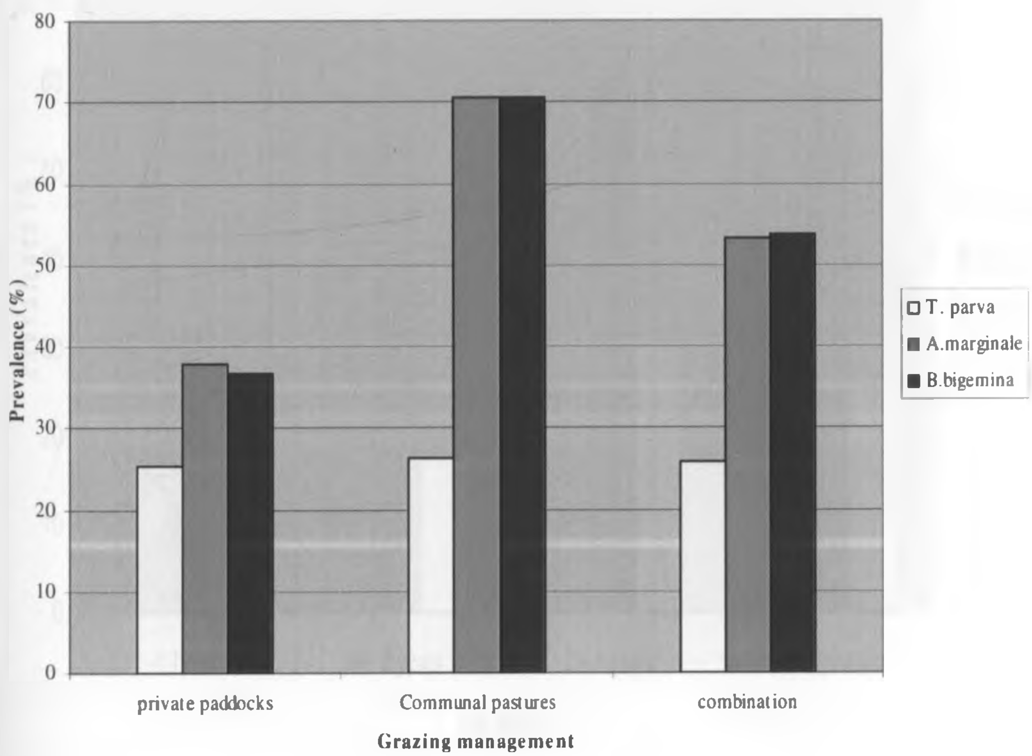


Figure 4.11: Prevalence of antibodies against *T. parva*, *A. marginale* and *B. bigemina* in different grazing managements in West Pokot District, 2006.

The probability of sero-positivity to *T. parva, A. marginale* and *B. bigemina* varied across the age groups. There was a significant difference in sero-positivity to *B. bigemina* in the different age groups ($p < 0.05$) whereas sero-positivity to *T. parva* and *A. marginale* were not significantly different in different age groups. The proportion of sero-positive animals to *T. parva* was higher (30.3%) in age groups 2-3 years for *T. parva* compared to 25% for calves less than 1 year and those between 1 to 2 years (Figure 4.12). On the other hand, the proportion of sero-positive animals to *A. marginale* and *B. bigemina* increased with age for animals in age for animals up to 3 years of age with the number decreasing for animals over 3 years of age.

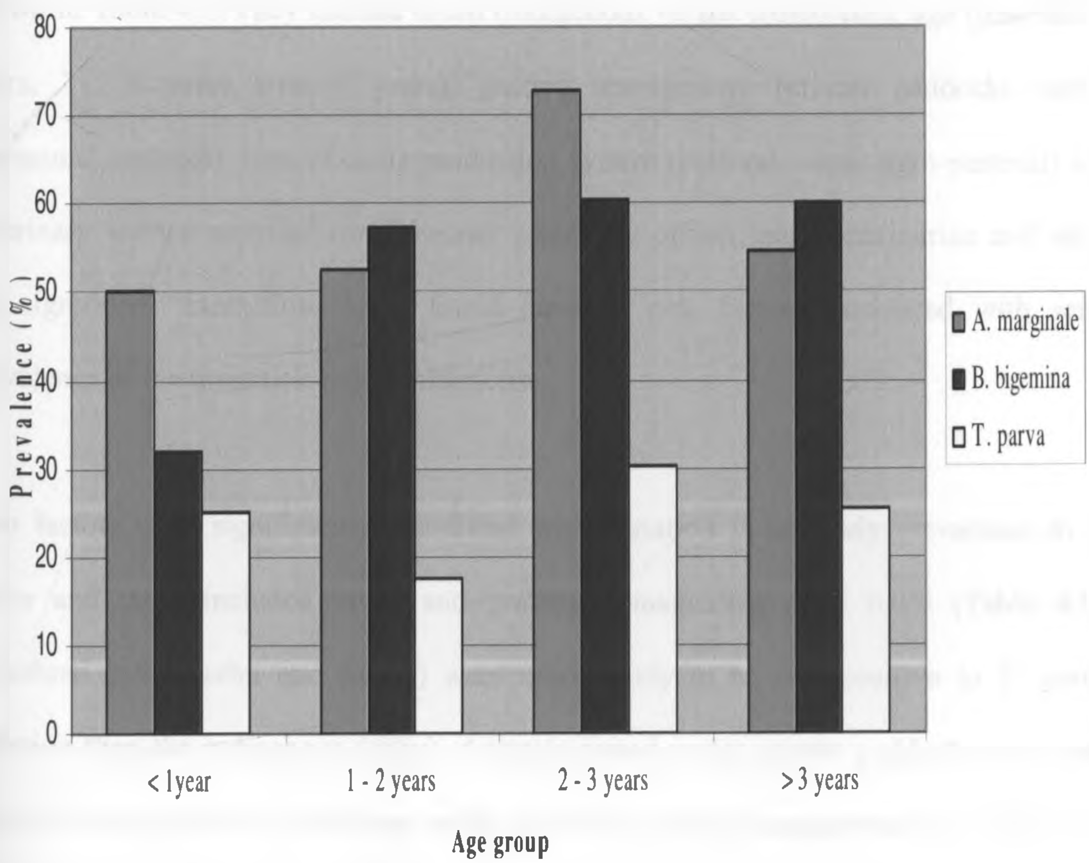


Figure 4.12: Prevalence of antibodies by ELISA against *T. parva*, *A. marginale* and *B. bigemina* in different age groups of cattle in West Pokot District, 2006.

4.6. Risk factors associated with serum antibody prevalence for *T. parva*, *A. marginale* and *B.bigemina.*

The variables included in the statistical analysis were factors thought to be associated with prevalence of tick-borne diseases in cattle. Univariate analysis demonstrated that sero-prevalences were highly and significantly associated with production system (pastoral versus agro-pastoral), grazing management, breed, age and veterinary service provider (Table 4.8).

The results of logistic regression analysis for the main effect variables left in the models and significantly associated with sero-positivity for the different tick-borne diseases are shown in Table 4.7. They include breed (indigenous versus crossbreds), age (less than 2 years, 2 – 4 years, over 4 years), grazing management (private paddocks versus communal pastures), type of cattle production system (pastoral versus agro-pastoral) and veterinary service provider (professional veterinary officer, para-veterinarian and self). No significant interactions were found between risk factors associated with sero-prevalence of the three tick-borne infections.

Two factors were significantly associated with variation in antibody prevalence to *T. parva* and these included breed and grazing management *(*$P < 0.05$*)* (Table 4.8). Crossbred cattle (zebu and exotic) were more likely to be sero-positive to *T. parva* infection than the indigenous (zebu). Animals reared under private paddocks were less likely to be sero-positive than those under communal grazing management ($p < 0.05$). For *A. marginale*, veterinary service provider was significantly associated with serum antibody prevalence. Animals in herds whose veterinary service provider was a professional veterinarian were less likely to be sero-positive to *A. marginale* than herds attended to by other veterinary service providers (para-veterinarian and the livestock keeper).

Two factors were significantly associated with sero-positivity to antibodies against *B. bigemina,* namely, age and type of production system. Cattle in age groups 2-4 years and over 4 years were more likely to be sero-positive than those less than two years of age. Also, cattle in agro-pastoral areas were more likely to be sero-positive than those in pastoral areas.

Table 4.7: Distribution of sero-prevalence of *T. parva, A. marginale* and *B..bigemina* among potential risk Factors in West Pokot District, 2006.

	T.parva			*A. marginale*			*B.bigemina*		
Risk Factor	**Pos.**	**Neg.**	**P-value**	**Pos.**	**Neg.**	**P-value**	**Pos.**	**Neg.**	**P-value**
Production system									
Pastoral	21	74	0.25	61	34	0.002	62	33	0.001
Agro-pastoral	28	67		40	55		40	55	
Grazing management									
Communal pastures	25	79	0.54	67	37	0.001	67	37	0.001
Private paddocks	24	62		34	52		35	51	
Breed									
Indigenous (Zebu)	23	85	0.1	68	40	0.002	68	40	0.003
Crossbred (Zebu*Exotic)	26	56		33	49		34	48	
Age									
0-2years	11	35	0.19	21	25	0.154	16	30	0.002
2-4 years	13	56		44	25		47	22	
> 4 years	14	27		24	17		22	19	
Tick control									
Yes	45	125	0.53	89	81	0.517	89	81	0.283
No	4	16		12	8		13	7	
Tick control frequency									
Frequent	9	17	0.27	8	18	0.014	13	13	0.685
Infrequent	40	124		93	71		89	75	
Acaricide mixing									
Correct	13	33	0.78	21	25	0.459	23	23	0.54
Incorrect	32	92		68	56		66	58	
No acaricide use	4	16		12	8		13	7	
Acaricide application									
Plunge dips	6	20	0.77	10	16	0.161	14	12	0.75
Hand spraying	22	52		36	38		38	36	
Hand washing	17	53		43	27		37	33	
No acaricide use	4	16		12	8		13	7	
Vet. service provider									
veterinarian	11	24	0.62	10	25	0.0001	18	17	0.341
para-veterinarian	5	12		15	2		12	5	
self	33	105		76	62		72	66	

Table 4.8: Variables associated with *T. parva, A. marginale* and *B. bigemina* sero-prevalence from the logistic regression model for 190 animals in West Pokot District, 2006.

Variable	b	SE (b)	p-value
T. parva			
Breed			
(1 = crossbred, 0 = indigenous)	2.47	1.17	0.035
Grazing			
(1private paddocks, 0 = communal pastures)	-2.43	1.16	0.036
age-group			
(1= < 2 years, 0 = other age categories)	0.90	0.46	0.052
A. marginale			
Grazing			
(0 = private paddocks, 1 = communal pastures)	0.63	0.35	0.074
vet. service provider			
(1= professional vet., 0 = other service providers)	1.72	0.78	0.026
B. bigemina			
age-group			
(1= < 2 years, 0 = other age categories)	-1.09	0.43	0.010
production system			
(0 = pastoral, 1 = agro-pastoral)	0.86	0.36	0.020

4.6. Blood Smears and Lymph node biopsies

Out of the 176 Giemsa stained blood smears submitted for microscopy, 39.2% (69/170 were positive for *Theileria* piroplasms while 5.7% (10/170) and only 0.6% (1/170) were positive for *Anaplasma* and *Babesia* piroplasms, respectively. None of the lymph node biopsy smears were positive for *Theileria* schizonts.

4.7. Tick species distribution and abudance.

Ticks were found on animals in 98% (55/56) of the herds participating in the study. Adult and immature tick counts from individual cattle in both pastoral and agro-pastoral production systems are presented in Table 4.9. Total body count was done *in-situ* on all the animals randomly selected for bleeding. A total of 1244 tick specimens were collected for identification. Four species of ixodid ticks were identified in the study. The most frequent species was *R. appendiculatus*, followed by *B. decoloratus*, *A. variagatum* and *Hyalomma* spp in order of abundance (Table 4.9). *R. evertsi* and *R. pulchelus* were found in small numbers. Field infestation levels varied greatly across farms and locations within the district (Figure 4.13a and b).

Table 4.9: Total ticks counted and distribution of the tick collection sites by location in West Pokot District, 2006.

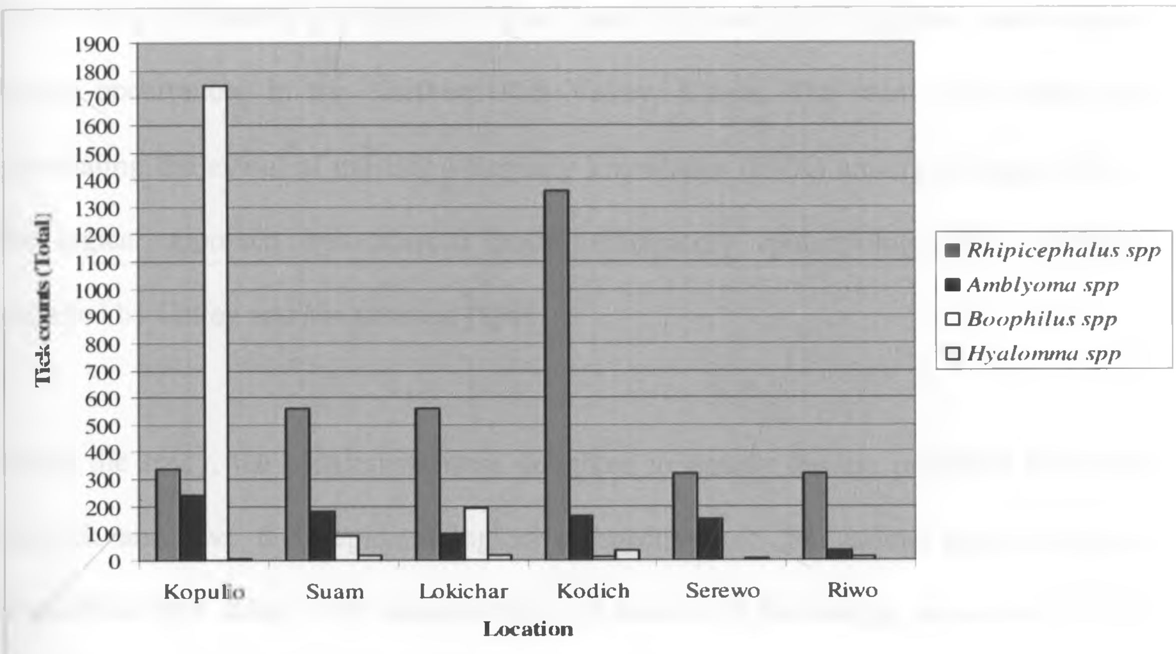
	Tick Counts			
	Rhipicephalus spp	*Boophilus spp*	*Hyaloma spp*	*Amblyoma spp*
Location	No. (%)	No. (%)	No. (%)	No. (%)
Kopulio[a]	339 (6.0)	1744 (77.4)	6 (4.5)	240 (23.2)
Suam[a]	557 (9.8)	93 (4.1)	20 (14.9)	182 (17.6)
Lokichar[a]	557 (9.8)	193 (8.6)	21 15.7)	99 (9.6)
Kodich[a]	1356 (23.8)	14 (0.6)	36 (26.9)	162 15.7)
Serewo[a]	319 (6.6)	0 (0)	4 (3.0)	152 (14.7)
Riwo[a]	319 (5.6)	12 (0.5)	2 (1.5)	36 (3.5)
Ywalateke[b]	563 (9.9)	58 (2.6)	1 (0.7)	70 (6.8)
Chepkopeigh[b]	366 (6.4)	8 (0.4)	26 (19.4)	18 (1.7)
Senetwo[b]	725 (12.7)	34 (1.5)	2 (1.5)	18 (1.7)
Kipkomo[b]	242 (4.3)	98 (4.3)	0 (0)	4 (0.4)
Batei[b]	346 (6.1)	0 (0)	16 (11.9)	54 (5.2)
TOTAL	5689	2254	134	1035

[a] Locations in pastoral livelihood zones
[b] Locations in agro-pastoral livelihood zones

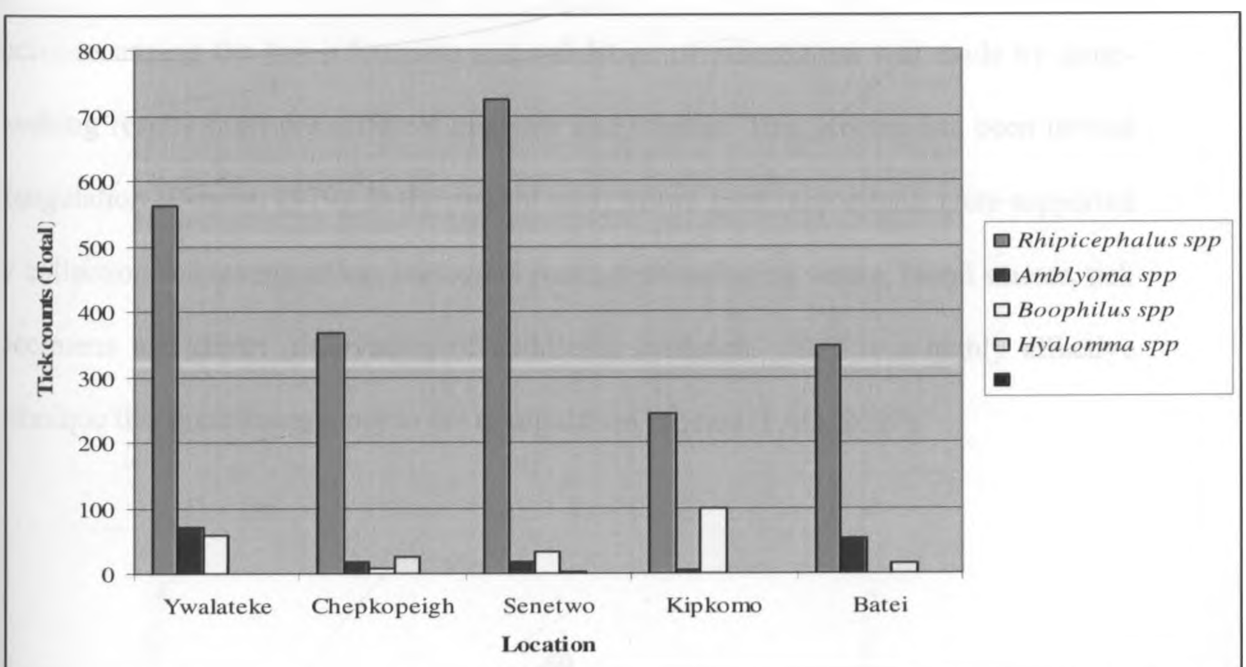
The highest tick challenge was recorded in locations in pastoral areas while low challenge was recorded in locations in agro-pastoral areas where grazing is mainly on private paddocks and tick control practice was reported in all the herds. The total ticks collected according to species in the study locations is presented in Figure 4.12. The range and abudance of different species found at the study sites were markedly different. Most of the locations (81%) had predominantly *Rhipicephalus spp* whereas the rest of the species were found in small numbers. *Rhipicephalus Appendiculatus* dominated collections in agro-pastoral areas. None of the 26 *R. appendiculatus* ticks dissected for microscopy were positive for infection with *T. parva* parasites.

Figure 4.13: Tick distribution by species in eleven study locations in (a) pastoral and (b) agro-pastoral livelihood zones in West Pokot District, December, 2006 – January, 2007.

a) Locations in pastoral livelihood zone



b) Locations in agro-pastoral livelihood zone



CHAPTER FIVE: DISCUSSION

The present study created an open and dynamic interactive opportunity between the research team and livestock keepers. The opportunity was important in understanding livestock production systems and challenges facing pastoralists and in addition appreciating community perceptions of East Coast fever and other important vector-borne disease occurrences in the Northern Rift Valley, Kenya. The study also helped in appreciating the extent of existing veterinary knowledge (EVK) among the pastoralists. The logical approach was adapted from participatory epidemiology (PE) methods described by Catley and Mohammed (1996).

During the study, the pastoralists were delighted to openly discuss problems affecting livestock and give their epidemiological perspectives of the various cattle diseases common in their areas. This revealed the vast reserve of knowledge possessed by the communities and was indeed a learning session for both the researchers and livestock keepers. Results from the various PE exercises were arrived at by consensus-based decisions among the key informants and validation of information was made by cross-checking results from the different methods and sources. This process has been termed triangulation (Denzin, 1979). In the present study views from respondents were supported by collection and testing of key biological parameters including serum, blood smears, tick specimens and direct observation of additional evidence. This is a highly effective technique that contributes more to the triangulation process (FAO, 2000).

West Pokot and Baringo districts were selected as representative from a list of the districts in northern Rift Valley because of logistic reasons. The choice of *Pokot* and *Tugen* communities to participate in the exercise was based on their economic dependence on livestock, cultural beliefs and practices and the nature of their ecological setting, typical for pastoral and agro-pastoral systems.

The study provided baseline data for identification and prioritisation of animal health constraints within these communities and estimation of tick-borne disease prevalence, and economic impact in pastoral livelihoods in marginal areas. The information is important in formulation of extension messages targeting VBD control and drawing of an action plan for ECF control in pastoral rangelands. A number of constraints affecting livestock production in the area were identified. Overall, livestock diseases were ranked as the main problem faced by the livestock keepers in the region followed by shortage of animal feeds. Other important constraints reported were shortage of water for livestock, insecurity, tick infestation, predation by wildlife and poor market outlets for animals, their products, among others. The results compare with those findings obtained in a similar study conducted in Marsabit District by Njanja *et al.,* 2003.

There was variation in prioritization of shortage of animal feed as the second most important constraint after livestock diseases in pastoral and agro-pastoral areas. This can be explained by the migratory nature of the herds in pastoral areas to dry season grazing areas, unlike those in agro-pastoral areas who had no alternative to avert the effects associated with prolonged drought spells.

East Coast fever (ECF) was ranked highest in both production systems in the region relative to other cattle diseases recorded across the study areas. The disease was considered to be of economic importance by majority of the livestock keepers in the study area. This was contrary to what veterinary authorities believe that ECF is not an important problem in the marginal areas. Hence, there was no specific control programme for TBDs in these areas. Trypanosomosis was ranked as the second most important disease after ECF followed by anaplasmosis, heartwater and babesiosis among the vector-borne diseases recorded. It is possible that the pastoralists' perception of the importance of ECF was influenced by the year round nature of ECF, combined with its high mortality. Livestock keepers tend to remember the disease that causes death than other diseases.

In this study, livestock keepers demonstrated good ethno-veterinary knowledge in ECF recognition. ECF was associated with swollen lymph nodes, deep cough, anorexia, lachrimation, nasal discharge and bloody diarrhoea as common signs. The clinical signs provided by pastoralists were very close to the much referenced text book descriptions such as Radostitts *et al.* (2000). It has been argued that the presence of other diseases with similar symptoms makes it difficult for cattle owners to identify ECF (Norval *et al.*, 1992).

Almost two thirds of informants positively associated ECF with ticks as the main aetiological agent. However, some livestock keepers including those citing ticks considered other aetiological agents such as soil, grass and climate as potential causes of ECF. The pastoralists were right in associating grass and climate with ECF since most cases of the disease were reported to occur during the wet season when grass is abundant and ticks are abundant. The evidence of inability of livestock keepers to correctly associate the disease with the accepted scientific aetiological agent suggests that veterinary extension targeting this area will be essential to improve herd-level disease understanding and control.

The study revealed high cattle losses resulting from ECF during the wet season. This underscores the role seasons, which may be the source of tick infestation and subsequent disease outbreaks. A similar finding by De Leeuw *et al.* (1995) reported outbreaks of ECF in cattle when the Maasai moved their stock to apparently affected areas to escape drought. Other studies by Norval and Perry, 1990 and IFAD, 2000 have shown extensions of distribution of *R. appendiculatus* into dry areas during years of above average rainfall as a result of occurrence of foci which have favourable micro-climates. Serious losses, even among local breeds, may occur with changes to the environment (Chinombo *et al.*, 1989).

There was a variation in reported incidence of ECF (by proportional piling method) across the cattle age groups in all the study districts with overall mean morbidity of 37.9% in calves and 17.1% and 19.4% in weaners and adults, respectively, and resultant mortality rates of a similar trend (23% in calves and 10% in both weaners and adults). The results were consistent with the findings by a conventional epidemiological method from a study in Rusinga Island, Western Kenya based on zebu cattle kept under traditional husbandry conditions (Latif *et al.,* 1995) where ECF accounted for 21% mortality in calves.

In the current study, the pastoralists had a general observation that calves that were exposed to ECF early in life developed some resistance to subsequent infection and thought it was a reason for the low incidence of disease in weaners and adults. However, animals that escaped infection while young are more susceptible to infection at older age due to their naive immune system which is evidenced by the slightly higher reported morbidity of 19.4% compared to 17.7 % in adults and weaners respectively. This is a clear indication of possible endemic instability due to low periodic tick challenge, hence the lack of development of immunity against the disease (Moll *et al.*, 1984; Moll, 1986; Norval *et al.*, 1992). This observation by the livestock keepers underscores the need for induction of immunity in pastoral herds to avert mortality risks from ECF outbreak.

In relation to other diseases used as controls, cases attributed to ECF in all age groups were high (21%) compared to those for trypanosomosis (15%) and other diseases (18%) put together. It is possible that the scoring of diseases of importance presented in the results are likely to have been influenced by the perceived incidences reported during the study period which in turn had an effect on the perceived importance of the same disease. The mortality rates as a result of ECF in different age groups irrespective of age of the animal were within the reported range of 0 – 50% in endemic areas though from different study designs (Staak, 1981; Moll *et al.*, 1984; Berkvens *et al.*, 1989). The reported high mortality in calves may be as a result of difficulties encountered in diagnosis of early cases of the disease in this age group and hence treatment was usually delayed and/or incorrect. On the other hand ECF in weaners and adults was thought to be as a result of mixing of animals in grazing areas where they were in constant contact with the tick vector.

The detection of serum antibodies for the major tick-borne diseases of focus in this study confirmed their existence and provided an understanding of the degree of endemic status in the region. Only cattle over 4 months of age were sampled to avoid confusion with passively transferred colostral antibodies which in the case of *T. parva* have been shown to decrease to undetectable levels by the age of 2-4 months (Burridge and Kimber, 1973). It was therefore concluded that the antibodies detected in animals during this study were due to infection. Results from the study indicated that there was no significant difference in serum antibody prevalence to *T. parva* across the grazing management and production systems.

The overall sero-prevalence estimate of 25.8% was suggestive of the existence of the disease in probably an endemically unstable state based on the understanding that an endemic stable state is characterized, among other things, by high antibody prevalence (>70%) and low or no mortality due to a constant tick challenge, while endemic instability is characterized by low antibody prevalence of <30% (Norval et al., 1992; Deem et al., 1993; Perry and Young, 1995). However, this could not be strongly supported in the absence of other parameters such as morbidity and mortality rates in various age groups *Anaplasma marginale* and *B. bigemina,* antibody profiles were significantly different across the grazing management and production system. Animals in pastoral areas had higher antibody levels (> 60%) than those in agro-pastoral areas. This could be explained by the difference in *B. decoloratus* tick challenge as a result of the variation in tick control measures across the production systems. *Anaplasma marginale* and *B. bigemina* antibody profiles showed intermediate antibody prevalence (approximately 50%) and provides evidence that the infections were widespread in the region.

None of the TBDs had serum antibody prevalence rates typical of an endemically stable state. However, the low levels of *A. marginale* and *B. bigemina* piroplasms detected in blood smears from cattle selected for serology, together with a low risk of clinical cases reported by the livestock keepers suggests the possibility of the two diseases occurring in sub-clinical states and most of the animals were carriers of the infections. It was possible that livestock keepers were more concerned with the disease causing overt cattle mortality and subsequent economic impact rather than the sub-clinical infections that had no obvious clinical manifestation and impact on cattle-derived benefits. This may result in indirect production losses especially if there is no initiative to institute appropriate treatment and control measures by most of the livestock keepers who may not be aware of the existence of the diseases either as single or mixed infections.

Indeed, anaplasmosis which was the second most prevalent disease according to serological results was not mentioned in any of the groups among the important diseases. The disease was perceived to be absent by most of the livestock keepers. In most cases, anaplasmosis may be mild and with less distinct clinical signs thus making it difficult to diagnose compared to ECF and babesiosis. This increases the risk of confusion of the disease with other diseases.

Results from the various group discussions demonstrated good agreement among the informants on effects of the diseases on most of cattle benefits. East Coast fever was reported to exert the greatest impact on benefits relative to other diseases. The impact on milk was greatly felt by most of the respondents and this was attributed to the losses experienced as a result of deaths of both adults and calves which seriously affected the herd structure. In addition, they also cited a reduction in milk yield during the convalescence period of the disease and the loss of calves which had a significant effect on milk let-down and lactation period of the dams. It was reported that, cows losing calves almost dry-up immediately due to lack of the suckling stimulus to maintain milk production. A study in Malawi using different study design, reported a mortality rate of 66% in calves affected by ECF in each year's calf crop before they reach two years of age (Moody, 1987). Radley *et al.,* (1981) observed that ECF caused a reduction in productivity and was also costly because of the money and time spent on tick control. The disease also affected other cattle derived benefits including cash, dowry, meat, manure and hides. Income from sale of cattle and cattle products was shown to reduce significantly as a result of outbreak of the disease, hence lowering purchasing power of households. Except for trypanosomosis which, according to the livestock keepers, had the second highest economic impact, the other diseases were reported to be either seasonal or rare in occurrence and their individual effects on cattle benefits were of little importance.

Analysis of ECF and associated risk factors indicated that the disease followed a seasonal pattern of occurrence and was closely linked with rainfall and the presence of the vector ticks. Otim (1989) noted that majority of animals in the drier areas lack immunity and outbreaks of ECF occur in periods when tick burdens are unusually high. There was moderate to good agreement among the different informant groups with coefficient of concordance (W) values on the seasonality of ECF and its risk factors among different groups with W values between 0.31 and 0.98. The findings indicated that the livestock keepers were scoring the disease and it associated risk factors using a similar standard according to critical values for W provided by Siegel and Castellan (1994).

Ticks were perceived to be present in high numbers during the wet season and the inter-phase. The most frequently found species was *R. appendiculatus*, followed by *B. decoloratus*, *A. variagatum* and *Hyalomma* spp in order of abundance. Rainfall was found to be the main climatic factor that affected seasonal variation in the tick infestations and occurrence of ECF which was consistent with the findings of Pegram *et al.* (1982). There were high cases of ECF perceived to occur after the rainy season. The pronounced effect of seasons on the occurrence of ECF could be attributed to the seasonal activity of the tick vector, *R. appendiculatus*. This is to be expected as climatic conditions become very favourable for tick survival allowing intensive vector-host interactions and subsequent challenge of cattle with *T. parva*. This was revealed in seasonal calendars and the village maps developed by the informants during the participatory exercises. The findings form an important aspect in epidemiology and control of ECF in these areas.

There was evidence from the study that herd disease control is mostly in the hands of livestock keepers and majority (67%) of them carried out animal drug administration on their own with very few of them seeking expert consultation. This is an indication that veterinary service delivery in marginal areas remains a hurdle to cattle production. It is generally accepted that these areas are characterized by poor infrastructure, harsh climate, low household incomes, and low literacy levels. Very few veterinarians are willing to work or set up private practices in these areas, given the cost of establishment and the low demand for these services (Umali *et al*, 1994).

Although a majority of the livestock keepers in the region (94.6%) use commercial drugs for treating sick animals, they may not be knowledgeable about their application. For example in this study, most of the livestock keepers reported long dipping intervals and incorrect acaricide mixing regiments which are indications of lack of proper tick control practices common in the study areas. Minjauw and McLeod (2003) noted that it is important to get the correct levels of treatment as acaricide resistance may develop with under-dosing and skin damage with over-dosing. This improper acaricide use is indeed a key issue for veterinary extension.

Finally, the study provided a preliminary assessment of VBD infections in pastoral and agro-pastoral production systems in northern Rift Valley region. Given the role played by livestock to livelihoods in these areas, the economic importance of ECF and other VBDs and the livestock keepers' knowledge of the diseases, there is need for stakeholders in the livestock industry, to reconsider developing control options that are supportive of the production systems. This calls for the establishment and/or strengthening of their collaborative network in an effort to come up with alternative control strategies of ticks and VBDs and better ways of delivering the technologies to the marginalised pastoral communities. The immediate challenge is to improve on field extension and animal health delivery services in pastoral areas. It is important to integrate the livestock keepers' indigenous technical knowledge and modern concepts of disease occurrence, transmission dynamics and prevention to facilitate uptake of current recommendations for control of the disease and the associated causative agents in order to promote livestock productivity and sustainability in marginal areas.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

A number of epidemiological studies on East Coast fever have been carried out and reports widely published for the dairy and mixed farming systems in high potential areas of the country. There are, however, very few, non-specific reports from the pastoral and agro-pastoral production systems in marginal areas and in some cases, it is believed that the climatic conditions here are not favorable for the tick vector responsible for transmission of the disease. A lack of baseline data has made it hard to estimate the prevalence and economic impact of the diseases in pastoral livelihoods in the North Rift Valley. The present study provided an opportunity to realize community perceptions and generate quantitative and qualitative information about the status of the disease in the region which is expected to form a basis for detailed investigations to be undertaken in future.

The study has shown that the incidence and prevalence of ECF and other Vector-Borne Diseases like Babesiosis and Anaplasmosis is high among the pastoral communities in the Northern Rift Valley. However the serum antibody levels detected in blood samples were suggestive of the existence of the disease in probably an endemically unstable state based on the understanding that an endemic stable state is characterized, among other things, by high antibody prevalence (>70%) and low or no mortality due to a constant tick challenge, while endemic instability is characterized by low antibody prevalence of <30% (Norval et al., 1992; Deem et al., 1993; Perry and Young, 1995). *Rhipicephalus. appendiculatus*, the vector ticks responsible for the transmission of ECF were collected from the animals selected for bleeding during the study. The finding further confirmed the existence of tick in the region otherwise thought to be unfavorable. Rainfall was found to be the main climatic factor that affected seasonal variation in the tick infestations and occurrence of ECF which was consistent with the findings of Pegram *et al.* (1982).

There was a variation in reported incidence of ECF across the cattle age groups in all the study districts with high morbidity (37.9%) and mortality (23%) in calves compared to weaner and adults (where morbidity was estimated at 17.1% and 19.4% respectively and mortality at about 10% for both weaners and adults). The pastoralists observed that calves exposed to ECF early in life developed some resistance to subsequent infection and thought it was a reason for the low incidence of disease in weaners and adults. The finding gives much support to the induction of immunity in pastoral herds to avert mortality risks from ECF outbreak.

The study provides an understanding of livestock keepers' of knowledge on the etiology of ECF, its association with risk factors and control options including traditional practices available for the communities in pastoral and agro-pastoral livestock production systems. The results indicate that livestock keepers are good at ECF symptoms and differential diagnosis but the transmission mechanisms and association with some risk factors is poorly understood in most areas. In most cases herd management is in the hands of livestock keepers with most of them being the main administrators of animal drugs and only a few seek expert consultation. This is of great importance to stakeholders involved in livestock disease control in order to improve on the current animal health delivery schemes in marginal areas.

6.2. Recommendations

The approach to this study was particularly suitable for investigating animal health problems in highly mobile herds in the remote and insecure pastoral settings in the study areas that were characterised by poor infrastructural network and high levels of illiteracy. Under such conditions, conventional veterinary investigations and epidemiological methods would have been constrained by the severe operational and resource limitations. Data collected during this study was subjected to a limited level of randomization and supported by collection and testing of key biological samples including serum, blood smears and tick specimens for identification and examination for results to be compared by a process of triangulation. The use of a mixture of quantitative and qualitative methods was expected to reduce the above concerns about the reliability and validity of the results.

The study was, however, based on some specific locations and communities with small sample sizes and therefore extreme care should be taken when extrapolating the results to describe the wider production system. It is worthy to note that the relative incidence rates of ECF obtained during this study were based on cases of diseases observed during the year 2005-2006 and reported by pastoralists. Although the results were within the range reported in many conventional studies they were dependent on the livestock keepers' ability to diagnose and remember episodes of occurrence and their knowledge on symptoms of diseases which was subject to recall and person bias. It would be interesting to compare the results obtained during this study with those from exercises repeated with many group discussions and key informants with varying degrees of knowledge in order to ensure a more accurate estimate of disease incidence in ASALs by pastoralists. Equally, there is need to conduct well structured epidemiological studies to get a more accurate estimate of the disease.

In an effort to improve the delivery of animal health services in marginal areas, the government should consider increasing public expenditure for veterinary services in these areas and to devolve some services from the central government to private, public, and community sectors (including other cadre of trained animal health workers) in order to adequately exploit the resultant positive synergy. Mobile veterinary clinics can be licensed to allow livestock keepers access drugs and other veterinary services along migratory routes in search of pasture during periods of drought due to their nomadic nature of life.

The findings from this study are expected to guide future research aimed at developing appropriate and sustainable disease control strategies especially ECF and other VBDs in pastoral and agro-pastoral production systems. In addition the findings will redirect efforts of the extension staff to meet the interests of the livestock keepers. However, the author recommends a more detailed epidemiologic study to be conducted in marginal areas based on the baseline results of this study to provide further evidence on the incidence and prevalence of ECF and other VBDS, and a broader quantification of losses incurred by the livestock keepers in this region, including an economic study on losses and market opportunities.

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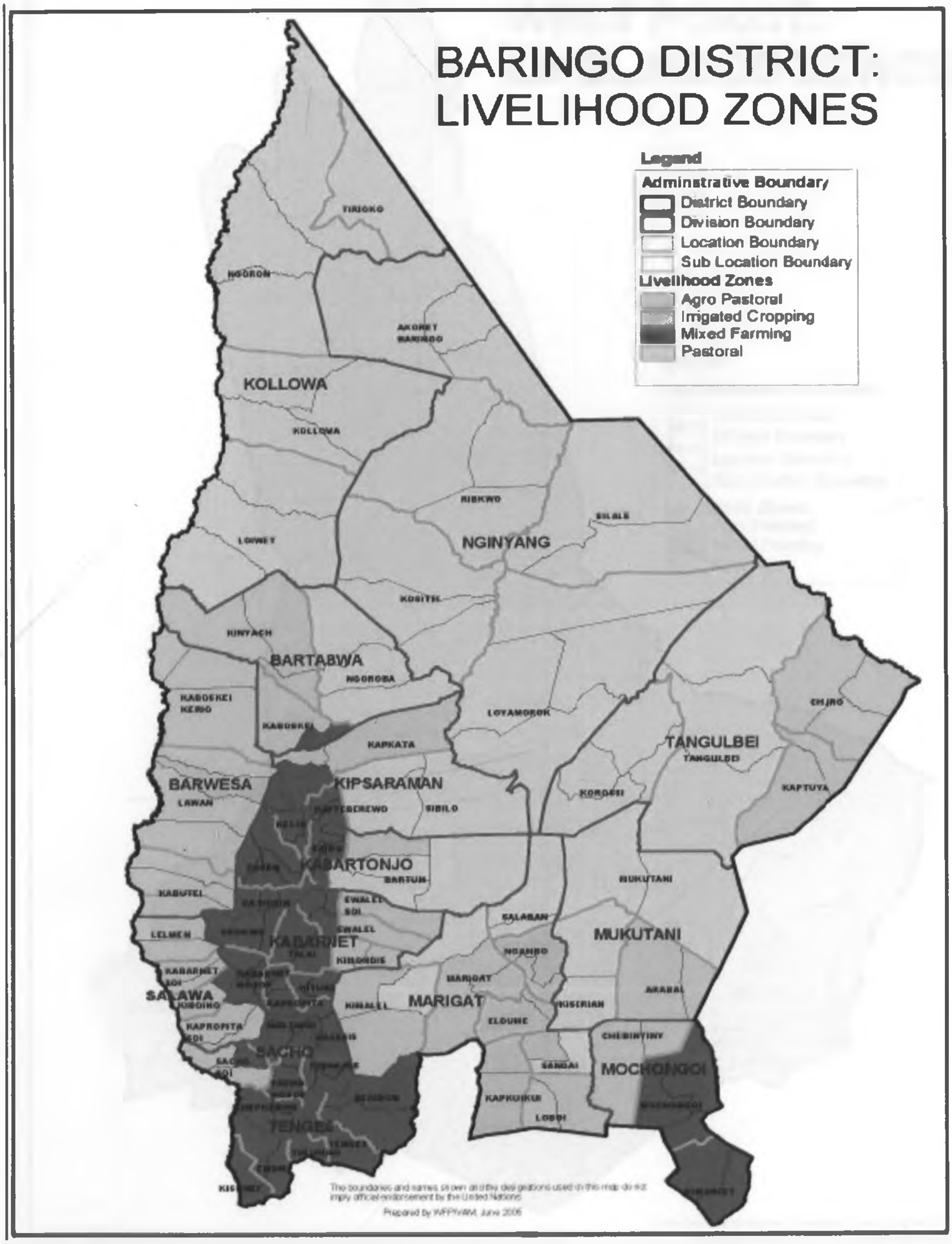
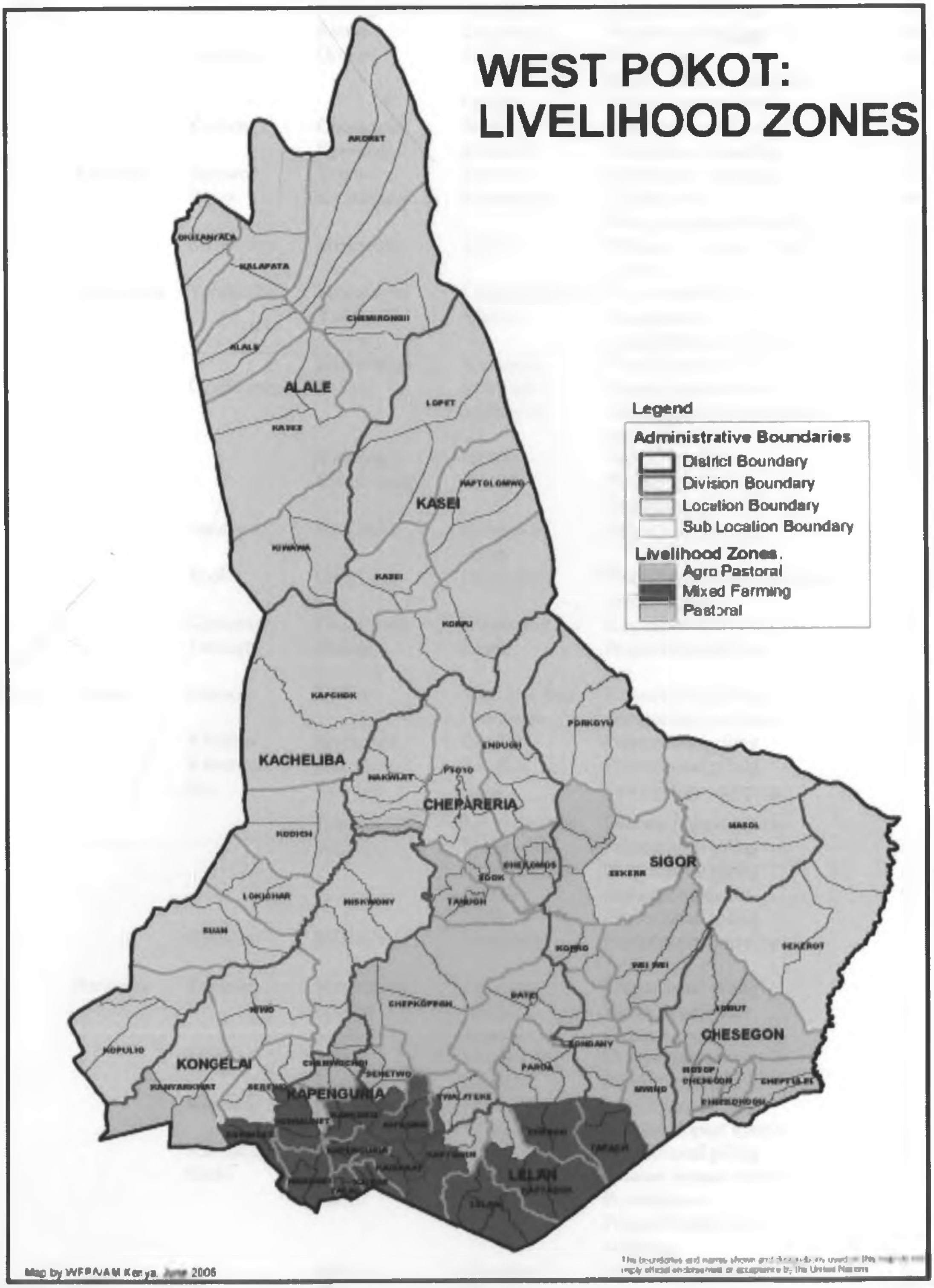
APPENDICES

Appendix 1: Baringo District: Livelihood zones.



Source; Drought Monitoring Bulletin; Arid Lands Resource Management Project II, May, 2007.

Appendix 2: West Pokot District: Livelihood Zones.



Source; Drought Monitoring Bulletin; Arid Lands Resource Management Project II, May, 2007.

Appendix 3: Summary of study sites and PE exercises conducted.

District	Division	Locations	S/Locations	Villages	PE exercise conducted	Participants
West-Pokot	Kacheliba	Kopulio	Nakuyen	Lokomolo	Proportional piling	17
				Kitaralengen	Seasonal calender	12
		Suam	Ng'eng'echwo	Katuberot	Proportional piling	19
			Karon	Lopsiekou	Proportional piling	14
		Lokichar	Orolwo	Kapul	Proportional piling/Seasonal calender	10
				Orolwo	Disease impact matrix	12
		Kodich	Cherangan	Nakwijit	Disease impact matrix	20
			Karameri	Karameri	Particpatory mapping	18
	Kongelai	Serewo	Serewo	Serewo	Particpatory mapping	18
		Riwo	Kitalakapel	Kitalakapel	Proportional piling/Seasonal calender	20
		Miskwony	Miskwony	Lokuna	Disease impact matrix scoring	15
	Chepareria	Ywalateke	Mongorion	Chepkorniswa	Proportional piling	27
			Ywalateke	Karron	Proportional piling/Seasonal calender	17
			Kachemuge	Kamanwa	Proportional piling	11
		Chepkopegh	Pserum	Lokwapuo	Disease impact matrix	23
				Kishaunet	Proportional piling/disease impact matrix	7
			Sialpough	Tiriken	Proportional piling	11
			Chepkopeigh	Kaikai	Proportional piling /Participatory mapping	14
		Senetwo	Korellach	Korellach Parak	Proportional piling	31
		Sook	Chepnyal	Chepnyal	Proportional piling/Disease impact matrix	26
		Kipkomo	Chepareria	Chepareria	Key informant interview	2
		Tamugh	Tamugh	Patei	Proportional piling	10
Baringo	Salawa	Lelmen	Lelmen	Sach ang'wan	Proportional piling	12
				Chesongo	Disease impact matrix	9
		Kiboino	Kapyemit	Kipsoit	Proportional piling	26
		Kabarnet-Soi	Kiboino	Kiboino	Proportional piling	17
			Kimoso	Eron	Particpatory mapping	7
			Kabarnet soi	Kurumpopsoo	Disease impact matrix	12
			Salawa	Metipmoso	Proportional piling	11
				Kabarnet-Soi	Proportional piling	10
				Salawa	Seasonal calender	10
				Endo	Proportional piling	7
		Kiboino	Kiboino	Oinobmoi	Particpatory mapping	8
	Barwessa	Kaputiei	Muchukwo	Turuturu	Proportional piling	21
			Katibel	Katibel	Seasonal calender	21
			Kapluk	Kiptolyo	Disease impact matrix	14
		Lawan	Konoo	Kerewonin	Disease impact matrix	16
			Kaptilomwo	Likwon	Proportional piling	14
		Kinyach	Barwessa	Kipkolony	Proportional piling	18
			Kinyach	Tilingwo	Disease impact matrix	15
		Kaboskei-Kerio	Keturwo	Litein	Proportional piling	18
			Marigut	Marigut	Disease impact matrix	15
			Kuikui	Kuikui	Proportional Piling/Participatory mapping	15
			Ayatya	Chatingoi	Proportional piling	8
TOTAL	5	21	37	44		658

Appendix 4: Checklist for the investigation of ECF and other TBDs in pastoral and agro-pastoral areas of Rift Valley, Kenya.

1. Introduction of the appraisal team.
2. Self introductions by the participants.
3. Mission statement.
5. Prioritization of livestock species kept.
4. Identification of livelihood activities in the area.
6. Listing of general constraints affecting livestock keeping.
7. Identification and description of diseases commonly affecting the major species of animal kept.
8. Proportional piling exercises on disease importance.
9. Disease impact matrix scoring on the effects of diseases on benefits derived from the major species of animal kept.
10. Seasonal calendar on disease occurrence relative to risk factors
11. Participatory mapping of grazing locations, dry season grazing areas, migratory routes, tick and disease risk areas
12. Semi-structured interviews for further explanations on results from PE exercises

NB: The target disease was not introduced as a subject of discussion to avoid biased and exaggerated results. Otherwise the basic principle was to discuss general disease issues until the respondents raised the target disease as a problem which gave a chance for the facilitator to probe more into the issues.

Appendix 5: Pokot /Tugen Lexicon.

English	Pokot	Tugen
B. Important Cattle Diseases		
Contagious Bovine Pleuro-pneumonia	*Loukoi*	*Chebuon*
East Coast Fever	*Lokit/yit/Cheptigon*	*Cheptiogon*
Heartwater	*Chepirpirmet/Chemilei*	
Trypanosomiasis	*Plis*	*Esse*
Lumpy Skin Disease	*Perperoi*	*Kiporom*
Babesiosis	*Kissen*	*Siboeni*
Foot and Mouth Disease	*AyalaNgo'rien*	*Maigut*
Blackquarter	*Kotit/Tiombo ugho/Tiombo barak*	
Ephemeral fever (3-days sickness)	*Cheployos*	*Chemukuny*
Insect poisoning	*Muserer*	
Anaplasmosis	*Sak*	
Bloat	*Lotony*	*Lotul/Lessan*
B. Disease vectors		
Ticks	*Tilis/Singor*	*Kerbes*
Tsetsefly	*Tapirwak*	*Soisoiyon*
C. Seasons		
Wet season	*Sarng'atat/Peng'at*	*Iwot*
Interphase	*Kitokot*	*Roron*
Dry season	*Komoi*	*Kemei/Telelo*
D. Benefits from Cattle		
Milk	*Cho*	*Chego*
Calves	*Mow*	*Moi*
Meat	*Peny*	*Pendo*
Cash	*Ropien*	*Ropia*
Hides	*Menyon*	*Mui*
Dowry	*Tartaigh*	
Blood	*Kisen*	*Korotik*
Cud	*Ngo'muiyon*	*Eyan*
F. Others		
Grass	*Sus*	*Suswo*
Water	*Pough*	*Bek*
Lymph nodes	*Ng'uriel/Tigiren*	*Ng'ulyel*
Lungs	*Puon*	*Puon*

Appendix 6: Household Questionnaire used during collection of sera.

1. Enumerator Name……………………………………………………………………………

2. Questionnaire Number...................................Date of Interview…………...…...............

3. District...Division……………………...Location…………….

4. GPS readings…………………………………...…Elevation……………………...…

5. (a) Name of Respondent……………………………………Gender……………………

b) Major sources income.

1) Farming (Specify if crop, livestock or both)
2) Business
3) Civil servant
4) Other

c) Annual income (Kshs)

1=less than 50000
2=between 50000 & 100000
3=100000-500000
4=over 500000

d) Family size _________ members.

e) Children level of education.

	Upper primary (Class 6 & above)	Secondary	College	Other (specify)
No.currently in:				

f) Current cattle herd size.

Sex	Calves (0-12 months)	Weaners (12-18 months)	Immatures (18-36 months)	Adults (>36 months?)
Male				
Female				

6. Production system practiced (Enumerator to observe and record).

1) Pastoral
2) Agro-Pastoral
3) Others (specify)

7. Breed of cattle in the farm/boma.
   1) Exotic (Friesian, Guernsey, Aryhire, Jersey), Tick where applicable
   2) Crossbred (specify)
   3) Indigenous (Zebu,Boran, Sahiwal) , Tick where applicable

8. Grazing system practiced.
   (1) Pivate paddocks
   (2) Communal pastures
   (3) Others. (Specify)

9. Water sources for cattle.
   (1) Piped water
   (2) Stream/River.
   (3) Borehole
   (4) Dam
   (5) Others (Specify)

10. Tick control practices.
   0) No
   1) Yes

11. (a) [If Yes] frequency of tick control.
   1. Once weekly
   2. Once fortnightly
   3 Once every 3 weeks
   4. Once a month
   5. Other (specify)

   b) Mode of application.
   1) Plunge dip [Communal]
   2) Handspray
   3) Hand wash
   4) Spray race
   5) Other (specify)

   c) Which acaricides did you use in the last one year? ______________________________

   d) Mixing regiment: I put __________ milliltress of acaricide in ________litres of water.

12. Perceived TBD challenge.

Perceived challenge	ECF	Anaplasmosis	Babesiosis
High			
Medium			
Low			

13. Cases of TBDs in the herd within the year.

Cases of TBDs in herd	ECF	Anaplasmosis	Babesiosis
<5			
5 - 10			
>10			

14. Treatment options employed.
   1) Traditional remedies/medicine
   2) Commercial drugs
   3) None

15. Veterinary service provider(s).

Service provider (SP)	Charges/case			Distance from homestead to SP	Most preferred SP	Most used SP
	ECF	Anap.	Bab.			
1. Government vet						
2. Private vet						
3. Private AHA						
4. Community animal health worker						
5. Other specify						