CALF HEALTH AND PRODUCTION UNDER MAASAI PASTORAL SYSTEMS IN KAJIADO DISTRICT OF KENYA

By

Stephen Karimi Kibiru
BVM (Nairobi, Kenya), MVM (Glasgow, Scotland, U.K.)

A thesis presented for the award of Degree of Doctor of Philosophy (PhD)

In

Veterinary Epidemiology

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

DECLARATION

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

----

Stephen Karimi Kibiru

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

----

PROF. J. M. GATHUMA (BVSc, MSc, PhD)
Department of Public Health, Pharmacology and Toxicology
P.O. Box 29053, Nairobi

PROF. J. J. McDERMOTT (DVM, MPVM, PhD)
International Livestock Research Institute, P.O. Box 30709, Nairobi

----

DR. G. K. GITAU (BVM, MSc, PhD)
Department of Clinical Studies, P.O. Box 29053, Nairobi

DR. R. KINUTHIA NGUGI (BSc, MSc, PhD)
Department of Range Management, P.O. Box 29053, Nairobi

DEDICATION

To

The Glory of God the Father,

the Son Jesus Christ, and the Holy Spirit

ACKNOWLEDGEMENTS

I am very grateful to the Government of Kenya, the Kenya Agricultural Research Institute (KARI) and the European Union (EU) for the award of the scholarship that enabled me to undertake this project. I would like to thank Dr. R.M. Kiome, the former Director KARI, for granting me study leave in order to implement the project. Many thanks also to Dr. H. Recke and all the staff working in the National Coordination Unit of the EU-KARI Agricultural Research Support Program (ASRP) II for providing the necessary logistic backup.

I am very grateful to my supervisors and mentors, Prof. J.M. Gathuma, Prof. J.J. McDermott, Dr. G.K. Gitau and Dr. R.K. Ngugi for their friendship, patience, support and encouragement. You have been a great source of inspiration. I say thank you to all of you. Many thanks to Prof. J.J. McDermott made arrangements for my attachment at the International Livestock Research Institute (ILRI) as Research Fellow to enable me have access to excellent laboratory and library facilities. I am particularly grateful to colleagues at the Epicenter (Dr. B.D. Perry, Dr. T. F. Randolph, Dr. H.K. Kiara, Dr. A. Lee, Dr. L.W. Ndungu, Dr. J.M.Mugambi, Dr. J. Githiori, Dr. J.C. Njanja, Dr. B. Bett, Mr. P. Irungu, Mr. S.G. Kuria, Mrs. Vivian Maina, Ms. Stella Masawe, and Ms. Carol Mugo). You helped to create an enabling environment that was conducive for the study. Thanks for great company and friendship. I am also grateful to the following persons who gave useful advice and assistance during the implementation of this project: Dr. S. Morzaria, Dr. A. Musoke, Mr. J. Katende, Mr. S. Mwaura, Mr. T. Njoroge, Ms. Alice Njoki, and T. Njuguna.

I am very grateful to Mrs. Brigid McDermott who gave me a lot of support and training in Biostatistics. The late Dr. Thomas Gitau and Ms. Caroline Mugo gave me assistance in creation of Microsoft Access database. Thanks also to Sonal Nagdal, Crispin Matere and Nicholas Ndhiwa who shared their experiences on statistical data analysis. Russ Kruska, S. Massawe, Joseph Matere and M. Baya assisted with the use of GIS. Thanks to G. Ogoti, S. Kisonzo, H. Kariuki and T. Nganga for sorting out my computer hardware and software problems. Thanks also to Mbindyo and Mureithi who took care of my automobile problems.

Thanks to the KARI Assistant Directors Mrs. L. Kimani (Training), Dr. H. Cheruiyot (Range Management) and Dr. L. Wamae (Animal Health and Production) whose encouragement gave me hope in times of desperation. I thank the Centre Director, Mr. P. K. Kibet, and the entire staff of KARI Kiboko for their support. The Centre Director and the Coordinators of the EU program at Kiboko (Mr. W.N. Mnene and Dr. A. M. Gitunu) facilitated the flow of finances and other logistics. I am grateful to Mr. A. Mosu and Mr. D. Kamunyu who assisted in collection of field data.

I interacted and consulted with members of the Department of Public Health, Pharmacology and Toxicology (PHPT) on various issues including the administration of the thesis. I am particularly grateful to Prof. F. M. Njeru, Chairman of the Department, for his great concern and encouragement. I wish to extend my thanks to my 'extended family' at ANP hostel (Kiiru, Leiyan, Tezira, Zipporah, Wambua, Korir, Luiz, Marjorie, Beatrice) for friendship, moral and spiritual support. Together we endured some very hard times from thugs but God gave us the strength and love to support each other. I will miss you all. Many thanks also to the Extension Staff of the Ministry of Agriculture and Rural Development and the Ministry of Livestock and Fisheries Development, Kajiado District, namely, Dr. E. Wanasamba, Mr. G. K. Mwangi and J. Waweru who gave a lot of assistance throughout the course of the study. Thanks also to the Maasai pastoralists who allowed me to sample their herds.

I am very grateful to my Dad, Mr. O. Kibiru Githendu, my mother, Mrs. B. Wanjiru Kibiru, and Mother-in law, Mrs. P. Wambugi Njagi, brothers, sisters, nephews, cousins, uncles, aunties and friends, for their unconditional love which provided social, moral and spiritual support that I needed all along. I take this opportunity to pay special tribute, albeit posthumously, to Mr. Timothy Githendu, my elder brother, and Mrs. Florence Njeri Kuria, my sister. Both of them passed on in the middle of my study. They encouraged me to excel in my career. Rest in peace until we meet.

And finally to my dear wife, Rosemary, who took up extra family responsibilities to ensure that all was okay when I was away. Thanks for your tremendous support and understanding. And to my dear daughters, Patience Wanjiru, Faith Nyawira and Grace Njoki, thank you for your understanding. Many times I was not there to give you and receive love from you, but now we can settle down and catch up.

To God be the glory for the great things He has done.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AD	Assistant Director
ACZ	Agro-climatic zone
ADWG	Average Daily Weight Gain
AHA	Animal Health Assistant
AIC	Alkaike's Information Criteria
ASAL	Arid Semi Arid Lands
CBAHS	Community Based Animal Health Services
CBPP	Contagious Bovine Pleuropneumonia
CI	Confidence Interval
DAHS	Delivery of Animal Health Services
DLPO	District Livestock Production Office
DPBS	Diphosphate Buffered Saline
DVO	District Veterinary Office
e.p.g.	Eggs per gram of faeces
ECF	East Coast Fever or theileriosis
ELISA	Enzyme-Linked Immunosorbent Assay
EU	European Union
FAO	Food and Agriculture Organisation
GEE	Generalised Estimating Equations
GIS	Geographical Information Systems
GL-CRSP	Global Livestock-Collaborative Research Support Program
GLIMMIX	Generalised Linear Mixed Models
GLM	Generalised Linear Model

GoK	Government of Kenya
ICIPE	International Centre for Insect Physiology and Ecology
ILCA	International Livestock Centre for Africa
IPAL	Integrated Program on Arid Lands
ITM	Infection Treatment Method
KARI	Kenya Agricultural Research Institute
LSD	Lumpy Skin Disease
MARD	Ministry of Agriculture and Rural Development
NIRS	Near Infrared Spectroscopy
OD	Optical Density
OLR	Ordinary Logistic Regression
OR	Odds Ratio
PCV	Packed Cell Volume
PI	Principal Investigator
PPS	Pastoral Production Systems
PPV	Percent Positivity Value
PRA	Participatory Rural Appraisal
RBT	Rose Bengal Plate Test
RR	Relative Risk
RRA	Rapid Rural Appraisal
RT	Room Temperature
SAPS	Structural Adjustment Programs
SAS	Statistical Analysis Software
SD	Standard Deviation
SE	Standard Error

SSA	Sub-Saharan Africa
TBDs	Tick Borne Diseases
UNDP	United Nations Development Program
UNESCO	United Nations Education Scientific Cultural Organisation
USAID	United States of America International Development
WASH	West African Short Horn

ABSTRACT

The on-farm study described in this thesis involved the use of novel research methodologies and approaches including the application of Participatory Epidemiological tools in conjunction with conventional veterinary investigation techniques to analyse the causes of poor calf health and production in Maasai pastoral systems in the southern rangelands of Kenya. The use of participatory approaches ensured that Maasai pastoralists were involved in the design of the study through identification and ranking of calf health and production constraints. Thus, neither did the Principal Investigator choose the disease or diseases to be investigated nor did he envisage the emphasis on tick borne diseases, especially East Coast fever or theileriosis.

The epidemiological study on factors associated with poor health and slow growth rate of calves in Maasai pastoral systems was implemented in three phases using a combination of different study approaches for data collection, i.e Rapid Rural Appraisal (RRA), Cross-section Survey and Longitudinal Observational Study, consecutively. The RRA was used to assess the community's perceptions of the causes of the constraints for improved calf health and productivity in the district. The results indicate shortage of water was the most important constraint followed by high incidence of disease, lack of extension services, feed shortage, wildlife menace, costly inputs, lack of credit facilities, livestock marketing, communal land ownership. Of the diseases of calves that were cited, tick-borne diseases (especially theileriosis) were ranked the highest, followed by foot and mouth and helminthosis. Due to the limited extension services, many pastoralists were forced to treat their own animals. Although the pastoralists have a wide

knowledge of clinical signs of diseases, they were not clear about the actual causes. Thus, quite often they gave the wrong treatment for certain diseases. A wide range of ethno veterinary practices were also used to treat livestock diseases.

Qualitative methods of data collection and analysis for epidemiological studies useful in identification of constraints for improved calf health and productivity. Besides being cheaper to implement, qualitative methods enhanced participation of stakeholders, allowed investigation of broad objectives and provided results rapidly. However, they failed to provide necessary precision in specific evaluations of disease risks, productivity measures and intervention studies. Thus, the need for elaborate investigations using cross-sectional and longitudinal studies to analyse prevalence and incidence of diseases.

In the cross-sectional study, both qualitative and quantitative methods were used to characterise the Maasai pastoral cattle production systems, and identify the factors that enhance the prevalence of tick borne diseases of calves in the study area, and the methods applied at farm level to control them. This study showed that major changes in livestock production were taking place in this area. These changes were mainly attributed to changes in land tenure systems, increased human population pressure and orientation towards commercial farming. More productive breeds which are more susceptible to a wide range of diseases have recently been introduced into these area. Animal Health Delivery Systems remain inadequate. Grazing land continues being excised for crop cultivation.

The pattern and distribution of estimates of sero-prevalence of TBDs and the associated risk factors varied between and within agro-climatic zones, group ranches and farms. The study suggests that environmental factors (vector distribution), farm management (watering and grazing practices) and calf factors (age, breed) were playing a major role in the epidemiology of TBDs in the district. The study suggested that targeted rather than blanket immunisation of calves and other tick control measures be conducted, targeting agro-climatic zones, group ranches and farms.

The longitudinal study was conducted to quantify the incidence of the diseases that cause morbidity, mortality and slow growth of calves. Emphasis was on the role of TBDs, especially theileriosis and anaplasmosis because it was perceived that they had the greatest impact on survival and growth of the calves through decreased average daily weight gain (ADWG), mortality and high cost of treatment and control. The overall ADWG was 0.26 kg (range=-0.57-0.81 kg). Both farm- and calf- factors were associated with ADWG of calves. Average daily weight gain of calves was associated with age, initial calf body weight, occurrence of clinical illness, lower amounts of milk fed to calves, decrease in frequency of water intake, and seroconversion rate of *T. parva*, *T.mutans* and *A. marginale*.

The causes and patterns of morbidity and mortality in pastoral calves during the first 12 months after birth were also investigated. The study which involved 593 calves from 23 herds showed that the risk of calf morbidity was greatest during the first month of life and decreased gradually up to seven months. About 27 per cent of the calves did not fall sick during the first 12 months while 88 per cent of the calves survived during the same period. The main causes of morbidity were fleas, lice, ringworms, anaplasmosis, helminthosis and theileriosis, while the most common causes of calf mortality were theileriosis and anaplasmosis. The study suggests that calf management practices such as poor hygiene and overcrowding in the calf house or pen were major predisposing factors for high calf morbidity in the early stages of growth.

Calf mortality was highest between 5-10 months of age. The highest calf mortality coincided with the age when colostral antibodies had waned and calves started getting exposed to tick borne diseases. The study suggests that more attention should be given to the improvement of calf management practices early in life to reduce morbidity while integrated control of ticks and tick borne diseases through spraying and early immunization could increase the survivability of calves in pastoral herds.

The epidemiological status and economic impact of other diseases such as helminthosis, ecto-parasites (fleas, lice), ringworms and non-specific causes of diarrhoea in causing poor calf health and production was possibly underestimated and needs further investigation. These diseases which are mainly associated with poor calf husbandry practices were also ranked high by the pastoralists during the RRA. There is a wide range of interventions already available that could be applied to improve calf health and production in Maasai pastoral systems. Such technologies include improved calf husbandry practices (such as increased access to water, improved housing), immunisation against ECF, strategic deworming and vaccination against notifiable and contagious diseases such as black quarter, Lumpy skin disease. However, improving health constraints alone without addressing nutritional requirements of the calf will not be able to increase production substantially. Therefore`, besides the need for application of appropriate and integrated interventions for strategic control of livestock diseases, future research and development should address calf nutrition and management aspects in pastoral systems of the southern rangelands of Kenya.

In conclusion, this study has shown that epidemiological prevalence and incidence assessments confirmed pastoralists' perceptions of diseases causing poor calf health and production. Thus, a combination of qualitative data from the RRA and quantitative data from the cross-sectional and longitudinal studies showed that tick borne diseases, especially theileriosis and anaplasmosis, occurred in varying proportions throughout the study region and were indeed a major constraint to improved calf health and production in Maasai pastoral system.

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Overview of Livestock Production in Kenya

Livestock production accounts for about 10 percent of Kenya's Gross Domestic Product (GDP) and over 30 percent of farm-gate value of agricultural commodities (GoK, 2003). The livestock sector employs over 50 percent of the agricultural labour force and provides substantial raw materials for the local dairy, meat and meat processing industries, as well as hides and skins for tanneries, wool and hair. The total annual production of milk from cattle and goats was estimated at 3.1 million metric tones, equivalent to over Kshs 43 billion, whilst beef and small ruminant meat production was estimated at over 0.37 million tonnes, worth over Kshs 39 billion (GoK, 2003). Cattle production systems alone produced 89 percent of the total value of cattle, sheep and goat production. However, there is great potential for increased livestock production in this sector.

1.2 Livestock production in ASAL of Kenya

Kenya's arid and semi arid lands (ASAL) cover about 84 percent of the total land surface and support 25 percent of the human population and account for more than 80 percent of eco-tourism interests in the country (GoK, 2003). Presently, over 50 percent of the country's livestock population is based in the ASAL It is estimated that the livestock sector accounts for 90 percent of employment and more than 95 percent of family incomes in the

ASAL (GoK, 2003). Most of the livestock slaughtered in major urban centres today originate from these areas. These areas have the highest incidence of poverty, averaging about 65 percent, and very poor access to basic social services. The level of infrastructure development is also low compared to the other parts of the country and literacy levels are wanting (GoK, 2003).

The main production system in the ASAL is large-scale milk-meat (dual purpose) production through nomadic pastoralism (Peeler and Omore, 1996). Traditional nomadic pastoralism is based on communal grazing system and is well suited to the annual and seasonal fluctuations of rainfall of these areas (Jahnke, 1983). The pastoralists move to areas where forage and water may be found during dry periods. These movements have implications on animal health and usually result in transmission of highly infectious diseases, such as foot and mouth disease disease (FMD), Contagious Bovine Pleuropneumonia (CBPP) and East Coast Fever (ECF) from one place to another (MacPherson, 1994). In addition, such movements usually take livestock to remote areas which are inaccessible to conventional animal health services. Prevalent diseases go unrecorded and rarely are any attempts made to diagnose and control them. During periods of prolonged drought, free movement of livestock is necessary to prevent herds from overgrazing and damaging the fragile environments. When numbers of animals exceed the carrying capacity of the land, regeneration of vegetation is inhibited (Oba and Lusigi, 1987).

Delivery of animal health services in the ASAL is not easy due to the vastness of the area, the rough terrain, poor infrastructure and insecurity (Hubl *et al.,* 1998). Additionally, there is a severe shortage of qualified extension staff mainly due to the hostile environment described above. Funds allocated for operations and maintenance are insufficient, leading to shortage of transport, drugs and vaccines, and poor maintenance of equipment such as refrigerators. The result is a decline in service delivery leading to poor disease monitoring and surveillance, poor disease prevention and control (Hubl *et al.*, 1998).

1.3 Livestock production in Kajiado District

Kajiado is one of the ASAL districts in Kenya. The indigenous people, comprising of predominantly the Maasai community, practise nomadic pastoralism (Bekure *et al.,* 1991). However, some areas in the district, such as Loitokitok and Ngurumani that are arable and have attracted human settlements. Other areas in close proximity to Nairobi City, such as Ngong and Kitengela have also experienced rapid human settlement and urbanisation by settlements, with peri-urban agriculture (both crops and livestock) replacing communal grazing. Nevertheless, the bigger part of the district is semi-arid, with pastoralism being the predominant mode of life.

Recent studies indicate that nomadic pastoralism was steadily declining in Kajiado District (Kimani and Pritchard, 1998; Oyaya, 1998; Campbell *et al.,* 2000). This was attributed to frequent drought, rapid population growth, subdivision of ranches and creation of National Parks, which denied pastoralists access to the traditional dry season grazing and watering resources (Oyaya, 1998). Consequently, changes have occurred in livestock management including a decline in herd size, introduction of exotic breeds, improved housing and nutrition of calves (Mwangi, 2000).

Cattle account for 77 percent of the livestock units in Maasai areas while sheep and goats account for most of the remaining livestock units (Bekure *et al.,* 1991). The parameters that determine the productivity of a cattle herd are 1) the rproductive performance of the breeding females, 2) mortality, 3) growth rates from birth to maturity, and 4) the division of milk between calves and people (de Leeuw *et al.,* 1991). However, although overall mortality and growth are important, it is the cow-calf unit that drives the systems, in the short-term because of the milk supply and in the long-term because it is the number of calves, their survival and growth that determines the sustained viability the herd

1.4 Objectives of the study

The broad objective of this study was to identify the causes and provide quantitative data on estimates of morbidity, mortality and slow growth rates of calves under pastoral production system in the southern rangelands of Kenya. Additionally, information on calf management practices and traditional methods used by pastoralists to improve calf health and production was also investigated. The specific objectives are listed in chapters four, five, six and seven.

CHAPTER TWO

GENERAL LITERATURE REVIEW

2.1 Introduction

Pastoral production systems (PPS) are found in the arid and semi arid lands (ASAL) of Africa. The ASAL are characterised by low, erratic and poorly distributed rainfall and high temperatures (Sandford, 1983). Livestock production is the main economic activity, a source of food and cash for many pastoral families (Jahnke, 1983). The majority of pastoral communities living in the ASAL keep different kinds of livestock which have different feed and water requirements, ecological adaptation, growth rates, adaptation to diseases and management requirements (Cossins, 1983). The main livestock species are camels, cattle, sheep and goats, while the main products are milk and meat (Jahnke, 1983). Generally, it has been observed that camels and goats dominate as the degree of aridity increases possibly due to the associated decrease in pasture and increase in browse (Mace, 1989).

Livestock management strategies in PPS are characterised by close correlation between spatial and temporal distributions of water and forage (Jahnke, 1983). During periods of prolonged drought, free movement of livestock is necessary to prevent herds from overgrazing certain areas and damaging the fragile environment (Mace, 1989). The number of times and distance a given community migrates within a certain period depends on the degree of aridity. Migratory distances become longer as the degree of aridity increases, resulting in various types of pastoralism. Nomadic pastoralists occupy the most arid parts of the continent (Jahnke, 1983). They include the

CHAPTER TWO

GENERAL LITERATURE REVIEW

2.1 Introduction

Pastoral production systems (PPS) are found in the arid and semi arid lands (ASAL) of Africa. The ASAL are characterised by low, erratic and poorly distributed rainfall and high temperatures (Sandford, 1983). Livestock production is the main economic activity, a source of food and cash for many pastoral families (Jahnke, 1983). The majority of pastoral communities living in the ASAL keep different kinds of livestock which have different feed and water requirements, ecological adaptation, growth rates, adaptation to diseases and management requirements (Cossins, 1983). The main livestock species are camels, cattle, sheep and goats, while the main products are milk and meat (Jahnke, 1983). Generally, it has been observed that camels and goats dominate as the degree of aridity increases possibly due to the associated decrease in pasture and increase in browse (Mace, 1989).

Livestock management strategies in PPS are characterised by close correlation between spatial and temporal distributions of water and forage (Jahnke, 1983). During periods of prolonged drought, free movement of livestock is necessary to prevent herds from overgrazing certain areas and damaging the fragile environment (Mace, 1989). The number of times and distance a given community migrates within a certain period depends on the degree of aridity. Migratory distances become longer as the degree of aridity increases, resulting in various types of pastoralism. Nomadic pastoralists occupy the most arid parts of the continent (Jahnke, 1983). They include the

Turkana, Rendille, Somali and the Gabbra of Kenya and the Tuaregs and Fulanis of Nigeria. Transhumant pastoral communities have relatively fixed migration patterns, coinciding with different seasons (Sollod and Stem, 1991). They include the Bahimas of south-western Uganda, the Maasai of southern Kenya and the Tutsis of Rwanda and Burundi. Agro-pastoralists are sedentarised communities, which have home bases where they practice crop and livestock farming (Jahnke, 1983). The livestock are usually grazed in different areas at different times. This category includes the Boranas of northern Kenya (Hogg, 1980), the Karamajong of north western Uganda and the Datoga of Northern Tanzania (Sieff, 1999).

2.2 General constraints to livestock production in ASAL

Livestock production in the ASAL is constrained by several factors. The main ones are poor animal nutrition caused by poor quality and quantity of forage (Wandera *et al.,* 1997a) and shortage of water (Beede, 1991). Poor animal nutrition not only limits yield of meat and milk, but also increases the animal's susceptibility to diseases (Coppock, 1994). Leguminous trees and browse contribute significantly to the diet of livestock and accounts for over 50 percent of the total biomass and up to 40 percent of the available forage. However, the utility of browse is limited by anti-nutritive factors such as tannins, rectins and other chemicals (Teferedegne, 2000).

Traditionally, pastoralists designate grazing sites located close to the homestead as a coping strategy for seasonal feed shortages (Ndikumana *et al.,* 2000). During drought, pastoralists split herds into core and satellite herds. The core herd consists of the breeding stock, young animals and the old ones and is allowed to graze around the homestead. The satellite herd consists of males and dry females and is usually trekked to the emergency grazing sites located far away from the homestead.

Minerals play a very important role in the early development and subsequent growth of young animals. In in the adult animals, trace elements are important for maintenance of body functions such as reproduction (Schillhorn van Veen and Loeffler, 1990). Due to the fairly extensive grazing areas they cover, livestock are exposed to various types of soils, pastures and forages resulting in seasonal imbalance in mineral contents in the blood (Kabaija, 1989). The most common mineral deficiencies are selenium, phosphorus, magnesium, copper and manganese (Schillhorn van Veen and Loeffler, 1990).

Animal diseases are a big challenge for livestock improvement programs in the PPS (de Leeuw *et al.,* 1991). Nomadic pastoralism involves the seasonal movement of people and their livestock to other areas in search of water and pasture, and in areas where there are invariably no veterinary services (MacPherson, 1995). Prevalent diseases go unrecorded and there are rarely any attempts made at disease diagnosis and control. Frequent movement of animals prevents the build-up of free-living parasites such as helminths. However, such movements may increase the chances of contracting vector-borne diseases such as ECF and Trypanosomosis whose prevalence is dependent on the availability of a suitable habitat and host (MacPherson, 1994).

Except for Rinderpest which has been "successfully controlled" through regular annual vaccinations (Rossiter and Wamwayi, 1989), other endemic diseases such as foot and mouth disease disease (Hunter, 1998), contagious bovine pleuro-pneumonia (CBPP) (Faye *et al.*, 1997), black quarter and anthrax (Coulibaly and Yameogo, 2000) continue to cause severe economic losses through morbidity and mortality. Vector borne diseases such as trypanosomosis (Kristjanson *et al.*, 1999) and tick-borne diseases (Deem *et al.*, 1993) and helminths (Abdalla, 1989) are also major cause of loss of production.

Some of the drugs that were previously successful in treatment and control of diseases are no longer effective because of acquired drug resistance by the parasites (Clausen *et al.*, 1992; Eisler *et al.*, 2001; Rowlands *et al.*, 2001; Atanasio *et al.*, 2002). Furthermore, animal health delivery systems are weak due to a reduction in funds for extension and research by the national governments (Mlangwa and Kisauzi, 1994; Hubl *et al.*, 1998; Catley and Leyland, 2001). Consequently, pastoralists are forced to rely on traditional methods of disease treatment and control (Alawa *et al.*, 2002; Giday *et al.*, 2003). Currently, national governments are promoting privatisation of aspects of animal health delivery services, especially curative services (Hubl *et al.*, 1998; Turkson, 2001; Huttner *et al.*, 2001; Curran and MacLehose, 2002; Martin and MacLehose, 2002). One of the approach has been the facilitation of community-based personnel and organizations so that they are able to provide better and affordable alternatives to poorly functioning public veterinary delivery systems (Ahmed, 2002).

Infrastructure development is very poor in ASAL and pastoral people do not have adequate access to social amenities. For example, infrastructure for livestock marketing is inadequate and pastoralists have to trek long distances to dispose their animals causing loss of live body weight and hence lower market prices for the pastoralists and impoverishment (Jahnke, 1983).

The ASAL have been experiencing a rapid increase in human population caused by increased birth rates and survivability, coupled with emigration of people from the highly populated high potential areas to marginal areas in search of land for cultivation. As a result, the traditional highlands and swampy grazing areas, which were reserved for the dry season, have diminished, causing concentration of animals on already degraded lowland areas. The latter, coupled with uncontrolled grazing around watering points and near villages, and the cutting down of trees for fuel, also caused further degradation (Oba and Lusigi,1987). The frequency of inter- and intra-ethnic conflicts has also increased due to high competition between land use systems such as livestock and crop production (Hendrickson *et al.*, 1998). These conflicts affect the adaptive strategies and livelihoods of the pastoral communities living in the ASAL.

2.3 Past Livestock Improvement programs in Pastoral systems of Africa

In the past, several livestock improvement programs were initiated in pastoral systems but the achievements were far below the stated objectives (Waters-Bayer and Water, 1994). The primary cause of failure was lack of adequate understanding of the relationship between the biological, economical and social components of pastoral production systems. The majority were broad and general characterization studies where diseases and other factors influencing livestock productivity were assessed within the overall production system (de Leeuw *et al.,* 1995). Such studies included baseline surveys that were carried out by the International Livestock Centre for Africa (ILCA) in a wide range of livestock production systems (Jahnke, 1983) and the Integrated Project on Arid Lands in northern Kenya (Lusigi, 1983).

Environmental and pathological factors affecting the morbidity and mortality of cattle, sheep and goats in traditional livestock production systems in central Mali were investigated, respectively (Traore and Wilson, 1988). Pre-weaning death rates were 10, 28 and 35 percent in the three species. Adult mortality was about 5 percent per year in cattle and 12-13 percent per year in sheep and goats. Management system, season and year were environmental variables that had significant effects on mortality rate. In cattle, the overall morbidity caused by malnutrition and mange were 26.3 percent and 25.5 percent, respectively while cause-specific mortality caused by malnutrition was 10.4 percent.

The effect of a community-based animal health service (CBAHS) program on livestock mortality, off-take and husbandry measures were compared between full users, part-users and non-users of the program in a semi arid area in northern Malawi (Huttner *et al.*, 2001). The results showed that full users of the programme owned larger herds of ruminants compared to part-users and non-users. For non-users, mean monthly mortalities in calves were twice as high (3.2 percent) compared to user farms (1.4 percent) but the difference was not significant. Full users of the CBAHS programme applied some improved livestock management measures more often than either of the other groups. The results showed that usage of CBAHS by the smallholder farmers in northern Malawi resulted in reduced mortality and improved livestock production.

In Kenya, several programs were conducted and these have provided baseline information on livestock production and health in pastoral systems. They include the Integrated Project on Arid Lands among the nomadic Rendille people of northern Kenya (Lusigi, 1986) and the Turkana Resource Evaluation Monitoring Unit among the Turkana of north western Kenya (Njanja, 1991). In Kajiado District, the Livestock Development Project which was funded by UNDP/FAO, was initiated in the early 1960 (Pasha, 1986). Under the project, the GoK introduced the concept of communal ranches with the aim of creating a sustainable market oriented economy for the pastoral communities. In addition, it was supposed to stop environmental degradation caused by overstocking and overgrazing. Group ranches were supposed to promote optimum grazing and stocking rates by increasing off take rates thereby increasing the productivity of pastoral herds.

The Group Ranch Development model provided that each consisted of about 10,000 hectares supporting about 100 households with an average of 96 heads of cattle, 76 sheep, and 191 goats and five donkeys per family (Oyaya, 1998). Although livestock management practices such as tick control and crossbreeding improved this was not sustainable due to poor management of resources and lack of finances (Were and Wanjara, 1986). More than 50 percent of the ranches have already been subdivided (Ole Katampoi *et al.*, 1990; van and Seitah, 1990).

2.4 Methods to collect calf health and production in pastoral systems

There are very few studies specifically designed to study calf health and production in pastoral systems of Africa (Black, 1984; Coppock, 1993; Coulibaly and Nialibouly, 1998; Ganaba *et al.,* 2002). Majority of the investigations have been conducted as part of broad studies on livestock production and health (Catley and Mohammed, 1996; Clements *et al.,* 2002; Kariuki, 1996; Sollod and Stem, 1991). Several of such studies have been conducted under controlled conditions on institutional farms and on commercial ranches (Gregory *et al.,* 1984; Trail *et al.,* 1984; Ahunu *et al.,* 1993; Das *et al.,* 1999) thus making it difficult to infer them on extensive grazing systems. Generally, calf mortality was a major cause of low productivity in pastoral production systems (de Leeuw *et al.,* 1991). The calf was considered at great risk of death soon after birth and this risk decreased with increasing age of the calf. Mortality rates of 60 percent have been recorded (Bekure *et al.,* 1991) while calves that survived had slow growth rates (Wilson, 1987).

In majority of the studies on livestock health and production in PPS, the methods used to collect data involved the use of secondary sources such as veterinary records and slaughterhouses (ILCA, 1990). There are very few studies that have used primary sources of data such as farmer interviews, through use of semi-structured questionnaire, cross-sectional and longitudinal designs. Furthermore, there were wide variations in the methods used in the selection of study herds and sampling units. Besides, there are inconsistencies in the measurements, definitions and reporting of production parameters thus, making between-study comparison difficult (Clements *et al.*, 2002).

The poor impact of many projects has been attributed to a poor understanding by project planners of the aims of the pastoralists, the functioning and productivity of pastoral production systems relative to the environment, and the economies of extensive animal husbandry (Waters-Bayer and Water, 1994). The search for cost-effective ways of involving communities in rural development has led to the development of Participatory Rural Appraisal (PRA) methods which comprise a wide range of methods of data collection, learning and facilitation, that enable local people to play an active role in defining, analysing and solving their problems (Catley and Leyland, 2001).

The use of PRA methods to identify constraints to livestock health and production in have recently been reviewed (Chambers, 1994; Cornwall and Jewkes, 1995; Catley, 2000). Conventional veterinary-investigation methods and PRA were used concurrently to characterise a chronic wasting disease and identify linkages between indigenous knowledge and modern veterinary knowledge in southern Sudan (Catley *et al.*, 2001). The local communities were able to characterise a chronic wasting disease syndrome that encompassed fascioliasis, trypanosomosis, parasitic gastroenteritis and schistosomosis (as both single and mixed infections). Comparison of matrix-scoring results showed much overlap with modern veterinary descriptions of cattle diseases and the results of conventional veterinary investigation. Elsewhere, conventional and participatory methods of sampling were used separately to establish socio-economic well-being ranks of communities in one district of Tanzania (Temu and Doe, 2000). When the results were compared, the well-being ranks established using PRA tools were valid and the approach was found to be reliable.

Cross-sectional studies are commonly used to investigate the prevalence and the risk or explanatory factors associated with the presence or absence of a disease (Martin *et al.,* 1987; Dohoo *et al.,* 2003) . An example of such a study was designed to investigate the prevalence of bovine brucellosis and contagious bovine pleuropneumonia (CBPP) in Kongor Rural Council, Southern Sudan and to assess associations between the presence of antibodies for these diseases with age, sex and breed (McDermott *et al.,* 1987a). The detection of Brucella antibodies using the Rose-Bengal plate test was significantly associated with increasing age. Although no linear association between age and CBPP complement fixation tests results were found, cattle of 2-4 years of age appeared to be at higher risk. A follow up investigation on the association between clinical findings, calving rate and brucellosis serological diagnosis revealed that both abortions and hygromas were significantly associated with the disease (McDermott *et al.,* 1987b).

Cross-sectional studies cannot provide estimates of incidence rates because they are normally once-off surveys (Martin *et al.,* 1994). However, they are relatively cheap to conduct (compared to prospective studies) except where laboratory analysis for confirmatory diagnosis is required. For some diseases such as foot rot and ringworm, clinical signs are obvious and therefore collection of laboratory samples is not necessary, while for others such as theileriosis whose clinical syndrome may be confused with other diseases, laboratory samples would have to be collected to confirm the prevalence of disease.

A very important consideration when selecting sample herds and or flocks is the sampling unit, which should be representative of the production system under study. A number of cross sectional studies have used administrative units as a basis for herd sampling (McDermott and Schukken, 1994; Kadohira *et al.,* 1997; McDermott *et al.,* 1997). However, determinants of disease are usually associated with environmental factors, specific production systems and animal husbandry practices. Under such circumstances, it becomes necessary to distinguish producers based on production systems rather than based on administrative or political boundaries. Similarly, some determinants of diseases could be associated with system of production (extensive or intensive production), herd size and land tenure system (de Leeuw *et al.,* 1995). Thus, appropriate stratification of the target population should be done. Once the boundaries of the production system have been identified, the sample size should be estimated, taking in consideration the labour resources and other logistics. In order to calculate the sample size required, there is a need to know the actual population size and expected proportions of animals affected by the disease under investigation. Unfortunately, information on actual livestock populations and disease prevalence are lacking for the pastoral systems and most studies have had to rely on estimates, which can be very inaccurate (GoK, 1988; Peeler and Omore, 1996).

Prospective observational (longitudinal) studies (also called cohort studies) have been used to identify the consequences of specific exposure factors. Such factors include any potential cause of disease measured on dichotomous scale (exposed or non-exposed), an ordinal scale (low, medium, or high dose), or a continuous scale such as tick counts (McCown, 2002) or faecal eggs per gram (absolute number) (Dohoo *et al.*, 2003). These continuous studies usually include information-gathering techniques such as semi-structured questionnaires to record all the necessary data which not only improves the chances of correctly identifying the determinants of disease, but also ensures accurate recording of events as they occur (Martin *et al.*, 1994). Sentinel herd studies fall into this category and involve following sample herds and or flocks for observation purposes (ILCA, 1990). An example is a study of mortality, morbidity and productivity of cattle on smallholder dairy farms that was conducted in Chiquita communal land, Zimbabwe. This was done to estimate the frequency and determinants of mortality in cattle (French *et al.*, 2001). The animal-level variables associated with mortality were age, sex and breed. Calf mortality was 35 percent within the first year of life.

Retrospective studies are different from prospective studies in that they rely on pre-recorded data from one or more secondary sources about the exposure and the outcome events, both of which must have occurred before the start of the study (Dohoo *et al.*, 2003). They are useful in exploring associations between exposure factors and outcome variables of diseases whose outbreaks are rare (Martin *et al.*, 1994). The results can then serve as a guide for the design of subsequent follow-up field studies. An example was a study carried out in Morogoro Region in the Eastern zone of Tanzania to investigate disease conditions that led to the condemnation of whole carcasses and organs in slaughtered animals (Kambarage *et al.*, 1995). Such studies are relatively cheap to conduct compared to cross-sectional and prospective (observational) studies (ILCA, 1990). Another example is a retrospective case-study or survey (without controls) that was carried out at the Kenya Meat Commission (KMC) plant in Athi River to study the distribution of hydatidosis in Kenya (Wamae and Cheruiyot, 1985). The observed cases of hydatidosis were highest in animals that originated from Narok (60.7 percent) and Kajiado Districts while the lowest was in animals that originated from Machakos District (10.3 percent). The high rate of infection observed in cattle from Narok and Kajiado Districts was associated with the abundant presence of dogs, jackals, foxes and hyenas in the two districts.

2.5 Calf Health and Production in pastoral systems in Kajiado District

Kajiado is one of the ASAL districts of Kenya where the major economic activity is livestock production through semi-nomadic pastoralism (Ole Katampoi *et al.*, 1990). The predominant ethnic tribe are Maasai but it is estimated that approximately 30 percent of the population were other ethnic tribes such as Kikuyu and Kamba who had migrated from other parts of the country in search of arable land for crop cultivation (Little *et al.*, 1983).

Recent reports indicate that Kajiado District has had a rapid increase in human population (Table 2.1) while the actual numbers of key livestock species in the district has been on the decline thus creating a food deficit. Table 2.2 shows that except for camels whose population increased by 280 percent between the years 1991 and 2001, cattle, sheep and goat population decreased by 55.9 percent, 45.2 percent and 48.7 percent, respectively,

Table 2.1 Human population growth in Kajiado District, Kenya, 1969 – 1999

Year	Kajiado District			Kenya
	Population	Inter-census growth (percent)	Average annual Growth (percent)	Average annual growth (percent)
1969	85,093 [a]	-	-	-
1979	149,005 [a]	75.1	5.76	3.8
1989	258,659 [a]	73.6	5.67	3.4
1999	405,000 [b]	56.6	4.58	2.9 [a]

Sources: [a] Kenya, Central Bureau of Statistics, Population Census 1969, 1979, 1989

[b] Ministry of Finance and Planning, February, 2000. Results of the 1999 Population and Housing Census.

Table 2.2 Changes in actual numbers of key livestock species in Kajiado District between 1991 and 2001

Livestock species	Year		Overall change (percent)
	1991	2001	
Cattle	806,132 [a]	355,339 [b]	55.9 [c]
Sheep	905,877 [a]	496,426 [b]	45.2 [c]
Goats	847,968 [a]	435,305 [b]	48.7 [c]
Camels	230 [a]	874 [b]	280 [d]

Source: [a] (GoK, 1998)

[b] (Mwangi, 2000)

[c] Negative percent change

[d] Positive percent change

during the same period (Table 2.2). This was possibly caused by the effects of the 1995-97 drought and 1997-98 El Nino rains (Ndikumana *et al.*, 2000) and the drought of 2000 (Mwangi, 2000).

While the productivity of herds depends on the reproductive performance of breeding females, mortality and growth rate of calves from birth to maturity. it is the number of calves born, their survival and growth that determines the viability of the herd (de Leeuw *et al.*, 1991). Earlier studies (King *et al.*, 1984), showed that the proportion of females in Maasai herds was 65-70 percent. Furthermore, the proportion of bulls in the herd declined with increasing herd size while the number of cows per bull increased as the wealth of the household increased. Large herds (151-300 head) had the smallest proportion of breeding females (female weighing more than 200 kg) but the highest young female/cow ratio and one of the highest calf/cow ratio. The low calf/calf ratio in small (1-40 head) herds suggested a lower calving rate. Another reason for the low calf/cow ratio in small sized herds was possibly due to sale or exchange of young female stock for cash and / or marketable steers from the rich and medium wealth producers (King *et al.*, 1984).

In their study, de Leeuw *et al.*, (1991) reported that 95 percent of Maasai cattle were Small East African Zebu (SEAZ) while five percent were classified as mixed-breed (crosses of SEAZ with Boran and / or Sahiwal). Semenye (1987) reported that about 19 percent of calves were crosses of SEAZ and Sahiwal. The proportion of crossbred breeding bulls was higher in herds of poor and medium-wealth producers (23 percent) than in those of rich producers (15 percent).

The mean weights of cattle varied among and within classes (King *et al.*, 1984). The mean weights of adult females were similar across herd sizes and ranches. The mean steer weight varied with and wealth status (an increase of 233$\pm$18 kg to 284$\pm$10 k from the poor to the wealthy producers). Calves were weaned at 100-120 kg body weight, which corresponded with an average age of 12-14 months. There were no differences in weight at weaning between ranches or wealth classes (King *et al.*, 1984).

Maasai cows are allowed to graze together with the bulls throughout the year implying that mating and conception can take place any time of the year. However, although one would expect calving to be evenly distributed throughout the year, there were two calving peaks, one from September to November and another one from February to May (Bekure *et al.*, 1991). This implied that there were two conceptions peaks that coincided with the two major rainfall seasons (December – January and April – May). The average calving rate of cattle for three ranches in Kajiado District (Olkarkar, Merueshi and Mbirikani) was 58 percent (with a range of 56 to 61 percent) and was influenced by season of birth, length of lactation period and calving intervals (Semenye, 1987) Coppock (1994) also reported that season, which determined nutritional status of animals, had an effect on cattle breeding such that in the Boran region of Ethiopia, most calves were born during the long rains coinciding with optimal environmental and nutritional conditions for calf growth and recovery of the cows at the time of their greatest nutritional demands.

In the study by Bekure *et al.* (1991), Maasai calf raising practices were described. Calves were penned in well protected enclosures until they were one month old. Between 1-3 months, they were tethered in the shade and occasionally taken out to graze. During the dry season, women sometimes cut grass for calves. At 3-4 months old, calves were allowed to graze in the reserve grazing paddocks *(olopololis),* which had better quality herbage than the unprotected areas. Usually, the reserve grazing paddocks were located close to the homestead and along the pathway to the watering point so that the trekking distance was minimized. Calves from homesteads that were located in close proximity to the watering points were watered at an earlier age and were subsequently watered more frequently than calves from homesteads further from watering point. Calf suckling could continue even after milking had stopped while weaning was naturally done by the dam (Bekure *et al.*, 1991).

Calf feeding among the Maasai pastoralists aims at avoiding losses rather than promoting fast growth (Bekure *et al.,* 1991). Milk off take is carefully controlled to maintain a safe balance between the needs of the calf and human consumption. During the first 3-4 days of birth, the calf is allowed to suckle almost all of the dam's milk. Thereafter, the dams are milked once per day for several weeks while calves are allowed to suckle during and immediately after milking, before being separated from their dams. Usually, women milked the two left teats leaving the two right teats for the calf to suckle. However, in times of need the woman may strip three teats.

A study among the Boran pastoralists of Ethiopia (Coppock, 1994) where calf management practices are very similar to that of the Maasai pastoralists of Kenya showed that, calf survival had a marked effect on milk output of the dam. Indeed, dams whose calves survived had longer lactations (three times more) and produced more milk (three times as much) compared to dams whose calves died. (Coppock, 1994).

Generally, calf health and production in Kajiado District is below optimum due to poor animal husbandry practices, high morbidity and mortality caused by high prevalence and incidence of infectious diseases. This is further compounded by lack of adequate veterinary extension services and the deterioration of animal health delivery system (Hubl *et al.*, 1998). Estimates of calf health and production indicators are generally lacking (Peeler and Omore, 1996). Traditionally, pastoralists do not allow enumeration of their animals and their migratory lifestyle does not allow accurate recording of livestock health and productivity (Wilson and Semenye, 1983).

The indirect methods of estimating livestock population in pastoral systems relied on the use of returns from marketed output, sale of hides and skins which are not accurate, while direct methods such as low-level aerial surveys were used to enumerate livestock numbers (de Leeuw *et al.*, 1995). However, these methods do not provide accurate information on herd recruitment (births, purchases) and attrition (sales, deaths). An accurate assessment of changes in herd structure and composition, growth rates, off take rates, production parameters for milk, meat, hides and skins production can be done using longitudinal studies.

Very few studies have estimated the growth of calves in Maasai pastoral systems. Semenye (1987) reported that the average body weights of Maasai pastoral calves at birth, one, two, three, four and seven months of age were 19.2, 28.4, 35.2, 41.4, 47.5, and 64.4 kg, respectively. and breed were consistent sources of variation in body weights for all ages. In the semi arid Trans Mara District, Maasai zebu calves that had been raised in an area that was endemic for theileriosis had a mean body weight of 17.5 kgs. at birth, and an average body weight of 53.4 kgs. at six months old (Moll *et al.*, 1986). Low body weight gains were associated with sub-clinical *T. mutans* and acute *T. parva* infections.

High mortality in calves is a major cause of low productivity in Maasai pastoral systems. During drought, calf losses are much higher. Mortality rates of 60 percent are commonly recorded for calves less than one year old (Bekure *et al.,* 1991). Generally, mortality increased when the calves were sent out to graze and were mainly due to theileriosis, malignant catarrh fever, helminthosis and malnutrition (de Leeuw *et al.,* 1991). However, estimates of age-specific morbidity and mortality for these diseases are lacking.

A study on the use of veterinary drugs by Maasai pastoralists in an area where tsetse flies and trypanosomosis was endemic in Kajiado District revealed that pastoralists were forced by circumstances to use drugs without veterinary supervision (Roderick *et al.,* 2000). The rate of drug usage varied between animal and year, thereby raising concerns with regard to the possibility of drug misuse and the development of drug resistance.

2.6 Challenges and opportunities for improving calf health and production in PPS

Most traditional Pastoral Production Systems (PPS) of sub-Saharan Africa (SSA) are declining (Kimani and Pritchard, 1998) and their future survival depends on enhancing their capacity to satisfy the subsistence and income needs of pastoral communities. Indeed, the ability of pastoral households to subsist on their pastoral production has been on the decline and their traditional pastoral way of life is continuosly under threat due to increased human population and decreased livestock production (Campbell *et al.*, 2000; Hogg, 1980). Traditionally, supply of milk has been critical to the nutrition of the pastoralists. The pastoral population has been on the increase while pastoral herds numbers have been on the decline resulting in low milk production and an increase in malnutrition especially in children below five years (Blewett, 1995).

Generally, PPS suffer an acute shortage of infrastructure to improve accessibility to market and information. They also lack adequate policies and institutions (such as cooperative movements) that can reduce risk of investment, provide credit, and encourage private investment in livestock services (feeds, health, and breeding) and support livestock research and extension (Mutiso, 1995). The challenge of improving the livelihood of pastoral communities without causing further displacement calls for new and innovative development efforts through research. Indeed, any new interventions into PPS must integrate the indigenous knowledge pastoral strategy of managing natural resources. Thus, in order to avoid the repeat of past failures (Waters-Bayer and Water, 1994), research and development programs should focus on obtaining greater understanding of the coping mechanisms of the pastoral communities in order to determine ways of harnessing community responses and reinforcing them with appropriate measures for more efficient resource management. Projects that encourage community participation and mobilisation are most likely to result in sustained benefits for livestock keepers.

Water shortage is a major constraint in Kajiado District and a cause of mortality and slow growth rate in calves. Majority of Maasai calves are not given water until after three months (Personal observation). The situation becomes fatal if the calf has diarrhoea. The common practice is to withdraw all water from the calf (Personal observation). There are very few permanent water sources and the estimated distance to the nearest watering site (5–15 km) is usually far for the calf (Bekure *et al.*, 1991). A temporary solution could be to collect rainwater from roofs into big drums. However, this is a solution only during the rainy season and probably the roof areas for water collection are too small to obtain considerable amounts of water needed. However, for the calves this source of clean water during the time of confinement could be of major significance. A more permanent solution is to construct more boreholes and pumps. This is important not only to the health of cattle, but also to the health of people.

Feed shortage is a major constraint to improving livestock production in pastoral systems especially during the dry season. Feed supply and feed quality can be improved in various ways. Quality of pasture could be improved by introducing legumes, which also provide the rumen microbes with extra nitrogen thus making them more capable of degrading the dry plants (Teferedegne, 2000). However, in communal grazing pastures such as ranches, improvement of the pasture requires good organisation and cooperation of the farmers. Another option is to promote cultivation and storage of forage in form of hay. However, production of hay will require extra labour for cutting, drying, transporting and storing. Hence, labour could very well be a limiting factor for the success of hay production. One way to address this problem is to ensure that the time for hay harvesting does not coincide with the period when labour is readily available such scholl holidays. Necessarily, hay making from the communal grazing land would require improvement of pasture and animals would have to be kept out of the areas until after hay-making is finished.

The leaves and fruits from bushes and trees are important feed resources, especially in the dry season (Wandera *et al.,* 1997c). When trees drop their leaves on the ground, cattle pick them even when the leaves are partially decomposed. Investigations are needed to determine the preferred species and their nutritive values and if these could be cultivated. In addition, tree and bush residues are low cost supplements and have other advantages including provision of fuel wood, shade for people and animals and, in some cases, they provide edible fruits such as *Balanites aegyptica* and *Acacia tortilis*. They also help to control erosion, which is important since semi-arid areas are also vulnerable to soil erosion.

Some pastoralists grow some cereals such as maize and sorghum. Therefore, crop by-products especially maize stovers are available at certain times of the year and can be used as animal feed, albeit their low nutritive value (Coppock, 1994). Their bulky nature is a constraint to feed intake and prevents the animal from consuming sufficient amounts to meet daily energy requirements (Teferedegne, 200). However, maize stovers can be utilised more efficiently by offering them to animals along with urea-molasses blocks. Urea-molasses blocks are relatively cheap and can be obtained from many commercial shops.

The ASAL cut across international borders and international cooperation is required for successful efforts aimed at improving livestock production including development of early warning capabilities and appropriate mitigation strategies. Such networking has so far been lacking. Recent studies have indicated the usefulness of Near-Infrared Reflectance Spectroscopy (NIRS) as a tool for nutritional profiling of forage intake by free-ranging ruminants (Stuth, *et al.,* 2002) This method has potential for utilisation in research and management, and for use in remote regions characteristic of arid and semi-arid areas. Near-Infrared Reflectance Spectroscopy can also be interfaced with geographical information systems (GIS) to create databases, and facilitate early warning capabilities and networking (Stuth *et al.,* 2002)

In many developing countries, public animal health services are characterized by inadequate budgets, poor infrastructure and insufficient staff (Hubl *et al.,* 1998). Although private veterinary practices do exist, they usually only benefit the more profitable medium-to-large commercial farmers rather than pastoral communities in the ASAL. Furthermore, the provision of animal health services in developing countries has for the past several years been undergoing changes as a direct result of the structural adjustment programs (SAP) being implemented by national governments (Catley and Leyland, 2001). A major focus of SAP has been the transfer of the delivery of animal health services from national governments to private or partially government funded community animal health workers (CAHW). The objective is to increase farmer's accessibility to services while reducing the financial burden on governments. This then frees limited government's resources, which can be redirected to the delivery of vital public services such as disease surveillance, control of livestock movement, research and quality control of veterinary drugs (Hubl *et al.,* 1998).

The majority of epidemic diseases can be controlled through the vaccines that are now available (Rossiterl and James, 1989; Alwa *et al.,* 2002). However, endemic diseases continue to cause severe economic losses through morbidity and mortality. The latter include the infections caused by vector-borne haemoparasites and helminthosis (Lessard *et al.,* 1988; Lessard *et al.,* 1990; Deem *et al.,* 1993; Maloo *et al.,* 2001). Most of chemotherapeutic agents and vaccines that were previously successful in controlling these diseases, are no longer effective because of acquired resistance and/or insufficient delivery services (Mlangwa and Kisauzi, 1994; Hubl *et al.,* 1998; Catley and Leyland, 2001). Appropriate alternative drugs, vaccines and options of their delivery systems are often lacking. The situation is further compounded by removal of subsidies resulting from the privatisation of veterinary services. Compared to the high potential areas where rainfall distribution is high and livestock farming is more intensive, there are very few private firms offering veterinary extension services in pastoral systems. The few private firms available are currently located in the urban areas.

The prevalence and incidence of infectious diseases of calves are influenced by individual animal factors (such as age, sex, and immune status), animal husbandry practices and environmental factors (McDermott and Schukken, 1994). Geographic information systems (GIS) have been used to describe the distribution of a vector-borne diseases on an environmental basis (Lessard *et al.,* 1988; Lessard *et al.,* 1990). However, environmental factors may not be the sole determinants of the occurrence of a vector-borne disease. For example, interaction between environment and farm factors has been found to be associated with tick-borne diseases (Deem *et al.,* 1993; Gitau, 2000). Furthermore, in areas of high tick challenge all animals were infected regardless of farm management, whereas, in areas that were marginal for tick survival and low tick challenge farm infection rates appeared to be related to farm management (Lessard *et al.,* 1990; Michel *et al.,* 2002). Thus, under such circumstances, information on both the level of tick challenge and farm management practices is required for planning disease control programs.

In the semi arid areas where nomadic pastoralism is practiced, helminth parasite eggs and larvae are less likely to survive in the environment due to the high temperatures. However, an increase in cattle movements, for example to watering places, increases the chances of transmitting the parasites to the calves (McPherson, 1995). Threfore, applying certain herd management factors such as movement control, optimal grazing patterns, and strategic anthelmintic treatment could reasonably control the incidence of helminthosis (McPherson, 1995

Individual animal characteristics such as breed, age and sex also influence the prevalence of infectious diseases. For example, exotic breeds are more susceptible to tick-borne diseases and trypanosomosis than zebu cattle (Norval *et al.,* 1992). For both anaplasmosis and babesiosis, there is reverse age immunity where calves are more resistant to the diseases than adult cattle (Young and Morzaria, 1986; Young, 1987). Differences in antibody prevalence for *B. bigemina* between sexes have been reported (Karimi *et al.*, 2003) and were possibly due to differences in management of female and male calves such as more milk.

Opportunities exist for exploiting recent advances in epidemiology and systems analysis thus making it possible to better understand and describe the spatial and temporal distribution of diseases affecting livestock in extensive pastoral production systems. One approach is to develop geographical information systems (GIS) that integrate available information on the distribution of vectors and impact of livestock diseases, agro-ecological and socio-economic factors that influence the distribution of diseases in pastoral production systems (Lessard *et al.,* 1988). The four indicators that have been used to define the epidemiological state of infectious diseases, such as tick-borne diseases, are antibody prevalence, disease incidence, age ranchesof clinically affected animals and case-fatality rate (Norval *et al.*, 1992). While antibody prevalence can be estimated from cross-sectional studies, the other indicators can only be reliably estimated in a longitudinal study. Such information systems will improve the setting of research priorities, in selected species, diseases and they will serve as a basis for cost-benefit analysis of control interventions. Further refinement of such information system could be done using improved epidemiological tools and models based on case studies specific to pastoral production systems.

Integrated control of economically important diseases by better use of new and existing technologies such as vaccines will reduce calf morbidity and mortality thereby increasing animal production and income of resource-poor livestock keepers in PPS. Opportunities exist to either improve or repackage chemotherapeutic agents and live vaccines for effective delivery in pastoral production systems. This could be achieved by improving the shelf-life of existing vaccines while at the same time reducing the number of doses in a single batch to cater for smaller herd sizes which are becoming increasingly common among pastoral communities.

It is now recognised that pastoralists have a wide knowledge of diseases that afflict their livestock and they practice traditional methods of disease treatment and control (Cornwall, 1995; Catley, 2000). Current emphasis on use of participatory analytical tools and the involvement of pastoral communities in identifying and analysing constraints influencing livestock production aims at documenting and validating pastoralist's knowledge on causes of poor health and production in livestock (Alawa *et al.*, 2002). Some of the traditional methods of treatments involve use of plant parts (Lans and Brown, 1998). This could form a good basis for identification of medicinal plants for commercial exploitation and opportunities for improving calf health.

Selective breeding within the existing population and some limited cross-breeding with exotic breeds could improve and conserve the genetic potential of indigenous animals in pastoral systems (Syrstad and Ruane, 1998). Selection within the existing population has advantages because it ensures the development of animals which are able to adapt well to the existing disease risk, feeding and management systems (Gregory *et al.*, 1984; Trail *et al.*, 1984). In Kajiado District, crossbreeding of indigenous animals with exotic animals has been haphazard without a clear breeding policy and record keeping (Were and Wanjala, 1986). Therefore, it is not possible to evaluate how much improvement or erosion of indigenous genetic material has been achieved in the district. Generallty, hardly any selection has until now taken place within local populations in the tropics, but there should be good prospects for improving the production potentials of tropical breeds by selection within local animal populations (Syrstad, 1998). By selecting for better production traits within the existing population the development of better performing animals will happen gradually, which means the farmers will have time to adjust to animals which will require better management, especially better feeding practices. Moreover, indigenous animals especially cattle, are multi-purpose and any improvement of cattle breeds must bear this in mind. The resultant of these actions would lead to improvement of calf health and production in PPS.

Improved calf husbandry such as clean calf pens will have a positive effect on calf health and production. Often the rains turn the pens into pools of mud and manure. This can be the cause of many infectious and spread of disease (Pedersen and Madsen, 1998). A roof, either metallic or made of straw could decrease the amount of water within the pen while providing shade. Pens are rarely moved in sedentary Maasai pastoral communities and manure is allowed to accumulate. Thus, the pens must be considered as constantly infected with parasites.

In Maasai pastoral herds, calves are weaned naturally by the dams at around the age of one year (de Leeuw *et al.*, 1991). There is a need to investigate the effects of early weaning on calf growth, milk production and reproductive performance of the dam. Earlier weaning could lower pressure on the dam and re-gain lost weight quicker in addition to having calving intervals shortened. Early introduction of fodder to the calf would also enhance rumination thereby increasing the ability of the calf to fully utilise available fodder at the time of weaning. However, supplies of better quality fodder must also be secured. Early development of rumen activity can also be attained by supplementing the calf with concentrates. A concentrate feed is a parasite-free fodder and would be good for the young calf because it does not yet possess any immunity against parasites. It is envisaged that supplementation would also hasten growth of female calves, which will then reach sexual maturity early, thus lowering the age of first calving. However, the cost and benefits of such a feeding system need to be evaluated.

2.7 Objectives of the study

The rapid development changes that have taken place in Kajiado District in the recent past have presented new challenges and opportunities for improving livestock production in the district. For example, the increase in human population and the decline in actual numbers of key livestock species have resulted in food insecurity forcing the pastoral communities to rely mainly on relief food. Livestock production and especially cattle remains the main source of livelihood for the majority of households. Survival of calves is very important for replacement of herds. However, calf morbidity and mortality in Maasai pastoral systems are generally higher than what has been reported in other production systems (Bekure *et al.*, 1991; Gitau *et al.*, 1994; Gitau *et al.*, 1999). This study aims at analysing the factors that affect calf health and production of calves in pastoral systems. The information will be useful in formulating appropriate management practices and disease control programs for increasing calf production in pastoral areas.

CHAPTER THREE

GENERAL MATERIALS AND METHODS

The study was conducted in Kajiado District among the Maasai pastoralists. The district is located at the southern tip of Rift Valley Province of Kenya and lies between longitudes 36^0 5' and 37^0 55' East and between latitude 1^0 10' and 3^0 10' South (Ole Katampoi *et al.,1990*). The district covers an area of 21,105 km^2 and is divided into seven administrative divisions, namely, Ngong, Isinya, Mashuru, Namanga, Loitokitok, Magadi and Central. The district borders the following districts: Machakos to the east, Nakuru, Kiambu and Nairobi to the north, Narok to the west, Taita Taveta to the southeast, and the Republic of Tanzania to the south (Figure 3.1).

The climate of Kajiado District is highly influenced by altitude (Ole Katampoi *et al.,*1990). The district has a bimodal pattern of rainfall distribution. The short rains fall between October and December, while the long rains fall between March and May. Loitokitok, which has a high elevation, receives the highest average annual rainfall of 1,250 millimetres while Magadi and Amboseli with the lowest elevation, have the lowest average annual rainfall of 500 mm. Relatively heavy rains also occur around Ngong Hills, Chyulu Hills and Ngurumani Escarpments. Similarly, the mean daily temperatures also vary with the altitude and season (Ole Katampoi *et al.,*1990). The daily mean maximum and minimum temperatures are 34^0 and 22^0C, respectively. Highest temperaturesoccur around Lake Magadi, while the lowest have been recorded temperature at Loitokitok and Ngong Hills. The coldest months are July and August, while the hottest months are from November to April.

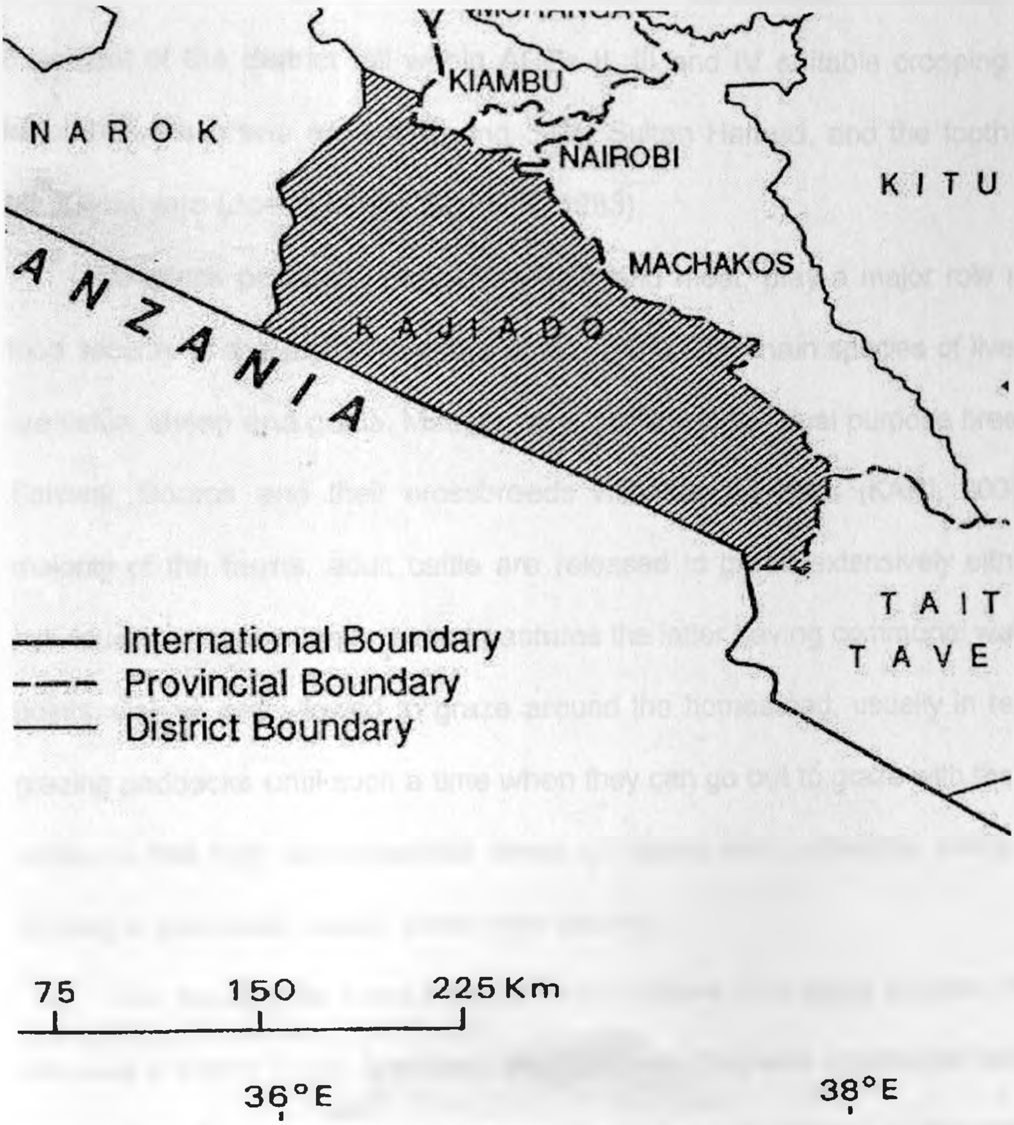
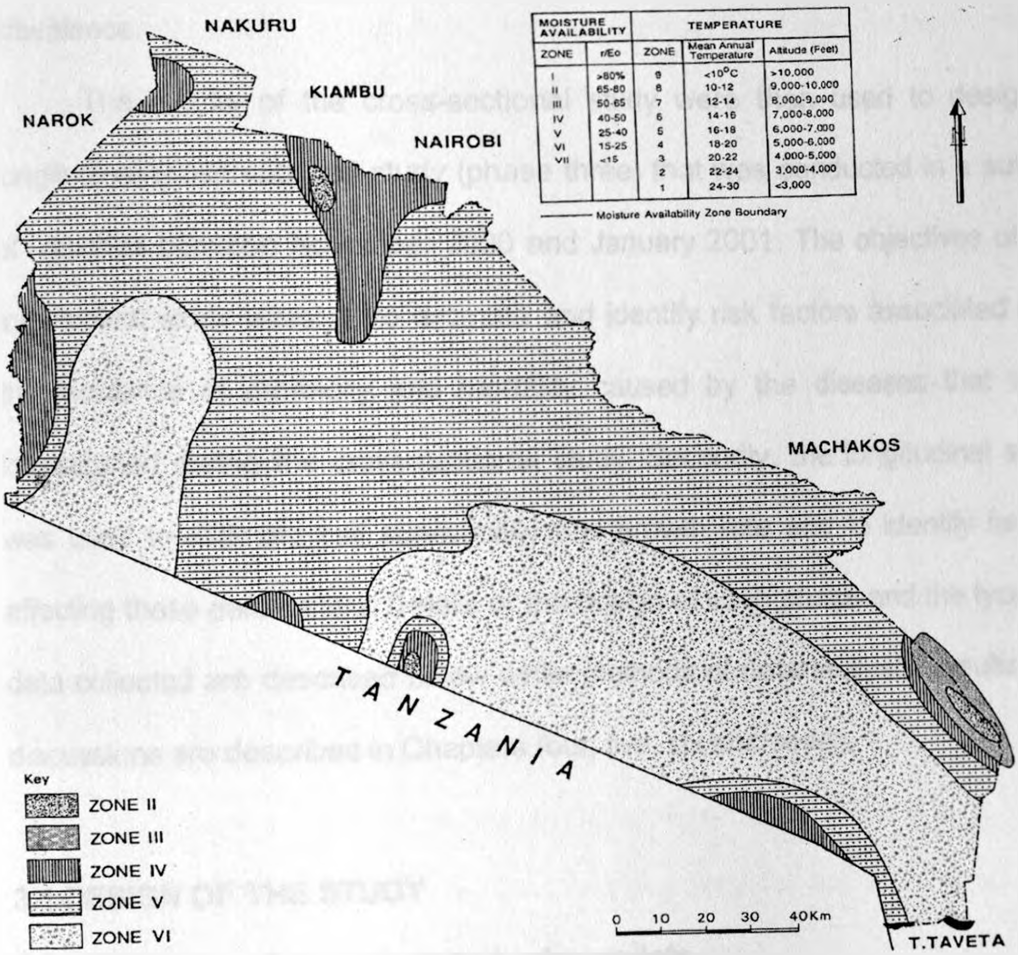


Figure 3.1 Map of Kenya showing the location of Kajiado District

Based on average annual rainfall (r):average annual evaporation (Eo) ratio, Kajiado District has been divided into five agro-climatic zones (ACZ): II to VI (Pratt and Gwynn, 1977) (Figure 3.2). Most of the district falls in ACZs V (55 percent) and VI (37 percent) and is suitable for livestock production. Only 8 percent of the district fall within ACZs II, III and IV suitable cropping. The latter includes areas around Ngong Hills, Sultan Hamud, and the foothills of Mt. Kilimanjaro (Jaetzold and Schmidt, 1983).

Livestock products, particularly milk and meat, play a major role in the food security of the district (Bekure *et al.,* 1991). The main species of livestock are cattle, sheep and goats. Maasai zebu cattle and the dual purpose breeds of Sahiwal, Borans and their crossbreeds with Maasai zebu (KARI, 2003). In majority of the farms, adult cattle are released to graze extensively either on individually or communally owned pastures the latter having communal watering points. Calves are allowed to graze around the homestead, usually in reserve grazing paddocks until such a time when they can go out to graze with the adult cattle. In the high agro-potential areas of Ngong and Loitokitok, some dairy farming is practiced, usually under zero grazing.

The study was conducted in three phases in Kajiado District. Phase one was a Rapid Rural Appraisal (RRA) survey that was conducted between August and September 1999 to investigate the perceptions of the pastoral community towards: 1) the general constraints that hinder improvement of calf health and production; 2) the causes, coping strategies and opportunities for specific diseases causing calf morbidit, mortality and slow growth. The results of the RRA survey were used to guide the design of a cross-sectional study (Phase Two), conducted between December 1999 and January 2000, one, to



MOISTURE AVAILABILITY		TEMPERATURE		
ZONE	r/Eo	ZONE	Mean Annual Temperature	Altitude (Feet)
I	>80%	9	<10°C	>10,000
II	65-80	8	10-12	9,000-10,000
III	50-65	7	12-14	8,000-9,000
IV	40-50	6	14-16	7,000-8,000
V	25-40	5	16-18	6,000-7,000
VI	15-25	4	18-20	5,000-6,000
VII	<15	3	20-22	4,000-5,000
		2	22-24	3,000-4,000
		1	24-30	<3,000

Figure 3.2 Map of Kajiado District showing Agro-Climatic Zones (ACZs)

characterize cattle production systems in the district and two, to estimate the prevalence of serum antibodies for the major diseases listed by pastoralists listed during the RRA and to identify the risk factors associated with the prevalence.

The results of the cross-sectional study were then used to design a longitudinal (observational) study (phase three) that was conducted in a subset of ranches between November 2000 and January 2001. The objectives of the longitudinal study were: 1) to estimate and identify risk factors associated with the incidence of morbidity and mortality caused by the diseases that were investigated during the cross-sectional study. Secondly, the longitudinal study was used to estimate calf survivability and growth rate and to identify factors affecting these parameters. Details of the design of each phase and the types of data collected are described below while methods of data analysis, results and discussions are described in Chapters four, five, six and seven.

3.1 DESIGN OF THE STUDY

3.1.1 Collection of secondary and primary data

Secondary data were obtained through visits to institutional libraries and relevant departments at Kajiado District headquarters. Discussions were held with relevant departmental extension officers to explain the purpose of the study and to obtain some general information on factors affecting livestock production in the district. Verification of information was done by perusing monthly reports, project documents and development reports. The information collected was summarized in tables. Information collected included land tenure and farming enterprises, resource endowment, proximity to game parks, household types and composition, key livestock species and their uses, production constraints and accessibility to services and livestock markets.

Primary data were obtained in three phases: Rapid Rural Appraisal (RRA) survey, cross-sectional survey and longitudinal observational study. The design of each phase is described below.

3.1.2 Phase one – Rapid Rural Appraisal

3.1.2.1 Selection of study sites

The three major ACZs in the district, IV, V and VI, comprising the main areas where nomadic cattle production is practiced by the Maasai pastoralists were purposively selected for the study. Most of Kajiado District falls in ACZ IV,V and VI (Table 3.1) and these were have been shown to affect disease prevalence (Deem *et al.*, 1993). Majority of the Maasai pastoralists were either practicing communal grazing on unsubdivided ranches or were grazing their cattle on individual land following subdivision of the ranches. A list of unsubdivided and subdivided ranches was prepared for each of the selected ACZ. This was followed by a stratified random sampling of two ranches per ACZ (one subdivided and one unsubdivided), using random numbers (Table 3.1 and Figure 3.3).

For each of the study es, a RRA was conducted on different dates. First, preliminary visits were made to the divisional headquarters one week prior to the start of the actual RRA survey. During the visits meetings were held with local provincial administration and staff of the Ministry of Agriculture and Livestock Development in order to explain the purpose, procedures of the RRA and to set convenient dates for the survey.

Table 3.1 Distribution of ranches and households by ACZ sampled d
Appraisal Survey and the Cross-sectional study in Kajiado District

ACZ	ranches			
	Subdivided			
	Name of es	Total no. of households	No. of households sampled	Name of es
IV	Olosho Oiborr	83	11	Shompole
V	Olodonyo Orok	484	7	Emarti
VI	Nentanai	57	9	Kuku 'B'

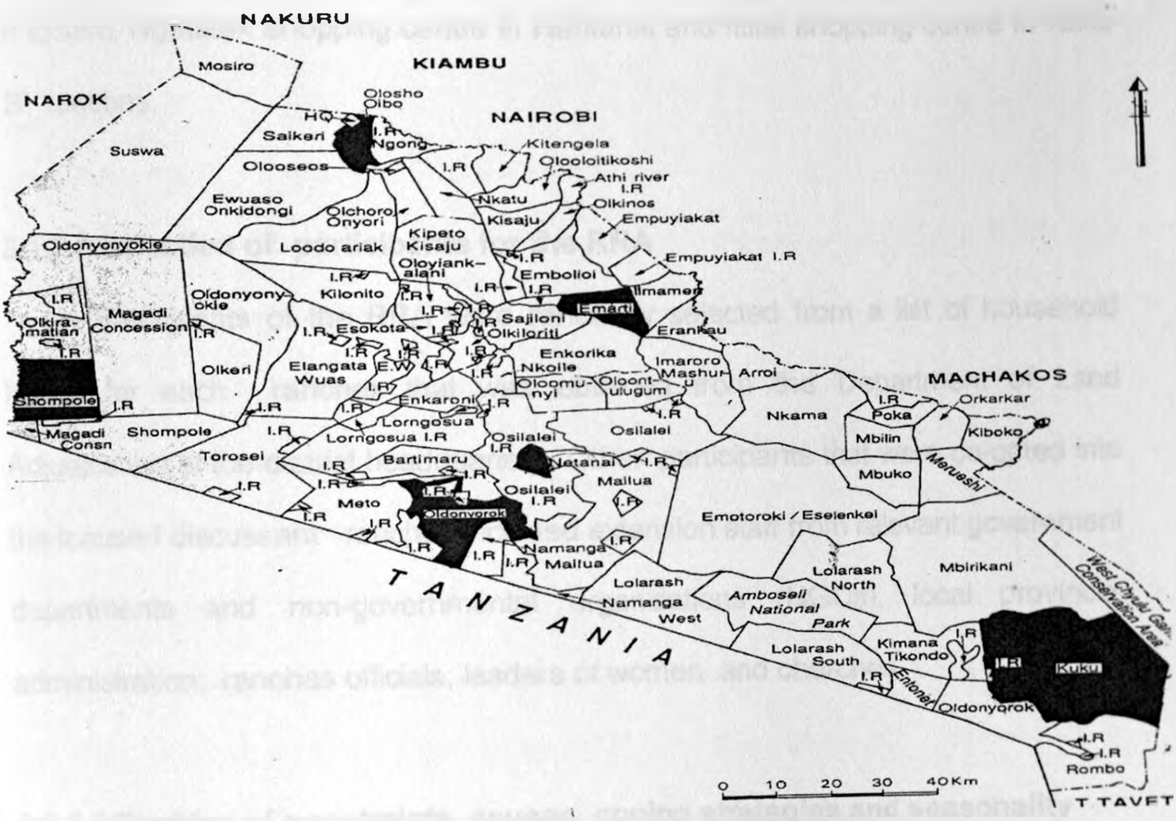


Figure 3.3 Distribution of individual ranches and ranches in Kajiado District
(Shaded areas show ranches that were sampled).

The following venues were selected for the RRA exercise: Simba Maasai Outreach Organisation (SIMOO) offices in Olosho Oiborr, Parkase settlement scheme in Shompole, Community water tank in Olodonyo Orok, Oloibora Jijik primary school in Emarti, Ngatatek shopping centre in Nentanai and Iltilal shopping centre in Kuku 'B' ranches.

3.1.2.2 Selection of participants for the RRA

Participants of the RRA were randomly selected from a list of household heads for each ranches that was obtained from the Department of Land Adjudication at the district headquarters. Other participants that were co-opted into the focused discussant ranches included extension staff from relevant government departments and non-governmental organizations (NGOs), local provincial administration, ranches officials, leaders of women and churches.

3.1.2.3 Ranking of constraints, causes, coping strategies and seasonality

During the actual RRA, participants were guided through the exercise by use of a semi-structured questionnaire (Appendix 3.1). Participants were asked to list the general constraints to the improvement of livestock production, followed by listing of specific disease causing morbidity, mortality and slow growth rate of calves. Ranking of the constraints was done using 'pair-wise' ranking method. Second, for each of the constraints, a list of the perceived causes or predisposing factors and coping strategies was also made. A seasonal calendar was also made (based on the diseases that were listed by the pastoralists) showing when various constraints occur. Further probing was done on selected disease in order to assess the pastoralists' ability to relate various clinical signs to specific diseases.

3.1.3 Phase two – Cross-sectional study

This phase of the study was conducted between November 1999 and January 2000. Agro-climatic, farm management and calf-level factors were important potential explanatory and risk factors affecting prevalence and incidence of diseases causing morbidity, mortality and slow growth rate of calves in Kajiado District. In deed, serum antibody prevalence for tick borne diseases have been shown to vary with ACZ (Deem *et al.,* 1993), while farm management variables were major factors affecting mortality and growth performance of animals (Gitau *et al.* 1994; Gitau *et al.* 2000; Kadohira *et al.* 1997; McDermott *et al.* 1997). The farm variables that were investigated included grazing management, disease control practices, calf housing, calf nutrition (source of forage and feeding practices). The calf factors that were considered to be potentially and significantly associated with differences in prevalence and incidence of calf diseases were sex, age, breed, acquired and passive immunity.

3.1.3.1 Selection of study area and households

The same ranches and households that had been selected for the RRA (Phase One) were used for the cross-sectional study (Table 3.1). Relatively few households within ranches were selected because the average prevalence and incidence of calf diseases by site and farm were expected to be relatively constant due to similar exposure variables such as grazing management, watering and housing practices within sites resulting in uniform exposure to diseases causing agents.

3.1.3.2 Selection of study animals

For each of the households selected all calves that were less than 13 months old at the time of survey were identified for sampling. In order to estimate the sample size, the formula, $n=4PQ/L^2$ (Martin *et al.,* 1994), was used based on the assumption that the prevalence for major diseases listed in phase one was 50% (plus 10% allowable error). A sample size of 100 calves per site was obtained and was also considered the practical minimum. A total of 729 calves were identified and sampled for seroprevalence of tick borne diseases that were ranked highest by the pastoralists in phase one.

3.1.4 Phase three – Longitudinal observational study

This phase of the study was from November 2000 and February 2002, nine months after the cross-sectional study. The cause of the delay was a prolonged drought in the year 2000 which forced some of the households that were engaged in the study to relocate to other areas. The objectives of this phase of the study were to estimate the incidence of morbidity and mortality caused by tick borne diseases identified in phase one, and to investigate the factors that affect their epidemiological status.

3.1.4.1 Selection of study area

Two out of the original six ranches used in Phases one and two) were purposively selected for the study. The two ranches had contrasting ACZ and had the highest prevalence of East Coast Fever (ECF) from the cross-sectional study. Thus, Olosho Oiborr ranch (ACZ 4) in Ngong Division (mean serum antibody prevalence of ECF=71 percent) and Nentanai ranch (ACZ 6) in Namanga District (mean serum antibody prevalence=60 percent) were selected for this study.

3.1.4.2 Selection of households and herds

The same household herds that were used during the cross-sectional study were sampled in Nentanai ranch. In Olosho Oiborr , three out of the eleven household herds that were sampled during the cross-sectional survey did not have calves due to high mortalities experienced during the year 2000 drought. Therefore, a simple random procedure was used to select other households to obtain the targeted minimum number of 100 calves per required at the start of the study. The sample size of 100 calves per ranch was considered a reasonable sample size for statistical analysis and logistic considerations.

3.2 Sampling procedure and general laboratory tests

3.2.1 Collection of blood and serum preparation

Ten mls of blood were drawn from each calf by jugular venopuncture method into plain capillary tubes. The blood samples were stored in a box containing ice packs until they could be separated by centrifugation, usually 2-6 hours later. The sera separated by centrifugation at 3000 g for 10 minutes. The sera were each divided into three aliquots of 0.5 ml and stored in dry ice (solid CO_2) at approximately -70^{0}C and transported to the International Livestock Research Institute (ILRI) laboratories in Nairobi where they were stored in freezers at – 20^0 C, until the time for antibody assays.

3.2.2 ELISA for antibody detection

The ELISA test was used for the detection of serum antibodies for *Theileria parva, T. mutans, Anaplasma marginale* and *Babesia bigemina* (Katende *et al.,* 1990; Tebele, 1996; Katende *et al.,* 1998) . Polysorb micro-ELISA plates (polysorb, Nunc, Denmark) were coated with recombinant antigens at a concentration of 50ng/well and frozen. The specific recombinant antigens used were: *T. parva*, p85 or the polymorphic immunodominant antigen (specificity of 96 percent and sensitivity greater than 99 percent); *T. mutans*, p32 kilo Dalton antigen (overall specificity and sensitivity, unpublished), *A.*

marganale, major surface protein five (MSP-5) (overall specificity and sensitivity, unpublished) and *B. bigemina*, p200 kilo Dalton antigen (overall specificity = 97.5 percent and sensitivity = 96 percent). Excess antigen solution was discarded and the uncoated sites on wells of the microlitre plate and the non-specific sites on the antigen were blocked by adding 0.25 percent casein and incubating at 37^0C for two hours. Test sera, diluted at 1:200 (*T. parva*) and 1:100 (*T. mutans* and *B. bigemina*) in Dulbeco's phosphate buffered saline (DPBS) pH 7.4, containing 0.1 percent tween 20 and 5 percent skimmed milk, were added to the wells of the micro-ELISA plate in two replicates (100 microlitres per well). Control sera (strong positive, weak positive and negative control) were diluted as for the test sera. These, together with the conjugate control (DPBS alone), were added to the plate in four replicates. The antibodies were allowed to bind to the antigen by incubating the plate for 25 minutes at room temperature with continuous gentle agitation on a micro-agitator (Heidolph, France). The unbound antibodies were then removed by washing the plate extensively with DPBS.

To each well, 100 µl anti-bovine IgG horse radish peroxidase conjugate, diluted 1:5000 in DPBS containing 0.1 percent tween 20 and 2.5 percent skimmed milk, were added. The plate was incubated for 25 minutes at room temperature and washed as before. The reaction was developed by adding 100 µl sodium citrate buffer pH 4.0 containing 1percent hydrogen peroxide substrate and 40 µm 2,2'–azino-bis (3-ethybenz–thiazoline-6-sulphuric acid), diamonium salt (ABTS) as chromogen and incubated for 1 hour in the dark. During incubation, the micro-ELISA plate was shaken for five minutes every 15 minutes to ensure maximum colour development. The optical density (OD) was determined in a Multiscan (MCC/340) spectrophotometer (Biological Diagnostic Supplies LTD., (BDSL), UK).

The OD readings from the reference strong-positive control serum were used to compute the percent positivity (PP) for the test sera (Wright *et al.,* 1993). Percent positivity for test serum was expressed as follows: test serum OD divided by the mean OD from the strong positive control serum and expressed as percent (simply expressed: (OD of test/OD of strong positive) x 100). These were obtained from the linear curve of OD against the reciprocal of serial dilutions (Wright *et al.,* 1993). All the results were expressed as percent positivity (PP). Percent positivity (PP) values were preferred to optical density readings because they were adjusted for variations associated with inconsistent background activity while performing the ELISA tests (Wright *et al.,* 1993). Readings > 19 PP were considered positive for *T. parva* and *T. mutans* while readings >14 PP were considered positive for *A. marginale* and *B. bigemina.*

3.2.3 Estimation of packed cell volume and parasite counts

Whole blood was collected through jugular venopuncture in 5 ml heparinised test tubes. Blood was then drawn into two heparinised capillary tubes. One capillary tube was centrifuged at 12,000 g for 5 minutes using a microhaematocrit centrifuge. Packed cell volume (PCV) was then determined on a micro-haematocrit reader and recorded as a percentage of packed red blood cells to total volume of whole blood (Jain, 1986).

Approximately 5µl of blood from the second heparinised capillary tube were used to prepare thin blood films for haemoparasite examination (Jain, 1986). The thin blood smears were dried in air and fixed in methanol for 3 minutes. They were then stained with 1/10 diluted Giemsa stain for 20 minutes. Excess stain was washed off with tap water and the slides allowed to dry. Microscopic examination for theileria piroplasms, *A. marginale and B. bigemina* parasites was done under oil immersion using x100 objective.

3.2.4 Tick counts and identification

Adult ticks were identified by species (Kaiser *et al.*, 1988) and counted on the whole body surface (including the face, ears, body, brisket, dewlap, perineum, scrotum, udder, tail, and limbs) (Mattioli *et al.*, 1998).

3.2.5 Faecal parasite egg counts

Faecal samples were obtained from the rectum of each calf more than 3 months old and analyzed by the floatation technique (Hansen and Perry, 1990). For each calf, 3 gms of faeces were weighed and water added to make a 30 ml suspension. A vortex mixer was then used to homogenise the suspension. Ten mls of the homogenized solution were transferred into a plastic tube and centrifuged for 2 minutes at 1,200 g. The supernatant was discarded and the sediment resuspended in 10 ml of saturated salt (NaCl) solution (specific gravity 1.2). The contents were then mixed by inverting several times. Using a Pasteur pipette, both chambers of a McMaster counting slide (Hawksley and Sons Ltd, UK) were filled with the suspension. Helminth eggs were identified by their morphological appearance and grouped as either strongyles or strongyloides. Other parasite eggs such as Monieza and Coccidia were recorded as present or absent. The number of eggs per gram (e.p.g.) was obtained by multiplying the total number of egg counts on both chambers by 50.

CHAPTER FOUR

DESCRIPTION OF CATTLE PRODUCTION SYSTEMS, PASTORALISTS' PERCEPTIONS OF CONSTRAINTS TO CALF HEALTH AND PRODUCTION IN KAJIADO DISTRICT, KENYA

4.1 INTRODUCTION

In Maasai pastoral systems, cattle production largely depends on animal management activities, availability and distribution of water and forage resources (de Leeuw *et al.,* 1991). Households are the basic units of Maasai pastoral system and, indeed, individual household decisions on livestock management activities and allocation of resources such as water, forage and labour reflect their production goals (Grandin, 1991). Herd/flock structure and composition are useful indicators of the goals and management practices operating at the household level and are influenced by climatic factors, wealth status and other development changes (King *et al.,* 1984).

The production strategy of the Maasai pastoralists aims at satisfying their subsistence needs with a relatively low level of market off take (de Leeuw *et al.,* 1984). For example, data from 5100 cattle sampled from 41 households in three ranches comprised of a high percentage of females while the proportion of mature steers was less than 5 percent (King *et al.,* 1984). This type of herd structure is characteristic of subsistence production with milk as a primary output and ensures that the herd has a high potential of recovery after drought.

King *et al.,* (1984) reported an increase in the use of Sahiwal bulls that were introduced to upgrade the Small East African Zebu. The same study also sampled more than 2730 sheep and 2300 goats and reported that poor households preferred goats and the richer households preferred sheep. The Small East African goat was ubiquitous while, crosses of Dorper with Red Maasai sheep were more common in the more developed es. The least developed and more arid es had a high population of Somali Blackhead sheep. The Dorper crossbred was used to supply the market with mutton, while the Somali Blackhead was slaughtered primarily for home consumption (King *et al.,* 1984)

In spite of great investment in pastoral production systems, the majority of livestock improvement programs did not achieve their objectives. This was attributed to a wrong approach to project formulation and implementation by development agencies who were the sole identifiers of constraints, ignoring the pastoralists' knowledge and experience in resource management accumulated over time (Waters-Bayer and Water, 1994). The search for cost-effective ways of involving communities in rural development led to the development of participatory methods of research such as Participatory Rural Appraisal (PRA) and Rapid Rural Apprisal (RRA). Participatory Rural Appraisal method of data collection is a learning and facilitation process where local people play an active role in defining, analysing and solving their problems (Cornwall and Jewkes, 1995; Webber and Ison, 1995; Martin and Sherington, 1997). Rural Rapid Appraisal (RRA) which uses some of the PRA tools is more focused and takes much less time to complete (Melville, 1993; Ngoma, 1994)

The use of PRA tools to identify constraints to livestock health and production in pastoral systems has been reviewed (Catley, 2000; Catley and Leyland, 2001). Using these tools a survey was conducted among Dinka pastoralists of southern Sudan to characterise a chronic wasting disease of cattle and to identify linkages between indigenous knowledge and modern veterinary knowledge (Catley *et al.*, 2001). The results indicated that local communities were able to characterise this wasting disease syndrome that encompassed fascioliasis, trypanosomosis, parasitic gastroenteritis and schistosomosis (as both single and mixed infections). Further, in southern Sudan, Dinka pastoralists' perceptions of seasonal variations in cattle diseases, disease vectors, intermediate hosts and rainfall were investigated using a PRA tool called a 'seasonal calendar' (Catley *et al.*, 2002). Repetition of a standardized "seasonal calendar" demonstrated good reproducibility of the method, while comparison of rainfall data produced by seasonal calendars and objective measures of rainfall demonstrated good validity of the seasonal calendar method. Similarly, subjective assessment of seasonal calendar scoring patterns by veterinarians indicated that herders' perceptions of seasonal populations of biting flies, ticks and snails were similar to modern veterinary knowledge (Catley *et al.*, 2002).

The overall objective of this study was to characterise cattle production systems in Maasai pastoral systems of Kajiado District. The RRA tools were used to list and rank the constraints to calf health and production; to assess the Maasai pastoralists' perceptions of causes and predisposing factors to major constraints.

Further, probing was done to assess the pastoralists' ability to recognise clinical signs associated with specific diseases.

4.2 MATERIAL AND METHODS

4.2.1 Design of the study

The study area and methods of selecting participants have been described in Chapter three sections 3.1.1 and 3.1.2.

4.2.2 Data collection and analysis

4.2.2.1 Secondary data

The information collected from secondary sources (including land tenure and farming enterprises, resource endowment, proximity to game parks, household types and composition, key livestock species and their uses, production constraints and accessibility to services and livestock markets) is summarized in tables 4.1 and 4.2.

4.2.2.2 Primary data

Primary data were collected during the RRA survey, cross-sectional and longitudinal studies. Semi-structured questionnaires and focused group discussions were conducted during the RRA cross-sectional survey (Chapter two and Appendices 3.1 and 3.2). Such information and data included land tenure system, sources of household income, types of farm enterprises, resource endowment such as watering and grazing pastures, livestock management activities, livestock species, cattle breed, herd sizes, structure and composition. Data on ranking of constraints, their causes, coping mechanisms and seasonality were also extracted for presentation and discussion. Data were stored in Microsoft Excel.

4.2.3 Data analysis

Descriptive statistics were obtained using appropriate commands in SPSS. Differences in the mean herd sizes and composition between ranches were evaluated using multiple-comparison procedures in SPSS. The differences were considered significant at $p < 0.05$.

4.3 RESULTS

4.3.1 Land use systems, economic activities and resource endowment

Table 4.1 shows the differences in land tenure system among the six study sites. Shompole, Emarti and Kuku 'B' ranches were unsubdivided while Olosho Oiborr, Olodonyo Orok and Nentanai ranches were fully sub-divided. The Maasai ethnic group dominated the human population in all the ranches sampled. However, there were differences in the distribution of other ethnic communities found in the ranches. For example, in Olosho Oiborr , there were a number of Kikuyus who had either bought land from pastoralists after subdivision, or had settled in the area through intermarriage. Similarly, in Shompole and Kuku 'B' there were Kikuyus who had settled there because of the opportunities for crop farming.

Table 4.1 Land tenure systems, major economic activities and types of off-farm enterprises in six ranches in Kajiado District.

Name of ranches	Olosho Oiborr	Shompole	Olodonyo Orok	Emarti	Nentanai	Kuku 'B'
Land tenure system,	Individual	Communal	Individual	Communal	Individual	Communal
Ethnic communities	Maasai, Kikuyu,	Maasai, Kikuyu, Merus, Akamba	Maasai, Somali	Maasai, Akamba,	Maasai, Kikuyu	Maasai, Kikuyu, Chagga
Economic activity	Livestock keeping[1], crop farming	Livestock keeping[1], horticultural farming	Livestock keeping[1] crop farming	Livestock keeping[1] crop farming	Livestock keeping[1] crop farming	Livestock keeping[1], horticultural farming
Crop enterprises	maize[2], beans[2], vegetables	maize[2] , beans[2], cowpeas[2], mangoes[2], vegetables, green peas[2], water melon[2], pepper[2], pumpkins, tomatoes	maize[2] , beans[2]	maize[2], beans[2] sorghum	maize[2] , beans[2]	maize[2], beans[2], onions[2], vegetables, tomatoes
Source of water for Farming	Rain water	Irrigation water from River Parkase	Rain water	Rain water	Rain water	Irrigation water from River Nolturesh
Off-farm employment opportunities	Good	Few	Very few	Very few	Very few	Very few
Type of off-farm employment	Civil servants, teachers, small business shops	Magadi soda company, Small business shops	Small business shops	Small business shops	small business shops	Tourist lodges, Ecotourism e.g. cultural bomas,

Key: [1]Main economic activity; [2]Main crop enterprises

Kamba ethnic community were also common in Shompole and Emarti where they were mainly involved in crop farming. In Kuku 'B', Chaggas who had emigrated from neighboring Tanzania were doing some crop farming. In Shompole and Olodonyo ranches, there were Somalis who were involved in business such as shops and hotels.

Compared to the others, Olosho Oiborr ranch had a good communication network, including roads and telephone. Accessibility to such as education and health facilities and livestock markets were better. Its members had more opportunities for off-farm employment because of its close proximity to Nairobi and minor urban towns such as Ngong, Kiserian and Ongata Rongai. In Shompole ranch, the Magadi Soda Company created employment for people. There were very few opportunities for off-farm employment in Olodonyo Orok, Emarti and Nentanai ranches. However, in Kuku 'B' ranch, there was a fair distribution of tourist lodges which offered employment opportunities for the local communities.

Compared to the others, water resources were also more developed in Olosho Oiborr ranch (Table 4.2). Major sources of water were a communal dam, seasonal springs from Ngong Hills and some individual water pans. Although Shompole and Kuku 'B' ranches had permanent water resources such as lakes and rivers, the distribution of their waters could only benefit a very small proportion of the members who lived close to them. The latter two were quite large compared to the other four and therefore, the members felt that accessibility to water resources was a major hindrance to livestock improvement.

Table 4.2 Water resources, grazing management and other infrastructure development

Group ranch	Olosho Oiborr	Shompole	Olodonyo Orok	Emarti
Availability of water resources	Good	Fair	Fair	Poor
Types of water resources	Communal dam, seasonal springs from Ngong hills, individual pans	Permanent river, Enkare Nyiro swamp, Lake Natron	Pipe, boreholes, seasonal streams	Seasonal ri ponds
Major vegetation types	Open grassland	Wooded grassland	Bush land, shrub	Open grass
Grazing management	Reserve grazing pasture, semi-zero grazing during dry season	Reserve grazing pasture, semi-zero grazing during dry season	Purely free grazing in reserve pastures	Reserve gra pasture, ser zero grazing during dry season
Infrastructure development	Good road and telephone network	Poor road and telephone network	Poor road and telephone network	Poor road a telephone network
Proximity to national parks, game reserves	Very near	Far	Far	Far
Accessibility to services and livestock markets	Very good	Poor	Poor	Good

Three ranches (Shompole, Olodonyo Orok and Emarti) were relatively far from national parks compared to Olosho Oiborr, Nentanai and Kuku 'B' (Table 4.2). Olosho Oiborr had was best placed in terms of infrastructure development and accessibility to livestock markets and other veterinary services. Table 4.3 shows that although livestock farming was still an important enterprise, crop farming was also on the increase in all the study sites.

4.3.2 Distribution of key livestock species

All the households sampled kept cattle of various breeds (Table 4.4). Further, all the households sampled in Olosho Oiborr, Shompole and Olodonyo Orok kept various breeds of sheep but only 88 percent, 89 percent, 88 percent kept sheep in Emarti, Nentanai and Kuku 'B' ranches, respectively. All the households sampled in Olosho Oiborr , Olodonyo Orok and Nentanai kept goats but only 63 percent, 88 percent, 88 percent of the households were keeping goats in Shompole, Emarti and Kuku 'B' ranches, respectively.

The proportion of households that were keeping donkeys varied between the ranches ranging from 56 percent in Olosho Oiborr to 78 percent in Nentanai (Table 4.4). The proportion of households that were raising chicken varied among ranches (ranged from 15 percent in Olodonyo Orok to 86 percent in Emarti ranches). Bee keeping was more common in Olosho Oiborr where 56 percent of the households sampled indicated they kept them compared to equal or less than 13 percent of all the households sampled in the other ranches.

Table 4.3 Proportion (percent) of households (n = sample size) practising livestock farming only or mixed crop and livestock farming in six ranches in Kajiado District (Cross-sectional study, 1999).

	ranches					
Economic activity	Olosho Oiborr (n=11)	Shompole (n=8)	Olodonyo Orok (n=7)	Emarti (n=8)	Nentanai (n=9)	Kuku 'B' (n=8)
Livestock only	27	0	57	38	11	63
Mixed crops and livestock	73	100	43	62	89	37

Table 4.4 Proportion (percent) of households (n = sample size) keeping key livestock species among Maasai pastoralists in six ranches in Kajiado District (Cross-sectional study, 1999).

	ranches					
Livestock species	Olosho Oiborr (n=11)	Shompole (n=8)	Olodonyo Orok (n=7)	Emarti (n=8)	Nentanai (n=9)	Kuku 'B' (n=8)
Cattle	100	100	100	100	100	100
Sheep	100	100	100	88	89	88
Goats	100	63	100	88	100	88
Donkeys	56	63	72	63	78	75
Chicken	73	63	15	86	50	75
Bees	56	13	13	13	11	13

4.3.3 Cattle herd structure, breeds and functions

The overall mean cattle herd size varied from 52 to 104 (Table 4.5). The proportion of breeding cows in the herd varied among ranches and was highest in Emarti (56.3 percent) and lowest in Kuku 'B' (50 percent). The proportion of breeding bulls in the herds was significantly higher in Kuku 'B' ranch compared to Olosho Oiborr, Shompole and Emarti ranches. Kuku 'B had a significantly higher ($p < 0.05$) number of breeding bulls compared to Olosho Oiborr, Shompole and Emarti. However, the mean numbers of breeding cows, castrated bulls and calves less than one year old were not significantly different among ranches.

Kuku 'B' had a breeding cow: bull ratio of 6:1 as compared to a ratio of 18:1 for Olosho Oiborr, 16:1 for Shompole and 24:1 for Emarti. Nentanai had the lowest breeding cow: bull ratio of 12:1. The proportion of castrated males. in the herds also varied between ranches ranging from 5.8 percent in Shompole to 18.5 percent in Nentanai. The proportion of calves varied from a minimum of 26.2 percent in Nentanai to a maximum of 34.6 percent in Shompole ranch. The estimated calving rate (total number of calves divided by the number of breeding cows multiplied by 100) was 52 percent for Olosho Oiborr , 61 percent for Shompole, 53 percent for Olodonyo Orok, 61 percent for Emarti, 51 percent for Nentanai and 60 percent for Kuku 'B'.

The relative proportion of calf breeds by ACZ and ranch are shown in tables 4.6 and 4.7, respectively. The results indicate that upgrading of Maasai Zebu cattle was highly prevalent in all the ACZs. There were variations in relative proportions of pure Maasai Zebu and crossbred calves among ranches.

Table 4.5 Mean of cattle herd size by class (percentage of total number sampled per site in parenthesis) in six ranches in Kajiado District (Cross-sectional study, 1999).

Class	ranches					
	Olosho Oiborr (n=11)	Shompole (n=8)	Olodonyo Orok (n=7)	Emarti (n=8)	Nentanai (n=9)	Kuku 'B' (n=8)
Breeding cows	39 (53.4)	29 (55.8)	57 (54.8)	36 (56.3)	33 (50.8)	33 (50)
Breeding bulls	2[a] (2.7)	2[a] (3.8)	3[a] (2.9)	2[a] (3.1)	3[a] (4.6)	6[b] (9.1)
Castrated males	12 (16.4)	3 (5.8)	16 (15.4)	4 (6.3)	12 (18.5)	7 (10.6)
Calves	20 (27.4)	18 (34.6)	28 (26.9)	22 (34.4)	17 (26.2)	20 (30.3)
Mean herd size	73	52	104	64	65	66

n = Number of households sampled

[a,b] Means with same superscript across the rows were not significantly different at $p < 0.05$.

Table 4.6 Proportional distribution (percent) of calf breeds by Agro-Climatic Zone in Maasai pastoral systems, Kajiado District, Kenya (Cross-sectional study, 1999).

Cattle breed	Agro-Climatic Zone (ACZ) 4	5	6	Total number of cattle
Maasai Zebu	29 (n=64)	27 (n=64)	33 (n=90)	217
Crosses of Maasai Zebu with either Sahiwal, Boran or European breeds	71 (n=155)	73 (n=173)	67 (n=183)	512
Total number of cattle	219	237	273	729

Key: n = number of calves by type of breed

Table 4.7 Proportional distribution (percent) of calf breed by ranches in Maasai pastoral systems, Kajiado District, Kenya (Cross-sectional study, 1999).

	ACZ IV		ACZ V		ACZ VI		Total no. of cattle
	ranches		ranches		ranches		
Cattle breed	Olosho Oiborr	Shompole	Olondonyo Orok	Emarti	Nentanai	Kuku 'B'	
Maasai Zebu	4 (n=4)	52 (n=59)	20 (n=26)	35 (n=37)	4 (n=4)	53 (n=86)	217
Crosses of Maasai Zebu with Sahiwal, Boran or European breeds	96 (n=101)	48 (n=55)	80 (n=54)	65 (n=68)	96 (n=101)	47 (n=77)	512
Total no. of cattle	105	114	132	105	110	163	729

Key: n = number of calves by type of breed

However, when the breed distributions were compared between ranches there were noticeable differences in the distribution of calf breeds between ranches. The results further show unlike in ACZ V and VI where there were no differences in the proportional distribution of calf breeds, in ACZ IV there was a higher proportion of Maasai Zebu calves in Shompole (52 percent) than in Olosho Oiborr (4 percent) (Table 4.7).

Table 4.8 shows the proportion of households that listed cattle functions into rank positions 1, 2 and 3. Fifty six percent of the households ranked production of milk for household consumption in position one while only 6 percent of the households ranked milk for sale in position one. Thirty eight (38) percent ranked sale of live animals for cash income in position one. Meat for household consumption was listed in rank positions 2 and 3 by 8.1 percent and 29.5 percent, respectively. Other functions of cattle that were ranked in position three only were hides for domestic use (13.3 percent), meatfor sale (4.5 percent), manure for farm use (2.5 percent), traction (2.5 percent) and manure for sale (2.5 percent).

4.3.4 Relative ranking of general constraints to increased calf production

There were wide variations in the rankings of general constraints to increased calf production among the six ranches (Table 4.9). Out of the overall total of 17 general constraints that were listed, the five most important constraints in order of importance were water shortage, high incidence of diseases, feed shortage, inadequate extension services and costly inputs.

Table 4.8 Cattle functions and the proportion of households (percent) (n = 51) that ranked them in position one, two and three in Maasai pastoral systems, Kajiado District (Cross-sectional study, 1999).

	Proportion (percent) of responses		
Cattle functions	Rank 1	Rank 2	Rank 3
Milk for household consumption	56	34.7	11.4
Sale of live animals for cash	38	32.7	22.7
Milk for sale	6	24.5	9.1
Meat for household use	-	8.1	29.5
Hides for domestic use	-	-	13.3
Meat for sale	-	-	4.5
Manure for farm use	-	-	4.5
raction	-	-	2.5
Manure for sale	-		2.5

Table 4.9_Ranking of general constraints to calf health and production in six M
Rapid Rural Appraisal survey, 1999 (rank position 1 = highest, rank position 1

Constraint	Overall ranking	Ranking within ranches		
		Olosho Oiborr	Shompole	Olodony Orok
Water shortage	1	4	1	2
High incidence of diseases	2	1	2	3
Inadequate extension services	3	2	4	5
Feed shortage	4	3	3	4
Costly inputs	5	7	5	7
Wildlife as a menace	6	6	8	6
Poor livestock marketing	7	5	6	-
Poor road network	8	-	7	-
Soil erosion	9	9	-	10
Inadequate credit facilities	10	-	-	8
Lack of good animal breeds	11	10	-	11
Wild bush fires	12	11	9	-
Overstocking/overgrazing	13	8	-	9
Drought	14	-	-	1
Communal land ownership	15	-	-	-
Shortage of labour	16	-	-	12
Poor housing	17	-	-	-

Water shortage was ranked as the number one constraint in three (Shompole, Nentanai and Kuku 'B') out of six ranches. High incidence of diseases was ranked as number one in Olosho Oiborr , number two in Shompole and number three in Olodonyo Orok, Nentanai and Kuku 'B' ranches. The other general constraints that were listed were wildlife menace (through predation, competition of feed).

4.3.5 Causes and coping strategies of constraints to calf production

Appendices 4.1-4.2 show the constraints and coping strategies for calf health and production in six ranches. Shortage of water and forage were associated with frequent droughts. The coping strategies for water shortage included construction of dams, use of water pans and rock catchments. Feed shortage was mainly caused by frequent droughts, overstocking and presence of wildlife. Communities in Olosho Oiborr , Shompole, Nentanai and Kuku 'B' reported that outbreaks of wild bush fire that were caused by poachers and fishermen were common during the dry season thus contributing to further shortage of pasture for livestock.Maasai pastoralists associated high incidence of disease with high prevalence of vectors (for East Coast Fever and trypanosomosis), uncontrolled movement of animals (for contagious bovine pleuropneumonia and foot and mouth disease), inadequate diagnosis for treatment and control caused by inadequate veterinary extension services.

The coping strategies for high incidences of diseases included use of ethno-veterinary practices, injection of sick calves with tetracyclines and application of acaricide to spray calves against ticks. High cost of inputs such as drugs and acaricide was associated with poor distribution of agro-vet shops that usually stock and sell drugs to pastoralists (Appendix 4.1).

Poor infrastructure was associated with rough terrain. Thus, there was a shortage of good roads and means of transportation for animal and people was inadequate. As a result, transportation was very expensive and pastoralists were forced to walk long distances. The use of donkey for transportation was quite common.

Shortage of labour was listed in Olodonyo Orok and Kuku 'B' and was acute during school days. Hired labour was very expensive for most of the pastoral families. One of the coping strategies listed was marrying of more wives who were involved in herding and watering of calves (Appendix 4.1). In addition having more children increased the labour force.

4.3.6 Predisposing factors and coping strategies for calf disease

The perceived causes of calf diseases, coping strategies and opportunities for their controlling in the six ranches are listed in Appendix 4.2. The communities listed high prevalence of vectors and presence of thick bush as causes of theileriosis and trypanosomosis while helminthosis, intestinal obstruction, coccidiosis, anthrax and black quarter were associated with environmental contamination. Calf diarrhoea was associated with excessive intake of water and indeed one of the coping strategies was withdrawal of water.

The strategies used to treat and or control calf diseases included both conventional methods and ethno-veterinary control practises (Appendix 4.2). Control of ticks relied mainly on the use of acaricide through hand spraying and very rarely by manual removal.

4.3.7 Relative ranking of calf diseases and their seasonality

Overall, the most important diseases of calves were listed in order of importance as East Coast Fever, Foot and mouth disease (FMD), helminthosis and ringworms (Table 4.10). East Coast Fever (or theileriosis) (locally known as *Oldikana*) was listed in rank position one in all the six ranches. Other important diseases that were listed were Anthrax, Black quarter, Rinderpest, Lumpy skin disease (LSD), Calf diarrhoea, Coccidiosis, Contagious Bovine pleuropneumonia (CBPP), trypanosomosis and pneumonia.

Other diseases that were listed but ranked relatively low included fleas (Olosho Oiborr), bloat (Olodonyo Orok) and intestinal obstruction (Emarti). Further probing revealed that pastoralists could identify two broad types of calf diarrhoea, bloody and non-bloody. The former was reportedly more severe and the listed clinical signs were suspicious of coccidiosis (Appendix 4.3).

Table 4.11 shows the seasonal occurrence of calf diseases in six ranches in Kajiado District. East coast fever which was ranked the highest in all the six ranches occurred throughout the year. In Olosho Oiborr ranch, more cases were observed during the wet seasons (April and

Table 4.10 Ranking of diseases of calves in six ranches Maasai pastoral herds in Kajiado District. Rapid Rural Appraisal survey, 1999. (rank position 1 = highest, rank position 17 = lowest).

		Ranking within ranches					
Diseases	Overall rank	Olosho Oiborr	Shompole	Olodonyo Orok	Emarti	Nentanai	Kuku 'B'
East Coast fever	1	1	1	1	1	1	1
Foot and mouth disease	2	3	6	4	5	3	5
Helminthosis	3	7	10	8	8	4	7
Ring worms	4	5	11	9	9	6	-
Anthrax	5	-	4	2	3	-	4
Black quarter	6	-	3	3	2	2	-
Rinderpest	7	2	2	-	-	-	3
Lumpy skin disease	8	-	9	-	6	-	6
Calf diarrhoea	9	6	-	10	-	5	-
Coccidiosis	10	-	5	6	4	-	-
Contagious Bovine Pleuro-pneumonia	11	-	7	-	-	-	2
Trypanosomosis	12	-	8	-	-	-	8
Fleas	13	4	-	-	-	-	-
Pneumonia	14	-	-	7	-	-	-
Bloat	15	-	-	5	-	-	-
Intestinal obstruction	16	-	-	-	7	-	-

Table 4.11 Seasonal occurrence of diseases of calves in six ranches, Kajiado District. Rapid Rural Appraisal survey, 1999.

Disease	ranches					
	Olosho Oiborr	Shompole	Olodonyo Orok	Emarti	Nentanai	Kuku 'B'
East Coast Fever	All seasons, peaks during wet seasons	All seasons	All seasons	All seasons	All seasons	All seasons, but more cases in June, July
Foot and mouth	All seasons.	All seasons	All seasons	All seasons	Wet season	Sporadic outbreaks
Helminthosis	Mainly after the rains	-	Dry season	All seasons, peaks observed during wet seasons	All seasons, peaks during dry seasons	All seasons
CBPP	-	-	-	-	-	Sporadic outbreaks
Ring worms	Dry season	-	Dry season	Dry season	Dry season	-
Bloody diarrhoea	Wet season	-	Dry season	-	Wet season	-
Rinderpest	Sporadic outbreaks	-	-	-	-	Sporadic outbreaks
Lumpy skin	-	Sporadic outbreaks	-	Sporadic outbreaks	-	-
Anthrax	-	All seasons	-	-	-	-
Black quarter	-	-	Dry season	-	-	-
Trypanosomosis	-	Wet season	-	-	-	Wet season
Bloat	-	-	Wet season	-	-	-
Coccidiosis	-	-	-	Dry season	-	-
Intestinal obstruction	-	-	-	Dry season	-	-

December) while in Kuku 'B' infections peaked during the dry months (June and July). Foot and mouth disease disease (FMD) was reportedly common throughout the year except in Nentanai where outbreaks were common during the wet season and sporadic outbreaks in Kuku 'B'. Ring worms was prevalent during the dry season in all the four sites where it was listed.In all the six es various formulations of oxytetracyclines were used to treat diseases including non-bacterial ones such as trypanosomosis. Vaccination against contagious and notifiable diseases such as FMD, anthrax, black quarter, CBPP and LSD was rarely done. Similarly, although helminthosis in calves was ranked quite high (overall position=3), the use of anthelmintic for deworming was very rarely done. Various ethno-veterinary activities were also used to treat calf diseases (Appendix 4.2). Among the pastoralists, excision or burning of superficial lymph nodes was commonly used to treat theileriosis. Some Maasai pastoralists in trying to treat the symptoms withdrew water from the calf thus causing further dehydration and death of the calf.

The communities listed high prevalence of vectors and presence of thick bush as predisposing factors for theileriosis and trypanosomosis while helminthosis, intestinal obstruction, coccidiosis, anthrax and black quarter were associated with environmental contamination. Calf diarrhoea was associated with excessive intake of water and one of the coping strategies was to completely withdraw water.

Pastoralists had substantial knowledge of clinical signs and some of the post mortem signs associated with major calf diseases (Appendix 4.3). For example, theileriosis, anthrax, blackquater and rinderpest were associated with high mortality rates. The pastoralists were able to differentiate theileriosis *(Oldikana)* from anaplasmosis (*Lipis)* based on clinical signs. Thus, while theileriosis had a very short course and did not respond well to tetracyclines, Anaplasmosis had a relatively low mortality, long duration and responded well to tetracyclines treatment and was associated with constipation and hard faeces. However, when asked to list the causes of the diseases, they could not identify the actual causative agents. Instead, the list that was generated was treated as factors that predisposed calves to major diseases (Appendix 4.2).

4.4 DISCUSSION

This study suggests that although the household economy of Maasai pastoralists was still largely dependent on livestock production, the production system was gradually changing from purely nomadic pastoralists to agro-pastoralists. Over 50 percent of the households sampled indicated that the major farming enterprise was a mixture of crop and livestock farming. The factors that influenced changes in Maasai pastoral production systems include rapid population growthand changes in land use and tenure (Oyaya, 1998). Generally, Maasai pastoralists in Kajiado District kept mixed herds of cattle, sheep and goats.. However, the composition of livestock species varied among and within ranches. Different species of livestock kept together ensure efficient utilisation of forage resources since cattle and sheep are primarily grazers while goats are browsers (Jahnke, 1983). Thus, a combination of different types of livestock provides Maasai pastoralists with a wide array of animal products. Herd diversification was also an important strategy for household security in terms of ensuring minimum subsistence if one species was affected by disease or lack of forage and drinking water (as in drought).

The vast majority of cattle kept by Maasai pastoralists are Shorthorn East African zebus in mixed herds with indigenous breeds of sheep and goats. In some of the areas, improved Boran and Sahiwal bulls have been introduced which agrees with findings of other investigators (King *et al.*, 1984). This study has hown that cattle herd sizes and composition varied greatly among the six ranches. Oyaya (1998) reported that the average number of livestock per family was 96 heads of cattle, 76 sheep and 191 goats. These estimates are over and above the mean number of cattle recorded in this study (except for Olodonyo Orok where mean cattle herd size was 95). The most important factors that influence cattle herd structure in Maasai pastoral systems are calving rate and mortality (de Leeuw *et al.*, 1991). Other less important determinants of herd structure and composition are off take for sale and / or gifts. However, it is the calving and mortality rates determine the relative proportions of various classes of animals in a herd. Thus, although Shompole ranch had the highest estimate of calving rate the proportion of breeding cows was the lowest. This could possibly be due to relatively high mortalities of adult cattle in herds in this particular . Unfortunately, this particular study did not investigate mortality of adult cattle. Therefore, it is recommended that such studies should be conducted in order to clarify all factors that affect herd growth and recruitments in Maasai pastoral systems.

The proportions of breeding cows among the 51 herds sampled in this study ranged from 56.8 - 59.2 percent (mean=53.1 percent). Similar results have been recorded confirming that Maasai pastoral farmers in Kajiado District continued to manage their cattle for maximum milk production and herd restocking rather than for beef production (de Leeuw *et al.*, 1984; King *et al.*, 1984). The estimated calving rate of 50.8-60.8 percent was lower than 68 percent reported for similar herds within the same district (Semenye, 1987). On average calves comprised 21.6 percent of the herd in this study which was also within the range quoted by others (Peeler and Omore, 1996). Although this study did not come up with estimates of calf mortality, it was possible that some of the calves that were born alive had died within the first 12 months after birth (Bekure *et al.*, 1991), which might explain the relatively low calving rate observed in this study.

Although there were a wide range of constraints affecting calf health and production in all the six ranches sampled, there was a fair agreement in response that the four most important constraints were water and feed shortages (both are drought related), high incidence of diseases, and inadequate extension services. An earlier survey (Wandera *et al.*, 1997a) also reported that water was a major constraint affecting the improvement of meat from goats and sheep in the arid and semi arid areas of Kenya. This study shows that the availability of water resources varied among ranches. For example, water resources in Olosho Oiborr were more readily available compared to Shompole, Kuku 'B' and Emarti. Although, Shompole and Kuku 'B' had some permanent water resources (Rivers Parkase and Nolturesh) the water was not readily available for the wider community members due to the large size of the ranches and the wide distribution of human population. On the other hand, apart from using spring water from the Ngong hills, the construction of a communal dam had made tremendous improvement in water availability in Olosho Oiborr . The community in Shompole ranch reported that Ewaso Nyiro Rriver had changed it course following the heavy *El nino* rains of 1997, which left a dry riverbed resulting in long distance treks in search of water for both people and animals. Unfortunately, the options for alleviating water shortage in the ASAL were very limited due to the lack of permanent rivers and the high cost of constructing dams and boreholes. However, there are opportunities for improving water resources such as development of roof catchments and dams.

Among the diseases of calves, pastoralists in all the study sites listed theileriosis was ranked position one was prevalent throughout the year. In Olosho Oiborr ranch, however, pastoralists indicated that the highest prevalence occurred during the wet seasons. This was expected as temperature and rainfall have a significant influence on the abundance and longevity of the *R. appendiculatus* vector ticks (Norval *et al.,* 1992). In contrast to Olosho Oiborr , pastoralists in Kuku 'B' reported that the peak of theileriosis infections occurred during the months of June and July which are relatively dry months. One possible reason for this was the movement of wild game, especially buffaloes, from the game reserves into the settlement areas in search of water and forage during the dry season. Buffaloes are carriers of *T. parva lawrencei* which causes the fatal corridor disease of cattle (Radley *et al.*, 1979; Grootenhuis, 1999)

Trypanosomosis was perceived to be prevalent throughout the year in Shompole and Kuku 'B' ranches. Farmers in Shompole identified two peaks in the prevalence of trypanosomosis, between January and May and another one between October and December. The ability of farmers to identify peaks of the disease prevalence was also reported from formal surveys (Catley *et al.*, 2002) thus indicating that pastoralists' indigenous knowledge on animal diseases prevalent in their regions should not be ignored.

Oxytetracyclines in various formulations were commonly used by Maasai pastoralists to treat diseases including non-bacterial ones such as trypanosomosis. which this could lead to drug resistance and poisoning. Tick-borne diseases (especially theileriosis and anaplasmosis) were better controlled by use of acaricide. However, despite the widespread availability and application of acaricide in the pastoral systems, these health problems have persisted in calves. Outbreaks of FMD which was ranked position two overall had become a common phenomenon in spite of annual vaccinations conducted by the staff of the Ministry of Livestock and Fisheries Development (MLFD)(DVO, 1998, 1999).

Helminthosis persist in the pastoral production systems and even assume high ranking in some areas such as Nentanai ranch as a constraint possibly due to non-application of anthelmintics, ineffectiveness of anthelmintics in the market and under dosing. Diseases such as anthrax, black quarter, CBPP and Lumpy Skin disease can be effectively controlled by vaccination. However, this was not commonly done except when there was an outbreak.

There are other reports which identified feed shortage as a constraint to improvement of livestock in ASAL (Wandera *et al.,* 1997b; (Pedersen and Madsen, 1998;). In this study, feed shortage was associated with drought, presence of free roaming wild game and overstocking. While prescribed and organised burning was one of the accepted methods of bush management, wild fires caused by arsonists, poachers and fishermen were reportedly common during the dry season thus contributing further to the shortage of forage. Overstocking was reported in the subdivided ranches. Apart from exacerbating the problem of feed shortage, overstocking causes overgrazing, land degradation and soil erosion. Among the mitigation strategies mentioned were temporary exchanget of excess animals with other families with excess pasture, and / or relocation of herds to areas. Thus, although majority of the ranches were subdivided into individual land parcels, there was some sharing of some resources such as grazing pastures and water. Interestingly, pastoralists in unsubdivided es did not identify overstocking nor overgrazing as constraints possibly because there was no restriction to movement of animals in unsubdivided grazing.

While the pastoral communities were aware that tourism was a major foreign exchange earner for the country, wildlife was considered a menace especially to communities living next to the game parks. Almost, all the major types of game animals were commonly found in Kajiado District. They included Wildebeest, Zebras, Buffaloes, Elephants, Lions, Hyenas, Leopards, Elephants, Antelopes, Ostriches, Monkeys and Apes (Ole Katampoi *et al.,* 1990), They are known to be reservoirs for diseases such as theileriosis (Buffaloes) (Grootenhuis, 1999), Malignant Catarrhal fever (MCF) (Grootenhuis, 1999), predators (lions, hyenas, apes), and destroy and farm structures (elephants) and are feed competitors.

With the recent liberalization of the economy by the GoK (Hubl *et al.,* 1998), cross-border livestock marketing and high cost of inputs for production among pastoral communities in ASAL has adversely affected livestock production. The pastoralists observed that lack of price control and the free trade between countries had affected the prices of animals. During the implementation of RRA there were traders who were transporting animals across the border from Tanzanian markets to Kenyan markets (such as those in Shompole ranch). Apart from flooding the livestock market, such traders were willing to accept less money due to relative difference in currency exchange rates (1 Ksh. was equivalent to 10 Tsh. at the time of the study) thus causing further decrease in livestock prices. Although it is not clear how trade in livestock and their products affected calf health and production, it was assumed that part of the proceedings from the sale of animals was used to purchase drugs for treatment and control of calf diseases (Gitunu *et al.,* 2003). Thus, a livestock marketing survey was necessary to determine supply and demand trends and how these impacted on price fluctuations and input into production especially purchase of veterinary inputs such as drugs and acaricide.

Lack of breeding stock and limited extension coverage were also a constraint for improved calf health and production in the six ranches. The appropriate approach to lack of breeding stock would be to identify the "best animals" within the herds which would then be characterised for their production and survivability traits. This would then be followed by followed by development of selection criteria and a multiplicative system that should involve interested private producers to act as sources of breeding stock for sustainablity . Unfortunately, most of the indigenous breeds of cattle have not been adequately characterised. Thus information on phenotypic and genotypic characteristics of indigenous cattle is either acking or incomplete (Rege *et al.*, 2001).

This study has suggested that there was a high risk of TBDs in pastoral systems of Kajiado District. Perhaps one of the reasons could be attributed to the introduction of exotic breeds to upgrade indigenous cattle (Gregory *et al.*, 1984; Trail *et al.*, 1984). The level of introduction of exotic blood was higher in Olosho Oiborr ranch than in others ranches. These animals are more susceptible to TBDs than the local *Bos indicus* breeds (Fivaz *et al.*, 1992; Mwangi *et al.*, 1998; Bakheit and Latif, 2002) . Another possible contributing factor is the distribution of suitable habitats for vectors. Thus, while tickborne diseases were listed in all the study es, the risk of trypanosomosis was higher in Shompole and Kuku 'B' than in the others es perhaps due to the relatively suitable vegetation cover for tsetse flies within them.

From the foregoing discussions the following conclusions can be drawn: one, the impact of tick-borne diseases on calf health and production should be a priority goal for research in Maasai pastoral systems; two, there iss need to evaluate the effectiveness of vaccination schedulse for FMD, CBPP, Blanthrax, Lumpy skin disease; three, there is need to assess the impact of helminthosis on calf production. This should go hand in hand with evaluation of the anthelmintics on the market and strategic drenching schedules for control of worms.

Water and forage shortage were perceived as key constraints to improving calf health and production among Maasai pastoralists in Kajiado District. These constraints need to be addressed. There is need for efficient use of the little water and forage resources available for increased calf production. However, increasing water and feed resources for calves and livestock in general was outside the scope of this study.

Finally, the RRA survey was a valuable approach to working with communities in analysing the constraints for improvement of calf health and production. In this study, RRA methods were applied to assess the Maasai pastoralists' perception of constraints affecting with calf health and production, their causes and predisposing factors. The participatory nature of the study enhanced relationship between the investigator and the pastoralists, a concept considered as a major benefit in using RRA and PRA methodologies (Biggs, 1989). While majority of pastoralists were ready to discuss and participate fully in the surveys, a few of them were inclined to demand incentives such as drugs, acaricide, free veterinary services in order to participate in the survey.

Rapid Rural Appraisal (RRA) method of data collection has advantages over the more-detailed cross-sectional and longitudinal studies because it can be used to collect data more quickly and cost effectively and it uses a wide range of multidisciplinary information as well as enabling on-the-spot assessment. It has a high level of community participation and is accessible to many users with or without quantitative skills (Snow and Rawlings, 1999). Unfortunately, information collected using RRA/PRA methods usually lacks some detail and the precision cannot be estimated. In addition, the reliability of estimates of disease prevalence obtained from such studies depends mainly on the extent of knowledge of diseases by livestock owners and herdsmen. Thus, although the pastoralists could correctly point out the role of dense vegetation and the presence of ticks in the transmission of theileriosis they were not aware of the causal relationship between *R. appendiculatus* and *T. parva*. Similarly, they could not identify the causal relationship between environmental factors such as soil contamination and the bacteria that transmit anthrax and black quarter. The mere presence of ticks may also give very little indication of an impact on livestock production especially where several genera of ticks with different abilities to transmit disease agents occur. Further, other survey methods are required to estimate the prevalence of, and production loss associated with presence of disease. In order to obtain this information, the results of the RRA were used to design cross-sectional and longitudinal observational studies whose results are presented in the chapters six, seven and eight.

CHAPTER FIVE

RISK FACTORS ASSOCIATED WITH SEROPREVALENCE OF TICK-BORNE DISEASES OF CALVES IN MAASAI PASTORAL HERDS IN KAJIADO DISTRICT, KENYA

5.1 INTRODUCTION

Ticks and tick-borne diseases (TBDs) are a major constraint to improved cattle production in Kajiado District (Bekure *et al.,* 1991; DVO, 1997; 1998; 1999). Indeed, during the Rapid Rural Appraisal survey (Chapter four) they were ranked the highest among the diseases of calves by Maasai pastoralist in all six ranches that were sampled. The most important TBD is East Coast fever (theileriosis) caused by *Theileria parva* and transmitted by the Brown ear tick, *Rhipicephalus appendiculatus* (Ole Katampoi *et al.,* 1990; Bekure *et al.,* 1991). Other TBDs of cattle are benign theileriosis caused by *Theileria mutans*, anaplasmosis caused by *Anaplasma marginale*, babesiosis caused by *Babesia bigemina* and cowdriosis caused by *Cowdria ruminatium.*

Control of TBDS is quite expensive and relies mainly on application of acaricide through hand spraying. Application of acaricide must be regular and skilful in order to avoid under exposure of ticks and resistance development. Over exposure of the animal to chemical causes poisoning. The design of effective strategies for control of disease requires data on the estimates of prevalence, incidence rate and impact of disease on production (Martin *et al.,* 1994). Except for the information contained in annual reports (DVO, 1997; 1998;

1999) such data are lacking in Kajiado District. Estimates of disease prevalence are usually obtained from cross-sectional studies while incidence rate of disease and their impact on animal production are obtained from longitudinal studies (Dohoo *et al.,* 2003). The objective of this study was to estimate the seroprevalence of TBDs in calves in Maasai pastoral systems of Kajiado District and to identify risks factors associated with these diseases, and the potential for controlling these in these pastoral production systems.

5.2 MATERIALS AND METHODS

5.2.1 Design of the study

The study design, areas and methods used to select households and herds have been descibed in chapter three.

5.2.2 Data collection and storage

For each of the households, a semi-structured questionnaire (Appendix 3.2) was administered to the herd owner or his representative to gather specific information on herdingg activities (verified by the interviewer). Information on variables potentially associated with sero-prevalence of TBDs at the farm and calf levels were collected (Table 5.1). As much as possible, the variables were derived from the causes and / or predisposing factors that were listed by pastoralists during the RRA (Chapter 4) and were known to have some biological relationship with the prevalence of TBDs. For example, water and feed availability for the calf were dependent on type of grazing management, age at

Table 5.1 Potential explanatory risk factors associated with antibody prevalence to *T. parva, T. mutans, A. marginale* and *B. bigemina* from the cross-sectional study in Kajiado District.

Farm management factors

- Grazing management system: communal / individual land ownership
- Calf herd size: 1-10 calves / 11-30 calves / 31-60 calves
- Calf pen treated? : yes / no
- Calf pen treatment method? : none / ash / insecticide
- Colostrum feeding time at birth: < 6 hours / > 6 hours
- Colostrum feeding method at birth: assisted suckling / free suckling
- Age at first watering: < one month / 1-3 months / > 4 months
- Watering method: Use of a pail or basin / treks to the river
- Watering frequency:*Adlibitum* / once daily / once every two days
- Age at first free grazing on pastures:<one month / 1-2 months / >3 months
- Age at start of tick control: none / < one month / 1-2 months / > 3 months
- Method of tick control: none / dipping / spraying / handpicking / grazing management
- Frequency of tick control: once per week / twice per week / when tick burdens high

Calf-related factors

- Age of calf at time of visit
- Sex of calf: male / female
- Breed of calf: Maasai zebu / exotic (mainly Sahiwal and Boran) / crosses (mainly crosses of Maasai zebu with Sahiwal, Boran and *Bos taurus*)
- Packed red cell volume

first free grazing and watering methods and frequency while the prevalence and incidence of tick-borne diseases would depend on the methods and frequency of tick control.

The farm-level variables that were collected included grazing management (individual land or communal), calf feeding practices (including colostrum feeding time and method), calf herd size (categorised into groups of 1-10 calves, 11-30 calves, 31-60 calves), tick control methods (initial age at tick control, frequency of control), calf watering management (age at first watering, method and frequency of watering), calf grazing practices (age at which calves start going out to graze on pasture), calf housing and hygiene.

A separate questionnaire was administered to gather the following information:: age, sex and breed. Calf age was categorized (from birth up to 3 months, 4-6 months, 7-9 months, and 10-12 months) because there were no records of calving dates. Similarly breed type was also categorized as Maasai zebu, exotic and crosses (includes Maasai zebu crossed with Sahiwal, Boran and Taurine breeds) based on phenotypic identification by the Principal Investigator (PI). All questions were presented in a closed-ended format.. For the purpose of maintaining consistency, all interviews were conducted in Kiswahili and translated into Maasai dialect by local translators.

Data files of responses to questionnaires and the results of laboratory assays were prepared in Microsoft Access database. Separate files were prepared for the farm and individual calf variables.

5.2.3 Data analysis

Data nalysis were conducted using Statistical Analysis Software (SAS) for Windows, version 8.2 (SAS 1985). Percent positivity (PP) values from the serum antibody tests (described in Chapter three section 3.2.2) were the outcome variables and were either positive or negative (coded zero) using the fixed cut-off points of >19 for *T. parva* and *T. mutans* and >14 for *A. marginale* and *B. bigemina*. First, descriptive analyses were used to estimate mean serum antibody prevalence for *T. parva, T. mutans, A. marginale* and *B. bigemina* by ACZ, ranch, and calf age using the PP values. The 95 percent confidence limits (C.L.) for the seroprevalence estimates (binomial proportions) (Snedecor and Cochran 1989) for each ACZ and ranches were generated. Secondly, in order to investigate the endemic status of herds for tick-borne diseases, the prevalence of serum antibodies against *T. parva, T. mutans, A. marginale* and *B. bigemina* in herds within each of the six ranches were categorised as low (0-30 percent), moderate (31-70 percent) and high (71-100 percent) (Gitau, 1997). Histograms were then used to compare variation within and between ranches and herds.

The Ordinary Logistic Regression was then used to investigate the association between the serum antibody prevalence of TBD parasites and potential risk factors (Table 5.1) using percent positivity (PP) values as the outcome variables. First, ACZ and ranches variables were analysed separately followed by farm and calf variables. Farm variables were grouped into feeding practices, tick control and other management practices. Each ranchesof farm variables was analysed separately prior to their inclusion into the full model. For each of these separate analyses, variables to be included in the full main effects model (comprising all groups' variables) were obtained by backward elimination of non-significant variables at $p < 0.1$. Several interaction terms were created using variables that were found to be significant in the main effects model. The final regression model was generated by backward elimination of non-significant variables from the overall model based on Wald's test ($p < 0.05$). The ACZ and breed were forced into the model.

The actual number of calves per household varied from 2 - 54 calves (mean = 22.7; standard deviation =14; median = 18). Thus, the possibility that clustering of responses at the ranches and farm level might cause a larger than expected variance was investigated using Generalized Estimating Equations (GEE) in SAS. The significance ($p < 0.05$) of the variables chosen for the final models was reassessed using the model-based variance-covariance estimates assuming a common correlation pattern across households within ranches.

5.3. RESULTS

5.3.1 Descriptive statistics

A total of 729 calves were sampled from a total of 51 households. Calves aged less than one month to 3 months made up 18.79 percent (137/729) while 48 percent (350/729) were between 4-6 months old. Calves aged between 7-9 months comprised 22.6 percent (165/729) while 10.56 percent (77/729) were aged between 10-12 months (Table 5.2). Forty nine point one percent (358/729) were male calves while 50.9 percent (371/729) were female calves. The breeds

Table 5.2 Characteristics of selected calves (n=729) in terms of age, sex, breed, herd size, house cleaning and feeding practices from the cross-sectional study in Kajiado District (November, 1999 – January, 2000.

Variable	Category	No. of calves tested	Percent
Calf age	< 4 months old	137	18.8
	4-6 months old	350	48.0
	7-9 months old	165	22.6
	10-12 months old	77	10.6
Sex	Male	358	49.1
	Female	371	50.9
Breed	Maasai zebu	216	29.6
	Crosses	472	64.7
	Exotic	41	
Calf house cleaning method	None	634	87.0
	Ash	28	3.8
	Insecticide	67	9.2
Colostrum feeding time	<6 hours of birth	716	98.2
	>6 hours of birth	13	1.8
Colostrum feeding method	Assisted suckling	95	13.0
	Free suckling	634	87.0
Suckling frequency per day	Once	89	12.2
	Twice	640	87.8
Herd size	< 11 calves	120	16.5
	11-30 calves	404	55.4
	31-60 calves	205	28.1

of calves comprised of crossbreds 64.8 percent (472/729), Maasai zebu, 29.6 percent (216/729) and exotic, 5.6 percent (41/729).

Table 5.2 shows that 55.4 percent of the calves were from calf-herd sizes that varied from 11-30 calves while 16.5 percent and 28.1 percent of the calves were from calf-herd sizes varying from 2-10 calves and 31-60 calves, respectively. Majority (87.3 percent) of calves were kept in pens that were not treated against ectoparasites such as fleas and lice while the rest were kept in pens that were regularly treated with either ash (3.8 percent) or insecticides (9.2 percent). Over 98 percent (716/729) of calves were fed on colostrum within the first six hours after birth, while only 13.0 percent (95/729) of the calves required some assistance during suckling. Most (87.8 percent) calves were suckled twice per day, in the evening and in the morning.

The most popular farm and calf management variables including tick control, watering and grazing management practices are shown in Table 5.3. Thirty two percent of the calves were first sprayed when they were less than one month old while 49.5 percent were first sprayed at the age of 1-2 months old. Only 18.2 percent of the calves were first sprayed when they were $\geq$ 3 months of age. Maasai pastoralists used both spraying and hand picking methods of tick control but hand spraying using a pump was the most popular method used. Approximately 6.7 percent of the calves were sprayed when tick burdens were observed to be high, 15.8 percent of the calves were sprayed at least once per month and 77.2 percent were sprayed at least once per week.

Table 5.3 Management practices of calves (n=729) selected for the cross-sectional study in Kajiado District (November, 1999 – January, 2000).

Variable	Categories	No. of calves tested	Percent
Age of calf at start of tick control	< one month	233	32.0
	1-2 months	361	49.5
	> 3 months	135	18.5
Frequency of spraying against ticks	When tick burdens high	49	6.7
	At least once per month	117	16.1
	At least once per week	563	77.2
Grazing system	Individual land	381	52.3
	Communal land	348	47.7
Age at first watering	< one month old	45	6.2
	1-4 months old	401	55.0
	> 4 months	283	38.8
Watering frequency	*adlibitum*	97	13.3
	Once daily	547	75.0
	Less than once daily	85	11.7
Watering method used	Pail or basin	297	40.7
	Treks to the watering place	432	59.3
Age at free grazing on natural pasture	< one month old	281	38.5
	1-2 months old	321	44.1
	3-4 months	107	14.7
	5-6 months	20	2.7

About 52.3 percent of the calves were grazed on individually owned farms while 47.5 percent were grazed on communally owned land (Table 5.3). Thirty eight point five percent of the calves were taken out for free grazing when they were less than one month old while 17.4 percent went out for grazing when they were more than 3 months old.

About 6.2 percent of calves started drinking water when they were less than one month old while 55 percent of the calves were not provided with water until they were 1- 4 months. Only 38.8 percent of the calves were watered at least 4 months of age. Majority (75 percent) of the calves were given water once per day.

5.3.2 Prevalence of serum antibody by ACZ and ranches

Figure 5.1 shows the prevalence of serum antibodies for *T. parva, T. mutans* and *A. marginale* and *B. bigemina* by ACZs. The prevalence of *T. parva* was significantly ($p < 0.05$) higher in ACZ IV than in ACZ V but not between ACZ IV and ACZ VI or ACZ V and ACZ VI. The prevalence of *T. mutans* was significantly ($p < 0.05$) lower in ACZ IV than in ACZs 5 and 6. The prevalence of *A. marginale* was relatively high (> 60 percent) while that of *B. bigemina* was relatively low (< 30 percent) in all the three ACZs. However, there no significant differences in the prevalence of the two parasites between ACZs.

Figure 5.2 shows the prevalence of serum antibodies to *T. parva, T. mutans* and *A. marginale* and *B. bigemina* by ranches. In ACZ IV, Olosho Oiborr had significantly ($p < 0.05$) higher prevalence of *T. parva* antibodies than in

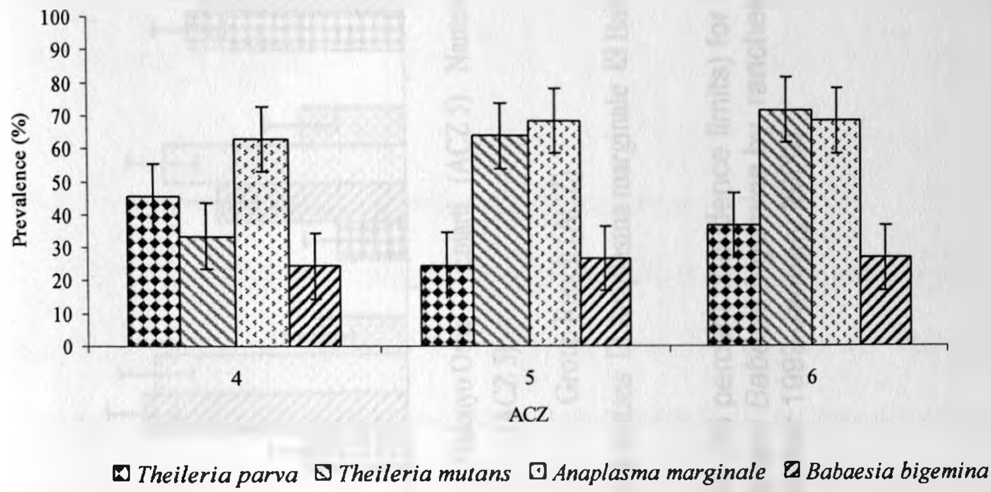


Figure 5.1 Prevalence of serum antibodies (95 percent confidence limits) for *Theileria parva, Theileria mutans, Anplasma marginale* and *Babesia bigemina* by ACZ in Kajiado District (Cross-sectional study, November 1999-January 2000)

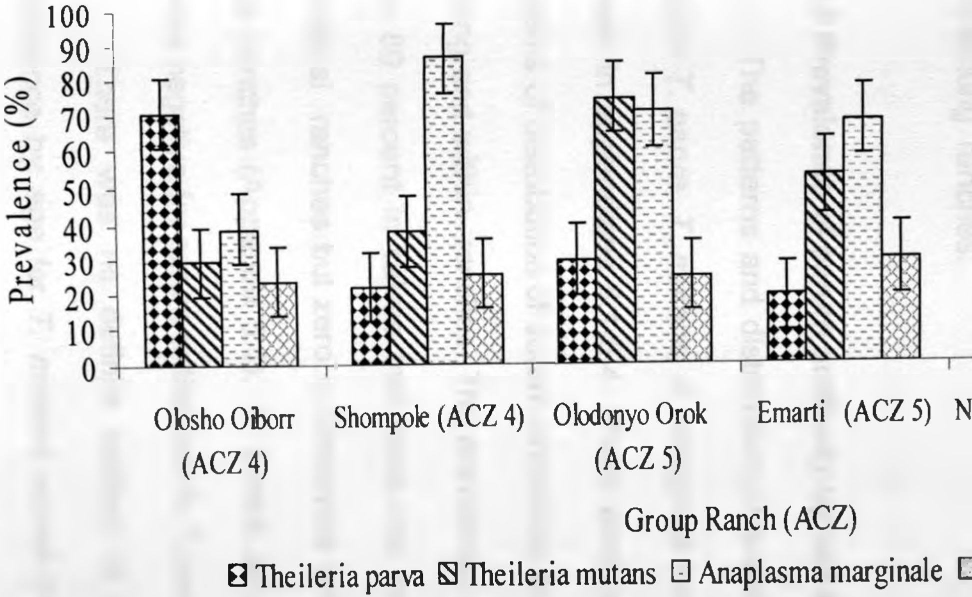


Figure 5.2 Prevalence of serum antibodies (95 percent confidence limits)
mutans, *Anaplasma marginale* and *Babesia bigemina* by ran
(Cross-Sectional study, November 1999-January 2000)

Shompole. However, Shompole had significantly ($p < 0.05$) higher prevalence for *A. marginal* antibodies than Olosho Oiborr .

In ACZ V, there were no significant ($p < 0.05$) differences between Olodonyo Orok and Emarti es in the prevalence of antibodies to the four parasites In ACZ VI, Nentanai had significantly ($p < 0.05$) higher prevalence of *T. parva* antibodies than in Kuku 'B' while the prevalence for *T. mutans* antibodies was significantly ($p < 0.05$) higher in Kuku'B' than in Nentanai. The prevalence of serum antibodies for *B. bigemina* did not significantly ($p < 0.05$) differ among ranches.

5.3.3 Prevalence of serum antibody by calf age

The patterns and distribution of serum antibodies prevalence by calf age for *T. parva, T. mutans, A. marginale* and *B. bigemina* for the six es are shown in appendices 5.1-5.4. There were variations in the prevalence and patterns of distribution of serum antibodies by age for all four haemoparasites among and within ranches. The prevalence of serum antibodies for *T. parva* was 80 percent in calves that were one month old in Olosho Oiborr and Nentanai ranches but zero in Shompole and Emarti ranches for the same age ranches (Appendix 5.1). In Emarti, all calves less than five months old tested negative for serum antibodies to *T. parva.*

There was no definite pattern of distribution of serum antibody prevalence by age for *T. mutans* across the six ranches (Appendix 5.2). Calves in Olodonyo Orok, Nentanai and Kuku 'B' ranches had relatively high prevalence of serum antibodies for *T. mutans* for all ages compared to their counterparts in Olosho Oiborr, Shompole and Emarti ranches. In Shompole , the prevalence of serum antibodies to *A. marginale* was 80 percent in one month old calves and remained persistently high up to 12 months of age (Appendix 5.3). Similar trends were observed in Nentanai and Kuku 'B' ranches except that relatively low prevalence was observed in calves that were one to two months old in the latter sites.

Serum antibodies prevalence for *B. bigemina* by age in Kuku 'B' was highest (100%) in one-month-old calves, declined in three-month-old calves and then gradually increased up to the eighth month of calf age (Appendix 5.4). Another drop was observed in 10-month-old calves but peaked again in the 11 and 12 months old calves. Generally, the serum antibody prevalence for *B. bigemina* was below 60 percent for all ages in Olosho Oiborr and Olodonyo Orok ranches. Surprisingly, there were no serum antibodies for *B. bigemina* in calves aged seven to eleven months in Nentanai.

5.3.4 Herd prevalence of serum antibodies

The distribution of serum antibody prevalence for *T. parva, T. mutans, A. marginale* and *B. bigemina* within in herds and among ranches is shown in Appendix 5.5. There were wide variations in prevalences of serum antibodies within herds within and between ranches. Majority of the herds in Olosho Oiborr had moderate to high prevalence of serum antibodies to *T. parva* (Appendix 5.5). Relatively high proportions of herds in Emarti, Kuku 'B and Shompole es (71 percent) had a low prevalence (0 – 30 percent) of serum antibodies for *T. parva.* A high prevalence (71-100 percent) of serum antibodies for *T. parva* was observed in Olosho Oiborr (45 percent of herds), Olodonyo Orok (29 percent of herds) and Nentanai (22 percent of herds).

Over 80 percent of herds in Kuku 'B' and Olodonyo Orok es had high prevalence (71-100 percent) of serum antibodies for *T. mutans* compared to 25 percent in Emarti and 11 percent of herds in Nentanai es (Appendix 5.5).

Except in Olosho Oiborr where a high proportion of herds had low to moderate prevalence (0 – 70 percent) of serum antibodies for *A. marginale*, majority of herds in other sites had relatively high prevalence (71 – 100 percent) of serum antibodies for the same parasite (Appendix 5.5c). The proportion of herds with a high prevalence of serum antibodies for *A. marginale* was highest in Shompole (86 percent), followed by Olodonyo Orok (71 percent), Emarti (63 percent), Kuku 'B' (63 percent) and Nentanai . Only 18 percent of herds in Olosho Oiborr had a high prevalence of serum antibodies for *A. marginale* while 36 percent of the herds had low prevalence of serum antibodies for the same parasite. A high proportion of herds sampled in each of the ranches had a low prevalence of serum antibodies for *B. bigemina* (86 percent for Shompole , 78 percent for Nentanai , 71 percent for Olodonyo Orok , 64 percent for Olosho Oiborr , 50 percent for both Kuku 'B' and Emarti es) (Appendix 5.5).

5.3.5 Factors associated with serum antibody prevalence of TBDs

Table 5.4 shows that ACZ, grazing system, use of chemical and ash to clean the calf pen, mean calf herd size per household and age at first grazing of natural pasture were significantly associated with prevalence of serum antibodies to *T. parva*. Calves in ACZ V had significantly (p = 0.001 lower) prevalence for *T. parva* compared to calves in ACZ VI from the OLR model but the difference was insignificant (p = 0.15) after adjusting for the clustering

Table 5.4 Variables associated with *T. parva* serum antibody prevalence from the multivariate analysis (Ordinary Logistic Regression (OLR) and Generalized Estimated Equations (GEE) models) for 729 calves in Kajiado District, Kenya (Cross-sectional study, November 1999 - January, 2000).

Variable	OLR			GEE		
	b	Se (b)	p-value	b	Se (b)	p-value
a) Agro-Climatic Zone (ACZ)						
ACZ IV (1), ACZ VI (0)	-0.20	0.24	0.395	-0.04	0.30	0.90
ACZ V (1), ACZ VI (0)	-0.78	0.23	0.001	-0.53	0.37	0.15
b) Farm level variables						
Grazing system						
communal (1), individual (0)	-1.07	0.21	<0.0001	-1.27	0.24	<0.0001
Chemical used to clean calf pen						
Ash (1), none (0)	-1.52	0.77	0.047	-1.20	0.68	0.080
Insecticide (1), none (0)	-2.29	0.71	0.001	-1.94	0.59	0.0009
Calf herd size						
11-30 calves (1),<11 calves (0)	-0.46	0.28	0.097	-0.33	0.32	0.297
31-60 calves (1),<11 calves (0)	-1.17	0.32	0.0002	-1.10	0.52	0.033
Age at first grazing on pasture						
< one month (1), > 3 months (0)	-2.23	0.65	0.0006	-1.99	0.58	0.0006
1-2 months (1), > 3 months (0)	-2.08	0.63	0.0010	-1.81	0.56	0.0012
c) Calf level variables						
Breed						
Crosses (1), Maasai zebu (0)	0.03	0.23	0.912	-0.05	0.20	0.939
Exotic (1), Maasai zebu (0)	0.21	0.43	0.627	0.38	0.46	0.410

Key: b – parameter coefficient estimate

Se (b) – standard errer of the coefficient estimate

of calves in herds within the same ACZ. Calves that were kept on communally owned land had significantly ($p < 0.0001$) low serum antibodies to *T. parva* than calves that were kept on individual land. The use of ash marginally significant at $p = 0.047$) and chemicals (pesticides) ($p < 0.001$) was associated with significantly low prevalence to *T. parva* while calves that were kept together in groups of herds whose sizes was greater than 30 had significantly ($p = 0.0002$) low prevalence to *T. parva*.

Calves that started grazing on natural pasture at the age of less than three months had significantly ($p = 0.001$) lower serum antibody prevalence of *T. parva* than calves that started grazing on natural pastures later than three months of age. None of the calf variable listed in Table 5.2 was significantly associated with prevalence of *T. parva.*

The variables associated with prevalence of serum antibodies for *T. mutans* are shown in Table 5.5. The prevalence of serum antibodies to *T. mutans* was significantly lower ($p < 0.0001$) in ACZ IV than in ACZ VI. Calves that had access to colostrum milk within the first six hours after birth had significantly ($p < 0.0001$) higher serum antibody prevalence than those that suckled more than six hours after calving. Suckling once per day was significantly ($p = 0.0016$) associated with higher serum antibody prevalence than those that suck twice per day. At least once per month spraying of calves was associated with significantly ($p = 0.014$) lower serum antibody prevalence of *T. mutans*.

Among the calf variables listed in Table 5.2, only calf age was significantly associated with prevalence of serum antibodies to *T. mutans.* Table 5.5 shows that older calves (10-12 months old) had significantly

Table 5.5 Variables associated with *T. mutans* serum antibody prevalence from the multivariate analysis (Ordinary Logistic Regression (OLR) and Generalized Estimated Equations (GEE) models) for 729 calves in Kajiado District, Kenya (Cross-sectional study, November 1999 - January, 2000).

Variable	OLR			GEE		
	b	Se (b)	p-value	b	Se (b)	p-value
a) Agro-Climatic Zone (ACZ)						
ACZ IV (1) vs ACZ VI (0)	-1.63	0.23	<0.000	-1.63	0.26	<0.0001
ACZ V (1) vs ACZ VI (0)	-0.18	0.22	0.397	-0.18	0.25	0.470
b) Farm level variables						
Colostrum feeding method						
Assisted suckling (1), free suckling (0)	-0.54	0.26	0.039	1.35	0.15	<0.0001
Time of colostrum feeding at birth						
<6 hours after birth (1), > 6 hours after birth (0)	1.35	0.64	0.030	1.35	0.15	<0.0001
Suckling frequency						
Once per day (1), twice per day (0)	0.77	0.29	0.009	0.76	0.24	0.0016
Frequency of tick control						
At least once per month (1), when tick burdens high (0)	-0.78	0.34	0.023	-0.79	0.32	0.014
c) Calf level variables						
Calf age						
4-6 months (1), <4 months (0)	0.23	0.23	0.313	0.23	0.18	0.191
7-9 months (1),<4 months (0)	-0.02	0.27	0.954	-0.02	0.25	0.944
10-12 months(1),<4 month (0)	-0.63	0.33	0.060	-0.63	0.28	0.028
Breed						
Crosses (1), Maasai zebu (0)	-0.05	0.19	0.810	-0.05	0.37	0.866
Exotic (1), Maasai zebu (0)	0.15	0.41	0.714	0.15	0.39	0.711

Key: b – parameter coefficient estimate

Se (b) – standard errer of the coefficient estimate

(p=0.028) lower prevalence of serum antibodies to *T. mutans* than calves that were less than 4 months old.

From the OLR model, the prevalence of serum antibodies to *A. marginale* was significantly (p = 0.045) higher in calves that were kept in individual land than those that were kept in communally owned land. However, the association was not significant (p=0.109) after adjusting for clustering effects using the GEE model (Table 5.6). Calves that had access to colostrum within the first six hours after birth had significantly (p < 0.0001) higher serum antibody prevalence to *A. marginale* than those that suckled more than six hours after calving. Frequent spraying (at least once per week) was associated with significantly (p=0.012) lower serum antibody prevalence of the parasite.

Calves that were provided water by pail or bucket had significantly (p=0.015) lower prevalence of serum antibodies to *A. marginale* than calves that were trekked to the watering point In addition, calves that started trekking to distant watering points when aged 1-6 months of age had significantly lower prevalence of serum antibodies to *A. marginale* than calves that were trekked to the same points at the age of less than one month.

Table 5.7 shows the variables that were associated with prevalence of antibodies to *B. bigemina*. The results confirm earlier report that there were no difference in the prevalence of serum antibodies to *B. bigemina* at the ACZ and ranches (Figures 5.1 and 5.2) Calves from farms that started tick control after 3 months of age had significantly (p=0.002) lower serum antibody prevalence for *B. bigemina* (Table 5.7). The prevalence of serum antibodies to *B. bigemina* was significantly lower for older calves than for younger ones (p <

Table 5.6 Variables associated with *A. marginale* serum antibody prevalence from the multivariate analysis (Ordinary Logistic Regression (OLR) and Generalized Estimated Equations (GEE) models) for 729 calves in Kajiado District (Cross-section study, November 1999 - January, 2000).

Variable	OLR			GEE		
	b	Se (b)	p-value	b	Se (b)	p-value
a) Farm level variables						
Grazing system						
Individual (1), communal (0)	0.38	0.19	0.045	0.37	0.23	0.109
Time of colostrum feeding						
< 6 hours after birth (1), > 6 hours after birth	1.56	0.63	0.013	1.54	0.32	0.0001
Frequency of tick control						
At least once per week (1) , when tick burdens are high (0)	-1.05	0.45	0.021	-1.07	0.42	0.012
Age at first tick control						
1-2 month (1), > 3 months (0)	-0.51	0.29	0.074	-0.52	0.27	0.050
<one month (1),> 3 months (0)	0.06	0.41	0.882	0.07	0.39	0.859
Age when distant watering starts						
1-2 months (1), <one month (0)	-0.72	0.45	0.111	-0.74	0.27	0.006
3-4 months (1), <one month (0)	-0.80	0.46	0.083	-0.78	0.24	0.001
5-6 months (1), <one month (0)	-0.77	0.46	0.0001	-1.76	0.26	0.0001
7-9 months (1), <one month (0)	-0.41	0.49	0.394	-0.42	0.29	0.152
Watering method						
Pail/bucket (1), trekked to the watering point (0)	-0.80	0.31	0.009	0.80	0.33	0.015

Key: b – parameter coefficient estimate

Se (b) – standard errer of the coefficient estimate

Table 5.7 Variables associated with *B. bigemina* serum antibody prevalence from the multivariate analysis (Ordinary Logistic Regression (OLR) and Generalized Estimated Equations (GEE) models) for 729 calves in Kajiado District, Kenya (Cross-sectional study, November 1999 - January, 2000).

	OLR			GEE		
Variable	b	Se (b)	p-value	b	Se (b)	p-value
a) Farm level variables						
Age at start of tick control						
1-2 months (1), > 3 months (0)	0.19	0.12	0.099	0.08	0.24	0.722
<one month (1), > 3 months (0)	-0.41	0.14	0.002	-0.53	0.27	0.046
b) Calf level variables						
Calf age						
4-6 months (1), <4 months (0)	-0.38	0.13	0.004	-0.39	0.23	0.096
7-9 months (1), <4 months (0)	-0.01	0.16	0.946	-0.04	0.32	0.900
10-12months (1),<4 months (0)	0.32	0.20	0.102	0.27	0.26	0.291
Sex						
Female (1), male (0)	0.21	0.09	0.015	0.39	0.14	0.006

Key: b – parameter coefficient estimate

Se (b) – standard errer of the coefficient estimate

0.004) while female calves had significantly higher (p=0.006) prevalence of serum antibodies to *B. bigemina* than male calves.

5.4 DISCUSSION

In this section of the study, the emphasis was on prevalence of tick-borne diseases, especially East Coast Fever (ECF) or theileriosis, because apart from being ranked the highest in the RRA by the pastoralists, the disease was expected to have the greatest impacts on calf health and production. East Coast fever is caused by *T. parva* and transmitted by the 3-host tick, *R. appendiculatus*. Control of this disease is very expensive because of total reliance on the use of acaricide by Maasai pastoralists. In Kajiado District, the disease was compounded by the abundant presence of buffaloes, which are carriers of the virulent *T. parva* parasites of cattle (Grootenhuis, 1999). Other forms of bovine theileriosis such as *T. mutans* and *T. taurotragi* are mostly benign and economically unimportant. However, *T. mutans* reportedly causes anaemia and poor growth rate in calves (Norval *et al.*, 1992) and the economic impacts of iton calf health and production requires further investigations.

Anaplasmosis caused by *Anaplasma marginale* is an acute, sub-acute or chronic disease that is biologically transmitted by the blue tick, *Boophilus decoloratus*, and mechanically by biting flies, fomites (needles and other surgical instruments). While pastoralists could easily underestimate the disease from the clinical signs, it was highly prevalent from the cross-sectional survey. The disease responds well to oxytetracyclines injections and is relatively easier to manage compared to ECF. Moreover, calves have an innate immunity which wanes off in adulthood (Young, 1987).

The other disease that was investigated was Babesiosis or red water caused by *Babesia bigemina*. The disease is characterised by extensive destruction of red blood cells leading to anaemia, jaundice and haemoglobinuria (Young and Morzaria, 1986). In Kenya, the disease is transmitted by *B. decoloratus* (Blue tick). Just like in anaplasmosis, there is reverse age immunity where calves are more resistant to the disease than adult cattle. The disease had comparatively low mean serum antibody prevalence across the six ranches.

This study has shown that there was wide variation in sero-prevalence of *T. parva, T. mutans, A. marginale* and *B. bigemina* across ACZs and ranches suggesting the existence of different "epidemiological statuses" for the four parasites in Kajiado District. Sero-prevalence has been used to determine the presence and degree of endemic stability and or instability in herds for TBDs (Norval *et al.*, 1992). Endemic stability exists where sero-prevalence to the infection is high (greater than 70 percent), while in endemic instability status sero-prevalence is low (less than 30 percent) (Gitau, 1997). Majority of the herds that were investigated in this study were in a state of "endemic instability" and therefore highly susceptible to TBDs. This is unlike the neighbouring semi arid Trans-Mara District where endemic stability was reported (Moll *et al.*, 1986). Differences in variation of sero-prevalence for the parasites between ACZs, ranches and farms could result in differences in production loss among ranches and farms within each ranches.

The variations in sero-prevalence of TBDs between ACZs were possibly due to environmental factors that affect the distribution of vectors of TBDs. In the relatively higher altitude areas such as those found in ACZ IV, higher numbers of *R. appendiculatus* ticks are present while higher numbers of *Boophilus* and *Amblyomma* species are present in the lower atltitude areas commonly found in ACZ V and VI (Norval *et al.*, 1992). However, variations of serum antibody prevalence between ranches within ACZ and among farms within ranches suggest calf management other than environmental factors were more important determinants of sero-prevalence of TBDs in the district. In ACZ IV, the prevalence of serum antibodies to *T. parva* was significantly higher in Olosho Oiborr (subdivided) than in Shompole ranches (unsubdivided). Pastoral communities practice rotational grazing to control parasites in their herds (personal observations). Shompole and Kuku 'B' ranches were unsubdivided and vast which allows more extensive grazing of animals compared to the relatively small and subdivided Olosho Oiborr and Nentanai ranches.

Majority (98 percent) of farms sampled frequently sprayed (2-4 times per month) their calves against TBDs form as early as one month old. However, the method of acaricide application was highly ineffective due to poor restraint of animals (Personal observations). It is possible that the relatively high frequency of spraying calves against ticks prevented the build up of a certain threshold tick burdens necessary to infect calves and thus induce production of protective antibodies. This could possibly explain the relatively low prevalence of TBDs observed in majority of the herds investigated in this study.

Maasai pastoralists use tetracycline to treat a wide variety of livestock diseases including theileriosis. While they would report mixed responses to treatment, the RRA report indicated that they lacked skill in disease diagnosis. In deed, *Oldikana* (commonly used name for theileriosis in *Kimaasai*) could be a broad spectrum of diseases with related clinical signs including anorexia, high temperature, dullness, raising of the hair and swollen superficial lymph nodes. In places where trypanosomosis occurs together with theileriosis such as Shompole and Kuku'B' (Chapter four) the two diseases can easily be confused from the clinical signs. In some cases, the treatment was not specific but was given to treat a wide spectrum of suspect disease (personal observations). This is drug abuse and could easily result in the development of microbial resistance. Currently, Buparvaquone (Butalex[R], Pitman-Moore), is the drug of choice for treating theileriosis (Muraguri *et al.,* 1999). However, few pastoralists can afford to purchase the drug because of its high cost.

There were other management variables that identified herds with high sero-positivity but the biological association between these variables and the disease was not clear. These variables select calves that are managed differently from the lower sero-prevalence herds within the same ranches. However, the association was not apparently cause and effect. It is hereby proposed that there are other management or local environmental variables that are having a true biological association with the disease. For example, the differences in sero-prevalence between sexes of calves for *B. bigemina* was possibly due to differences in management of females and males such as more milk being given to female. Hence a higher intake of maternal antibodies through colostrum.

Unexpectedly, this study did not record significant differences in prevalence of serum antibodies among breeds. This is because several workers have frequently reported that exotic breeds and their crosses with local Zebu were more susceptible to *T. parva* infection than the pure indigenous Zebu (Fivaz *et al.*, 1992; Mwangi *et al.*, 1998; Bakheit *et al.*, 2002). Data on disease prevalence should be combined with mortality data (Chapter seven) for better interpretation of results on breed susceptibility.

Generally, case fatality rates from ECF in untreated exotic cattle can approach 100 percent while mortality of indigenous cattle is relatively low (Norval *et al.*, 1992) although calf growth is often severely impaired (Moll *et al.*, 1984). This study proposes that calves should be immunised against ECF at around 1-2 months of age. This is the age when maternal antibodies start waning. It is also the stage when calves start oing out to the pastures for grazing and or watering point thereby getting exposed to ticks and TBDs.

In conclusion, the study suggests that different endemic states may exist in pastoral herds in Kajiado District for TBDs and these may result in different production losses. The important variables associated with varying levels of "endemic status" were ACZ, grazing management system and calf management practices at farm level and calf age. Among the important calf management practices that affected the "endemic status" of calves included exposure variables such as calf feeding practices (colostrum feeding, grazing system and watering methods) and frequency of tick control. The results also suggest that although majority of Maasai pastoralists frequently sprayed calves against ticks the method used was not effective. Efforts geared towards improved cost-effective control of TBDs in pastoral systems should include education and demonstrations on appropriate acaricide application. Alternative methods of tick control such as immunization against theileriosis should be also explored. Clearly, it is not possible to estimate the potential benefits of improved tick control methods based purely on the results of a cross-section study. Data on incidence and loss of production associated with disease infection can only be obtained from a longitudinal study. The results of this study were used as baseline information for designing a longitudinal study whose results will be reported in Chapters six and seven.

CHAPTER SIX

FACTORS ASSOCIATED WITH DAILY WEIGHT GAIN OF CALVES IN MAASAI PASTORAL SYSTEMS IN KAJIADO DISTRICT, KENYA

6.1 INTRODUCTION

The productivity of indigenous cattle in Maasai pastoral systems is low relative to that of their crosses with exotic breeds (Gregory *et al.*, 1984; Trail *et al.*, 1984; Syrstad, 1996). The factors that have been associated with low production include high calf mortality and sub-optimal calf growth caused by poor nutrition and the high incidence of disease (Lambourne *et al.*, 1983; Traore and Wilson, 1988).

Maasai pastoralists practice partial milking of animals in the morning before they leave the *boma* (temporary enclosure) and on return in the evening (Semenye, 1987). This practice leads to low calf growth from birth to weaning resulting in delayed maturity of the calves (Cossins, 1983). However, no studies on the effect of varying the regime of calf suckling have been reported for Maasai pastoral herds. However, a few studies have reported the effects of dietary supplementation on calf growth in pastoral systems. An example is a 90-day trial that was designed to compare the growth performance of calves on three dry-season diets comprising of local resources from the Boran pastoral system (Coppock, 1994). The study's objective was to observe whether modest changes in traditional feeding management could enhance nutrient intake and growth of calves under conditions of restricted water access. The control ranchesreceived a traditional diet of cut-and-carry, standing-brown grass while the other diets consisted of grass hay stored since the previous wet season with or without *Acacia tortilis* fruits as protein supplements. All calves had access to water once every three days as was traditional. The hay had a higher nitrogen content and *in vitro* digestibility than the standing grass, and the *Acacia* fruits had significantly higher nutrient concentrations than the hay. Calves on hay plus *Acacia* fruits had significantly higher nitrogen intakes than those on hay only, and those on hay only had higher nitrogen intakes than those on standing grass. Calves on standing grass lost weight and condition, those on hay only maintained weight but lost condition, and those on hay plus *Acacia* fruits gained weight and maintained condition. Calves consumed the most feed on day two of the watering cycle, regardless of treatment. Water intake increased 27 percent for animals on both hay diets compared to those on standing grass. Feeding packages based on haymaking and collection of browse legumes are appropriate options for semi-settled pastoralists.

Exotic breeds of cattle have been used to upgrade local indigenous cattle as a strategy for improving calf growth rates in pastoral systems (Syrstad, 1996; Muhuyi *et al.,* 2002). Growth records of 621 West African Shorthorn (WASH) and 3 grades of Jersey x WASH crossbreds were used to analyze for the effects of the level of Jersey breeding on birth weight, 205-day weaning weight and average daily gain (ADG) (Ahunu *et al.*, 1993). The study showed that crossbred calves were significantly heavier at birth than purebred WASH and birth weights increased with increasing level of Jersey breeding while no significant differences were observed for 205-day weaning weight. However, ADG declined with increasing level of Jersey breeding suggesting possible problems of adaptation for calves of over 75 percent Jersey breeding. Age of dam was significant and linear for birth weight and significant for weaning weight and ADG, with values increasing from 3-year old dams to a peak in 7-year-old dams.

In Kajiado District of Kenya where the predominantly Maasai pastoral community keep indigenous cattle for subsistence, the body weights of calves at birth, one, two, three, four, seven, and eighteen months of age were 19.2, 28.4, 35.2, 41.4, 47.5, 64.4, and 132.8 kg, respectively (Semenye, 1987). Semenye and Chabari (1980) reported that and breed were consistently sources of variation of body weight. The majority of calves that survive up to one year were characterised by stunted growth, low body weight and delayed sexual maturity (de Leeuw *et al.,* 1991). In another study in the neighbouring semi arid district of Trans Mara, it was reported that Zebu calves that had been raised in an area that was endemic for theileriosis had a mean birth weight of 17.5 kgs and an average six-month weight of 53.4 kgs (Moll *et al.*, 1986). Low weight gains were associated with patent *T. mutans* infections and acute *T. parva* infections.

Although upgrading of indigenous Maasai Zebu has been on the increase in Kajiado District, there is paucity of data on factors that influence calf growth rate in Maasai pastoral systems. The objective of this study was to estimate and identify causes of slow growth rates of calves in Maasai pastoral systems in Kajiado District, Kenya.

6.2 MATERIALS AND METHODS

6.2.1 Study area and selection of study herds

The study was conducted in Kajiado District among the Maasai pastoral farmers. Detailed description of the study area and methods used to select the study herds are described in chapter three.

6.2.2 Body weight measurements and condition scoring

Body weight and heart girth measurements were taken early in the morning (between 07:00 and 08:00 a.m.) before the calves were watered and/or allowed to graze. This was done for all calves that were less than 13 months of age at every visit. Each calf was made to stand in an upright position and then, the circumference (cm) of the heart girth was measured using a tape. The corresponding body weight estimates (kg) were read directly on the measuring tape and tabulated. Calves were tied around the abdomen and then suspended on a Salter Scale Balance (Avery, Kenya Ltd) which was hanging on a tripod stand (The scale was calibrated to weigh objects of upto 150 kgs). Body weight measurements were read directly from the weighing scale and recorded to the nearest 0.5 kg live weight. For the purpose of estimating the body weight at birth, any weight of a calf that was recorded within the first week of life was taken to be the birth weight. Only body weight measurements from the Avery scale were used to compute the average daily weight gain (ADWG).

Body condition was assessed on a four-point scale as follows: 1 (one) or very poor for a calf that was emaciated, very weak, possibly ill and showing prominent hip bones; 2 (two) or fair for a weak calf that was thin but not emaciated; 3 (three) or good for a calf with good muscle cover but not fat; and 4 (four) or fat for a calf with very good muscle and fat cover (Modified from Nicholson and Sayer, 1987).

6.2.3 Data handling and storage

Data files of questionnaires and laboratory results were prepared in Microsoft Access and analysed using Statistical Analysis Systems (SAS, 1985) Institute Inc., Cary, NC. Factors associated with calf growth rates were considered and were generally grouped at three levels, namely, , farm and calf levels.

6.2.4 Data analysis

6.2.4.1 Outcome variable

The outcome variable of interest was average daily weight gain (ADWG). It was calculated as the difference between body weights of two consecutive visits divided by the number of days between the visits. The inter-visit period for repeated observations of individual calf varied between 1-4 months. The missing data were caused by re-location or withdrawal and / or re-entry of calves into the study (Appendix 7.4). In addition, no calf observations were made in the month of July 2001 because no visits were made to the es due to some logistic problems.

In order to associate ADWG with a particular explanatory variable, two consecutive ADWG measurements whose inter-visit period was too long were not included in the analysis. Seroconversion was used as an indicator of exposure to *T. parva, T. mutans, A. marginale* or *B. bigemina.* A calf that seroconverted to any of the parasites during the current visit was considered to have been exposed during the period between the previous sampling and the current one. For example, an ADWG calculated over the last four months would not reflect the effect of seroconversion that took place during the last two months. Therefore it was decided to accept the loss of observations and use only ADWG data that were calculated over a one or two visit gap (approximately two months). Elimination of the observations with days more than two months resulted in a total of 1294 calf observations.

6.2.4.2 Explanatory variables

The potential explanatory variables associated with ADWG investigated in this study are listed in tables 6.1 and 6.2, respectively. Explanatory variables for ADWG were grouped into ranches, farm visit-specific, fixed and visit-specific calf variables. Farm visit specific variables were maximum calf herd size during sampling period, season, pasture condition and calf management practices (nutrition, housing, grazing, watering). Calf fixed factors were sex, breed and initial body weight. Breed was categorized as Maasai Zebu, crosses (crosses of Maasai Zebu with Borans or Sahiwal) and exotic (pure Boran or Sahiwal). Calf visit-specific variables included age, clinical diagnosis of any sickness, clinical diagnosis of specific sicknesses (theileriosis, anaplasmosis, babesiosis, helminthosis and ringworms), serology (absolute PP values of serum antibody titres, seropositivity and seroconversion status for *T. parva, T. mutans, A. marginale* and *B. bigemina* during the current and previous visits (lag)).

6.2.4.3 Descriptive Statistics

Descriptive statistical analysis was used to explore both continuous and categorical variables and the associations between them. Estimates of body weight (mean and standard deviation) were calculated at birth, three, six, nine and 12 months for all the calves and separately for each ranches. The patterns of calf growth were explored by plotting individual calf-growth curves in multiple-plot trellis of graphs for each farm. Thus, line graphs were plotted for body weight and ADWG against calf age in S-Plus for all calves stratified by farm.

6.2.4.4 Simple and multi-variable regression models

Associations between the ADWG and various explanatory variables were explored as uni- or multivariable models with ranches and age using PROC GLM. Data were classified by ranches, farm and calf identity. First, ranches was forced into the model. Then the relationship between age and daily weight gain was explored graphically by comparing transformed (quadratic and cubic) fits of age to daily weight gain with a plot of observed average daily weight gain by age in months. Thereafter, associations between ADWG and each possible explanatory variable were evaluated by adding the variable to a linear model with ADWG as the outcome and the explanatory co-variables: ranches, age, age square and age cubed.

The possible interactions of each explanatory variable with ranches were also assessed in the same way. Associations between the outcome variables and the explanatory variables for the univariate analysis were considered significant if the test of significant of the type III sums of squares was less than ten percent ($p<0.1$).

For the multi-variate regression model, a full model which included ranches, plus the quadratic age structure and all univariate effects that were significant as described above (at least 10 percent or $p<0.1$) was constructed. The mean daily weight gain data were clustered in time and space. Using this full model, the SAS procedure PROC MIXED was employed to choose a variance-covariance structure that addressed the correlations between calves within farm and repeated weight measurements.. Farm was treated as a random effect and a variance component was estimated for farm. The correlations among repeated measures was estimated from different specifications of the correlation structure as allowed by PROC MIXED. First, model fitting was tried by specifying a compound symmetric (CS) in the repeated statement. The correlation estimate was the same regardless of the length of the inter-visit period between measurements and this was rejected. The autoregressive order one covariance (AR(1)) was then specified in the repeat statement and was found to have the desired property of correlations being larger for close measurements than for distant measurements. The final choice of variance-covariance structure was guided by comparison of model using Akaike's Information Criteria (AIC) (Lancelot *et al.,* 2002). Having chosen a variance-covariance structure using the full model, the backward elimination method was used to generate the final model through elimination of non-significant variables from the full model using PROC MIXED. Associations between the outcome variable and the explanatory variables were considered significant at $p<0.05$.

6.3 RESULTS

6.3.1 Descriptive statistics

A total of 1694 calf observations were made on 292 calves that were sampled from 23 farms (17 farms in Olosho Oiborr and six farms in Nentanai). Out of the total number of calves sampled, 36 percent (105/292) were from Olosho Oiborr while 64 percent (187/292) were from Nentanai . One hundred and sixty three were female calves while 129 were male calves. The distribution of breeds was 188 Maasai Zebu, 63 crosses of Maasai Zebu with Boran or Sahiwal and 41 pure breeds of Boran or Sahiwal.

Table 6.1 lists ranches and farm variables that were observed during this longitudinal study. Sixty-five-point-eight (65.8) percent of the calf observations were from Nentanai ranches. Sixty-point-seven (60.7) percent of the calf observations were made during the dry season while 76.6 percent of the observations were made when calves were on poor pasture conditions. Eighty-two point six (82.6) percent of the calf observations were made when calves were kept outside at night while 94 percent of the observations were made when calves were not housed during the day. Sixty four (64) percent of the observations were made on calves that were suckling at least twice in a day while only 33.3 percent of the observations were made on calves that had *ad libitum* water intake.

Table 6.2 is a list of calf-level variables that were observed during the longitudinal study. About 70 percent of the calves were more than 3 months old. Females comprised 56.6 percent of the calf observations. Slightly over 60 percent of the observations were on crossbred calves. About 3.8 percent of

Table 6.1 ranches and farm level factors associated with daily weight gain of 292 calves observed in a longitudinal study in Maasai pastoral systems in Kajiado District, Kenya (November, 2000 – February, 2002).

Factor and level	Number of calf Observations	Percent	Daily weight gain (Kg)	
			Mean	sd
ranchesRanch				
Olosho Oiborr	443	34.2	0.27	0.2
Nentanai	851	65.8	0.26	0.18
Season				
Dry	786	60.7	0.24	0.19
Wet	508	39.3	0.3	0.16
Pasture condition				
Poor	991	76.6	0.25	0.19
Good	303	23.4	0.31	0.15
Sprayed against ticks				
No	169	13.1	0.25	0.17
Yes	1125	86.9	0.26	0.18
Day housing				
None	1132	94.3	0.25	0.18
Outside	69	5.7	0.38	0.17
Suckling frequency				
Frequent	144	64	0.27	0.18
Infrequent	81	36	0.13	0.19
Watering frequency				
Ad libitum	406	33.3	0.33	0.15
Less than once per day	450	36.9	0.2	0.17
None	48	3.9	0.35	0.13
Once daily	317	26	0.25	0.2
Age start grazing				
No	800	61.8	0.26	0.19
Yes	494	38.2	0.27	0.18
Fed crop residues				
No	1183	96.1	0.26	0.18
Yes	48	3.9	0.2	0.21
Distant grazing pastures				
No	1200	97.7	0.26	0.18
Yes	28	2.3	0.17	0.19
Restricted grazing				
No	65	28	0.27	0.18
Yes	167	72	0.26	0.18
Housing during daytime				
Indoor or in-house	208	17.4	0.26	0.19
None	988	82.6	0.26	0.19
Mineral supplementation				
Yes	685	56.1	0.27	0.16
No	535	43.9	0.25	0.21

Key: sd = standard deviation

Table 6.2 Calf level factors associated with daily weight gain of calves observed from a longitudinal study in Maasai pastoral systems, Kajiado District, Kenya (November 2000 – February 2002).

Factor and level	Number of calf Observations	Percent	Daily weight gain (Kg)	
			mean	sd
Age group				
Up to 3 months	363	28.1	0.31	0.14
>3 months	931	71.9	0.24	0.2
Age category				
Up to 3 month	363	28.1	0.31	0.14
4-6 months	489	37.8	0.27	0.18
7-9 months	327	25.3	0.25	0.21
10-12 months	115	8.9	0.13	0.2
Sex				
Female	733	56.6	0.27	0.19
Male	561	43.4	0.26	0.17
Breed				
Maasai zebu	293	22.6	0.24	0.18
Exotic	150	11.6	0.25	0.21
Crosses	851	65.8	0.27	0.18
Body condition score				
Very thin	47	3.8	0.02	0.14
Fair	404	32.4	0.18	0.16
Good	761	61.1	0.31	0.16
Fat	433	2.7	0.23	0.2
T. parva seropositive				
No	593	41.2	0.27	0.18
Yes	433	58.9	0.24	0.2
T. mutans seropositive				
No	377	36.7	0.27	0.18
Yes	649	63.3	0.25	0.19
A. marginale seropositive				
No	332	32.4	0.26	0.18
Yes	694	67.6	0.25	0.19
B. bigemina seropositive				
No	706	68.8	0.25	0.18
Yes	320	31.2	0.26	0.19
T. parva seroconversion				
No	935	91.1	0.26	0.19
Yes	91	8.9	0.19	0.18
T. mutans seroconversion				
No	932	90.8	0.26	0.19
Yes	94	9.2	0.29	0.17

Key: sd = standard deviation

Table 6.2 (continued....)

Factor and level	Number of calf Observations	Percent	Daily weight gain (Kg)	
			mean	sd
A. marginale seroconversion				
No	932	90.8	0.26	0.18
Yes	94	9.2	0.17	0.21
B. bigemina seroconversion				
No	952	92.8	0.26	0.18
Yes	74	7.2	0.18	0.22
Lag *T. parva* seroconversion				
No	917	93.1	0.26	0.19
Yes	68	6.9	0.21	0.19
Lag *T. mutans* seroconversion				
No	910	92.4	0.26	0.18
Yes	75	7.6	0.17	0.2
Lag *A. marginale* seroconversion				
No	902	91.8	0.26	0.19
Yes	81	8.2	0.21	0.19
Lag *B. bigemina* *seroconversion*				
No	930	94.4	0.26	0.18
Yes	55	5.6	0.17	0.24
Any sickness				
No	848	65.5	0.28	0.18
Yes	446	34.5	0.23	0.18
Cause-specific Theileriosis				
No	1271	98.2	0.26	0.18
Yes	23	1.8	0.23	0.2
Cause-specific Anaplasmosis				
No	1194	92.3	0.27	0.18
Yes	100	8.7	0.15	0.2
Cause-specific Helminthosis				
No	1279	98.8	0.26	0.18
Yes	15	1.2	0.11	0.14
Cause-specific Ringworm				
No	1218	94.1	0.26	0.19
Yes	76	5.9	0.28	0.14
Feeding on Colostrum				
No	1228	99.8	0.26	0.18
Yes	2	0.2	0.33	0.07

Key: sd = standard deviation

the observations were made on very thin calves. The proportion of calf observations that were seropositive for *T. parva, T. mutans, A. marginale* and *B. bigemina* comprised 8.9 percent, 63.3 percent, 67.6 percent and 31.2 percent, respectively.

The means of body weights (in kilograms) of calves at birth, 3, 6, 9 and 12 months were 25.9 ± 5.5, 46.2 ± 11.7, 67.7 ± 15.7, 89.8 ± 21.2 and 104.5 ± 23.1, respectively. The overall mean ADWG was 0.26 ± 0.18 kg per day (minimum and maximum were -0.57 and 0.81, respectively) and the cubic function of age appeared a better fit for ADWG (Figure 6.1).

The ADWG of calves varied between farms (Figure 6.2) while individual calf body weights varied between and within farms (Figure 6.3). The results also show that calves that had low initial body weight were growing at lower rate than calves that started with high initial body weight (Figure 6.3).

6.3.2 Farm level variables associated with ADWG from the univariate models

Calves that were allowed to suckle frequently (more than once per day) had significantly ($p = 0.026$) higher ADWG than calves that suckled less than once per day (Table 6.3). Calves that were taken out for grazing as early as 3-6 months of age had significantly ($p=0.0505$) lower ADWG than calves that were taken out to graze later than 6 months of age. Exploration of the interaction effect from addition of ranches showed that there was a

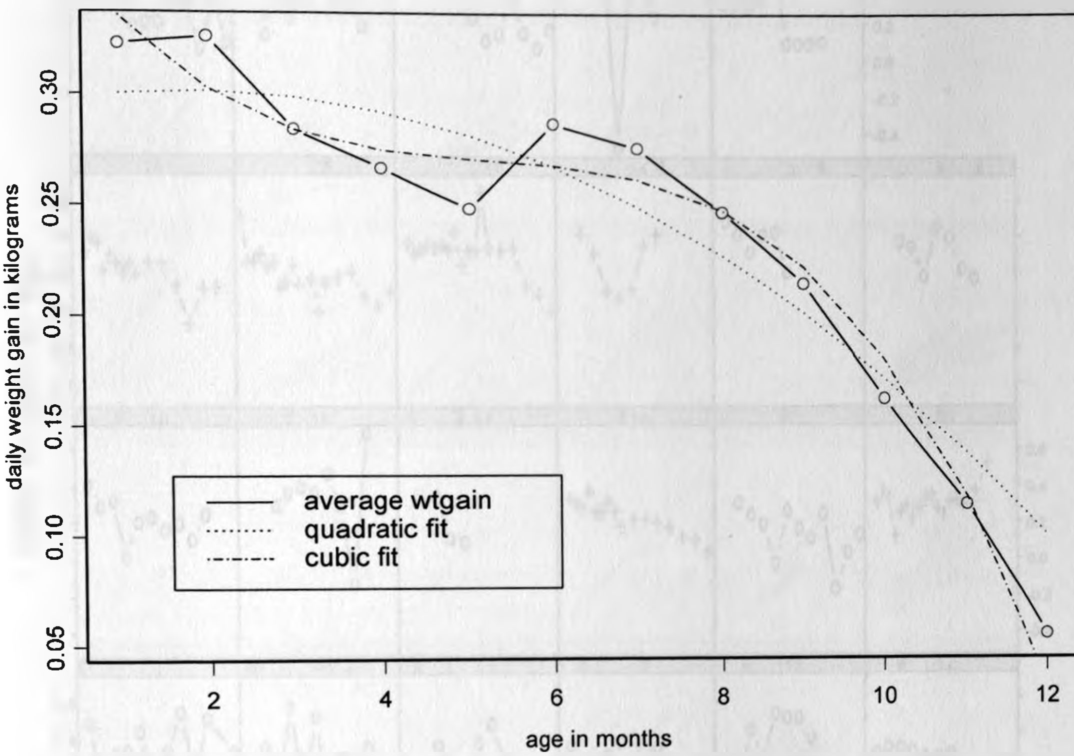


Figure 6.1 Relationships between linear, quadratic and cubit fits for average daily weight gain for calves in Maasai pastoral systems in Kajiado District (Longitudinal study, November 2000– February 2002).

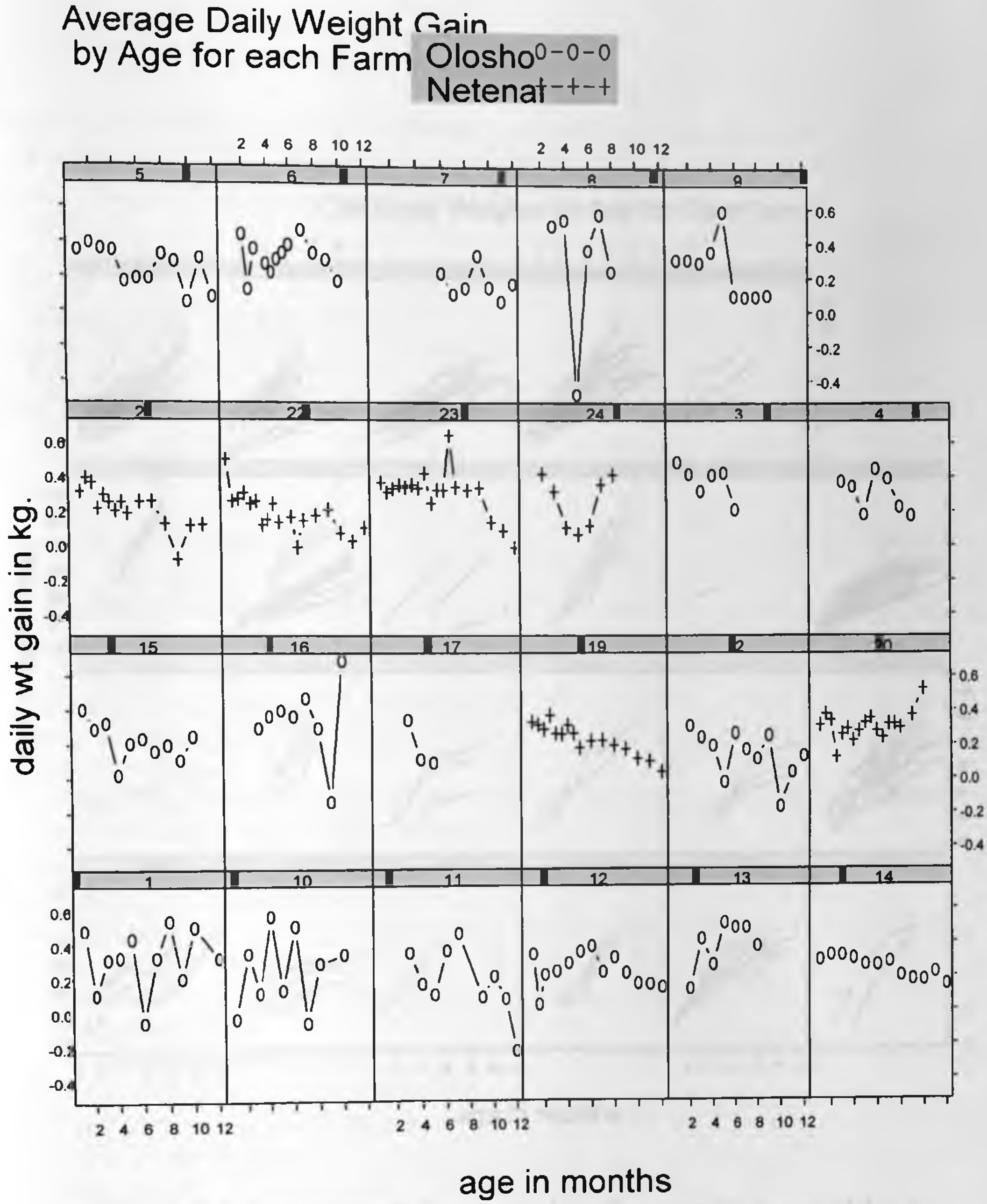


Figure 6.2 Relationships of average daily weight gains and calf ages by farm in Maasai pastoral systems in Kajiado District (Longitudinal Study, November 2000 - February 2002)

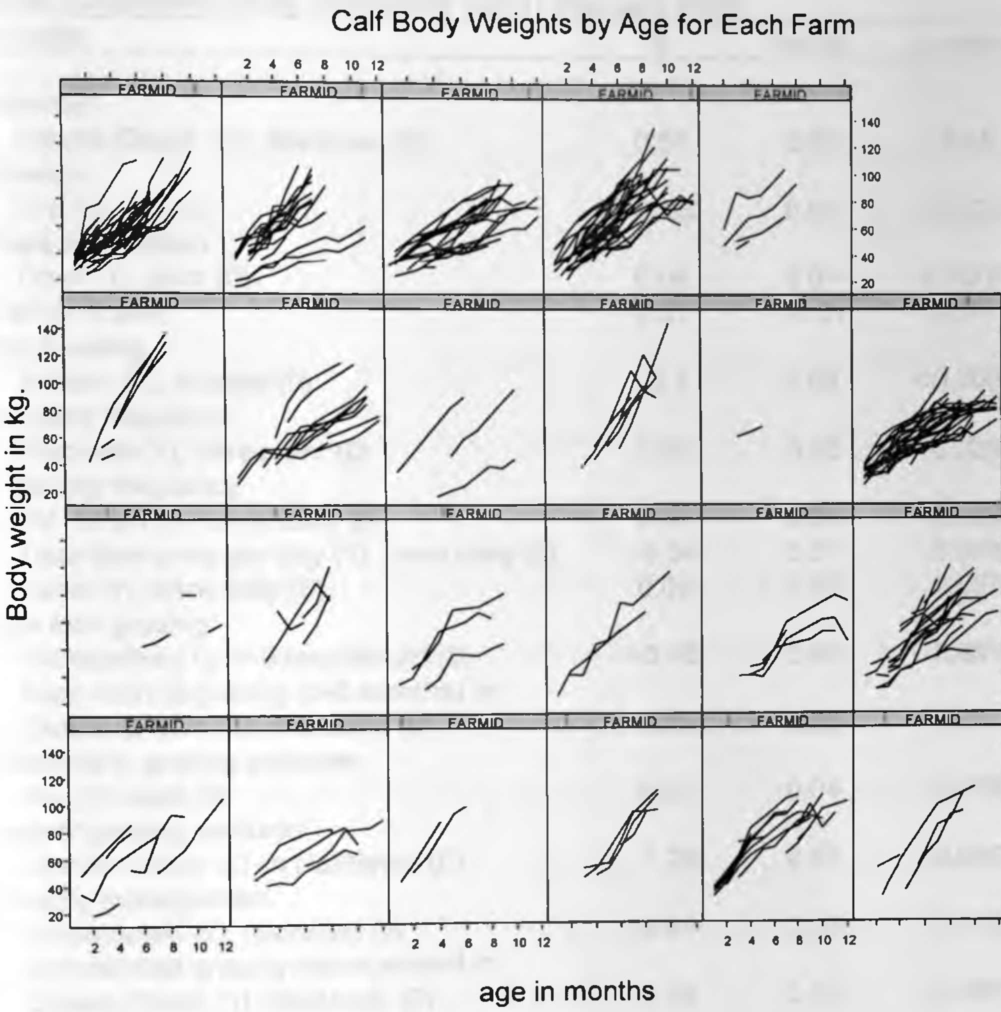


Figure 6.3 Variations of body weights of calves by age and farm in Maasai pastoral systems in Kajiado District (Longitudinal Study, November 2000-February 2002).

Table 6.3 ranches and farm level factors significantly associated with ADWG from the univariate model for all sampled from Maasai pastoral systems in Kajiado District, Kenya (Longitudinal study, November 2000 - February 2002).

Variable	b	Se (b)	p-value
ranches			
Olosho Oiborr (1), Nentanai (0)	0.03	0.01	0.01
Season			
Dry (1), wet (0)	-0.06	0.01	<0.0001
Pasture condition			
Good (1), poor (0)	0.04	0.01	0.0007
Calf herd size	0.01	<0.01	0.077
Day housing			
Indoors (1), outside (0)	-0.1	0.02	<0.0001
Suckling frequency			
Frequent (1), infrequent (0)	0.05	0.02	0.026
Watering frequency			
Ad libitum (1), once daily (0)	0.08	0.01	<0.0001
Less than once per day (1), once daily (0)	-0.04	0.01	0.008
None (1), once daily (0)	0.08	0.03	0.007
Age start grazing			
3-6 months (1), > 6 months old (0)	-0.03	0.02	0.051
Early start to grazing (3-6 months) in Olosho Oiborr (1), Nentanai (0)	0.05	0.02	0.03
Distance to grazing pastures			
Far (1), near (0)	0.08	0.04	0.076
Distant grazing pastures			
Olosho Oiborr (1) vs Nentanai (0)	-0.28	0.07	<0.0001
Grazing management			
Unrestricted (1), restricted (0)	0.04	0.03	0.112
Unrestricted grazing management in Olosho Oiborr (1), Nentanai (0)	-0.24	0.06	<0.0001
Mineral supplementation			
Yes (1), no (0)	0.02	0.01	0.02

Key: b – parameter coefficient estimate

Se (b) – standard errer of the coefficient estimate

significantly ($p = 0.0289$) higher decrease in Nentanai ranches than in Olosho Oiborr ranches.

Calves that were weaned and grazed in distant pastures in Olosho Oiborr ranches showed significantly ($p < 0.0001$) low ADWG compared to calves that were managed in the same way in Nentanai ranches. Supplementation of calves with mineral caused significant ($p=0.0199$) increase in the ADWG of calves. However, calves that were supplemented with crop residue at time of visit had lower ADWG but the effect was not significant ($p=0.187$). Unrestricted grazing of calves had positive strong effects in Nentanai ranches and strong negative effect in Olosho Oiborr ranches ($p < 0.0001$). Calves had significantly ($p < 0.0001$) lower ADWG during the dry than the wet season.Calves that had access *to ad libitum* supply of water had significantly ($p < 0.0001$) higher ADWG than calves that were watered once daily. Calves that had access to water less than once per day had significantly ($p = 0.0083$) low ADWG compared to those watered at least once per day. Calves that were housed inside (in-house) during the day had significantly ($p < 0.0001$) lower ADWG than calves that were left to roam freely either in the compound or in the *olopololi* (a reserve grazing paddock a few kilometres from the homestead).

6.3.3 Calf level variables associated with ADWG from univariate analysis

Increasing calf age was associated with decreased ADWG (p values for age, age squared and age cubed were < 0.0016, 0.0092 and 0.0002, respectively) (Table 6.4). Graphically there appeared to be some difference in the fit between ranches but the interaction terms for age and ranches were

Table 6.4 Calf level factors associated with ADWG (univariate model) in Maasai pastoral systems in Kajiado District, Kenya (Longitudinal study, November 2000 – February 2002).

Variable and categories	b	Se (b)	p-value
Age	-0.06	0.02	0.0016
Age2	0.01	<0.01	0.0019
Age3	<-0.01	<0.01	0.0002
Initial body weight	<0.01	<0.01	<0.0001
Breed			
Zebu (1) , exotic (0)	0.01	0.02	0.715
Crosses (1) , exotic (0)	0.03	0.02	0.046
PP values (absolute)			
T. parva	<-0.01	<0.01	0.002
T. mutans	<-0.01	<0.01	<0.0001
B. bigemina	< 0.01	<0.01	0.002
B. bigemina in Olosho Oiborr (1), Nentanai (0)	<-0.01	<0.01	0.0009
T. parva seropositive Yes (1) , no(0)	-0.03	0.01	0.004
T. mutans seropositive Yes (1) , no(0)	0.04	0.02	0.017
A.marginale seropositive Olosho Oiborr (1), Nentanai (0)	0.07	0.03	0.007
B. bigemina seropositive Yes(1) , no (0)	0.03	0.03	0.038
B. bigemina seropositive Olosho Oiborr (1), Nentanai (0)	-0.07	0.02	0.004
T. parva seroconversion Yes(1) , no (0)	-0.06	0.02	0.004
T. mutans seroconversion Yes(1) , no (0)	-0.04	0.02	0.022
A. marginale seroconversion Yes (1) , no(0)	-0.12	0.03	<0.0001
A. marginale seroconversion Olosho Oiborr (1), Nentanai (0)	0.07	0.04	0.085
B. bigemina seroconversion Yes (1) , no (0)	-0.05	0.02	0.012
Lag *T. parva* seroconversion Yes (1) , no (0)	-0.13	0.03	<0.0001

Key: b – parameter coefficient estimate

Se (b) – standard errer of the coefficient estimate

Table 6.4 (continued.........)

Variable and Categories	b	Se (b)	p-value
Lag *T. mutans* seroconversion			
Yes (1), no (0)	0.12	0.04	0.004
Lag *A. marginale* seroconversion			
Yes (1), no (0)	-0.09	0.03	0.002
Lag *A. marginale* seroconversion			
Olosho Oiborr (1), Nentanai (0)	0.11	0.04	0.01
Lag B. bigemina seroconversion			
Yes (1), no (0)	-0.05	0.02	0.026
Packed red cell volume (pcv)	0.01	<0.01	<0.0001
Any sickness			
Yes (1), no (0)	-0.06	0.01	<0.0001
Theileriosis			
Yes (1), no (0)	-0.05	0.04	0.205
Anaplasmosis			
Yes (1), no (0)	-0.12	0.02	<0.0001
Helminthosis			
Yes (1), no (0)	-0.15	0.05	0.0008
Tick burdens			
B. decoloratus	-0.13	0.06	0.016
R. appendiculatus	-0.01	<0.01	<0.0001
R. appendiculatus in Olosho Oiborr (1) , Nentanai (0)	0.01	<0.01	<0.042
R. pulchelus	-0.01	<0.01	0.023
Total tick counts	-0.01	<0.01	0.0002

Key: b – parameter coefficient estimate

Se (b) – standard errer of the coefficient estimate

not significant (p=0.67, 0.18, 0.15 for the linear, quadratic and cubic terms, respectively) so no age- ranches interaction was considered further.

There was no significant difference in ADWG between indigenous Maasai Zebu and exotic (either pure Sahiwal or pure Boran). However, crosses of Maasai Zebu with the exotic breeds (either Sahiwal or Boran) had significantly (p=0.046) higher ADWG. Calves that had higher initial body weight had significantly (marginally) (p <0.0001) higher ADWG than calves with lower initial body weight.

Calves that were sick (from TBDs or any other disease) had significantly (p < 0.0001) lower ADWG than calves that were healthy. Of the four major clinically diagnosed calf diseases (theileriosis, anaplasmosis, helminthosis and ringworms), only anaplasmosis (p<0.0001) and helminthosis (p < 0.0008) had a significant negative effects on ADWG. There was a negative and significant association between increasing PP values and ADWG for *T. parva* (p=0.002) and *T. mutans* (p<0.0001) while the association between increasing PP values for B. *bigemina* with ADWG was positive and significant (p=0.0021) (Table 6.4). Further, exploration of the interaction between increasing PP values for *B. bigemina* and ranches revealed that calves in Olosho Oiborr ranch had significantly lower ADWG than calves in Nentanai ranches (p=0.0009).

Calves that were seropositive for *T. parva* at the time of visit had significantly (p=0.004) low ADWG. Similarly calves that had seroconverted for *T. parva* had significantly (p= 0.004) lower ADWG. Calves that were seropositive for *T. mutans* at the time of visit had low but insignificant (p =0.1633) ADWG. However, calves that had seroconverted for *T. mutans* at the time of visit had significantly ($p= 0.022$) lower ADWG. Calves that had seroconverted to *T. mutans* in the previous visit had significantly ($p <0.0001$) lower ADWG. The interaction between ranches with seroconversion for *T. mutans* had significant ($p = 0.0037$) higher negative effect on ADWG in Nentanai than in Olosho Oiborr ..

The distribution of tick counts by species for Olosho Oiborr and Nentanai ranches are shown in Appendix 6.1. Compared to Olosho Oiborr , Nentanai had significantly ($p < 0.05$) higher mean of the total tick counts. Similarly, the total tick counts for *A. gemma, A. variegatum, B. decoloratus* and *R. pulchellus* were significantly ($p < 0.05$) higher in Nentanai than in Olosho Oiborr . The mean of tick counts of *H. truncatum* was significantly ($p < 0.05$) higher in Olosho Oiborr than in Nentanai . The means of total tick counts for *R. appendiculatus* and *R. evertsi* were relatively higher in Olosho Oiborr than in Nentanai but the difference was not significant ($p > 0.05$).

An increase in total tick burdens was associated with significantly ($p=0.0002$) low ADWG of calves (Table 6.4). An increase in the number of individual tick species including *R. appendiculatus, R. pulchelus* and *B. decoloratus* significantly lowered ADWG (p values were <0.0001, 0.023, 0.016 for *R. appendiculatus, R. pulchelus* and *B. decoloratus*, respectively). The decrease in ADWG associated with higher counts of *R. appendiculatus* and *B. decoloratus* was significantly ($p=0.0422$) higher in Nentanai than in Olosho Oiborr .

Calves that were seropositive for *A. marginale* at the time of visit had significantly ($p =0.0168$) low ADWG (Table 6.4). The interaction between *A. marginale* seropositivity and had significantly ($p = 0.0067$) higher effect in lowering ADWG in Olosho Oiborr than in Nentanai . Similarly, calves that had seroconverted for *A. marginale* at the time of visit had significantly ($p < 0001$) lower ADWG. The interactive effect between ranches and seroconversion at time of visit for *A. marginale* significantly ($p =0.085$) lowered ADWG in Nentanai more than in Olosho Oiborr ranches. Calves that had seroconverted to *A. marginale* in the previous visit had significantly ($p <0.0001$) lower ADWG. Similarly, the interaction between ranches with previous visit's seroconversion for *A. marginale* had a significant ($p = 0.0037$) and more negative effect on ADWG but more so in Nentanai than in Olosho Oiborr . Calves that had seroconverted for *A. marginale* during a previous visit had significantly ($p = 0.0024$) low ADWG.

Calves that were seropositive for *B. bigemina* at the time of visit had significantly ($p = 0.038$) higher ADWG (Table 6.4). The interaction between *B. bigemina* seropositivity and had significantly ($p = 0.004$) higher effect in lowering ADWG in Olosho Oiborr than in Nentanai . Similarly, calves that had seroconverted for *B. bigemina* at the time of visit had significantly ($p < 0.0123$) lower ADWG but the interaction between seroconversion for *B. bigemina* and ranches did not significantly affect ADWG. Calves that had seroconverted to *B. bigemina* in the previous visit had significantly ($p <0.026$) lower ADWG.

6.3.4 Variables associated with ADWG from the multi-variate analysis

Table 6.5 shows associations of fixed and random variables with ADWG of calves from a mixed model analysis of variance. The estimated variance within calves (same farms) was greater but significant (σ^2=0.024,

Table 6.5 Fixed- and random-effects for a mixed model analysis of variables associated with average daily weight gain from 647 calf observations in Maasai pastoral systems in Kajiado District, Kenya (Longitudinal study, November 2000 – February 2002).

Variable	Category	b	se(b)	p-value
a) Fixed effects				
Intercept		0.06	0.06	0.3
ranches	Olosho Oiborr (1), Nentanai (0)	0.05	0.02	0.029
Farm variables				
Grazing	Restricted (1), free (0)	0.28	0.11	0.013
	Restricted in Olosho Oiborr (1), restricted in Nentanai (0)	-0.36	0.14	0.024
Pasture condition	Good (1), poor (0	0.14	0.02	<0.0001
Season	Wet (1), dry (0)	0.07	0.02	<0.0001
Distance to pastures (relative to boma)	Near (<5km) (1), far (>5km) (0)	0.15	0.05	0.005
	Near (<5km) in Olosho Oiborr (1), near (<5km) in Nentanai (0)	-0.36	0.07	<0.0001
Watering frequency	Ad libitum (1), once daily (0)	0.07	0.02	<0.0001
	Less than once (1), once daily (0)	-0.04	0.02	0.01
	None (not started watering)(1), once daily (0)	0.08	0.04	0.04
Calf variables				
Age		-0.06	0.03	0.248
Age2		0.01	0.01	0.111
Age3		<-0.01	<0.01	0.031
Initial body weight		< 0.01	<0.01	<0.0001
Breed	Crosses (1), Maasai zebu (0)	0.05	0.01	0.0008
	Exotic (1), Maasai zebu (0)	0.03	0.02	0.085
Clinical disease				
Anaplasmosis	Yes (1), No (1)	-0.09	0.02	<0.0001
Seroconversion status				
TpConvert	Yes (1), No (1)	-0.06	0.02	0.0004
LagTmConvert	Yes (1), No (1)	-0.06	0.02	0.011
Lag Am Convert	Yes (1), No (1)	-0.04	0.02	0.023
(b) Random effects				
Farm		0.0003	0.0005	0.26
Residual error		0.024	0.001	<0.0001

Key: b – parameter coefficient estimate
Se (b) – standard errer of the coefficient estimate

$p<0.0001$) compared to the estimated variance within calves (different farms) which was insignificant ($\tau^2=0.0003$, $p=0.30$). Out of the total variance observed in this study, the variance component attributed to farm level variables was 1.2% (or 0.0003/(0.0003+0.024)*100) while the variance component attributable to calf-level variables was 98.8% (or 0.024/(0.0003+0.024)*100). The correlation between consecutive repeated measures of ADWG on the same calf was negative and significant (correlation was - 0.174 and $p=0.001$).

Calves in Olosho Oiborr had significantly ($p=0.0291$) higher ADWG than calves in Nentanai . Generally, calves that were restricted from grazing had significantly ($p<0.013$) higher ADWG but the effect was significantly ($p<0.002$) higher in Nentanai than in Olosho Oiborr . Both wet season and good pasture were associated withsignificant increase in ADWG of calves ($p<0.0001$) while calves that trekked to far pastures for grazing had significantly lower ($p<0.024$) ADWG in Olosho Oiborr than in Nentanai ranches. At the same time, calves that were watered once daily had significantly ($P=0.0003$) lower ADWG compared to calves that had *ad libitum* access to water. Similarly, calves that were watered less than once per day (such as during drought) had significantly ($p=0.007$)lower ADWG than calves that were watered once per day.

The calf level variables that were significantly associated with ADWG from the multivariate analysis were age cubed, initial body weight, breed, clinical anaplasmosis, *T. parva* seroconversion at time of visit and *A. marginale* seroconversion in the visit prior to the current one (Table 6.5). The association between age cubed and ADWG was negative but significant at p=0.0306 while calves with relatively high initial body weight (body weight at the time of recruitment)had significantly (p<0.0001) higher ADWG. Crossbred calves had significantly (p=0.0008) higher ADWG than Maasai Zebu calves. Clinical anaplasmosis was associated with significantly (<0.0001) low ADWG while seroconversion for *T. parva* (current visit), *T. mutans* (previous visit) and *A. marginale* (previous visit) were associated with significantly (p=0.0004, 0.0113 and 0.023, respectively) low ADWG.

6.4 DISCUSSIONS

The mean calf birth weight of 25.9 kgs observed in this study was higher than 17.5 kgs reported by Moll *et al.*, (1984) and 19.2 kgs reported by Semenye (1987). The calf body weight of 46.2 kgs at 3 months that was observed in this study was higher than the 35.2 kgs reported by Semenye (1987) indicating that calves in that study were growing at a lower rate than the ones observed in this study. In the semi-arid central Mali, birth weight of indigenous calves kept under traditional management system was 16.6 kg while ADWG to weaning at seven months was 0.19 kg/day (Wilson, 1987). The low mean birth weight and ADWG were caused by chronic overstocking on already denuded feed resources and drought. Both farm- and calf-level factors were associated with calf daily weight gain.

The ADWG of 0.26 kg/day observed in this study was slightly lower than 0.28 kg/day which was reported for calves on Olosentu in Trans-Mara District (Muhuyi *et al.*, 2002) but higher than 0.21 kg/day reported for calves on smallholder farms in Kiambu District (Gitau *et al.*, 1994). The ADWG of calves in Maasai pastoral systems varied between ranches, farms and calves within the same farm. Thus, calves in Olosho Oiborr had significantly higher ADWG than those in Nentanai ranches. Similar observations have been reported in which ranches was associated with ADWG (Semenye and Chabari, 1980). The higher growth rate of calves on Olosentu was attributed to better feeding and management while the lower growth rates of calves on smallholder farms in Kiambu District was associated with increased number of years the owner was in dairy farming, lower amounts of milk fed to calves, male calves and the occurrence of clinical illness. In another study among smallholder dairy farmers in Muranga District (Gitau *et al.*, 2001), the ADWG of calves varied between 0.24-0.29 kg/day which was similar to what is reported in this study.

The study has shown that wet season which influenced pasture availability had positive effects on ADWG of calves. The results also agree with earlier findings that calves that entered the long dry season (July-November) at an early age were exposed to poor pastures for long resulting in growth retardation (de Leeuw *et al.*, 1991). Among the smallholder dairy farmers in Muranga, differences in ADWG were associated with AEZ-grazing strata and calf-level factors such as breed of calf, calf sickness, incidence of ECF, feeding of milk, concentrate feeds and minerals and interaction between calf age and AEZ-grazing strata. East Coast Fever and other calf sicknesses exerted a temporal effect on calf-growth at the height of illness and immediately after; calves later recovered the lost growth except where other factors such as poor calf nutrition prevailed. In this study, calves that suffered from sickness (TBDs or any other clinical disease) had low ADWG. In particular, clinical anaplasmosis, seroconversion for *T. parva* (current visit), *T.*

mutans (previous visit) and *A. marginale* (previous visit) were associated with significantly low ADWG. For example, over 60 percent of the calves were crossbreds that were observed to have higher ADWG than the Maasai Zebu observed by Moll *et al.*, (1984). Moll *et al.*, (1984) also associated the low weight gains of calves in their study with patent *T. mutans* and acute *T. parva* infections.

The results of this study also agree with those of Ahunu *et al.*, (1993) who reported that crossbred calves were significantly heavier at birth than purebred indigenous calves. Das *et al.*, (1999) also reported that crossbred calves had significantly higher live weights at three and six months of age and higher mean daily weight gain to three months of age and up to weaning age than pure Zebu calves. Calf feeding practices that were associated with significant improvement in ADWG of calves included increased frequency of milk and water intake, mineral supplementation and grazing system. The effect of milk intake on growth rate of Zebu calves was compared using different suckling regimes in Mali (Coulibaly and Nialibouly, 1998). A ranchesof calves that were allowed *ad libitum* suckling in the first three months of life had higher growth rate rates compared to other groups where, either, calves were given *ad labium* milk artificially (bottle-fed), or cows were milked partially then allowed to suckle their calves.

In the current investigation, wet season and good pasture were associated with increased ADWG of calves in this study because of improved forage quality and quantity and watering. Das *et al.*, (1999) reported that calves that were born in the wet season had higher live weights at three and six months of age than calves born in the dry season. In the semi arid central

Mali, the effects of season of birth were significant on calf growth throughout life but effects of year of birth only persisted for nine months (Wilson, 1987). During the dry season calves spend more energy trekking to distant pastures and watering places but during the wet season there are ponds and plenty of feed including forbs and rush pasture around the homestead. This drastically reduced the walking distances, thus conserving energy that is made available for other essential body functions.

Increased watering frequency was associated with increased ADWG of calves, which agrees with other studies that have shown that increasing watering frequency improves feed intake (Bekure *et al.*, 1991; Coppock, 1994). The effects of modest changes in traditional feeding management in the enhancement of nutrient intake and growth of calves under conditions of restricted water access were investigated in Ethiopian Boran pastoral system (Coppock, 1993). The 90-day trial which comprised of 3 dry-season diets (cut-carry forage, standing-brown grass and grass hay (plus or minus *Acacia* fruits) stored from a previous harvest season) reported that calves consumed the most feed on day 2 of the watering cycle while water intake increased 27 percent for animals on grass hay diets compared to those on standing grass.

Supplementation of calves with crop residues was associated with negative ADWG. This was probably due to the fact that Maasai pastoralists' allow sick and weak calves to graze on relatively low quality standing crop residues (Bekure *et al.*, 1991). Mineral supplementation increased the ADWG of calves. Maasai pastoralists start supplementing calves with minerals from as early as less than one month old. Trace minerals play a very important role in development and subsequent growth of young animals (Schillhorn and

Loeffler, 1990). Hitherto, no investigative results have reported on the quality and quantity of trace elements contained in the various salt preparations currently in use among the Maasai pastoralists. The most commonly mentioned mineral deficiencies in Africa are selenium, phosphorous, magnesium, copper and manganese (Kabaija, 1989).

The results of the univariate analysis showed that calves that were grazed in *olopololis* (reserve grazing paddock) did not have superior growth rates compared to those that were grazing in open pastures while the results of the multivariate analysis showed that calves that were trekked to distant grazing pastures had negative effects on calf growth rate in Olosho Oiborr but positive effects in Nentanai. Compared to Nentanai, the area around Olosho Oiborr was more densely populated causing overstocking and denudation of forage (Personal observation). Consequently, calves in Olosho Oiborr had to trek long distances in search of pasture thus causing further decrease in ADWG. Among the Maasai pastoralists, pre-weaned calves (< 7 months old) usually graze in *olopololis* where there was more herbage but of inferior quality than the open pastures (de Leeuw *et al.*, 1991). Weaned calves had access to a wider grazing orbit with greater chance of quality forage selection. However, pre-weaned calves by virtue of their young age and increased frequency of milk intake had higher ADWG than weaned calves, which possibly explains why their ADWG was superior to that of weaned calves in spite of the latter's access to better forage quality.

Adequate milk intakes by calves during the first three months of age was very important in ensuring better growth rates. Although majority of the Maasai pastoralists allow the calf to suckle at least twice a day during the preweaning period, quite often competition for milk is common especially where there was ready market for milk (de Leeuw *et al.,* 1984; King *et al.,* 1984). Thus, there is need to educate the pastoralists on the importance of adequate milk intake by the calf for improved growth. Similarly, pastoral farmers need to be made aware of the importance of providing adequate and clean water to calves improve their growth rates. However, there was need to investigate the effect of restricted suckling coupled with a feed supplementation on calf growth performance in Zebu and crossbred cattle.

Water shortage was cited as a major constraint to calf production and was attributed to lack of adequate permanent rivers in Kajiado District (chapter 4). A temporary solution would be to harvest rain-water from roofs into big drums. However, this would work only during the rainy season and possibly if the roof areas are large enough to obtain considerable amounts of water. However, for the calves this source of clean water during the time of confinement could be of major significance. A more permanent solution is to construct more boreholes.

Maasai pastoralists have been upgrading the indigenous Maasai Zebu using improved bulls of Sahiwal and Boran breeds, which significantly improved growth rates of calves. While this should be encouraged to continue, there was need to monitor the survival and adaptability of crossbred animals under the harsh environment and the reality of high disease challenge especially in a situation where extension services are inadequate.

In conclusion, approximately 98% of the monthly variability of daily weight gain was attributed to the farm. The remainder was associated with the variability between daily weight gains for the same calf from month to month.

A multivariate regression method, Proc Mixed model analysis of variance Generalised Estimating Equations (GEE), was used to determine the association between daily weight gain and potential explanatory factors, since consecutive daily weight gains were correlated. Both farm- and calf-level factors were associated with calf daily weight gain.

CHAPTER SEVEN

FACTORS ASSOCIATED WITH MORBIDITY AND MORTALITY OF CALVES IN MAASAI PASTORAL SYSTEMS IN KAJIADO DISTRICT, KENYA

7.1 INTRODUCTION

Recent estimates of human population growth and changes in actual numbers of cattle, sheep and goats indicate an inverse relationship thus creating food insecurity in the district (Campbell *et al.*, 2000; Mwangi, 2000). The decline in numbers of key livestock species was associated with the effects of the 1995-97 and 2002 droughts and 1997-98 *El Nino* rains (Ndikumana *et al.*, 2000) and a high incidence of diseases (DVO, 1999). Cattle mortality was higher during the drought (26 percent of the herd) than in the *El Nino* rains and calves were the most vulnerable during the drought phase as 45 percent of them died compared to 23 percent of the cows (Ndikumana *et al.*, 2000). Bekure *et al.*, (1991) in their study reported that calf mortality (ranged from 10-60 percent) in Maasai pastoral herds in Kajiado District was caused by single or multiple combinations of theileriosis, malignant catarrh fever, helminthosis and malnutrition (de Leeuw *et al.*, 1991).

Successful rearing of calves depends on a combination of good management practices such as adequate nutrition including early feeding of colostrum, adequate housing and control of infectious diseases (Perez *et al.*, 1990). Survival of calves is important for the replacement of older animals and for the expansion of pastoral herds especially after a major drought or disease epidemic. Life-table methods have been used to investigate survivorship of calves within the first year of life in traditionally managed herds in Bauchi, Nigeria (Kudi *et al.*, 1998). In their study, the proportion of calves in the herds surviving for the first 12 months was 53.8 percent. The main causes of calf mortality were septicaemia, malnutrition and injuries. The probability of calf mortality was greatest during the first month of life and decreased with increasing age.

There is lack of sufficient data on estimates of measures calf health and survivability in Maasai pastoral systems (Peeler and Omore, 1996). Hence, the objectives of this study are to investigate the survival rates, risk factors for incidence of morbidity and mortality of calves in Maasai pastoral systems in Kajiado District. The information gathered would be useful in formulating appropriate management practices and disease control programs for the improvement of calf survivability, health and production in pastoral systems.

7.2 MATERIALS AND METHODS

7.2.1 Study area and herds

Details of study design and methods used to select the study sites and herds are described in Chapter three.

7.2.2 Data and sample collection

A total of 15 visits, approximately one month apart, were made to all the household herds during the study period between November 2000 and February 2002. For each of the selected es one animal health assistant from the Ministry of Livestock and Fisheries Development (MLFD) was seconded to the project and charged with the responsibility of attending to all sick cases that were reported by the pastoralists. Two casuals per were also hired from the local Maasai community and trained on methods of restraining animals. They were also to report sick animals to the local animal health assistant for diagnosis, treatment and post-mortem. All information collected by the animal health assistant and the casuals was verified by the principal investigator during the monthly farm visits. The morbidity, mortality and their causes were confirmed by clinical examination of animals, laboratory tests and post mortem examination wherever possible.

During the initial visit in each farm, all calves less than six months were recruited for the study (Appendix 7.4). The calves were ear-tagged and identified by sex, age, and breed. The dam and sire for each calf were also identified by breed and recorded. Thereafter, new calves were recruited into the study herds either through birth or through transfer such as gifts. Calves dropped from the study either through death, withdrawals, transfers, or after attaining the age of 13 months.

7.2.3 Calf management practices, clinical examination and treatment

During each visit, household owners were interviewed on current calf management practices, disease control and treatment using a structured questionnaire (Appendices 3.3 and 3.4). Each calf was also clinically examined for demeanor, discharges from the eyes and external orifices, colour of mucous membrane, gait, respiration, urination, defaecation and consistence of faeces, superficial lymph nodes, skin coat and rectal temperature. Wherever possible, appropriate treatment was administered to all sick calves following the clinical examination and diagnosis.

7.2.4 Samples collection and processing

Tick and faecal samples were collected for examination and identification using procedures described in Chapter three. Similarly, the methods of blood collection, processing and laboratory analysis were described in the same chapter.

7.2.5 Data handling and processing

Data files of questionnaire responses and laboratory results were prepared in Microsoft Access and analysed using STATA (Stata Corporation., 2003) and Statistical Analysis Systems (SAS 1985, Institute Inc., Cary, NC). The outcome variables investigated in this study are givenand defined in Appendix 7.1. The differential diagnosis of tick-borne diseases of calves investigated in this study are listed and each described briefly in Appendix 7.2. Appendix 7.3 gives a description of the general clinical signs of tick-borne diseases that cause calf morbidity and mortality in Kajiado District, Kenya.

7.2.6 Data analysis

7.2.6.1 Estimates of calf morbidity and mortality

Definitions of morbidity, mortality, sero-conversion and other measurements that were used to estimate calf health and production levels are defined in Appendix 7.1. Briefly, calf morbidity was defined as any calf sickness that had a recognizable clinical manifestation while calf mortality was defined as any death.

Initially, crude calf morbidity and crude mortality rates were estimated from the morbidity and mortality events. Cause-specific morbidity and cause-specific mortality were estimated from confirmatory diagnoses based on laboratory tests and post-mortem results. For example, estimates of morbidity and mortality caused by ECF (caused by *T. parva* and / or *T. mutans*), anaplasmosis (caused by *A. marginale*) and babesiosis (caused by *B. bigemina*), were initially based on clinical assessment and confirmed using seroconversion status and/or post-mortem results.

The annual incidence rates (I) of crude morbidity and mortality were calculated as the total number of sick/dead calves (in a time period) divided by the number of calf-years at risk (Martin *et al.,* 1994). The exact 95 percent confidence intervals (C.I.) were calculated based on probabilities derived from the poisson distribution using STATA (Stata Corporation, 2003) (Dohoo *et al.,* 2003).

The number of calf-days at risk was obtained by, first, listing of all the household visits and the specific dates of the visits. Second, the number of days between two consecutive visits was calculated. Thereafter, the specific dates of entry and exit were determined for each calf. A universal method, whereby a calf completing an inter-visit interval was considered to contribute calf-days equivalent to the inter-visit number of days was adopted. A calf whose exit occurred within an inter-visit period was assumed random across the period of observation and thus an observation period equivalent to half the interval in days was used in the analysis. The number of calves with outcome events (morbidity or mortality) was obtained by counting the number of new cases that achieved the outcome of interest within the specified age period. Only calves that were free of the outcome event at their time of recruitment were considered at risk.

7.2.6.2 Proportional morbidity and mortality rates

Proportional cause-specific morbidity and mortality rates were obtained by dividing the number of sick / dead cases due to a specific disease by the number of sick / dead calves from all diseases diagnosed (Dohoo *et al.*, 2003).

7.2.6.3 Survival analysis

The calf survival analysis from the age of recruitment into the study to crude morbidity and mortality were determined using follow-up life table (Actuarial) method (Dohoo *et al.*, 2003). First, the total number of calves by age-interval period at the start of the study (visit one) were listed in one column followed by listing of the number of new entries (non-births), the number of withdrawals (missing or lost), the number of sick calves and the number of dead calves by age-interval period for each visit, in separate columns (Appendix 7.4). The average number of calves at risk per age interval was calculated as the total number of calves at risk at the start minus half the number of withdrawals for that age interval.

Risk rate was calculated as the number of outcome events divided by the average number of calves at risk at the beginning of each age-interval period. Curnmulative survivorship from birth for each age interval was calculated by multiplying the survival rate of the "current age" interval by that of the previous age interval. Survivorship curves were plotted and compared between ranches.

7.2.6.4 Modeling risk factors of seroconversion (exposure) to TBDs

Data were prepared for for analysis using the PROC FREQ, PROC GENMOD and Generalised Estimating Equations (GEE) in SAS. When calves acquired the event of interest (seroconversion for *T. parva, T. mutans, A. marginale* and *B. bigemina*) they were coded one (1). Those that did not acquire the event of interest (non-seroconverters) were coded zero (0). For the calves that had acquired the event of interest, the set of covariates during the visit of event were entered into the model. However, for the calves that did not acquire the event of interest, one of the visits was randomly selected and the corresponding set of covariates were entered into the model.

Data were first explored in PROC FREQ for simple associations between seroconversion (measure of exposure) and each covariate. Second, PROC GENMOD (Ordinary Logistic Regression (OLR)) was used to model the covariates associated with seroconversion status to *T. parva, T. mutans, A. marginale*, and *B. bigemina*. First, a separate OLR model was prepared for all calves with ranches as the independent variable. Then, two separate logistic models were prepared for the herd level and calf level variables. The "variable" ranches was forced into the model as a dummy variable for the intercept with Nentanai as the baseline risk ranches. All the logistic regression models were fitted by stepwise backward elimination procedure where the risk factors were considered significant at $p<0.1$. A full model was then prepared with all the variables that were found to be significant above. A stepwise backward elimination method for non-significant variables ($p<0.05$) was used to produce the final regression model.

In the third analysis, Generalised Estimating Equations (GEE) procedure was applied to model the potential factors associated with seroconversion. Unlike the logistic regression procedure, the GEE procedure is a multi-level mixed model procedure for outcome variables with binomial distributions. This procedure accounts for both random and fixed effects variables and uses them to estimate the fixed effects parameters. Thus, a GEE model was prepared for all calves in the two ranches and the association between the outcome variables and all the potential explanatory factors that were significant from the logistic model. Farm was used as a random-effect factor in the model. Associations between the outcome variable (seroconversion) and the explanatory variables (risk factors) were considered significant at $p<0.05$.

7.2.6.5 Modeling of risk factors for calf morbidity and mortality

Data were prepared for use in PROC GENMODE and GLIMMIX data analysis procedures in SAS (SAS 1985). When calves acquired the event of interest (morbidity and mortality) the first time, they *were* classified as positive (coded 1) while those that did not acquire the event of interest were classified negative (coded 0). For the positive responses, the set of covariates during the visit of event were entered in the model. For the negative responses, one visit was randomly selected and the set of covariates for the visit entered in the model.

The PROC GENMODE data analysis procedure was used to model the risk factors associated with morbidity and mortality. First, the association between morbidity and mortality and each explanatory variable were explored using uni-variate models in PROC GENMOD. A poisson distribution link function was specified for the two outcome variables with log as the link function and years-at-risk as the offset. Second, the association between the outcome variables (morbidity and mortality) and all the explanatory factors were explored together in a multi-variate model containing all the variables that were significant from the uni-variate analysis. All the logistic regression models were fitted by backward elimination procedure while the risk factors were considered significant if the p – value was less than 0.05.

In the third analysis, the GLIMMIX Procedure was applied to model the factors associated with calf morbidity and mortality. Unlike the logistic regression procedure, the Glimmix Procedure is a multi-level mixed model procedure for outcome variables with a binomial distribution. This procedure accounts for both the random and fixed effects variables in the analysis and estimates the variance components associated with random effects variables and uses them in estimating the fixed-effects parameters (Little *et al.*, 1996).

A Glimmix model was prepared for all calves in both sites. The association between the outcome variables (morbidity and mortality) and all the potential explanatory factors were explored together in a multi-level model. Data were classified by farm and calf identity and these two variables were used as random-effects factors in the model. All risk factors were considered significant at the level of $p < 0.1$.

7 .3 RESULTS

7.3.1 Descriptive statistics

A total of 593 calves were recruited and a total of 2328 observations were made during the 15 visits that were made during the longitudinal study (Appendix 7.4). They comprised of 330 calves (55.6 percent) and 263 calves (44.4 percent) from Olosho Oiborr and Nentanai ranches, respectively (Table 7.1) of which were 308 (51.9 percent) female calves and 285 (48.1 percent) male calves. There were 174 (29.3 percent) were Maasai Zebu calves, 347 (58.6 percent) crossbred calves and 72 (12.1 percent) exotic calves. Thirty-two calves were recruited during the first visit while 72, 66, 23 and 50 new calves were recruited during the second, third, fourth and fifth visit, respectively. The highest numbers of calves (193) were recruited during the 15 visits, which coincided with the main calving season (December - January) for cattle in Kajiado District.

Farmer cooperation was also good except during the second visit when one herd of eight calves in Olosho Oiborr withdrew from the study. The farmer had complained that harvesting too much blood from calves caused them to grow weak and susceptible to diseases and death. He also complained that he could not see the benefits of his involvement in the study. Attempts to convince him did not bear fruit. Interestingly, by the seventh visit the farmer requested to be allowed to continue in the study. The eight calves were re-entered for observation. A total of 23 calves were given out as presents and / or bride prize while 67 calves (Appendix 7.4) died of various causes. The highest number of deaths observed during one single visit was 28.

Table 7.1 Location, sex and breed of 593 calves observed in Maasai pastoral systems in Kajiado District (Longitudinal study, November 2000-February 2002).

Variable	Categories	Count	Frequency (percent)
ranches	Olosho Oiborr	330	55.6
	Nentanai	263	44.4
Sex	Females	308	51.9
	Males	285	48.1
Breed	Maasai zebu	174	29.3
	Crosses	347	58.6
	Exotic	72	12.1

7.3.2 Factors associated with risk of seroconversion for *T. parva*

There were significantly (p = 0.0003) more calves that were at risk of *T. parva* seroconversion in Olosho Oiborr than in Nentanai (Appendix 7.9). Farm level variables that were associated with seroconversion for *T. parva* included watering frequency, grazing management and spraying against ticks. Calves that were watered more frequently had significantly (p=0.01) higher risk of *T. parva* seroconversion compared to calves that were watered less frequently. Calves that went out to graze when 3-6 months old were at a higher risk of *T. parva* seroconversion than calves that went out to graze when they were > 6 months old. Similarly calves that were grazed near the *boma* had significantly (p<0.0001) higher risk of *T. parva* seroconversion than calves that were grazed further from the boma. Calves that were grazed in the reserve paddocks *(olopololi)* had significantly (p=0.0001) higher seroconversions for *T. parva* than calves that were grazed in distant and open pastures. Female calves were at a higher risk of *T. parva* seroconversion than male calves.

However, table 7.2 shows that there were no ranches effects on the risk of *T. parva* seroconversion in calves when multivariate OLR was used and, clustering of calves affected parameter estimates of various variables investigated for their association with *T. parva* seroconversion. Thus, there was no difference in risk of seroconversion for *T. parva* between calves that were frequently sprayed against ticks compared to those that were sprayed infrequently.

Table 7.2 Variables associated with seroconversion for *T. parva* in calves older than 3 months (n=241) from the Ordinary Logistic Regression (OLR) and Generalised Estimating Equations (GEE) in Maasai pastoral system in Kajiado District (Longitudinal study, November 2000 – February 2002).

Level and variable	OLR b	s.e.	p-value	Odds ratio	GEE b	s.e.	p-value
a) ranches							
Olosho Oiborr (1), Nentanai (0)	-0.51	0.52	0.35	0.60	-0.51	0.57	0.37
b) Farm level							
Age at first Grazing							
3-6 months (1) > 6 months (0)	-1.57	0.52	<0.01	0.21	-1.59	0.57	<0.01
Distance to grazing pastures from *boma*							
Far (>5 km) (1), Near (≤5 km) (0)	3.27	0.79	<0.01	26.2	3.29	0.82	<0.01
Frequency of watering per day	1.08	0.53	0.04	2.96	1.07	0.87	0.22
At least once (1), Less than once (0)							
Ad libitum (1), Less than once (0)	2.08	0.93	0.02	7.99	2.01	0.92	0.03
Frequency of spraying against ticks per week							
Once (1), less than once (0)	-1.03	0.54	0.06	0.36	-0.99	0.69	0.15
c) Calf level							
Age	0.50	0.23	0.03	1.64	0.50	0.24	0.04
Age class							
4-6 months (1), 7-9 months (0)	1.40	0.78	0.07	0.12	1.45	0.65	0.03
10-12 months (1), 7-9 months 0)	-2.16	0.85	0.01	4.07	-2.20	0.87	0.01

Key: b – parameter coefficient estimate

S.e. – standard errer of the coefficient estimates

The risk of Seroconversion with *T. parva* was 26.2 ($e^{3.27}$) times higher in calves that were grazed in far pastures compared to calves that were grazing near the homestead *(boma).* From the OLR analysis, calves that were watered more frequently (at least once per day) had marginally significant ($p=0.04$) lower risk of *T. parva* seroconversion than calves that were watered less frequently (less than once per day) but when clustering effects were adjusted for, the association was not significant ($p=0.22$). Older calves were at a higher risk (O.R.=4.07) of seroconversion with *T. parva* than young calves (Table 7.2). Calves that were 4-6 months old were at a higher risk of seroconversion than calves that were 7-9 months.

7.3.3 Factors associated with risk of seroconversion for *T. mutans*

There were no significant ($p=0.59$) differences in risk for *T. mutans* seroconversion between Olosho Oiborr and Nentanai ranches (Appendix 7.10). Calves that were not sprayed had significantly ($p<0.0001$) lower risk of *T. mutans* seroconversion compared to calves that were sprayed. Calves that were grazing in distant pastures had significantly ($p=0.0013$) higher risk of *T. mutans* seroconversion than calves that were grazing in paddocks near the *boma*. Calves that were taken out to graze as early as 3-6 months of age had significantly ($p = 0.0003$) higher risk of *T. mutans* seroconversion *compared* to calves that were taken to graze later than 6 months of age. Calves that were grazed in reserve paddocks (restricted grazing) had significantly ($p=0.004$) higher seroconversion compared to calves that were grazing freely in open pastures.

Of the calf variables, only breed and age class were significantly associated with risk of *T. mutans* seroconversion (Table 7.3). There were no apparent clustering effects from the GEE model (parameter estimates were the same for the OLR and GEE).

The crosses had significantly ($p=0.04$) lower risk of *T. mutans* seroconversion compared to Maasai Zebu and the exotic calves (Appendix 7.10). Calves that were aged 4-6 months old had significantly ($p<0.0001$) lower risk of *T. mutans* seroconversion compared to calves 7-9 and 10-12 months old. Similarly, calves that were grazed in far pastures were at a higher risk (O.R. = 4.9 or $e^{1.59}$) of seroconverting to *T. mutans* than calves that were grazing very near the homestead *(boma)*

7.3.4 Factors associated with risk of seroconversion for *A. marginale*

There were significantly ($p < 0.0002$) more calves seroconverting for *A. marginale* in Olosho Oiborr than in Nentanai (Appendix 7.11). Calves that were grazing in distant pastures had significantly ($p = 0.0002$) higher chances of seroconverting to *A. marginale* than calves that were grazing in paddocks near the *boma*. Calves that were taken out to graze as early as 3-6 months of age had significantly ($p < 0.0001$) higher seroconversion than those that went out to graze at >6 months of age. Among the calf variables only age rancheswas significantly associated with seroconversion for *A. marginale.* Calves that were aged 4-6 months old had significantly ($p<0.0001$) higher number of calves seroconverting for *A. marginale* compared to calves 7-9 and 10-12 months old.

Table 7.3 Variables with seroconversion for *T. mutans* in calves older than 3 months (n=241) from the Ordinary Logistic Regression (OLR) and Generalised Estimating Equations (GEE) in Maasai pastoral system in Kajiado District (Longitudinal study, November 2000 – February 2002).

Level and variable	OLR				GEE		
	b	se(b)	p-value	Odds ratio	b	se(b)	p-value
a) ranches level							
Olosho Oiborr (1), Nentanai (0)	-0.31	0.36	0.40	0.74	-0.31	0.36	0.40
b) Farm level							
Distance to grazing pastures from *boma*							
Far (> 5 km) (1), Near (≤ 5 km) (0)	1.59	0.55	<0.01	4.9	1.59	0.55	<0.01
c) Calf level							
Age	-0.43	0.08	<0.01	0.65	-0.43	0.08	<0.01

Key: b – parameter coefficient estimate

se(b). – standard error of the coefficient estimate

The factors that were associated with risk of seroconversion for *A. marginale* from the OLR and GEE are listed in Table 7.4. Calves that went out to graze when 3-6 months old were at a higher risk of *A. marginale* seroconversion (p = 0.0006) compared to calves that went out to graze at the age > 6 months. Similarly calves that were watered frequently (at least once per day) were at a higher risk of *A. marginale* seroconversion compared to calves that were watered infrequently (less than once per day).

7.3.5 Factors associated with risk of seroconversion for *B. bigemina*

There were no significant (p = 0.24) differences in the risk of seroconversion with *B. bigemina* between Olosho Oiborr and Nentanai ranches (Appendix 7.12). Calves that were grazing in distant pastures had significantly (p = 0.006) higher chances of seroconverting to *B. bigemina* than calves that were grazing in paddocks near the *boma*. Calves that were taken out to graze as early as 3-6 months of age had significantly (p<0.0003) higher seroconversion for *B. bigemina* compared to calves that were taken to graze later than 6 months of age. Significantly (p<0.0001) higher number of calves converted for *B. bigemina* at 4 -6 months of age than at 7-9 months and 10-12 months of age.

Multi-level analysis using OLR and GEE showed that calves that were grazing in restricted paddocks (*olopololis*) had a higher risk of *B. bigemina* seroconversion compared to calves that were not grazing in the reserve paddocks (Table 7.5). Older calves were also at lower risk of *B. bigemina* seroconversion compared to younger calves.

Table 7.4 Variables associated with seroconversion for *A. marginale* from the Ordinary Logistic Regression (OLR) and Generalised Estimating Equations (GEE) for calves older than three months (n=241) in Maasai pastoral systems in Kajiado District (Longitudinal study, November 2000 – February 2002).

	OLR			GEE			
Level and variable	b	Se(b)	p-value	Odds Ratio	b	se(b)	p-value
a) ranches level							
Olosho Oiborr (1), Nentanai (0)	0.13	0.45	0.78	1.14	0.13	0.45	0.78
b) Farm level							
Age at first grazing							
3-6 months (1), > 6 months (0)	1.70	0.49	<0.01	0.10	1.70	0.49	<0.01
Frequency of watering per day							
At least once (1), less than once (0)	1.02	0.48	0.04	2.75	1.01	0.48	0.04
Ad libitum (1), less than once (0)	-0.04	0.85	0.96	0.96	-0.04	0.85	0.96
c) Calf level							
Age class							
0-12 months (1), 7-9 months (0)	-1.13	0.42	<0.01	0.32	-1.13	0.42	<0.01

Key: b – parameter coefficient estimate

se(b) – standard errer of the coefficient estimate

Table 7.5 Variables associated with seroconversion for and *B. bigemina* from the Ordinary Logistic Regression and Generalised Estimating Equations (GEE) in calves older than three months (n=241) in Maasai pastoral systems in Kajiado District (Longitudinal study, November 2000 – February 2002).

	OLR				GEE		
Level and variable	b	Se (b)	p-value	Odds Ratio	b	Se (b)	p-value
a) ranches level							
Olosho Oiborr (1) , Nentanai (0)	0.25	0.35	0.47	1.29	0.25	0.35	0.47
b) Farm level							
Restricted grazing in reserve paddocks (olopololi)							
Yes (1) , No (0)	1.53	0.55	<0.01	0.22	1.53	0.55	<0.01
c) Calf level							
Age (<13 months old)	-0.34	0.08	<0.01	0.72	-0.34	0.09	<0.01

Key: b – parameter coefficient estimate

se(b) – standard errer of the coefficient estimate

7.3.6 Patterns of distribution and causes of calf morbidity

Table 7.6 and Appendix 7.5 show that the incidence of calf morbidity was 1.9/calf-year at risk for the two es combined. Table 7.6 also shows that the incidence of morbidity was significantly higher ($p<0.05$) in Olosho Oiborr (3.8/calf-year at risk) than in Nentanai (1.4/calf-year at risk). There were no sex and breed effects on the incidence of calf morbidity.

The proportional cause-specific rates of disease conditions that caused calf morbidity are shown in Table 7.7. In Olosho Oiborr, five diseases with relatively high proportional morbidity rate were fleas (19.8 percent), anaplasmosis (13.2 percent), helminthosis (12.8 percent), and non-specific diarrhoea (12.3 percent) and warts (7.2 percent). In Nentanai, five diseases that caused relatively high proportional morbidity were anaplasmosis (15.5 percent), ring worms (15.2 percent) lice (11.7 percent), East Coast fever (8.8 percent) and fleas (8.7 percent).

The highest risk of morbidity was 35.7 percent that was observed immediately after birth but declined rapidly to 11.6 percent in the third month (Appendix 7.6). Thereafter, the risk of morbidity declined gradually up to 3.8 percent in the seventh month and remained almost constant at 1.0 percent. Figure 7.1 shows that the calves that were less than one month old had a higher risk of morbidity in Olosho Oiborr (50 percent) compared to Nentanai (27 percent). The overall cumulative survivorship from birth to morbidity was significantly higher in Nentanai than in Olosho Oiborr during the first 3 months of life (Figure 7.2).

Table 7.6 Incidence of morbidity in 593 calves by , sex and breeds found in Maasai_pastoral herds in Kajiado District, Kenya (Longitudinal study, November 2000 – February 2002).

Variable	Categories	Calf morbidity	
		Incidence Rate per calf-year at risk	95 percent Confidence Interval
Overall	-	1.9	1.7 - 2.1
	Olosho Oiborr	3.8[a]	3.2 – 4.4
	Nentanai	1.4[b]	1.2 - 1.6
Sex	Female	2.0	1.7 - 2.3
	Male	1.8	1.5 - 2.1
Breed	Maasai Zebu	2.0	1.7 – 2.3
	Crosses	1.8	1.7 – 1.9
	Exotic	2.1	1.5 – 2.7

[a,b]Values with different superscripts within the same column are significantly different at $p<0.05$ (or the 95 percent CIs do not overlap).

Table 7.7 Proportional cause-specific morbidity of confirmed cases of sick calves in Maasai pastoral systems in Kajiado District, Kenya (Longitudinal study, November 2000 – February 2002).

Disease	Total morbidity (cases)	Morbidity by ranches		Proportional cause-specific morbidity (%) by ranches	
		Olosho Oiborr	Nentanai	Olosho Oiborr	Nentanai
Anaplasmosis	155	62	93	13.2	15.5
Fleas	145	93	52	19.8	8.7
Ring worms	114	23	91	4.9	15.2
Non-specific diarrhoea	107	58	49	12.3	8.2
Lice	101	31	70	6.6	11.7
Helminthosis	100	60	40	12.8	6.7
East Coast fever	73	20	53	4.3	8.8
Eye infection	60	15	45	3.2	7.5
Warts	43	34	9	7.2	1.5
Coccidiosis	32	15	17	3.2	2.8
Pneumonia	31	15	16	3.2	2.7
Lumpy skin disease	25	2	23	0.4	3.8
Wounds	17	7	10	1.5	1.7
Lameness	13	4	9	0.9	1.5
Black quarter	10	0	10	0.0	1.7
Malnutrition	9	5	4	1.1	0.7
Hernia	7	5	2	1.1	0.3
Foot rot	7	7	0	1.5	0.0
Arthritis	5	3	2	0.6	0.3
Abscesses	4	3	1	0.6	0.2
Congenital weakness	3	3	0	0.6	0.0
Ephemeral fever	2	1	1	0.2	0.2
Babesiosis	2	2	0	0.4	0.0
Gastrointestinal obstruction	1	1	0	0.2	0.0
Excess milk intake	1	1	0	0.2	0.0
Balanoposthitis	1	0	1	0.0	0.2
Accident	1	0	1	0.0	0.2
Total morbidity	1069	470	599	100	100

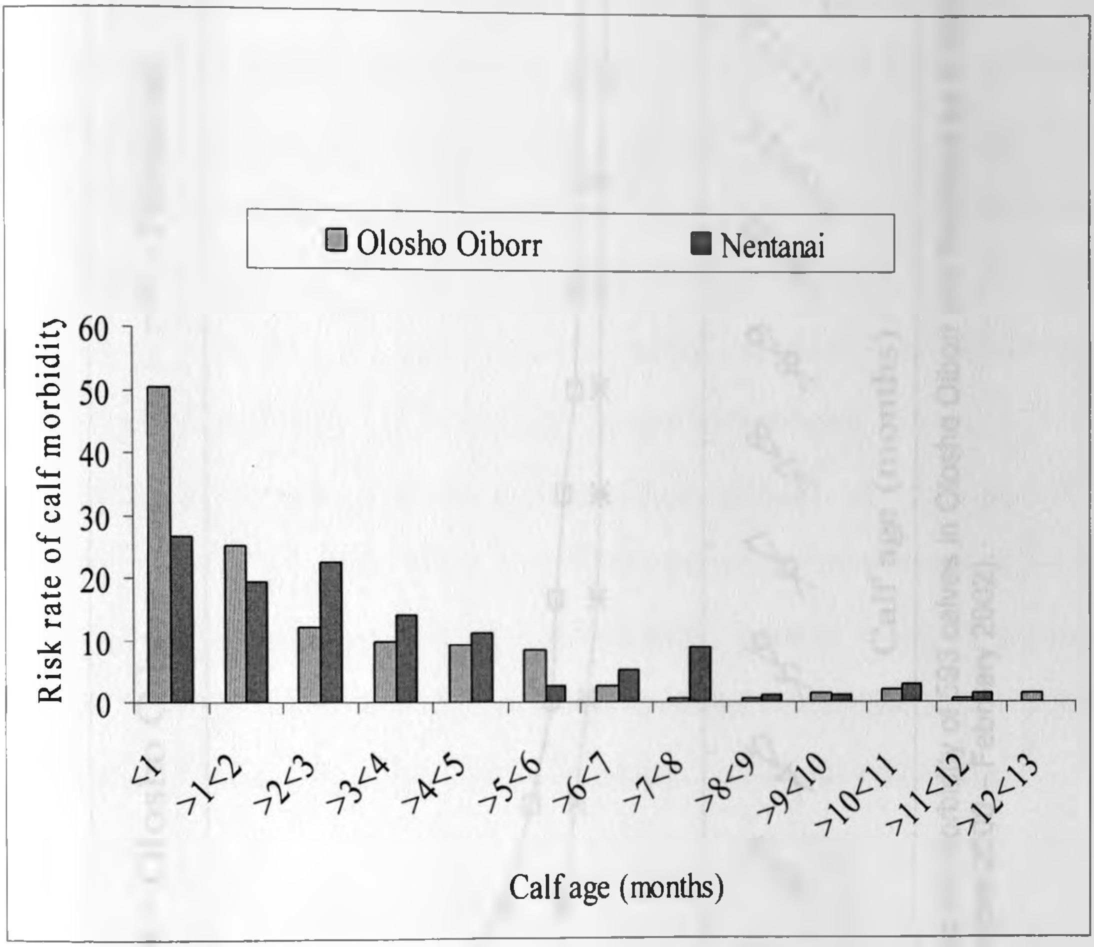


Figure 7.1 Risk of morbidity (percent) by age in 593 calves sampled in Olosho Oiborr and Nentanai es in Kajiado District (Longitudinal study, November 2000 – February 2002).

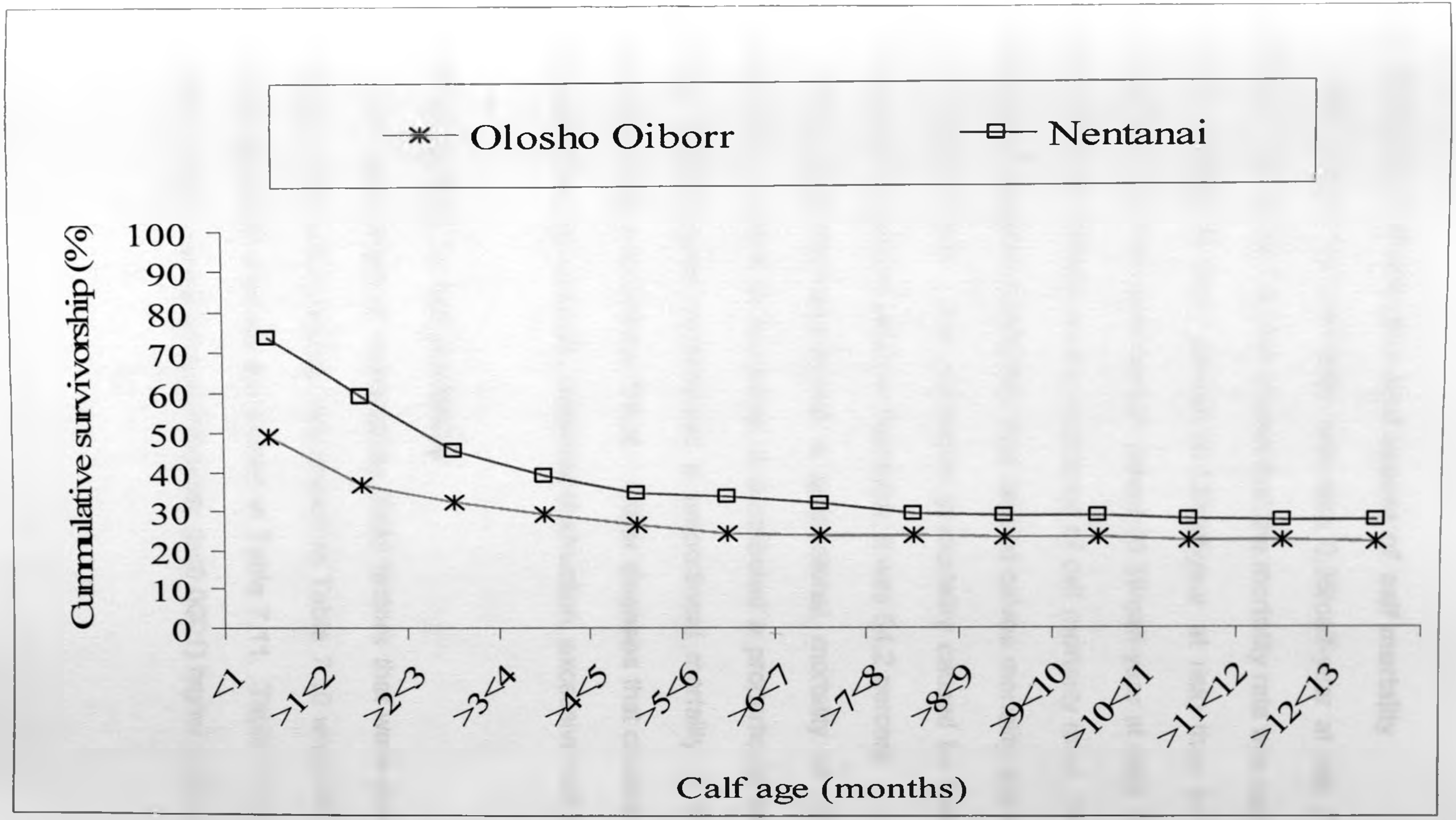


Figure 7.2 Cumulative survivorship for morbidity of 593 calves in Olosho Oiborr and Nentanai es in Kajiado District, Kenya (Longitudinal study, November 2000 – February 2002).

7.3.7 Patterns of distribution and causes of calf mortality

The overall calf mortality rate was 0.36/calf-year at risk (Table 7.8 and Appendix 7.7). Table 7.8 also shows that the mortality rate was significantly lower ($p<0.05$) in Maasai Zebu calves (0.12/calf-year at risk) than in the crossbred (0.41/calf-year at risk) and exotic calves (0.59/calf-year at risk). There were no ranches and sex effects on the incidence of calf mortality rates. The proportional distribution of disease conditions that caused calves mortality are shown in Table 7.9. In Olosho Oiborr , the proportion of mortality caused by East Coast Fever (ECF) was 68.4 percent while in Nentanai, it was 54.2 percent.

Anaplasmosis contributed a proportional mortality of 10.2 percent in Olosho Oiborr , while in Nentanai, it contributed a proportional mortality of 16.7 percent. Black quarter contributed a proportional mortality of 20.8 percent in Nentanai but none in Olosho Oiborr . Other diseases that caused mortality were ephemeral fever, babesiosis, intestinal obstruction, excessive milk intake.

7.3.8 Risk factors for calf morbidity

The distribution of explanatory (risk) factors that were analysed for their association with calf morbidity are shown in Table 7.10 while the results of the OLR and GLIMMIX models are shown in Table 7.11. Table 7.10 shows that the proportion of sick calves was significantly ($p<0.0001$) higher in Nentanai (76.8

Table 7.8 Incidence of mortality in 593 calves by , sex and breed in Maasai pastoral herds in Kajiado District, Kenya (Longitudinal study, November 2000 – February 2002).

Variable	Categories	Calf mortality	
		Incidence rate per calf-year at risk	95 percent confidence interval
Overall	-	0.36	0.28-0.44
	Olosho Oiborr	0.24	0.15-0.33
	Nentanai	0.44	0.32-0.56
Sex	Female	0.36	0.26-0.46
	Male	0.35	0.23-0.47
Breed	Maasai Zebu	0.12[a]	0.04-0.20
	Crosses	0.41[b]	0.30-0.52
	Exotic	0.59[b]	0.31-0.75

[a,b] Values with different superscripts within the same column are significantly different at $p < 0.05$ (or the 95 percent CIs do not overlap)

Table 7.9 Proportional cause-specific mortality of calves in Maasai pastoral systems in Kajiado District, Kenya (Longitudinal study, November 2000 – February 2002).

Cause of mortality	Total mortality (cases)	Mortality by ranches		Proportional cause-specific mortality (%) by ranches	
		Olosho Oiborr	Nentanai	Olosho Oiborr	Nentanai
Theileriosis	39	13	26	68.4	54.2
Anaplasmosis	10	2	8	10.5	16.7
Black quarter	10	-	10	-	20.8
Ephemeral fever	2	1	1	5.3	2.1
Intestinal obstruction	2	1	1	5.3	2.1
Non-specific	2	-	2	-	4.2
Babesiosis	1	1	-	5.3	-
Excessive milk intake	1	1	-	5.3	-
Total mortality	67	19	48	100	100

Table 7.10 Frequency distribution of calf morbidity by various farm management and calf variables in Maasai herds, Kajiado District (Longitudinal study, November 2000 - February 2002).

Category	Category levels	No. of calves sampled	Proportion (percent) of sick calves	df, χ_2	p-value
a) ranches	Olosho Oiborr	330	39.7	1, 81.9	<0.0001
	Nentanai	263	76.8		
a) Farm variables					
Season of sampling	Dry	162	47.5	1, 6.7	0.01
	Wet	431	59.4		
Housing	Yes	91	51.7	1, 0.11	0.74
	No	364	49.7		
Frequency of milk intake	Frequent	442	52.0	1, 12	0.0005
	Infrequent	151	68.2		
Frequency of tick control	Frequent	296	56.9	2, 8.2	0.02
	Infrequent	147	46.9		
	None	177	62.7		
Frequency of watering	Frequent (daily)	119	45.4	2, 2.5	0.28
	Infrequent (<once per day)	141	54.6		
	None	211	53.1		
Grazing distant from homestead	Near (< 1 km)	450	51.1	1, 0.43	0.51
	Far (> 2km)	26	57.7		
Calf age at start of grazing	Early (< one month old)	439	45.1	1, 64	<0.0001
	Late(>one month old)	87	92		
Restricted grazing	Yes	338	59.2	1, 27.7	<0.0001
	No	138	32.6		
b) Calf variables					
Age	< 4 months	333	51.7	3, 19.2	0.0003
	>3<7 months	35	34.3		
	>6<10 months	45	62.2		
	>9<13 months	180	67.2		

Table 7.10 (continued..................)

Category	Category levels	No. of calves sampled	Proportion (percent) of sick calves	df, X_2	p-value
Sex	Female	308	58.8	1, 1.8	0.18
	Male	285	53.3		
Breed	Maasai Zebu	174	57.5	2, 0.17	0.91
	Crosses	347	55.6		
	Exotic	72	55.6		
T. parva positive	Yes (1)	281	45.6	1, 17.9	<0.0001
	No (0)	198	65.2		
T. parva seroconversion	Yes (1)	24	91.7	1, 12.8	0.0003
	No (0)	569	54.7		
T. parva lag seroconversion	Yes (1)	29	93.1	1, 16.9	<0.0001
	No (0)	564	54.3		
T. mutans positive	Yes (1)	307	56.0	1, 0.004	0.95
	No (0)	286	56.3		
T. mutans seroconversion	Yes (1)	32	81.2	1, 8.7	0.003
	No (0)	313	54.7		
T. mutans lag seroconversion	Yes (1)	27	88.9	1, 12.3	0.0005
	No (0)	566	54.6		
A. marginale positive	Yes (1)	324	51.2	1, 7.0	0.008
	No (0)	269	62.1		
A. marginale seroconversion	Yes (1)	30	90.0	1, 14.7	0.0001
	No (0)	563	54.4		
A. marginale lag seroconversion	Yes (1)	24	100	1, 19.5	<0.0001
	No (0)	569	54.3		
B. bigemina positive	Yes (1)	210	49.5	1, 5.8	0.02
	No (0)	383	59.8		
B. bigemina seroconversion	Yes (1)	21	90.5	1, 10.4	0.001
	No (0)	572	54.9		
B. bigemina lag seroconversion	Yes (1)	21	95.2	1, 13.5	0.0002
	No (0)	572	54.7		

Table 7.11 Variables associated with calf morbidity from the multi-variate analysis (O
Kajiado District (Longitudinal study, November 2000 - February 2002).

Category	Levels	OLR	
		b	SE (b)
Fixed effects			
a) ranches	Olosho Oiborr (1), Nentanai(0)	-1.77	0.250
b)Farm level variables			
Season	Dry (1), wet (0)	-1.09	0.3
b) Calf level variables			
Age	< 4 months (1), >9<13 months (0)	-0.84	0.3
	>3<7 months (1), >9<13 months (0)	-1.8	0.52
	>6<10 months (1) >9<13 months (0)	-0.95	0.47
A. marginale positive	No (1), Yes (0)	0.51	0.23
Random effects			
Farm			
Residual			

Key: b – parameter coefficient estimate

SE (b) – standard errer of the coefficient estimate

ne - not estimated

percent) than in Olosho Oiborr (39.7 percent). The difference was also significant (p<0.0001) in the OLR and GLIMMIX models (Table 7.11). Other factors that were associated with calf morbidity from the OLR and GLIMMIX are shown in Table 7.11. Calf morbidity was significantly (p<0.0001) lower in Olosho Oiborr compared to Nentanai in both the OLR and GLIMMIX analysis. Calf morbidity was significantly lower during the dry season compared to the wet season (p-value was 0.0003 from OLR and 0.02 from GLIMMIX). Calves that were <4 months old had significantly lower morbidity compared to calves that were >9<13 months old (p-value was 0.005 from OLR and 0.041 from GLIMMIX). From the OLR analysis, morbidity for calves that were >6<10 months old was significantly low (p=0.046) compared to calves that were >9<13 months old but not from the GLIMMIX analysis (p=0.14). Calves that had no serum antibodies for *A. marginale* had significantly higher morbidity from OLR (p=0.03) and GLIMMIX analysis (p=0.05).

7.3.9 Risk factors for calf mortality

The distribution of variables that were analysed for association with calf mortality is shown in Table 7.12 while the results of the OLR and GLIMMIX analysis are shown in Table 7.13. The proportion of dead calves was significantly higher in Nentanai (18.3 percent) compared to Olosho Oiborr (5.8 percent) (p<0.0001). Results of the OLR analysis (Table 7.13) show that calf morbidity was significantly lower (p=0.005) in Olosho Oiborr compared to Nentanai (association was not significant from the GLIMMIX analysis).

Table 7.12 Frequency distribution of calf mortality by ranches, farm management and calf variables in Maasai herds, Kajiado District (Longitudinal study, November 2000 - February 2002).

Category	Category levels	No. of calves sampled	Proportion (percent) of dead calves	df, X_2	p-value
a) Ranch	Olosho Oiborr	330	5.8	1, 22.8	<0.0001
	Nentanai	263	18.3		
b) Farm level variables					
Season of sampling	Dry	185	22.7	1, 34.9	<0.0001
	Wet	408	6.1		
Housing	Yes	103	6.8	1, 2.0	0.36
	No	407	11.4		
Frequency of milk intake	Frequent	496	10.9	1, 1.36	0.72
	Infrequent	38	5.3		
Frequency of tick Control	Frequent	296	11.8	2, 0.17	0.92
	Infrequent	165	10.9		
	None	132	10.6		
Frequency of Watering	Frequent (daily)	181	17.7	2, 48.4	<0.0001
	Infrequent (<once per day)	102	21.6		
	None	251	0.8		
Grazing distance (from the homestead)	Near (< 1 km)	143	21.0	1, 0.17	0.68
	Far (> 2km)	20	25.0		
Calf age at start of grazing	Early (<one month old)	115	22.6	1, 18.8	<0.0001
	Late (> one month old)	476	8.4		
Restricted grazing	Yes	390	13.3	1, 12.4	0.0004
	No	143	2.8		

Table 7.12 (continued..................)

Category	Category levels	No. of calves sampled	Proportion (percent) of dead calves	df, X_2	p-value
c) Calf level variables					
Age	< 4 months	333	4.5	3, 136.1	<0.0001
	>3<7 months	35	65.7		
	>6<10 months	76	25.0		
	>9<13 months	149	6.7		
Breed	Maasai Zebu	174	2.9	2, 18.4	0.0001
	Crosses	347	14.1		
	Exotic	72	18.1		
Sex	Female	308	12.3	1, 0.69	0.41
	Male	285	10.2		
T. parva positive	Yes (1)	281	0.5	1, 0.06	0.8
	No (0)	198	0.4		
T. parva seroconversion	Yes (1)	24	16.7	1, 0.8	0.37
	No (0)	491	10.8		
T.parva lag seroconversion	Yes (1)	29	0	1, 0.15	0.70
	No (0)	196	0.51		
T. mutans positive	Yes (1)	307	0	1, 1.13	0.29
	No (0)	172	0.7		
T. mutans seroconversion	Yes (1)	32	12.5	1, 0.16	0.69
	No (0)	477	10.3		
T.mutans lag seroconversion	Yes (1)	27	0	1, 0.14	0.71
	No (0)	197	0.51		
A. marginale positive	Yes (1)	324	0.3	1, 0.29	0.59
	No (0)	155	0.7		

Table 7.12 (continued..................)

Category	Category levels	No. of calves sampled	Proportion (percent) of dead calves	df, X_2	p-value
A.marginale seroconversion	Yes (1) No (0)	30 255	13.3 19.2	1, 0.61	0.43
A. marginale lag seroconversion	Yes (1) No (0)	24 200	0 0.5	1, 0.12	0.73
B. bigemina positive	Yes (1) No (0)	210 269	0.48 0.37	1, 0.03	0.86
B. bigemina seroconversion	Yes (1) No (0)	21 208	0 0.5	1, 0.10	0.75
B. bigemina lag seroconversion	Yes (1) No (0)	21 200	0 0	ne	ne

ne = not estimated (due to zero in some cells)

Table 7.13 Variables associated with calf mortality from the multi-variate analysis (OL
Kajiado District (Longitudinal study, November 2000 - February 2002).

Category	Levels	OLR	
		b	SE (b
Fixed effects			
a) ranches	Olosho Oiborr (1) , Nentanai(0)	-1.10	0.39
b) Farm level variables			
Frequency of watering	Frequent (daily)(1) , none(0)	3.6	0.79
	Infrequent (<once per day) (1) , none (0)	2.9	0.78
c) Calf level variables			
Age	<4 months (1) , >9<13 months (0)	1.68	0.53
	>3<7months (1) , >9<13 months (0)	4.5	0.7
	>6<10months(1), >9<13 months (0)	1.8	0.5
b)Random effects			
Farm			

Key: b – parameter coefficient estimate

SE (b). – standard errer of the coefficient estimate

ne _ not estimated

Table 7.12 also shows that proportion of dead calves was significantly higher during the dry season (22.7 percent) compared to wet season (6.1 percent) (p=0.0003 from OLR and 0.002 from GLIMMIX). Calves that were watered more frequently had significantly higher mortality (p<0.0001) compared to calves that were not watered at all (Table 7.12). Table 7.12 shows that significantly higher proportion of calves died at the age of >3<7 months (65.7 percent) compared to other ages. This relationship was also seen in the multivariate analysis where, calf mortality was significantly higher (p<0.0001) in calves that were >3<7 months old compared to calves that were >9<13 months old (Table 7.13). Table 7.12 shows that propotion the of dead calves was lowest in calves <4 months old and >9<13 month old calves. The multivariate analysis shows that <4 month old calves had higher mortality than >9<13 month old calves but the two classes are still lower than >3<7 and >6<10 month old calves (Table 7.13).

7.4. DISCUSSION

This study has shown a high degree of pastoralists' cooperation possibly because of the potential benefits accruing from the study. Initially, majority of the pastoralists were not willing to allow young calves (less than one month old) to be bled. Continuous bleeding of calves was met with suspicion by some pastoralists. However, after some discussion and convincing the pastoralists they were willing to cooperate. Calves that were confirmed to be sick were treated and this enhanced the pastoralists' confidence and cooperation. The one monthly interval visit for sampling of the herds enabled the principal investigator to observe changes in farm management, to verify new calf entries (due to births and gifts), to detect when young calves were first exposed to TBDs and to record morbidity and morbidity. However, even with increased intensity of visits to the herds, it was difficult to confirm the diagnosis of acute infections such as ECF and black quarter due to the short duration of the diseases.

The proportion of calves that had seroconverted to *T. parva* was significantly higher in Olosho Oiborr (58.2 percent) than in Nentanai (35 percent) while the proportion of ECF clinical cases was significantly higher in Nentanai (8.8 percent) than in Olosho Oiborr (4.3 percent) indicating an inverse relationship between seroconversion and ECF clinical illness. Interestingly, the proportion of deaths that were attributed to ECF was higher in Olosho Oiborr (68.4 percent) than in Nentanai (54.2 percent). The results suggest that a direct relationship exists between seroconversion for *T. parva* and ECF mortality in Olosho Oiborr but no such relationship existed in Nentanai. It is possible that calves in Olosho Oiborr were more exposed to the vector that transmits *T. parva.* O'Callaghan (1998) also reported that the risk of ECF varied between different grazing management systems such that calves in semi-/full-pasture grazing management both seroconverted earlier and had higher levels of antibody activity. This study also shows that grazing management systems affected exposure to the *T. parva* infection measured by seroconversion rates. Furthermore, in Chapter six, the mean of total tick counts for *R. appendiculatus* were relatively higher in Olosho Oiborr than in Nentanai. There could be other factors such as differences in the distribution of breed that are able to tolerate *T. parva* infections. In chapters four and five, there were significantly more crosses and exotic calves in Olosho Oiborr than in Nentanai

The overall crude calf morbidity rate of 56.2 percent reported in this study was much higher than the calf morbidity rate of 20.7 percent recorded in smallholder dairy farms in Muranga District (Gitau *et al.,* 1999). Crude morbidity of calves among smallholder dairy farmers in Kiambu was also lower at 30.4 percent (O'Callaghan, 1998) and ECF-specific morbidity was 7.3 percent. In the study by Gitau *et al.* (1999), morbidity was caused by ECF and was more common in calves that were kept in open-grazing areas than on zero-grazing farms.

In the current study, simple proportions showed that more calves were significantly getting sick in Nentanai (76.8 percent) compared to Olosho Oiborr (39.7 percent) but the incidence rate of morbidity was significantly higher in Olosho Oiborr (3.8/calf-year) than in Nentanai (1.4/calf-year). Results of the multivariate models (OLR and GLIMMIX) also show that the morbidity rate was significantly higher in Nentanai than in Olosho Oiborr . This discrepancy suggests that there were more chronically ill calves in Olosho Oiborr and short duration illnesses in Nentanai. Duration of a disease depends on timely diagnosis and administration of appropriate treatment. Proportionately higher cases of chronic diseases such as fleas, non-specific diarrhoea, helminthosis and warts were recorded in the study and there were rarely any attempts to control these diseases of calves among the Maasai pastoralists (Personal observations).

The risk of calf morbidity was greatest during the first month of life and decreased gradually up to seven months while the proportion of the calves in the herds that did not fall sick during the first 12 months was 26.9 percent. An earlier survey of livestock diseases in Kajiado District (Bekure *et al.*, 1991) found that malignant catarrhal fever (MCF), Bovine otitis and helminthosis were the most important disease of calves. Except for helminthosis, none of the other diseases was encountered during the current study possibly due to lack of their sufficient causes in the study sites. In Kajiado District, sporadic outbreaks of MCF were seasonal and have been associated with the calving of the wildebeest (Grootenhuis, 1999), but no case was observed or reported during this study. Bovine otitis is an infection of the ear caused by the nematode *Rhabditis bovis* (Soulsby, 1982) but the conditions for infection are not clear. Indigenous knowledge among the Maasai usually associates the disease with the use of plunge dipping method for controlling cattle ticks. All the plunge dips in the study sites were non-functional due to either destruction or lack of water (Ole Katampoi *et al.*, 1990).

The crude mortality rate of 11.2 percent reported in the present study was higher than 2.4 percent reported from an earlier survey in the same district but in different study sites (Bekure *et al.*, 1991) but lower than 23.3 percent reported in Trans Mara District (Moll *et al.*, 1984). The risk of calf mortality in the present study was also high between 4-6 months of age. Similar observations were made that calf mortality increased when calves were sent out to graze (de Leeuw *et al.*, 1991). Among the smallholder dairy farmers of Muranga District, Gitau *et al.*, (1999) reported a crude mortality of

7.4 percent, which was lower than 11.2 percent reported in this study. In Kiambu District, calf mortality on smallholder dairy farms was slightly higher (15 percent) and was caused mainly by diarrhoea and very rarely by ECF (Gitau *et al.,* 1994). More than half of the mortality in the present study was caused by theileriosis. Other causes included anaplasmosis and black quarter. Lesser causes of mortality were ephemeral fever, intestinal obstruction, babesiosis and diarrhoea associated with excessive milk intake.

In the study by Moll *et al.* (1984), calf mortality was caused by starvation, neonatal diarrhoea, chronic indigestion and theileriosis. Elsewhere, among the agro-pastoral Fulanis of Nigeria, the highest probability of calf mortality was observed in the first month of life (Kudi *et al.,* 1998) and was associated with lack of sufficient passive immunity due to inadequate colostrum intake and poor nutrition of dams especially during the dry season. In the present study, cumulative survivorship of calves during the first three months was high (96.3 percent) and this was attributed to the efficient management system that Maasai have adopted for young calves which are kept in and around the boma and rely exclusively on their dam's milk.

Generally, calf morbidity was highest during the wet season than in the dry season while mortality was higher during the dry period than in wet season. During prolonged dry season (drought) calf nutrition is very limiting. Calves have to trek longer distances for pasture and water. Apart from physical exhaustion and loss of weight trekking also increases the chances of exposure to diseases including TBDs (MacPherson, 1995). During the wet season, there is plenty of good pasture and water and calves are in good body condition. Although, wet season is associated with relatively high prevalence of vector borne diseases and helminthosis, exposure of calves to these diseases is limited due to less movement. However, transmission could still occur around the *boma*.

The distribution of calf morbidity and mortality varied with age. Calves that were <4 months old had significantly lower morbidity compared to calves that were >9<13 months old while mortality was highest in calves >3<7 months. From the OLR results, morbidity of calves that were >6<10 months old was significantly low compared to calves that were >9<13 months old but not from the GLIMMIX analysis indicating some clustering effects. Calves that had no serum antibodies for *A. marginale* had significantly high morbidity. Calves that were >3<7 (4-6) months old had significantly higher seroconversion for *T. parva* than 7-9 month old calves. This was further confirmed by the simple proportional and multivariate analysis that showed >3<7 month old calves had significantly higher mortality compared to 7-9 month old calves. It is apparent that although most calves to at 4-6 months old were exposed to *T. parva* when they went out to graze high numbers of them died due to infection.

The longitudinal study has confirmed the findings of the cross-sectional study that most of the herds were in a state of "endemic instability". One of the pertinent question is whether it is feasible to create a state of "endemic stability" in Maasai pastoral herds and what are the alternative methods of achieving this. There is no straightforward answer to this because this study did not set out specifically to investigate factors affecting establishment of endemic stability. Further field studies are needed to estimate the minimum threshold of tick burdens and intensity of parasite infection necessary to establish endemic stability. In Trans Mara District which is more ecologically suited for *R. appendiculatus* because of its high elevation and higher and better rainfall distribution (Jaetzold and Schmidt, 1983), endemic stability was reported and was characterised by very low ECF-fatality proportions and close to 100 percent seroconversion in six months ageed calves. Proportional ECF-mortality was much high in this study while majority of the herds had low to moderate prevalence to TBDs.

In Maasai pastoral systems of Kajiado District, open-grazing management system exposed calves that were taken early (3-6 months old) to graze. Majority of them were not able to resist infection. During drought, calves trekked long distances for pasture and water and this increased the chances of exposure to TBDs. The current scenario where immigrant farmers from the high potential areas are buying land and settling in marginal lands of Kajiado District has introduced high quality and more susceptible animals into the district. The latter is bound to continue even in future. Thus, there is a small window of opportunity for targeting ECF immunisation in Kajiado District. Crossbred calves in the newly settled marginal areas of the district would be very important targets. During drought, areas that border the national parks such as Nentanai and Kuku 'B' were more susceptible to ECF infections and, therefore, it is recommended that targeting of such areas just before the drought could drastically reduce calf mortality. Increased vaccination coverage would enhance development of herd immunity while modification of acaricide application would allow build up of sufficient number of ticks necessary to sustain establishment of endemic stability. Application of Infection and Treatment Method (ITM) and acaricide usage would have to consider variation in ECF risk, which was affected by season (prolonged drought versus wet season) and movements of people and animals.

The study also suggests that calf management practices such as poor housing and overcrowding were major predisposing factors for high calf morbidity in early age of growth. During the RRA, poor calf housing was listed as one of the constraints to increased calf health and production in Kuku 'B' but not in Olosho Oiborr and Nentanai. The highest calf mortality coincided with the age when colostral antibodies had waned and calves started getting exposed to tick-borne diseases. It was concluded that more attention should be given to improving the management of calves early in life in order to reduce morbidity while integrated control of ticks and tick-borne diseases through spraying and possibly early immunization could improve health and reduce mortality of calves in pastoral herds.

CHAPTER EIGHT

GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

Calf health and production in Maasai pastoral systems in Kajiado District is below optimum (Bekure *et al.*, 1991) but estimates of prevalence and incidence rate of morbidity and mortality and growth rate of calves are lacking thus making it difficult to design appropriate disease control strategies (Peeler and Omore, 1997). This epidemiological study was designed for the purpose of identifying the causes, and to estimate prevalence and incidence rate of morbidity and mortality and slow growth rate due to major diseases affecting calves in Maasai pastoral systems. In the past, majority of the studies ignored the indigenous or traditional knowledge and other socioeconomic factors that influence pastoralists' decision-making process on how to treat and control animal diseases (Waters-Bayer and Water, 1984). In the design of this study, a deliberate decision was made to involve pastoralists and to incorporate their views on identification, ranking and analysis of constraints causing slow growth rate and high morbidity and mortality of calves in Kajiado District.

The study was implemented in three phases using a combination of different study approaches for data collection *vis a viz* a rapid rural appraisal, a cross-sectional survey and a longitudinal observational study. The RRA (a qualitative method) was to ensure pastoralists' participation in the prioritization of constraints hindering the improvement of calf health and production and to assess their perception of the causes of the constraints, their predisposing factors, coping strategies and opportunities for improving calf health and production in the district. It is important to point out here that the disease or diseases to be investigated during the cross-sectional and longitudinal studies were neither chosen by the researcher nor was the emphasis on tick-borne diseases envisioned. This emphasis was mandated by views and information provided by the pastoralists during the RRA.

There were a wide range of constraints affecting calf health and production in all the six different es that were sampled, but the four most important constraints were shortages of water and feeds ,high incidence of disease and inadequate extension services. An earlier survey (Wandera *et al.*, 1997a) also reported that water was a major constraint affecting the improvement of meat from goats and sheep in pastoral areas of Kenya. The main cause was inadequate permanent rivers and frequent droughts. Distribution of water sources varied between sites and included water pans, dams, boreholes, natural springs and wells. The two permanent rivers namely, Parkase and Nolturesh, have their waters available to a limited number of pastoralists due to the vastness of the es they traverse. The options for alleviating water shortage in the ASAL were very limited due to the lack of permanent rivers and the high cost of constructing dams and boreholes. However, there are opportunities for improving water sources such as development of roof catchment and dams.

Pastoralists in all the study es ranked theileriosis as number one constraint and reported that the disease was prevalent throughout the year although intensity varied with seasons. This was expected as temperature and rainfall have a significant influence on the abundance and longevity of its vector, *R. appendiculatus* (Norval *et al.*, 1992). The study es adjacent to national parks such as Kuku 'B' pastoralists reported that the peak of theileriosis infections occurred during the months of June and July which are relatively dry months of the year. One possible reason for this was the movement of wild game, especially buffaloes, from the game reserves into the settlement areas in search of water and forage during the dry season. Buffaloes are carriers of *T. parva lawrencei* which causes the fatal corridor disease of cattle (Grootenhuis, 1999)

Extension services, which offer an important pathway for dissemination and diffusion of agricultural technologies and intervention messages, were inadequate in Kajiado District. One option to overcome this constraint would be to employ more extension officers. However, due to the freezing of employment by the government it is recommended that communities identify local persons who could be trained in aspects of animal husbandry, disease control and treatment. The para-professionals have successfully been used in Sudan, Somalia, India and Nepal with considerable success (Catley and Leyland, 2001). In some areas of Kajiado District, para-professionals were trained in basic animal health knowledge but sought employment elsewhere in search of better salaried vocations (Wanasaba, 2004). Currently, family members provided the bulk of the animal health services in Maasai pastoral sytem while public veterinarians were mainly involved in disease control and issuance of various permits.

Studies on identification of constraints affecting livestock productivity in pastoral systems are numerous (de Leeuw *et al.*, 1984; Bekure *et al.*, 1991; Blewett, 1995; Karimi *et al.*, 2005) but the intervention for mitigating them are yet to be tested. Such interventions include improvement of the feed resources, strategic anthelmintic treatment and vaccination against diseases (Wandera *et al.*, 1997a) and regulation of the private sector in the provision of animal health services (Hubl *et al.*, 1998). In order to enhance uptake or adoption of any technology, the testing stage should ensure pastoralists' participation while at the same time taking into account their socioeconomic environment.

The benefits of the RRA were low cost and the farmers' feeling of prompt feedback. Within a duration of three days, it was possible to gather data on all major constraints, disease risk and control strategies. In Kajiado District, many similar surveys have been conducted and pastoralists reported that there had been very little feedback. They regarded the open discussions (guided by a checklist) as a prompt feedback because their questions were answered 'on-site'. This helped to avoid the requirement for costly incentives and helped to gain farmer confidence during subsequent cross-sectional surveys and longitudinal studies. Thus, the RRA was an important exploratory tool to initially collect data, facilitate researcher entry and promote confidence of the farmers towards the research team.

During the cross-sectional study, livestock production systems in the district were characterised followed by quantification of the prevalence of the main tick-borne diseases. Morbidity rate, mortality rate and growth rate of pastoral calves reared under various calf management practices and different disease challenges were evaluated during the longitudinal studies. The level of cooperation by the participating farmers was excellent because out of the 23 household that were recruited for the longitudinal study, only one opted out of the monitoring but later decided to re-enter into the study.

The design and sampling methods of the cross-sectional and longitudinal studies yielded data that were hierarchical in structure. This is because repeated measures were made on individual animals which were themselves grouped by farms and in turn the farms were grouped by es. Therefore, clustered or correlated responses, which were obtained, were accounted for in various multi-variable levels described in the thesis (Chapters five, six and seven). The consequence of ignoring them would be an underestimation of parameter variance estimates and residual error such that the potential for making wrong statistical inferences by erroneously rejecting true null hypothesis (Type I error) would be increased. In the current study, clustering or correlation of responses within ranches groups of animals either at the farm level, level or at ACZ level is important when targeting disease control strategies

Results from the RRA and cross-sectional studies show that Maasai Zebu cattle and their crosses with Sahiwal and Boran formed the majority of Maasai pastoral herds. For an average cattle herd sizes in the study area, the mean of 9.6 cattle per farm was comparatively higher than in the central Kenya highlands region (Gitau *et al.,* 1994; Gitau 2001). Keeping of the indigenous cattle, perceived to withstand the local physical and management conditions better than the exotic breeds (Syrstad and Ruane, 1998), was a 'security' measure against the many constraints that beset the Maasai pastoralists. This study supports this hypothesis particularly given the lower mortality observed in the Maasai zebu compared to the exotic and the crosses. Except for mature body weights that are supposedly lower for indigenous calves compared to exotic or Bos taurus calves, growth rates of calves in Maasai pastoral systems also compared favourably with those of calves in high potential areas (Gitau *et al.*, 1994).

The majority of the bulls used to upgrade Maasai pastoral cattle are obtained from the Central Kenya or bought from a few large-scale farms within the Rift Valley. During the period of this study, the price of a breeding Sahiwal bull ranged from Ksh 40,000 to 60,000 (Personal observation). The majority of pastoral farmers in the region considered this price to be very high. As already alluded to, availability of credit facilities that could alleviate this problem are largely lacking (chapter 4). Moreover, for the sustainability of the credit lending facility, the market for livestock and their products needs to be ascertained for farmers to be able to repay their loans. Introduction of animals in the area was also uncoordinated and farmers in certain instances bought culled animals from large farms or stock traders. Such farmers were discouraged by the poor performance of the purchased cows. Several farmers who had Boran cattle during the span of the project had reverted to keeping local zebu breeds or failed to replace those that had died. Farmers complained of high cattle mortalities after end of the project because of fewer field veterinary staff to 'look' after the animals (chapter 4).

The cross-sectional study showed that there were wide variations in sero-prevalence of TBDs for *T. Parva, T. mutans, A. marginale* and *B. bigemina* by ACZs and ranches, suggesting the existence of different epidemiological statuses for the four parasites in Kajiado District. The differences in seroprevalence of these parasites could be due to agro-climatic factors which influence the distribution of their vectors. However, seroprevalence alone is not sufficient indicator of "endemic stability". Other indicators that have been used to explain it include breed susceptibility, disease incidence, case-fatality and degree of tick challenge (Noval *et al.*, 1992).

The longitudinal study provided an opportunity to measure morbidity and mortality rates. More than half of the calf mortality (proportionate) was caused by ECF (68.4 percent in Olosho Oiborr and 54.2 percent in Nentanai). The overall mortality (11.3 percent) was higher than the 7.4 percent in the smallholder dairy farms in Muranga (Gitau *et al.*, 1999) where open-grazing of calves was associated with greater exposure to ticks than zero-grazed calves. This study also showed that grazing management was an important exposure variable in determining the risk of exposure to TBDs. Majority of the herds that were investigated in this study were in a state of endemic instability and therefore highly susceptible to TBDs. This is unlike in the neighbouring semi-arid Trans-Mara district of where endemic stability was reported (Moll *et al.*, 1986). Variations of sero-prevalence for the parasites among ACZ, ranches and farms could result in differences in production losses among ranches and farms within each ranches.

In this study, the results of the cross-sectional study confirmed the Maasai pastoralists' perception of diseases causing poor calf health and production. Thus, using a combination of farmer's perceptions, epidemiological prevalence and incidence assessments, it was shown that tick-borne diseases, especially theileriosis and anaplasmosis occurred in varying proportions throughout the study region and were indeed considered a major constraint to the Maasai pastoral sector. This study confirmed that tick-borne diseases were indeed prevalent in the whole of the Maasai pastoral region. The most commonly used drug for treatment of diseases including tick-borne diseases was various concentrations of oxytetracyclines while the control of tick-borne disease relied mainly on use of different types of acaricide and was found to be highly ineffective.

In conclusion, based on the foregoing results of this study on calf health and production in Kajiado District, the several recommendations on areas that require further investigations are suggested. Clearly, calf health and production in Maasai pastorals systems is currently under high risk of tick-borne diseases, especially ECF. The disease exists under endemic unstable conditions and any intervention strategies aimed and controlling these diseases should be designed against a background of these epidemiological states.. During a normal year where rainfall distribution is regular and there is no drought to warrant movement of animals, priority should be given to immunisation of pastoral herds in ACZ IV where the survival of the vector, *R. appendiculatus*, is expected to be higher because of favourable environmental conditions. Furthermore, with increased migration of people from the high potential areas and creation of more settlements, livestock production in the district will become more intensive. The ACZ IV is expected to have a higher proportion of crossbred cattle (Table 4.7) which are more susceptible to TBDs. From this study, calves on individual es had low prevalence of serum antibodies and therefore were at a higher risk of infection with TBDs. Livestock production in majority of the individual es is intensive and geared to commercial production. The quality of animals kept in individual es is also relatively high compared to those kept in communally owned land (Table 4.7). It is expected that immunisation of cattle would form part of routine disease prevention measures on the farm. As a result, survivability and off take of animals will increase thereby allowing the economics of scale to operate so that the cost of immunisation would be expected to decrease with increasing number of animals per farm (Muraguri *et al.*, 1998).

Control and treatment of other TBDs (anaplasmosis and babesiosis) using the currently available methods and drugs should continue. Like in theileriosis, these diseases also existed under endemic unstable conditions. Therefore, research on the epidemiological and cost-benefit analysis of different control and treatment methods in pastoral herds should be initiated. Earlier reports indicated that *T. mutans* infection caused decrease in weight gains and low packed red cell volume (Moll *et al.*, 1986). Further investigations are required for the epidemiological factors necessary for the infection and to quantify loss of production.

Routine vaccination against notifiable diseases such as LSD and black quarter would go a long way in controlling these diseases. At the time of implementation of the study, there was an outbreak of lumpy skin disease and black quarter. The latter caused 10 out of the 67 deaths reported in this study (Table 7.9). The outbreak occurred on one farm in Nentanai. Some farmers were not aware that there was a locally available vaccine (Blanthrax) for protecting cattle against the disease indicating the need for creating awareness and capacity building to improve usage of this and other vaccines. The need for capacity building among pastoralists in simple techniques of disease diagnosis and treatment was also identified during the RRA meetings. In general, pastoralists were able to identify predisposing factors of diseases affecti calves but not the actual causes and therefore quite often, wrong treatment was administered. Helminthosis was associated with decrease in weight gain. Nevertheless, the impact of gastrointestinal parasites of calves on production could be easily underestimated because all calves found to suffer from the disease were treated. This study made no provision for control ranches(non-treated) to allow meaningful comparison between groups. It is recommended that studies aimed at testing and demonstrating the effects of strategic anthelmintic use for control and treatment of gastrointestinal parasites of calves be initiated. Such studies should include cost-benefit analysis of the methods used.

Under the current policy of privatisation of public services in Kenya that have led to a decrease in public animal health providers, the shift to communities or groups arranging for the local animal health services was expected to continue (Hubl *et al.,* 1998). In Kajiado District, for example, farmers have formed community-based organizations (CBOs) that would serve as the entry points for the delivery of animal health services. However, it is anticipated that pastoralists will continue having problems with proper storage, accounting and restocking of drugs until they are trained in simple business skills such as record keeping, procurement, and preparation of balance sheets. Facilities such as a cold chain for vaccines and sera are also necessary. By and large, pastoralists would still expect the Government to fund the delivery of animal health services. It is pertinent therefore for the government, NGOs and other stakeholders to educate farmers on their roles in the framework of this change in policy.

Besides the need for application of appropriate and integrated interventions for strategic control of livestock diseases, future research should address calf nutrition and management aspects in Maasai pastoral systems in Kajiado District. Water shortage was cited as a major constraint to calf production and was attributed to lack of adequate permanent rivers in Kajiado District (Chapter 4). A temporary solution would be to harvest rainwater from roofs into big drums. However, this would work only during the rainy season and possibly the roof areas for water collection was too small to obtain considerable amounts of water. However, for the calves this source of clean water during the time of confinement could be of major significance. A more permanent solution is to drill more boreholes.

Feed shortage especially during the dry season was also listed as a major constraint for improved calf production in Maasai pastoral systems in Kajiado District (Chapter 4). Feeding packages based on haymaking and collection of browse legumes are relatively cheaper options for extension to these semi-settled pastoralists. Improvement of pasture in the reserve grazing paddocks *(olopololis)* through selective introduction of leguminous plant species should be tested as a means of improving calf nutrition. The majority of Maasai pastoralists also grow cereals such as maize and they should be encouraged to supplement calves with maize stover. The latter however, are bulky and of low nutritive value and could be offered along with urea-molasses blocks to improve efficiency of utilization. Urea-molasses blocks are cheap and readily available in many commercial shops.

It is apparent from literature review that studies on effect of varying milk intake on calf growth rate and survival are lacking in pastoral systems of Kajiado District. Similar investigations like those of Coulibaly and Nialibouly (1998) on the effect of suckling regime on calf growth, milk production and off take of Maasai zebu cattle are needed. Information generated from such studies should form part of broad recommendations for improving calf nutrition in pastoral systems.

There were opportunities for improvement of calf health and production that were identified by the pastoralists during the RRA meetings. The project also organised follow-up feed back meetings and farmer-exchange visits which exposed pastoralists to a variety of new opportunities such as availability of vaccines which could be used to control notifiable diseases of calves. However, cost of purchase and storage facilities were major hindrances cited. Pastoralists were encouraged to form CBOs where pooling of resources and organised sourcing of services and other inputs would improve delivery of animal health services while reducing some of the costs.

By the time of completion of the study pastoralists in Olosho Oiborr and Nentanai had formed and registered the CBOs. Future livestock research and development activities should target the CBOs and other organised community based institutions for collaboration and further participatory approaches to ensure sustainability and increased uptake of technologies. In areas where CBOs do not exist, it is recommended that efforts geared to the formation of 'common-problem' farmer groups be initiated in order to improve service delivery.

CHAPTER NINE

REFERENCES

Abdalla, H. S. (1989). Effects of endoparasites on the growth rate of Sudanese sheep and cattle. *Trop. Anim. Hlth. Prod.* **21**, 3.

Ahmed, E. S. (2002). Livestock Development and Rangelands Management. Cluster Module: Privatisation of Veterinary Services in Sub-Saharan Africa. pp 1-10.

Ahunu, B. K., Arthur, P. F., Danbaro, G., and Aboagye, G. S. (1993). Preweaning growth performance of west African shorthorn cattle and their Jersey crossbreds in Ghana. *Trop.Anim. Hlth. Prod.* **25**, 33-40.

Alawa, J. P., Jokthan, G. E., and Akut, K. (2002). Ethnoveterinary medical practice for ruminants in the subhumid zone of northern Nigeria. *Prev.Vet.Med.* **54**, 79-90.

Atanasio, A., Boomker, J., and Sitoe, C. (2002). A survey on the occurrence of resistance to anthelmintics of gastrointestinal nematodes of goats in Mozambique. *Onderstepoort J. Vet. Res.* **69**, 215-220.

Bakheit, M. A. and Latif, A. A. (2002). The innate resistance of Kenana cattle to tropical theileriosis (*Theileria annulata* infection) in the Sudan. *Ann.N.Y.Acad.Sci.* **969:** 159-163.

Beede, D. K. (1991). Mineral and water nutrition. *Vet.Clin.North Am.Food Anim Pract.* **7**, 373-390.

Bekure, S., de Leeuw, P. N., Grandin, B. E., and Neate, P. J. H. (1991). Maasai herding: an analysis of the livestock production system of Maasai pastoralists in eastern Kajiado District, Kenya. ILCA Systems Study 4. 1-172.

Biggs, S. (1989). Resource -poor farmer participation in research: a synthesis of experiencies from nine agricultural research systems. OFCOR Comparative Study Paper No 3. ISNAR. The Hague.

Black, D. H. (1982). Calf rearing in the tropics: growth rates and utilisation of milk substitute diets. *Trop.Anim. Hlth. Prod.* **14**, 172-176.

Black, D. H. (1984). Calf rearing in the tropics: behavioural response by *Bos indicus* calves to an artificial rearing system. *Trop.Anim. Hlth. Prod.* **16**, 47-48.

Blewett, R. A. (1995). Institutional change and the pastoral Maasai of Kenya. *East Economical Journal* **21**, 477-489.

Campbell, D. J., Gichohi, H., Mwangi, A., and Chege, L. (2000). Land Use conflict in Kajiado District, Kenya. *Land Use Policy.* **17**, 337-348.

Catley, A. (2000). The use of participatory appraisal by veterinarians in Africa. *Rev.Sci.Tech.* **19**, 702-714.

Catley, A. and Leyland, T. (2001a). Community participation and the delivery of veterinary services in Africa. *Prev. Vet. Med.* **49**, 95-113.

Catley, A., Okoth, S., Osman, J., Fison, T., Njiru, Z., Mwangi, J., Jones, B. A., and Leyland, T. J. (2001b). Participatory diagnosis of a chronic wasting disease in cattle in southern Sudan. *Prev.Vet.Med.* **51**, 161-181.

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

Catley, A. P. and Mohammed, A. A. (1996). The use of livestock-disease scoring by a primary animal-health project in Somaliland. *Prev.Vet.Med.* **28**, 175-186.

Chambers, R. (1994). The origins and practice of participatory rural appraisal. *World Development* **22**, 953-969.

Clausen, P. H., Sidibe, I., Kabore, I., and Bauer, B. (1992). Development of multiple drug resistance of *Trypanosoma congolense* in Zebu cattle under high natural tsetse fly challenge in the pastoral zone of Samorogouan, Burkina Faso. *Acta Trop.* **51**, 229-236.

Clements, A. C. A., Pfeiffer, D. U., Otte, M. J., Morteo, K., and Chen, L. (2002). A global livestock production and health atlas (GLiPHA) for interactive presentation, integration and analysis of livestock data. *Prev.Vet.Med.* **56**, 19-32.

Coppock, D. L. (1993). Grass hay and Acacia fruits: a local feeding system for improved calf performance in semi-arid Ethiopia. *Trop. Anim. Hlth. Prod.* **25**, 41-49.

Coppock, D. L. (1994). The Boran Plateau of Southern Ethiopia: Synthesis of pastoral research, development and change, 1980-91. International Livestock Research Centre for Africa. ILCA. 5, 1-393. Addis Ababa, Ethiopia.

Cornwall, A. and Jewkes, R. (1995). What is participatory research? *Soc.Sci.Med.* **41**, 1667-1676.

Cossins, N. J. Production strategies and pastoral man. In:Pastoral systems research in sub-Saharan Africa. Proceedings of the workshop held at ILCA, Addis Ababa, Ethiopia, 21-24 March 1983. 1983.

Coulibaly, M. and Nialibouly, O. (1998). Effect of suckling regime on calf growth, milk production and off-take of zebu cattle in Mali. *Trop. Anim. Hlth. Prod.* **30**, 179-189.

Coulibaly, N. D. and Yameogo, K. R. (2000). Prevalence and control of zoonotic diseases: collaboration between public health workers and veterinarians in Burkina Faso. *Acta Tropica.* 76 (1) 53-57.

Curran, M. M. and MacLehose, H. G. (2002). Community animal health services for improving household wealth and health status of low-income farmers. *Trop. Anim. Hlth. Prod.* **34**, 449-470.

Das, S. M., Forsberg, M., and Wiktorsson, H. (1999). Influence of restricted suckling and level of feed supplementation on postpartum reproductive performance of zebu and crossbred cattle in the semi-arid tropics. *Acta Vet.Scand.* **40**, 57-67.

Das, S. M., Wiktorsson, H., and Forsberg, M. (1999). Effects of calf management and level of feed supplementation on milk yield and calf growth of Zebu and crossbreed cattle in the semi-arid tropics. *Livestock Production Science* **59**, 67-75.

de Leeuw, P. N., Bekure, S., and Grandin, B. E. (1984). Aspects of livestock productivity in Maasai ranches in Kenya. *ILCA Bulletin* **19**, 17-20.

de Leeuw, P. N., McDermott, J. J., and Lebbie, S. H. B. (1995). Monitoring of livestock health and production in sub-Saharan Africa. *Prev.Vet.Med.* **25**, 195-212.

de Leeuw, P. N., Semenye, P. P., Peacock, C., P., and Grandin, B. E. (1991). Productivity of cattle and smallstock. In: Maasai herding: An analysis of the livestock production system in eastern Kajiado District, Kenya. ILCA Systems study. Eds S. Bekure, P. N. de Leeuw, B. E. Grandin, and P. J. H. Neate. pp. 83-102. ILCA: Addis Ababa, Ethiopia.

Deem, S. L., Perry, B. D., Katende, J. M., McDermott, J. J., Mahan, S. M., Maloo, S. H., Morzaria, S. P., Musoke, A. J., and Rowlands, G. J. (1993). Variations in prevalence rates of tick-borne diseases in Zebu cattle by agroecological zone: implications for East Coast fever immunization. *Prev.Vet.Med.* **16**, 171-187.

Dohoo, I., Martin, W., and Stryhn, H. (2003). Veterinary Epidemiologic research. (AVC Inc.: Charlottetown. Prince Edward Island. Canada.)

DVO. Annual Reports, Kajiado District. 1997.

DVO. Annual Reports, Kajiado District. 1998.

DVO. Annual Reports, Kajiado District. 1999.

Eisler, M. C., Brandt, J., Bauer, B., Clausen, P.-H., Delespaux, V., Holmes, P. H., Ilemobade, A., Machila, N., Mbwambo, H., and McDermott, J. (2001). Standardised tests in mice and cattle for the detection of drug resistance in tsetse-transmitted trypanosomes of African domestic cattle. *Veterinary Parasitology* **97**, 171-183.

Faye, B., Lescourret, F., Dorr, N., Tillard, E., McDermott, B., and McDermott, J. (1997). Interrelationships between herd management practices and udder health status using canonical correspondence analysis. *Prev.Vet.Med.* **32**, 171-192.

Fivaz, B. H., de Waal, D. T., and Lander, K. (1992). Indigenous and crossbred cattle--a comparison of resistance to ticks and implications for their strategic control in Zimbabwe. *Trop. Anim. Hlth. Prod.* **24**, 81-89.

French, N. P., Tyrer, J., and Hirst, W. M. (2001). Smallholder dairy farming in the Chikwaka communal land, Zimbabwe: birth, death and demographic trends. *Prev.Vet.Med.* **48**, 101-112.

Ganaba, R., Bengaly, Z., and Ouattara, L. (2002). Calf morbidity, mortality and parasite prevalences in the cotton zone of Burkina Faso. *Prev.Vet.Med.* **55**, 209-216.

Giday, M., Asfaw, Z., Elmqvist, T., and Woldu, Z. (2003). An ethnobotanical study of medicinal plants used by the Zay people in Ethiopia. *J.Ethnopharmacol.* **85**, 43-52.

Gitau, G. K., McDermott, J. J., Adams, J. E., Lissemore, K. D., and Waltner-Toews, D. (1994). Factors influencing calf growth and daily weight gain on smallholder dairy farms in Kiambu District, Kenya. *Prev. Vet. Med.* **21**, 179-190.

Gitau, G. K. (1997). A Study of factors influencing endemic stability and instability to Theileriosis and Babesiosis on dairy production in Muranga District, Kenya. PhD Thesis. University of Nairobi, Kenya. 1-183.

Gitau, G.K.; Perry, B.D.; McDermott, J.J. (1999). The incidence, calf morbidity and mortality due to *Theileria parva* infections in smallholder dairy farms in Murang'a District, Kenya. *Prev. Vet. Med.* **39** (1) 65-79.

Gitau, G. K., McDermott, J. J., Katende, J. M., O'Callaghan, C. J., Brown, R. N., and Perry, B. D. (2000). Differences in the epidemiology of theileriosis on smallholder dairy farms in contrasting agro-ecological and grazing strata of highland Kenya. *Epidemiol.Infect.* **124**, 325-335.

Gitau, G. K., McDermott, J. J., McDermott, B., and Perry, B. D. (2001). The impact of *Theileria parva* infections and other factors on calf mean daily weight gains in smallholder dairy farms in Murang'a District, Kenya. *Prev.Vet.Med.* **51**, 149-160.

Gitunu, A., Mnene, W. N., Muthiani, E. N., Mwacharo, J. M., Ireri, R., Ogilo, B., and Karimi, S. K. (2003). Increasing the productivity of livestock and natural resources in semi-arid areas of Kenya: A case study from the southern Kenyan Rangelands.Proceedings of the Agricultural Research and Development for Sustainable Resource Management and Food Security in Kenya held at KARI Headquarters on 11-12th November, 2003. KARI, Nairobi, Kenya, KARI/EU.

GoK. (1988). Kajiado Livestock Census. Integrated Livestock Census and Infrastructure Survey Report. Ministry of Livestock Development. Department of Livestock Production, Kajiado District, Kenya.

GoK (2003). Economic Recovery Strategy for Wealth and Employment Creation., 2003-2007. Ministry of Planning and National Development. http://www.planning.go.ke.

GoK (1998). 'Kajiado District Development Plan, '1997-2001'. Office of the Vice-President and Ministry of Planning and National Development.Kenya.'

Grandin, B. E. (1991). The Maasai: Socio-historical context and ranches.In: Maasai herding. An analysis of the livestock production systems of Maasai pastoralists in eastern Kajiado District, Kenya. Eds. Bekure, S.; de Leeuw, P.H.; Grandin, B.E.; Neate, P.J.H. 21-39.

Gregory, K. E., Trail, J. C., Sandford, J., and Durkin, J. (1984). Crossbreeding cattle in beef production programs in Kenya. I. Comparison of purebred Boran and Boran crossed with the Charolais, Ayrshire and Santa Gertrudis breeds. *Trop. Anim. Hlth. Prod.* **16**, 181-186.

Grootenhuis, J. G. (1999). '25 Years of Wildlife Disease Research in Kenya. Kenya Agricultural Research Institute, Kenya.'

Hansen, J. and Perry, B. (1990). 'The epidemiology, diagnosis and control of gastrointestinal parasites of ruminants in Africa.' (International Laboratory for Research on Animal Diseases. Nairobi, Kenya.)

Hendrickson, D., Armon, J. and Mearns, R. (1998). The changing nature of conflict and famine vulnerability: the case of livestock raiding in Turkana District, Kenya. *Disasters* 22 (3), 185-199., 1998.

Hogg, R. (1980). Pastoralism and impoverishment: The case of the Isiolo Boran of northern Kenya. *Disasters* **4**, 299-310.

Hosmer, D. W. and Lemeshow, S. (1989). 'Applied Logistic Regression. Wiley Series in Probability and Mathematical Statistics.'

Hubl, K. K., Gathuma, J. M., and Kajume, J. (1998). Improved Delivery of Animal Health Services in Kenya. Final Report. European Union/Ministry of Agriculture, Republic of Kenya.

Hunter, P. (1998). Vaccination as a means of control of foot-and-mouth disease in sub-Saharan Africa. *Vaccine* **16**, 261-264.

Huttner, K., Leidl, K., Pfeiffer, D. U., Kasambara, D., and Jere, F. B. D. (2001). The effect of a community-based animal health service programme on livestock mortality, off-take and selected husbandry applications: A field study in northern Malawi. *Livestock Production Science* **72**, 263-278.

ILCA. (1990). Livestock systems research manual. Working Paper 1. (1), 1-287. 1990. ILCA, Addis Ababa, Ethiopia.

Jaetzold, R. and Schmidt, H. (1983). 'Farm Management Handbook of Kenya. Ministry of Agriculture. Nairobi. Kenya.'

Jahnke, H. E. (1983). 'Livestock Production systems and livestock development in tropical Africa. Kieler Wissenschaftsverlag Van, Kiel, 253pp.'

Jain, N. C. (1986). 'Schalm's Veterinary Haematology. Fourth edition.'

Kabaija, E. (1989). Non-conventional indigenous mineral supplements used for cattle feeding in the pastoral rangelands of Ethiopia. *Trop. Anim. Hlth. Prod.* **21**, 256-262.

Kadohira, M., McDermott, J. J., Shoukri, M. M., and Thorburn, M. A. (1997). Assessing infections at multiple levels of aggregation. *Prev.Vet.Med.* **29**, 161-177.

Kaiser, M. N., Sutherst, R. W., Bourne, A. S., Gorissen, L., and Floyd, R. B. (1988). Population dynamics of ticks on Ankole cattle in five ecological zones in Burundi and strategies for their control. *Prev.Vet.Med.* **6**, 199-222.

Kambarage, D. M., Kimera, S. I., Kazwala, R. R., and Mafwere, B. M. (1995). Disease conditions responsible for condemnation of carcasses and organs in short-horn Zebu cattle slaughtered in Tanzania. *Prev.Vet.Med.* **22**, 249-255.

KARI.(3003).Agricultural Research and Development for Sustainable Resource Management and Food Security in Kenya. Agriculture/Livestock Research Support Program, Phase II. End of

Programme Conference. Kenya Agricultural Research Institute. 11-12 November, 2003. 1-144. 2003. Nairobi, Kenya.

Karimi,S.K.; McDermott,J.J.; Gitau,G.K.; McDermott,B.; Gathuma,J.M.; Kinuthia,R.N. (2003). Risk factors for seroprevalence of tick-borne diseases of calves in Maasai pastoral herds in Kajiado District, Kenya. Proceedings of the 10th International Symposium for Veterinary Epidemiology and Economics. Vina del Mar, Chile. 17-21 November 2003.

Karimi, S. K., Gitau, G. K., McDermott, J. J., Kinuthia, R. N., and Gathuma, J. M. (2005). Estimation of body weight of Maasai Zebu calves and their crosses with Sahiwal and Boran in Kajiado District, Kenya. *Bulletin of Animal Health and Production in Africa.* **53**, 35-41.

Kariuki, D. P. L. W. (1996). 'Livestock Production and Health Challenges in Pastoral Areas. Samburu District, Kenya.' (Kenya Agricultural Research Institute. Nairobi, Kenya)'

Katende, J., Morzaria, S., Toye, P., Skilton, R., Nene, V., Nkonge, C., and Musoke, A. (1998). An enzyme-linked immunosorbent assay for detection of *Theileria parva* antibodies in cattle using a recombinant polymorphic immunodominant molecule. *Parasitol.Res.* **84**, 408-416.

Katende, J. M., Goddeeris, B. M., Morzaria, S. P., Nkonge, C. G., and Musoke, A. J. (1990). Identification of a *Theileria mutans*-specific antigen for use in an antibody and antigen detection ELISA. *Parasite Immunol.* **12**, 419-433.

Kimani, K. and Pritchard, J. (1998). Recent trends and implications of ranches sub-division and fragmentation in Kajiado District, Kenya. *The Geographical Journal* **164**, 203-213.

King, J. M., Sayers, A. R., Peacock, C. P., and Kontrohr, E. (1984). Maasai Herd and Flock Structures in Relation to Livestock Wealth, Climate and Development. *Agricultural Systems* **13**, 21-56.

Kristjanson, P. M., Swallow, B. M., Rowlands, G. J., Kruska, R. L., and de Leeuw, P. N. (1999). Measuring the costs of African animal trypanosomosis, the potential benefits of control and returns to research. *Agricultural Systems* **59**, 79-98.

Kudi, A. C., Umoh, J. U., Eduvie, L. O., and Gefu, J. (1998). Relative survival of calves in 16 traditionally managed herds in Bauchi, Nigeria. *Prev.Vet.Med.* **36**, 307-312.

Lambourne, L. J., Dicko, M. S., Semenye, P. and Butterworth, M. (1983). Animal nutrition. In: Pastoral Systems Research in sub-Saharan Africa. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 21-24 March 1983.

Lancelot, R., Lesnoff, M., and McDermott, J. J. (2002). Use of Akaike information criteria for model selection and inference. An application to assess prevention of gastrointestinal parasitism and respiratory mortality of Guinean goats in Kolda, Senegal. *Prev.Vet.Med.* **55**, 217-240.

Lans, C. and Brown, G. (1998). Ethnoveterinary medicines used for ruminants in Trinidad and Tobago. *Prev.Vet.Med.* **35** (3) 149-163.

Lessard, P.; L'Eplattenier, R.; Norval, R.A.; Perry, B.D.; Dolan, T.T.; Burrill, A.; Croze, H.; Sorensen, M.; Grootenhuis, J.G.; Irvin, A.D. (1988). The use of geographical information systems in estimating East Coast fever risk to African livestock. *Acta Vet. Scand. Suppl.* 84, 234-236.

Lessard, P.; L'Eplattenier, R.; Norval, R.A.; Kundert, K.; Dolan, T.T.; Croze, H.; Walker, J.B.; Irvin, A.D.; Perry, B.D.(1990). Geographical information systems for studying the epidemiology of cattle diseases caused by Theileria parva. Vet.Rec. 126 (11) 255-262

Little, M. A., Galvin, K., and Mugambi, M. (1983). Cross-sectional growth of nomadic Turkana pastoralists. *Hum.Biol.* **55**, 811-830.

Little, R. C., Milliken, G. A., Stroup, W. W., and Wolfinger, R. D. (1996). 'SAS System for Mixed Model, Cary, NC: SAS Institute Inc.'

Lusigi, W. J. (1983). Integrated Resource Assessment and Management Plan for Western Marsabit District, Northern Kenya. IPAL Technical Report A-6, Parts I and II. 1983. UNESCO, Nairobi.

Lusigi, W. J. (1986). Kenya Arid Lands Research Station. In: Range Development and Research in Kenya. Proceedings of a conference, Egerton College, Njoro, Kenya. April 1-5, 1986.

Mace, R. H. A. (1989). Pastoralists strategies for survival in unpredictable enviroments: A model of Herd composition that maximises household viability. *Agricultural Systems* **31**, 185-204.

MacPherson, C. N. L. (1994). Epidemiology and control of parasites in nomadic situations. *Veterinary Parasitology* **54**, 87-102.

MacPherson, C. N. L. (1995). The effect of transhumance on the epidemiology of animal diseases. *Prev.Vet.Med.* **25**, 213-224.

Maloo,S.H.; Rowlands,G.J.; Thorpe,W.; Gettinby,G.; Perry,B.D. (2001). A longitudinal study of disease incidence and case-fatality risks on small-holder dairy farms in coastal Kenya. *Prev.Vet.Med.* **52** (1) 17-29.

Martin, A. and Sherington, J. (1997). Participatory Research Methods--Implementation, Effectiveness and Institutional Context. *Agricultural Systems* **55**, 195-216.

Martin, C. U. and MacLehose, H. G. (2002). Community animal health services for improving household wealth and health status of low income farmers. *Cochrane.Database.Syst.Rev.* CD003049..

Martin, S. W., Meek, A. H., and Willeberg, P. (1987). 'Veterinary Epidemiology. Principles and Methods.Iowa State University Press. Ames, Iowa, USA.'

Mattioli, R. C., Dampha, K., Bah, M., Verhulst, A., and Pandey, V. S. (1998). Effect of controlling natural field-tick infestation on the growth of N'Dama and Gobra zebu cattle in the Gambia. *Prev.Vet.Med.* **34**, 137-146.

McCown, R. L. (2002). Changing systems for supporting farmers' decisions: problems, paradigms, and prospects. *Agricultural Systems* **74**, 179-220.

McDermott, J. J., Deng, K. A., Jayatileka, T. N., and El Jack, M. A. (1987a). A cross-sectional cattle disease study in Kongor rural council, southern Sudan. I. prevalence estimates and age, sex and breed associations for brucellosis and contagious bovine pleuropneumonia. *Prev.Vet.Med.* **5**, 111-123.

McDermott, J. J., Deng, K. A., Jayatileka, T. N., and El Jack, M. A. (1987b). A cross-sectional cattle disease study in Kongor Rural Council, Southern Sudan. II. Brucellosis in cows: Associated factors, impact on production and disease control considerations. *Prev.Vet.Med.* **5**, 125-132.

McDermott, J. J., Kadohira, M., O'Callaghan, C. J., and Shoukri, M. M. (1997). A comparison of different models for assessing variations in the sero-prevalence of infectious bovine rhinotracheitis by farm, area and district in Kenya. *Prev.Vet.Med.* **32**, 219-234.

McDermott, J. J. and Schukken, Y. H. (1994). A review of methods used to adjust for cluster effects in explanatory epidemiological studies of animal populations. *Prev.Vet.Med.***18**, 155-173.

Melville, B. (1993). Rapid rural appraisal: its role in health planning in developing countries. *Trop Doct.* **23**, 55-58.

Michel,J. F.; Dray, S.; La Rocque, S.; Desquesnes, M.; Solano, P.; De Wispelaere,G.; Cuisance, D. (2002). Modelling bovine trypanosomosis spatial distribution by GIS in an agro-pastoral zone of Burkina Faso. *Prev.Vet.Med.* **56** (1) 5-18.

Mlangwa, J. E. and Kisauzi, D. N. (1994). Systems approach to animal health services delivery in sub-Saharan Africa: the case of privatisation. *Rev.Sci.Tech.* **13**, 673-685.

Moll, G., Lohding, A., and Young, A. S. (1984). Epidemiology of theilerioses in the Trans-Mara division, Kenya: Husbandry and disease background and preliminary investigations on theilerioses in calves. *Prev.Vet.Med.* **2**, 801-831.

Moll, G., Lohding, A., Young, A. S., and Leitch, B. L. (1986). Epidemiology of theileriosis in calves in an endemic area of Kenya. *Veterinary Parasitology* **19**, 255-273.

Muhuyi, W. B., Lokwaleput, I., ole Sinket, S. N., and Lukibisi, F. B. (2002). Performance of Sahiwal-Zebu crossbreeds from birth to 12 months of age on Olosentu in Trans-Mara District, Kenya. In: Proceedings of the 7th KARI Biennial Conference.13-17th November , 2000.KARI Headquarters, Kaptagat Road, Loresho, Nairobi, Kenya. 1-610.

Muraguri, G.R.; Mbogo, S.K.; McHardy, N. and Kariuki, D.P. (1998). Cost analysis of immunisation against East Coast fever on smallholder dairy farms in Kenya. *Prev.Vet.Med.* 34(4) 307-316.

Muraguri,G. R.; Kiara, H.K. and McHardy, N. (1999). Treatment of East Coast fever: a comparison of parvaquone and buparvaquone. *Veterinary Parasitology*. **87**(1) 25-37.

Mutiso, S. K. (1995). Adaptive Strategies for Sustainable Livelihoods: A Review and Analysis of Development Policy for Arid and Semia-arid Areas of Kenya.Unpublished.

Mwangi, E. K., Stevenson, P., Ndung'u, J. M., Stear, M. J., Reid, S. W., Gettinby, G., and Murray, M. (1998). Studies on host resistance to tick infestations among trypanotolerant *Bos indicus* cattle breeds in East Africa. *Ann.N.Y.Acad.Sci.* **849**, 195-208.

Mwangi, J. K. (2000). An Overview of Livestock Development in Kajiado District. Proceedings of a Camel forum held at Elangata Wuas Ecosystem Centre, Maili 46, Kajiado District, Kenya. 12-15 March, 2000.

Ndikumana, J. Stuth J. Kamindi R. Ossiya S. Marambii R. and Hamlet P. (2000). Coping mechanisms and their efficiencey in disaster-prone pastoral systems of the Greater Horn of Africa. Effects of the 1995-97 drought and the 1997-98 *El Nino* rains and the responses of pastoralists and livestock. ILRI Project Report. 1-124., 2000.

Ngoma, M. (1994). Rapid rural appraisal. *Trop Doct.* **24**, 81.

Nicholson, M. J. and Sayer, A. R. (1987). Repeatability, reproducibility and sequential use of condition scoring of Bos indicus cattle. *Trop Anim Hlth Prod.* **19**, 127-135.

Njanja, J. C. (1991). Livestock Ecology in Central Turkana. Turkana Resource Evaluation Monitoring Unit (TREMU). Technical Report No. E-1. Nairobi, Kenya.

Norval, R. A. I., Perry, B. D., and Young, A. S. (1992). 'The Epidemiology of Theileriosis in Africa. Academic Press, London, UK.'

Oba, G. and Lusigi, W. J. (1987). An overview of drought strategies and land use in Africal Pastoral systems. Overseas . Pastoral Development Network 23a, 1-33. Regent's Park, London, U.K., Oversease Development Institute.

O'Callaghen, C.J. (1998). A study of the epidemiology of theileriosis on smallholder dairy farms in Kiambu District, Kenya. PhD Thesis, University of Guelph.

Ole Katampoi, K., Genga, G. O., Mwangi, M., Kipkan, J., Ole Seitah, J., van Klinken, M. K., and Mwangi, M. S. (1990). 'Kajiado District Atlas. Ministry of Reclamation and Development of Arid, Semi arid areas and Wastelands.'

Oyaya, C. O. (1998). 'Population growth and sustainable land use systems: A critical analysis of population and land use planning priorities in arid and semi arid Kajiado District. Dakar-Ponty, Senegal.'

Pasha, I. K. (1986). Evolution and individualization of ranches in Maasailand. In: Hansen, R.M., Woie, B.M. and Childs, R.D. (eds) Range Development and Research in Kenya. Morrilton. Winrock International Institute for Agricultural Development. 303-318. 1986.

Pedersen, C. and Madsen, J. (1998). Constraints and opportunities for improved milk production and calf rearing in Sanyati communal farming area, Zimbabwe. *Livestock Research for Rural Development.* **10**, 1-14.

Peeler, E. and Omore, A. (1986). Manual of Livestock Production systems in Kenya. 2nd Edition. KARI/DFID, NARPII, Kenya.

Perez, E., Noordhuizen, J. P. T. M., van Wuijkhuise, L. A., and Stassen, E. N. (1990). Management factors related to calf morbidity and mortality rates. *Livestock Production Science.* **25**, 79-93.

Pratt, D. J. and Gwynn, M. D. (1977). 'Rangeland Management and Ecology in East Africa. Hotter and Stoughton, London, U.K. 130 pp.'

Radley, D. E., Young, A. S., Grootenhuis, J. G., Cunningham, M. P., Dolan, T. T., and Morzaria, S. P. (1979). Further studies on the immunization of cattle against *Theileria lawrencei* by infection and chemoprophylaxis. *Veterinary Parasitology* **5**, 117-128.

Rege, J. E. O., Kahi, A., Okomo-Adhiambo, M., Mwacharo, J., and Hanotte, O. (2001). 'Zebu cattle of Kenya: Uses, performance, farmer preferences, measures of genetic diversity and options for improved use. Animal Genetic Resources Research 1.' (ILRI: Nairobi, Kenya.)

Roderick, S., Stevenson, P., Mwendia, C., and Okech, G. (2000). The use of trypanocides and antibiotics by Maasai pastoralists. *Trop. Anim. Hlth. Prod.* **32**, 361-374.

Rossiter, P.B. and James, A.D. (1989). An epidemiological model of rinderpest. II. Simulations of the behaviour of rinderpest virus in populations. *Trop. Anim. Hlth. Prod.* **21** (1) 69-84.

Rossiter, P. B. and Wamwayi, H. M. (1989). Surveillance and monitoring programs in the control of rinderpest: a review. *Trop. Anim. Hlth. Prod.* **21**, 89-99.

Rowlands, G. J., Leak, S. G., Peregrine, A. S., Nagda, S. M., Mulatu, W., and d'Ieteren, G. D. (2001). The incidence of new and the prevalence and persistence of recurrent trypanosome infections in cattle in southwest Ethiopia exposed to a high challenge with drug-resistant parasites. *Acta Trop.* **79**, 149-163.

Sandford, S. (1983). The development experience. In: Pastoral systems research in sub-Saharan Africa. Proceedings of the workshop held at ILCA, Addis Ababa, Ethiopia, 21-24 March 1983.

SAS (1985). 'SAS User's Guide. Statistics. SAS Inst. Inc. Cary NC, USA.'

Schillhorn van Veen and Loeffler, I. K. (1990). Mineral deficiency in ruminants in sub-Saharan Africa: a review. *Trop. Anim. Hlth. Prod.* **22**, 197-205.

Semenye, P. P. (1987). Factors influencing Maasai cattle productivity in Kajiado District, Kenya. PhD Thesis, University of Nairobi, Kenya.

Semenye, P. P. Chabari F. N. (1980). Monitoring of 10 es under the Kenyan Livestock Development project. ILCA Working document 21, Nairobi. Kenya.

Sieff, D. F. (1999). The effects of wealth on livestock dynamics among the Datoga pastoralists of Tanzania. *Agricultural Systems* **59**, 1-25.

Snedecor, G. W. and Cochran, W. G. (1989). 'Statistical methods, 8th edition. Iowa State University Press, Ames. Iowa pp 121.'

Snow, W. F. and Rawlings, P. (1999). Methods for the rapid appraisal of African animal trypanosomosis in the Gambia. *Prev.Vet. Med.* **42**, 67-86.

Soulsby, E. J. L. (1982). Helminths, Arthropods and Protozoa of Domesticated Animals. Editions. ELSB.

Sollod, A. E. and Stem, C. (1991). Appropriate animal health information systems for nomadic and transhumant livestock populations in Africa. *Rev.Sci.Tech.* **10**, 89-101.

Stata Corporation. STATA 8.0 for Windows. Statistical and Data Analysis. 4905 Lakeway Drive, College Station. TX77845, USA. 2003.

Syrstad, O. (1996). Dairy cattle crossbreeding in the tropics: choice of crossbreeding strategy. *Trop.Anim. Hlth. Prod.* **28**, 223-229.

Syrstad, O. and Ruane, J. (1998). Prospects and strategies for genetic improvement of the dairy potential of tropical cattle by selection. *Trop. Anim. Hlth. Prod.* **30**, 257-268.

Tebele, N. (1996). Characterisation of the cDNA encoding a 200 kDa polypeptide of *Babesia bigemina* and generation of a recombinant antigen for the detection of antibodies in an enzyme-linked immunosorbent assay. PhD Thesis. Brunel University, U.K.

Teferedegne, B. (2000). New perspectives on the use of tropical plants to improve ruminant nutrition. *Proc.Nutr.Soc.* **59**, 209-214.

Temu, A. E. and Doe, J. M. (2000). Participatory appraisal approaches versus sample survey data collection: a case of smallholder farmers well-being ranking in Njombe District, Tanzania. *Journal of African Economies* **9**, 44-62.

Trail, J. C., Gregory, K. E., Durkin, J., and Sandford, J. (1984). Crossbreeding cattle in beef production programs in Kenya. II. Comparison of purebred Boran and Boran crossed with the Red Poll and Santa Gertrudis breeds. *Trop. Anim. Hlth. Prod.* **16**, 191-200.

Traore, A. and Wilson, R. T. (1988). Livestock production in central Mali: Environmental and pathological factors affecting morbidity and mortality of ruminants in the agro-pastoral system. *Prev. Vet.Med.* **6**, 63-75.

Turkson, P. K. (2001). Technical communication. Implications of the liberalization of veterinary drug marketing in Ghana. *Trop. Anim. Hlth. Prod.* **33**, 43-47.

van Klinken, M. K. and Ole Seitah, J. (1990). 'The future of Maasai Pastoralists in Kajiado District, Kenya. Proceedings of a conference held in Brackenhurst Baptist International Conference Centre, Limuru, Kenya. 28-31st May 1989.' (ASAL Programme.: Kajiado, Kenya.)

Wamae, L. W. and Cheruiyot, H. K. (1985). Geographical distribution of hydatidosis in Kenya as determined from slaughter animals. *East African Agricultural and Forestry Journal* **50**, 78-79.

Wanasaba. E. (2004). Deputy District Veterinary Officer, Kajiado. Personnal communication.

Wandera, F. P., Audi, P. O., Sitiene, J. K., Ahuya, C. O., Mnene, W. N., and and Wanyangu, S. W. (1997a). Results of a Participatory Rural Appraisal (PRA) study in Kajido and Baringo Districts of Kenya. KARI/ILRI Project.

Wandera, F. P., Indetie, D., Mnene, W. N., Shompole, D., Wanyangu, S. W., and Wesonga, H. O. (1997b). Strategies for Improving Smal Ruminant Meat Production in Pastoral Systems. KARI/ILRI Collaborative Research Program. 1-35.

Wandera, F. P., Tessema, S., Njarui, D. M. G., Wanyama, M., Kavoi, J., Nzioka, M., and Njihia, P. (1997c). 'More milk meat, animal traction and manure from semi-arid Kenya through Improved forage production and feeding management.'

Waters-Bayer. and Water, A.(1994). 'Planning with pastoralists: PRA and more. A review of methods focussed on Africa. Deutsche Gessellschaft fur Technische Zusammenarbeit (GTZ), Eschborn.'

Webber, L. M. and Ison, R. L. (1995). Participatory Rural Appraisal Design: Conceptual and Process Issues. *Agricultural Systems* **47**, 107-131.

Were, S. G. and Wanjala, C. J. (1986). Kajiado Diustrict Socio-Cultural Profile. Nairobi. Institute of African Studies, University of Nairobi. .

White, J. M. and Meadows, S. J. (1983). The evaluation of the contribution of individual es in Kajiado District, Kenya, to economic development and pastoral production strategies. Ministry of Livestock Development, Government of Kenya.

Wilson, R. T. (1987). Livestock production in central Mali: factors influencing growth and liveweight in agro-pastoral cattle. *Trop. Anim. Hlth. Prod.* **19**, 103-114.

Wilson, R. T. and Semenye, P. P. (1983). Livestock productivity and management. In: Pastoral Systems Research in sub-Saharan Africa. Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia, 21-24 March..

Wright, P. F., Nilsson, E., Van Rooij, E. M., Lelenta, M., and Jeggo, M. H. (1993). Standardisation and validation of enzyme-linked immunosorbent assay techniques for the detection of antibody in infectious disease diagnosis. *Rev.Sci.Tech.* **12**, 435-450.

Young, A. S. (1987). Anaplasmosis. *Kenya Veterinarian* **10**, 12-13.

Young, A. S. and Morzaria, S. P. (1986). Biology of Babesiosis. *Parasitology Today* **2**, 211-219.

CHAPTER TEN

APPENDICES

Appendix 3.1: Rural Rapid Appraisal survey on calf health and production

1. QUESTIONNAIRE NUMBER ---------- 2. INTERVIEWER .... DATE:----/-----/----

Please answer the following questions by putting a circle around the correct answer wherever choices are given
e.g. 1,2,3, etc

3.ACZ	4. DIVISION	5. RANCHES	6. SUB-DIVISION STATUS	7. LOCATION	8. SUB-LOCATION	VILLAGE/ TOWN
4 5 6	1. Ngong 2. Magadi 3. Mashuru 4. Namanga 5. Central 6. Loitokitok	1. Olosho-Oiborr 2. Shompole 3. Emarti 4. Oldonyo Orok 5. Nentanai 6. Kuku 'B'	1. Subdivided 2. Unsubdivided			
					GPS READING	

9. Names of interviewees, sex, age, level of education, occupation, responsibilities

1. Name	Sex 1 = male 2 = female	3.Age (years)	4. Level of education 0= none 1=nursery 2=primary 3=secondary 4=university 5=other colleges 6=adult education	5. Occupation 1= teacher 2=civil servant 3=business 4=none 5=student/pupil 6=farmer 7=Others	6. Responsibilities 1=chairman 2=vice-chairman 3=secretary 4=vice-secretary 5=treasurer 6=vice-treasurer 7=member 8=other posts(specify)
1.					
2.					
3.					
4					

10. Indicators of human population in the ranches

Size of ranches (acres or hectares)	No. of members in the ranches

11. Indicators of livestock species and composition in the ranches

1. Do you keep the following species and types of livestock on the ranches? Answer 1=yes or 2=no										
1. Cattle	2. Sheep	3. Goats	4. Camel	5. Donkey	6. Chicken	7. Ostrich	8. Rabbits	9. Bees	10. Pigs	11. Others
2. Do you have the following breeds and types of livestock on the ranches? (put a circle)										
Breeds 1=Mz 2=Sah 3=Bor 4=Frie 5=Ary 6=Gue 7=Jer 8=Oth	1=Rm 2=Dor 3=Bhp 4=Oth	1=SEA 2=Gal 3=oth	1=Som 2=Pak 3=Ren 4=Gab 5=Tur 6=Sam 7=Oth		1=Ind 2=Ex.bl 3=Ex.la					

Key:
Cattle breeds: Mz=Maasai zebu, sah=Sahiwal, bor=Boran, frie=Friesian, ary=Aryshire, gue=Guernsey, jer=Jersey, oth=others
sheep breeds: rm=red maasai,dor=dorper,bhp=blackhead persian.
Goat breeds: SEA=Small East Africa, gal=Galla;
camel breeds:som=somali,pak=pakistan,ren=rendille,gab=gabbra,tur=turkana,sam=samburu;
chicken breeds:ind=indigenous,exbl=exotic-broilers,exla=exotic-layers,

12. Give six (6) reasons for keeping the particular species or breed (1=most important, 2=second most important, 3=third most important, 4= fourth and 5 = fifth reason, respectively)
Main reasons suggested include: 1 = Sale for cash income; 2 = meat for sale; 3 = meat for household use; 4 = milk for sale; 5 = milk for household use; 6 = hides & skins for sale; 7 = hides and skins for household use; 8 = traction; 9 = manure for sale; 10 = manure for farm use; 11 = religious rituals; 12 = breeding; 13 = eggs for sale; 14 = eggs for household use; 15 = transport; 16=others(specify).

Breed /types	1	2	3	4	5	6
Maasai zebu						
Sahiwals						
Borans						
Grade cattle						
Red Maasai sheep						
Black head sheep						
Dorper sheep						
East African goat						
Galla goat						
Somali camel						
Pakistan camel						
Indigen. chicken						
Exotic chicken						
Ostrich						
Donkey						
Pigs						

Indicators for types of farming activities on the ranches

1. How do you classify your farming enterprise?		
1. mainly livestock	2.mixed livestock/crops	3.Mainly crops

2.Crop enterprise	1. grown? 1=yes 2=no	2. Acreage	3. Manure used? 1=yes 2=no	4. Primary use: 1= subsistence 2= cash income 3=animal feed	5. Secondary uses: 1=subsistence 2=cash income 3=animal feed	6. Tertiary uses: 1=subsistence 2=cash income 3=animal feed
1. maize						
2. beans						
3. sorghum						
4. millet						
5. pigeon pea						
6. wheat						
7. barley						
8. kales (sukuma wiki)						
9. cabbages						
10. onions						
11. cassava						
12. sweet potatoes						
13. bananas						
14. Napier grass						
15. fruit trees						
16.desmodium						
17.lucerne						
18.natural pasture						
19.sown pasture						
20.multi-purpose trees						

14. List the general constraints to livestock production - pair-wise ranking

CONSTRAINT												

15. List the causes, coping mechanisms and opportunities for the constraints listed in 14.

CONSTRAINT	CAUSES	COPING MECHANISM	OPPORTUNITIES

16. List the diseases that cause high death and slow growth rate of calves – pair-wise ranking

DISEASE											

17. List the causes, coping mechanisms and opportunities for the diseases listed in 16.

CONSTRAINT	CAUSES	COPING MECHANISM	OPPORTUNITIES

Indicate the time during the year (seasonal calendar) when various calf management activities and diseases occur.

ACTIVITY/ DISEASE	J	F	M	A	M	J	J	A	S	O	N	D	OTHER REMARKS
Births													
Weaning													
Castration													
Selection													
Dehorning													
Vaccinations													
Deworming													
Tick control													
Disease treatment													
Sale													
Buying													
Diseases													

19. Indicate the time when the following calf management activities are done and by whom?

.1. ACTIVITY	TIME	Who does it?	OTHER REMARKS
1. Watering supervision			
2.Herding			
3.Dipping/spraying			
4.Milking/calf suckling			
5.Construction of calf boma			
6.General treatment			
7.Castration			
8.Dehorning			
9.Selling of milk			
10.Cleaning boma (hygiene)			
11.Splitting of calf herd			
12. Vaccination			
13. Slaughtering			

20. Perception of wealth by the community

1. What criteria do you use when you talk of a rich and poor household, e.g. assets?		2.Indicate size, numbers, etc		
		1.Rich household	2. Medium household	3.Poor household
1.Land or farm size				
2.Species of livestock owned	1. cattle numbers			
	2. sheep numbers			
	3. goats numbers			
	4. others(specify)			

3. Family size	1. wives			
	2. boy			
	3. girls			
	4. hired labour			
4. Type of house : 1=stone/bricks,2=iron-sheets 3=tiles,4=mud, 5=wood, 6=thatch				
5. Source of income: 1=Salaried (e.g. civil servant/teacher), 2=business,3. others(specify)				
Education level: 0= none, 1=primary 2 =secondary 3=university, 4=other colleges, 5=adult education				

How often do you water the calf? Source of the water and seasonal movements including distance?

Season	Source of water: 1=piped, 2=borehole, 3=ponds, 4=pans, 5=dams, 6=river, 7=lake 8=rock catchment, 9=roof catchment, 10=others (specify)	distance to watering source	Frequency of watering
Dry season			
Wet season			

Where do you graze your calves during the dry and the wet season and how far (distance in km) from the boma?

Season	Type of pasture: 1=reserve *(olopololis);* 2=natural pasture, unimproved; 3=improved pasture	distance to grazing pasture	Frequency of movement
Dry season			
Wet season			

23. Do you supplement your calves)? Answer: 1 = yes or 2 = no
If yes, what do you supplement with and at what age?

Type of supplement : 1 = minerals 2 = *Acacia tortilis* pods, 3 = crop residues 4 = others (specify)	Age when supplementation starts? 1 = birth – 1 week,; 2 = 2 weeks – 4 weeks, 3 = 1 month – 2 months; 4 = 3 months - 6 months; 5 = 7 months – 9 months; 6 = 10 months – 12 months; 7 = over 12 months	Source of supplement: 1= purchase from shop 2= purchase from neighbour 3= from own farm 4= natural soil/rock 5=others (specify)

Do you control helminths (worms) in your calves? Answer: 1 = yes or 2 = no
If yes, at what of the calf do you start controlling and what method and /or type of chemical do you use?

1.Age when control starts 1 = birth–week, 2 = 2–4weeks, 3 = 1 month – 2 months, 4 = 3 months - 6 months, 5 = 7 months – 9 months, 6 = 10 months – 12 months, 7 = over 12 months	2.=Methods of control 1=drenching with anthelmintics 2=injectable anthelmintics 3=grazing restriction 4=traditional treatment 5=others (specify)	3.Type of chemicals used	4.Source of the chemical 1= purchase from shop 2= purchase from neighbour 3= from own farm 4= natural soil/rock 5=others (specify

Appendix 3.2: Cross-sectional survey on calf health and production in Kajiado District

1. IDENTIFICATION OF STUDY SITE

DATE .... 1.2 QUESTIONNAIRE NUMBER ---------

1.3. INTERVIEWER .... 1.4 Name of respondent: ....

1.4 AEZ: 1) IV 2) V 3) VI

1.5 ranches name:

1) OloshoOiborr 2) Shompole 3) Olodonyo Orok 4) Emarti
5) Nantenai 6) Kuku 'B'

1.6 Is the ranches subdivided? 1) Yes 2) No

2. GPS READING:

3. HOUSEHOLD INFORMATION

3.1 Household no..............

3.2 Household Name:.................

3.3 Is the household head (males only) monogamous (M) or polygamous (P)? 1) M 2) P

3.4 If the household head (males only) is polygamous, how many wive does he have?

3.5 If the household head (males only) is polygamous, are all the wives living together in the same boma or manyatta? 1) Yes 2) No

3.6. If there are several wives living together in the same manyatta or boma, how do they manage the milking animals? each wife manages and milks their own animals; milking animals are herded and milked together, pooled milk shared among the wives; Collective herding but milking separate for each wife, milk not pooled together; others (describe)

3.7 If there are several wives living together in the same manyatta or boma, does each one own calves/kids /lambs separately?

1) Yes 2) No

3.8 If Question 3.7 is No, are the kids/lambs/calves pooled together during herding?

1) Yes 2) No

3.9 Household size and composition (List the names of household members <u>starting</u> with the household head (HH) giving all details in the table below)

Household members includes all the people whom the household head (male or female) lidentified as normally living in the boma. It inludes members who are usually absent (employed in town or attending boarding school) as long as they were expected to retum to the boma to live in the next six (6) months.

1. Name	2. Sex 1 = male 2 = female	3.Age (years)	Relationship with household head 1=wife 2=son 3=daughter 4=father 5=mother 6=servant 7=others	4. Level of education 0= none 1=nursery 2=primary 3=secondary 4=university 5=other colleges 6=adult education	5. Occupation 0=none 1= pupil/student 2= business 3= teacher 4=civil servant 6=farmer 7=Others
1.					
2.					
3.					
4.					
5.					

3.10 Name of Manyatta....... ....
3.11 Total no. of households in Manyatta.............

3.12 Which year did you register as a member of the ranches? 19.......

3.13 For how long have you been on this site?

less than 1 year 2) between 1-3 years 3) between 3-5 years 4) between 5-10 years 5) over 10 years

3.14 Where were you before you came to settle here? ....

3.15 How far (distance) was it from present boma/manyata site? ....Kilometres

3.16 Give reasons why you moved to the present site...

....

3.17 How would you classify your sources of income?

1) From lives animals and product sales 1) 0 – 25% 2) 26 – 50% 3) 51 – 75% 4) 76 – 100% 5) none

2) from crop sales 1) 0 – 25% 2) 26 – 50% 3) 51 – 75% 4) 76 – 100% 5) none

3) Off-farm employment 1) 0 – 25% 2) 26 – 50% 3) 51 – 75% 4) 76 – 100% 5) none

3.18 Size of this farm? .... Acres.

Area under pasture ....Acres
3.18.2 Area under crop farming .... Acres

3.19 If No, why haven't you acquired your title deed? Reason ....

.20 Do you own other land elsewhere? 1) Yes 2) No

3.21 If Yes, how did you acquire the land? 1) purchased 2) inherited 3) allocated during subdivision 4) others

LIVESTOCK SPECIES AND COMPOSITION IN THE HOUSEHOLD

4.1 Do you keep the following species and types of livestock on the ranches?1) yes 2) no

Cattle	Sheep	Goats	Camel	Donkey	Chicken	Ostrich	Rabbits	Bees	Pigs	Others

4.2 Do you have the following breeds and types of livestock on the ranches? (put a circle)

Breeds 1) Mz 2) Sah 3) Bor 4) Frie 5) Ary 6) Gue 7) Jer 8) Oth	1) Rm 2) Dor 3) Bhp 4) Oth	1)SEA 2)Gal 3) oth	1) Som 2) Pak 3) Ren 4) Gab 5) Tur 6) Sam 7) Oth		1) Ind 2) Ex.bl 3) Ex.la					

Key: Cattle dreeds: Mz=maasai zebu, sah=sahiwal, bor=boran, frie=friesian, ary=aryshire, gue=guernsey, jer=jersey,oth=others
sheep breeds::rm=red maasai,dor=dorper,bhp=blackhead persian.
Goat breeds: SEA=Small eas africa,gal=galla;
camel breeds:som=somali,pak=pakistan,ren=rendille,gab=gabbra,tur=turkana,sam=samburu;
chicken breeds:ind=indigenous,exbl=exotic-broilers,exla=exotic-layers,

4.3 Livestock herd/flock structures in the household

1. Cattle	Breeding Cows	Breeding bulls	Castrated bulls	4. Male calves (less 1 year)	5. Female calves
2.Camels	Breeding Females	Breeding males	Castrated males(mature)	4. Male calves	5. Female calves
3. Sheep	Breeding Ewes	Breeding rams	Castrated rams	4. Male lambs	5.Female lambs
4. Goats	1.Breeding does	2.Breeding bucks	3.Castrated bucks	4. Male kids	Female kids

4.4 Give six (6) reasons for keeping the particular species (1=most important, 2=second most important, 3=third most important, 4= fourth and 5 = fith reason, respectively)
Main reasons suggested include: 1 = Sale for cash income; 2 = meat for sale; 3 = meat for household use; 4 = milk for sale; 5 = milk for household use; 6 = hides & skins for sale; 7 = hides and skins for household use; 8 = traction; 9 = manure for sale; 10 = manure for farm use; 11 = religious rituals; 12 = breeding; 13 = eggs for sale; 14 = eggs for household use; 15 = transport; 16= blood 17=others(specify).

Types	1	2	3	4	5	6
Cattle						
Sheep						
Goats						
Camels						
Donkeys						
Chicken						

OTHER TYPES OF FARMING ACTIVITIES ON THE FARM

5.1 How do you classify your farming enterprise?		
1. mainly livestock	2.mixed livestock/crops	3.Mainly crops

5.2 Crop enterprise	1. Is it grown? 1=yes 2=no	2. Acreage	3. Manure used? 1=yes 2=no	4. Primary use: 1= subsistence 2= cash income 3=animal feed	5. Secondary uses: 1=subsitence 2=cash income 3=animal feed	6. Tertiary uses: 1=subsistence 2=cash income 3=animal feed
1. maize						
2. beans						
3. sorghum						
4. millet						
5. pigeon pea						
6. wheat						
7. barley						
8. kales (sukuma wiki)						
9. cabbages						
10. onions						
11. cassava						
12. sweet potatoes						
13. bananas						
14. napier grass						
15. fruit trees						
16.desmodium						
17.lucerne						
18.natural pasture						
19.sown pasture						
20.multi-purpose trees						

RESOURCE ENDOWMENT

What kind of shelter or housing do you have?

1) stone/bricks 2) iron sheets, roof and walls 3) wooden walls, iron sheets' roof 4) mud walls, iron sheets' roof 5) mud, walls and roof 6) mud walls, thatch 7) pure thatch 8) others (specify)

Which one of the following resources do you own on the farm or household?

vehicle 2) tractor 3) plough 4) cart 5) motorbike 6) bicycle 7) radio 8) television

Which of the following farm implements do you own on the farm?

1) jembe 2) panga) spade 4) crowbar 5) axe 6) pump 7) muttock 8) others (specify)

ACTIVITY PROFILE, ACCESS AND CONTROL OF RESOURCES AND BENSFITS

7.1 Indicate the kind of resources are used when the following calf management activities are done.
Who has access and control of the resources?

1.ACTIVITY	2.RESOURCES	3.ACESSED BY? 1=man; 2=wife; 3=moran; 4=big girls; 5=small boys; 6=small girls; 7=male servant 8=female servant 9=community, 10=others	4.CONTOLLED BY? 1=man; 2=wife;3=moran; 4=big girls; 5=small boys; 6=small girls;7=male servant 8=female servant, 9=community, 10=others
1. watering of calves			
2. milking of dam			
3. Herding of calves			
4. Sale of milk			
5. Treatment of sick animals			
6. Tick control / spraying			
7. Tsetse control			
8. Trypanosomosis treatment			
9. Deworming			
10. Castration			
11. House			

construction			
12. House cleaning			
13. On-farm use of manure			

7.2 Indicate the kind of resources are used when the following calf management activities are done.
Who has access and control of the benefits

1.RESOURCE	2.ACESSED BY? 1=man; 2=wife; 3=moran; 4=big girls; 5=small boys; 6=small girls; 7=male servant 8=female servant 9=community, 10=others	3.CONTOLLED BY? 1=man; 2=wife;3=moran; 4=big girls; 5=small boys; 6=small girls;7=male servant 8=female servant, 9=community, 10=others
1. Benefits from animal sales		
2. Benefits from milk sales		
3. Benefits from hides sales		
4. Benefits from skin sales		
5. Benefits manure sales		

CALVING AND NURSING OF THE NEWBORN CALF

8.1 How many calves were born alive on your farm in the past 12 months?................

8.2 How many calves were born dead or aborted in the past 12 months? ....

8.3 In the last 12 months, were there calves that became sick, were treated and recovered or died? 1) yes 2) no

If yes, how many were treated and recovered or died from the following sicknesses?

Sickness	Treated	Recovered	Died
Heartwater			
Babesiosis or red water			
Other Tick-borne disease			
Foot and mouth disease			
Difficult kidding/lambing			
Hind limb paralysis			
Foot rot			
Lameness			
Swollen lymph nodes /glands			
Wounds on the body			
Difficult breathing			
Weakness due to starvation			
Born weak			
Bottle jaw or oedema			
Madness/circling/star gazing			
Abortions			
Diarrhoea			
Pneumonia			
Abscesses			
Bloat			
Predation			
Poisoning			

Accidents			
Trypanosomosis			
CCBPP(*Olkipiei*)			
Red urine			
Anthrax			
Blackquarter			
Bloody diarrhoea			
Orf			
Mange			
Congenital abnormalities			
Internal parasites			
Blue tongue			
Fleas			

Where do most of your calving occur?

1) on pasture 2) in the boma 3) other places (specify)

During calving, what percentage of the times is someone present?

1) 0 –25% 2) 25-50% 3) 50-75% 4) 75-100% 5) Unknown

8.7 Do you vaccinate the calves against any diseases? 1) yes 2) no

8.8 Type of vaccine: 1..
2..
3..

8.9 How soon after kidding/lambing do you separate the kid/lamb from the dam?

1) immediately 2) < 4 hours 3) 4 – 12 hours 4) 12 – 24 hours 5) 24 - 48 hours 6) 48 - 72 hours

CALF HOUSING

How do you house the calf after separation from the dam?

outdoor, tied in calf boma 2) outdoor, free in calf boma 3) indoor/in house 4) others (specify)

8.10.1 Are calves housed together with kids and lambs? 1) Yes 2) No

8.11 If calves are kept individually immediately after birth, at what age do you begin to group them together?

1) < 2 weeks 2) 2 – 4 weeks 3) 4 - 6 weeks 4) 6 – 8 weeks 5) > 8 weeks

8.12 If calves are put together into ranchespens, how many are usually put per pen?

1) 2 – 4 2) 4 – 6 3) 6 - 10 4) > 10

8.12.1 What is the AREA of the calf house? -------------------------------- square metres

8.12.2 What material is the house roof? 1) grass 2) mud 3) iron sheets 4) others 5) none

8.12.3 What material is the wall of the house? 1) grass 2) mud 3) timber 4) iron sheets 5) life fence 6) *mathanzu* 7) others 8) none

8.13 How often do you clean the calf area?

1) once per month during dry and wet season 2) once per month, wet season only 3) once during the dry season 4) several times during the wet season 5) none 6) others (specify)

8.14 Do you use any treatment after cleaning the calfb area? 1) yes 2) no

8.15 If yes, what chemicals or products do you use? (including ash)
…………………………………………………………………………

MILKING, CALF SUCKLING

How do your calf usually receive their first colostrum?

1) free suckling 2) assisted suckling 3) nursing bottle 4) bucket feeding 5) others (specify)

How soon after birth do most of your calves receive colostrum?

1) < 2 hours 2) 2 – 6 hours 3) 6 – 12 hours 4) 12 - 24 hours 5) not known

During the first month after birth, how often is the calves allowed to suckle in a day?

1) once only 2) twice only 3) three times only 4) four or more times

WATERING OF THE CALVES

At what age do you start offering water to your calves?

no offered 2) < 2 weeks 3) 2 – 4 weeks 4) 1 – 2 months 5) 2 – 4 months 6) 4 – 6 months
6 – 9 months 8) 9 – 12 months

How is the water offered?

1) pail/bucket/basin 2) as for adult 3) others (specify) …………………

10.2.1 If calves are taken to the dam/river/stream what distance do the walk? …………….. KM

How often is the water offered?

1) once daily 2) twice daily 3) ad libitum (unlimited) 4) others (specify)

Does the frequency of watering differ with the season? 1) yes 2) no

If yes, give reasons why…………………………………………………………

What are the various sources of water during the <u>dry</u> season? Who owns them and how far from the house/boma are they?

<u>Sources</u>	<u>ownership</u>	<u>distance (km)</u>
1. Stream	………………	………………………
2. pond	………………	………………………
3. shallow wells	………………	………………………
4. borehole	………………	………………………
5. piped water	………………	………………………
6. dam	………………	………………………
7. roof catchment	………………	………………………
8. rock catchment	………………	………………………
9. River	………………	………………………
10. others	………………	………………………

What are the various sources of water during the <u>wet</u> season? Who owns them and how far from the house/boma are they?

<u>Sources</u>	<u>ownership</u>	<u>distance (km)</u>
1. Stream	………………	………………………
2. pond	………………	………………………
3. shallow wells	………………	………………………
4. borehole	………………	………………………
5. piped water	………………	………………………
6. dam	………………	………………………
7. roof catchment	………………	………………………
8. rock catchment	………………	………………………
9. river	………………	………………………

10. others ....

HERDING DURING GRAZING

At what age do you start to offer grass/forage to the calves?

1) not offered 2) < 2 weeks 3) 2 - 4 weeks 4) 1 - 2 months 5) 2– 4 months
4 – 6 months 7) 6 – 12 months

What kind of forage is offered to the calves?

natural pasture, free grazing 2) natural pasture, cut and carry 3) napier grass
4) sweet potato vines 5) legumes 6) others (specify) ....

Do you supplement the calves? 1) Yes 2) No

If yes, what supplements do you give calves?

1) minerals 2) concentrates 3) porridge 4) Acacia ponds 5) crop residues 6) sisal 7) others (specify)

DISEASE CONTROL AND TREATMENT

TICK CONTROL

Do you control ticks on your farm? 1) Yes 2) No

If Yes, what animals do you treat for ticks?

1) adult cattle 2) calves only 3) adult sheep and goats 4) kids/lambs
5) others (specify).......................

What diseases do you hope to prevent by controlling ticks? 1) Oltikana (ECF)
2) Olomiro (Hearwater) 3) Babesiosis or Red water (urine) 4) Anaplasmosis
5) Others (specify).........................

What method do you use to control ticks on your farm? (could be a combination of two or more methods)

1) dipping 2) spraying 3) hand picking 4) grazing management 5) pour-on 6) spot-on
7) others (specify)

At what age do you begin tick control for calves?

1) less 1 month 2) between 1-2 months 3) 3-6 months 4) 7-12 months 5) over 1 year

What season of the year do you control ticks?

1) all year round 2) wet season 3) dry season 4) only when ticks found on body

12.7 Is your method of tick control different depending on the season of year? 1) yes 2) no

Explain..

12.8 Is you method of tick control for adult sheep and goats different from that of calves? 1) yes 2) no
Explain..

When you control ticks, how often do you do it ?

1) once per week 2) twice per week 3) once every two weeks 4) once every three weeks
5) once per month 6) less than once per month 7) when tick burden is high 8) others (specify)

12.10 Does the frequency of tick control depend on the season? 1) yes 2) no

Explain..

12.11 Is you frequency of tick control different for the adult cattle and the calves? 1) yes 2) no

Explain..

If you use dipping method of tick control, which dip tank do you us and how far is it from your farm?

Name of dip tank ....

Distance from farm: 1) < 1 km 2) 1-2 km 3) 2-3 km 4) 3-5 km 5) > 5 km

If you practice tick control by spraying, what product(s) or acaricide(s) do you use?

Product(s) name ....

Concentration of product..

Acaricide ....

How much of the concentrated product do you use to make this volume of spray?

Volume of concentrated product: .... (litres)

Approximately how many litres of the final mixture do you spray on each ADULT cattle?

Volume per ADULT cattle .... (litres)

12.16 Approximately how many litres of the final mixture do you spray on each calf?

Volume per calf......................... (litres)

HELMINTH CONTROL

12.17 Do you deworm LIVESTOCK (in general) 1) yes 2) no

12.18 If yes, what ranchesof animals do you deworm?

1) adult cattle 2) calves 3) sheep and goats 4) kids/lambs 5) others (specify)

When do you start deworming your calves?

1) less 1 month 2) between 1-2 months 3) 3-6 months 4) 7-12 months 5) over 1 year

What diseases do you hope to prevent by controlling helminths?

1) tapewrms 2) gastrointestinal nematodes 3) liver flukes 4) others (specify)

What method do you use to control ticks on your farm? (could be a combination of two or more methods)

1) drenching 2) injectable 3) grazing management 4) others (specify)

What season of the year do you helminths?

1) all year round 2) wet season 3) dry season 4) only when parasite eggs seen in faeces

12.23 Is your method of helminth control different depending on the season of year? 1) yes 2) no

Explain..

Is you method of helminth control for adult sheep/goats different from that of calves?

1) yes 2) no

Explain..

When you control helminths, how often do you do it ?

once per year in wet season 2) once per year in wet season 3) twice per year 4) three times per year only when parasite eggs seen in faeces 6) others (specify)

12.25 Does the frequency of helminth control depend on the season? 1) yes 2) no

Explain..

Is you frequency of helminth control different for the adult shepp/goats and the calves?
1) yes 2) no
Explain...

If you use anthelmintics for Helminth control by drenching or injection, what product(s) do you use?

Method of application	Product	Route of administration	Volume (mls)
Drenching			
Injection			

TSETSE CONTROL

Do you control TSETSE flies on your farm? 1) Yes 2) No

If yes, what method of control do you use to control tsetse flies on your farm (could be a combination of different strategies)?

dipping 2) spraying 3) hand picking 4) grazing management 5) pour-on 6) spot-on 7) trapping

8) others (specify) ....

Against what class of animals do you control tsetse fies?

all cattle 2) adult cattle only 3) calves only 4) sheep and goats 5) kids/lambs 6) others (specify) ....

What diseases do you hope to prevent by controlling tsetse flies? Oltikana (ECF) 2) Olomiro (Heartwater) 3) Babesiosis or red water (urine) 4) Anaplasmosis 5) Trypanosomosis 6) Others (specify)

TRYPANOSOMOSIS CONTROL

12.32 Do you treat your livestock against TRYPANOSOMOSIS ? 1) Yes 2) No

12.33 If yes, What class of animals do your treat against trypanosomosis?

All cattle 2) adult cattle only 3) calves only 4) sheep and goats 5) Kids/lambs 6) others (specify) ....

Which Method do you use to control trypanosomosis?

1) dipping 2) spraying 3) hand picking 4) grazing management 5) pour-on 6) spot-on 7) trapping

8) chemoprophylaxis 9)others (specify) ....

At what age do you start to treat calves against trypanosomosis?

less than 1 month 2) 1 – 2 months 3) 3 – 6 months 4) 7 – 12 months 5) over 1 year

What season of the year do you control trypanosomosis?

all year round 2) wet season 3) dry season 4) only when flies seen)

When you treat against trypanosomosis, how often do you do it?

1) once per week 2) twicw per week 3) once every two weeks 4) once every three weeks 5) once per month 6) less than once per month 7) when population of tsetse is high 8) others (specify)

What CHEMICALS or DRUGS do you use to control TSETSE flies?

....

What CHEMICALS or DRUGS do you use to treat TRYPANOSOMOSIS?

....

WILDLIFE INTERACTION

Which of the following wild animals are common in the same areas where your livestock graze or drink water?

none 2) elephant 3) buffalo 4) giraffe 5) zebra 6) wildebeest 7) eland 8) antelopes lion 10) leopard 11) hyena 12) wild dogs e.g. foxes 13) baboons 14) monkeys apes 16) ostrich 17) others (specify) ....

Which is the nearest national park or game reserve ? ....

13.3 How far is from the boma to the park/reserve? ....(km)

13.4 Do you get any benefits from the wildlife or KWS? 1) Yes 2) no

13.5 If no, list four things that could ensure benefits from wildlife or KWS

1...
2...
3...
4...

If yes, list four beneficial things from wildlife or KWS

1...
2...
3...
4...

DELIVERY OF ANIMAL HEALTH SERVICES

14.1 When an animal is sick which of the following do you consult? 1) Private Vet, 2) Govt.Vet, CABAHA, 4)Traditional Medicine man 5) Self, 6) Do nothing

Sickness	Person consulted	Treatment given:1) antbiotic 2) anthelmintic 3) herbs 4) acaricide 5) trypanocide 6) multivitamins 7) others	Consultant response 1)delayed 2) 1mmediate 3) none
Heartwater			
Babesiosis or red water			
Other Tick-borne disease			
Foot and mouth disease			
Difficult calving			
Hind limb paralysis			
Foot rot			
Lameness			
Swollen lymph nodes /glands			
Wounds on the body			
Difficult breathing			
Weakness due to starvation			
Born weak			
Bottle jaw or oedema			
Madness/circling/star gazing			

Abortions			
Diarrhoea			
Pneumonia			
Abscesses			
Bloat			
Predation			
Poisoning			
Accidents			
Trypanosomosis			
CCPP(*Olkipiei*)			
Red urine			
Anthrax			
Blackquarter			
Bloody diarrhoea			
Orf			
Mange			
Congenital abnormalities			
Internal parasites			
Blue tongue			
Fleas			

What are your sources of chemicals and or drugs ? How far ? How reliable are they?

Type of drug	Source	Distance	Reliability
1. Antibiotics			
2. Acaricides			
3. Anthelmintics			
4. Trypanocides			
5. Multivitamins			
6. Herbs			
7. Vaccines			
8. Others			

LIVESTOCK MARKETING

Which of the following classes of animals did you SELL in the last 12 months?

cattle 2) sheep 3) goats 4) camels 5) chicken 6) donkeys 7) others

Which of the following classes of animals did you BUY in the last 12 months?

cattle 2) sheep 3) goats 4) camels 5) chicken 6) donkeys 7) others

What were the buying/ selling prices of the class of animals per head?

	cattle	sheep	goats	camels	chicken	donkeys	others
Buying price							
Selling price							
Reason(s) for buying							
Reason(s) for selling							

Which of the following products did you SELL/BUY in the last 12 months? What was the buying/selling price per unit? Why did you have to sell or buy?

	Meat	Milk	Hides	Skins	Manure	Eggs	Honey	others
Buying price								
Selling price								
Reason(s) for buying								
Reason(s) for selling								

Which are the nearest markets where you sell/buy livestock/animal products? How far are they?

Name of market	Distance from boma to the market (km)
1.	
2.	
3.	

Appendix 3.3: Longitudinal survey on calf health and production - initial household visit

The following questions will be completed for each calf aged between ONE DAY TO 12 MONTHS. Circle or fill in The appropriate response or answer.

1.Date ----/-----/------ 2. Household no./Name........... Interviewer ....

Calf Id no.	Sex	Date of BIRTH (where possible) Or age in days, weeks, months	Dam Id no.	Sire Id. No. ....
Breed:1).Maasai zebu 2).Sahiwal, 3) Boran 4) Exotic 5) others	1. male 2. female		Breed 1)Maasai zebu 2)Sahiwal 3) Boran 4) Exotic 5) others	Breed: 1).Maasai zebu 2).Sahiwal, 3) Boran 4) Exotic 5) others

HISTORY OF THE CALF

3. Has this calf experienced any of the following sicknesses/conditions SINCE BIRTH?

SICKNESS/CONDITION	1) yes 2) no	TYPE OF TREATMENT:: 1) none, 2) antibiotic, 3) nthelmintics, 4) traditional,5) trypanocides, 6) vaccination 7) others	BY WHO? 1) Self 2) GoK Vet 3) Private Vet 4) Paravet 5) Tradition medicineman
1. theileriosis (*Oldi*kana)			
2. Foot and mouth disease(*Oloilobi*)			
3. Difficult calving			
4. Hind limb paralysis			
5. Foot rot			
6. Lameness			
7. Swollen lymph nodes			
8. Wounds on the body			
10. Weakness due to starvation			
11. Born weak			
12. Bottle jaw or oedema			
13.Madness/circling/star gazing			
14. Abortion			
15. Diarrhoea			
16. Pneumonia			
17. Anaplasmosis			
18. Bloat			
19. Predation			
20. Poisoning			
21. Accidents			
22. Trypanosomosis			
23. CBPP			
24. Red urine			
25. Rinderpest			
26. Anthrax			
27. Black quarter			
28. Bloody diarrhoea			
29. Ring worm			
30. Lumpy skin disease			
31. Congenital abnormalities			
32. Internal parasites			
33. Fleas			

1. Has this calf received any vaccination SINCE birth? Yes .... Or No ....
2. Type of vaccine(s) ....
Dates or month of vaccination.........................

3. Has this calf received any anthelmintics SINCE BIRTH? Yes .... Or No ....
Type of anthelmintics(s) ....
Dates or month anthelmintic given.............................

4. Has this calf been sprayed or dipped SINCE BIRTH? Yes .... Or No ....
Dates or month anthelmintic given.............................
Type of chemical used?.......................................

5. Has this calf received any prophylactic (preventive) medication SINCE BIRTH? Yes...... or No......

6. Type of medications ....
Dates or week or month of medication ....

9. CURRENTLY, what is this calf feeding on and how many times per day?

	frequency
1) colostrum	....
2) milk	....
3) forage (*Lalerorasho*)	....
4) forage (*Olopololi*)	....
5) forage (open pasture)	....
6) mineral supplement	....
7) legumes e.g. pods	....
8) Water	....
9) crop residues	....
10) Others (specify)	....

10. How would you classify the appetite of this calf?
1) Anorexic 2) poor (less than normal) 3) normal (average) 4) great (higher than average)

CLINICAL EXAMINATION
11. Body condition score 1) very thin 2) fair 3) good 4) fat
12. Respiratory rate: ....(breaths/min)
13. Type of cough: 1) absent 2) infrequent/"normal" 3) frequent/harsh
14. Dyspnoea: 1) absent 2) mild 3) moderate 4) severe
15. Nasal discharge: 1) absent 2) serous 3) mucoid 4)purulent 5) haemorrhagic 6)others
16. Mentation: 1)alert/normal 2)dull/depressed 3) others (specify)
17. Gait/lameness: 1) normal 2) abnormal/lame
18 .Skin/coat: 1) smooth and shiny 2) rough and raised 3) some alopecia 4) extensive alopecia 5) wounds
19.Rectal temperature: ....^{0}C
20. Heart /Pulse rate:.................. beats/min
21.Rumen mortility: 1) absent/no motility 2) weak contractions 3) strong contractions
22. Urination: 1) absent /difficult 2)bloody 3) normal
23. Defaecation: 1) absent/difficult 2) diarrhoea 3) bloody 4) mucoid 5) parasite eggs 6)normal
24. Labia: 1) normal 2) abnormal Describe:...
25. Vaginal discharge: 1) absent 2) serous mucoid 3)purulent 4)haemorrhagic 5)bloody tinged
26. Vaginal mucous membranes: 1) pink/normal 2) pale/White and Meadow 3) jaundiced 4) bluish/cyanotic
5) haemorrhages 6) conjested/injected
27.Rumen mortility: 1) absent/no motility 2) weak contractions 3) strong contractions
28. No. of rumen contractions per minute.............................
29. Superficial lymph nodes: 1) normal 2) swollen 3) burned 4) swollen and burned
30. Weight of the calf (to nearest 0.5 of a Kg) .... Heart girth.............cm (............. kgs)
31. Eyes:1) normal 2) lacrimation 3) serous discharge 4) muco-purulent discharge 5) sunken
6) blindness

32. Tick counts:

Species	Eyes	Ears	Face	Horn base	Dewlap and Brisket	Udder or Scrotum	Tail	Perineum	Body	Limbs
Rhipicephalus appendiculatus										
Rhipicephalus evertsi										
Rhipicephalus pulchellus										
Rhipicephalus simus										
Rhipicephalus sanguineous										
Boophilus decoloratus										
Boophilus microplus										
Amblyomma gemma										
Amblyomma variegatum										
Hyalomma sp										
Others.										

Appendix 3.4:Longitudinal survey on calf health and production- follow up household visit

The following questions will be completed for each calf aged between ONE DAY TO 12 MONTHS. Circle or fill in the appropriate response or answer.

1.Date ----/-----/------ 2. Household no./Name.......... Interviewer ....

Calf Id no.	Sex	Date of LAST VISIT (where possible) Or age in days, weeks, months	Dam Id no. ...	Sire Id. No.
....			....	....
Breed:1).Maasai zebu 2).Sahiwal, 3) Boran 4) Exotic 5) others	1. male 2. female		Breed 1)Maasai zebu 2)Sahiwal 3) Boran 4) Exotic 5) others	Breed: 1).Maasai zebu 2).Sahiwal, 3) Boran 4) Exotic 5) others

3. Has this calf experienced any of the following sicknesses/conditions SINCE LAST VISIT?

SICKNESS/CONDITION	1) yes 2) no	TYPE OF TREATMENT: 1)none, 2) antibiotic, 3) anthelmintics 4) traditional, 5) trypanocides 6) vaccination 7) others	BY WHO? 1) Self 2) GoK Vet 3) Private Vet 4) Paravet 5) Tradition medicineman
1. theileriosis (*Oldi*kana)			
2. Anaplasmosis (Lipis)			
3. Heart water (Olomiro)			
4. Babesiosis			
5. Foot and mouth disease (Oloilobi)			
6. Difficult calving			
7. Foot rot			
8. Lameness			
9. Wounds on the body			
10. Weakness due to starvation			
11. Born weak			
12. Abortions			
13. Pneumonia			
14. Bloat			
15. Predation			
16. Poisoning			
17. Accidents			
18. Trypanosomosis			
19. CBPP			
20. Rinderpest			
21. Anthrax			
22. Blackquarter			
23. Ring worm			
24. Lumpy skin disease			
25. Congenital abnormalities			
26. Internal parasites			
27. Fleas			
28. Others (specify)			

1. Has this calf received any vaccination SINCE LAST VISIT ? Yes .... Or No ....
If yes, how many days post-vaccination? 1) one 2) 2-3 days 3) 4-7 days 4) 8-14 days
Type of vaccine(s) ....
2. Has this calf received any anthelmintics SINCE LAST VISIT? Yes .... Or No ....
If yes, how many days post-treatment? 1) One 2) 2-3 days 3) 4-7 days 4) 8-14 days
Type of anthelmintics(s) ....
3. Has this calf been sprayed or dipped SINCE LAST VISIT? Yes .... Or No ....
If yes, how many days post-dipping/spraying? 1) One 2) 2-3 days 3) 4-7 days 4) 8-14 days

Type of chemical used?..

4. CURRENTLY, what is this calf feeding on and how many times per day?
   1) colostrum 1) none 2) ad libitum 3) once 4) twice 5) others
   2) milk 1) none 2) ad libitum 3) once 4) twice 5) others
   3) forage (*Lalerorasho*) 1) none 2) ad libitum 3) once 4) twice 5) others
   4) forage (*Olopololi*) 1) none 2) ad libitum 3) once 4) twice 5) others
   5) forage (open pasture) 1) none 2) ad libitum 3) once 4) twice 5) others
   6) mineral supplement 1) none 2) ad libitum 3) once 4) twice 5) others
   7) legumes e.g. pods 1) none 2) ad libitum 3) once 4) twice 5) others
   8) Water 1) none 2) ad libitum 3) once 4) twice 5) others
   9) crop residues 1) none 2) ad libitum 3) once 4) twice 5) others
   10) Others (specify) 1) none 2) ad libitum 3) once 4) twice 5) others

5. How would you classify the appetite of this calf?
   1) Anorexic 2) poor (less than normal) 3) normal (average) 4) great (higher than average)

CLINICAL EXAMINATION

11. Body condition score 1) very thin 2) fair 3) good 4) fat
12. Type of cough: 1) absent 2) infrequent/"normal" 3) frequent/harsh
13. Nasal discharge: 1) absent 2) serous 3) mucoid 4)purulent 5) haemorrhagic 6)others
14. Eyes:1) normal 2) lacrimation 3) serous discharge 4) muco purulent discharge 5) sunken 6) blindness
15. Mentation: 1)alert/normal 2)dull/depressed 3) others (specify)
16. Gait/lameness: 1) normal 2) abnormal/lame
17 .Skin/coat: 1) smooth and shiny 2) rough and raised 3) some alopecia 4) extensive alopecia 5) wounds
18.Rectal temperature: ....^{o}C
19. Urination: 1) absent /difficult 2)bloody 3) normal
20. Defaecation: 1) absent/difficult 2) diarrhoea 3) bloody 4) mucoid 5) parasite eggs 6)normal
21. Labia: 1) normal 2) abnormal Describe:...
22. Vaginal discharge: 1) absent 2) serous mucoid 3)purulent 4)haemorrhagic 5)bloody tinged

Mucous membranes: 1) pink/normal 2) pale/White and Meadow 3) jaundiced 4) bluish/cyanotic 5) haemorrhages 6) conjested/injected

24. Superficial lymph nodes: 1) normal 2) swollen 3) burned 4) burned
25. Weight of the calf (to nearest 0.5 of a Kg) .... Heart girth..........cm (............. kgs)
26. Tick counts:

Species	Eyes	Ears	Face	Horn base	Dewlap and Brisket	Udder or Scrotum	Tail	Perineum	Body	Limbs
Rhipicephalus appendiculatus										
Rhipicephalus evertsi										
Rhipicephalus pulchellus										
Rhipicephalus simus										
Rhipicephalus sanguineous										
Boophilus decoloratus										
Boophilus microplus										
Amblyomma gemma										
Amblyomma variegatum										
Hyalomma sp										
Others.										

Diagnosis: ....
Treatment given:)..

Other advice given to farmer: ....

Appendix 4.1 Summary of the causes and coping strategies for constraints to calf health and production in Kajiado District.

Constraint	Cause	Coping strategies
Drought	1.Lack of rain 2.An act of God	1.Migrate to areas with water and pasture 2.Keep many animals so that if some die, others will remain to build the herd/flock
Shortage of water	1. Drought 2. Wildlife destroy dams 3. Overstocking 4. Lack of permanent rivers	1. Dams, 2. Water pans, 3. Spring water 4. Lake water, 5. River water 6. Shallow wells, 7. Boreholes 8. Roof catchment water
High incidence of diseases	1. High prevalence of vectors 2. Presence of wildlife 3. Uncontrolled movement of animals, especially from Tanzania 4. Inadequate knowledge of disease treatment/prevention methods 5. Inadequate extension staff 6. New/unknown diseases 7. Poor animal husbandry 8. Inadequate diseases diagnosis by self 9. Very expensive drugs e.g. butalex, territ 10. Poor animal nutrition	1. Individuals treat their own animals 2. Vaccination 3. Use traditional medicine 4. Spray against ticks using acaricide 5. Mineral supplementation
Inadequate extension services	1. GoK frozen new field staff employment 2. Normal staff attrition e.g. through retirement, death 3. Lack of training opportunities 4. Staff transfer without replacement 5. High illiteracy level 6. Inability to attract qualified personnel due to harsh environment	1. Individuals treat their own animals 2. Use Community Animal health assistants 3. Use traditional medicine
Feed shortage	1.Frequent drought 2.Presence of wildlife 3.Overstocking	1.Reserve grazing pastures 2. Cull animals for sale 3. Migrate to highlands 4. Move to GoK land e.g. KARI Kiboko
Communal land tenure system	1. Lack of finances for survey and subdivision 2. Leadership wrangles resulting in poor management of resources	Subdivision of ranches into individual units
Wildlife menace	1.High population of wildlife cause predation and compete for pasture and water with livestock 2.Lack of compensation following predation or destruction of crops 3. Transmit diseases to livestock 4. Lack of fencing of land because land is communally owned 5.Severe restriction of wildlife cropping	1.Community mobilization for ecotourism through NGOs. 2. Very limited cropping of wildlife allowed for certain individuals
Poor animal breeding practices	1.High cost of breeding animals 2. Inadequate sources of breeding animals	Purchase breeding bulls from KARI Naivasha, Mtara .

Appendix 4.1 (continued............)

Constraint	Cause	Coping strategies
Very expensive inputs	1.High cost of inputs e.g. drugs 2.Very few sources of drugs e.g. agro-vet shops	1.Sell some animals to purchase some inputs
Overgrazing due to overstocking	1. Increased livestock population relative to land carrying capacity 2.Emphasis on quantity but not quality of animals 3. Communal land tenure system	1.Sell excess livestock 2.Diversification into crop farming 3.Loan out some animals to families with extra feed 4. Migrate to an areas with fewer grazing animals 5. Subdivision of ranches into individual units
Soil erosion	1. Lack of incentive to control soil erosion because of communal ownership of land 2. Single movement tracks for animals e.g. to watering sites	1. Leave the affected area farrow to allow some re-growth of vegetation 2. Use alternative trekking routes for waterng animals
Inadequate credit facilities	1.Lack of title deeds 2.Lack of money	1. Subdivision of into individual ownership and issuing of title deeds
Shortage of labor	1. Children go to school 2. Hired labour is expensive	1. Hire laborers 2. Marry more wives.

Appendix 4.2 Summary of perceived causes and predisposing factors for calf diseases in six Maasai pastoral comm
District, Kenya.

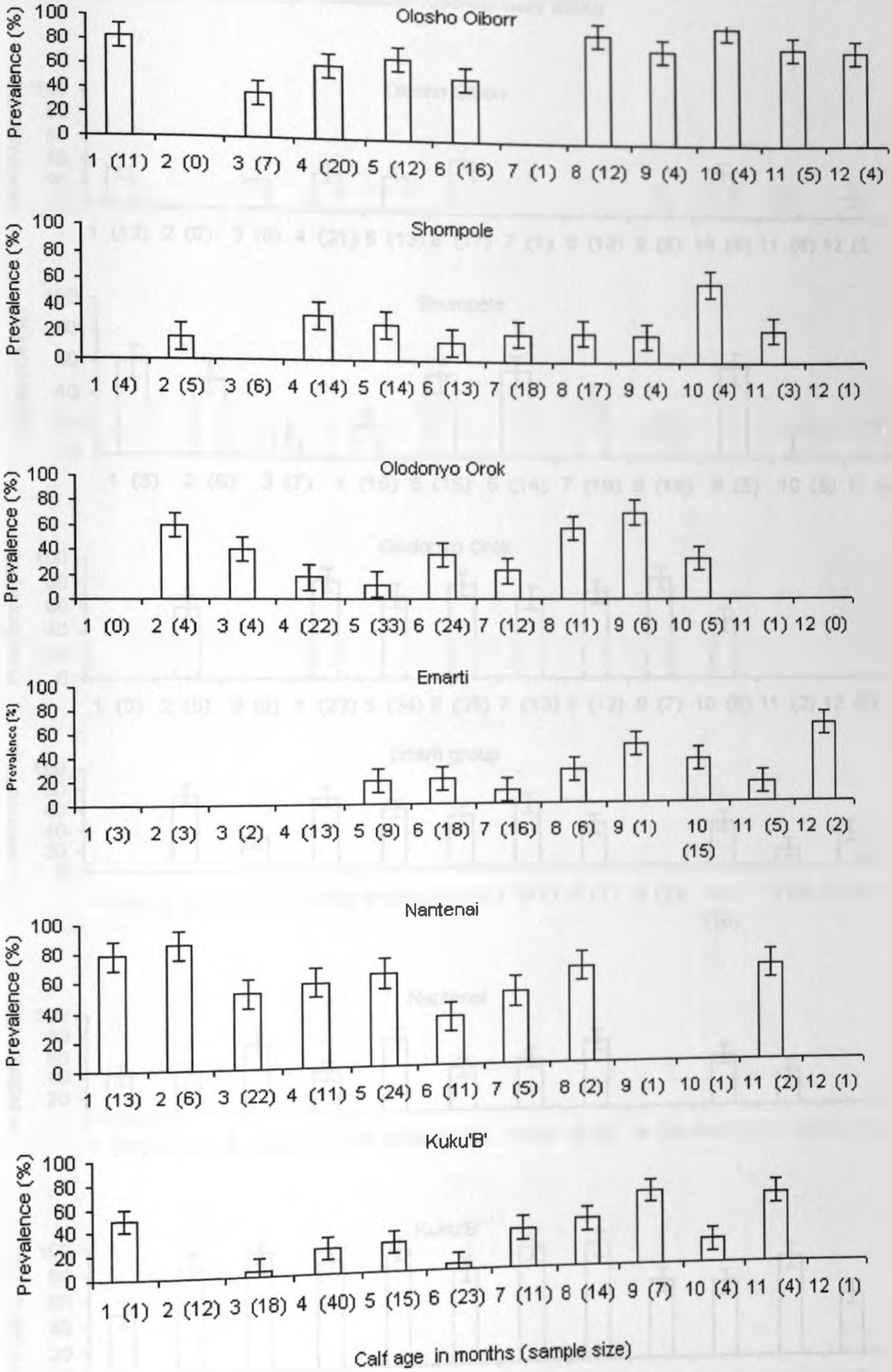
Disease	Causes and predisposing factors	Coping strategies
Trypanosomosis	1. Thick bush 2. Presence of vectors	1. Use tetracyclines 2. Trypanocidal drugs
Anthrax	1. Animal fat 2. Environmental contamination 3. High environmental temperatures 4. Presence of wildlife	1. Ethnoveterinary medicine 2. Use penicilline 3. Use tetracyclines 4. Vaccination
Black quarter	1. Animal fat 2. Environmental contamination 3. High environmental temperatures 4. Presence of wildlife	1. Ethnoveterinary medicine 2. Grazing management 3. Use tetracyclines 4. Vaccination
Bloat	Not known	Ethnoveterinary medicine
Calf diarrhoea	1. Poor calf feeding 2. Unhygienic calf housing 3. Environmental contamination	1. Ethoveterinary medicine 2. No known treatment 3. Use anthelmintics 4. Use tetracyclines
Contagious Bovine Pleuropneumonia	Transit animals	1. Use tetracyclines 2. Vaccination
Coccidiosis	1. Calf housing 2. Environmental contamination 3. Presence of wildlife	1. Calf watering 2. Ethnoveterinary medicine 3. Grazing management 4. Use anthelmintics 5. Use tetracyclines

Appendix 4.3 Pastoralists' ability to relate clinical/post mortem signs to specific diseases of calves in Maasai pastoral systems, Kajiado District.

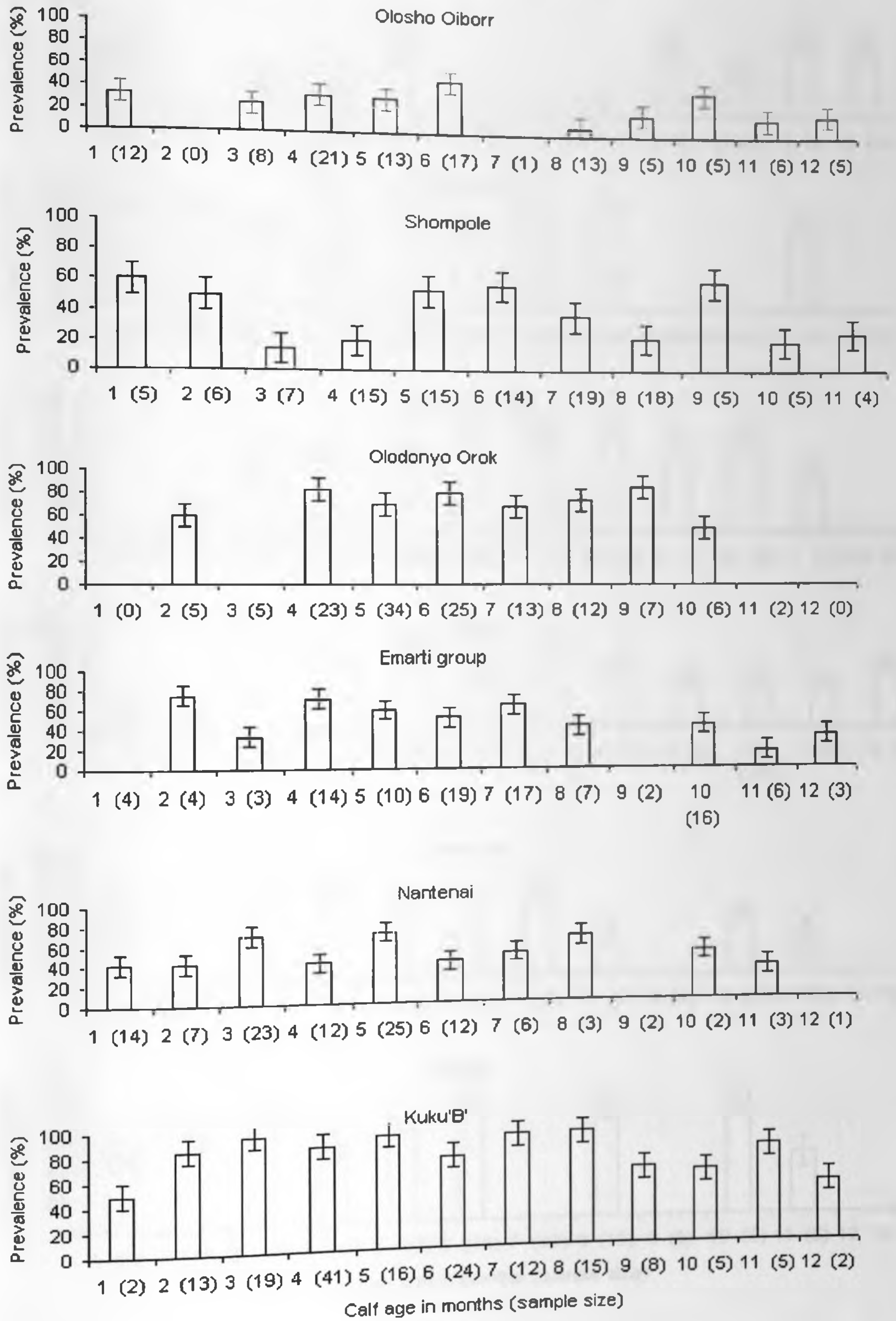
Clinical or post mortem signs	Disease										
	theileriosis	Anplas	FMD	Anth	BQ	LSD	Tryps	CBPP	Cocc	Rind	E/fever
Depression, inappetance	yes	yes	yes	-	-	yes	yes	yes	yes	yes	yes
Cough present	yes	-	-	-	-	-	-	yes	-	-	-
Swollen lymph nodes	yes	-	-	-	-	yes	yes	-	-	-	-
Lameness on more than one limb	-	-	yes	-	-	-	-	-	-	-	yes
Lameness on single limb	-	-	-	-	yes	-	-	-	-	-	-
Lacrimation	yes	yes	-	-	-	yes	yes	-	-	-	-
Salivation or frothing	-	-	yes	-	-	-	-	-	-	-	-
Response to tetracyclines	poor	good	poor	-	-	poor	none	good	-	-	none
Swollen spleen	-	-	-	yes	-	-	-	-	-	-	-
Blood oozing from body openings	-	-	-	yes	yes	-	-	-	-	-	-
Swollen abdomen (tympany)	-	-	-	-	yes	-	-	-	-	-	-
Morbidity	-	-	high	high	high	high	low	high	-	high	low
Mortality	Very high	low	Very low	Very high	Very high	Moderate	low	Moderate	high	Very high	rare
Course of disease	short	long	long	Very short	Very short	long	long	short	-	short	2-3 days
Diarrhoea	-	-	-	-	-	-	-	-	bloody	yes	-
Constipation	-	yes	-	-	-	-	-		-	-	-
Nature of outbreaks	endemic	endemic	endemic	Sporadic	Sporadic	Sporadic	Few cases	Sporadic	-	Last one in 1996	Sporadic

Key: theileriosis=East Coast fever; Anplas=Anaplasmosis; FMD=Foot and mouth disease; Anth=Anthrax; BQ=Black quarter; LSD=Lumpy Skin disease; Tryps=Trypanosomosis; CBPP=Contagious Bovine Pleuropneumonia; Cocc=Coccidiosis; Rind=Rinderpest; E/fever=Ephemeral fever

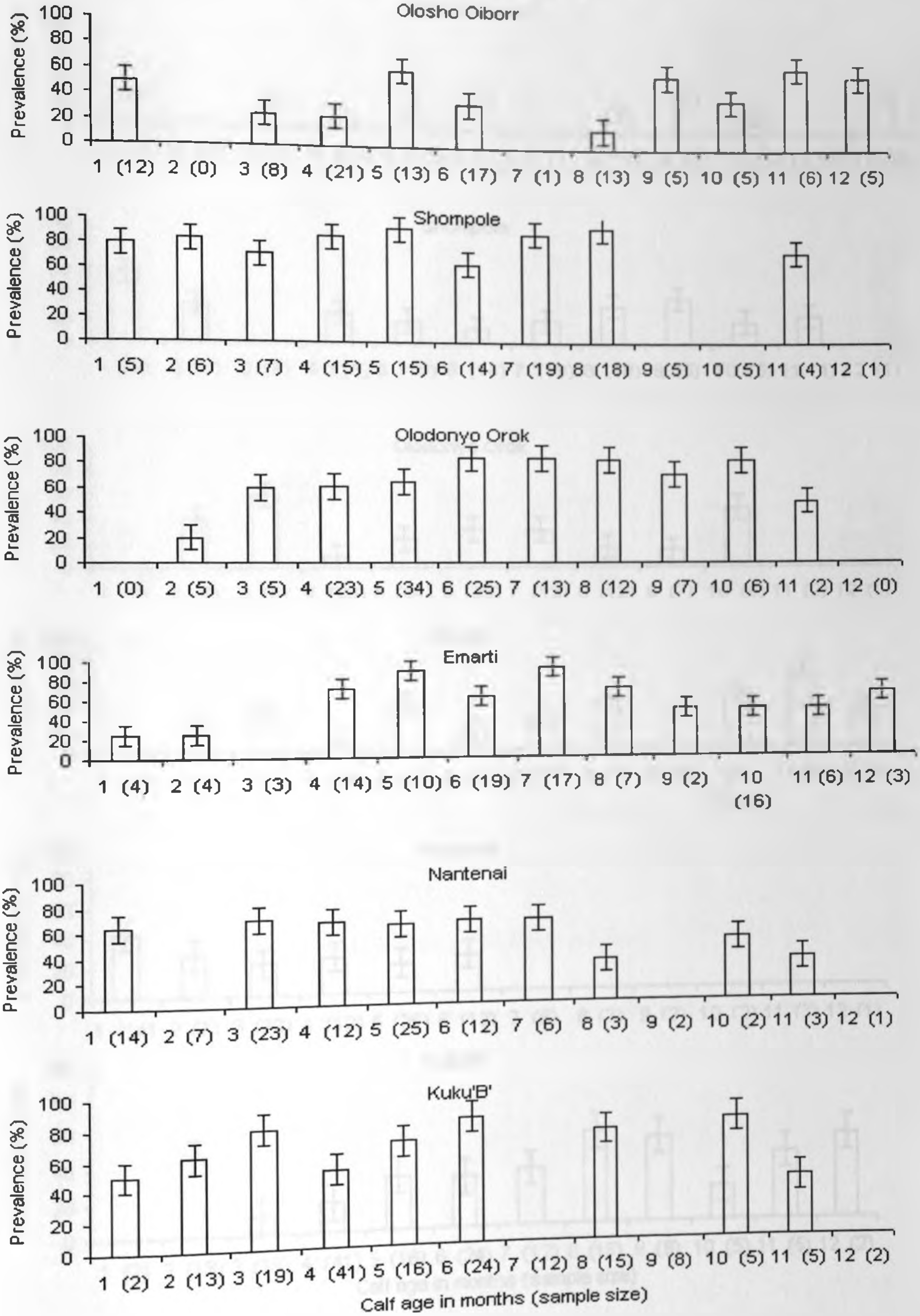
Appendix 5.1 Prevalence of serum antibodies for *T. parva* by calf age in six ranches in Kajiado District, Kenya (Cross-section study, November, 1999-January, 2000)



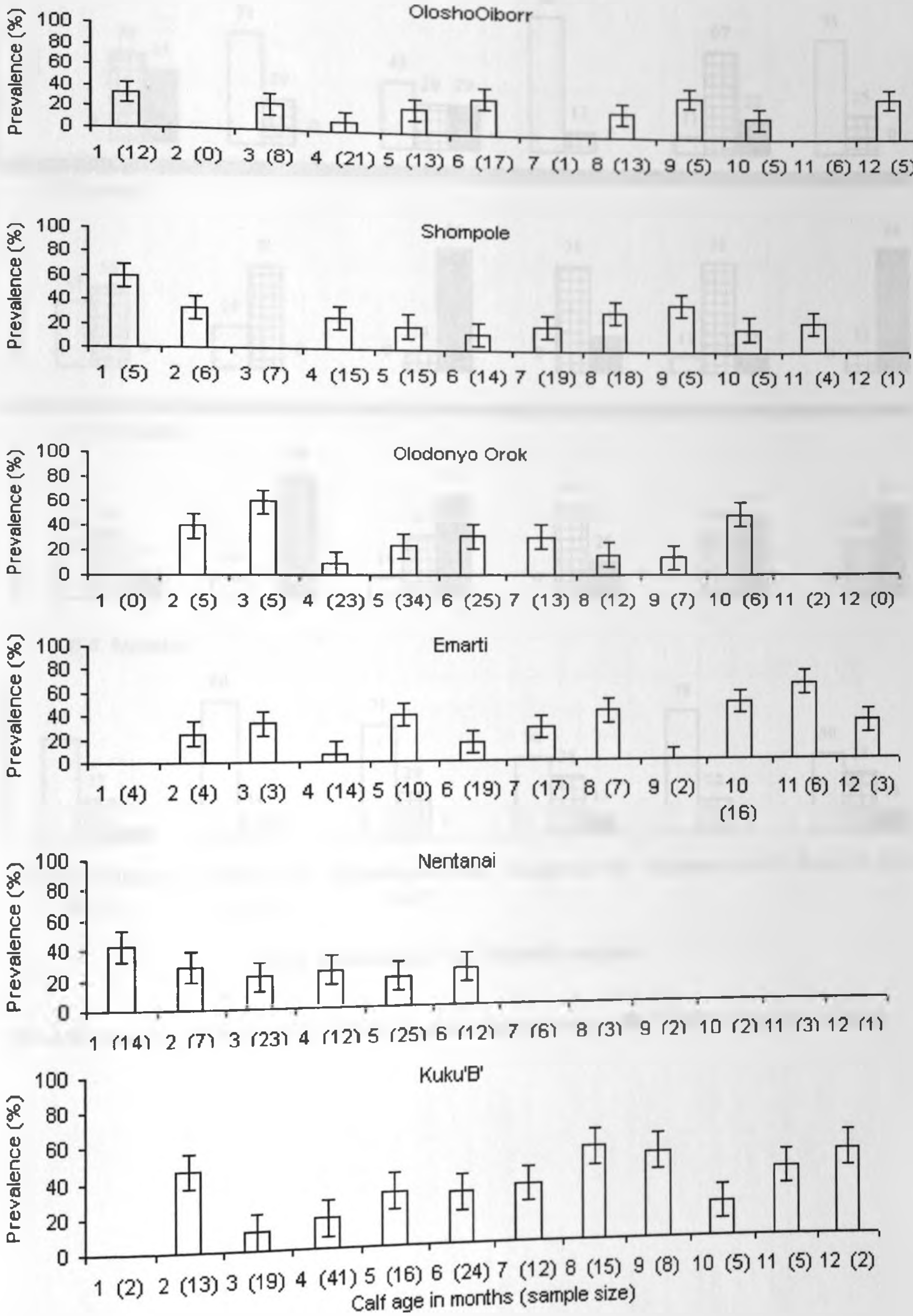
Appendix 5.2 Prevalence of serum antibodies for *T. mutans* by calf age in six ranches in Kajiado District, Kenya (Cross-section study, November 1999-January 2000)



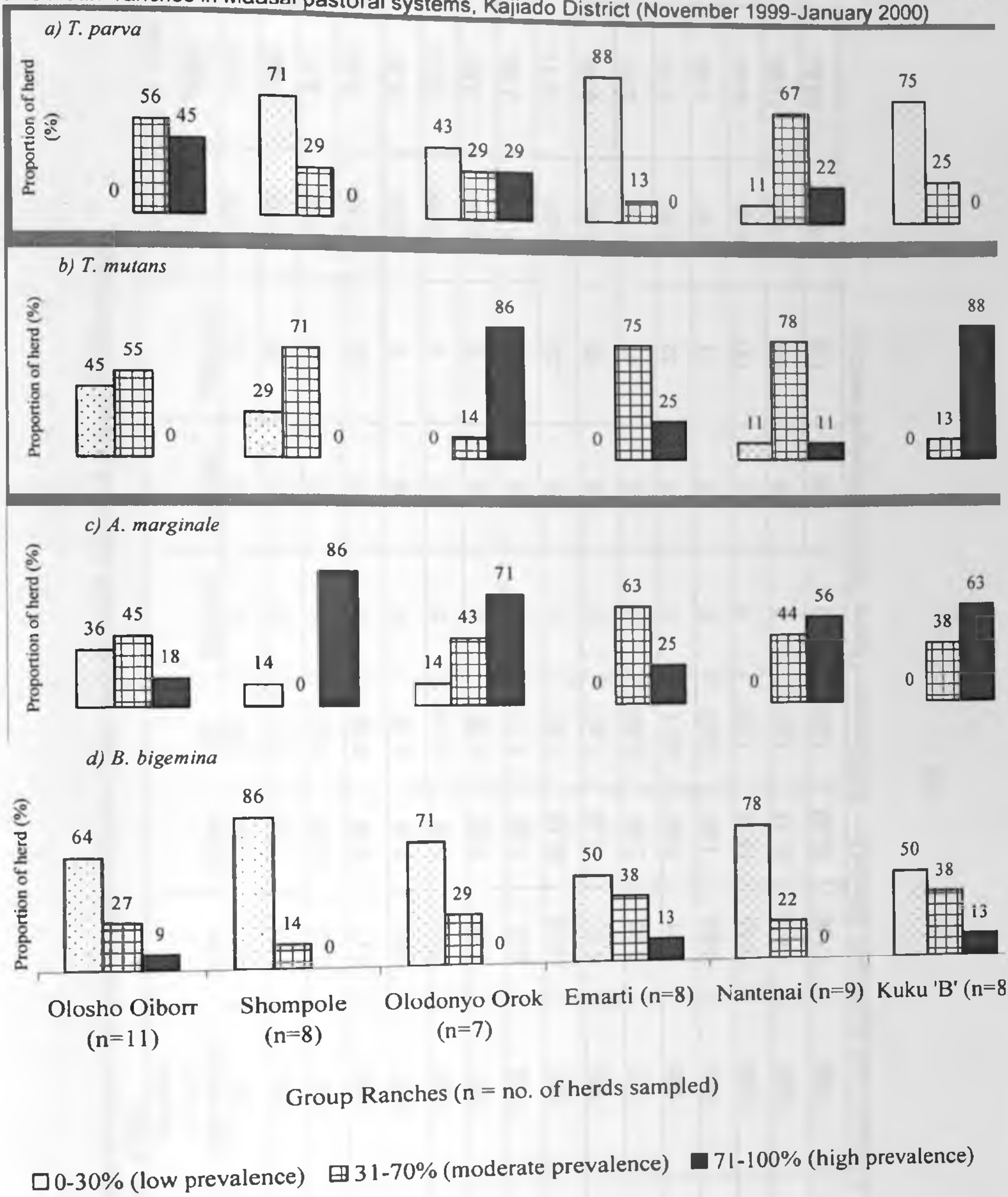
Appendix 5.3 Prevalence of serum antibodies for *A. marginale* by calf age in six ranches in Kajiado District, Kenya (Cross-section study, November 1999-January 2000).



Appendix 5.4 Prevalence of serum antibodies for *B. bigemina* by calf age in six ranches in Kajiado District, Kenya (Cross-section study, November, 1999-January 2000)



Appendix 5.5 Prevalence of serum antibodies for *T. parva*, *T. mutans*, *A. marginale* and *B. bigemina* in herds within ranches in Maasai pastoral systems, Kajiado District (November 1999-January 2000)



Appendix 6.1 Distribution of total ticks by species on calves that were sampled in Olosho Oiborr and Nentanai ranches in Kajiado District, Kenya (Longitudinal study, November 2000 – February 2002).

Tick species	ranchesranch	Number of calf observations	Mean	StDev	SE	Minimum	Median	Maximum	95 % Confidence limits	
									Lower	Upper
*A. gemma**	Olosho Oiborr	967	0.11	0.60	0.04	0	0	13	0.07	0.14
	Nentanai	1285	0.55	1.74	3.13	0	0	37	2.57	3.68
*A. variegatum**	Olosho Oiborr	967	0.10	0.44	4.68	0	0	6	4.58	4.77
	Nentanai	1285	0.11	0.84	8.03	0	0	21	7.93	8.14
*B. decoloratus**	Olosho Oiborr	967	0.01	0.12	8.25	0	0	1	8.24	8.27
	Nentanai	1285	0.02	0.18	10.18	0	0	4	10.16	10.19
*H. truncatum**	Olosho Oiborr	967	0.13	0.62	4.78	0	0	8	4.65	4.91
	Nentanai	1285	0.23	0.95	4.15	0	0	14	3.93	4.38
R.appendiculatus	Olosho Oiborr	967	10.86	20.14	1.86	0	4	250	9.00	12.71
	Nentanai	1285	8.13	11.53	1.42	0	4	102	6.72	9.55
R. evertsi	Olosho Oiborr	967	0.96	2.55	2.64	0	0	47	1.68	3.61
	Nentanai	1285	1.21	2.55	2.11	0	0	32	0.90	3.32
*R. pulchellus**	Olosho Oiborr	967	0.80	1.97	2.47	0	0	21	1.67	3.26
	Nentanai	1285	7.74	13.12	1.70	0	3	127	6.05	9.44
Total tick counts*	Olosho Oiborr	967	12.96	21.17	1.63	0	6	257	11.33	14.60
	Nentanai	1285	17.99	22.42	1.25	0	10	196	16.74	19.24

* Indicates that the mean of tick counts for the species was significantly different ($p < 0.05$) between Olosho Oiborr and Nentanai ranches.

Appendix 7.1 Definitions of specific measures of calf health and production for the longitudinal study in Kajiado District, Kenya (NOvember 2000 - February 2002).

Outcome measure	Definitions
Morbidity	Any cause of change in normal health status of a calf that was accompanied by clear clinical signs, initially reported by the farmer and verified by the veterinarian.
Cause –specific morbidity	Calf morbidity caused by an established or defined cause.
Mortality	Any calf death, irrespective of the cause.
Cause-specific mortality	Calf death caused by a definite or established cause.
Animal-at-risk	Number of calves at risk from a specified cause or ranches or breed or age ranchesor sex.
Number at the beginning	Number of calves at risk during a specified interval period (visit here defined as interval).
Risk rates	Number of calves with a event of interest/number at risk at the beginning of period – ½ withdrawals.
Sero-conversion	A persistent change in antibody level from negative to positive > 19 PP and above for *T. parva* and *T. mutans*, and > 14 PP and above for *A. marginale* or *B. bigemina*, for at least two consecutive visits. For calves showing presence of maternal antibodies had declined.
Average daily weight gain	The average daily weight gain (ADWG) was calculated as the difference in weights between two consecutive visits divided by the number of days between the two visits.

Appendix 7.2 Differential diagnosis of tick-borne diseases of calves in Kajiado District.

Disease	Clinical syndrome
East coast fever	Calf morbidity caused by either *T. parva* with the following clinical syndrome: fever (39.5°C or above), enlarged superficial lymph nodes (parotid, precrural and prescapular), petecchial hemorrhages on oral and or vulva mucous membranes, difficult breathing (dyspnoea) and sometimes coughing; parasitaemia and sero-conversion on ELISA except where acute/paracute death occurred before antibody rise. *T. mutans* causes a mild form of theileriosis and is associated with anaemia and poor growth rate (attempts to be made to differentiate *T. parva* infections from *T. mutans* infections)
Anaplasmosis	Calf morbidity with the following clinical syndrome: fever (39.5°C or above), anaemia, jaundice, parasitaemia, hard faeces, dullness, seroconversion on ELISA except where acute death occurred before antibody rise.
Babesiosis	Calf morbidity with the following clinical syndrome: dullness, fever (39.5°C or above), red urine, anaemia, jaundice, parasitaemia, sero-conversion on ELISA except where acute death occurred before antibody rise.

Appendix 7.3 Description of clinical signs of tick-borne diseases causing calf morbidity and mortality in Kajiado District, Kenya.

Body system/clinical sign	Description
Cough	absent /normal/harsh
Nasal Discharge	absent/serious/ mucoid/purulent/haemorrhagic/others
Eye status	normal/lacrimation/ serious discharge/muco-purulent/sunken/blindness
Mentation	alert or normal/dull or depressed/others
Gait/lameness	normal/ abnormal or lame
Skin coat	smooth and shinny/ rough and raised/ some alopecia/ extensive alopecia /wounds
Rectal temperature	absolute value (degrees centigrade)
Urination	difficult or absent/bloody/normal
Defaecation	difficult or absent/ diarrhoes/ bloody/ mucoid/parasite eggs /normal
Vaginal Discharge	absent/serious/mucoid/purulent/haemorrhagic/blood tinged
Mucous membranes	pink or normal/pale or White and Meadow/jaundice/bluish or cyanotic/haemorrhages/ congested or injected
Superficial lymph nodes	normal/ swollen and or burned.

Appendix 7.4 Loss to follow-up and reasons for censoring of calves during the longitudinal study in Maasai pastoral systems in Kajiado District, Kenya (November 2000 – February 2002).

Visit number	New recruits	No. of calf observations during the visit	Deaths	Withdrawn	Re-entry	Transfer
1	32	32	0	0	0	0
2	72	104	0	8	0	1
3	66	161	2	0	0	2
4	23	180	0	0	0	4
5	50	226	9	0	0	2
6	20	235	11	0	0	3
7	13	234	6	0	8	5
8	0	231	0	0	0	0
9	6	237	28	0	0	3
10	0	206	2	0	0	0
11	0	204	4	0	0	0
12	21	221	1	0	0	0
13	26	246	2	0	0	0
14	71	315	0	0	0	0
15	193	508	2	0	0	3
TOTAL	593	3340	67	8	8	23

Appendix 7.5 Proportional and incidence rate of morbidity between Olosho Oiborr and Nentanai ranches in Kajiado District (Longitudinal study, November 2000 - February 2002).

Measurement	Group ranch		Total counts (Calves, DAR, YAR) and or overall proportional morbidity and Incidence rate of morbidity
	Olosho Oiborr	Nentanai	
Count of non-sick calves	199	61	260
Days at risk (DAR) for non-sick calves	3493	4652	8145
Count of sick calves	131	202	333
Days at risk (DAR) for sick calves	8951.5	47359.5	56311
Total no. of calves sampled	330	263	593
Total DAR for non-sick and sick calves	12444.5	52011.5	64456
Years at Risk (YAR) non-sick and sick calves	34.1	142.5	176.6
Proportional morbidity (%)	39.7	76.8	56.2
Incidence morbidity (per calf-year)	3.8	1.4	1.9

Appendix 7.6 Follow-up life table (Actuarial) showing overall morbidity survivorship for the 593 calves from the longitudinal study in Kajiado District, Kenya (November 2000 – February 2002).

Calf age (months)	No. of calves present at start	No. of new entries (non-births)	Withdrawals	No. of sick calves	No. of dead calves	Average no. of calves at risk	Risk rate	Survival rate	Cummulative survivorship from birth	SE
<1	241	0	0	86	2	241	35.7	64.3	64.3	0.025
≥1<2	184	0	6	74	2	334	22.2	77.8	50.1	0.019
≥2<3	93	2	5	60	5	351	17.1	82.9	41.5	0.017
≥3<4	33	0	3	37	6	317	11.7	88.3	36.6	0.016
≥4<5	29	0	6	30	2	300	10.0	90.0	33.0	0.016
≥5<6	13	1	4	17	15	280	6.1	93.9	31.0	0.015
≥6<7	0	2	2	9	6	249	3.6	96.4	29.9	0.016
≥7<8	0	4	1	9	4	238	3.8	96.2	28.7	0.016
≥8<9	0	8	4	2	7	231	0.9	99.1	28.5	0.016
≥9<10	0	3	1	3	8	224	1.3	98.7	28.1	0.016
≥10<11	0	3	1	5	5	216	2.3	97.7	27.4	0.016
≥11<12	0	0	0	2	1	206	1.0	99.0	27.2	0.016
≥12<13	0	0	0	2	4	203	1.0	99.1	26.9	0.016

Appendix 7.7 Proportional and incidence rate of mortality between Olosho Oiborr and Nentanai ranches in Kajiado District, Kenya (Longitudinal study, November 2000 - February 2002).

	Group ranch		Total counts (Calves, DAR, YAR) and or overall proportional morbidity and Incidence rate of morbidity
	Olosho Oiborr	Nentanai	
Count of non-dead calves	311	215	526
Days at risk (DAR) for non-dead calves	26270	33207	59477
Count of dead calves	19	48	67
Days at risk (DAR) for dead calves	2224	6827.5	9051.5
Total no. of calves sampled	330	263	593
Total DAR for non-dead and dead calves	28494	40034.5	68528.5
Years at Risk (YAR) non-dead and dead calves	78.1	109.7	187.7
Proportional mortality (%)	5.8	18.3	11.3
Incidence of mortality (per calf-year)	0.24	0.44	0.36

Appendix 7.8 Follow-up life table (Actuarial) showing overall mortality survivorship for the 593 calves from the longitudinal study in Kajiado District, Kenya (November 2000 – February 2002).

Calf age (months)	No. of calves present at start	No. of new entries (non-births)	Withdrawals	No. of dead calves	Average no. of calves at risk	Risk rate	Survival rate	Cummulative survivorship from birth	SE
<1	241	0	0	2	241	0.8	99.2	99.2	0.006
≥1<2	184	0	6	2	420	0.5	99.5	98.7	0.005
≥2<3	93	2	5	5	511	1.0	99.0	97.8	0.006
≥3<4	33	0	3	6	537	1.1	98.9	96.7	0.008
≥4<5	29	0	6	2	557	0.4	99.6	96.3	0.008
≥5<6	13	1	4	15	567	2.6	97.4	93.8	0.010
≥6<7	0	2	2	6	553	1.1	98.9	92.8	0.011
≥7<8	0	4	1	4	551	0.7	99.3	92.1	0.011
≥8<9	0	8	4	7	553	1.3	98.7	90.9	0.012
≥9<10	0	3	1	8	548	1.5	98.5	89.6	0.012
≥10<11	0	3	1	5	543	0.9	99.1	88.8	0.013
≥11<12	0	0	0	1	538	0.2	99.8	88.6	0.013
≥12<13	0	0	0	4	537	0.7	99.3	87.9	0.013

Appendix 7.9 Distribution of variables associated with seroconversion for *T. parva* calves older than 3 months in Maasai pastoral areas in Kajiado District, Kenya (Longitudinal study, November 2000 – February 2002).

Variable	categories	Frequency (%) of seroconversion	*df*, χ^2	*p-value*
ranches	Olosho Oiborr	110 (58.2)	1, 13.2	0.0003
	Nentanai	137 (35.0)		
Farm level				
Watering frequency per day	Less than once	111 (48.3)	2, 9.18	0.01
	At least once	60 (58.3)		
	Ad libitum	16 (87.5)		
Grazing distance from boma	Far (> 5 km)	32 (9.4)	1, 32.3	<0.0001
	Near (≤ 5 km)	159 (64.2)		
Age at first grazing	3-6 months	69 (62.3)	1, 11.1	0.0008
	> 6 months	178 (38.8)		
Frequency sprayed against ticks week^{-1}	Once	125 (51.2)	1, 2.11	0.15
	Less than once	54 (63.0)		
Restricted grazing (in reserve paddock)	Yes	161 (63.4)	1, 29.1	<0.0001
	No	30 (10.0)		
Sprayed against ticks	Yes	179 (54.8)	1, 23.2	<0.0001
	No	68 (20.6)		
Calf level				
Age class	4-6 months	73 (49.3)	2, 2.1	0.34
	7-9 months	87 (48.3)		
	10-12 months	87 (39.1)		
Body condition score	Very thin	6 (66.7)	3, 3.43	0.33
	Fair	73 (57.5)		
	Good	92 (53.3)		
	Fat	35 (40.0)		
Breed	Maasai Zebu	54 (55.6)	2, 4.25	0.12
	Crosses	160 (44.4)		
	Exotic	33 (33.3)		
Sex	Female	136 (48.5)	1, 1.24	<0.0001
	Male	111 (41.4)		

Appendix 7.10 Distribution of variables associated with seroconversion for *T. mutans*, calves older than 3 months in Maasai pastoral areas in Kajiado District, Kenya Kenya (Longitudinal study, November 2000 – February 2002).

Variabe	categories	Frequency (%) of seroconversion	df, χ^2	p- value
a) *ranches*	Olosho Oiborr	105 (47.6)	1, 0.29	0.59
	Nentanai	136 (44.1)		
b) Farm level				
Watering frequency per day	Less than once	108 (56.5)	2, 3.43	0.18
	At least once	66 (53.0)		
	Ad libitum	11 (27.3)		
Grazing distance from boma	Far (> 5 km)	157 (58.6)	1, 58.6	0.0013
	Near (≤ 5 km)	30 (26.7)		
Age at first grazing	3-6 months	65 (64.6)	1, 12.9	0.0003
	> 6 months	176 (38.6)		
Frequency sprayed against ticks week^{-1}	Once	112 (57.6)	1, 0.13	0.71
	Less than once	62 (56.5)		
Restricted grazing (in reserve paddock)	Yes	159 (57.9)	1, 8.2	0.004
	No	28 (28.6)		
Sprayed against ticks	Yes	175 (54.3)	1, 19.3	<0.0001
	No	66 (22.7)		
Calf level				
Age class	4-6 months	65 (28.7)	2, 22.3	<0.0001
	7-9 months	75 (64.6)		
	10-12 months	101 (52.0)		
Body condition score	Very thin	11 (81.8)	3, 4.5	0.21
	Fair	61 (49.2)		
	Good	91 (53.9)		
	Fat	38 (47.4)		
Breed	Maasai Zebu	56 (55.4)	2, 6.29	0.04
	Crosses	156 (39.7)		
	Exotic	29 (58.6)		
Sex	Female	133 (46.6)	1, 0.11	0.74
	Male	108 (44.4)		

Appendix 7.11 Distribution of variables associated with seroconversion for *A. marginale* in calves older than 3 months in Maasai pastoral areas in Kajiado District, Kenya (Longitudinal study, November 2000 – February 2002).

Level and group	category	Frequency (%) of seroconversion	df, χ^2	p- value
ranches	Olosho Oiborr	105 (59.1)	1, 14.0	0.0002
	Nentanai	140 (35.0)		
Farm level				
Watering frequency per day	Less than once	112 (42.9)	2, 10.5	0.005
	At least once	67 (67.2)		
	Ad libitum	11 (63.6)		
Grazing distance from boma	Far (> 5 km)	34 (58.6)	1, 13.8	0.0002
	Near (≤ 5 km)	157 (23.5)		
Age at first grazing	3-6 months	83 (72.3)	1, 36.9	<0.0001
	> 6 months	162 (31.5)		
Frequency sprayed against ticks week^{-1}	Once	116 (54.3)	1, 0.023	0.88
	Less than once	64 (53.1)		
Restricted grazing (in reserve paddock)	Yes	157 (58.0)	1, 11.1	0.0009
	No	34 (26.3)		
Sprayed against ticks	Yes	182 (20.6)	1, 20.8	<0.0001
	No	63 (53.9)		
Calf level				
Age class	4-6 months	83 (72.3)	2, 36.7	<0.0001
	7-9 months	63 (39.7)		
	10-12 months	99 (26.3)		
Body condition score	Very thin	8 (62.5)	3, 4.1	0.25
	Fair	71 (59.2)		
	Good	95 (50.5)		
	Fat	31 (38.7)		
Breed	Maasai Zebu	57 (45.6)	2, 3.2	0.203
	Crosses	160 (42.5)		
	Exotic	28 (60.7)		
Sex	Female	134 (41.8)	1, 1.47	0.22
	Male	111 (49.6)		

Appendix 7.12 Distribution of variables associated with seroconversion for *B. bigemina* in calves older than 3 months in Maasai pastoral areas in Kajiado District, Kenya (Longitudinal study, November 2000 – February 2002).

Level and group	Category	Frequency (%) of seroconversion	df, χ^2	p- value
ranches	Olosho Oiborr	91 (48.4)	1, 1.38	0.24
	Nentanai	105 (40.0)		
Farm level				
Watering frequency per day	Less than once	108 (43.5)	2, 0.38	0.83
	At least once	63 (46.0)		
	Ad libitum	11 (36.4)		
Grazing distance from boma	Far (> 5 km)	35 (124)	1, 7.6	0.006
	Near (≤ 5 km)	146 (48.6)		
Age at first grazing	3-6 months	35 (71.4)	1, 13.1	0.0003
	> 6 months	161 (37.9)		
Frequency sprayed against ticks week^{-1}	Once	104 (47.1)	1, 0.14	0.71
	Less than once	59 (44.1)		
Restricted grazing (in reserve paddock)	Yes	149 (49.0)	1, 8.5	0.004
	No	33 (21.2)		
Sprayed against ticks	Yes	164 (45.7)	1, 1.4	0.24
	No	32 (34.4)		
Calf level				
Age class	4-6 months	35 (71.4)	2, 7.6	0.006
	7-9 months	68 (50.0)		
	10-12 months	93 (29.0)		
Body condition score	Very thin	7 (42.9)	3, 5.9	0.12
	Fair	58 (34.5)		
	Good	95 (52.6)		
	Fat	36 (36.1)		
Breed	Maasai Zebu	52 (51.9)	2, 5.3	0.07
	Crosses	122 (37.7)		
	Exotic	22 (59.1)		
Sex	Female	108 (44.4)	1, 0.03	0.86
	Male	88 (43.2)		