PREVALENCE OF MASTITIS AND ASSOCIATED RISK FACTORS IN LACTATING ONE-HUMPED CAMELS IN WEST POKOT COUNTY, KENYA

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DECLARATION

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DEDICATION

This thesis is dedicated to my dear wife:

Mercy Jepkemei Toroitich

And our children: Kigen Tembu Toroitich

Jesaina Tembu Toroitich

Jerono Tembu Toroitich

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ABBREVIATIONS AND ACRONYMS

ALLPRO	ASAL Based Livestock & Livelihood Support Project
ASAL	Arid and Semi Arid Lands
BA	Blood Agar
CAMP	Christie, Atkins and Munch-Petersen
Chi-2	Chi-square
CMT	California Mastitis Test
CPP	Country Program Paper
DNA	Deoxyribonucleic Acid
FAO	Food and Agriculture Organization of the United Nations
HH	Households
HoA	Horn of Africa
KCA	Kenya Camel Association
MA	MacConkey Agar
LFQ	Left Fore Quarter
LHQ	Left Hind Quarter
OR	Odds Ratio
RFQ	Right Fore Quarters
RHQ	Right Hind Quarter
STAT	Statistics
Spp	Species

ABSTRACT

In spite of it living in harsh environments of semiarid and arid zones, the dromedary camel is able to produce milk in valuable quantity. Camel milk is one of the main components of diet of the nomads in semiarid and arid zones and is an essential food for livelihood of people and it may be the only milk available in the ASALs where other milking animals cannot be maintained. However, like other dairy animals, dromedary camels could be affected by udder infections such as mastitis, a complex disease occurring worldwide among dairy animals, with heavy economic losses largely due to clinical and subclinical mastitis.

A cross sectional study was conducted to determine the prevalence of mastitis and to identify the associated risk factors in 95 clinically healthy lactating and traditionally managed one-hump camels (*Camelus dromedarius*) in Kongelai, Kacheliba, Konyao, Kasei, Kiwawa and Alale divisions of West Pokot County, Kenya. Fifty two households were conveniently selected from a list provided by Kenya Camel Association West Pokot County based on the presence of a lactating camel in the household. Data on camel management including milking procedures were collected through interviews using closed ended questionnaires.

A total of 380 quarter milk samples (56 from Kongelai division, 40 from Kacheliba division, 8 from Konyao division, 148 from Kiwawa division, 92 from Kasei division and 36 from Alale division) were collected aseptically. The samples were transported in cool boxes with ice packs to the Bacteriology Laboratory at the Department of Veterinary Pathology, Microbiology and Parasitology, Faculty of Veterinary Medicine, University of Nairobi for bacterial culture. Of the 380 quarter milk samples cultured, 169 samples tested positive for subclinical mastitis which gave a prevalence of quarter infection at 44.5% (169/380). At animal (camel) level the prevalence of subclinical mastitis was 76.8% (73/95 camels).Therefore the results of this study showed that subclinical mastitis is prevalent in dromedary camels of West Pokot County. The same results showed that, the right hind

quarter (RHQ) was the most frequently infected quarter (prevalence of 12.1% (46/380)) followed by the right fore quarter (RFQ) (prevalence of 11.3% (43/380)). The two left quarters, left fore quarter (LFQ) &left hind quarter (LHQ) were least infected. This could point out that the Pokot herders tended to milk the right quarters more often and left the left quarters to be suckled by the calves and because of poor & unhygienic milking procedures the right quarters become more infected.

The most predominant isolated bacterium was gram-positive *Staphylococcus aureus* with prevalence of 36.0% (49/136) followed by gram-negative *Escherichia coli* with prevalence of 27.2% (37/136). *Streptococcus agalactiae & Staphylococcus epidermidis* were the third predominant isolates with prevalence of 9.6% (13/136) each. *Micrococcus spp & Pseudomonas* were least isolated with less than 1% prevalence each. A diagnosis of 'no bacterial growth' was made in 22 cases; which translates to 16.2% (22/136). Several mastitis control strategies need to be put in place such as milking procedures, milking order, strict hygiene, post milking teat disinfection, use of antibiotic dry-off therapy and the culling of persistently infected camels.

Significant ($p<0.05$) differences in subclinical mastitis prevalence were observed between camels in different lactating stages and parities. Camels in more than two months lactation stages were affected at higher rate (OR=2.75, $p<0.05$) than those in less than two months lactation stages. Also camels which had given birth to more than two calves (second parity or more) were affected at higher rate (OR=2.90, $p<0.05$) compared to camels which have given birth to less than two calves.

The fact that the pathogens isolated from camel milk samples in this study were bacteria that cause both environmental and contagious mastitis, this study concludes that proper management of lactating camels and adequate hygienic conditions of the environment are required in order to minimize occurrence of mastitis in the study areas. It also recommends treatments of camels with mastitis infections using the conventional drugs and avoid non-conventional treatment.

Keywords: Dromedary camels, subclinical mastitis, quarter samples, West Pokot Kenya.

CHAPTER ONE

1.1 INTRODUCTION

1.1.1 Classification and geographical distribution of camels in the world

In zoological taxonomy, Camelids are classified in the suborder *Tylopoda* (pad-footed animals) that represents with the suborders *Suiformes* (pig-like) and *Ruminantia* (ruminants) the order *Artiodactyla* (even-toed ungulates). This makes obvious that Camelids (family *Camelidae)* as ruminating animals are classified in proximity to ruminants but developed in parallel and are not part of the suborder *Ruminantia*. Some differences like foot anatomy, stomach system and the absence of horns underline this fact (Schwartz & Dioli, 1992; Fowler, 1998; Wernery, 2003).

The family *Camelidae* is divided into three genera: The old world camels (genus *Camelus*) and the new world camels (genus *Lama* with the species *L. glama, L. guanicoe, L. pacos* and genus *Vicugna* with the species *V. vicugna*) (Wilson & Reeder, 2005). Two domesticated species of old world camels exist: the dromedary or one humped camel (*Camelus dromedarius,)* that has its distribution in the hot deserts of Africa and Asia and the Bactrian or two-humped camel (*Camelus bactrianus)* that can be found in the cold deserts and dry steppes of Asia. In the desert Gobi there is still a population of wild two-humped camels classified as *Camelus ferus* (Rao *et al*., 1970; Peters, 1997; Fowler, 1998).

The Bactrian camel was named after the area of Bactriana in Central Asia. The name of the dromedary was derived from the Greek word “dromeus” which means runner or “droma” - running (Jassim & Naji, 2002). The one-humped camel was probably domesticated in the region of today’s Yemen and Oman about 3.000 to 4.000 years ago (Fowler, 1998). The wild Arabian

camel became extinct (Lensch, 1999). Curasson (1947) and Epstein (1971) indicate that the dromedary (*Camelus dromedarius*) was introduced into North Africa (Egypt) from Southwest Asia (Arabia and Persia). The former indicates that occasional shipments were also made to Spain, Italy, Turkey, France, the Canaries, North America and Australia. The latter country still contains a small feral herd of around 20,000. Once in Africa, Mikesell (1955) suggests that the camel spread West and Southwards from Egypt, although Bulliet (1975) is of the view that the camels of the Horn of Africa are more likely to have come across the sea from the Arabian Peninsula than spread southwards from Egypt and Sudan.

In East Africa, it is thought that the camel was introduced following a more direct route through the Horn of Africa during the middle of the 1st millennium BC (Epstein 1971). The camels found their way to Kenya from Somalia after domestication in Southern Arabia between 1 & 4 B.C (Bulliet, 1975; Wilson, 1984).

1.1.2 Camel population

According to FAO statistics (Global Livestock Production and Health Atlas - GLIPHA, 2006) the world population of camels is about 20 million, mainly in arid zones, of which 15 million live in Africa and 5 million in Asia (GLIPHA, 2006). In 2001, the total camel population was 19 million of which 17 million were dromedaries (*Camelus dromedarius*) and 2 million were Bactrian camels (*Camelus bactrianus*) (Farah, 2004). In most countries, the camel population is increasing after a period of decreasing number due to the introduction of modern transport facilities (Farah, 2004). Kenya has an estimated dromedary camel population of 2,971,000, with majority of the camels about 1,700,000 (57%) in North Eastern followed by Rift Valley Province carrying 968,000 (33%) camels (Kenya National Census, 2009). West Pokot County has a

population of 30,600 camels with majority of the camels found in Pokot North Sub County (Kenya National Census, 2009).

1.1.3 Local breeds of camels

There are three local recognizable dromedary camel breeds in Kenya which are named after the pastoral communities who own and keep them. These are Somali, Rendille/Gabbra and Turkana breeds; the former generally being the largest and the later the smallest in size (Bremaud, 1969, Simpkin, 1983). The fourth breed is the exotic "Pakistani" breed which was introduced into Kenya in the last three decades by researchers and development agents (Hulsebusch and Kaufmann, 2002). This breed has better productive and genetic characteristics compared to the local breeds.

The Somali breed camels are named after the pastoralist group of the same name and referred to as Benadir camels (probably the same as the Benadir type found in Somalia) by some authors (Wilson, 1984). They are primarily owned by the Somali people of North-Eastern province of Kenya, are the most productive local breed, and can be considered as part of the larger population of camels in Somalia (Karue, 1989). This breed of camels is generally larger than the other breeds found in the country (Bremaud, 1969; Kegode, 1990). Field (1993) and Simpkin (1995a) reported that Somali breed camel owners in Kenya differentiated camels into three, or sometimes four, races: that is Sifdaar, Hoor, Gelab and Aidimo.

These different races may be associated to certain Somali clans or families (Simpkin, 1995a). According to Simpkin (1996) the Somali breed camel in Kenya produces more milk than the Turkana breed under the identical conditions. Rendille/Gabbra breed camels are found mainly in Marsabit County amongst the Rendille and Gabbra tribes (Simpkin, 1995a). The traditions of

these people against selling or trading breeding females with other people have limited the distribution of these camels (Stiles, 1995). The Turkana breed camels are commonly found in Turkana County as well as Samburu and Pokot counties where they were obtained by trading or raiding (Stiles, 1995).

1.1.4 Socio-Economic importance of the camel in Kenya

The ASALs occupy 89% of the of the Kenyan landmass of which 70% is arid (Northern Kenya) and 19% semi-arid lands dispersed all over the country (Government of Kenya Sessional Paper No 8 for 2012 and Kenya Country Program Paper (CPP) October 2012). The ASALs are home to about 14 million people, of whom 4 million are pastoralists (Kirbride and Grahn 2008). Approximately 95% of ASAL households derive their income from the livestock subsector where 70% of livestock is produced. The camel is considered to be potentially the most important animal source of food in pastoral areas (Farah *et al*., 2006).

Schwartz and Dioli, (1992) reported that dromedary camel is a multipurpose animal adapted to the harsh environments of semi-arid and arid zones, essentially kept for milk and meat production and transportation. It is also a financial reserve (asset) and security (drought-prone risk management) for pastoralists and plays an important role in social prestige and wealth.

The position of the camel in providing food for the pastoralists in Northern Kenya may become even more important in the face of global warming and climate change (Ndikumana *et al*,. 2000). Camels (*Camelus dromedarius*) are multipurpose animals increasingly kept for milk and meat (Abdurahman, 2005). Nomadic pastoralist communities living in ASAL regions largely

depend on milk produced by camels which contribute 80% of the household needs (Schwartz and Dioli, 1992; Guliye, 2006).

Camel milk is one of the main components of diet of the nomads in semiarid and arid zones and is an essential food for livelihood of people and it may be the only milk available in places where other milking animals cannot be maintained (Kazmi, 2002; Abdurahman, 2006). Camels may produce six times the volume of milk produced by local cattle under the same arid conditions (Field and Simpkin, 1985). This milk is an important source of protein (Yagoub, 2003) for nomadic tribes and the ignored rural citizens. Also it is a good source of vitamin C in these areas where the traditional sources of vitamin C are rare (Schwartz and Diole, 1992; Wilson, 1998). The amount of vitamin C in camel milk is said to be three times more than in the cow's milk, iron content ten times and B vitamins present in reasonable amounts (Barbour *et al*., 1985; Elagamy *et al*., 1992; Arrowal *et al.,* 2005). Unfortunately, many reports revealed that lactating she-camels easily succumb to mastitis (Abdurhman *et al*., 1995, Obied *et al.*,1996, Abdel Gadir *et al*., 2006).

Apart from being source of food, camels' milk is also taken traditionally for the control and management of diabetes type-1 and a recent study in India has given scientific support to this belief (Agrawal *et al.*, 2002). Clinical trials in human diabetes mellitus type 1 have shown that camel milk reduces the need for insulin medication by an average of 30% (Agrawal *et al*., 2005). This is attributed to the fact that camels browse on various plant species and the active agents with therapeutic properties from these plants are secreted into the milk of camels (Muli *et al*., 2008). There is also an account in the memories of Emperor Jahangir (1579-1627 AD) about the usefulness and acceptability of camel milk (Rogers, 1989). It was found that one of the camel milk proteins has many characteristics similar to insulin (Beg *et al*, 1989). Furthermore, it does

not form a coagulum in an acidic environment (Wangoh, 1993). Oral insulin therapy has been known for many years but the important drawback is its coagulum formation in acidic environment such as the stomach, thereby neutralizing its potency. This lack of coagulum formation allows the camel milk to pass rapidly through the stomach together with the specific insulin like-protein and remains available for absorption in the intestine. Radioimmunoassay tests of camel milk has revealed high concentration of insulin at about 52 micro units/ml. The concentration of insulin in human milk is also significantly higher (60.23 ± 41.05 micro units/ml) whereas it is low in cow milk (16.32 ± 5.98 micro units/ml) (Shehadeh *et al*, 2001). There is strong evidence that oral insulin products would provide insulin in a more physiological manner, resulting in a decrease in peripheral insulin concentrations thus "insulinsing" life (Gwinup *et al,* 1991 and Hoffman and Siv, 1997).

The camel is considered the most important dairy animal in Kenya's Arid and Semi-Arid Lands (ASALs) and according to Muli *et al.* (2008), camel milk production in Kenya in 2007 was estimated to have stood at over 340 million litres. Only about 12% of the milk was marketed, the bulk of which was sold in raw form to rural consumers (10%) and only 2% reached urban consumers. From the remaining milk (88%) that did not reach the market, 38% was directly used by camel keeping households and their herders as part of their food requirements and the remaining 50% (or 170 million litres) went into waste representing a great opportunity for commercialization and enhanced incomes for communities in pastoral areas.

Mastitis has both an extreme zoonotic and economic importance and it is the cause of multiple hazardous effects on human health and animal production (Makovec and Ruegg, 2003; Hegazy *et al*., 2004; Al-Majali *et al*., 2008). Little work has been done on mastitis in camels comparing to studies on sheep and cows. Three decades ago, there was no mention of mastitis

problem at herd level; today it is reported from almost all camel rearing countries (Al-Ani and Al-Shareefi, 1998; Guliye *et al*., 2002; Khedid *et al*., 2003; Mohammed *et al*., 2005). Milk is a nutritious food for human beings, but it also serves as a good medium for the growth of many microorganisms, especially bacterial pathogens. *Lactococcus, Lactobacillus, Streptococcus*, *Staphylococcus* and *Micrococcus* spp. are among the common bacterial flora of fresh milk (Chye *et al.*, 2004).

Many different bacteria have been isolated from mastitic mammary glands in camels either in the form of pure or mixed infection (Abdel Gadir *et al*., 2006; Abdurahman, 2006; Hegazy *et al*., 2004; Bekele and Molla, 2001;Woubit *et al*., 2001; Younan *et al*., 2001; Abdurahman, 1996 and Barbour *et al.*, 1985).

1.2 Problem Statement

Camels are adapted to the ASALs, but their full milking potential is affected by udder infections especially sub-clinical mastitis and yet little work has been done on mastitis in camels compared to studies on cows, goats and sheep.

1.3 Objectives

The overall objective of this study was to estimate the prevalence of mastitis and the associated risk factors in traditionally managed one-humped camels in West Pokot County of Kenya. This main objective was achieved through the following two specific objectives;

a) To estimate the prevalence of clinical and sub-clinical mastitis in lactating camels in West Pokot County.
b) To determine the potential risk factors associated with the prevalence of mastitis in lactating camels in the study County.

CHAPTER TWO

2.1 LITERATURE REVIEW

2.1.1 Introduction

In spite of it living in harsh environments of semiarid and arid zones, the dromedary camel is able to produce milk in valuable quantity (Schwartz and Dioli, 1992; Faye, 2005). However, like other dairy animals, dromedary camels could be affected by udder infections such as mastitis, a complex disease occurring worldwide among dairy animals, with heavy economic losses largely due to clinical and subclinical mastitis. The latter requires indirect means of diagnosis (Matofari *et al*., 2003). Camel mastitis is both medically and economically important due to its multiple hazardous effects on human health and animal production (Younan, 2004; Akweya *et al*., 2010; Njage *et al.*, 2010). In addition to these health concerns, mastitis reduces production (Musinga *et al*., 2008) and quality (Matofari *et al*., 2003; Mengistu *et al*., 2010) of milk of traditionally managed camels. In the arid and the semi-arid areas of Kenya (ASALs), milk is consumed fresh or sour posing a health hazard to consumers (Younan, 2004). It has recently come to light (Younan et al., 2001) that infections of the udder of lactating camels are quite widespread. Generally, bacteria in milk can occur through colonization of the teat canal or an infected udder (clinical or subclinical mastitis), or as contaminants (Younan, 2004).

Mastitis can be defined as the inflammation of the mammary gland regardless of the cause and is characterized by physical, chemical and, usually, bacteriological changes in the milk. It is also characterized by pathological changes in the glandular tissue. The most important changes in the milk include discoloration, the presence of milk clots and the presence of a large

number of leucocytes (Radostits *et al*, 2000). Although there is supposed to be swelling, heat, pain and indurations in the mammary gland, a large proportion of mastitis cases are not readily detectable by manual palpation, neither by visual examination of the milk using a strip cup; such cases are referred to as "subclinical mastitis". Because of the very large number of sub-clinical mastitis cases, the diagnosis of mastitis has become dependent largely on indirect tests which depend in turn on the leucocytes content of the milk (Radostits *et al.,* 2000).

Evidence indicates that subclinical mastitis causes suffering of the animal, reduces milk yield, alters milk properties, impairs preservation and processing and is of public health concern for consumers of camel milk (Fthenakis and Jones, 1990; Tibary and Anouassi, 2000). Very little is known about aetiology and occurrence of mastitis in *Camelidae (*Abdel Gadir *et al.,* 2006; Kalla *et al*., 2008). However, cases of mastitis in camel have recently been reported in Saudi Arabia (Barbour et al., 1985); Egypt (Mostafa *et al*., 1987); Somalia (Abdurahman *et al.*, 1991); Ethiopia (Bekele and Molla, 2001); Israel (Guliye et al., 2002) and Kenya (Matofari *et al*., 2003). During the past decade there have been several reports on subclinical mastitis in *dromedary camels* (Obeid, 1983; Arush *et al*., 1984; Quandil and Oudar, 1984; Barbour *et al*., 1985; Mostafa *et al*., 1987) and a few in *Bactrian camels* (Kospakov, 1976a,b); however, little work has been done on subclinical mastitis and the udder's response to bacterial invasion. Barbour *et al*. (1985) and Saber *et al*. (2010) applied CMT to composite milk samples from the *dromedary camels* and concluded that the test was useful for screening subclinically infected udders. Obeid (1983) found a good correlation between the milk leukocyte count and the 'rapid mastitis test'.

The prevalence of mastitis causing organisms in camel milk is a concern of Public Health. Early problem recognition and improved hygiene can reduce the milk loss due to mastitis resulting in high economic gain (Abdurahman, 2006). Better herd management of mastitis can also increase

milk production and thus income for pastoralists (Abdurahman and Younan, 2004). The greatest economic loss of mastitis in both subclinical and clinical mastitis is reduced milk production (Wood and Booth, 1983).

Traditionally, the Pokots are nomadic pastoralists whose lifestyle rotates mainly on livestock keeping but there is evidence to suggest that they have had a longer involvement with camels in the past (McGovern, 1995). Their recent acquisition of camel was through their role as mercenaries during punitive raids against the Turkana in 1917, or trading with Somali camel traders in the 1950s (Bollig, 1992).

Access of the camel calf to the dam is the most commonly used stimulus for initiating milk let down (Dorman, 1984). The calves are often only permitted to initiate milk letdown by suckling for 1-2 minutes (Mares, 1954; Hashi, 1984; Simpkin, 1985) and are then either totally restricted from suckling whilst all the four quarters are milked, or permitted to suckle one or two teats whilst the remainder are milked.

2.1.2 Epidemiology of Mastitis

2.1.2.1 Occurrence and distribution of mastitis

The prevalence and causes of mastitis differ markedly due to geographical area and individual herd management (Guidry, 1985). Even in well-managed herds, as judged by somatic cell count level and a low level of milk production, there may still be occurrence of high incidence of clinical mastitis (Erskine *et al*., 1989; Hogan *et al*., 1990 and Schukken *et al*., 1991).

Clinical mastitis is mostly caused by bacteria with the most important causative agents being *Staphylococcus aureus*, *Streptococcus spp* (*Streptococcus uberis* and *dysagalactia)*, *Escherichia coli* and *Klebsiella spp*.

Clinical mastitis is only an indicator of the herd infection though subclinical mastitis is by far the more costly disease in the majority of herds, and is often defined as the presence of a microorganism in combination with an elevated somatic cell count (SCC) in the milk. In subclinical mastitis, there are no obvious clinical signs such as milk clot and flakes, udder swelling or tenderness, or systemic signs such as fever, depression. Instead there is an increase in somatic cell counts of the milk (Radostis *et al.,* 1999).

While clinical mastitis is rather easy to detect, animals suffering from subclinical mastitis are often very difficult to find since there is lack of reliable diagnostic methods, especially at farm level (Leitner *et al.,* 2004). However, two indirect tests *viz.* somatic cell count and bacterial load count are accepted reliably for detecting the early infection (Schalm *et al.,* 1971). In addition, other indirect tests like White Side Test and California Mastitis Test (CMT) have been developed for rapid screening of udder infection (Schalm *et al.,* 1971; Guha *et al.,* 1989). If the cases are not detected on time, subclinical mastitis may progress and develop into clinical mastitis (Adwan *et al*., 2005). Mastitis is a complex disease problem and presents as a classical example of the interaction of microorganisms, host factors and the environment.

Infection patterns

There are two distinct patterns in the epidemiology of mastitis that can be recognized;

The contagious disease pattern where transfer of microorganisms from animal to animal is essential to propagate the disease.

The opportunistic microorganisms' pattern where host factors and environmental factors put an animal at risk. A wide range of microorganisms can then enter the mammary gland and cause the disease.

Contagious mastitis can be transmitted from an infected or carrier animal to a susceptible host. The organisms mainly associated with the spread of contagious mastitis in the dairy population are *Streptococcus agalactiae* and *Staphylococcus aureus* (Natzke, 1981). Other epidemic contagious disease outbreaks have been reported, and involve *Nocardia spp, Mycoplasma spp*. and in some situations environmental Streptococci.

Contagious diseases only remain endemic when the mean number of susceptible individuals infected by the respective organism is appreciably larger than one (Becker, 1989).

Reduction of the number of new mastitis infections is the major goal of any mastitis prevention program. New mastitis infections may be reduced by optimizing milking procedures and post milking teat disinfection. These practices can reduce the number of shedders in the herd, separate the shedders from the uninfected camels, and optimize the immune function of the animal, which are key components of decreasing new infections. Eliminating existing infections reduces the exposure of susceptible quarters and may be obtained by treatment during lactation or at dry off, or by culling of the infected animals. Again, separation of the infected animals from the susceptible group may also be an effective method to limit the exposure of susceptible animals and reduce the risk of new infections.

2.1.2.2 Disease determinants for mastitis infections

2.1.2.2.1 Disease causative agents

Historically, mastitis pathogens have been classified as either “contagious” or “environmental” (Blowery & Edmondson, 1995). The contagious pathogens are considered as organisms adapted to survive within the host, in particular within the mammary gland, and are typically spread from animal to animal at or around the time of milking (Radostits *et al.*, 1994, Blowery and Edmondson, 1995). In contrast, the environmental pathogens are best described as opportunistic invaders of the mammary gland, not especially adapted to survival within the host; typically they enter, multiply, elicit a host immune response and are eliminated. The major contagious pathogens are *Staphylococcus aureus*, *Streptococcus dysgalactiae* and *Streptococcus agalactiae* and the major environmental pathogens are the *Enterobacteriacae* and *Streptococcus uberis.*

Incidences of pathogenic organisms in camel milk have been reported in Kenya (Younan *et al.*, 2000). The most common isolates from camel mastitis are *Streptococcus agalactiae* and *Staphylococcus aureus*, however other isolates such as *Streptococcus uberis, Streptococcus dysgalactiae, Streptococcus pyogenes, Diplococcus pneumonia, Escherichia coli, Bacillus cereus, Corynebacterium bovis, Pseudomonas aeruginosa, Pasteurella spp., Pasteurella haemolytica* (chronic suppurative mastitis), *Klebsiella spp., Corynebacterium pseudotuberculosis, Corynebacterium equi and Corynebacterium Pyogenes, Candida albicans* have also been reported (Barbour *et al*., 1985; Almaw and Molla, 2000 and Bekele and Molla, 2001).

Smith *et al*., (1985) reported that the most important microorganisms involved in mastitis are the coliforms (*E. coli* and *Klebsiella* spp.) and the environmental *Streptococcus spp*. The severity of clinical mastitis depends on other microorganism related factors such as serum resistance and antigen determinants. However, any control/treatment approach that is only based on microorganism elimination is likely to fail because most host and environmental risk factors will still remain. It is likely that another microorganism will fill the niche that is created by expelling one specific organism. Many different bacteria have been isolated from mastitic mammary glands in camels either in the form of pure or mixed infection (Barbour *et al.*, 1985; Abdurahman, 1996; Bekele and Molla, 2001; Younan *et al*., 2001; Woubit *et al*., 2001; Hegazy *et al*., 2004; Abdurahman, 2006 and Abdel Gadir *et al*., 2006). The prevalence and causes of mastitis differ markedly due to geographical area and individual herd management (Guidry, 1985).

2.1.2.2.2 Host factors associated with mastitis

Several host factors are important in determining the probability of an infection in camels.

Most infections do not result in the development of clinical signs, and host characteristics' for example: peripheral blood leukocyte activity, blood leukocyte count, and presence of antibodies partially predict the outcome of infection (Lohuis, 1989). Other factors such as age of the animal, nutritional status, stress and milk production level also affect the outcome of infection. Animals in early lactation appear to be more susceptible to clinical mastitis and have a relatively high probability of becoming severely sick.

2.1.2.2.3 Environmental factors associated with mastitis

Environmental factors play significant role in the prevalence of sub-clinical (Sandholm, 1995) and clinical (Honkanen-Buzalski and Pyörälä, 1995) mastitis in dairy animals. Several factors in the environment affect the exposure of a camel to microorganisms. Sources of environmental contamination include manure, milkers hands, feeds, dirt, mud and water. A good example of this is *E. coli,* which is present in the environment of the camel.

Observational studies have shown that most infections with coliform and environmental Streptococcus take place in the last two weeks before calving, and often only show signs of clinical mastitis after calving. Reducing exposure of the mammary gland by improving hygiene or providing a physical barrier at the teat end have shown to reduce the incidence of mastitis.

2.1.2.3 Diagnosis of mastitis

a) California mastitis test (CMT)

Schukken *et al.* (1988) reported that CMT remains the only reliable screening test for detection of subclinical mastitis in dairy herds. Kapaga *et al*. (1995) concluded that CMT test is a good tool for epidemiological survey of sub-clinical mastitis in dairy herds. Abdurahman (1998) stated that 100 % of the CMT positive samples tested were positive with pathogenic bacteria. Apparently there is a significant positive correlation between positive CMT results and the presence of clinical mastitis in dromedaries (Barbour *et al*., 1985; Kinne & Wernery, 2002). This leads to the presumption that the camel, like the cow, has phagocytic cells as one of the essential defence mechanisms of the mammary gland against pathogenic microorganisms (Schalm *et al*., 1971; Barbour *et al*., 1985; Abdurahman *et al*., 1992; Saad & Thabet, 1993).

b) Electrical activity in camel milk.

The electrical conductivity was not considered adequate as method for mastitis diagnosis in camels by Younan *et al*. (2001) and Bhatt *et al*. (2004) as no significant change can be proved in case of mastitis. Electrical conductivity is defined as the resistance of a material to electric current. It is widely used as a simple and effective tool for mastitis diagnosis in cows. In case of mastitis, the cell membranes of the udder parenchyma are damaged. This increases the permeability of the barrier between blood and milk. The content of chloride (Cl-) and sodium (Na+) increases and the content of lactose and potassium (K+) decreases leading to a higher electrical conductivity of the milk. The average conductivity of cow milk ranges between 4 and 5.8 mS/cm and depends on lactation stage, age, milking interval and race of the individual animal (Nielen *et al*., 1992; Walzel, 1997; Billon *et al*., 2001).

c) N-acetyl-ß-D-Glucosaminidase (NAGase)

N-acetyl-ß-D-Glucosaminidase (NAGase) is a lysosomal enzyme released from damaged epithelial and other somatic cells in the mammary gland estimated as a good indicator of mastitis in bovine and ovine milk. In camel milk NAGase activity is significantly higher than in cow milk which might be due to the high count of cell fragments. It does not clearly correlate with bacterial findings in contrary to somatic cells count (SCC) (Abdurahman, 1995; Guliye, 1996; Chaffer *et al*., 2000). Therefore NAGase activity has not been investigated as a diagnostic mean for infections or inflammations of camel udders.

d) Further diagnostic means for camel mastitis

Billon *et al*. (2001) proposed as additional diagnostic mean of subclinical mastitis in cows the close observation of the daily milk yield. In camels, the implementation of this idea could be difficult as dromedaries react very sensitively to their environment with yield variations. But generally, it is important to verify the udder health and general health status of the camels. As camels are very sensitive to udder pain, development of clinical mastitis can be easily detected.

2.1.2.4 Treatment of mastitis in camels

Various procedures have been proposed and/or tried for mastitis treatment in camels. Although some authors have suggested daily intramammary infusions with an antibiotic preparation, as applied in cows, there is reservation to this practice because of the particular anatomy of the camelidae udder and because of the difficulty in administering such treatment (Tibary and Anouassi, 2000). The therapeutic approach in treating acute mastitis is via systemic antibiotics (e.g. trimethoprim – sulfamethoxazole or penicillin/ Aminoglycoside) and anti-inflammatory drugs (flunixin meglumine), with regular stripping of the mammary glands. Hydrotherapy is also beneficial in reducing local edema.

Due to the smaller diameter of camel teats, intramammary tubes designed for administration in cattle are often unsuitable for routine use in camels. Currently, antibiotic intramammary tubes have been of limited success and it may be necessary to design an applicator with a finer nozzle (Younan, 2002). Camel teats have two or three teat orifices. There

is still lack of consensus as to whether the different teat openings also represent separate gland complexes (Khanna , 1986; Wernery , 2003) .

The teat of the camel udder may sometimes contain three separate teat canals that open independently into the teat sphincter. The separate canals drain separate gland complexes (Nosier, 1974); Smuts and Bezuidenhout, 1987). The latter implies that for intramammary treatment of mastitis, not only must each quarter but also each gland complex be treated separately, that is, one intramammary tube per gland complex. Great caution is therefore necessary when applying intramammary treatment to camels given that the teat canal openings in camel are smaller than those of the cow and thus require smaller canula. Unhygienic and traumatic application of intramammary treatment is very likely to cause more harm than good.

In the absence of control measures, *Streptococcus agalactiae* is the most common mastitis pathogen in dairy cattle (Aguilera, 1984) with average morbidity rates of 25% (Radostits *et al*, 1997). *Streptococcus agalactiae* eradication programs have been successful in dairy cattle herds and are economically justifiable (Edmondson, 1989); Hejlicek, 1994; Radostits *et al*, 1997). Intramammary infections (IMI) with *Streptococcus agalactiae* (Lancefield type B) in camels are common and have been diagnosed in the United Arab Emirates (Quandil and Qudar, 1984); Egypt (Karamy, 1990); Sudan (Abdurahman *et al*, 1995; Obied *et al.*, 1996) and Somalia (Younan *et al*, 2002). In Northern Kenya, *Streptococcus agalactiae* IMI prevalence of up to 50% in market oriented camel dairy herd (Younan *et al*, 2001) have become a concern to camel owners. One case of successful parenteral treatment of mastitis in a camel is reported in the literature (Barbour *et al.*, 1985). However, published treatment recommendations for mastitis in camels have not been validated (Youssef, 1992; Faye, 1997).

Pastoralists also use various traditional (ethno-veterinary) practices to treat sick camels (Bornstein, 1993; Hussein, 1993). However, the success and efficacy of these methods have not been verified.

2.1.2.5 Control of Camel Mastitis

The specific steps of all udder health management programs must be devised to fulfill three basic principles and these are: - elimination of existing infections, prevention of new infections and monitoring of udder health status (Radostits *et al.,* 1994). To establish an efficient mastitis control program in a dairy herd, baseline information on the nature of mastitis and economic impact of the problem needs to be known (Honkanen-Buzalski and Pyörälä, 1995). The principal steps in mastitis control program are to undertake a preliminary mastitis screening survey and to evaluate the udder health status in the herd (Honkanen-Buzalski and Pyörälä, 1995).

Mastitis can be prevented or reduced by improving animal health and udder hygiene but currently, there appears to be non-existence of modern mastitis control measures practiced by camel keepers. Attention must be paid to udder health and hygiene, not only during lactation, but even when the animal is dry. Animals suffering from any contagious disease, including mastitis, should be separated from the healthy animals and milk from diseased camels should be kept separate and disposed off safely. It is cheaper and easier to prevent mastitis by improving hygienic measures and culling chronically-infected camels to eliminate important pathogen reservoirs, than to treat by medication. The cost of treatment includes veterinary fees, medicine,

and the risk of quackery and costs of milk production. Any unprofessional management or treatment of camel mastitis can contribute to the buildup of antibiotic resistance.

2.1.2.6 Economic importance of mastitis in camels

Controlling mastitis is important for the dairy industry because the condition has significant ramifications. These include financial losses to dairy farmers, adverse effects on dairy animal welfare and potential influences on public health. The broad use of antibiotics in the treatment and control of mastitis has possible implications for human health through an increased risk of antibiotic resistant strains of bacteria emerging that may enter the food chain (White and McDermott, 2001).

Financial loss from clinical mastitis arises from the costs of treatment, culling, death, decreased milk production and decreased milk revenue. A single case of clinical mastitis is associated with average losses of around £175 (Kossaibati, 2000), and clinical mastitis on an average dairy unit accounts for approximately 38% of the total direct costs of the common production diseases (Kossaibati & Esslemont, 1997). Clinical mastitis in bovine alone has been estimated to cost the UK dairy industry in excess of £168 million per annum (Bradley, 2002).

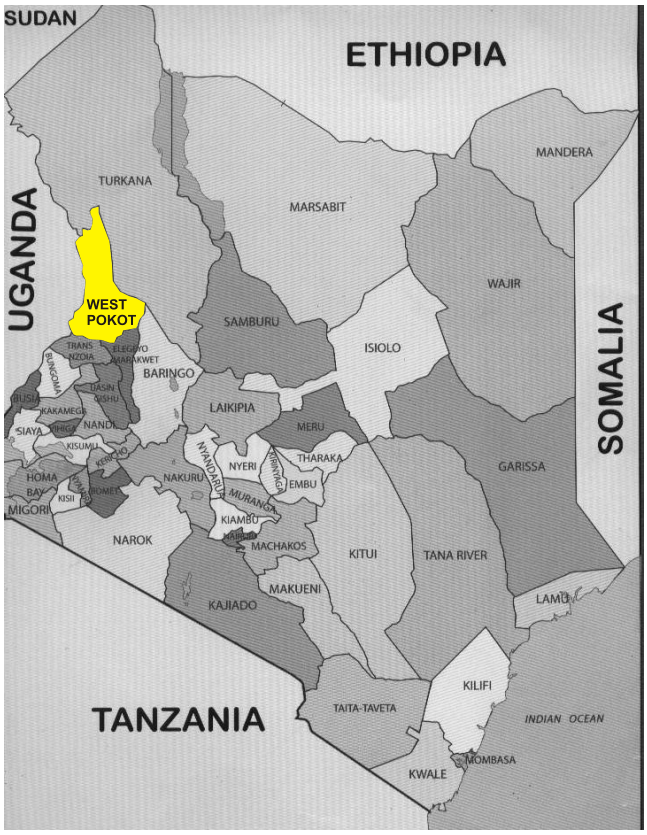
It is more difficult to quantify the losses associated with sub-clinical mastitis, because these are more variable, but losses arise from treatment costs, reduced milk yield, and decreased constituent quality, loss of livelihood and an increase in the risk of culling. However there are no estimated economic estimates available as per now.

CHAPTER THREE:

3.1 MATERIALS AND METHODS

3.1.1 Study area

The study was carried out in West Pokot County in the former Rift Valley Province of Kenya as shown in Figure 3.1.



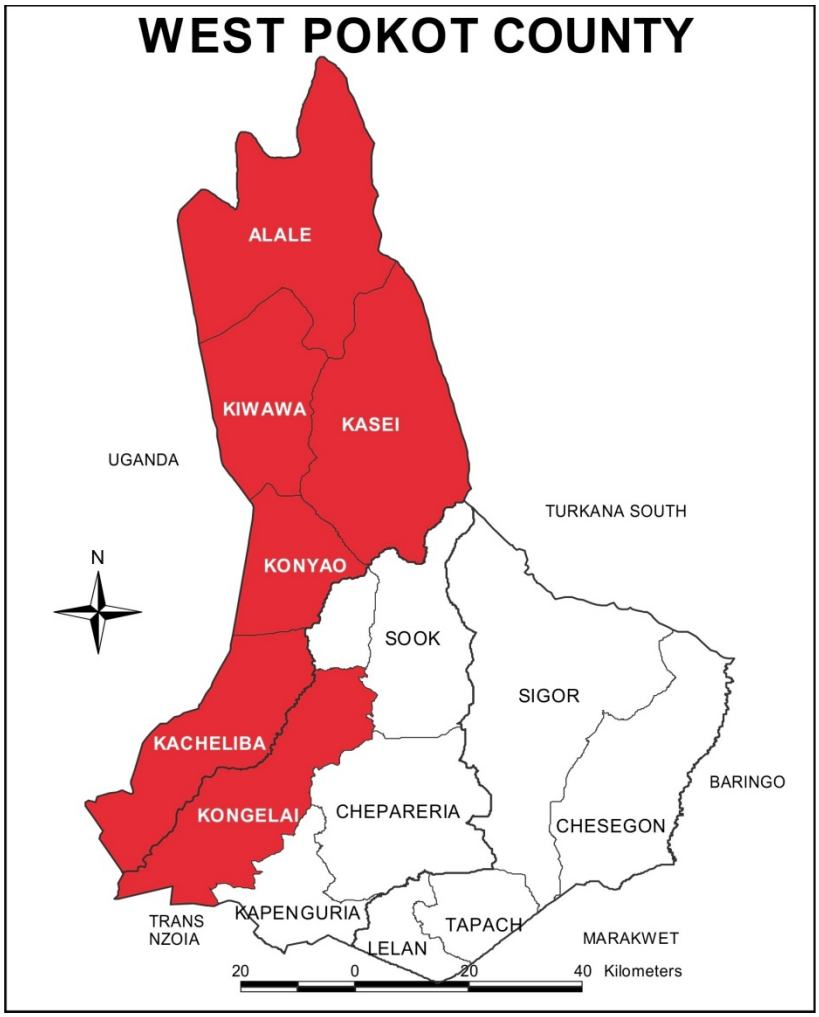
Source: Ministry for development of Northern Kenya and other arid lands

Figure 3.1: Map of Kenya showing West Pokot County the study area

West Pokot County is one of the 14 Counties that made the former Rift Valley Province of Kenya (Constitution of Kenya, 2010). It borders Uganda to the West, Trans Nzoia and Elgeyo-Marakwet Counties to the South, Turkana County to the North and East and Baringo

County to the South East. Geographically, it lies between Latitudes $1^0$10' and 3^0 40' N and Longitudes 34^0 50'and 35^0 50'E (Macmillan Education Ltd., 1999). The County has a total area estimated at 9,100 square kilometers and stretches a distance of 132 km from North to South. The County administrative headquarters is at Kapenguria town and the County is divided into four districts, 14 divisions, 58 locations and 188 sub-locations.

In times of peace between the Pokots who are the main inhabitants of West Pokot County and the Karamojong of Uganda, livestock (camels included) graze and browse across the border into Uganda.



Source: Ministry for development of Northern Kenya and other arid lands

Figure 3.2: Map of West Pokot County showing the six study divisions

Rainfall is bimodal with the long rains falling between March and June and the short rains occurring from September to November. The rainfall amounts range from 700 mm in the lowlands to 1600mm in the high altitude zones. Temperatures in the lowlands range from15ºC to 30ºC but the highlands may experience temperatures as low as 9ºC. The major drainage systems in the County are Turkwel, Kerio and Nzoia rivers. Both the Turkwel and Kerio Rivers drain Northwards into Lake Turkana while Nzoia River drains into the Lake Victoria in the South.

Traditionally, the Pokots are nomadic pastoralists whose lifestyle is rapidly changing to sedentary mixed farmers, especially in areas where conditions permit. Like many other arid and semi arid areas in the country, the area has been experiencing rapid population growth for both human and livestock. Physical infrastructure such as roads, telecommunications, hospitals and schools are poorly developed. The harsh climatic conditions over most of the area and difficult terrain make a large proportion of the County inaccessible. Traditional mobile pastoral lifestyle is practiced by most of the community members. The sustainable utilization of natural resources in the County is hampered by mainly socio-economic and technical capacity.

Insecurity was rampant in the County in the past and often involved theft of livestock, but there has been major shift towards the restoration of peace with neighbouring communities. Conflict over grazing resources is also common in part due to the breakdown of traditional pasture management systems and increasing individual herds. Insecurity especially across the border makes sustainable utilization of livestock resources difficult.

Livestock is the most important economic resource in the County and supports the main livelihood system. The main livestock species found in this County in order of importance are cattle, goats, sheep, donkeys, camels and poultry. There is, however, a gradual change in this order in response to population pressure, competition and availability for pasture. Consequently, agro-pastoralism is taking root in the County with a marked increase in crop farming where possible.

Another discernible shift is the rising popularity of goats and camels in relation to cattle in view of limited grass availability and more browse availability. Emerging livestock, especially poultry is also rising in popularity as women and youth who are not traditionally allowed to own cattle keep them and can easily sell them to raise money in periods of emergency need.

There are three sub counties which make up West Pokot County namely Pokot North, Pokot Central and West Pokot sub counties. The estimated livestock population is shown below in Table 3.1.

Table 3.1: Estimated livestock population in West Pokot County

Sub county	Cattle	Sheep	Goats	Camels	Donkeys
West Pokot	129,273	114,050	173,693	294	8,243
North Pokot	377,688	199,977	377,903	29,273	21,671
Pokot Central	179,212	146,300	213,141	1,050	6,559
Total	**686,375**	**460,327**	**764,737**	**30,617**	**36,473**

Source: Kenya National Bureau of Statistics, National Census 2009

3.1.2 Study Design

A cross sectional study was undertaken on 95 lactating and traditionally managed one-hump camels (*Camelus dromedarius*) in several selected households (*manyattas*). These *manyattas* were the sampling units. The study took place during the months of August and November 2012 in Kongelai, Kacheliba, Konyao, Kasei, Kiwawa and Alale divisions of West Pokot County (Figure 3.2).These divisions are the only divisions with the highest population of camels in West Pokot County and they are located along the border between Kenya and Uganda.

3.1.3 Selection of the study sites, households and camels

The divisions within West Pokot County were selected based on the sizeable population of camels, good security and passable roads. The local District Veterinary Officer (DVO) & the District Livestock Production Officer (DLPO) were engaged in the sensitization and mobilization of the camel producers so that the producers would be aware of this study and to explain their expected role in the study. The Kenya Camel Association (KCA) which is an umbrella Association for camel producers in Kenya was also involved in the mobilization of the camel keepers through the local KCA Regional Representatives in the County. The DVOs, DLPOs and KCA prepared the list frame of all the eligible camel owners in each study division within the county. In addition, they indicated the manyattas where there was at least one lactating camel.

All the eligible sampling units along the main road (transect two km on either side) from the South of the County to the furthest division in the North were selected through a systematic random sampling method. The number of camels sampled in each division was proportional to the population of camels in the division. The process continued until the required sample size was reached.

3.1.4 Data collection

Data on household demographics (human and animal) and known and/or reported diseases of camels, and animal level factors (each camel) such as age, parity number, stage of lactation, breed, current milk yield, milk abnormalities, whether the camel has had mastitis before and presence of udder/teat lesions were collected and recorded in a semi-structured

questionnaire (SSQ) (Appendix I) during sampling. Data were gathered through interviews administered to the household head or any other household member conversant with the camel management.

The age of the camels was estimated (by observing the eruption and wearing of the front permanent teeth) since there were no records available and were categorized as young adults (>4yrs to 6yrs), adults≥(6yrs to≤ 8yrs) and old >8yrs. The stage (length) of lactation was categorized as early (1st to 4th month), mid (> 4th month to 8th month) and late (> 8th month). Number of parity was categorized as few≤(3 calves), moderate (4 -7 calves) and many (> 7 calves).

The SSQ were also used to capture data from direct observations in addition to one-on-one interviews with the camel owners.

Data collected at herd-level included; herd size, the producer's knowledge on treatment attempts & control of mastitis (both conventional and traditional methods), milking frequencies & procedures such as washing the udder with clean warm water before milking.

3.1.5 Sample size determination for the number of milk samples

The following formula was used to calculate the sample size (Dohoo *et al*., 2003):

$n = Z_{\alpha}^2 pq/L^{2,}$ where, n=sample size, Zα = the value of z that gives 95% confidence interval (1.96), p = *a priori* prevalence (estimated prevalence), q = 1-p and L = Allowable error.

The prevalence of mastitis in camels in Kenya was estimated at 25% as was reported by Younan *et al* (2001). Thus adopting a p of 25% and L of 5%, then;

$n = (1.96^2 * 0.25 * 0.75)/ (0.05)^2 = 290$ (quarter milk samples).

3.1.6 Collection of milk samples

Prior to the commencement of sample taking the camel owner's consent was obtained after explaining the purpose of the study. Milk samples were then aseptically collected from each individual quarter from 95 lactating camels (14 from Kongelai, 10 from Kacheliba, 2 from Konyao, 37 from Kiwawa, 23 from Kasei and 9 from Alale division) during either morning, midday or evening milking time depending on what was logistically convenient. This was done after the calf was allowed to suckle to allow milk let down. Visual examination (by observation and palpation) of all the quarters was also carried out.

About 20 ml of milk was collected from each quarter directly into clean and sterile sample bottles that were clearly labeled and immediately stored in cool boxes with ice packs before refrigeration in the evening at around 5^0C and later transported in cool boxes with ice packs to the Bacteriology Laboratory at the Department of Veterinary Pathology, Microbiology and Parasitology, Faculty of Veterinary Medicine, University of Nairobi for bacterial culture.

3.1.7 Examination for sub-clinical mastitis at household level

This was done by carrying out California Mastitis Test (CMT) using the method described by Schalm and Noorlander (1957) immediately after sample collection an equal volume (about 2ml) of CMT reagents (Delaval, Poland) mix with an equal volume (about 2ml) of sampled milk in each segment of the CMT paddle and mixed gently. The results were read and visually scored for each quarter within ten seconds depending upon the amount of gel formation as follows:

Negative = no reaction.

Trace = appearance of streaks that can be made visible during rotation of the plate.

1+= distinct thickening during rotation, but no gel.

2+ = slight formation of gel which follows the rotating plate very slowly.

3+ = solid formation of gel that adheres to the base of the plate.

Quarters whose scores were negative, trace and 1+ were considered healthy while scores $\geq$ 2+ were considered infected or positive for subclinical mastitis. The test mixture (milk sample and the CMT reagent) was discarded and the paddle washed with clean water after each use to enable it to be used in the next selected lactating camel.

3.1.8 Bacteriological Examination and Isolations

After culturing, bacteriological examination was carried out following standard methods *laboratory and field handbook on bovine mastitis – (1987*), Sears *et al* (1993) and Quinn *et al* (1994) to identify major bacterial agents associated with mastitis. In brief, milk samples from the deep freezer were thawed to room temperature and one loopful (10ul or 0.01ml) of the samples was aseptically streaked on Blood Agar (5% defibrinated sheep blood) plates and MacConkey Agar (MA) plates (Carter *et al*, 1991). Bacterial growths were identified and recorded after incubation for 24 to 48 hours at 37ºC aerobically. Primary cultures were considered to be positive when bacterial growth was observed on the inoculated plates and negative when no bacterial growth was observed.

Pure culture was further obtained by sub-culturing part of typical and well isolated colony on a corresponding medium and incubated further at 37ºC aerobically for 24 hours.

Identification of bacterial isolates was done based on colony morphological features and hemolytic reactions (primary cultures), gram staining reactions and biochemical tests on pure cultures (Quinn *et al.*, 1994). Gram stain procedures were performed according to the method described by (Quinn *et al*., 1998; Bebora *et al*., 2007 and Forbes *et al*., 2007). To differentiate *Staphylococcus* and *Streptococcus spp*, catalase reaction was performed on all Gram- positive isolates employing the rapid slide technique described by Cheesburgh (2000). A drop of 3% hydrogen peroxide was placed on a slide, organism was added & mixed and observed for bubbling to confirm the presence of catalase enzyme. Catalase negative reaction indicated presence of *Streptococcus spp* whereas catalase positive indicated *Staphylococcus spp*. Coagulase test was carried out to differentiate *Staphylococcus aureus* from other *Staphylococcus spp*. CAMP (Christie, Atkins and Munch-Petersen) test and growth in MacConkey agar plate was also carried out to differentiate *Streptococcus agalactiae* from other mastitis causing Streptococcus.

3.1.9 Statistical Data Analysis

All data collected were entered in Microsoft Excel 2007 worksheet as database and exported to Instat Plus for statistical analysis. Descriptive statistics were generated using the same statistical package. Differences in proportions were assessed using the chi square at 5% level of significance in univariate analysis.

The odds ratio (OR) was used to assess the strength of any associations identified, initially in the logistic regression univariate analysis to screen variables ($p<0.1$) and later multivariate logistic regression models were used to test the above variables for significance

($p<0.05$). Significance of risk factors on the presence of mastitis (the variable outcome) was calculated using chi-square (x2) technique to test the existence of statistical association between mastitis and the risk factors (explanatory variables) such as age, parity, stage of lactation and breed. In all chi-square test applications level of $p<0.05$ was considered statistically significant. In addition logistic regression analysis was used to calculate the odds ratio (OR) to measure the degree/strength of association between the risk factors and the presence of mastitis in camel.

3.1.10 Definition of outcome variables

a) Subclinical mastitis defined by CMT

All CMT results/scores were judged as follows; trace and 1+ considered negative and 2+, 3+, 4+ & 5+ considered positive results. A quarter was considered CMT-Positive if it had a score of ≥ 2+ while a camel was defined CMT-Positive if it had at least one quarter with a CMT score ≥ 2+.

b) Subclinical mastitis defined by microbiological cultures

A quarter was defined as positive when a pathogen (bacterium) was isolated during microbiological culture. A camel was considered positive when at least one quarter milk sample had a pathogen isolated. When a herd had a camel with mastitis, that herd was considered positive for mastitis.

CHAPTER FOUR

4.1 RESULTS

4.1.1 Characterization of camel management practices

The results of the study showed that, many Pokot camel owners generally milked their camels thrice a day (90.4% (47/52)); at dawn or early in the morning; at 10 am (*limo* in Pokot) and at night about 8.00pm (2-3 hours after returning from grazing). Only 9.6% (5/52) milked their camels twice a day. Majority of the milkers (82.7% (43/52)) washed their hands once before milking all the livestock beginning with goats, cows and lastly the camels; while 17.3% (9/52) did not wash their hands at all. On washing the udder before milking, 76.9% (40/52) did not wash the udder. They believed that the calf would clean the udder by suckling. About 7.7% (4/52) washed the udder before milking. These were mostly camel keepers around trading centres. Those who did not respond to the practice of washing udder before milking were 15.4% (8/52) (Table 4.1).

Most (75% (39/52)) of the treatment of camel mastitis was done by the owners. Few (26.9% (14/52)) went for some assistance from the Community-based animal health workers (CBAHWs). Veterinarians (VOs) and animal health assistants (AHAs) were not consulted on treatment of mastitis. During mastitis infection, 75% (39/52) did not follow the milking order by starting to milk the clean camels first and the infected camels last. The rest 25% (13/52) (as shown in Table 4.1) abandoned milking the infected camel and left the calf to suckle. They claimed the camel was feeling pain during milking.

The camels were herded during the daytime on communal grazing lands and kept at night in traditional enclosures (*bigh* in Pokot) made of thorny bushes and tree branches as protection from predators. At night the calves were penned separately but during the day they accompanied their mothers and suckled freely. The milking frequency reduced or increased depending on the season, yield and the stage of lactation of the camels. It was also observed that the Pokots did not milk their camels outside the homesteads.

Table 4.1: Camel management practices

Household practices		**Frequency**	**Percentage (%)**
Milking Rates	Thrice a day	47	90.4
	Twice a day & below	5	9.6
Wash hands before milking	Yes	43	82.7
	No	9	17.3
Wash the udder before milking	Yes	4	7.7
	No	40	76.9
	No respond	8	15.4
Who milks the camels	Owners	14	26.9
	Wives	16	30.8
	Herders (young boys)	22	42.3
Who treats camels with mastitis	V.O	0	0
	AHA	0	0
	Self	39	75
	CBAHWs	14	26.9
Follow milking order during mastitis	Yes	13	25
	No	39	75

It was also observed during the study that the Pokot herders traditionally isolated near term she-camels and even after calving from the rest of the herd during the day and night for a month

before the calf was allowed to accompany the mother during the day for grazing. If a she-camel calved far away from the homestead she was left to remain with the calf for about three days before driven back to the homestead.

Amongst the Pokot people, camels were mostly milked by young boys (herders) (42.3% (22/52)) and adult women (30.8% (16/52)). In the absence of women, the men (26.9% (14/52)) could also milk the camels. During milking they allowed the calf to suckle to stimulate milk let down. It was also observed that the Pokot pastoralists kept camels together with other livestocks such as cattle, sheep and goats in the same *Manyatta*.

The herders also reported that camel mastitis existed in West Pokot and they believed it affected other livestock and even human beings (women). Majority of the respondents (80.8% (42/52)) as shown in Table 4.2 reported that they had traditional ways of managing the infection which included the following; treating using local herbs 26.9% (14/52) (using leaves, roots & exudates from various plants), 11.5% (6/52) milking the affected udder into a red hot *Panga* so that the smoke goes back to the udder to treat it, 21.2% (11/52) branding with hot Iron, 17.3% (9/52) smear with accaricide (dip) to prevent flies especially in the case of gangrenous mastitis. Two pastoralists (3.8%) from Kasei division reported they used *dawa nyoka* (anti-venom) to treat mastitis because they associated camel mastitis with snake bites.

Table 4. 2: Traditional ways of managing camel mastitis in West Pokot County

Traditional remedies	Frequency	Percentage (%)
Using local herbs (leaves, roots)	14	26.9
Using hot Iron	11	21.2
Using accaricide (dip)	9	17.3
Using hot *Panga*	6	11.5
Using *dawa nyoka* (anti-venom)	2	3.8
Total	**42**	**80.8**

The study further showed that the most commonly reported camel diseases by the camel keepers included Mange, Trypanosomiasis, mastitis, Haemorragic Septiceamia (HS) and abscesses as shown in Table 4.3. The results showed that mastitis was mentioned among the important diseases.

Table 4. 3: Camel diseases and conditions reported by Pokot herders

Disease or Condition	Local (Pokot) name	Frequencies	%
Mange	*Simbirion*	36	69.2
Trypanosomiasis	*Plis*	34	65.4
Mastitis	*Semewo Krusho*	29	55.8
Haemorrgic Septiceamia (HS)	*Chemotow*	26	50.0
Abscesses	*Pirieng'wa*	15	28.8
Wounds	*Moyoi*	11	21.2
Diarrhoea	*Kiyitagh*	9	17.3
Pneumonia	*Psosoi*	9	17.3
Tick infestation (especially in camel calves)	*Tilis*	8	15.4
Camel Orf	*Ng'rumen*	8	15.4
Sudden death	*Lotuler*	5	9.6
Abortion	*Toronogh*	3	5.8
Worms (Helminthiasis)	*Chepturu*	3	5.8

4.1.2 Household demographics

4.1.2.1 Age and sex distribution

The 52 households interviewed during the study were distributed as follows: Kongelai division (n=5), Kacheliba division (n=7), Konyao division (n=2), Kiwawa division (n=14), Kasei division (n=20) and Alale division (n=4).

Of the 52 households interviewed 86.5% (45/52 households) were headed by males and 13.5% (7/52 households) were headed by females. 100% (52/52) of the households were settled in communal land; therefore most of the camels were reared in communal range land. The age brackets of the camel owners were <20 yrs 3.8% (2/52); 21-30 yrs 15.4% (8/52); 31-40 yrs 36.5% (19/52); 41-50 yrs 26.9% (14/52); 51-60 yrs 9.6% (5/52) and >60 yrs 7.7% (4/52) (Table 4.4 & Figure 4.1). The majority of the camel owners were therefore between 31 & 40 years of age. The least owners of camels were below 20 yrs and above 60 yrs of age.

Table 4. 4: Age and sex distribution of the household's heads interviewed

Age (yrs)	**<20**	**21-30**	**31-40**	**41-50**	**51-60**	**>60**	**Total**
Male	2	5	18	12	4	4	45
Female	0	3	1	2	1	0	7
Total	**2**	**8**	**19**	**14**	**5**	**4**	**52**

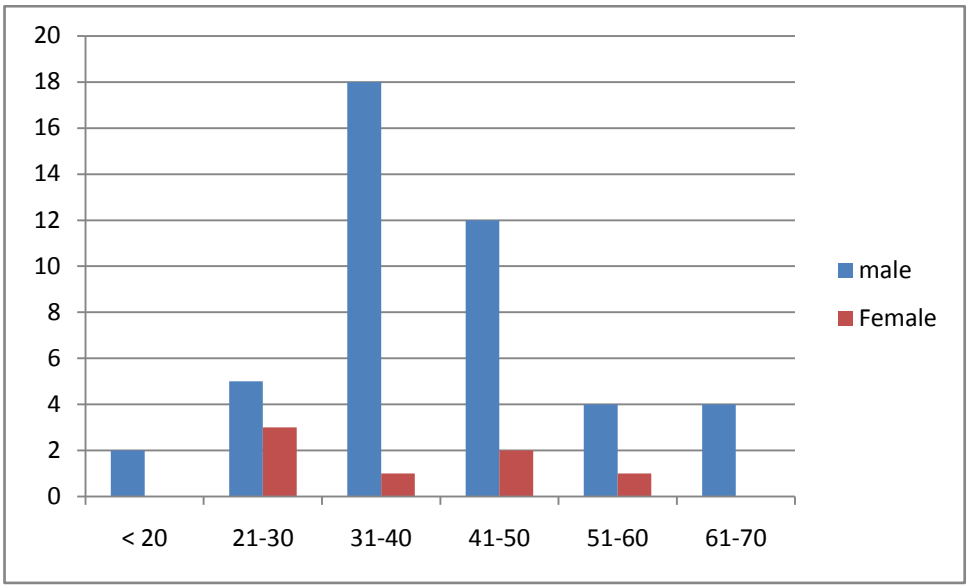


Figure 4.1: Age and sex distribution of the households' heads interviewed

4.1.2.2 Herd structure

The herd structure in the study area showed that there were more (42.9% (67/165)) lactating camels in Kiwawa division compared to other divisions. The least (2.6% (4/156)) number of lactating camels were in Konyao division. There were also more dry herds (41.1% (109/265)) in Kiwawa division than any other division. In overall, there were more (37.4% (326/872) camels in Kiwawa division in comparison to other divisions. Samples were collected from 95 lactating camels from the total of 165 lactating camels in 52 herds in the study areas.The herd size range from 3 to 50 camels with mean herd size of 16.8±. Forty four herds (84.6% (44/52)) tested positive for sub-clinical mastitis against 8 herds (15.4% (8/52)) which tested negative. The rest are as shown in Table 4.5.

Table 4.5: Summary of herd structure per division

Division	Lactating camels	Dry camels	Breeding bulls	Immature males	Immature females	Female calves	Male calves	Total
Kongelai	22	20	7	17	10	9	12	97
Kacheliba	17	27	6	16	26	12	7	110
Konyao	4	13	1	6	6	2	2	34
Kasei	36	51	4	30	31	16	19	187
Kiwawa	67	109	8	32	46	29	36	326
Alale	19	45	3	13	18	13	7	118
Total	**165**	**265**	**29**	**114**	**137**	**81**	**99**	**872**

4.1.3 Laboratory Results on bacterial culture and identification

A total of 380 quarter milk samples (56 from Kongelai division, 40 from Kacheliba division, 8 from Konyao division, 148 from Kiwawa division, 92 from Kasei and 36 from Alale) were collected during the study. The same samples from 95 apparently clinically healthy dromedary camels were cultured in the laboratory to identify subclinical mastitis and its causative agents.

4.1.3.1 Prevalence of subclinical mastitis at animal (camel) level in the study area

The results have shown that the prevalence of subclinical mastitis at animal level was highest in Kongelai division (100% (14/14)) followed by Kasei division (82.6 % (19/23)) then Kacheliba division (80% (8/10)). The lowest prevalence was in Konyao division at 0% (0/2) prevalence as shown in Table 4.6.

The overall animal (camel)-level prevalence of subclinical mastitis in the study area was 76.8% (73/95) out of which 23.2% (22/95 camels) had only one mammary quarter affected, 21.1% (20/95 camels) had two quarters affected, 17.9% (17/95 camels) had three quarters affected while 14.7% (14/95camels) had all the four quarters affected.

Table 4.6: Prevalence of subclinical mastitis at animal (camel) level in the study area

Division	**Positive**	**Negative**	**Total**	**Prevalence (%)**
Kongelai	14	0	14	100
Kasei	19	4	23	82.6
Kacheliba	8	2	10	80
Kiwawa	27	10	37	73
Alale	5	4	9	55.6
Konyao	0	2	2	0
Total	**73**	**22**	**95**	**76.8**

4.1.3.2 Quarter infection rates

Out of the 380 quarter samples cultured for bacteria, 44.5% (169/380) tested positive for subclinical mastitis giving a prevalence of quarter-level mastitis at 44.5% while the rest 55.5% (211/380) of the samples tested negative (Table 4.7 & Appendix II).

Table 4.7: Prevalence of subclinical mastitis at quarter level

Quarter	**Quarter**	**Positive**	**Negative**	**Total**	**Prevalence (%)**
Right	Fore quarter	43	52	95	11.3
Right	Hind quarter	46	49	95	12.1
Total		**89**	**101**	**190**	
Left	Fore quarter	40	55	95	10.5
Left	Hind quarter	40	55	95	10.5
Total		**80**	**110**	**190**	

The results also showed that the right quarters were more affected compared to the left quarters (12.1% (46/380) prevalence for RHQ and 11.3% for RFQ *vs* 10.5% each in both LFQ & LRQ) (Appendix II).

The Mhor & MHCh-2 (Mantel-Haenszel Chi-square) were 0.94 & 0.17 respectively while the adjusted (summary) odds ratio (OR) was 0.88. This showed that mastitis infection and the quarters of the camel udder were not significantly associated.

The results further showed that the RHQ was the most frequently infected quarter at a prevalence of 27.2% (46/169) followed by the RFQ at a prevalence of 25.4% (43/169) (Figure 4.2). The two left quarters (LFQ &LHQ) were least infected as shown in Figure 4.2.

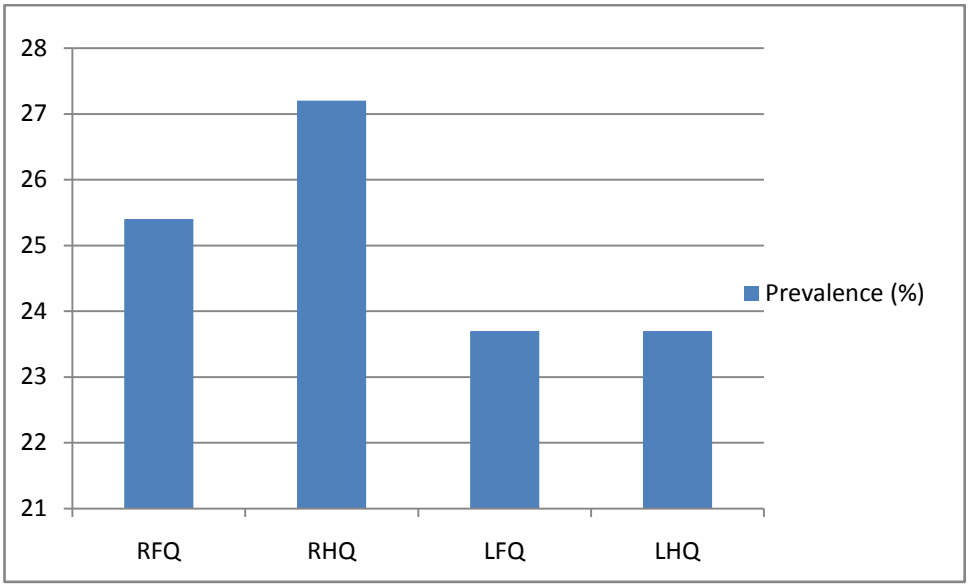


Figure 4.2: Prevalence of subclinical mastitis per quarter

Table 4.7 above was collapsed into two 2x2 tables as shown below in Tables 4.8 & 4.9.

Table 4.8: Prevalence of subclinical mastitis at two quarters (left & right) level

Quarters	Positive	Negative	Total	Prevalence (%)	Odds Ratio (OR)	Chi-square	P- value
Right quarters	89	101	190	46.8	1.2	0.86	0.05
Left quarters	80	110	190	42.1			
Total	**169**	**211**	**380**				

Table 4.9: Prevalence of subclinical mastitis at quarter level showing OR & Chi-2

Quarters	Positive	Negative	Total	Prevalence (%)	Odds Ratio (OR)	Chi-2	P- value
Front Quarters	83	107	190	43.7	0.94	0.1	0.05
Hind Quarters	86	104	190	45.3			
Total	**169**	**211**	**380**				

The results from the two tables above showed that there were no associations between the position of the quarters and the occurrence of mastitis in camels at $p>0.05$. This is because the calculated chi-square values in both tables are less than the critical value of 3.84 at 95% confidence.

4.1.4 Association between the occurrence of mastitis and other risk factors

Among many potential explanatory variables, two were considered as potential risk factors for the occurrence of sub clinical mastitis in this study. These were stage of lactation and parity of the lactating camels. The association of subclinical mastitis with these risk factors using chi-square and odds ratio (OR) are as shown in Table 4.10 and 4.11. The calculated values of both Chi-square and OR in Tables 4.9 & 4.10 showed that there was a significant association between the two risk factors (stage of lactation and parity) and subclinical mastitis at $P<0.05$.

This is because the calculated values of Chi-square (4.08 & 4.48 in both tables) were greater than the critical value of 3.84. The risk of subclinical mastitis infection in camels more than two months of lactation was 2.75 higher than in camels in less than two months in lactation.

Table 4.10: Association between the occurrence of mastitis and stage of lactation

Lactation Stage	Positive	Negative	Total	Prevalence (%)	OR	Chi-2	P- value
old (> 2 month)	56	12	68	82.4	2.75	4.08	0.05
young (≤ 2 month)	17	10	27	63.0			
Total	**73**	**22**	**95**				

The results also showed that lactating camels with parity of more than two calvings were 2.9 times more likely to be infected by mastitis than camels of lower or equal to two calving parity as shown in Table 4.11.

Table 4.11: Association between the occurrence of mastitis and parity

Parity	Positive	Negative	Total	Prevalence (%)	OR	Chi-2	p-value
> 2 calving	42	7	49	85.7	2.90	4.48	0.05
≤ 2 calving	31	15	46	67.4			
Total	**73**	**22**	**95**				

4.1.5 Bacterial Isolation Analysis

The bacteria isolated from the 380 quarter samples are shown in Table 4.12. A total of 114 bacteria were isolated with the most predominant bacterium being *Staphylococcus aureus* with prevalence of 36.0% (49/136), followed by *E. coli* with prevalence of 27.2% (37/136). *Streptococcus agalactiae & Staphylococcus epidermidis* were the third predominant isolates with prevalence of 9.6% (13/136) each. *Micrococcus spp & Pseudomonas* were the least isolates with less than 1% prevalence. A diagnosis of 'no bacterial growth' was made in 22 cases which is 16.2% (22/136). There were no contaminated samples recorded. Overall all milk samples produced mixed types of bacterial growth in the primary cultures. This indicated that there was a multiple infection of the quarters.

Identical pathogens were also isolated from different quarters of individual camels and from camels within the same herd suggesting that transmission from quarter to quarter and camel to camel had occurred.

Table 4.12: Bacterial isolation rates and their prevalences

Micro-organism	**Total number of Isolates (n)**	**Prevalence (%)**
Nil (no growth)	22	16.2
Staphylococcus aureus	49	36.0
Streptococcus agalactiae	13	9.6
Escherichia coli	37	27.2
Staphylococcus epidermidis	13	9.6
Micrococcus species	1	0.7
Pseudomonas	1	0.7
Contaminated	0	0
Total	**136**	**100**

4.1.5.1 Bacterial Isolation per division

The results showed that there were more bacterial isolations in Kiwawa division (36% (41/114)) followed by Kasei division at 22.8% (26/114). There was no isolation of pathogens in Konyao division. The highest isolation of *Staphylococcus aureus* (36.7% (18/49)) was in Kiwawa division while Alale division had the lowest isolation at 8.2% (4/49). *Escherichia coli* isolation was also high (32.4% (12/37)) in Kiwawa division followed by Kasei division at 24.3% (9/37) as shown in Table 4.13.

Table 4.13: Bacterial Isolation per division

Division	*S. aureus*	*E. coli*	*S. epidermidis*	*S. agalactiae*	*Micrococci spp*	*Pseudomonas*	**Total**	**Prevalence (%)**
Kongelai	7	7	5	5	-	-	24	21.1
Kacheliba	7	6	-	-	-	-	13	11.4
Konyao	-	-	-	-	-	-	-	0
Kiwawa	18	12	3	8	-	-	41	36
Kasei	13	9	2	-	1	1	26	22.8
Alale	4	3	3	-	-	-	10	8.8
Total	**49**	**37**	**13**	**13**	**1**	**1**	**114**	

4.2 Results per Division

4.2.1 Kongelai Division

4.2.1.1 Herd Structure by age of camel in Kongelai division

Lactating camels were 22.7% (22/97) which gave an average of 4.4 (22/5) lactating camels per household. Of these 63.6% (14/22) were sampled. The dry herd and the breeding bulls were 20.6% (20/97) and 7.2% (7/97) respectively as shown in Table 4.14 and Figure 4.3 below. Most (100%) of the camels were Turkana breeds.

Table 4.14: Herd structure by age of camel in Kongelai division

Household (HH)	Lactating camels	Dry camels	Breeding bulls	Immature males	Immature females	Female calves	Male calves	Total
1	10	8	3	6	5	4	6	42
2	4	3	1	5	2	1	2	18
3	3	2	1	2	1	1	2	12
4	3	4	1	1	0	2	1	12
5	2	3	1	3	2	1	1	13
Total	**22**	**20**	**7**	**17**	**10**	**9**	**12**	**97**

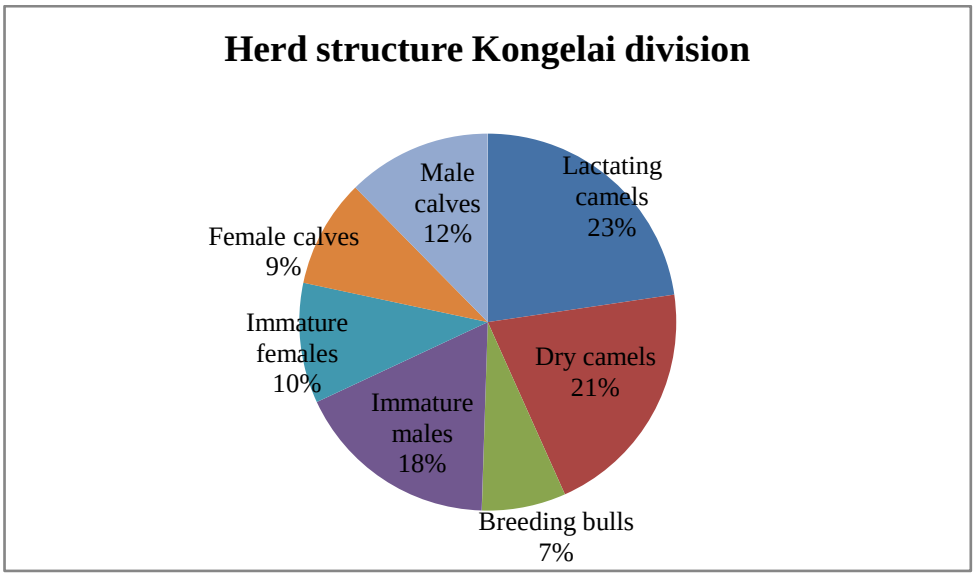


Figure 4.3: Herd structure in Kongelai division

4.2.1.2 Prevalence of subclinical mastitis at animal (camel) level in Kongelai division

The results of the bacterial culture from the 14 camels indicated that at least one quarter milk sample had a pathogen isolated from each camel. Therefore at camel (animal)-level the prevalence of subclinical mastitis in Kongelai division was 100% (14/14). About 14.3% (2/14 camels) had only one quarter infected, 42.9% (6/14 camels) had two quarters infected, 21.4% (3/14 camels) had three quarters infected while 21.4% (3/14camels) had all the four quarters infected) with *Staphylococcus aureus* being the predominant bacterium isolated from the milk samples.

4.2.1.3 Prevalence of subclinical mastitis at quarter level in Kongelai division

Of the 56 quarter samples cultured from Kongelai division 64.3% (36/56) quarter milk samples were positive for subclinical mastitis while 35.7% (20/56) were negative. The right fore quarter was the most affected 92.9% (13/14) and the right hind quarter was the least affected 35.7% (5/14). The overall quarter-level prevalence of subclinical mastitis in this division was 64.3% (36/56).

Table 4.15: Prevalence of subclinical mastitis at quarter level in Kongelai division

Quarter	Positive	Negative	Total	Prevalence (%)
RFQ	13	1	14	92.9
RHQ	5	9	14	35.7
LFQ	8	6	14	57.1
LHQ	10	4	14	71.4
Total	**36**	**20**	**56**	

4.2.2 Kacheliba Division

4.2.2.1 Herd structure by age of camel in Kacheliba division

Samples were collected from 10 lactating camels from the total 17 lactating camels in seven households selected in Kacheliba division. All (100%) the camels in the division were of Turkana breed. The lactating herd was 15% (17/110) which gave an average of 2.4 (17/7) lactating camels per household in the division. The dry herd and the breeding bulls were 24% (27/110) and 5% (6/110) respectively.

Table 4.16: Herd structure by age of camel in Kacheliba division

HH No	Lactating camels	Dry camels	Breeding bulls	Immature males	Immature females	Female calves	Male calves	Total
1	3	2	1	3	3	3	0	15
2	2	2	1	1	5	2	0	13
3	2	4	1	0	3	1	3	14
4	2	2	0	2	0	1	1	8
5	2	2	0	1	4	1	1	11
6	2	8	2	4	5	1	1	23
7	4	7	0	5	6	3	1	26
Total	**17**	**27**	**6**	**16**	**26**	**12**	**7**	**110**

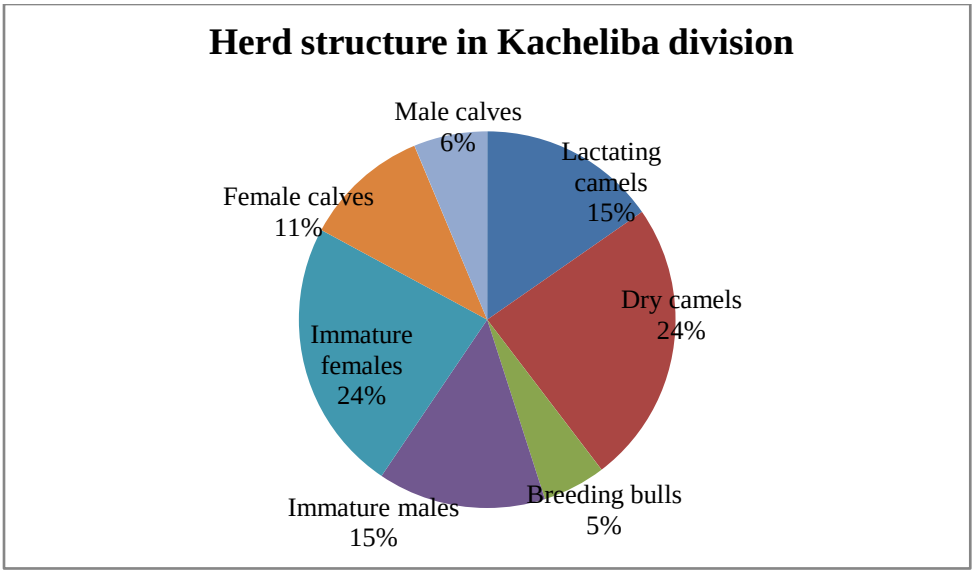


Figure 4. 4: Herd structure Kacheliba division of West Pokot County

4.2.2.2 Prevalence of subclinical mastitis at animal (camel) level in Kacheliba division

At the animal (camel)-level, the prevalence of mastitis was 80% (8/10). About 30% (3/10) had only one quarter affected, 30% (3/10) had two quarters affected, 10% (1/10) had three quarters affected while 10% (1/10) had all the four quarters infected. This was 20% lower than Kongelai division. *Staphylococcus aureus* and *E. coli* were the major causative agents of camel subclinical mastitis in Kacheliba division.

4.2.2.3 Prevalence of subclinical mastitis at quarter level in Kacheliba division

In this division, there were 40 quarter samples cultured out of which 40% (16/40) quarter milk samples were positive for subclinical mastitis while 60% (24/40) were negative, therefore at quarter level the prevalence of subclinical mastitis was 40% (16/40). The left hind quarter was the most affected 60% (6/10) followed by the right hind quarter 40% (4/10). The fore quarters were least infected 30% (3/10) each.

Table 4. 17: Prevalence of subclinical mastitis at quarter level in Kacheliba division

Quarter	Positive	Negative	Total	Prevalence (%)
RFQ	3	7	10	30
RHQ	4	6	10	40
LFQ	3	7	10	30
LHQ	6	4	10	60
Total	**16**	**24**	**40**	

4.2.3 Konyao Division

4.2.3.1 Herd structure by age of camels in Konyao division

Two households were sampled in this division and just like other divisions most camels were of Turkana breeds. Lactating camels were 12% (4/34) and 100% (4/4) were sampled.

Table 4.18: Herd structure by age of camels in Konyao division

Household (HH)	Lactating camels	Dry camels	Breeding bulls	Immature males	Immature females	Female calves	Male calves	Total
1	2	3	0	0	2	2	0	9
2	2	10	1	6	4	0	2	25
Total	**4**	**13**	**1**	**6**	**6**	**2**	**2**	**34**

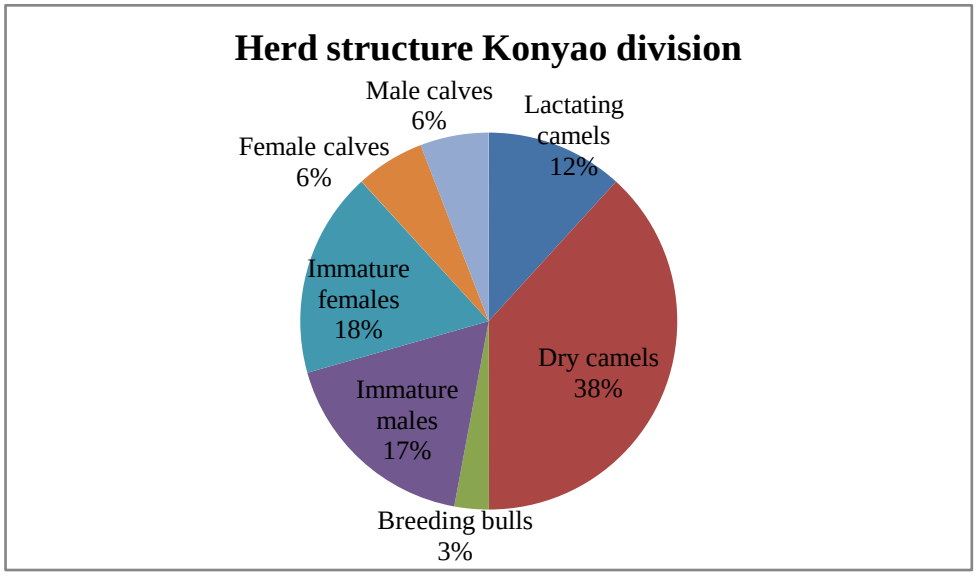


Figure 4.5: Herd structure Konyao division of West Pokot County

4.2.3.2 Prevalence of subclinical mastitis at animal (camel) level in Konyao division

There was no single pathogen isolated from the quarter milk samples taken from camels in the division, therefore at camel (animal) level the prevalence of subclinical mastitis was 0%. From the results, the two sampled herds were clean.

4.2.3.3 Prevalence of subclinical mastitis at quarter level in Konyao division

There were no pathogens isolated from the eight quarter milk samples taken from the division. This gave 0% (0/8) prevalence of subclinical mastitis at quarter level.

Table 4. 19: Prevalence of subclinical mastitis at quarter level in Konyao division

Quarter	Positive	Negative	Total	Prevalence (%)
RFQ	0	2	2	0
RHQ	0	2	2	0
LFQ	0	2	2	0
LHQ	0	2	2	0
Total	**0**	**8**	**8**	

4.2.4 Kiwawa Division

4.2.4.1 Herd structure by age of camel in Kiwawa division

Samples were taken from 37 lactating camels from the total 67 lactating camels in the 14 households selected in the division. The lactating camels were 20.6% (67/326) which gave an average of 4.8 (67/14) lactating camels per household in the division. Samples were taken from 52.2% (37/67) of the lactating camels as shown in Table 4.20 and Figure 4.6 below.

Table 4.20: Herd structure Kiwawa division

Household (HH)	Lactating camels	Dry camels	Breeding bulls	Immature males	Immature females	Female calves	Male calves	Total
1	5	9	1	2	2	3	2	24
2	7	30	2	0	3	3	4	49
3	2	18	1	7	6	1	1	36
4	4	5	0	1	4	3	1	18
5	4	5	0	1	5	1	3	19
6	4	5	1	3	4	1	3	21
7	3	2	0	2	2	1	2	12
8	8	26	1	2	3	3	5	48
9	3	2	0	0	0	1	1	7
10	2	0	1	5	2	1	1	12
11	2	0	0	0	0	0	2	4
12	6	0	0	0	0	2	4	12
13	10	5	1	2	8	7	3	36
14	7	2	0	7	6	2	4	28
Total	**67**	**109**	**8**	**32**	**46**	**29**	**36**	**326**

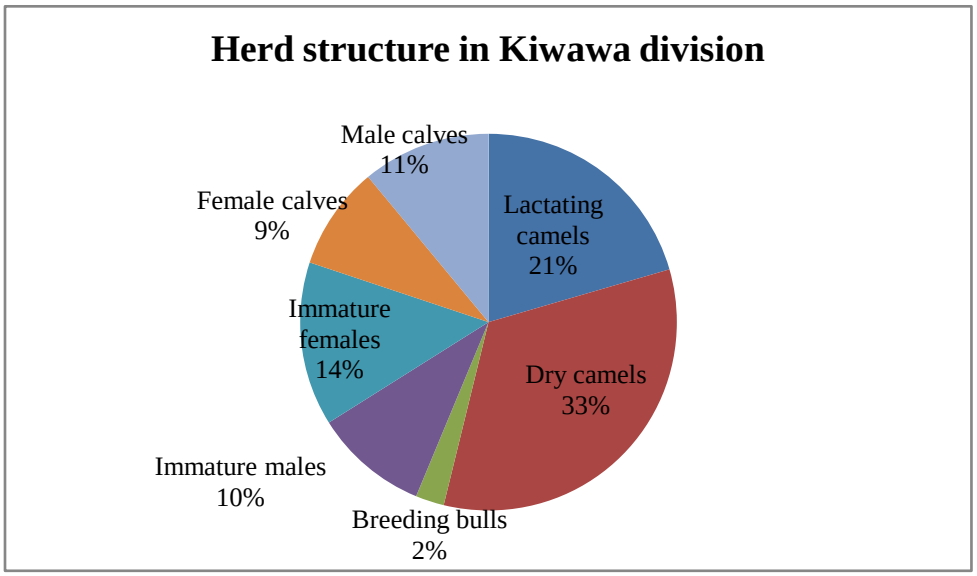


Figure 4.6: Herd structure in Kiwawa division of West Pokot County

4.2.4.2 Prevalence of subclinical mastitis at animal (camel) level in Kiwawa division

At the animal (camel) level the prevalence of mastitis was 73% (27/37). Majority of the animals 27.0% (10/37) had only one quarter affected, 16.2% (6/37) had two quarters affected, also 16.2% (6/37) had three quarters affected and 13.5% (5/37) had all the four quarters infected. *Staphylococcus aureus* and *E. coli* were the major causative agents of camel subclinical mastitis in the division.

4.2.4.3 Prevalence of subclinical mastitis at quarter level in Kiwawa division

At quarter level the prevalence of subclinical mastitis in the division was 40.5% (60/148). The right hind quarter was the most affected 48.6% (18/37) followed by the right front quarter at 40.5% (15/37). The left quarters were the least infected.

Table 4. 21: Prevalence of subclinical mastitis at quarter level in Kiwawa division

Quarter	Positive	Negative	Total	Prevalence (%)
RFQ	15	22	37	40.5
RHQ	18	19	37	48.6
LFQ	14	23	37	37.8
LHQ	13	24	37	35.1
Total	**60**	**88**	**148**	

4.2.5 Kasei Division

4.2.5.1 Herd structure in Kasei division

The lactating camels were 19.3% (36/187) which gave an average of 1.8 (36/20) lactating camel per household. The dry camels were 27.3% (51/187) while the breeding bulls were 2.1% (4/187). Samples were taken from 63.9% (23/36) of the lactating camels in 20 households selected in the division.

Table 4.22: Herd structure in Kasei division

Household (HH)	Lactating camels	Dry camels	Breeding bulls	Immature males	Immature females	Female calves	Male calves	Total
1	1	3	0	0	0	0	1	5
2	2	2	0	1	0	1	1	7
3	4	5	0	3	4	1	3	20
4	1	1	0	0	0	1	0	3
5	2	3	0	2	1	0	2	10
6	2	5	0	3	3	2	0	15
7	3	5	2	3	2	2	1	18
8	2	1	0	0	0	0	2	5
9	1	1	0	0	1	0	1	4
10	1	4	1	0	2	1	0	9
11	5	3	1	10	4	3	2	28
12	1	2	0	1	3	0	0	7
13	1	3	0	0	3	1	0	8
14	2	2	0	2	3	1	1	11
15	1	3	0	1	0	0	1	6
16	1	2	0	1	0	0	1	5
17	1	1	0	0	1	0	1	4
18	2	3	0	3	2	1	1	12
19	2	0	0	0	2	1	1	6
20	1	2	0	0	0	1	0	4
Total	**36**	**51**	**4**	**30**	**31**	**16**	**19**	**187**

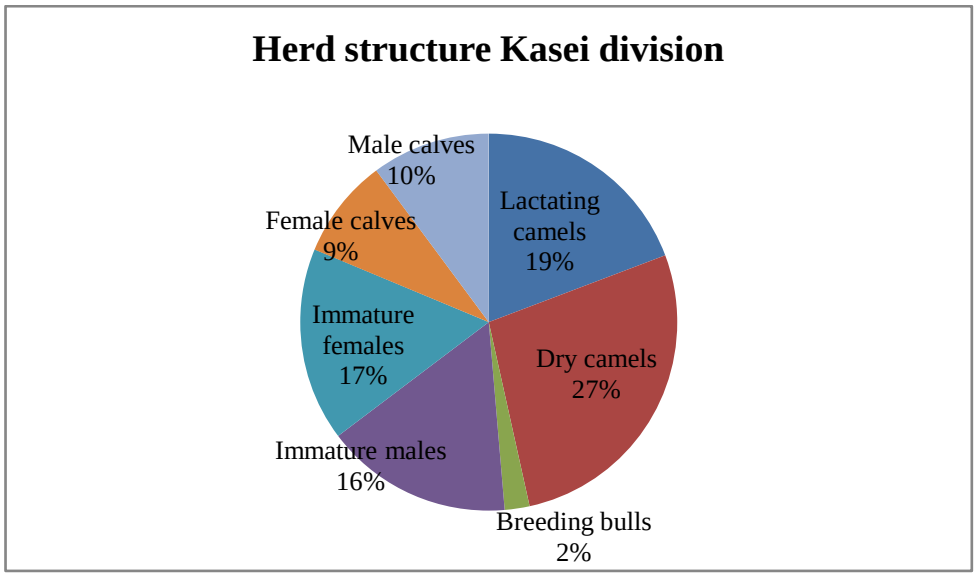


Figure 4.7: Herd structure in Kasei division of West Pokot County

4.2.5.2 Prevalence of subclinical mastitis at animal (camel) level Kasei division

From the results obtained the prevalence of subclinical mastitis at animal (camel) level was 82.6% (19/23). In terms of quarters affected 21.7% (5/23) had only one quarter affected, another 21.7% (5/23) had two quarters affected, also another 21.7% (5/23) had three quarters affected and 17.4% (4/23) had all the four quarters affected. Most of the udder infections were mixed and caused by both *Staphylococcus aureus* and *E. coli.*

4.2.5.3 Prevalence of subclinical mastitis at quarter level Kasei division

The overall quarter-level prevalence of subclinical mastitis in the division was 53.3% (49/92). The most affected quarter was the right hind-quarter 65.2% (15/23) followed by the right front quarter 56.5% (13/23) while the least affected was the left hind-quarter 39.1% (9/23).

Table 4.23: Prevalence of subclinical mastitis at quarter level in Kasei division

Quarter	Positive	Negative	Total	Prevalence (%)
RFQ	13	10	23	56.5
RHQ	15	8	23	65.2
LFQ	12	11	23	52.2
LHQ	9	14	23	39.1
Total	**49**	**43**	**92**	

Alale Division

4.2.6.1 Herd structure Alale division

Lactating camels were 16.1% (19/118) which gave an average of 4.75 lactating camels per household. Samples were taken from 47.4% (9/19) of the lactating camels. The dry herd was 38.1% (45/118) while the bulls were 3% (3/118) of the total herds in the division as shown in Table 4.24 and Figure 4.8.

Table 4.24: Herd structure Alale division

Household (HH)	Lactating camels	Dry camels	Breeding bulls	Immature males	Immature females	Female calves	Male calves	Total
1	6	30	1	7	0	5	1	50
2	4	1	0	0	0	2	2	9
3	5	14	1	1	4	4	2	31
4	4	0	1	5	14	2	2	28
Total	**19**	**45**	**3**	**13**	**18**	**13**	**7**	**118**

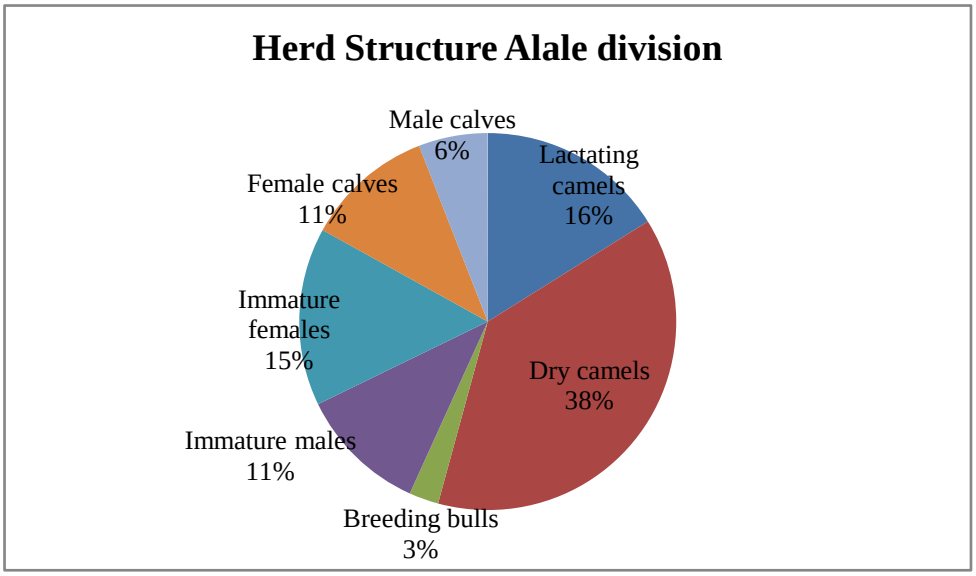


Figure 4.8: Herd structure Alale division of West Pokot County

4.2.6.2 Prevalence of subclinical mastitis at animal (camel) level Alale division

At the animal (camel) level the prevalence of subclinical mastitis was 55.6% (5/9). In terms of quarters affected, 11.1% (1/9) had only one quarter affected, 22.2% (2/9) had two quarters affected, none of the camels had three quarters affected and another 22.2% (2/9) had all the four quarters affected. From the results majority 44.4% (4/9) had both two and four quarters infected.

4.2.6.3 Prevalence of subclinical mastitis at quarter level in Alale division

Of the 36 quarter samples cultured from the division 36.1% (13/36) quarter milk samples were positive for subclinical mastitis while 63.9% (23/36) were negative. The right hind quarter was

the most affected 44.4% (4/9) and the other quarters were equally 33.3% (3/9) infected. The overall quarter-level prevalence of subclinical mastitis in this division was 36.1% (13/36).

Table 4. 25: Prevalence of subclinical mastitis at quarter level in Alale division

Quarter	Positive	Negative	Total	Prevalence (%)
RFQ	3	6	9	33.3
RHQ	4	5	9	44.4
LFQ	3	6	9	33.3
LHQ	3	6	9	33.3
Total	**13**	**23**	**36**	

CHAPTER FIVE

5.1 DISCUSSION

The observed milking frequencies practiced by the Pokot herders in this study were in agreement with earlier studies in Kenya by Schwartz and Dioli (1992) who reported that milking frequencies depended on season; yield and stage of lactation; availability of alternative food and sex and health of the calf. McGovern (1995) reported that during wet seasons the Pokot people milked their camels up to 4 times a day (morning, noon, evening and night), but in the dry seasons the frequency was reduced to a single milking at night only.

The high overall prevalence (44.5%) of bacterial isolates from apparently normal camel milk samples indicated a high percentage of subclinical mastitis in camels in West Pokot County. However, the findings from this study was consistent with the findings of Woubit *et al*. (2001) who reported high prevalence (51%) of mastitis in dromedary camels in Borena areas of South-Western Ethiopia.

The most predominant bacterium isolated from this study was *Staphylococcus aureus* with prevalence of 36.0% followed by *E. coli* with prevalence of 27.2% and *Streptococcus agalactiae* & *Staphylococcus epidermidis* at 9.6% prevalence each. This finding is in agreement with other findings from Eastern Sudan (Obied *et al*., 1996), Ethiopia (Workneh *et al*., 2002; Kerro and Tareke, 2003; Biffa *et al*,. 2005 and Almaw *et al*., 2008) and from Kenya (Younan *et al*., 2001) who reported that *Staphylococcus aureus* and *Streptococcus agalactiae* were the most common causes of camel mastitis. It has also been reported in Kenya (Maina, 1984, Omore, 1997) that *Staphylococcus aureus* was the major cause of subclinical mastitis in bovine (63%). As was also described by Younan *et al*. (2001), the prevalence of Staphylococci varies according

to different studies, but there is nearly no publication on bacteriological hygiene of milk where Staphylococci are not mentioned (Eberlein, 2007).

The prevalence of *E. coli* has been reported by other authors at between 1.0 and 17.3 % in samples taken from healthy camels (El-Jakee, 1998; Abdel Gadir *et al*., 2005). Therefore the prevalence of *E. coli* from this study was higher than what has been reported earlier in other studies.

Barbour *et al*. (1985) and Younan, (2004) stressed that the mastitis in milking dromedary camels caused by *Staphylococcus aureus* (Coagulase Positive) is not only of veterinary interest but represents a direct threat to human health considering that *S. aureus* can produce heat stable enterotoxins that are not inactivated during pasteurization of milk or production of milk products and can provoke food intoxication (vomiting and diarrhoea). The Coagulase negative *Staphylococcus* (CNS) most often isolated from camel milk is *Staphylococcus epidermidis* (Tuteja *et al*., 2003; Abdel Gadir *et al*., 2005).

Escherichia coli is also of public health importance since it is a pathogenic bacterium that can cause severe intestinal and extra-intestinal diseases in man (Kaper *et al*., 2004) as well as mastitis in cows (Bradley & Green, 2001). Abdel Gadir *et al*. (2005) isolated *E. coli* mainly (99.0 % of the isolates) from camel quarters that showed signs of subclinical mastitis. They also reported one case of clinical mastitis caused by *E. coli*. This pathogen is also a marker for fecal contamination due to the fact that it is a commensal of the intestinal tract (Schmidt-Lorenz & Spillmann, 1988). However, this holds true more for water than for food (Busse, 1985).

Almaw & Molla, (2000) and Younan, (2004) reported *Streptococcus agalactiae* as one of the main causes of clinical mastitis in camels and a potential human pathogen, causing intestinal infections mainly in newborns.

The results further showed that there was cross infection from different quarters of individual camels and from camels within the same herd because identical pathogens were isolated from them. The above suggested that there was strong probability of direct transmission by the milkers from one camel to another through poor milking procedures. Since most of the micro-organisms isolated (especially *Staphylococcus* spp.) are associated with clinical mastitis, particular attention should be given to the management of lactating camels to avoid development of clinical mastitis. Given that consumption of raw camel milk is a common practice among camel keepers in Kenya, the results from this study indicated the importance of pasteurization (or boiling) of camel milk before consumption since potentially infective bacterial agents were isolated. The high prevalence of subclinical mastitis could be attributed to unhygienic milking procedures in poor hygienic conditions of the milking areas and generally poor traditional management practices, where housing and sanitation was not a major priority in the study area. Earlier works (Birru, 1989; Girma, 2001 and Mungube *et al*., 2004) showed that animals were much more infected by mastitis, mainly in areas where hygienic conditions were poor and treatment of mastitis cases was not well pursued.

Most of the bacteria isolated in this study were gram-positive cocci. This finding is in agreement with what was reported previously by Obied *et al*. (1996) and Woubit *et al*. (2001).
The results also indicated that the most affected quarters were the right quarters with high prevalence of 48.4% in the right hind quarter (RHQ) and 45.3% in the right fore quarter (RFQ). This suggested the likelihood that in most cases during milking, the calf was left to suckle the left quarters and the right quarters were milked by the owners and because of poor hygienic milking procedures the right quarters were at a higher risk of getting infected.

The results also showed that the Pokots commonly kept camels together with other livestock such as cattle, sheep and goats (personal communication). During milking of the livestock, the results showed that the camels were the last to be milked therefore there was a high possibility of direct transmission of mastitis pathogens from other species of livestock to the camel. It was also noticed during this study that camel herders (mostly young boys) kept on milking camels throughout the day during grazing. This practice might have also contributed to the higher transmission rates of camel mastitis among camels in the same herd. Frequent milking and suckling by the calf keeps flushing the mastitis pathogens out but some studies have shown that it is the major cause of mastitis in camels (Obeid et al., 1996; Abdurahman, 1996).

The results also showed that most Pokot pastoralists were using various traditional herbs to manage camel mastitis. This is consistent with what has been observed elsewhere as reported by Bornstein, (1993) and Hussein, (1993) who reported that pastoralists use various traditional (ethno-veterinary) practices to treat sick camels in Ethiopia.

CHAPTER SIX

6.1 CONCLUSSIONS AND RECOMMENDATIONS

6.1.1 CONCLUSSIONS

- The fact that the pathogens isolated from camel milk samples in this study were bacteria that cause both environmental and contagious mastitis indicated that proper management of lactating camels and adequate hygienic conditions of the environment are required in order to minimize occurrence of mastitis in the study areas.
- It can also be concluded from the results of this study that mastitis was prevalent in camels in West Pokot and was a serious problem that affected camels which are essential for livelihoods of many nomadic tribes that live in the ASALs.
- More efforts are required to improve the general udder health in order to prevent and control subclinical mastitis in camels.
- Also camel producers need to be trained or capacity built on the importance of hygienic milking practices in order to minimize the potential adverse effect of mastitis on the yield and quality of camel milk.
- The most important way to continuously produce camel milk of good quality is to keep the mastitis level in the herd under optimum control.

6.1.2 RECOMMENDATIONS

- Camel producers and any other camel milk consumers should avoid consuming raw camel milk but instead boil the milk before consuming.

- Hygienic milking procedures should be followed when milking camels.

- Milking order where you milk non mastitic camels first and camels or quarters with mastitis infections last should be adhered to.
- Treatment of camels with mastitis infections using the conventional drugs should be promoted while avoiding non-conventional treatment.
- There is need to create awareness on camel mastitis among camel keepers. At the moment there is low level of awareness among pastoralists.

- More veterinary extension staff should be trained on camel mastitis diagnosis and control as it affects camel productivity in the ASALs.
- Several mastitis control strategies should be put in place such as milking procedures, milking order, strict hygiene, post milking teat disinfection, use of antibiotic dry-off therapy and the culling of persistently infected camels.

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8.0 APPENDICES

8.1 APPENDIX I: A CROSS SECTIONAL STUDY QUESTIONNAIRE

Part A: Household Information (one form to be completed for each household)

1) Interviewer …… Date…….

2) Survey (household)…….. Division……

3) Location…….. Sub location……

4) Owner's name…….. …….. Sex….. Age……

5) Interviewee……..

6) Camel Herd composition:
   a) Number of lactating camels……..
   b) Number of dry camels…….
   c) Breeding bulls……..
   d) Immature males……
   e) Immature females……..
   f) Male calves……..
   g) Female calves…….
7) Camel milk production (per day);

a) Total milk produced……..

b) Total milk consumed (domestic)…….

c) Total milk sold…….

d) Price per Litre (Ksh)……

8) Other Livestock owned by the family;

a) Cattle…….

b) Goats ……

c) Sheep …….

d) Donkeys ……..

e) Others …….

9) For how long have you been keeping camels?

a) < 1 year

b) ≥1year ≤ 5years

c) > 5years

10) Have you heard of mastitis in camel? Yes…… No……

11) What is the local name (Pokot) of mastitis……..

12) Have you ever had any case of mastitis? Yes ……. No ……

13) If yes what signs did you see to know it is mastitis?

a) Swollen and painful udder/quarter

b) Bloody milk

c) Reduced milk

d) Other signs……

14) Was any treatment given? Yes….. No ……

15) Who administered the treatment?

a) Veterinary officer

b) Animal Health Assistant

c) Community Animal Health Worker

d) Myself

e) Others (specify)……

16) Did the camel recover? Yes ….. No……

17) Who milks the camels?

a) Owner

b) Wife

c) Children

d) Other (specify)……..

18) If you have more than one milking camels, when a camel has mastitis, do you milk it last? Yes….. No…….

19) Are the camels milked using proper technique? (Observe)…….

20) Do you prepare (wash) the udder before milking? Yes …… No……..

21) How often do you remove the manure from the boma where the milking camels spent in the night?

a) < 3 months

b) ≥3 months ≤ 6 months

c) > 6 months ≤ 1 year

d) > 1 year.

22) What are the common camel diseases in the Manyatta?

a)……

b)……..

c)…….

d)……..

e)……

Part B: Individual Camel Information (one form to be completed for each individual camel)

1) Camel's Name…….

2) Camel's breed……..

3) Parity ……..

4) Last calving date…….

5) Current milk production per day……..

6) Current number of functional teats (observe)……

7) Has the camel ever had mastitis during the current lactation? Yes …….No…….

8) Any abnormalities on the teats? (observe) Yes …….No……..

9) If yes describe the lesions…….

10) Any abnormalities on the udder? (observe) Yes ……No……..

11) If yes describe the abnormalities……

12) Milk samples taken from the quarters:

a) Right forequarter sample No……

b) Left forequarter sample No……..

c) Right hindquarter sample No…….

d) Left hindquarter sample No…….

13) Carry out CMT and indicate the results:

a) Right forequarter……..

b) Left forequarter…….

c) Right hindquarter…….

d) Left hindquarter……..

14) Any other additional

information…….

CMT (California Mastitis Test)

CMT is the most indirect test used to detect Subclinical Mastitis as the degree of Gel formation is related with the number of cells in the milk.

Procedure: An equal volume of CMT Reagent and milk sample is mixed. The reactions are then scored and interpreted as follows;

a) Score 1….. No reaction

b) Score 2……Slight slime which tends to disappear with continued swirling.

c) Score 3…….Distinct slime but without Gel formation.

d) Score 4……..Immediate formation of Gel which moves as a mass during swirling.

e) Score 5…….The formed Gel develops a convex surface and also adheres to the bottom of the paddle.

8.2 APPENIX II: Laboratory Results on bacterial culture and identification

HH. No	Camel No.	Parity	Lactation Stage	RFQ	RHQ	LFQ	LHQ	Isolated Organism (s)	REMARKS
1	01	6th	2 months	+ve	-ve	+ve	+ve	*S. aureus*	Positive
	02	3rd	6 months	+ve	-ve	-ve	+ve	*S. aureus*	Positive
	03	4th	7 months	+ve	-ve	-ve	-ve	*S. aureus*	Positive
	04	1st	6 months	-ve	+ve	+ve	-ve	*S. aureus*	Positive
	05	2nd	3 months	+ve	-ve	-ve	-ve	*E. coli*	Positive
	06	1st	6 months	-ve	-ve	-ve	+ve	*S. aureus*	Positive
2	07	3rd	1 month	+ve	-ve	+ve	+ve	*S. aureus*	Positive
	08	3rd	4 months	+ve	+ve	+ve	+ve	*S. aureus*	Positive
3	09	3rd	7 months	-ve	-ve	-ve	+ve	*S. aureus &E. coli*	Positive
	10	1st	7 months	-ve	-ve	-ve	-ve	nil	Negative
4	11	3rd	6 months	-ve	+ve	-ve	+ve	*S. aureus*	Positive
5	12	6th	3 months	-ve	+ve	-ve	+ve	*S. aureus &E. coli*	Positive
6	13	4th	4 months	-ve	-ve	-ve	+ve	*S. aureus &E. coli*	Positive
7	14	2nd	3 months	+ve	+ve	-ve	-ve	*S. aureus &E. coli*	Positive
	15	1st	1 month	+ve	-ve	+ve	+ve	*S. aureus &E. coli*	Positive
8	16	3rd	5 months	-ve	-ve	+ve	-ve	*S. aureus*	Positive
	17	2nd	6 months	-ve	-ve	-ve	-ve	nil	Negative

9	18	2nd	1 month	+ve	+ve	+ve	-ve	*E. coli*	Positive
10	19	1st	1 month	-ve	-ve	-ve	-ve	nil	Negative
11	20	3rd	3 days	+ve	-ve	+ve	-ve	*S. aureus &E. coli*	Positive
	21	2nd	4 months	+ve	-ve	-ve	-ve	*E. coli*	Positive
	22	3rd	4 months	+ve	+ve	+ve	+ve	*S. aureus &E. coli*	Positive
12	23	2nd	1 months	+ve	+ve	-ve	-ve	*S. aureus*	Positive
	24	1st	1 month	-ve	-ve	-ve	+ve	*S. aureus*	Positive
13	25	3rd	1 month	+ve	+ve	+ve	-ve	*S. aureus &E. coli*	Positive
14	26	3rd	5 months	-ve	-ve	-ve	+ve	*E. coli*	Positive
15	27	4th	9 months	-ve	-ve	+ve	-ve	*S. aureus*	Positive
16	28	2nd	3 days	-ve	+ve	-ve	-ve	*E. coli*	Positive
17	29	1st	6 months	-ve	-ve	-ve	-ve	nil	Negative
18	30	2nd	9 months	-ve	-ve	+ve	-ve	*Micro-cocci*	Positive
19	31	3rd	6 months	-ve	+ve	-ve	-ve	*S. aureus*	Positive
20	32	4th	2 weeks	-ve	-ve	-ve	-ve	nil	Negative
21	33	2nd	3 months	-ve	+ve	+ve	-ve	*S. aureus*	Positive
22	34	2nd	4 months	+ve	+ve	+ve	+ve	*S. aureus*	Positive
	35	3rd	4 months	+ve	+ve	+ve	-ve	*S. aureus &E. coli*	Positive
23	36	7th	4 months	+ve	+ve	+ve	+ve	*E. coli*	Positive
	37	4th	3 months	+ve	+ve	+ve	+ve	*S. aureus*	Positive
24	38	2nd	1 month	-ve	+ve	-ve	-ve	*S. aureus*	Positive
	39	1st	1 month	-ve	+ve	-ve	-ve	*Pseudomonas*	Positive

25	40	3rd	7 months	-ve	+ve	+ve	-ve	*S. aureus &E. coli*	Positive
26	41	3rd	1 month	+ve	+ve	-ve	+ve	*S. aureus*	Positive
27	42	1st	1 month	-ve	-ve	-ve	-ve	nil	Negative
28	43	3rd	3 months	-ve	-ve	+ve	+ve	*S. aureus*	Positive
29	44	1st	2 months	+ve	-ve	+ve	+ve	*S. aureus &E. coli*	Positive
30	45	4th	3 months	+ve	+ve	+ve	+ve	*S. aureus &E. coli*	Positive
31	46	2nd	1 month	-ve	-ve	-ve	-ve	nil	Negative
32	47	3rd	10 months	+ve	-ve	+ve	+ve	*S. epidermidis, S. agalactiae & E. coli*	Positive
	48	4th	12 months	+ve	+ve	+ve	+ve	*S. agalactiae & E. coli*	Positive
	49	5th	11 months	+ve	-ve	-ve	+ve	*S. epidermidis, & E. coli*	Positive
33	50	1st	16 months	+ve	+ve	+ve	-ve	*S. epidermidis, S. agalactiae & E. coli*	Positive
	51	1st	8 months	+ve	-ve	-ve	+ve	*S. epidermidis, S. agalactiae & E. coli*	Positive
34	52	5th	10 months	+ve	+ve	+ve	+ve	*S. epidermidis, S. agalactiae & E. coli*	Positive
35	53	6th	1 week	+ve	+ve	+ve	-ve	*S. aureus & E. coli*	Positive
	54	4th	1 month	-ve	-ve	-ve	-ve	nil	Negative
	55	2nd	1 month	-ve	-ve	-ve	-ve	nil	Negative

36	56	4th	4 months	-ve	+ve	+ve	+ve	*S. aureus & S. agalactiae*	Positive
	57	2nd	11 months	-ve	+ve	-ve	-ve	*S. epidermidis, S. agalactiae & E. coli*	Positive
	58	5th	4 months	-ve	+ve	-ve	-ve	*S. aureus*	Positive
37	59	3rd	5 months	+ve	+ve	+ve	-ve	*S. aureus & S. agalactiae*	Positive
	60	5th	5 months	-ve	+ve	-ve	-ve	*S. agalactiae*	Positive
38	61	2nd	9 months	-ve	-ve	-ve	-ve	nil	Negative
39	62	5th	3 months	+ve	-ve	+ve	+ve	*S. aureus & S. agalactiae*	Positive
40	63	2nd	2 weeks	-ve	-ve	-ve	-ve	nil	Negative
	64	4th	14 months	+ve	+ve	+ve	+ve	*S. aureus &E. coli*	Positive
	65	2nd	13 months	-ve	-ve	-ve	-ve	nil	Negative
41	66	2nd	9 months	-ve	+ve	+ve	-ve	*S. aureus, S. epidermidis & E. coli*	Positive
	67	3rd	8 months	+ve	+ve	+ve	+ve	*S. aureus & S. epidermidis*	Positive
	68	1st	2 months	-ve	+ve	-ve	-ve	*E. coli*	Positive

42	69	2nd	5 months	-ve	-ve	-ve	-ve	nil	Negative
43	70	1st	2 months	-ve	-ve	-ve	-ve	nil	Negative
	71	3rd	3 months	+ve	-ve	-ve	+ve	*S. aureus & S. epidermidis*	Positive
44	72	6th	2 days	-ve	-ve	-ve	-ve	nil	Negative
	73	2nd	9 months	-ve	-ve	-ve	-ve	nil	Negative
	74	1st	5 months	+ve	+ve	+ve	+ve	*S. aureus & S. agalactiae*	Positive
	75	2nd	8 months	+ve	+ve	+ve	+ve	*S. aureus &E. coli*	Positive
	76	1st	4 months	-ve	+ve	+ve	+ve	*S. aureus*	Positive
	77	2nd	12 months	+ve	+ve	-ve	-ve	*S. aureus*	Positive
45	78	4th	9 months	-ve	-ve	-ve	+ve	*E. coli*	Positive
	79	2nd	10 months	+ve	+ve	+ve	+ve	*S. agalactiae & S. aureus*	Positive
	80	2nd	8 months	-ve	+ve	-ve	+ve	*S. agalactiae & E. coli*	Positive
	81	5th	8 months	-ve	-ve	-ve	-ve	nil	Negative
	82	1st	6 months	+ve	+ve	-ve	-ve	*S. aureus &E. coli*	Positive
	83	4th	8 months	-ve	-ve	-ve	-ve	nil	Negative
	84	3rd	9 months	- ve	-ve	+ve	-ve	*S. epidermidis*	Positive
46	85	7th	8 months	-ve	-ve	-ve	-ve	nil	Negative

	86	5th	5 month	+ve	-ve	-ve	+ve	*S. aureus*	Positive
	87	2nd	4 months	+ve	+ve	+ve	+ve	*S. epidermidis*	Positive
	88	4th	6 months	-ve	-ve	-ve	-ve	nil	Negative
	89	1st	7 months	-ve	-ve	-ve	-ve	nil	Negative
47	90	5th	6 months	+ve	+ve	-ve	-ve	*S. aureus &E. coli*	Positive
48	91	3rd	15 months	+ve	+ve	+ve	-ve	*S. aureus & S. epidermis*	Positive
49	92	1st	5 months	-ve	+ve	-ve	+ve	*E. coli*	Positive
50	93	3rd	2 months	-ve	+ve	+ve	+ve	*S. epidermidis & E. coli*	Positive
51	94	2nd	2 months	+ve	-ve	-ve	-ve	*E. coli*	Positive
52	95	1st	2 months	-ve	-ve	-ve	-ve	nil	Negative


Used Slide
Cover Slip