

**TO CHARACTERIZE DAIRY GOAT PRODUCTION IN MOUNT KENYA REGION;
DETERMINATION OF PREVALENCE AND RISK FACTORS OF SUBCLINICAL
MASTITIS, AND ANTIBIOTIC SENSITIVITY OF THE ISOLATES**

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DEDICATION

This thesis is dedicated to my family; Loving husband George Omondi, daughter Amara Atieno and parents Philip Mbindyo and Rosina Nzemi.

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LIST OF ABBREVIATIONS

- ASAL- Arid and Semi Arid Land
- ALLPRO- ASAL Based Livestock & Livelihood Support Project
- AHITI- Animal Health and Industry Training Centre
- CMT-California Mastitis Test
- CNS- Coagulase Positive Staphylococcus
- CPS- Coagulase Positive Staphylococcus
- CAEV- Caprine Arthritis and Encephalities Virus
- DMSCC–Direct Microscopic Somatic Cell Counts
- DLPO- District Livestock production officer
- DVO-District veterinary officer
- DGKA- Dairy goat association of Kenya
- FAO-Food and Agriculture Organization
- SCC- Somatic Cell Counts
- M.G.B.A -Meru goat breeder association
- MOLD-Ministry of Livestock Development
- MSCC- Milk Somatic Cell Counts
- MSA- Mannitol Salt Agar
- KAGRC-Kenya Animal Genetic Research Resources Centre
- KBS-Kenya Bureau of standards
- UK -United Kingdom
- GOK- Government of Kenya

ABSTRACT

Dairy goat production is an emerging enterprise, which has a lot of potential for poverty alleviation, improved nutrition, and increased income for the poor; it can play a role in contribution towards Kenya's development plan. Inadequate information on risk factors and prevalence of subclinical mastitis with associated antibiotic sensitivity are some of the challenges facing this industry. This study was carried out on dairy goats kept under zero grazing system in Mount Kenya region, from January 2012 to December 2012; the following were the objectives: (1) To characterize dairy goat production in Mount Kenya region (2) To determine the prevalence and risk factors of subclinical mastitis in lactating goats in Mount Kenya region (3) To isolate, characterize and determine antibiotic sensitivity of bacteria causing the subclinical mastitis.

This was a cross sectional study conducted in three counties (Meru, Nyeri, Embu) all located in Mount Kenya region. Semi-structured questionnaires were administered to farmers and stakeholders to collect data on dairy goat background and risk factors associated with intramammary infection (subclinical mastitis). A total of 310 lactating goats were randomly selected from populations in the three counties and screened for bacterial carriage, as evidence of subclinical mastitis. Six hundred and twenty (620) milk samples from the 310 goats (right and left quarters) were aseptically collected; first screened using California Mastitis Test (CMT), then cultured for bacterial isolation and characterization. Antibiotic sensitivity testing was also performed on the isolated bacteria.

According to the study, farmers faced a number of challenges which had a negative impact on production and hence there was need for the challenges to be addressed. The problems/challenges included high prevalence of subclinical mastitis, lack of market and diseases. Based on culture results, the prevalence of subclinical mastitis was 59% in Meru County, 58% in Embu County and 54 % in Nyeri County. An overall mean prevalence of 57% was estimated in the three counties. There was no significant difference in subclinical mastitis prevalence in the three counties ($P=0.75$). Based on CMT, the prevalence of subclinical mastitis was estimated to be 61% in Meru County, 61% in Embu and 60% in Nyeri County. The overall mean prevalence was estimated to be 61%. There was no significant difference between prevalence of subclinical mastitis in the three counties ($P=0.96$).

Among the 620 milk samples collected from the 310 lactating goats, 317 (51%) were California mastitis test positive, and on culturing, 304 (96%) yielded bacterial growth. The following bacteria were isolated from the milk samples; Coagulase Negative *Staphylococcus* was the most prevalent - at 28% (176/620), followed by *Staphylococcus aureus* - at 14% (84/620), *Streptococcus* - at 7% (46/620), *Escherichia coli* - at 3% (19/620), *Micrococcus* - at 4% (24/620), *Corynebacterium* - at 1% (7/620), *Pseudomonas* - at 0.2% (1/620). Of the *Streptococcus* isolates, 2% (9/620) were *Streptococcus agalactiae*.

For the risk factors; poor hygiene ($P = 0.001$) and parity ($P = 0.03$) showed statistically significant association with the occurrence of subclinical mastitis in dairy goats. However, there was no statistically significant association between risk factors such as study area ($P = 0.75$), stage of lactation ($P = 0.3$), breed ($P=0.5$) and housing ($P=0.5$). Norfloxacin and gentamycin

were antibiotics that the organisms were most sensitive to while kanamycin and amoxicillin were antibiotics that the organisms were least sensitive to.

Lack of market for milk and diseases were some of the main constraints experienced by farmers in Mount Kenya region.

The study revealed that there is high prevalence of subclinical mastitis in dairy goats in Mount Kenya region. The high prevalence of the disease recorded in this study has a negative impact in dairy goat production; there is, therefore, need to create awareness on subclinical mastitis and institute appropriate control measures to curb the problem. The study also revealed that CMT is a reliable test for subclinical mastitis in goats. Since it is easy to carry out, rapid and cheap, it is recommended that goat associations make use of it as part of the control measures; they can train specific personnel to carry out and interpret the test.

CHAPTER 1: INTRODUCTION

The dairy goat industry is rapidly gaining importance throughout the world (Boscós *et al.*, 1996). In Kenya dairy goat farming is emerging as a high-return option for Kenyan small-scale farmers, although it has been challenged in most regions by marketing and distribution problems (Ndegwa *et al.*, 2000).

Kenya has an estimated 28 million goats and about 80,000 dairy goats (MoLFD, 2009). The goat population in Kenya is predominantly indigenous Galla and East African goats which are reared in arid and semi arid areas (Kinuthia, 1997). Dairy goats in Kenya were obtained through a cross breeding programme between the indigenous goats and the exotic breeds and about eighty percent of these are reared in Mt Kenya Region (MoLFD, 2009). They provide a quick source of milk for consumption or sale and are thus of immense value especially to poor households. The fact that they can be reared in small land holdings is especially useful in these highly populated areas (Kinuthia, 1997).

Goats form the most important group of milk producing animals after dairy cattle in both temperate and tropical agriculture (Farnworth, 2002). The demand of dairy goats' milk is increasing because of the growing population of people, the increasing awareness of medicinal and nutritional status associated with goat milk and also the special interest in goat milk products, especially cheeses and yoghurt, in many developed countries which has led to increasing levels of disposable incomes (Epitaufik, 2007). Dairy goat has been used as source of income and source of food (meat and milk) especially to the poor (Haenlein, 2004).

Though dairy goat production is playing an important role in the improvement of income of the poor farmers, poverty and hunger alleviation, the dairy goat production is still faced by challenges such as diseases (diarrhea and pneumonia), inbreeding, poor feeding, lack of market and poor management practices (Ndegwa *et al.*, 2000). Among infectious diseases, mastitis is one of the major diseases affecting dairy goat productivity (Gebrewahid *et al.*, 2012). Several causative agents and predisposing factors have been implicated in dairy goat mastitis. Etiological agents include bacteria, viruses and yeasts. Several risk factors including, milking hygiene, management practice, feeding, number of lactation days and geographical locality have influenced the type and frequency of isolation of organisms causing mastitis (Ndegwa *et al.*, 2000).

Milk is one of the most important foods of human beings. It is universally recognized as a complete diet due to its essential components (Javaid *et al.*, 2009). The quality and quantity is however deteriorated by mastitis, which is one of the most important and expensive disease of dairy industry. It results in severe economic losses from reduced milk production, treatment cost, increased labor, milk withheld following treatment and premature culling (Sharif *et al.*, 2009).

Subclinical mastitis is the most common in goats and is mainly caused by contagious bacteria (Persson and Olofsson., 2011). Early diagnosis of mastitis with reliable tests facilitates successful treatment and control. The main control principles include: sound husbandry practices and sanitation, post milking teat dip, treatment of mastitis during non-lactating period, and culling of chronically infected animals (Sharif *et al.*, 2009).

Dairy goat milk is routinely consumed in rural and urban areas of Kenya. The quality and quantity of milk can be affected by sub-clinical mastitis; only a few studies have been done on the prevalence, and no studies have been done on the antibiotic sensitivity and disease situation in the country as compared to the disease in the cow (Ndegwa *et al.*, 2000).

Therefore, this study is geared towards establishing the prevalence of sub-clinical mastitis and antibiotic sensitivity patterns of the isolated bacteria. This will fill in the gap in information with a goal of improving dairy goat milk production in Kenya.

1.1 OBJECTIVES:

1.1.1 Overall objective

To characterize dairy goat production in Mount Kenya region and determination of prevalence and risk factors of subclinical mastitis and antibiotic sensitivity patterns of the respective isolates

1.1.2 Specific objectives

1. To characterize dairy goat production in Mount Kenya region
2. To determine prevalence and risk factors of subclinical mastitis in lactating goats in Mount Kenya region
3. To isolate, characterize and determine antibiotic sensitivity of the bacteria causing subclinical mastitis

1.2 JUSTIFICATION

Dairy goat production is an emerging enterprise, which has a lot of potential for poverty alleviation, improved nutrition, and increased income for the poor and can play a role in contribution towards Kenya's development plan. One of the challenges facing this sector is lack of information on the husbandry practices and shortcomings present in the industry. The other challenge facing this industry is lack of awareness on how the quality of milk can be affected by subclinical mastitis. Very little has been done towards establishing the scope and prevalence of sub-clinical mastitis in dairy goats (Ndegwa *et al.*, 2000). On the other hand, while antibiotics are commonly used in the dairy goats, no study has been done to establish the isolates' sensitivity patterns. Therefore this study will address these aspects with the goal of improving dairy goat production in Kenya.

1.3 HYPOTHESIS

There are no constraints facing dairy goat production in Mount Kenya region and there is no subclinical mastitis in dairy goats and, if there is, the responsible bacteria are not resistant to antibiotics

CHAPTER 2: LITERATURE REVIEW

2.1 DAIRY GOAT PRODUCTION

Dairy goat industry is rapidly gaining importance throughout the world (Boscos *et al.*, 1996). Goats are distributed over all types of ecological zones in the world, more being concentrated in the tropics and dry zones of developing countries. The population of goats in the world is approximately 617 million, about 97.3 % of them being found in the developing countries. The goat distribution is: 65.9 % in Asia, 27.4 % in Africa, 3.5 % in Europe and 3.0 % in Americas. The number of dairy goats in the world is 191 million; 47.7 % of them being in the 25 least developed countries (FAOSTAT 2012).

According to Galal (2005), while the developing countries harbor the highest number of the world goats' population, it has only 60% of the breeds. Europe has the heaviest goat breeds with the largest litter size and milk production. Goats contribute largely to the livelihoods of low- and medium-input farmers, many of whom have few resources beyond their small holdings and livestock (Boyazoglu *et al.*, 2005).

The high goat population in the developing world is largely due to the fact that goats are well adapted to the tropics, have short generation intervals, high fertility, prolificacy and fecundity; have high heritability for milk production (0.5); lower nutritional requirement as compared to the cow and they are a quick source of cash and food (Hossain *et al.*, 2004; Knights and Garcia, 1997). Dairy goats are kept in different production systems (Devendra *et al.*, 2007); the largest goat production system around the world is classified as extensive. Based on the subsistence level, the classification is extensive, semi intensive, and intensive.

The world's highest goat milk producers include India, Bangladesh, Sudan, Pakistan, France and Spain; they contribute 62.2 % of the goat milk produced in the world (Table 2.1). Most of the produced goat milk is directed to self-consumption while the rest is marketed as fresh-liquid milk and/or transformed into cheese or candies (FAOSTAT, 2012).

Table 2.1: Goat milk production in the world in 2010 (millions of litres and millions of heads)

Region	Production	Dairy goats	L/goat/year
Asian	9,794	110.9	88.3
Africa	3,751	61.9	60.6
Americas	541	8.4	64.3
Europe	2,604	9.8	265.7
Total	16,690	191.0	

L/goat/year means litres of milk per goat per year

Source: Adapted from FAOSTAT 2012

2.1.1 Overview of dairy goat production in Kenya

In Kenya, goat population is approximated to be 13.9 million, with over 1 million dairy goats (MOLDF, 2009). Dairy goats in Kenya were introduced in early 1990s through a community based goat improvement programme whose purpose was to improve the productivity of the local goats through better management, develop a more intensive goat milk and meat production system for farmers in areas with small sizes of land (Ahuya *et al.*, 1997). The increasing human population has led to increased land pressure and consequently the smaller land sizes cannot

support dairy cattle, making the dairy goat a better option. The national plan of promoting dairy goat production is aimed at addressing the millennium development goal of Alleviating extreme poverty and hunger (Kosgey *et al.*, 2008).

There are two main indigenous breeds in Kenya; the East African and the Galla. Both breeds are kept mainly for meat production. The main dairy goat breeds are German alpine, Toggenberg and Saneen. To produce adequate milk, a dairy goat requires a well-balanced diet for both self-maintenance and production of milk. Since it is very selective in what it eats, in order to maintain the body condition and productivity, farmers need to provide it with very high quality fodder. Goats feed on many types of fodder including Napier grass, pasture grasses, sweet potato vines and household vegetable waste (Kinyanjui *et al.*, 2010).

Though dairy goat production is playing an important role in the improvement of income of the poor farmers, poverty and hunger alleviation, the dairy goat production is still faced by challenges such as diseases (diarrhea and pneumonia), inbreeding, poor feeding, lack of market and poor management practices (Ndegwa *et al.*, 2000). Among infectious diseases, mastitis is one of the major diseases affecting dairy goat productivity. Several causative agents and predisposing factors have been implicated in dairy goat mastitis. Etiological agents include bacteria viruses and yeasts. Ndegwa, 1999 reported a overall prevalence of subclinical mastitis in Kenya to be 28.7%. Several risk factors including, milking hygiene, management practice, feeding, number of lactation days and geographical locality have influenced the type and frequency of isolation of organisms causing mastitis (Ndegwa *et al.*, 2000).

Though she did the prevalence and risk factors her study covered only Nyeri County and her study was a longitudinal study. Therefore hence there was need to do more counties and using a different study design.

Dairy goat milk is routinely consumed in rural and urban areas of Kenya. The quality and quantity of milk can be affected by sub-clinical mastitis; only a few studies have been done on the prevalence, and no studies have been done on the antibiotic sensitivity and disease situation in the country as compared to the disease in the cow (Ndegwa *et al.*, 2000).

Therefore, this study is geared towards establishing the prevalence of sub-clinical mastitis and antibiotic sensitivity patterns of the isolated bacteria. This will fill in the gap in information with a goal of improving dairy goat milk production in Kenya.

2.2 MASTITIS IN DAIRY GOATS

Mastitis is defined as the inflammation of the mammary gland regardless of the cause and is characterized by physical, chemical and bacteriological changes in the milk and pathological changes in the glandular tissue of the udder. The important changes in the milk include discoloration, presence of milk clots and presence of a large number of leucocytes (Blood and Radostits, 2000). Bacterial contamination of milk from the affected goats render it unfit for human consumption, as it can provide a mechanism of spread of diseases like sore-throat, brucellosis and leptospirosis which are of zoonotic importance (Sharif *et al.*, 2009). The disease is usually classified as clinical or sub-clinical based on aetio-pathological findings and

observation (Blood and Radostits, 2000). Subclinical mastitis is the more common in goats and is mainly caused by contagious bacteria (Persson and Olofsson., 2011). Poor management and unhygienic conditions, lack of therapeutics and control measures like pre- and post-milking teat dipping are some major factors which play vital role in the development of this disease in goats (Ali *et al.*, 2010). Therefore early recognition and prompt treatment of the disease are important for limiting tissue damage and production losses. However, since treatment is often unrewarding, emphasis should be on mastitis control and prevention (Shearer *et al.*, 2003).

2.3 Types of mastitis

Mastitis is almost always infectious and can broadly be classified as either clinical or subclinical depending on whether there are obvious physical clinical signs or not (Smith, 2002).

Clinical mastitis is characterized by grossly abnormal milk and mammary gland inflammation. There is pain, heat, redness and induration in the mammary gland. The milk is usually discoloured with few or many clots; in severe cases there is serum with clumps of fibrin (Smith, 2002, Blood and Radostits, 2000).

The signs and severity of clinical mastitis vary considerably. Clinical signs are dependent upon host, pathogen and environmental factors (Sharif *et al.*, 2009). Pathogen factors include such things as species of bacteria, virulence of the strain, and size of the inoculum. Host factors include parity, stage of lactation, somatic cell count, level of immunity and the presence of concurrent disease. These may vary greatly in severity during the course of the disease (Khan *et al.*, 2006). Clinical cases can be defined as sub acute (mildly clinical) when symptoms include

only minor alterations in the milk and the affected halves such as clots, flakes, or discolored secretion. The quarter may also be slightly swollen and tender.

Severe mastitis cases are characterized by sudden onset, pain, heat, swelling, and redness and reduced as well as altered milk secretion from affected halves. Abnormal secretion in the form of clots, flakes, or watery milk is the clinical sign most consistently observed. Depending upon severity and the causative agent, acute mastitis cases may have significant systemic involvement characterized by fever, depression, and weakness. In its most severe form it can be fatal and hence such cases call for immediate attention (Khan *et al.*, 2006). Clinical mastitis is further classified as: Peracute, Acute, Subacute or Chronic

2.3.1 Peracute form

This form presents with inflammation signs of the mammary gland, abnormal milk and also systemic signs which include fever, depression, anorexia and shivering (Blood and Radostits, 2000).

2.3.2 Acute mastitis

This form is less severe than peracute form and it is usually characterized by inflammation of the glands, abnormalities in the milk and systemic signs which may be slight or severe with a sudden onset. Systemic signs include depression, anorexia and fever. This form of mastitis can be a new infection or exacerbations of chronic infections and they are mostly caused by *Staphylococcus aureus* and *Staphylococcus agalactiae* (Blood and Radostits 2000, Smith, 2002).

2.3.3 Subacute mastitis:

This form of mastitis is less common and it is characterized by fever, anorexia, dehydration, depression and toxemia. The mammary glands are inflamed and the milk is usually watery and sanguineous. This form is usually caused by coliforms and *Staphylococcus* (Blood and Radostits, 2000).

2.3.4 Chronic mastitis

This form of mastitis shows no clinical signs for long intervals. The mammary glands remain infected for long time and sometimes due to certain factors may periodically cause acute mastitis (Blood and Radostits, 2000). The somatic cells are chronically elevated and the milk sometimes contains flakes and shreds of fibrin. The milk production is reduced and great economic losses are usually incurred. This form is usually caused by coliforms and staphylococci (Smith, 2002).

2.3.5 Sub-clinical mastitis

Sub-clinical mastitis occurs when the mammary glands are infected but there are no obvious clinical signs both in the udder and in the milk (Blood and Radostits, 2000). The milk production decreases and the somatic cell count (SCC) increases; they may, however, only be detectable by measures of the milk's cellular content (somatic cells) (Khan *et al.*, 2006). The predominant cells in milk are epithelial and white blood cells, the latter of which increases to tremendous numbers (millions/ml) whenever injury or infection of the gland occurs. Thus, by determining the number of cells present in a sample of milk from the mammary gland one can determine the likelihood of mastitis even though all other visible signs of inflammation are absent (Shearer *et al.*, 2003). According to Shearer *et al.*, (2003) subclinical mastitis is important due to the fact that it is 15 to

40 times more prevalent than the clinical form (for every clinical case of mastitis there will be 15-40 sub clinical cases); it usually precedes the clinical form, is of longer duration, difficult to detect, adversely affects milk quality production and constitutes a reservoir of micro organisms that lead to infection of other animals within the herd constituting major source of economic losses in dairy goat production (Khan *et al.*, 2006), not to mention transmission of zoonotic bacteria to humans who consume the milk.

2.4 Economic losses due to mastitis

Globally, the losses due to mastitis amount to about 53 billion dollars annually (Ali *et al.*, 2010). Severe economic losses due to mastitis occur from reduced milk production, treatment cost, increased labor, milk withheld following treatment and premature culling (Miller *et al.*, 1993). It is recognized that if this disease is diagnosed in early stages, a greater portion of this loss can be avoided (Sharif *et al.*, 2009).

2.5 Mastitis situation across the world

Prevalence of mastitis in dairy goats varies among different countries. Results of studies done on mastitis in goats across the world show that subclinical mastitis is the most prevalent form followed by clinical mastitis which is less frequent (Contreras *et al.*, 1995). Coagulase Negative *Staphylococcus* (CNS) is the most prevalent pathogen causing subclinical mastitis in dairy goats according to Contreras *et al.*, (2007). For instance, White and Hinckley (1999) examined goat milk from 2911 udder halves as part of a milk quality-monitoring program over 8 years in Connecticut and Rhode Island, USA. They found that the most prevalent mastitis agent was CNS (38.2%), Ndegwa *et al.*, (2001) reported that bacteria were isolated in 28.7% of the milk samples

from small-scale dairy goat farms in Kenya and the most prevalent bacteria were CNS (37.5%). Foschino *et al.* (2002) reported that CNS were found in 90% of goat milk samples collected from ten farms in the Bergamo area, Italy.

2.6 Etiology of mastitis

Numerous organisms have been associated with clinical and subclinical mastitis in goats, the commonest being bacteria (Shearer *et al.*, 2003). The most common causative organisms of udder disease include: staphylococci, streptococci and coliforms (mainly *E. coli*, *Enterobacter aerogenes* and *Klebsiella pneumoniae*). Other less frequent agents include: *Corynebacterium*, *Pseudomonas*, *Nocardia*, *Mycoplasma*, yeast and Caprine arthritis encephalitis virus (Tomita *et al.*, 2001).

2.6.1 Coagulase Positive Staphylococcus

Members of *Staphylococcus* genus are the most common bacteria causing mastitis in dairy goats; they are usually divided into coagulase-positive *Staphylococcus* (CPS; *Staphylococcus aureus*) and coagulase-negative *Staphylococcus* (CNS) (Shearer, 1992). Coagulase positive *Staphylococcus* is mostly associated with clinical mastitis in dairy goats. The main source of these organisms is the udder, the teats and milk from infected glands. Transmission from one animal to another usually occurs during milking through contaminated milking equipments and milkers' hands (Blood and Radostits 2000). These organisms cause acute clinical and chronic or subclinical mastitis; the species has also been associated with gangrenous mastitis. Gangrenous mastitis is a peracute form of mastitis, characterized by necrosis of the udder tissue, caused by alpha-toxins (Smith and Sherman, 2009). All forms of mastitis caused by *Staphylococcus aureus* are usually accompanied by systemic signs of illness (fever, anorexia, depression, toxemia and

recumbency) and occur mostly at parturition or during the first month of lactation (Smith, 2002). Coagulase Negative *Staphylococcus* are responsible for the majority of subclinical mastitis cases in dairy goats; the condition is characterized by significant increase in milk somatic cell count (SCC) (Contreras *et al.*, 2003). Clinical mastitis caused by these pathogens has occasionally been reported (Deinhofer *et al.*, 1995).

2.6.1.1 Coagulase Negative *Staphylococcus* (CNS)

Coagulase-negative *Staphylococcus* comprises a number of different species which include *Staphylococcus epidermidis*, *Staphylococcus caprae*, *Staphylococcus simulans*, *Staphylococcus chromogenes* and *Staphylococcus xylosus* (Contreras *et al.*, 2003; Bergonier *et al.*, 2003). The herd level prevalence of CNS is usually between 25-93%, and are isolated mainly from chronic and subclinical infections (Bergonier *et al.*, 2003). Coagulase Negative *Staphylococcus* are contagious pathogens found on the skin of goats and human hands and can easily be transmitted during unhygienic milking procedures. Thus, these organisms have public health importance. Once in susceptible foods, their growth may be expected to lead to the production of enterotoxin which can cause Staphylococcal food poisoning or food intoxication (Jay *et al.*, 2005, Smith, 2002). Control of staphylococcal mastitis should be through hygienic milking procedures to prevent the transmission from one goat to another (Blood and Radostits, 2000).

2.6.2 Streptococcal mastitis

This form of mastitis occurs in goats but at lesser extent than in cows. The mostly common isolated species is *Streptococcus agalactiae*; other less isolated organisms include: *Streptococcus dysagalactiae* and *Streptococcus uberis*. *Streptococcus agalactiae* is highly contagious and obligate resident of the udder; it mostly causes subclinical mastitis, where it is

also able to cause acute clinical mastitis and rarely chronic mastitis. Transmission occurs from one doe to another during milking through contaminated milking equipment or milker's hands (Blood and Radostits, 2000).

Streptococcus uberis and *Streptococcus dysgalactiae* are not obligate residents of the udder. They are mainly found in the environment where they can survive for long periods; they occasionally cause subclinical mastitis (Smith, 2002). *Streptococcus zooepidemicus* has also been isolated in goats and causes chronic suppurative mastitis (Blood and Radostits, 2000).

The prevalence rate of streptococcal infection in goats is very low (1-2%) (Contreras *et al.*, 1995) although they tend to result in high somatic cell counts (Hall, 2007). The importance of these bacteria is limited in goats because of the low prevalence rate (Min *et al.*, 2007).

2.6.3 Coliform mastitis

This form of mastitis is caused by coliforms which are mainly environmental organisms (Blood and Radostits, 2000). These pathogens include: *Escherichia coli*, *Enterobacter aerogenes* and *Klebsiella pneumoniae*. Other less-common pathogens include *Pseudomonas Species*, *Pasteurella multocida* and *Serratia marcescens*. Coliform mastitis is usually clinical, peracute and acute, with systemic involvement. Chronic mastitis has also been reported. Coliforms produce endotoxins which may lead to death of the animal (Shearer *et al.*, 1992). Transmission occurs at milking, between milking or at dry period when the organisms are transferred from the environment to the animal (Smith, 2002). Approximately 70-80% of coliform infections are manifested by abnormal milk, udder swelling and systemic disturbances such as high fever, swollen quarters, watery milk and depressed appetite (Blood and Radostits, 2000).

2.6.4 Mycoplasma mastitis

Organisms in the genus *Mycoplasma* have also been isolated from clinical mastitis cases in the does, primarily *Mycoplasma mycoides*, *Mycoplasma putrefaciens*, *Mycoplasma agalactiae* (Blood and Radostits, 2000). In goats, these organisms sometimes cause serious outbreaks of mastitis which are usually characterized by decreased milk production, systemic illness and peracute death in kids (Smith, 2002). *Mycoplasma putrefaciens* also causes septicemia, polyarthritis, pneumonia, and encephalitis, together with high mortality in suckling kids. *Mycoplasma capricolum* has also been reported to cause severe mastitis and infection in kids (Cynthia and Scott, 2011). Transmission of the organisms is through milking machines and milkers' hands. Treatment using antimicrobial is usually unsuccessful and therefore culling is recommended (Smith, 2002).

2.6.5 Other bacteria associated with mastitis

Other bacteria such as *Arcanobacter pyogenes*, *Bacillus coagulan* and *Corynebacterium*, *Actinobacillus*, *Brucella melintesis* and *Norcadia asteroides* have also been associated with mastitis in goats (Contreras *et al.*, 2003).

2.6.6 Mastitis caused by Caprine arthritis and encephalitis virus

Caprine arthritis encephalitis virus (CAEV) is also known to cause udder infections in goats. These infections are characterized by interstitial mastitis and clinical cases are known as “hard udder” (Blood and Radostits, 2000). The virus can also cause subclinical mastitis (Turin *et al.*, 2005).

2.7 Pathogenesis of mastitis

Mastitis generally results from ascending infection via the teat canal to the mammary gland. Factors that distort the teat or teat sphincter enhance chances of infection. Predisposing factors such as poor management and hygiene, teat injuries and faulty milking machines are known to hasten the entry of infectious agents and the course of the disease (Smith, 2002). Infection of the mammary gland always occurs via the teat canal and the pathogenesis of mastitis involves three phases: Invasion, infection and inflammation.

The invasion phase is the stage at which bacteria move from the exterior of the teat through the teat canal and cistern in to the milk (Blood and Radostits, 2000). The infection phase is one at which the agent persists in the milk cistern and duct in more or less equilibrium with its host. The pathogen multiplies rapidly and invades the mammary gland tissue and, depending on the susceptibility of the invading pathogen, endotoxins maybe released and this may result to systemic effect and inflammatory effects (Blood and Radostits, 2000). Inflammation phase follows immediately on penetration of tissue from the ducts. It is in the inflammation phase where varying degrees of clinical mastitis and also subclinical mastitis occur. Clinical mastitis is characterized by a varying degree of clinical abnormalities in the udder, milk and systemic effect. Sub-clinical mastitis is also significantly associated with a great increase of leucocytic cells in the milk, which are used as indicators of the condition. Presence of the cells in the milk is also used as a measurement of milk quality and udder health (Blood and Radostits, 2000). Reduction of incidences of mastitis can be best achieved through prevention of the invasion phase. This is done through good management and good hygiene procedures (Khan *et al.*, 2006).

In cases of systemic infections, spread of the etiological agent occurs through haematogenous colonization. This is frequent in diseases such as mycoplasmosis and brucellosis (Khan *et al.*, 2006).

2.8 Diagnosis of mastitis

While clinical mastitis is rather easy to detect, animals with subclinical mastitis are often difficult to diagnose since there is lack of reliable diagnostic methods especially at the farm level (Persson and Olofsson 2011).

2.8.1 Physical examination

Detection of clinical mastitis can be done through visualization and palpation of the udder to notice changes in consistency, size and changes in temperature (Blood and Radostits, 2000). The udder, teats and the supramammary lymph nodes should be palpated for evidence of abnormality (Shearer, 1992).

Proper visualization of the milk for presence of any abnormalities such as clots, flakes or serous milk is also important and this requires the use of a strip a cup. Discoloration of the milk may be in form of blood or wateriness. Presence of clots and flakes and discolouration of milk are a clear indication of severe inflammation (Blood and Radostits, 2000, Smith, 2002),

2.8.2 Indirect tests

Subclinical mastitis, which is characterized by absence of physical changes in the udder and the milk, can only be diagnosed using indirect methods. These tests include: California Mastitis test

(CMT), Somatic cell count (SCC), Bacteriological analyses and electrical conductivity test (Blood and Radostits, 2000).

2.8.2.1 California Mastitis Test (CMT)

California mastitis test (CMT), is a simple and rapid test that can be applied in the field. The test is used particularly for detection of subclinical udder infections. It is based on the formation of a gel when DNA in somatic cells reacts with the detergent. The reaction occurs in a CMT paddle and is graded subjectively as: trace, 1, 2, 3, 4, 5. The test results can be used as a rough estimate of the number of somatic cells in milk (Shearer *et al.*, 2003).

2.8.2.2 Somatic cell count (SCC)

It is a direct method of measuring subclinical mastitis in the milk. The relationship of SCC to the microbiological quality of small ruminant's milk and its expressiveness remains controversial (Zeng and Escobar, 1995). The test seems to be influenced by various factors such as stage of lactation, oestrus, parity, time of sampling (before, during or after milking), stress and lambing season (Haenlein, 2002; Sevi *et al.*, 2004). Several authors have not managed to link SCC with the presence of bacterial infection (Foschino *et al.*, 2002; Delgado-Pertinez *et al.*, 2003, Kyozaire *et al.*, 2005).

Moreover the panel on biological hazards of European Food Safety Authority (EFSA) (2005) has made an opinion on the usefulness of somatic cell counts for the safety of milk and milk-derived products from goats. The panel concluded that due to the high variability of SCC in goat milk, even in healthy animals, SCC cannot be relied on either as a specific indicator for TSE

(Transmissible Spongiform Encephalopathy) risk, nor as an indicator of udder health. Three main types of difficulties were noted in the EFSA review.

- The count accuracy is affected by the apocrine nature of milk secretion in goats. Cytoplasmic particles, which derive from the apical part of secretory cells, are normal constituents in goat milk. Certain methods used to count somatic cells cannot distinguish these cytoplasmic particles, similar in size to somatic cells, from real somatic cells, which may lead to false readings. Moreover, the reference microscopy method, which is based on staining 10 procedures, does not give satisfactory results in the majority of laboratories, when used on goat milk.
- Somatic cells that are identified in milk from healthy cows or ewes are mainly macrophages. Less than 30% are other leukocytes. Higher levels of the latter are considered to be indicative of inflammation. On the other hand, leukocytes can reach up to 60% of total cells in normal goat milk. The somatic cell count is therefore difficult to interpret in terms of udder inflammation.
- Non-infectious factors greatly influence the somatic cell count in goats. Physiological normality is dependent on the stage of lactation, age, time of sampling, the oestrus period, feed, stress, breed and the region. Most experts in this field therefore consider that a specific somatic cell count-value derived from one population of goats may describe a normal animal health status in a second population, and indicate mastitis in a third population.

2.8.2.3 Bacteriological analyses

Diagnosis of subclinical mastitis in goats is not easy and direct bacteriological assay using standard laboratory methods is the recommended method (Maisi and Riipinen, 1988; Maisi, 1990a; Fthenakis, 1995; Gonzalez-Rodriguez and Carmenes, 1996). Although some diagnostic tests (CMT, NAGase, SCC) (Poutrel and Lerondelle, 1983; Maisi and Riipinen, 1988) are used for determination of subclinical mastitis, bacteriological culture is the gold standard in the diagnosis of subclinical mastitis (Poutrel and Lerondelle, 1983; Sanchez *et al.*, 2004). Definitive detection of infected goats relies on positive culture of pathogens from aseptically collected milk samples (McDougall *et al.*, 2002).

2.8.2.4 Electrical conductivity

Electrical conductivity of milk increases during mastitis due to increases in Na⁺ and Cl⁻ and decreases in the K⁺ and lactose. Changes in conductivity can be detected by hand held or milk line instrumentation. The data obtained can be analyzed by computer programs to detect animals that have altered electrical conductivity from normal (Petzer *et al.*, 2008).

2.9 Treatment

Treatment of mastitis in dairy goats, just like in dairy cows, can either be local or parenteral. Parenteral treatment is usually recommended in all systemic reactions (Shearer *et al.*, 1999). Successful treatment usually depends on the etiological agent, sensitivity results, extent of tissue damage, severity of the infection, choice of drugs, their availability and access to the patient (Blood and Radostits, 2000). Treatment of clinical mastitis is through a therapeutic approach which involves use of systemic antibiotics and anti-inflammatory drugs with regular stripping of

the mammary glands. Hydrotherapy has also been used in reducing local edema (Epitaufik, 2007). Some systemic antibiotics have been proposed but the efficacy has not been published so far. These include: tobramycin, enrofloxacin, tiamulin, florfenicol, beta-lactamines and macrolides given intramuscularly or intravenously. Administration of these drugs is normally followed by infusion of the affected gland.

Subclinical mastitis treatment is usually done by use of commercially prepared intramammary antibiotics (Shearer *et al.*, 2003). Intramammary infusions are good since they ensure good systemic involvement. When systemic antibiotics are used, as in mastitis, higher doses are given to ensure enough concentrations get to the udder. Commonly used drugs for treatment of mastitis include Penicillins at 16500I.U/kg body weight, Oxytetracyclines at 10mg/kg body weight, Tylosine at 12.5/kg body weight and sulphadimidines 200mg/kg bodyweight (Blood and Radostits, 2000).

In all cases of mastitis treatment decisions need to be made early and should be based on clinical diagnosis not on culture results or pending antibiotic susceptibility tests (Garrison *et al.*,2000).

2.10 Prevention and control

The success of a dairy goat production is highly influenced by the prevention and control of mastitis. Mastitis control depends on either decreasing the exposure of the teat to potential pathogens or increasing resistance of dairy animals to infection. The dairy farmer must be conscious of the impact that mastitis may have on public health issues, the economy of the farm, and the well being of the goat (Sharif *et al.*, 2009; Tomita *et al.*, 2001). Proper control and prevention measures should be instilled in order to protect the public from zoonotic diseases

transmitted by consumption of unpasteurized milk and also prevent the economic losses incurred following mastitis infection in a goat flock (Tomita *et al.*, 2001).

Contagious mastitis can be transmitted from one goat to another during milking process and new infections are most often acquired during the lactation period. The primary reservoir of contagious pathogens is the mammary gland itself. The use of dry therapy, post milking teat disinfectants and effective pre-milking hygiene are effective control procedures for most contagious mastitis pathogens. Monitoring SCC and prompt identification and treatment of mastitis in dairy animals help in the reduction of mastitis (Sharif *et al.*, 2009).

Control of environmental mastitis can be achieved by reducing the number of bacteria to which teat is exposed. Reduced teat end exposure to environmental bacteria can be accomplished by providing goats with a clean and dry pasture or barn. The animal environment should be as clean and dry as possible to ensure no exposure to contamination. Post milking teat dips with germicidal compounds are recommended. Proper antibiotic therapy for all halves of all animals at drying off helps to control environmental streptococci during early dry period (Sharif *et al.*, 2009).

Since the elimination of environmental pathogens from the goats' surrounding is impossible to accomplish, enhancement of the animals' immune response to infection may be an alternative method of control (Khan *et al.*, 2006; Tomita *et al.*, 2001). Other practices which have been used to prevent contagious and environmental mastitis include the milking of infected animals last and preventing the animals from lying down after milking. This should allow enough time for the

proper closure of the teat orifice and chronically infected goats should be culled from the herd for they serve as a source of infection for the rest of the herd (Tomita *et al.*, 2001).

2.11 Antibiotic sensitivity

Antibiotic susceptibility test can be performed using disk diffusion method on Mueller-Hinton agar (Oxoid) according to the procedure described by National Committee of Clinical Laboratory Standards (NCCLS) 2006. All isolated bacteria can then be tested with different antibiotics, including: Tetracycline, Gentamicin and Kanamycin, Norfloxacin, Amoxicillin and chloramphenicol; these are widely used in veterinary practice in Kenya.

Antibiotic sensitivity testing is important in that it indicates which antimicrobial products would not likely be effective. The efficacy of antibiotic treatment of mastitis in does, just like in cows, depends on the cause, clinical manifestation, antibiotic susceptibility of etiological agent and the efficiency of immunological system. Mastitis therapy is commonly unsuccessful owing to pathological changes that occur in the udder parenchyma as a result of the inflammatory reaction, mastitogenic bacteria related factors, pharmacokinetic properties of antimicrobial drugs, poor animal husbandry and inadequate veterinary service (Preez *et al.*, 2000). Over the past years, bacteria that cause human diseases have developed resistance to many of the antibiotics commonly used for treatment (Witte, 1998).

2.12 Effect of diseases on production in Goats

Diseases affect the well-being of a dairy goats and hence reduce milk production, either directly through the effects on the individual animals, or indirectly through a reduction in fertility of the

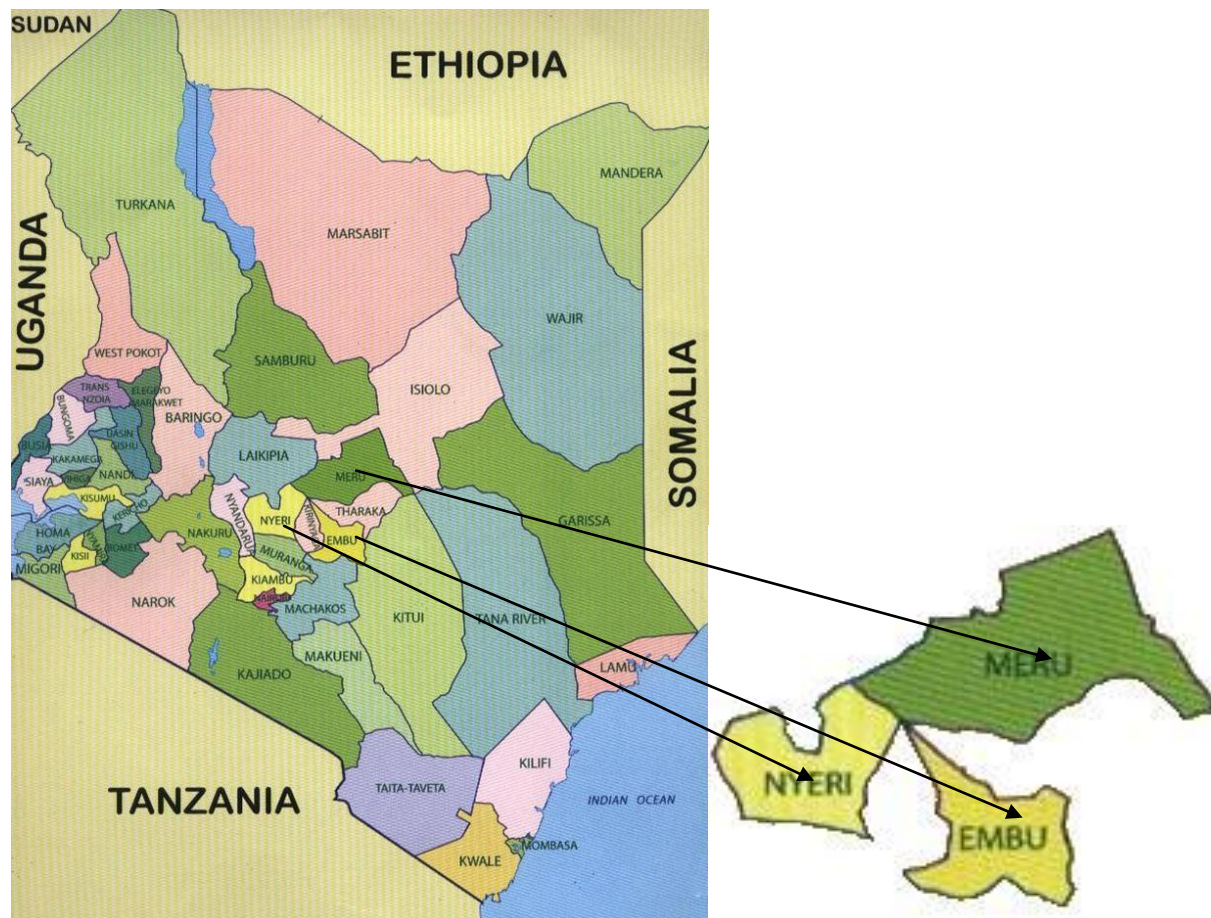
herd and therefore in the initiation of new lactations (Blood and Radostits, 2000). A wide range of diseases affect dairy goats and herd health programmes should be instituted to prevent them (Lebbie *et al.*, 1996). Severity of the impact on milk production will depend on the severity and nature of the disease; specific diseases having specific effect on the animals. For instance some diseases such as benign carcinomas will have little effect on herd productivity (Rajan *et al.*, 1982); or a more general effect, such as with pneumonia; or a specific effect on fertility, such as with toxoplasma (Dubey 1987); or an effect both on goats and humans, such as with brucellosis (Kolar 1987).

Many infectious diseases have been documented in dairy goats. These include; brucellosis, tuberculosis, Johne's disease, enterotoxaemia, mycoplasmosis, caseous lymphadenitis, Pox, foot and mouth disease, Mastitis, Pneumonia and other diarrhoeal diseases such as colibacillosis (Blood and Radostits, 2000; Wesonga *et al.*, 1993).

CHAPTER 3: MATERIALS AND METHODS

3.1 The study area

The study was carried out in Mount Kenya region and selected sites in three counties were included; Meru (Miriga miero east, Abo East divisions), Nyeri (Mukurweini and Nyeri municipality divisions) and Embu (Manyatta division) counties of Kenya (Figure 3.1). These are high potential areas that are densely populated and the dairy goat population is also high. The sites were purposively selected based on the large population of dairy goats in the areas. The local District Livestock Production Officers (DLPOs) & extension officers were engaged in the mobilization and location of all the dairy goat farmers in the study.



Source. Google maps (2013)

Figure 3.1: Map of Kenya showing the location of Meru, Nyeri and Embu Counties where the study was carried out

Nyeri County covers an area of 3284 km² and is situated about 150 km north of Nairobi at an altitude ranging between 1600-3000 metres. It lies between the Eastern base of the Aberdare range, which forms part of the Eastern end of the Great Rift Valley, and the Western slopes of Mount Kenya. Its geographical coordinates are 0° 25' 0" South, 36° 57' 0" East. The area has a humid climate receiving rainfall ranging from 700mm to 2000mm per annum and the temperatures range from 12⁰C to 27⁰C. The population in Nyeri is 6.7 million people with a population density of 208 people per km². The main economic activities are small scale dairy and crop farming (KBS, 2009).

Meru County covers an area of 6936 km² and is located in Eastern province of Kenya. It lies between longitude 37° 39' 0" East of the Northeast slope of Mt Kenya and latitudes 0° 30' 0" North. Temperature ranges from 16⁰C - 23⁰C. The rainfall ranges between 500mm- 2600mm per annum. It has a total population of 1.2 million people and population density is 195.5 per sq. km² and the main economic activities include crop farming and dairy farming (Kenya Bureau of Statistics, 2009).

Embu County covers an area of about 2814km² and is located in Eastern Kenya and it is approximately 120 km North East of Nairobi and South Eastern slopes of Mount Kenya. It lies between latitude 00°32'S and longitude 37°38'E. Temperature ranges from 12⁰C to 27⁰C and the average rainfall is 1495mm per annum. The population is 5.1 million people and the population density is 183 people per sq. km. Embu County occupies the main prime fertile lands in Kenya highlands and the weather is favourable for most agricultural activities. Main economic activities include dairy and crop farming and commercial businesses (Kenya Bureau of Statistics, 2009).

3.2 Sample size determination

The sample size was determined using formula by Martin *et al* (1987).

Sample size = $n = Z^2 \frac{pq}{L^2}$. where n=the required sample size, $Z_{\alpha} = 1.96$ = the normal deviate at 5% level of significance = the estimated prevalence (in percentages), $q = 1 - P$ and L = the precision of estimate which is considered to be 5% = **0.05**

Since the prevalence of mastitis in dairy goats in Kenya is estimated at 28.7% (Ndegwa *et al.*, 2000). **Sample size** $n = Z^2 \frac{pq}{L^2}$

$$1.96^2 \times 0.287 \times 0.713 / 0.05^2 = 314$$

3.3 Study animals

The study animals were lactating dairy goats of different ages, parities and stages of lactation.

The breeds were Toggenbergs, German Alpines and their crosses.

3.4 Study design

The survey was a cross sectional study conducted in the study areas. The sampling units were households with at least two lactating dairy goats.

A simple random sampling was used to select an estimated 157 farms from a list of dairy goat farmers (containing 1210 farmers) obtained from the District Veterinary Officer's (DVOs) office [they are registered members of Dairy Goat Association of Kenya (DGAK) and Meru Goat Breeders Association (M.G.B.A)]. The number of dairy goats sampled in each division was proportional to the population of goats in the division. The study included collection of baseline data on goat production through filling of questionnaires, bacterial isolation and usage of other diagnostic test (CMT). Antibiotic sensitivity testing of the isolated bacteria was also done.

3.5 Data collection through usage of questionnaires, Field observation and photographs

Two different semi-structured, pre-tested, questionnaires were designed to elicit information on the baseline data on production of dairy goats and occurrence of mastitis in the area. The questionnaires were pre tested separately. A total of 30 farmers were selected using simple random selection method from the three counties for pre testing of questionnaire. Modifications on the questionnaire were done after the pre test. One type of the questionnaire was administered to the farmers and the other type of questionnaire was administered to the key informants of the

Dairy Goat Association of Kenya (D.G.A.K) and Meru Goat Breeders Association (M.G.B.A). The pre tested questionnaires were administered by the investigator during the farm visits. The information sought is shown in the farmer's questionnaire (Appendix 1) and the information in the Dairy associations' questionnaire (Appendix 2).

Data was also collected through observations made on the ground during the farm visits by the investigator. These data included hygiene of the shelters, physical condition of the goats and type of feed. Photographs were also taken as evident in the various photographs in the results section of the thesis.

3.6 Milk sample collection

All milk samples were collected aseptically from each teat of the goat's udder into sterile universal bottles and analyzed by California Mastitis Test which was done at the goat side. All samples were transported to the laboratory in cool boxes with ice for bacteriological culture and isolation within 24 hours of sample collection. Briefly, the does were restrained and sampled in their pens or in the open. Before sampling the udder of the goat was thoroughly washed with water and dried with clean towel. After disinfecting the teats with 70% ethyl alcohol swabs, milk was collected. The first 3-4 streams of milk was discarded and then 5-10 ml of milk was collected from each teat aseptically and put in separate universal bottles held at slightly horizontal position in order to avoid contamination from the udder (Singh *et al.*, 2007). The bottles were then sealed properly and labeled. Samples were stored in ice-boxes with cool packs for transport to the Bacteriology Laboratory, Department of Veterinary Pathology, Microbiology and Parasitology, for bacteriological analysis.

3.7 California Mastitis Test (CMT)

The California mastitis test was conducted to diagnose the presence of subclinical mastitis. This screening test was performed according to the standard procedure described for mastitis by Quinn *et al.* (1994) and Schalm *et al.* (1971). The reagent contains a surface acting detergent (Sodium Alky aryl sulphonate and a dye bromocresol purple). It acts by reacting with the nucleus material in the cells (leucocytes, somatic cells) resulting in gel formation whose thickness depends on number of the cells in the milk. The paddle was rocked to allow proper mixing of the reagent and the sample and results read within 10 seconds. The results were then scored as 0 (negative), +1 (positive one), +2 (positive two) or +3 (Positive three) depending on the intensity of reaction (Appendix 3) depending on extent of gelling. The plate was washed and rinsed before the next set of sampling. In this study score of 0, trace, and +1 were considered negative while scores $\geq +2$ were considered positive.

3.8 Laboratory procedures

The milk samples collected from various farms were investigated for presence of mastitis using the following: California Mastitis Test (CMT); Total plate counts; isolation, identification and antibiotic sensitivity testing of the isolated bacteria.

3.8.1 Isolation and identification of bacteria

Bacteriological examination was carried out following standard methods (Quinn *et al.*, 1994, Shears *et al.*, 1993). Briefly, a loopful of milk sample was streaked on sheep blood agar (Oxoid UK) and Mac Conkey agar (Oxoid UK) using the quadrant streaking method. Both agar plates

were incubated aerobically at 37 °C and examined for characteristic bacterial colonies. If no growth was observed they were re-incubated for further 48 to 72 hours. When no growth was observed within the extra 72 hours the samples were regarded bacteriologically negative. Mixed growths were then subcultured onto fresh media of same type to obtain pure colonies. Gram stain procedure was performed according to the method described by Forbes *et al* (2002) and Bebora *et al* (2007), after which further biochemical tests and identification were carried out. The isolated organisms were identified to species levels, where possible, using a manual of veterinary laboratory techniques. *Staphylococcus* and *Micrococcus* species were identified based on their growth characteristics on Mannitol Salt agar (MSA), coagulase production, catalase, and oxidase tests. Oxidation fermentation test (O-F) test reaction was performed to differentiate *Staphylococcus* from *Micrococcus*; *Streptococcus* species were distinguished according to CAMP reaction (*Streptococcus agalactiae* potentiates *Staphylococcus aureus* hemolysin leading to complete or Beta (β) haemolysis of the red blood cells on Bovine blood Agar – a positive CAMP test), growth characteristics on 7% sheep blood agar, catalase production and sugar fermentation tests (Quinn *et al.*,1994; Sears *et al.*, 1993; Forbes *et al.*, 2002). Gram-negative isolates (Enterobacteriaceae) were sub-cultured on MacConkey agar and further tested using Triple sugar Iron (TSI) Agar, IMViC test (Indole, Methyl red, Voges-Proskauer and Citrate utilization tests) and oxidase reaction (Quinn *et al.*,1994; Shears *et al.*,1993; Forbes *et al.*, 2002).

Before bacterial isolation was carried out, smears were made from each milk sample and Gram-staining was done, according to the method described by Forbes *et al.*, 2002, Bebora *et al.*, 2007

and Quinn *et al.*, 1994. This was to enable the researcher get a rough idea of the expected bacteria in the milk.

3.8.2 Antibiotics susceptibility test

Antibiotic susceptibility test was performed using disk diffusion method on nutrient agar (Oxoid) according to the procedure described by Manual for Veterinary Investigation Laboratories (1986). All isolated bacteria were tested with different antibiotics including: Tetracycline, Gentamicin, Kanamycin, Norflaxacin, Chloramphenical and amoxicillin, all of which are widely used in veterinary practice in Kenya. Briefly, ten colonies from the Blood agar medium, incubated at 37°C for 24 hours, were suspended in 2 ml of sterile saline to a density approximately equal to McFarland Opacity Standard No. 0.5. A dry sterile cotton wool swab was placed in the suspension and excess liquid was expressed against the inside of the tube. The bacterial suspension was inoculated onto nutrient agar using the swab, in such a way that the whole surface of the agar was covered. Antibiotic disks were then placed on the inoculum. The antibiotic disks contained the six different antibiotics named above. The results were recorded as resistant or susceptible by measurement of inhibition zone diameter according to the interpretive standards of Manual for Veterinary Investigation Laboratories (1986).

3.8.3 Total viable counting

Total viable counting of isolated bacteria was done according to Miles and Misra (1938). Briefly, the milk samples were 10-fold diluted, from 10^{-1} to 10^{-10} . Using a pipette, calibrated at

25 ul (dropping 40 drops per ml), a drop from each of the different dilutions was placed on separate surface of agar plates; each drop appropriately labeled, with respect to the dilution factor. The plates were left on the bench to dry after which they were incubated at 37°C for 18 – 24 hours. Where countable, colonies were counted for each drop. The number of colony forming units (CFU) per ml was then calculated according to Miles and Misra (1938). The following equation was used to calculate the number of colony forming units (CFU) per ml from the original sample.

$$\text{CFU per ml} = \text{Average number of colonies for a dilution} \times 50 \times \text{respective dilution factor}$$

3.9 Data management and statistical analysis

All data collected were entered in Microsoft Excel 2007 spreadsheet as database and to SAS (Statistical Analytical System) 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 in the logistic regression univariate analysis ($p < 0.1$) 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 (χ^2) technique to test the existence of statistical association between mastitis and the risk factors (explanatory variables) such as site, parity, stage of lactation, breed housing and hygiene. In all chi-square test applications, level of $P < 0.05$ was considered statistically significant.

CHAPTER 4: RESULTS

3.1 Data derived from questionnaires

4.1.1 Characteristics of dairy goat production in Mount Kenya region

All the farms recruited for this study were small scale, located in Mount Kenya region. A total of 157 farms were visited out of which 62(40%) were in Meru county, 34(21%) in Embu and 61(39%) in Nyeri counties.

A total of 157 farmers were interviewed, out of whom 91(57%) were males and 42(42%) were females (Figure 4.1). The ages of the farmers varied; 135 (86%) being between the ages of 35-70 yrs, 9 (6%) between the ages of 20-34 while 13 (8%) were over 70 years of age (Table 4.1). There was no significant difference between the age groups in the study area ($P=0.4$).

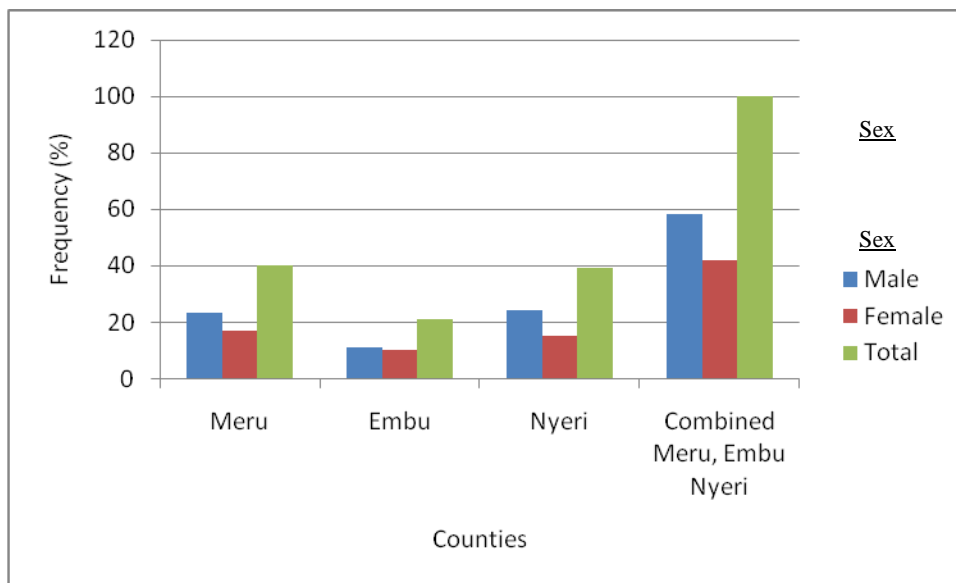


Figure 4.1: Proportion of male and female farmers interviewed in the three counties, separately and collectively

Table 4.1: Distribution of different age groups of farmers (in percentages) in the three different counties, separately and collectively

Age groups (years)	Meru County N=62		Embu County N=34		Nyeri County N=61		Combination Meru, Nyeri and Embu counties N=157	
	No.	%	No.	%	No.	%	No.	%
20-34	3	2	2	1	5	3	10	6
35-70	53	34	29	18	55	35	137	87
>70	6	4	3	2	1	1	7	10

For all the 3 counties, farmers in the age bracket 35-70 years were the majority (87%); those in the age bracket 20-34 were the least. Meru County recorded the highest number of farmers aged over 70 years (4%), whereas Nyeri County had the highest number of farmers aged 20-34 years of age (3%) (Table 4.1).

4.1.2 Land sizes

The average farm size in all counties was 2.38 hectares (Table 4.2). There was a significant difference between the land sizes in the three counties ($P=0.0001$). Nyeri County had the smallest pieces of land while Meru County had the largest pieces of land.

Table 4.2: Average farm sizes in the three counties

County	Average farm size(acres)	Standard deviation
Meru	3.47	1.81
Embu	2.49	1.89
Nyeri	1.28	0.99

Considering the number of farms of particular sizes per county, Nyeri County had the highest number [31(20%)] of farms which were smallest in size (0.25-0.4 acres) whereas Meru county had the highest number [48(31%)] of farms which were the largest in size (more than 1 acre). (Table 4.3)

Tables 4.3: Distribution of land sizes in the three counties, separately and combined.

Land sizes (acres)	Meru county N=62		Embu county N=34		Nyeri county N=61		Combined N=157	
	No.	%	No.	%	No.	%	No.	%
0.25-0.4	5	3	5	3	31	20	41	26
0.5-1	9	6	6	4	10	6	25	16
>1	48	31	23	14	20	13	91	58

4.1.3 Dairy goat associations

There were two main dairy goat associations in the Mount Kenya region: Meru Goat Breeders Association (MGBA) in Meru County and Dairy Goat Association of Kenya (DGAK) in Nyeri

and Embu Counties (Figure 4.2). The MGBA is a poor farmers' empowerment project of goat breeders in Meru County. This association was founded 1998 with support of Farm Africa and Ministry of livestock development. It was later registered as a self-help group in 2003. It targeted the very poor people who were given dairy goats with the aim of poverty alleviation. It comprised a network that involved various groups each of which had about 25 members, stretching from units to district to regional office. They imported 100 Toggenburg bucks and 80 does which were distributed to the farmers. There were also breeding stations with 1 buck and 4 does.

Activities of MGBA included: safeguarding and coordination of all Toggenburg dairy goat farmers, carrying out breeding programs through buck rotation in the district, health delivery activities, goat identification, training of farmers, monitoring of groups and maintaining good record keeping for information flow.

The challenges facing MGBA included: mismanagement, which has led to collapse of the milking plan; high cost of managing it; buck rotation, which has led to inbreeding; presence of brokers selling dairy product on behalf of the organization; greed for leadership from the members. Collapsing of the plant led to big problem of lack of market for milk.

The DGAK, on the other hand, is a farmers' organization and a service provider for poverty alleviation. It was registered in April 1994 as a product of a GOK/GTZ project (Integrated Small Livestock Project-ISLP) for sustainability of the programme. The project started a cross-breeding programme using local Kenyan female goats [Galla and Small East African] and imported

German Alpine bucks. Other activities by DGAK included: training staff and goat farmers in various aspects of good goat husbandry, provision of breeding stock, buck rotation/exchange between groups/members to avoid inbreeding, identification and registration of goats with Kenya Stud Book, marketing of milk and breeding goats through organized sales and provision of extension services through DGAK assistants.

Some of challenges faced by DGAK included: lack of disease free countries to import quality breeding goats, milk marketing constraints, shortage of DGAK assistants in view of the increasing number of farmer groups, inadequate skills by members in production and conservation of quality fodder and lack of ICT skills and equipment in the branch offices.

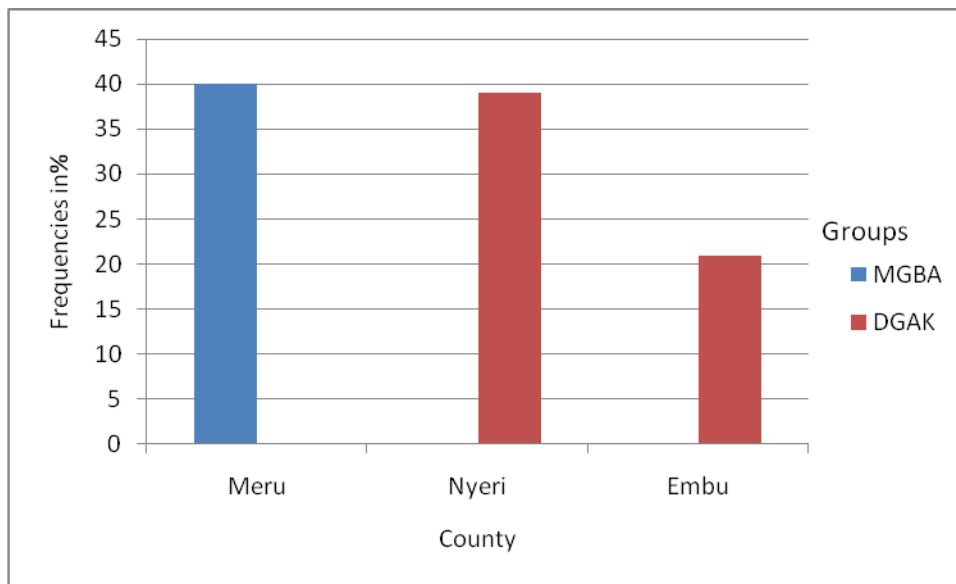


Figure 4.2: Shows distribution of dairy goat association groups in three counties separately.

4.1.4 Breeds of dairy goats kept

Does kept by the associations were Toggenberg crosses (at 36%) and Kenyan Alpines (at 64%). Kenya Alpine dairy goat (KADG) is a breed resulting from the grading-up of the local East African goat using pedigree German Alpine germplasm. This was and is still being done using natural service. The breed has four registration classes (genotypes) which include: foundation, intermediate, appendix and pedigree (Plate 4.1 A). Plate 4.1 B and 4.2 show samples of DGAK breeding plans for Nyeri and Meru counties, respectively.

The Toggenburg breeding plan was carried out through buck station managed by groups. Majority of farmers interviewed in Meru County said the does comprised $\frac{3}{4}$ Toggenberg goats.

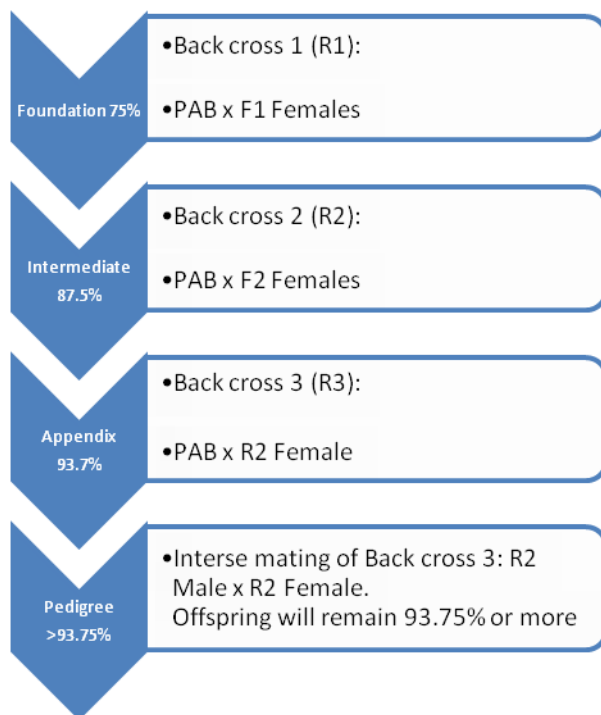


Plate 4.1. A. Genetic group and blood levels in percentages of Kenyan

Plate 4.1. B: DGAK breeding plan shown by one of the farmers in Nyeri county. Notice the different breeding levels represented by different colours on the chart

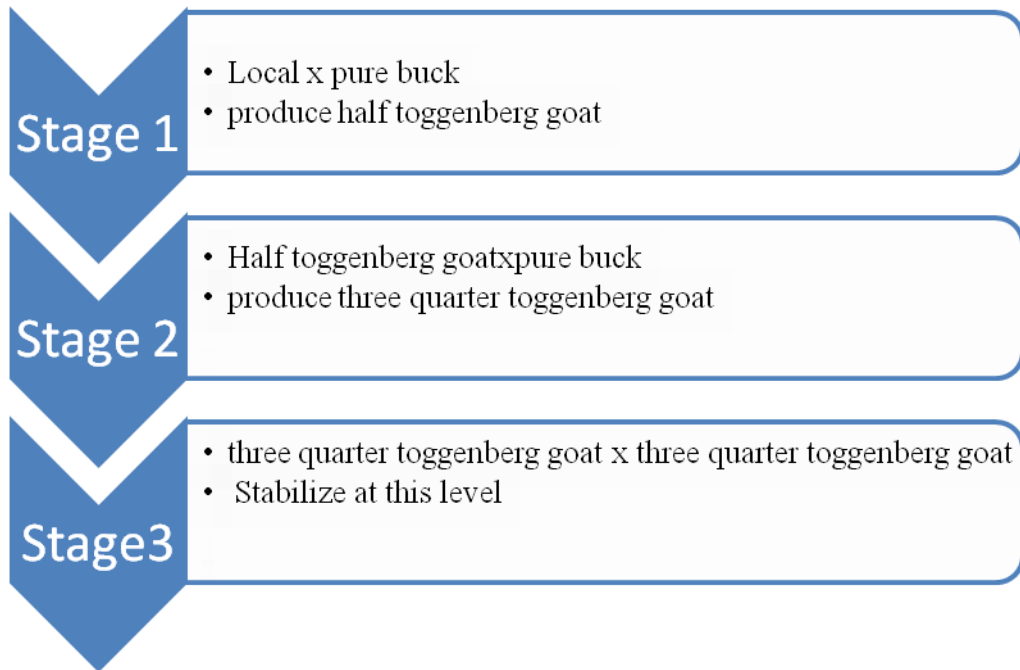


Plate 4.2: Breeding plan of Toggenberg crosses in Meru County from stage one to stage three

4.1.5 Flock structure

In all the three counties, Embu County had the highest number of lactating goats and kids per farm. There were few bucks in the three counties, with Embu having the least (Table 4.4).

Table 4.4: Average (\pm s.d) number of dairy goats per farmer across the three counties, separately and in combination.

	Meru county		Embu county		Nyeri county		Combined	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Dairy goats								
Total dairy goats	5.6	3.81	7.51	6.10	7.00	3.45	6.62	4.42
Lactating dairy goats	2.40	0.98	2.56	1.87	2.46	1.04	2.46	1.27
Drying dairy goats	1.12	1.56	1.44	1.57	1.52	1.19	1.36	1.43
Males	0.81	1.01	0.70	1.25	1.15	1.06	0.96	1.10
Kids	1.30	1.56	2.54	2.89	1.59	1.56	1.72	2.02

4.1.6 Livestock kept by the farmers

Farmers in Mount Kenya region kept a number of different types of livestock other than goats. These animals included cattle, poultry, sheep, pigs and rabbits. The respective Numbers and percentages are given in Table 4.5.

Table 4.5: Types, Numbers and percentages of other animals kept by the dairy goat farmer in Mount Kenya region per County

County N=157	Cattle		Poultry		Sheep		Pigs		Rabbits	
	No	%	No	%	No	%	No	%	No	%
Meru N=62(40%)	42	27	40	26	11	7	5	3	6	4
Embu N=34(21%)	24	15	23	14	1	1	1	1	1	1
Nyeri N=61(39%)	30	19	33	21	14	9	13	8	11	7

N = No = number

4.1.7 Housing and hygiene of the structure

From the study, it was observed that there were two types of houses used to keep goats (Plate 4.3 A and B). In both types, there were separate pens for does, bucks and kids. About 65% (103/157) of the farmers had raised timber structures while 34.39% (54/157) of the farmers used low timber structures.

It was observed that 25% (40/157) of the houses were in good condition, 70% (110/157) and 5% (7/157) were in fair and bad conditions respectively. The frequency of cleaning the houses also varied from farm to farm: 36% (57/157) of the farmers said that they cleaned the goat pens daily, 27 % (43/157) and 36% (57/157) once a week and twice, respectively.



Plate 4.3A. Raised-timber housing structure (raised slatted floor).



Plate 4.3B. Low-timber structures used by some farmers in Nyeri and Embu Counties

4.1.8 Feeding

All of the 157 farmers who were interviewed practiced zero grazing. From observations, the feed given to the goats consisted nappier grass, sweet potato vines, maize stalks and banana peels which were placed in feeding troughs (Plate 4.4 A) while in other farms, the feed was suspended using a rope on the walls of the pens. All the farmers supplied water to the does within the pens. One farmer indicated use of mineral supplement (salt lick) (Plate 4.4 B).



Plate 4.4 A. Zero grazed goat feeding on grass



Plate 4.4.B. A young goat licking a mineral supplement (salt lick).

4.1.9 Deworming and Spraying

Regular management tasks to maintain a healthy and productive herd of goats included deworming and dipping. Out of the 157 farmers who were interviewed, 86% (135/157) sprayed their goats with acaricides. The proportions of farmers who sprayed their animals in the counties were: 39% in Meru, 16% in Embu and 29% in Nyeri.

Of all the farmers interviewed, 99% (156/157) indicated that they dewormed their goats. In Meru and Embu counties, 40% and 21%, respectively, dewormed their goats, while in Nyeri only 35% of the farmers dewormed their goats. Farmers pegged the choice of anthelmintics used to cost, advice from animal health professionals and advice from shopkeepers.

4.1.10 Breeding

Tables 4.6 give the types of breeding methods used by the farmers in the three counties, separately and combined. There was a significant difference in the type of breeding practiced

($P < 0.05$); majority (90%) of the farmers used natural breeding. In Meru County all farmers used natural breeding while in Embu and Nyeri counties farmers practiced all the three forms of breeding.

Table 4.6: Breeding methods used by the farmers in the three counties, separately and in combination

Breeding system	Meru county N=62		Nyeri county N=61		Embu county N=34		Combined Meru, Nyeri, Embu N=157	
	No.	%	No.	%	No.	%	No.	%
Natural breeding	62	40	55	35	24	15	141	90
Artificial breeding	0	0	5	3	5	3	10	6
Both	0	0	1	1	5	3	6	4

N =No.= number

4.1.11 Farm records

Out of the 157 farmers who were interviewed, 67% (105/157) kept records on dairy goat milk production whereas the rest (33%; 53/157) did not keep records. Figure 4.3 gives the extent of record-keeping, with respect to the 3 counties.

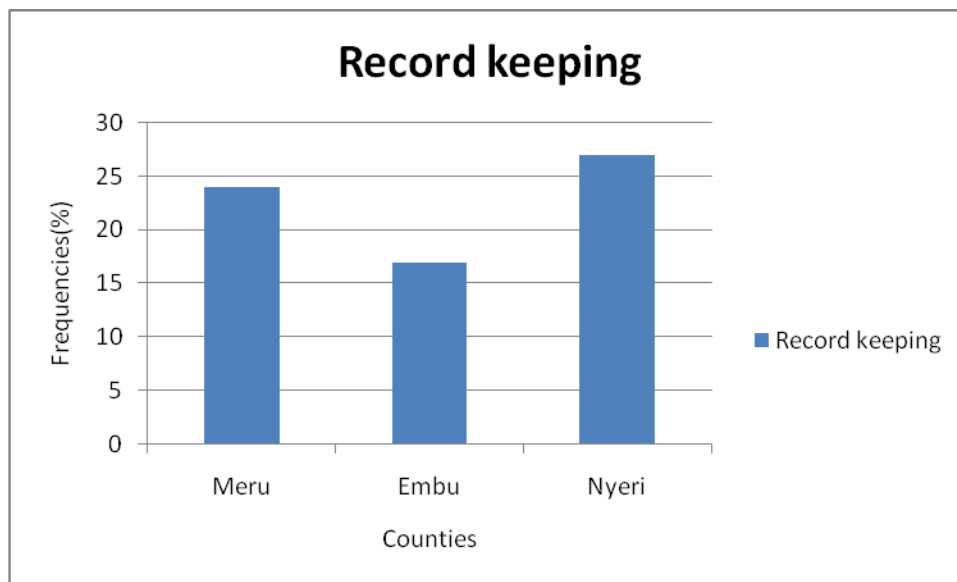


Figure 4.3. Farmers who kept milk production records in the three counties

4.1.12 Challenges experienced in dairy goat farming

List of challenges and respective frequencies in the region and in separate counties are given on Table 4.7. Across all the three counties lack of market for milk was the main challenge (46%), with Meru County having the highest (22%) and Embu County the lowest (7%). Diseases were the other main challenge in all the counties, with Nyeri County recording the highest prevalence of 15%. Lack of buck rotation was also recorded in Meru County. Lack of feed was reported across the counties, with Embu County recording the highest prevalence of 9%.

Out of the 157 farmers interviewed in the three counties, 25% complained of high cost of feed with Meru and Nyeri counties recording the highest prevalence of 10%, respectively.

Of all the farmers in the three counties, 9% experienced lack of supplement; 5% of them being from Meru County, High cost of treatment (9%) were also recorded across the counties. Insecurity was recorded in Meru and Embu counties at 1.2% and 0.6%, respectively. Lack of capital was recorded in Embu County (1%) and inadequate artificial insemination services was recorded in Meru County (5%).

Table 4.7. Various challenges facing dairy goat farming in the three counties separately and in combination

Challenges	Meru county N=62		Embu county N=34		Nyeri county N=61		Combination of the counties N=157	
	No.	%	No.	%	No.	%	No.	%
Lack of market	34	22	11	7	26	17	70	46
Diseases	20	13	8	5	23	15	52	33
Buck rotation	26	17.2	0	0	0	0	26	17.2
Lack of feed	9	6	15	9	6	4	30	19
High cost of feed	16	10	6	5	16	10	38	25
Lack of supplement	8	5	6	4	1	1	15	10
High cost of treatment	2	1	5	3	7	5	14	9
Insecurity	2	1.2	1	0.6	0	0	3	1.8
Lack of capital	0	0	1	1	0	0	1	1
Artificial insemination	8	5	0	0	0	0	8	5

N =No. = number

4.1.13 Common diseases affecting dairy goats

List of common diseases and their respective frequencies are given on Table 4.8; they are also graphically presented, per county, on Figure 4.4. Farmers reported that pneumonia was the most common disease experienced in Mount Kenya region (at 41%), followed by diarrhea (36%) especially in young goats below one year of age. Deformity was least prevalent (at 1%).

Plate 4.5 A, B and 4.6 present some of the clinical manifestations observed when the researcher visited the farms.

Table 4.8: Common diseases affecting dairy goats in Mount Kenya region

Common diseases noticed		No. of respondents	% response
1	Pneumonia	65	41
3	Diarrhoea	56	36
4	Mastitis	23	15
5	Foot rot	1	1
6	Teatpox	13	8
7	Skin infection	8	5
8	Mysterious disease	4	3
9	Dystocia	11	7
10	Worms	15	10
11	Deformity	2	1

Mysterious disease; the farmers complained of diarrhea and sudden death of the goats

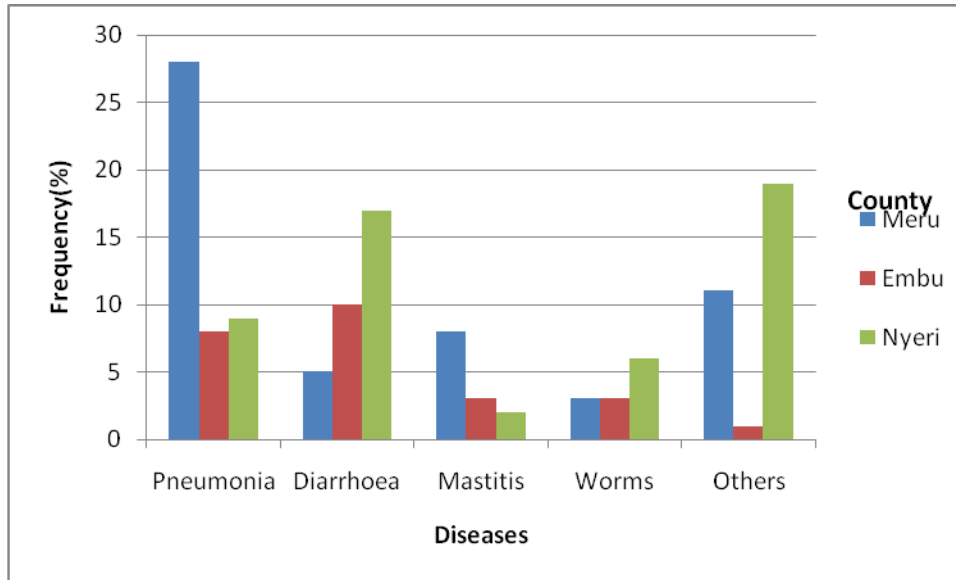


Figure 4.4: Frequencies of common diseases in dairy goat in different counties

Others=Flea, Deformity, foot rot, pink eye, mysterious diseases, teatpox, Skin condition, Overgrown hooves and dystocia



Plate 4.5A: Goat which had diarrhea as shown by the arrow from one of the farms in Nyeri county

Plate 4.5B: Fecal material from a goat suffering from diarrhea



Plate 4.6: Kid which was born with deformed forelimbs and she was unable to move properly in Meru County

4.1.14 Perception on Profitability of dairy goats

Of the 157 farmers interviewed, 145 (92%) said that dairy goat farming was profitable while 12 (8%) said that dairy goat farming was not profitable. In Meru County a total of 40% of the farmer perceived dairy goat profitable while in Embu (21%) and Nyeri 31% found dairy goat farming profitable.

4.1.15 Lactation and milk production

Out of 310 does in the study farms, 92 (29%) were at early lactation, 110 (35%) at mid lactation and 108 (34 %) at late lactation.

Out of the 157 farms visited, 3 (1%) had does that produced an average of 4 litres/day, 28 (17%) had does that produced an average of 3 litres/day, 95 (60 %) had does that produced an average of 2 litres/day, 21 (13%) had does that produced an average of one litre/day, and 10 (6%) had does that produced an average of 0.5 litre/day (Table 4.9). Overall, majority of goats produced more milk during first 6 months post kidding; production reduced subsequently during the rest of lactation period.

Majority of does (63.9%) produced 2 litres of milk daily across the counties whereas only 1.9% produced 4 litres and above daily.

Table 4.9: Average daily milk production per household per county

Average milk production L/day	Meru County N=62		Embu County N=34		Nyeri County N=61		Total N=157	
	No.	%	No.	%	No.	%	No.	%
0.5	1	0.63	3	1.9	2	1.2	6	3.8
1	9	5.7	5	3.1	5	3.1	19	12.1
2	38	24.8	19	12.1	42	26.7	99	63.9
3	12	7.6	5	3.1	12	7.6	29	18.4
4	2	1.2	1	0.63	0	0	3	1.9

N = No.= number

4.1.16 Milking procedure and Milking hygiene

In all the three counties, majority of the does were milked by spouses 132 (84.24%), daughters 22 (14.08), sons 19 (12.10%), herders 17 (11.46%) (Figure 4.5). Where owners' wives did the milking, the percentages were as follows: Meru 38%, Embu 20% and Nyeri 26%. Where sons did the milking, the percentages were: Meru 2%, Embu 1% and Nyeri 8%. Where daughters did the milking, the percentages were: Meru 4%, Nyeri 9.5% and Embu none. Where herders did the milking, the percentages were: Meru 1%, Embu 1% and Nyeri 10%.

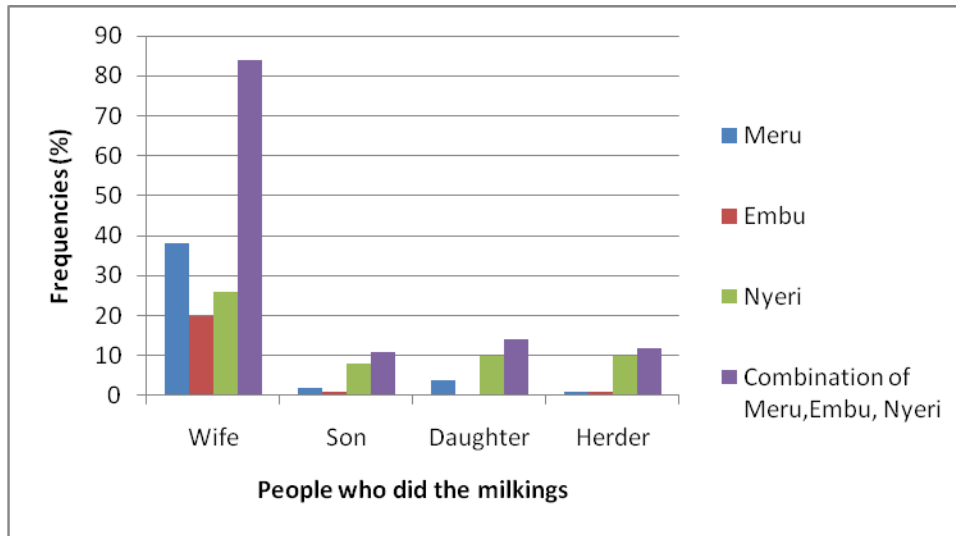


Figure 4.5: Distribution the people who used to do the milking of the does in the three counties, separately and collectively

The frequency of milking of the does differed from farm to farm. This was dependent on the farmer's preference the stage of lactation of the does, litter size and the demand of milk.

A total of 112 (70%) of the does were milked twice a day; the milking was done in the morning and in the evening. Forty five (30%) milked their does only once in a day - either in the morning or in the evening (Table 4.11). There was no significant difference ($P=0.09$) between the number of milkings per day per goat in the three counties. Meru County had the majority 21(12.74%) of goats milked once a day while Nyeri County had the highest number 45(29%) of goats milked twice a day.

Table 4.10: Distribution of number of milking per doe per day in the three counties

Number of milkings	Meru County N=62		Embu County N=34		Nyeri County N=61		Total N=157	
	No.	%	No.	%	No.	%	No.	%
1	20	12.74	11	7	17	10	48	30
2	42	27.34	23	14	44	28.57	109	70

N = No.= number

Of all the farmers interviewed, 154 (98.7%) said they cleaned the udder using warm water, and dried the udder using a clean towel before milking. Only 7 (5%) of the farmers indicated that they used teat dips after milking. In Meru and Nyeri counties, 1 (1%) and 6 (4%), respectively, of the farmers used teat dips after milking while Embu county farmers didn't use teat dips. Majority of the farmers milked their does until about 4-6 weeks to the expected date of the next kid

4.2.17 Milk use and milk market

A high percentage (72%; 114/157) of the farmers used the milk for home consumption, 15.98% (25/157) sold their milk privately whereas 11.46% (18/157) sold the milk through dairy goats association (Figure 4.6).

The mean price per litre was KSh. 40 in Meru, 100 in Embu and 50 in Nyeri. For Meru and Embu, milk was sold privately to hotels, neighbours, churches, hospitals, while for Nyeri, milk was sold through Dairy goat association (Table 4.11).

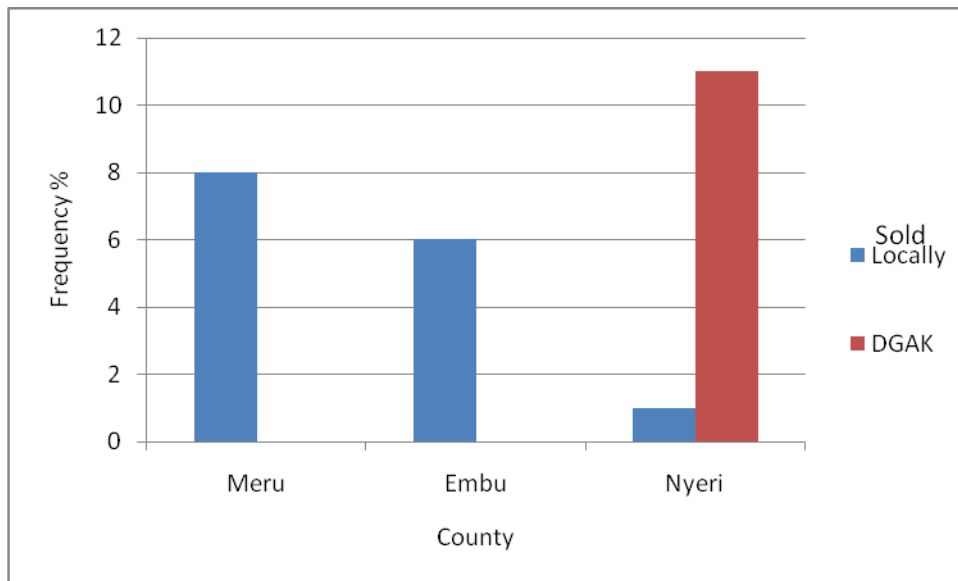


Figure 4.6: How farmers who sold their milk in the three different counties, separately and collectively

Table 4.11: Average milk prices (Ksh) per liter in different counties

County	Mean price (KShs)	How milk was sold
Meru	40	privately
Embu	100	privately
Nyeri	50	through DGAK

4.2 Prevalence of subclinical mastitis in lactating goats in Mount Kenya region and characterization of the isolates

4.2.1 California mastitis test results

The prevalence rate of subclinical mastitis, with respect to CMT, was found to be 61% in Meru County, 62% in Embu and 60% in Nyeri County. The overall mean prevalence was estimated to be 61 % (Table 4.12). There was no significant difference between prevalence of subclinical mastitis in the three counties ($P=0.96$).

Table 4.13 gives CMT results, with respect to right and left halves, for the study goats. The results showed that there was no particular preference for a particular quarter (both left and right quarters were infected at more-or-less same rate – 50 and 53%, respectively). Frequency distribution, with respect to positive CMT, per county, is given on Table 4.14.

Table 4.12: Results of the CMT as indicators of subclinical mastitis in the study goats in the three counties

County	Positive for infection No. (%)	Negative for infection No. (%)	Total number screened
Meru	41 (61%)	26 (38%)	67
Embu	54 (62%)	32 (37%)	86
Nyeri	95 (60%)	62 (39%)	157
Total	190 (61%)	120 (38%)	310

Table 4.13: CMT results of the udder halves for the three counties

Half	Number positive	Number negative	Total number screened	Prevalence (%) of positive cases
Left	154	156	310	50
Right	163	147	310	53
Overall	317	303	620	51

California mastitis test was conducted on 620 milk samples collected from 310 lactating goats for the presence of subclinical mastitis. Considering CMT scores of 0 and trace and 1+ as negative and $\geq 2+$ as positive, 317 (51%) milk samples were CMT positive, while 303 (49%) samples were CMT negative (Table 4.14). On the other hand, 13 (4%) of the 317 CMT-positive milk samples yielded no bacterial growth while the remaining 304 (96%) samples were also

culture positive in which diverse bacterial pathogens were identified (Table 4.15). Of the 303 (49%) CMT negative sample 2(0.6%) yielded bacteria (Table 4.15).

Table 4.14: Frequency distribution for California Mastitis Test (CMT) positive milk samples from the three counties, separately and collectively

CMT reaction	Meru N= 134		Embu N=172		Nyeri N=314		Combined N=620	
	No	%	No	%	No.	%	No.	%
Overall positive	72	53	98	55	147	46	317	51
≥+2	72	53	98	55	147	46	317	51
+1	3	3	5	5	9	3	17	3
Trace	9	7	9	5	12	4	30	5
Nil	50	37	60	35	146	46	256	41

≥+2, +1, Trace – refer to degrees of gelling for CMT positive milk samples

Nil – means negative reaction

Table 4.15: Results of California Mastitis Test (CMT) in Comparison with the Bacteriological Examinations

CMT score	Number of samples examined	Culture positive samples		Culture negative samples	
		No,	%	No.	%
0	256	0	0	256	100
Trace	30	0	0	30	100
1+	17	2	2	15	88
≥2+	317	304	96	13	4
Total	620	306	49	314	51

No. =Number

4.2.2 Bacteriology results

4.2.2.1 Bacterial isolations and prevalence

The prevalence of subclinical mastitis based on culture results was 59% in Meru County, 58% in Embu County and 54 % in Nyeri County. An overall mean prevalence of 57% was estimated in the three counties (Table 4.16). There was no significant difference in cultured mastitis prevalence in the three counties ($P=0.75$). Fourteen percent (46/176) of the goats were infected on one teat whereas 42 % (130/176) were infected on both teats.

When compared per half infection (right and left quarters), 306 samples tested positive for bacterial isolation, while 314 tested negative (Table 4.16), giving the prevalence of subclinical

mastitis at half infection level to be 49.4% (306/620). Infected left halves were more (with a prevalence of 50%) than the right halves (with a prevalence of 48.7%) in this study.

Table 4.16: Prevalence of mastitis in goats sampled from three Counties of Kenya, 2012

County	Total number screened	No. positive	Proportion positive
Meru	67	40	59.7
Embu	86	50	58.1
Nyeri	157	86	54.8
Total	310	176	56.8

No.=Number

Tables 4.17: Prevalence of mastitis at half infection level in goats sampled in the three Counties of Kenya, 2012.

Half	Number positive	Number negative	Total number screened	Prevalence (%) of positive cases
Left	155	155	310	50
Right	151	159	310	48.7
Total	306	314	620	49.4%

Out of the 620 samples examined on culture 306 samples yielded bacteria. Table 4.18 shows that coagulase-negative staphylococci were the most prevalent (at 28%; 176/620), followed by coagulase-positive staphylococci (*Staphylococcus aureus*) (at 14%; 84/620), *Streptococcus* was isolated at 7% (46/620) [*Streptococcus agalactiae* at 2% (9/620)], *Escherichia coli* at 3% (19/620), *Micrococcus* at 4% (24/620), *Corynebacterium* at 1% (7/620) *Pseudomonas* at 0.2% (1/620). Table 4.19 and Figure 4.7 give rates of isolations, per county and collectively. The three counties yielded similar patterns, with respect to bacterial isolations. Overall *Staphylococcus* was the most prevalent in the three counties (at 41.9 %), with coagulase-negative *Staphylococcus* being more prevalent (at 28.3%) than coagulase-positive *Staphylococcus* (at 13.5%). They were followed by *Streptococcus* (at 8.8%), *Micrococcus* (at 7%), *Escherichia coli* (at 3%), *Corynebacterium* (at 1.3) and *Pseudomonas* (at 1%).

Overall Embu had the highest number of *Staphylococcus* (at 47%), followed by Meru County (at 44%), then Nyeri County (at 38%). Of the CPS, Embu recorded the highest prevalence (at 15%), followed by Nyeri (at 14.7%) and then Meru (at 8%). On the other hand, Meru County had the highest prevalence of CNS.

Proportions of coagulase-positive and coagulase-negative *Staphylococcus* are highlighted in Figure 4.8, while those for CAMP-positive and CAMP-negative *Streptococcus* are highlighted in Figure 4.9.

Table 4.18: Laboratory bacterial culture results for goat sampled in the Mount Kenya region, 2012.

Bacteria	Number isolated	Proportion(%) isolated
Coagulase negative staphylococci	176	48
Coagulase-positive staphylococci (<i>Staphylococcus aureus</i>)	84	23
<i>Streptococcus</i>	46	13
<i>Streptococcus agalactiae</i>	9	3
<i>Escherichia coli</i>	19	5
<i>Micrococcus</i>	24	7
<i>Corynebacterium</i>	7	1
<i>Pseudomonas</i>	1	0.3
Total	366	100

Table 4.19: Bacteria isolated from the goat milk samples from Meru, Nyeri and Embu counties, separately and collectively

Bacteria		Meru N=134		Embu N=172		Nyeri N=314		Combined Meru, Embu, Nyeri N=620	
		No.	%	No.	%	No.	%	No.	%
<i>Staphylococcus</i>	Total isolated	60	44.1	81	47	119	38.1	260	41.9
	CPS	12	8.09	26	15	46	14.7	84	13.5
	CNS	48	35.5	55	31.9	73	23.4	176	28.3
<i>Streptococcus</i>	Total isolated	12	8.8	17	9.8	26	8.2	55	8.8
	<i>S. agalactiae</i>	6	4.4	1	0.5	2	0.6	9	1.4
	Other streptococci	6	4.4	16	9.3	24	7.6	46	7.4
<i>Micrococcus</i>		7	5	14	8.14	3	1	24	3.89
<i>Escherichia coli</i>		7	5	8	4.6	4	1.2	19	3
<i>Corynebacterium</i>		3	2.2	0	0	4	1.2	7	1.3
<i>Pseudomonas</i>		1	1	0	0	0	0	1	1

N = No. = number

CPS = coagulase positive staphylococci

CNS = coagulase negative staphylococci

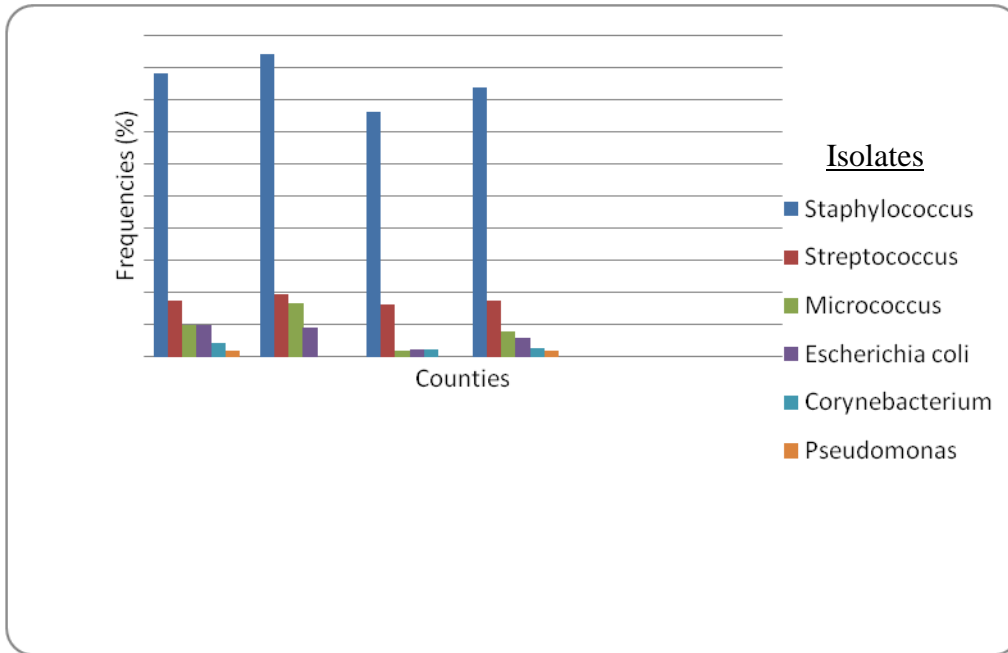


Figure 4.7: Comparison of percentage occurrences per bacterial organism in the three counties separately and in combination

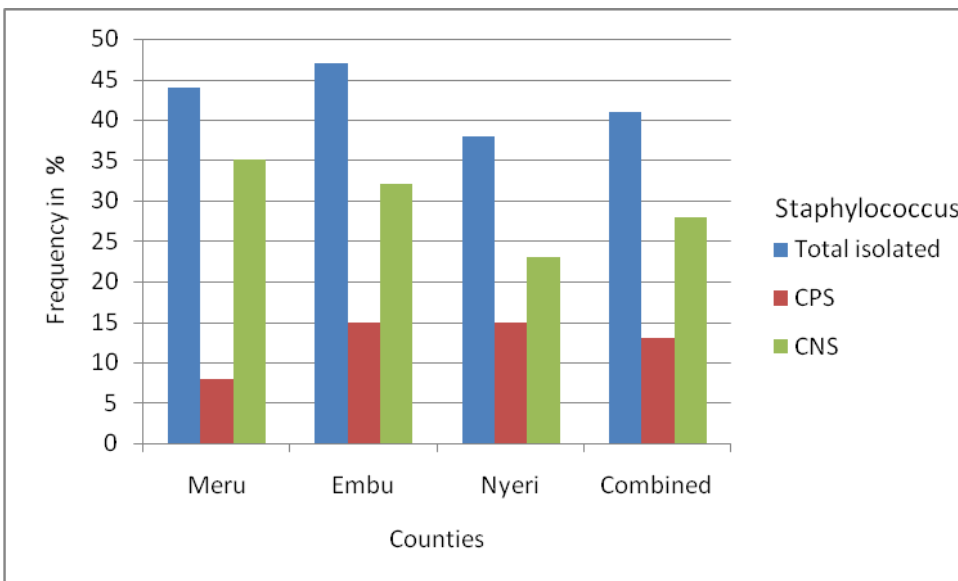


Figure 4.8: *Staphylococcus* prevalences (%): total, Coagulase Positive (CPS), Coagulase Negative *Staphylococcus* (CNS)

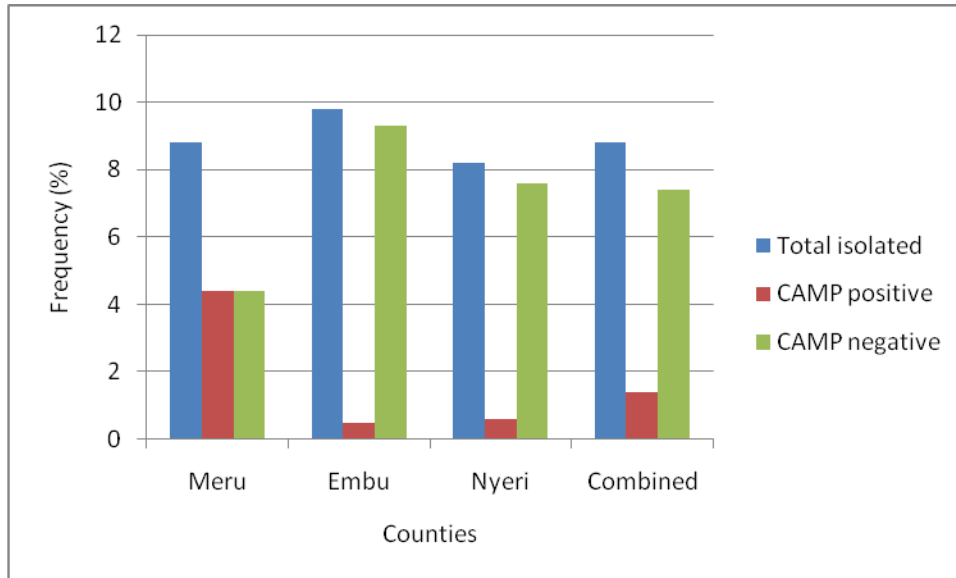


Figure 4.9 Streptococcus prevalences (%): total, CAMP positive, CAMP negative

4.2.2.2 Total bacterial counts

Table 4.20 gives total bacterial counts, presented in 100-fold groups, per county and collectively. Majority of the samples from the three counties fell in the lower bracket of (100-199cfu/ml and 1000-1999cfu/ml) with the highest number of count being in the lowest bracket 100-199cfu/ml. Meru county 67% recorded the highest number of total bacterial counts in this bracket.

The results also show that 23% (72/306) of the samples from the three counties fell under (>10000) bracket), with 32% of those from Nyeri County recording the highest number of total viable bacteria counts in this bracket. There was a significant difference between the three counties (P=0.001).

Out of the 306 samples, 301 (98%) samples were within the accepted total bacterial counts in goat milk (<50,000) (Hinckley *et al.*, 2006).

Table 4.20: Total Bacterial viable counts in the three counties, separately and collectively

County		Total viable bacterial count										
		100-199	1000-1999	2000-2999	3000-3999	4000-4999	5000-5999	6000-6999	7000-7999	8000-8999	9000-9999	>10000
Meru N= 71	Number	47	11	4	1	1	2	1	1	0	0	3
	%	67	15	5	1	1	1	1	1	0	0	4
Embu N=92	Number	32	9	10	4	0	3	2	3	7	0	22
	%	34	10	10	4	0	3	2	3	7	0	23
Nyeri N=143	Number	38	10	6	7	9	2	7	3	10	4	47
	%	26	7	4	4	6	1	4	2	7	3	32
Combined	Number	117	30	20	12	10	7	10	6	17	4	72
	%	38	9	6	3	3	2	3	2	5	1	23

N = number

4.3 Risk factors for subclinical mastitis

4.3.1 Effect of parity on infection status

The 157 does sampled were of different parities. The parities ranged between 1 and 17 (Table 4.21).

Table 4.21 Distribution of parities of does sampled in Mount Kenya region

Parity	Number of does at the parity	Respective (%)n/N
1	84	27
2	56	18
3	95	31
4	41	13
5	21	7
6	4	1
7	2	0.65
8	3	0.97
10	3	0.97
17	1	0.32
Total	310	100

N=total number of goat sampled, n= total number of goat in a given a parity group

For better presentation, the parity levels are grouped into four categories: Group 1 including those at 1st parity; Group 2 including those at 2nd parity; Group 3 including those at 3rd parity and Group 4 including those with parities greater than or equal to four. Comparing respective prevalences of subclinical mastitis/infection (Table 4.23), 44% of these were infected at 1st parity, 52% were infected at 2nd parity, 58% were infected at 3rd and 68% were infected at 4th parity or more. There was a significant difference between parity and infection status ($P=0.03$) and (OR =1.2).

The results show that subclinical mastitis was most prevalent in does in Group 4 (4 or more parities) - at 68% and least prevalent in does at 1st parity – at 44%. Thus, the greater the parity the more the chances of being infected.

Table 4.22: Proportion of dairy goats affected in the four categories

Parity	Proportion affected	P	OR
1	38/84(44%)	0.03	1.2
2	29/56 (52)		
3	55/95(58)		
4 and more	50/75(68)		

Mean= 2.62 ±S.D= 1.75

4.3.2 Effect of hygiene and infection status

Of the study goats 25% (29/113) infected were in the group of farmers who cleaned the pens daily, 69% (58/84) were in the group of farmers who cleaned their pens once a week and 75% (85/113) in the group that cleaned the pens twice in a month (Table 4.23). Statistically there was significant difference between the hygiene and the rate of infection (P=0.0001) and (OR=3).

Table 4.23. Proportion of dairy goats affected and hygiene of the pens

Hygiene of the pens	Proportion affected	P	OR
Daily	29/113(25%)	0.001	3
Weekly	58/84(69%)		
Twice a month	85/113(75%)		

4.3.3 Effect of stage of lactation on infection status of the halves

Table 4.24 gives effect of stages of lactation on infections. For better presentation, the lactation stages are divided into 3 groups: Group 1 being early lactation (1 day – 3 months post-kidding), Group 2 being mid lactation (3 – 6 months post-kidding) and Group 3 being late lactation (over 6 months post-kidding) (Table 4.25), Comparing respective prevalences of infection (Table 4.25), 54% of those in Group 1 were infected, while for Groups 2 and 3, the infection rates were at 52% and 61%, respectively.

There was no significant differences found between the stage of lactation and rate of infection (P=0.3).

Table 4.24: Stage of lactation in the does sampled and percent state of infection

Stage of lactation(months)	Number of does sampled	Proportion (%)
1	45	14.5
2	22	7
3	23	7
4	45	15
5	35	11
6	20	6
7	3	0.97
8	11	3.55
9	11	3.5
10	2	0.65
11	7	2.26
12	15	4.84
13	25	8
14	14	4.5
15	12	3.87
24	10	3.22
Total	310	100

(1-24 is the number in months of the does post kidding)

Table 4.25: Proportion of goats affected in the three categories

Stage of lactation	Proportion affected	P
1	49/90(54%)	0.3
2	57/110(52%)	
3	66/110(61%)	

Stage 1 – does at lactation stage of 1 day - 3 months post-kidding

Stage 2 – does at lactation stage of 3 - 6 months post-kidding

Stage 3 – does at lactation stage of over 6 months post-kidding

4.3.3 Effect of breed and status of infection

The two breeds researched on are Toggenberg and Kenyan alpins. Of the Toggenburgs 59% (40/67) were infected whereas of the Kenyan alpins 56% were infected (Table 4.26). There was no significant difference found between the two breeds and the rate of infection (P=0.5).

4.3.4 Effect of type of housing and infection status

The goat houses were classified as either raised slatted timber or low timber. Fifty nine percent (40/67) of the does housed in the raised slatted timber houses were infected whereas 56% (136/243) of the does housed in the low timber structures were infected (Table 4.27). Statistically there was no significant difference between the type of housing and the rate of half infection (P=0.5)

4.3.5 Effect of study site (county) and infection rate

With respect to the three counties included in the study 59% (40/67) were infected in Meru, 58% (50/86) in Embu and 54% (86/157) in Nyeri (Table 4.26). There was no significant difference in prevalence in the three counties, with respect to rate of infection ($P=0.75$).

Table 4.26. Proportion affected in different study areas

County	Proportion affected	P
Meru	40/67(59%)	0.75
Embu	50/86(58%)	
Nyeri	86/157(54%)	

Table 4.27: Risk factors associated with Mastitis in dairy goats in Multivariate analysis

Risk factor	Positive	Proportion	P	OR
Parity	172	55.4	0.023	1.29
Hygiene	172	55.4	0.001	2.93
Breed	176	56.7	0.71	0.80
Stage of lactation	172	55.4	0.12	1.27
County	176	56.7	0.5	1.21
Housing	176	56.7	0.71	0.81

Among many potential variables, two variables were considered as potential risk factors for the occurrence of sub clinical mastitis in this study. These were parity of the lactating goat and

hygiene. The association of subclinical mastitis with these risk factors were investigated using P values and odds ratio (OR) as shown in Table 4.22 and 4.23 above; The calculated values of both P value and OR in Tables 4.27 have shown that there was a significant association between the two risk factors (parity and hygiene) and subclinical mastitis at $P < 0.05$. The risk of subclinical mastitis infection in goats where the pens were cleaned twice a month is 2.93 higher than in goats whose pens were cleaned daily (Tables 4.23 and 4.27). The results have also shown that lactating goats with parity of more than one kidding were 1.2 times more likely to be infected by mastitis than goats in their first parity Table 4.22 and 4.27). The rest of the risk factors (Stage of lactation, Housing, County, and Breeds) did not show any statistically significant association with subclinical infection of mastitis.

4.4 ANTIBIOTIC SENSITIVITY RESULTS OF THE ISOLATED BACTERIA

Antibiotic susceptibility patterns for various isolates, separately, are given on Tables 4.28, 4.29, 4.30, 4.31 and 4.32. *Staphylococcus aureus* were most sensitive to Norfloxacin- at 81%, followed by Gentamycin - at 78% and Kanamycin - at 75%. The 3 antibiotics that *Staphylococcus aureus* showed most resistance to, in descending order, were: Amoxycilin - at 25%; Chloramphenical- at 19% and Tetracycline at 16% (Table 4.28). *Escherichia coli* were most sensitive to Norfloxacin- at 90%, followed by Amoxycilin- at 60% and then Chloramphenical- at 50%. The 3 antibiotics that the *E. coli* showed highest resistance to, in descending order, were: Tetracycline - at 50%, Gentamycin - at 40% and Kanamycin - at 30% (Table 4.29).

Coagulase negative *Staphylococcus* were most sensitive to Gentamycin - at 80%, followed by Kanamycin and tetracycline - both at 79%. Most bacteria showed resistance to Amoxycilin - at 33% (Table 4.30). *Streptococci* were most sensitive to Chloramphenical- at 53%, followed by Gentamycin - at 41% and Norflaxacin- at 41%. The 3 antibiotics that *Streptococcus* showed highest resistance to, in descending order, were: Tetracycline – at 59%, Kanamycin – at 58% and Amoxycilin –at 42% (Table 4.31). *Micrococcus* was most sensitive to Gentamycin - at 86%, followed by Tetracycline – at 72% and Norflaxacin- at 71%. The 3 antibiotics that *Micrococcus* showed highest resistance to, in descending order, were: Chloramphenical – at 43%, Kanamycin – at 29% and Amoxycilin - at 29% (Table 4.32).

Overall, when the mastitis pathogens were compared, majority of CPS (87.8%), CNS (82.5%) *Micrococcus* (76%) and *E.coli* (75%) were susceptible to most antibiotics tested. Resistance was recorded to Tetracycline (28%) and Kanamycin (30%) antibiotics. *Streptococcus* (56%) and *E.coli* (25%) showed moderately high resistance to most of the antibiotics tested. Most of the organisms were sensitive to Norflaxacin (82%), Chloramphenical (77%) and Amoxycilin (77%). Table 4.33 gives the general antibiotic sensitivity patterns for all organisms that were isolated from the study area.

Table 4.28: Antibiotic sensitivity pattern for the *Staphylococcus aureus* isolates from Mount Kenya region. N= 32

Antibiotics	Tetracycline	Gentamycin	Kanamycin	Amoxycilin	Chloramphenical	Norflaxacin
	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
Resistant	5(16%)	2(6%)	4(13%)	8(25%)	6(19%)	2(6%)
Intermediate	4(13%)	5(16%)	4(13%)	1(13%)	3(9%)	4(13%)
Sensitive	23(72%)	25(78%)	24(75%)	23(72%)	23(72%)	26(81%)

Table 4.29: Antibiotic sensitivity pattern for the *Escherichia coli* isolates from Mount Kenya region during the study N=10

Antibiotics	Tetracyclin	Gentamyci	Kanamyci	Amoxycli	Chloramphenic	Norflaxaci
	e No. (%)	n No. (%)	n No. (%)	n No. (%)	al No. (%)	n No. (%)
Resistant	5(50%)	4(40%)	3(30%)	3(30%)	1(10%)	0(0%)
Intermediat e	0(0%)	2(20%)	2(20%)	1(20%)	4(40%)	1(10%)
Sensitive	5(50%)	4(40%)	5(50%)	6(60%)	5(50%)	9(90%)

Table 4.30: Antibiotic sensitivity for the coagulase negative *Staphylococcus* isolates from Mount Kenya region N = 43

Antibiotics	Tetracyclin	Gentamycin	Kanamycin	Amoxycillin	Chloramphenicol	Norflaxacin
	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
Resistant	8(19%)	3(7%)	12(28%)	14(33%)	8(19%)	8(19%)
Intermediate	1(2%)	6(15%)	5(11%)	1(2%)	3(7%)	3(7%)
Sensitive	34(79%)	34(80%)	26(79%)	28(65%)	32(74%)	32(74%)

Table 4.31: Antibiotic sensitivity for *Streptococcus* N=17

Antibiotics	Tetracycline	Gentamycin	Kanamycin	Amoxycillin	Chloramphenicol	Norflaxacin
	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
Resistant	10(59%)	7(41%)	10(58%)	7(42%)	6(35%)	7(41%)
Intermediate	2(12%)	3(18%)	2(12%)	5(29%)	2(12%)	3(18%)
Sensitive	5(29%)	7(41%)	5(30%)	5(29%)	9(53%)	7(41%)

Table 4.32 Antibiotic sensitivity for the *Micrococcus* isolates from Kenya region N=7

Antibiotics	Tetracycline	Gentamycin	Kanamycin	Amoxycillin	Chloramphenicol	Norflaxacin
	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
Resistant	1(14%)	1(14%)	2(29%)	2(29%)	3(43%)	1(14%)
Intermediate	1(14%)	0(0%)	0(0%)	0(0%)	0(0%)	1(14%)
Sensitive	5(72%)	6(86%)	5(71%)	5(71%)	4(57%)	5(71%)

Table 4.33: General antibiotic sensitivity pattern for all organisms isolated during the study from Mount Kenya region. N = 109

Antibiotics	Tetracycline	Gentamycin	Kanamycin	Amoxycillin	Chloramphenicol	Norflaxacin
	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
Resistant	29 (27%)	17 (16)	31 (28%)	34 (31%)	24 (22%)	18 (16%)
Slightly resistance	8 (7%)	16 (15%)	13 (12%)	8 (7%)	12 (11%)	13 (12%)
Sensitive	72 (66%)	76 (69%)	65 (60%)	67 (62%)	73 (67%)	78 (72%)

CHAPTER 5: DISCUSSION

5.1 Characteristic of dairy goat production in Mount Kenya region

Dairy goat production is emerging as a high-return option for Kenyan small-scale farmer (Ndegwa *et al.*, 2000). The results of present study showed that dairy goat farming is practiced by both male and female farmers although the males were more than the females ($P=0.04$), most of whom are above the age of 35 but below the age of 70. This is in agreement with results by Kinyanjui *et al.* (2010) who reported that dairy farming was more of family issue and that goats can be taken care of by people of different ages and sex. This was in contrast with findings by Ogola *et al.* (2010), Kenya, who reported that dairy goat rearing mainly, targeted the females.

This diversity in dairy goat farming may be due to one of the following reasons: Increasing awareness role of goats in food production, economic importance of dairy goats and nutritional benefit associated with dairy goat milk, small space required to keep dairy goats, low cost associated with dairy goat production as compared to a cow and the fact that goats are a safe investment.

All the farmers included in the current study were members of one of the two dairy goat associations (DGKA and MGBA) found in Mount Kenya region. Majority of the farmers had practiced dairy goat farming for less than 10 years. This was just about the same time when the dairy goat project was introduced in the Mount Kenya region by Farm Africa in Meru and GTZ in Nyeri and Embu and by word of mouth from the farmers and leaders of the groups. Most of the farmers had attended the training by DGKA and MGBA and most of them were practicing what they were taught at the training. This is consistent with reports by Ogola *et al.* (2010).

Increasing population pressures has led to decrease in land sizes in Mount Kenya region. The results of this study shows that there was a significant difference ($P=0.0001$) in land sizes in the three counties. The results across the three counties generally showed that the land sizes are decreasing. These findings were in agreement with findings by Ahuya *et al.*, (2001) and Ogola *et al.*, (2010) who reported that there is a lot of pressure on the land in the area.

Nyeri County had the highest number of smallest farms compared to Meru and Embu counties. The reason for decreasing land sizes may be due to one of the following: increasing population, land inheritance leading to split up from generation to generation. These small pieces of land favoured the adoption of dairy goat farming in these areas.

Majority of dairy goats were producing 2 litres of milk daily on average in early lactation but decreased towards later lactations; this finding was in agreement with those of Ogola *et al.*(2010), Sulo *et al.*(2011) and Shirima (2005). The average milk production obtained in the current study was slightly higher than that recorded for crossbreds by Mtenga *et al.*(1992), and lower than that reported by Donklin *et al.* (2000). This reduction of milk production later in lactation might have been due to lack of proper feeding and husbandry practices (Sulo *et al.*, 2011). The fluctuation in milk production seemed to depend on the season, since there was higher production during the rainy season, when feed was readily available, and lower production during the dry seasons, due to scarcity of feed.

Seventy two percent (72%) of this milk was consumed at home and only a small proportion was sold and this was consistent with finding by Kinyanjui *et al.* (2010) in Kenya; they reported that

57% of the milk produced was consumed in the household. Sulo *et al.*, (2011) found that 75% of the milk produced by the goats was consumed at home. Ogola *et al.*, (2010) also reported similar findings. The increased consumption of dairy goat milk at home may have been due to one of the following reasons: Most farmers preferred consuming goat milk because of its nutritional and medicinal value; they believed that it is associated with alleviating or controlling some dermatological, respiratory and gastrointestinal diseases (Haenlein, 1988); existence of large families; and lack of market for goat milk - some farmers especially in Meru county complained that the prices of the milk per litre was low (Ksh 40) and therefore they preferred to consume the milk at home than to sell it so cheaply.

The milk was sold either locally (to hospitals, hotels or to individuals) or to dairy goat association and the prices ranged from Ksh 40-100. This was consistent with findings by Sulo *et al.*, (2011) and Kinyanjui *et al.*, (2010) who reported that the prices of goat milk ranged between Ksh 80 and 150. The prices were lower in Meru County; this might have been due to low demand for the milk since most of neighborhood farmers kept dairy goats, and the fact that some of the consumers still preferred cow milk over goat milk.

Results of the current study showed that there was a significant difference in the type of breeding practiced in Mount Kenya region ($P < 0.05$). Majority of farmers revealed that they used natural breeding. These results were in agreement with finding by Ahuya *et al.*, (1997). Farmers in Mount Kenya region used natural breeding because of easy availability of bucks. In this type of breeding does were taken to a buck. This method involved use of communal bucks which were owned and managed by the groups. Farmers in Nyeri and Embu counties used bucks which

belonged to DGAK and which were leased to the groups at Ksh 4000 and then rotated after every 15 months. In Meru County, the buck station services, which are operated by farmers and groups to produce their own crossbreds, facilitated the use of natural breeding methods. However, this form of breeding has been challenged by inbreeding due to logistics of buck rotation.

Results of this study revealed that artificial insemination in goats was being practiced in Nyeri and Embu County. This was in agreement with reports by Origa (2012). Artificial breeding in dairy goats was introduced in order to help with the problem of inbreeding which is currently affecting dairy goat farmers in Mount Kenya region.

Artificial insemination in goats in Nyeri and Embu counties is picking up well and according to recent report by DGAK officials the success rate for AI in goats has been reported at over 75% conception. Currently insemination is done using imported French Alpine semen. But they have a long term plan where some of the male kids from the current insemination will be selected and raised to produce semen in collaboration with Kenya Animal Genetic Research Resources Centre (KAGRC) and Animal Health and Industry Training Centre (AHITI) Ndomba. The artificial insemination industry have been faced by many challenged since it requires trained personnel.

Diseases have a negative effect on dairy goat production by causing high mortality and low production in flocks. For instance ILCA (1979) reported a kid mortality rate of 36.2% in Bendel State in Nigeria and Molokwu (1982) reported that the production target indicated for goats was not being achieved because of the high kid mortality and high disease prevalence in Nigerian goats.

The findings of the current study showed that some of the common diseases encountered included pneumonia, diarrhea especially in kids, mastitis and helminthiasis. Others included teatpox, deformity, and dystocia.

In this study farmers confirmed that the above mentioned diseases especially pneumonia and diarrhea were associated with high mortality especially in the kids and reduced production in the adult though mortality were low. This was in agreement with findings by Ramachadran *et al.*, (2006), of India, who reported that digestive and respiratory diseases contributed most to the total mortality. Donklin and Boyazoglu (2004) also reported that the main causes for mortality were: mastitis and pneumonia. Diarrheal diseases, or scours, are more common in young kids. In addition to coccidia, other causes included colibacillus such as *Escherichia coli* (*E. coli*), worms, *Salmonella* and viruses. Symptoms varied with the cause but, in general, were: anorexia, high temperature, weakness and watery or pasty feces. Good sanitation, housing and management were the primary methods to prevent diarrhea. Treatment included antibiotics, intestinal astringents (bolus or fluid to decrease contractions) and fluid and electrolyte therapy (Blood and Radostits, 2000).

According to this study pneumonia (41%) and diarrhea (36%) recorded the highest prevalence of all the diseases mentioned and there was need for more studies to be undertaken in order to determine the exact cause(s) of the disease(s) and advice on preventive measures.

Helminthes have a negative effect on goat performance due to loss of body weight and body condition (Gwaze *et al.*, 2009). In this study, helminthiasis (10%) was also reported and although

most of the farmers confirmed that they dewormed the animals, helmiathiasis was still a challenge and the reason might have been due to an unreliable deworming regime or the animals may have developed resistance to the dewormers.

In this study, clinical mastitis was also reported at a rate of 14% of the total disease conditions encountered. Therefore, this calls for increased awareness and improved control and preventive measure such as improved hygiene and dry goat therapy.

In this study, 66% of farmers kept records; some had notebooks for recording dairy milk production but majority kept record on breeding programmes of the goats. This finding was in agreement with finding by Ogola *et al.*, (2010). However, it was noted that the records were poorly updated. During the interviews, most of them stated that they forgot to update and others did not see the importance of keeping records.

The results of the study showed that majority of the farmers found dairy goat farming profitable. This was consistent with findings by Ogola *et al.*, (2010), Studies by Teufel *et al.*,(1998) in Punjab (Pakistan), and Kosgey *et al.*, (2008) in Kenya, reported similar findings. The reason for keeping goats included: quick source of income, food and as form of security, gifts and for paying dowry.

Constraints in smallholder dairy goat farming were evident and translated to difficulty to achieving high levels of performance. The results of the current study revealed that dairy goat production is constrained by a number of challenges which included; lack of market, diseases,

buck rotation, lack of feed, high cost of feed, lack of supplements, high cost of treatment, insecurity, lack of capital and inadequate artificial insemination services. This was consistent with findings by Ogola *et al.*, (2010) who reported similar challenges.

Lack of market for milk was one of the main challenges especially in Meru County. This was in agreement with previous results by Ogola *et al.*, (2010) who reported that this industry was being affected by lack market and distribution channels. Bett *et al.*, (2009) also reported that strengthening of the markets and the value chain was necessary in East and central Africa countries. The reason behind this challenge may have been lack of access to urban markets and large-scale buyers especially in Meru County, following the collapse of the milk plant.

The problem of buck rotation was noted and this failure to rotate the buck as required has led to inbreeding. These results were in agreement with findings by Ahuya *et al.*, (2005) who reported similar findings in Kenya and hence decreased performance of the goats.

In this study, Farmers did not follow recommended regimes for feed supplementation or routine disease management practices due to the high costs normally associated with concentrates and drugs. Constraints in smallholder dairy goat farming were evident, and translated to difficulty to achieving high levels of performance.

5.2 Prevalence of subclinical mastitis in dairy goats in Mount Kenya region

The results of this study were based on milk samples obtained from subclinical mastitis cases taken from 157 purposively selected farms in Mount Kenya region, in three different counties; Meru, Nyeri and Embu, to determine the infection status of goats/halves by microbiological

analysis (culturing), and antibiotics sensitivity of the isolated organisms. A total of 620 milk samples were collected from 310 dairy goats in the three counties.

The results of the study showed that the overall mean prevalence of subclinical mastitis in Mount Kenya region based on CMT results was 61% while a prevalence of 57% was estimated based on culture results. The finding in this study was in close agreement with results reported in Palestine, 52% (Adwan *et al.*, 2005), Tanzania 51.5% (Swai *et al.*, 2008). The results recorded in this study were higher than those recorded in other studies: Kenya 28.7% (Ndegwa *et al.*, 2000), Ethiopia 18.0% (Gebrewahid *et al.*, 2012), South Ethiopia 15.5% (Megersa *et al.*, 2009). Vermont (USA) 27.3% (McDougall *et al.*, 2002), However the results of the study were lower than those recorded in Tanzania 76.7% by Mibilu *et al.*, (2007). The prevalence of subclinical mastitis differs among countries. This might be due to the differences in host and management risk factors that influence intra-mammary infection of goats.

The prevalence of subclinical mastitis based on culture results was 59% in Meru County, 58% in Embu County and 54 % in Nyeri County. There was no significant difference ($P=0.75$) in prevalence across the counties. This may be partly due to the fact that the counties practiced similar livestock management systems.

The high incidence of subclinical mastitis in lactating goats in this study may be due to poor hygiene of the pens and absence of standard milking procedures, such as pre- and post-milking udder washing and use of teat dips. .

The half infection rate was 49.5%; this was lower than the doe infection rate (57%) and this indicated that most of infection affected one single half. According to the results of the study left halves (50%) recorded a high infection rate than the right halves (48.7%) although statistically it did not show any difference. This was in agreement with those results reported by Ndegwa (1999) in Kenya, Contreras *et al.*, (1995), in Spain and Boscós *et al.*, (1996) in Greece. They reported that half infection rate was lower than doe infection rates. Ndegwa (1999) and Bosco *et al.*, (1996) also reported that left halves had a higher prevalence than the right halves. The reasoning behind high infection rate on the left half may be due to the fact that most people in the population are right handed and therefore milk from the left.

The present study showed that the most prevalent pathogen causing subclinical mastitis in dairy goats was *Staphylococcus species* (71%) followed by *Streptococcus species* (13%), *Micrococcus spp* 7%, *E.coli* 5%, *Corynebacteria* 1% and *Pseudomonas* 0.2%. Of the *Staphylococcus* isolates, coagulase negative *Staphylococcus* (CNS) was more prevalent (48%) while Coagulase positive *Staphylococcus* (*Staphylococcus aureus*) had a prevalence of 23%. These results are in agreement with results from studies done in other countries (Epitaufik, 2007) who reported that CNS are the most prevalent pathogens causing subclinical mastitis in dairy ruminants.

Contreras *et al.* (1999) investigated bulk tank milk from commercial dairy goats in the USA and found that most of the bacteria isolated were of *Staphylococcus spp.* (95.7%), with coagulase negative *Staphylococcus* as the predominant (66.7%). Ndegwa (1999), working on milk samples from small-scale dairy goat farms in Kenya, reported *Staphylococcus spp.* as the most prevalent bacteria (at 78%) - coagulase negative *Staphylococcus* having a prevalence of 71%. Foschino *et al.* (2002) reported that CNS were found in 90% of milk samples collected from ten farms in the

Bergamo area, Italy. A study done in Ethiopia by (Gebrewahid *et al.*, 2012), reported most prevalent pathogen was CNS followed *S. aureus* which was found in 43% of samples, Kyozaire *et al.* (2005) in South Africa report that 85.7% of the infected udder halves had CNS, while the remaining 14.3% of the infection was due to *S. aureus* (Adwan *et al.*, 2005).

Coagulase negative staphylococci are the most prevalent organisms detectable on udder skin, inside the streak canal and in mammary glands of dairy goats and also humans' hands and can easily be transmitted during unhygienic milking procedures (Kalogridou-Vassiliadou, 1991). Various CNS species are commonly detected in goat milk and these microorganisms can frequently cause subclinical infections persisting for several months (Moroni *et al.*, 2005a). Therefore, this explains why CNS are most prevalent in dairy goats (Kalogridou-Vassiliadou, 1991). According to Koop *et al.*, (2009) CNS should be seen as major pathogens, given their potential to significantly increase SCC and decrease milk yield.

Coagulase positive *Staphylococcus* was the second most prevalent in this study with a prevalence of 14%; This may be attributed to the fact that *Staphylococcus aureus* is the second most prevalent bacteria in subclinical mastitis in dairy goats and the fact that milker's hands are considered to be the main tool in the distribution of microorganisms from teat to teat and from animal to animal, just like in cattle.

Other organisms isolated in the study were *Streptococcus* species (7%), *Micrococcus spp* (4%), *E.coli* (5%), *Corynebacteria* (1%) and *Pseudomonas* (0.3%); they are also important causes of subclinical mastitis in dairy goats although their prevalence is usually low compared to that of *Staphylococcus spp*. The presence of *Escherichia coli* (5%) and environmental *Streptococcus*

could have been due to poor hygiene as most of these pathogens are found on/in the animal's environment (Gebrewahid *et al.*, 2012). The prevalence rates of *E. coli* and *Streptococcus*, recorded in this study, were different from those recorded by (Ndegwa *et al.*, 2000), also in Kenya - he reported a prevalence of 1% for *Streptococcus* and zero for *E. coli*.

The CMT-positive and culture-negative results could be partly explained in two ways: (1) the udder could be injured and is recovering from infection or (2) the infection could be due to something other than bacteria. It could also be due to an organism such as mycoplasmas, which requires special media and cannot be identified in the routine bacterial isolation techniques. For the CMT negative cases which yielded bacterial growth on culture, the explanation could be a possibility of the bacterium being of low pathogenicity, to the extent that it does not induce detectable levels of somatic cell counts. The latter result was consistent with the reports of Ndegwa *et al.*, (2000) who isolated bacteria from 22.5% of 568 CMT negative milk samples and Wakwoya *et al.*, (2006). They both indicated that these bacteria may cause latent infection or they do not stimulate detectable increase in somatic cell counts.

5.2.1 Effect of risk factors on infection status

The present study did not find any association between the type of breeds (Toggenberg and Kenyan Alpines) and prevalence of mastitis. These results are in agreement with result reported by Ndegwa *et al.*, 2001) who found that there was no association between (Alpine and local crosses). The findings also agree with previous finding by Boscov *et al.*, (1996) who reported that no breed differences were observed with regard to the type of bacteria isolated. However, the findings were in contrast with results by East *et al.*, (1987) who concluded that there was an association between particular breeds (Nubian) and high prevalence of mastitis. Mibilu *et al.*,

(2007) demonstrated some differences in CMT positivity among the different breeds of animals with high percentage of positive animals being cross bred animals (Norwegian and Saanen).

Results of this study showed that there was no association between the stage of lactation and prevalence of mastitis. These findings were in agreement with results by Ndegwa *et al.*, 2001, Bergonier *et al.*, (2003), and Epitaufik (2007) who stated that the incidence of clinical mastitis did not vary with the lactation stage. However, this was in contrast with finding by Moroni *et al.*, (2005b) and Mabilu *et al.*, (2007) who concluded that later stages of lactation had more infection than earlier lactation stages.

A significant association was found between the parity and prevalence of mastitis in the current study. These results were comparable to those of Sanchez *et al.*, (1999) who reported that prevalence of intra mammary infection increased with the age of the goats and increased parity; McDougall *et al.*, (2002) reported that significant association in infection prevalence was found between goats older than 4 years and less than 4 years old; and Moroni *et al.*, (2005b) who reported that goats in third and fourth parities had significantly more infection than goats in first or second parities. The increasing prevalence with age may be due to the increased length of exposure to pathogens in older compared to younger animals (McDougall *et al.*, 2002).

This study did not show any association between the study sites and prevalence of mastitis. This contrasted the results by Ndegwa *et al.*, 2001 and (Gebrewahid *et al.*, 2012) who found different prevalences in different groups of goats located in different geographical areas. The lack of difference in prevalence of mastitis, in this study, might have been due to the fact that the 3 study

areas had almost similar prevailing agro ecological zones and hence similar climatic condition; it might also have been due to the fact that farmers of these areas were members of goat association groups. Though they belonged to different groups, the management practices and extension advises given were almost similar; this might have affected the trends of prevalence of mastitis in the three counties.

The results of this study revealed that there was a strong association between poor hygiene and increased rate of infection. These results were in agreement with previous results by Ndegwa *et al.*, 2000 who reported that there was high association between poor hygiene and prevalence of mastitis. Also Mibilu *et al.*, 2007 reported that subclinical mastitis was increased by such factors as dirty houses and poor milking hygiene. This is supported by the fact that most of the pathogens associated with subclinical mastitis in goats are found on the environment of the animal and on the animal skin. So, farmers who did not clean and change their pen beddings frequently created an environment where pathogens could harbor and hence infect the goat's udder and halves. However, the study did not show any association between the type of housing (Low timber and raised slatted timber).

5.3 Antibiotic sensitivity

Results of this study showed that the isolated bacteria were generally more sensitive to most of the antibiotics tested. Most pathogens showed high sensitivity to gentamycin, norfloxacin and tetracyclines. They were moderately sensitive to the other drugs tested. Coagulase negative *Staphylococcus*, which is the main cause of mastitis in dairy goats showed high sensitivities to gentamycin (at 80%), followed by kanamycin and tetracycline (both at 79%). This sensitivity

pattern is similar to the trend reported by Ndegwa, (1999) and this means that these drugs are still effective for treatment of mastitis in dairy goats.

The findings of this study were also in agreement with studies by Wakwoya *et al.*, (2006) in Ethiopia who reported that majority of coagulase positive *Staphylococcus* (92.5%), CNS (88.2%), *Corynebacterium* (91.6%), were susceptible to the antimicrobials tested.

Results of this study were also consistent with the reports of Egwu *et al.*, (1994) which indicated the presence of drug resistance to bacterial pathogens, including coliforms and streptococci isolated from mastitic goats in Nigeria. These results were, however, in contrast with finding by Malinowski *et al.*,(2002) who reported that most coagulase positive *Staphylococcus* species have developed multiple resistances to most antibiotics used. It is encouraging to note that bacteria that are normally isolated at high rates from the udder - coagulase negative *Staphylococcus*, followed by coagulase positive *Staphylococcus* are still susceptible to most antibiotics.

CHAPTER 6: CONCLUSION AND RECOMMENDATION

The results of this present study showed high prevalence of subclinical mastitis which had negative impact in dairy goat production and hence proper management practices should be instituted to curb the disease. These proper management practices include; awareness creation and implementation of hygiene practices.

- Use of post-milking teat dipping should be encouraged as it has been shown to be a very effective method towards preventing new intramammary infections.
- Dry off therapy, just like in cows, should also be encouraged.
- Chronically infected goats should be culled from the herd.
- The positive correlation of CMT with the presence of mastitis pathogens in goat milk has shown that CMT is a useful screening test in the detection of subclinical mastitis in goats. The goat associations should be encouraged to obtain CMT test kits and some members of the group to be trained on how to use them. This activity can be made part of the extension services to the farmers.
- Most antibiotics can be used for treatment of subclinical mastitis as there was minimal evidence of antibiotic resistance.

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APPENDICES

APPENDIX 1

QUESTIONNAIRE NO.....

STUDY OF SUBCLICAL MASTITIS IN DAIRY GOAT IN MOUNT KENYA REGION

Questionnaire on baseline data on dairy goat production

BACKGROUND INFORMATION

1. Location of the farm: County.....Division.....Location.....
Farm size.....
 2. Owner details: Name.....
Age.....
Level of education.....
Occupation
 - Family size.....
For how long have you been keeping goats.....
Do you belong to any dairy goat society: Yes (1) No (2)
If Yes which one
 3. Current goat herd size.....
 4. Breed of goats kept
 - a. Toggenburg
 - b. German Alpines
 - c. Kenyan Alpines
 - d. Saneen
 - e. Galla
 - f. Anglonubian
 - g. Crosses
 5. Any other form of livestock kept
 - a. Cattle
 - b. Sheep
 - c. Pig
 - d. Poultry
 6. Do they have contact with goats Yes (1) No(2)
- General Management Processes
7. Deworming Yes(1) No(2)
 8. Dipping/spraying Yes(1) No(2)
 9. Vaccination (CPBP) Yes(1) No (2)

Breeding, reproduction and production

10. What type of service is used in breeding
 - a. Artificial Insemination
 - b. Natural breeding and why
 - c. Of own choice
 - d. Inseminators choice
 - e. Others specify

11. Age of first service.....
 12. Parity a. 1st b. 2nd c. 3rd
 13. Litter size a. 1, b. 2, c. 3
 14. Twinning rate
 15. Average litres of milk produced per goat per day?
 16. Where do you sell the milk?
 17. How much is 1 litre of milk in shillings
 18. At what age do you wean the kid?
 19. Where do you take the kids after weaning:
 - a. Sold
 - b. Replacement stock
 20. Any herd health programme carried out? (Yes) (No)
- Milking procedures
21. Size of the udder
 - a. Pendulous size
 - b. Medium size
 22. Who does the milking?
 - a) Wife Yes(1) No(2)
 - b) Son Yes(1) No(2)
 - c) Daughter Yes(1) No(2)
 - d) Herder Yes(1)No(2)
 - e) Others Yes(1) No(2)
 23. Do you wash your hands before milking and after? (Yes) (No)
 24. Do you wash the udder and teat before and after milking? Yes(1) No(2)

If Yes with water alone Yes (1) No (2)

Water and disinfectant Yes (1) No (2)
 25. Is the udder dried – Yes (1) No(2)

If yes what is used?

 - a. Disposable paper towels
 - b. Reusable towels
 - c. Others specify
 26. Do you use teat dips; Yes (1) No(2)
 27. How many times are the goat milked
 - a. Once
 - b. Twice
 - c. Thrice
 28. Dry of periods –Yes(1) No(2)

If yes; stop milking at once or gradually

Any treatment performed? Yes (1) No (2)

All quarters? Yes (1) No (2)

Mastitic quarters? Yes (1) No (2)

Others Yes (1) No (2)
- Specific conditions
29. Have you ever had a case of dystocia? Yes (1) No(2)
 30. Have you ever had a case of mastitis Yes(1) No(2)

If yes how was it treated?

31. Name of the antibiotic used.....
32. Have you had an animal with still birth/abortions Yes (1) No(2)
What was the diagnosis?
33. What other common disease affecting the goats
 - a. Diarrhea
 - b. pneumonia
34. Any reports of culling due to mastitis? Yes (1) No (2)
35. What is the local name given to mastitis.....
36. What are the clinical sign observed.....
37. Any teat / Milk abnormalities observed.....
38. Any rejection of milk due to mastitis in the past 12 months Yes (1) No (2)
39. Carry out CMT and indicate the results:
 - a) Right quarter.....
 - b) Left quarter.....

Observational study

Farm structures

40. Type of housing
 - a. Earthen
 - b. Raised timbers
41. Maintenance of the structures and hygiene of the structures
 - a. Good
 - b. Fair
 - c. Bad
42. How often is the structure cleaned?
 - a. Daily
 - b. Once a week
 - c. Twice a month
 - d. Others

43. Feeding system

- a. Zero grazing
- b. Open grazing
- c. Other tethering

44. Farm records Yes (1) No (2)

45. Which types of records do you keep

- | | |
|-----------------------------|-----|
| a) Mating records | [] |
| b) Birth records | [] |
| c) Feed and feeding records | [] |
| d) Health records | [] |
| e) Milk production | [] |
| f) Sales | [] |
| g) Weight records | [] |
| h) Any other (specify)..... | |

46. Do you find dairy goat keeping profitable..... (1) Yes (2) No

47. Challenges experienced in Dairy goat farming

- a. Insecurity
- b. Lack of market
- c. Diseases
- d. Lack of food
- e. High cost of feeds
- f. High cost of treatment
- g. Lack of breeding stock

Any other (specify).....

APPENDIX 2

QUESTIONNAIRE NO.....

STUDY OF SUBCLICAL MASTITIS IN DAIRY GOAT IN MOUNT KENYA REGION

Questionnaire on Milk collection and processing

General information

1. Interviewees Name.....Sex 1=Male 0=Female
2. Age of the interviewee: (1) Up to 30 years (2) >30 – 60 years (3) Over 60 year
3. Occupation: (1) farming, (2) trading (3) Employee (4)other
4. What is the name of the association?
.....
5. Location County.....
6. When was the association formed?
.....
7. What are the objectives of forming the association?
.....
8. Current number of registered member?
.....

Milk collection and processing

9. What is the volume of milk received from farmers every day? a. <10litre b. >10litres
10. What is the type of container used by farmer/association to transport milk to the association? a. Aluminium b. plastic c. others
11. Who collects the milk from the farm? a. Farmer b. Association c. Others
12. How is the milk transported to the association from the farms? a. Vehicle b. Motor bike c. on foot d. Bicycle e. others
13. Have you experience problem of mastitis? (Yes) (No)
14. Is the milk pasteurized before it is sold? (Yes) (No)
15. How much is a litre of milk from the farmer?
16. How much is the milk sold per litre?
17. Do you make any milk products (Yes) (No)
18. If yes which ones?
19. Where do you sell the products a. locally b. other places
20. Do you hold training to the farmer on milk production and handling? (Yes) (No)
21. If yes how often?
22. What are the main challenges experienced
 - a. Milk shortage
 - b. Lack of market
 - c. Mismanagement
 - d. Poor leadership
 - e. Spoiled milk
 - f. Storage facilities

APPENDIX 3

Table 1	Interpretation of California mastitis test	Test scores on goats milk
Test results/ml-(SCC/ml)	Reaction observed	
0	No reaction	68,000
Trace	Slight slime tends to disappear with continued swirling	268,000
1	Distinct slime but without gel	800,000
2	Immediate gel formation; moves as mass during swirling	2,560,000
3	Gel develops a convex surface and adheres to the bottom of the cup	>10,000,000

(Source; Schalm, O.W., Carroll, E.J., and Jain, N.C.: Bovine Mastitis. Lea and Febiger, Philadelphia, PA, 1971)