UNIVERSITY OF BOTSWANA
FACULTY OF AGRICULTURE
DEPARTMENT OF ANIMAL SCIENCE AND PRODUCTION

MILK PRODUCTION AND CAPRINE MASTITIS OCCURANCE IN THE PRODUCTION STAGE OF THE GABORONE REGION GOAT MILK VALUE CHAIN

BY
WAZHA MUGABE

MASTER OF SCIENCE IN ANIMAL SCIENCE
(ANIMAL MANAGEMENT SYSTEMS)

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A dissertation presented in partial fulfillment of the requirement for the degree of Master of Science in Animal Science (Animal Management Systems)

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ABSTRACT

The first study was initiated with the objectives of analyzing the production stage of the goat milk value chain and prevalence of caprine mastitis and its impact on the value chain. The study was conducted in the Gaborone agricultural region of Botswana. The primary data was collected using a participatory survey from purposefully selected samples of 91 farmers, 4 traders and 220 consumers through self-administered questionnaires. The results show that 88% of the farmers were subsistence orientated meanwhile semi-commercial and commercial farmers constituted 11% and 1 % respectively. A mean milk yield of 1.18L /goat/ per day was produced across farms and this was mostly channeled towards the 88.6% of non-purchasing consumers for home consumption. The average lactation length in the region was 5.37 months, therefore affecting milk consumption and availability patterns. However, unavailability of land, shortage of feeds, labour and disease were some of the challenges affecting goat milk producers. Caprine mastitis as an important constraint in the milk production chain affected 41.8% of the farms across the region. Respondents failing to adopt mastitis detection methods, treatments, CCP's, culling and isolation, exhibited high mastitis prevalence rates compared to their counterparts. Thus negatively affecting farmer and animal productivity due to the decline in milk yield and kid survival. In view of the large number of farms affected by caprine mastitis, a cross-sectional study was conducted to determine the prevalence of mastitis in lactating goats. A total of 163 lactating goats were purposefully selected from 17 flocks in the Oodi extension area. The results were analyzed using the multiple logistic regression models of SAS. An overall prevalence of 17.78% was recorded. Meanwhile the clinical and subclinical mastitis prevalence was 4.29% and 13.49% respectively. A significant ($P<0.05$) association between mastitis occurrence and risk factors (parity, previous mastitis history, injuries and lesions on the udder and teats, breed, production system, flock size and suckling litter size) was reported. Dairy goat development policies should be aimed at increasing farmers' access to inputs, developing and improving infrastructure, cooperative development and improving extension system. Such policies will positively support mastitis management, food safety and value chain functions.

Key words: Gaborone agricultural region, goat milk value chain, mastitis, Oodi extension area, prevalence.

APPROVAL

Main Supervisor	Signature	Date
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DECLARATION

The work contained in this dissertation was compiled by the author at the University of Botswana, Botswana College of Agriculture, during the period of January 2012 to August 2014. The dissertation is my original work and all the sources used or quoted have been indicated and acknowledged by means of complete references. The work has not been submitted and shall not be submitted for the award of any other degree or diploma of any other university.

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Wazha Mugabe

April 2015

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DEDICATION

This dissertation is dedicated to my family, friends and a great friend who is no longer with us, Gaopelo Kitsiso may his kind heart live among us. Above all I thank God for the grace, wisdom and the courage he gave me to complete this work.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

APRRD	Animal Production and Range Research Division.
BIDPA	Botswana Institute for Development Policy Analysis
BOBS	Botswana bureau of standards
BWP	Botswana currency in Pula
CAC	Codex Alimentarius Commission
CARE- Ethiopia	Cooperative for American Relief to Europe - Ethiopia
CCP	Critical Control Points
CI	Confidence Interval
CSO	Central Statistics Office
FAO	Food and Agriculture Organization
HACCP	Hazard Analysis Critical Control Points
IDF	International Dairy Federation
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
MoA	Ministry of Agriculture
NDP6	National Development Plan 6
NAMPAAD	National Master Plan for Agricultural and Dairy Development
OR	Odd ratio
RF	Reference factor
SCC	Somatic Cell Counts
SPSS	Statistical Package for Social Sciences.
X^2	Chi square test value

CHAPTER 1

1.1.General Introduction

Livestock production in Botswana is a very important socio-economic activity at household and national level. Currently, Botswana is self-sufficient in beef and poultry production sectors but continues to spend vast amounts of resources on the dairy sector (Ministry of Agriculture (MoA), 2009). To enhance the growth and participation of the dairy sector to the economy, government has included dairy farming in the economic diversification drive (EDD's) core thematic areas spanning from year 2011 to 2016. The EDD thematic areas develop strategies that will optimize the growth of the export sector and its contribution towards the diversification of Botswana's economic and export base (Ministry of Trade and Industry, 2011).

Over the years, the government of Botswana has implemented two major dairy development initiatives, as a means of addressing food security and poverty alleviation. Among the initiatives was the 1985/91 National Development Plan 6 (NDP6) which was aimed at increasing local milk production in peri-urban areas of Botswana as well as increasing milk surpluses for export market through small-scale dairy farming projects (Ministry of Finance Development Planning, 1985). In 2002 the National Master Plan for Agricultural and Dairy Development (NAMPAAD), was initiated and continues to be implemented as a means of improving dairy farm management practices and systems (MoA, 2002). All the initiatives were focused mainly on development of dairy cattle farming while other milk producing species such as goats, sheep and camels were overlooked.

Botswana has been cited among the countries with the highest per capita consumption of milk in sub-Saharan Africa (88.89 kg/capita/year) (ILRI, 2003). The local annual *per capita* consumption of milk was estimated to be 25.2 litres per person per year in 2009 (Moreki *et al.*, 2009). The annual milk demand stands at 48 million litres against the national production of 8 million litres (MoA, 2010). A deficit of 83.3% is covered by imports from neighboring countries especially South Africa and these were valued at around P96.8 million in the year 2010 (Aganga, 2010). The African Statistical Yearbook (2006) reported that goat milk plays a less significant role in Botswana with a low and constant annual production of 4 tonnes in the years from 1997- 2005.

Goat milk production and marketing in Botswana is constrained by multiple factors that necessitate for the design of collaborative and demand driven policies and systems (Mpapho, 2011). The ever changing framework conditions as efforts to improve livestock productivity have motivated management systems to adopt the value chain approach. The value chain is a collaboration among stakeholders that is focused on adding value, increasing market share and satisfying or exceeding consumer demand (Devanney, 2006). With a growing focus on improving milk value chains, dairy sectors globally recognize mastitis as one of the major constraints to functional and aspiring dairy industries chains (Alert, 1995). It's economic and public health significance impedes the productivity and success of the dairy industry.

1.2. Justification

At present, the focus of value chain analysis and mastitis related research is still mainly placed on dairy cattle while milking goat aspects remain unexplored. Information and awareness on goat mastitis occurrence and goat milk value chain function is vital for policy development, control interventions and the designing of appropriate systems for milk production, marketing and quality control (IFAD, 2006). Value chains communicate knowledge and can play a very important role in risk communication, thus leading to more informed decision-making on mastitis management (FAO, 2012). Due to little documented research efforts on dairy goat in Botswana such information is not available hence little is known about the commercial feasibility of dairy goat farming. Thus this thesis is aimed at availing information on the production stage of the goat milk value chain and prevalence of caprine mastitis and its impact on the value chain.

1.3. Overall objectives

The Overall Objectives of this research project were:

1. To carry out an investigation on goat milk production within the Gaborone agricultural region goat milk value chain.
2. To investigate on the prevalence of caprine mastitis and its risk factors in lactating goats in the Oodi extension area (Kgatleng District of Botswana).

1.4. Scope of the study

- The first study was focused on the production stage of the goat milk value chain. Therefore the study was limited to farmers/producers participating in the value chain only.

- The second study was focused on determining the prevalence of caprine mastitis in lactating goat in the Oodi extension area in the Kgatleng district of Botswana. It was worth noting that the Oodi extension area forms part of the Gaborone Agricultural

Region. Hence, the study was limited spatially to Oodi extension area as well as temporally from July- August 2013.

- Furthermore the study was a cross-sectional type of study thus, observations and data collection were done during the winter season (July-August). During the period the region recorded no rain fall while environmental temperature ranged between 2-20°C.

CHAPTER 2

2.0. Literature review

2.1. The Dairy Goat industry in Botswana

Commercial dairy goat farming compared to other livestock sectors is unpopular in Botswana. MoA (2009) has cited inadequate extension and lack of trained staff as constraints affecting the growing number of farmers willing to venture into dairy goats farming. The goat population in Botswana is estimated at 1.6 million hence dairy goats account for an estimated 0.14% (2170 animals) (CSO, 2008). The indigenous Tswana goat breed has been cited as the most common breed used for milking in rural households but lack of selection for milk traits have resulted in low production capacity (APRRD, 2006). Institutions such as Botswana College of Agriculture (BCA) and Department of Agricultural Research (DAR) have initiated dairy goat research projects thus featuring exotic dairy breeds Toggenburg, British Alpine and Saanen (Boitshepo, 2012).

2.2. Goat milk production trends

Between the years 2000 - 2003, goat milk production in Botswana declined gradually from 3000- 2400 tonnes (Figure 2.1). Production steadily increased between 2004 -2006 where it stabilized at around 3800 tonnes in between 2006-2009. Substantial amount of goat milk and milk products are imported indicating that the domestic production is not sufficient to meet market demands.

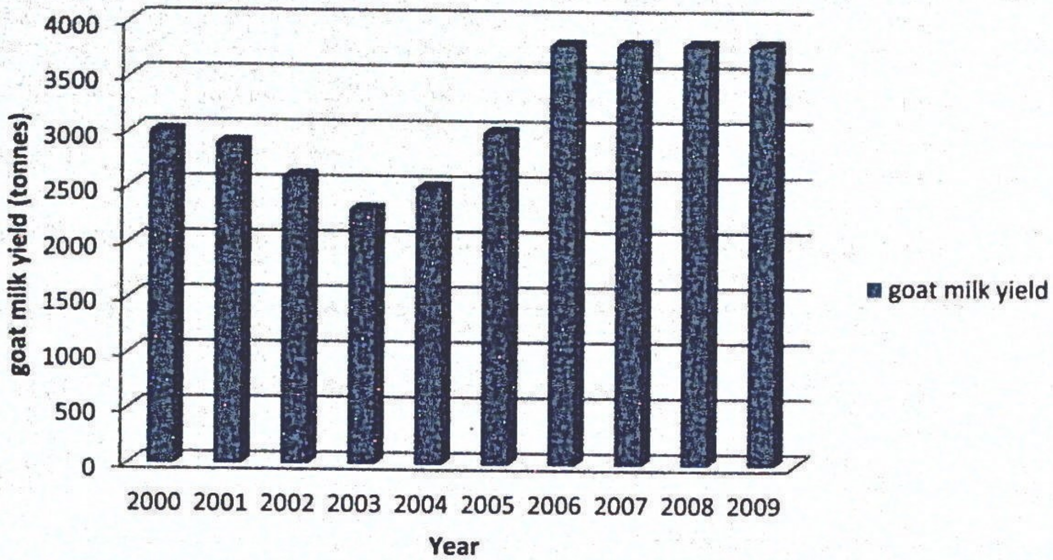

Figure 2.1: Production quantity of goat milk in Botswana from 2000-2009 (FAOSTATS 2011).

2.3. Productivity of dairy goat in Botswana

A study by Adogla-Bessa and Aganga (2000) reported that daily milk yields of Tswana goat does fed diets with high, medium and low energy contents to be 0.72^{a}, 0.53^{b} and 0.47^{c} kg/ day respectively which was in line with findings by Kibuuka (2011) and Paggot (1992) who reported a yield of 0.56 kg/ day. Even though low milk productivity has been reported for Tswana goat breed APRRD (2006) reported that the breed can have a high milking potential if selected for milk traits since heritability of milk traits is high. Local dairy goat research by Kibuuka (2011) indicated that local daily milk yields (kg/day) was higher in the Saanen, 1.61 ± 0.04^{a} followed by the Toggenburg 1.60 ± 0.04^{a}, British Alpine 1.30 ± 0.05^{b} and lowest in the Tswana at 0.56 ± 0.04^{c}. Contrary to local findings, a research in South Africa by Norris *et al.* (2011) reported a daily milk yields (kg/day) of 1.45^{a}, 0.75^{b} and 0.56^{c} for the Saanen, British Alpine and Toggenburg respectively.

2.4. Prevalence of Caprine mastitis

The prevalence of Caprine mastitis in Botswana has not been documented due to the infant status of the entire dairy sector as well as limited research efforts on goats. A great variation in the prevalence rates of subclinical goat mastitis has been reported in different research studies globally (Contreras *et al.*, 2003). A summary of results from various research groups by Contreras *et al.* (2007) indicated goat subclinical mastitis to range between 5- 30% while clinical mastitis is not more that 5%. Even though the prevalence of both clinical and subclinical mastitis in small ruminants is perceived to be lower it can periodically be high depending on the number and level of risk factors to which the animals are exposed to. Farm management systems, milking management practices, breed considered or technical skills of the investigators are among the factors associated with the variability in the prevalence of goat mastitis between research reports (Islam *et al.*, 2011).

2.5. Goat milk somatic cell counts (SCC) standards

The somatic cell counts (SCC) analytical methodology is a quantitative index tests adopted globally for diagnosis of sub-clinical mastitis across all species. Even though the SCC method is adopted globally, the absence and/or variation in analytic SCC standards and instrument calibration continue to spark controversies and circumstances where normal milk would be inappropriately labeled to be unfit for sale while unsafe milk is labeled to fit for consumption (Park and Humphrey, 1986). Pirisi *et al.* (2007) argued against the use of cow milk SCC limits to evaluate and grade goat milk, which is a practice adopted by several countries including Botswana that have not developed goat milk SCC standards. Zeng *et al.* (1999) supported the idea that an overestimation and/or unfair grading of goat SCC was highly possible for somatic cell counters calibrated using cow SCC standards.

According to Dairy Practices Council (2006), the standard limit for goat bulk milk SCC is 1×10^6 cells/ml or less which is in contrast to the USA 7.5×10^4 cells/ml (Shearer and Harris, 1992) and Thai 1.5×10^6 (Thai Agricultural Standard (TAS), 2008). Escobar (2003) argued against the USA SCC grade standard with reasons that the apocrine secretory process in the goat's udder results in increased epithelium cell slough off and cytoplasmic mass that artificially elevate electronic mass enumeration reaching and exceeding the 750,000 cells/ml threshold easily. The 94/71 Directive of European Union that regulates goat milk standards has not established somatic cell threshold limits with reasons that research results from ongoing European Research Programs will guide their decision (International Dairy Federation (IDF), 2002). Striking a balance between milk quality and producer welfare requires research based goat milk standards due to variations in climates and management environment of goat across the globe.

2.6. The Value Chain concepts

The value chain is defined as a market focused and demand driven collaboration among different stakeholders who produce and market value-added products and services for a determined market (IFAD, 2006). The value chain analysis concept was conceived in the early 1990s as a methodology for understanding the dynamics of economic globalization and international trade (Riisgaard *et al.*, 2010). In agricultural production cycles, the value chain concept is used to describe approaches aimed at improving market prospects, producer competitiveness and scaling up profit margins (Twizeyimana, 2012). Through the adaptation of the value chain framework, conceptual framework of various services and products including dairy can be established and refashioned to suit the desired needs (see Figure 2.2). Every value chain comprises of primary activities related with production and support activities that provide the background necessary for the effective and efficient running of a firm (Porter, 1985).

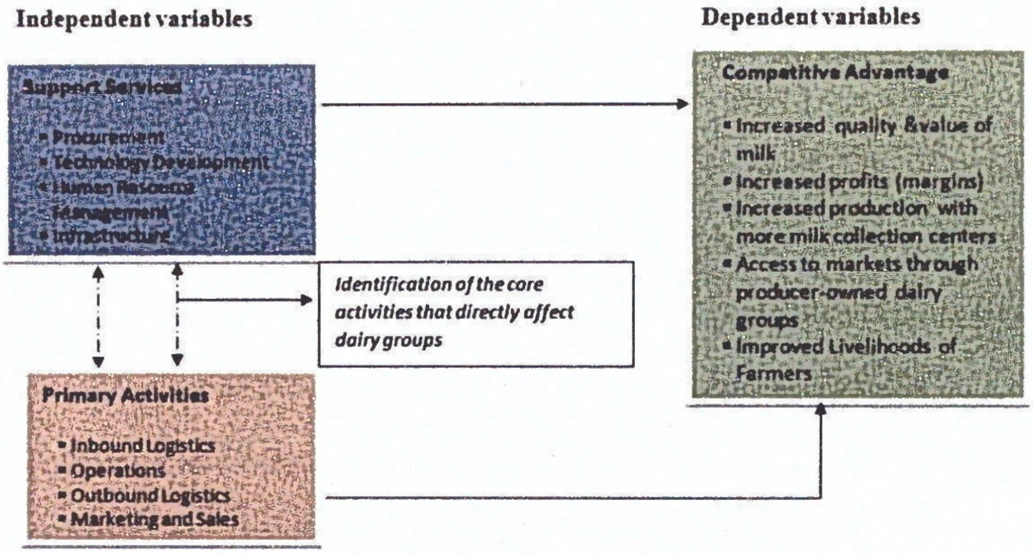

Figure 2.2: Conceptual Framework of a Dairy Value Chain (Bolo *et al.*, 2009).

2.7. Role of value chains in mastitis management

Zoonotic diseases are of major concern in livestock derived products particularly in developing countries where such diseases and their causes are often not realized because of the lack of diagnostic capacity along the production chain (Trench *et al.*, 2011). Contreras *et al.* (2007) cited mastitis-causing bacteria, especially enterotoxigenic bacteria such as *Staphylococcus aureus* and *Escherichia coli* to easily enter and move along the dairy food chains without being recognized. Ellen *et al.* (2008) noted that traditional food chain systems usually lack or bypass food safety measures and trace back systems hence compromising food safety, lacking accountability and failing to meet consumer expectations. The value-chain approach has been cited as an effective way for subscribing and assessing the performance of quality and trace back systems (Narrod *et al.*, 2009). Value addition and profit margin realized as milk move along different stages of the value chains have been linked to the support of food safety since different actors have different incentives and approaches to alter food safety risks (Trench *et al.*, 2011). Value chain stages are able to subject milk to accredited processing and transformation procedures such as desiccation, heat treatments, fermentation and cold treatments that add value while, increasing shelf life and market share through branding.

Food traceability systems permit supply chain actors and regulatory authorities to recognize areas and source of contamination that may impede on food safety while initiating procedures that rectify them as means of removing of unsafe food from the markets (Smyth and Phillips, 2002). Codex Alimentarius Commission (2006) stipulates that the traceability/product tracing methodology should be able to identify at any specified stage of the food chain (from production to distribution) from where the food came (one step back) and to where the food went (one step forward), in accordance to food inspection and certification system.

CHAPTER 3

GOAT MILK PRODUCTION IN THE PRODUCTION STAGE OF THE GOAT MILK VALUE CHAIN OF THE GABORONE AGRICULTURAL REGION, BOTSWANA.

Abstract

The aim of the study was to analyze the value chain of goat milk in the Gaborone agricultural region of Botswana. The primary data for the study was collected from 91 farmers, 4 traders and 220 consumers through self-administered questionnaires. Data analysis was performed using Statistical Package for Social Sciences. The major actors in the Gaborone informal chain were input suppliers, milk producers and consumers. The average daily milk yield, production per farm, milking flock sizes and lactation periods was 2.84L, 1.18L, 9 animals and 5.37 months respectively. Milk producers were constrained by lack of modern input supply (shortage of land 79%, feeds and water 82%, finances 68% and labour 44%). Mastitis affected 41.8% of the farms across the region. Mastitis management assessments exhibited a significant difference at (P = 0.001), for mastitis detection methodologies, Critical Control Points treatment, culling and isolation. Mastitis cases were higher for respondents, who clinically diagnosed mastitis (27.5%), as well as those who did not employ treatment (22%), culling (11%) or isolation (11%) for infected animals. These results suggest the need for policy development in order to improve the participation of farmers to formal markets through access to modern inputs, cooperative development and improving extension system. Farm productivity per lactation should be increased by introducing improved breeds, increasing milking flock sizes, increased lactation periods, and continued access to modern technologies and input.

Key words: Botswana, Critical Control Points, Gaborone agricultural region, goat milk, mastitis, value chain.

3.1. Introduction

The goat industry plays an important role in supporting the social and economic safety nets of marginalized households and communities (FAO, 1990). Indigenous goats in the hands of small-scale producers contribute primarily to family needs for meat and to a lesser extent for milk, depending on the prejudices of the community. Although commercial dairy goat farming is a new and unpopular practice locally, goat milk remains an important food source in rural communities. The high milk import bill may justify the integration of goats to the dairy milk chains thus providing a commercial avenue in rural economic development.

According to Lie (2011) establishing a new value chain and/or entering an existing value chain is challenging for smallholder farmers. Nonetheless local value chains that meet growing local demand might be within reach for resource poor and smallholder farmers. Therefore local value chains need to be tailor made from available resource and existing management system in order to suit the needs of local communities. Tapping into the existing animal resources and integrating goat farming into dairy production could lead the growth of domestic dairy industry and spur economic growth, which has been proven to be a necessary condition for poverty alleviation (Stamm, 2004). Value chains information plays a very important role in risk communication, thus guiding transparent decision-making in order to safeguard the industry from various threats (FAO, 2012). Mastitis as a major disease and constraint affecting dairy value chains impacts significantly on public health and production economics (Alert, 1995). Therefore its impact on value chain activities and players cannot be overlooked if goat milk is to be used as an instrument in poverty alleviation.

To date information on goat milk value chains and mastitis risks on the current production chains remains undocumented due to limited research efforts on goat milk production in Botswana. This information gap could discourage investment on dairy goat farming since the commercial feasibility and risks are not known. This study was therefore designed to assess goat milk value chain function and mastitis risks along the value chain in the Gaborone agricultural region of Botswana

The specific objectives of this study were:

i. To identify the primary goat milk value chain actors (formal and informal) in the Gaborone agricultural region.

ii. To assess current milk production status and constraints within the Gaborone agricultural region goat milk value chain.

iii. To assess mastitis management and constraints within the Gaborone agricultural region goat milk value chain.

3.2. Methodology

3.2.1. Study design

The theoretical background of this study was the value chain approach. The methodology was focused on participatory mapping using research tools that involved collecting both quantitative and qualitative information from different stakeholders within the value chain. The empirical data was based on a field survey carried out from May to July 2013 in the Gaborone agricultural regions mentioned below.

3.2.2. Description of the Study Area

The study was conducted in the Gaborone agricultural region of Botswana. The geographical location of the Gaborone agricultural region is between the Longitude 25° 45′ and 26° 00′ East and Latitude 24° 35′ and 24° 45′ south. The area includes to the east the tribal villages of Tlokweng and Oodi, to the west Mogoditshane, Metsimotlhabe and Gabane (Sebego and Seane, 2002). The Gaborone agricultural region falls within the South Eastern Planning Region of Botswana and covers portions of the South East, Kgatleng and Kweneng districts as illustrated in Figure 3.1. The study area encompasses urban areas that fall within Gaborone city as well as peri-urban constituencies of Bamalete/Tlokweng, Kweneng South, Kweneng West and Kgatleng South. The human population of Gaborone agricultural region is estimated at around 421 107 (CSO, 2011).

According to Sebego and Seane (2002) shortage of land for residential use within the city of Gaborone has forced government to solicit for land from the surrounding villages. Recent trends indicate that ranch owners in the periphery of the city have now turned their farms into new suburbs (Phakalane, Gaborone north and Mokolodi). Thus agricultural holdings (arable and grazing) are rapidly being converted to urban area while agriculture areas are being pushed further away from the Gaborone city. Even though this is the case, communities within the Kweneng and Kgatleng district carry out urban agriculture which includes keeping a few goats in the homestead.

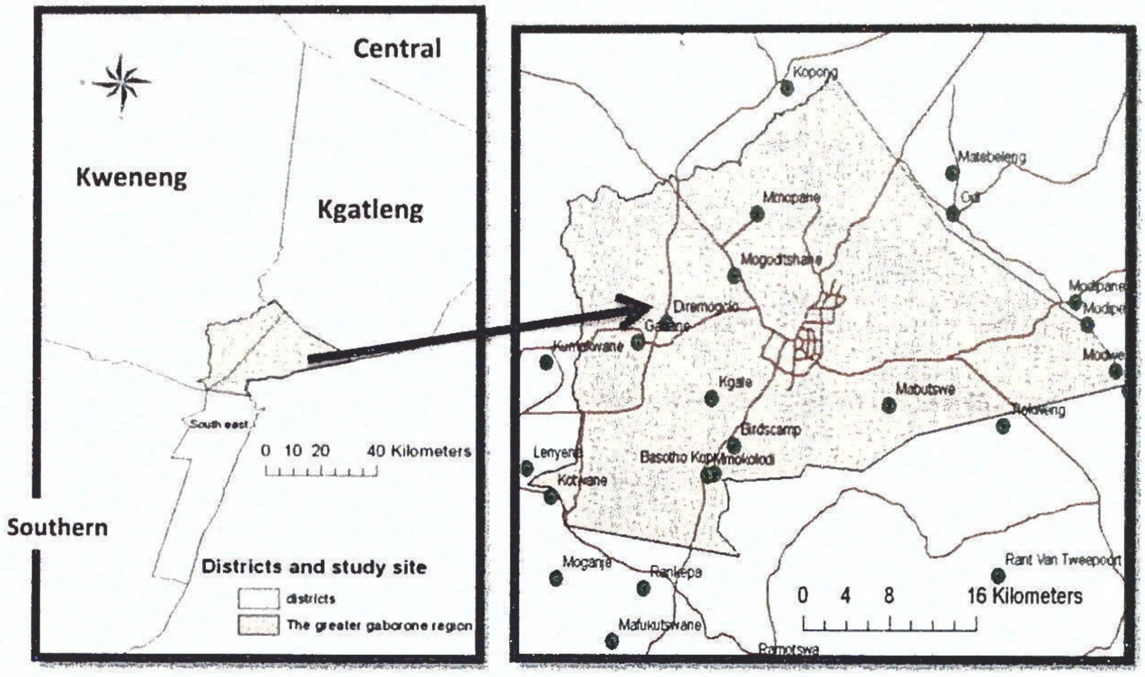

Figure 3.1: Gaborone agricultural region study area (Geographic Information System map service, 2008).

3.2.3. Sampling method and sample size

The selection of the participants focused on people and organization involved in goat milk chain and those willing to participate in the study. A two stage stratified random sampling procedure was employed in selecting goat milk trading outlets and goat farming households in 10 villages/location of the study area. In the first stage, trade outlets and farms were purposively selected based on milk production potential and involvement in dairy activities. Prior to sampling an initial listing (census) of goat farms and trading outlets in the villages was obtained through the help of Smallstock Extension Offices in the Ministry of Agriculture, Botswana and Dairy Association Members. On the second stage, a random number generator was employed to randomly select the participants listed from the first stage. A total of 4 trade outlets and 91 goat farms were selected across the Gaborone agricultural region with 10 farms for each of the 9 villages and 1 for Gaborone city (Table 3.1).

A total of 220 consumer participants were randomly selected from the study area. The goat milk consumer sample size was determined by the formula $n = \frac{(z)^2pq}{e^2}$ given by Kothari (2004).

Where,

- n= the desired sample size,
- p= 1.96, the standard variant at a required confidence level,
- q= 0.5, the proportion in the target population (potential consumers of goat milk = 0.5, (1- p) and e= acceptable error of 10%.

The sample size was therefore, calculated as; $n = \frac{(1.96)^2 0.25}{0.1^2} = 196$. An additional 24 respondents were included in the sample to take care of incomplete responses and increase the robustness of the results. Consequently, a sample of 220 consumer respondents was interviewed across the Gaborone agricultural region with 20 participants for each of the 9 villages and 40 for Gaborone city.

Table 3.1: Breakdown of interviewees for the Gaborone goat milk value chain survey

Districts	Villages	Producers	Consumers	Trade outlets
South East	Gaborone	1	40	3
	Tlokweng	10	20	1
	Ramotswa	10	20	-
Kweneng	Mogoditshane	10	20	-
	Mmopane	10	20	-
	Metsimotlhabe	10	20	-
	Tsolamosese	10	20	-
	Gabane	10	20	-
Kgatleng South	Oodi	10	20	-
	Modipane	10	20	-
Total (n)		**91**	**220**	**4**

3.2.4. Data sources and collection methods

Both primary and secondary data collection methods were used in gathering data. The primary data on goat milk value chain aspects were collected through pretested self-administered questionnaires. Three types of questionnaires were prepared for the consumers, producers and trade outlets. Each questionnaire was divided into three parts aimed at collecting data on population demographic, marketing issues and value chain framework conditions and constraints thus including mastitis. To validate the questionnaire to the situation on-site and test its applicability, the questionnaires were reviewed by an expert panel.

3.2.5. Data Analysis

The collected survey data were coded and analyzed using Statistical Package for Social Sciences (SPSS version 17.0 for windows) (SPSS, 2008). Descriptive statistics such as $\chi 2$-test, mean, frequencies, percentages and cross tabulation were used to capture a comprehensible profile of the value chain aspects. A probability of $P < 0.05$ was considered as statistically significant. The formal and informal goat milk chain was mapped in order to trace the primary actors and product flows.

3.3. Results and discussion

3.3.1. Socio-economic status of sample households

3.3.1.1. Gender

The gender categorical levels for producers (P=0.19) and consumers (P=0.45) exhibited no significant difference. Despite the lack of significant difference, female headed household produced (52%) and consumed (55%) more goat milk than male headed households (Table 3.2). Shivairo *et al.* (2013) reported that in Kenya, women are mostly involved in milk production and trades sectors than men (ratio of 4:1). Furthermore findings in Kenya by Jerop (2012) revealed that 90% of the female respondents were willing to pay for goat milk compared to male respondents at 64.1%.

Table 3.2: Gender characteristics of goat milk consumers and producers in the Gaborone Agricultural Region of Botswana.

Variables	Gender	Sample no.	Sample %	χ^2	p value
Consumers	Males	100	45	3.32	0.19^{ns}
	Females	120	55		
Producers	Males	44	48	1.61	0.45^{ns}
	Females	47	52		

ns = Not significant (superscript indicates no significant level on categorical variable)

High involvement of women in goat milk production and consumption may be attributed to empowerment schemes that have allowed them to benefit from various small-stock programs. Mrema and Rannobe (1985) reported that resource poor women in Botswana own more goats than their male counterparts who have more resources and can afford to own cattle. Programs such as SLOCA and ALDEP have provided support for small-stock rearing, targeting women farmers in Botswana (Centre for Applied Research (CAR), 2005). According to Ajani (2008) female-headed households are vulnerability to food insecurity and poverty due to limited access to land, education, information, credit, technology and decision making fora. Therefore, rural women are actively involved in goat production as a way to generating sustainable source of nutrition and income.

3.3.1.2. Age

The producer and consumer age groups exhibited no significant difference with p-values of 0.68 and 0.72 respectively. Even though the age groups lacked significant variation, the social structure of producers and consumers was dominated (35%) by the adults and middle age group respectively. Goat milk consumption by youth and children was low at 17 percent each (Table 3.3). Findings by Schwerin *et al.* (2013) showed that goat milk consumption was at minority for children ranging between 3%- 28% in two villages, Kainar (Kazakh) and Dolon (Russian).

Table 3.3: Age characteristics of goat milk consumers and producers in the Gaborone agricultural region of Botswana.

Variables	Age	Sample no.	Sample %	χ^2	p- value
Consumers	Children	37	17	3.67	0.72^{ns}
	Youth	37	17		
	Middle age	69	35		
	Adults	77	31		
Producers	Children	1	1	3.95	0.68^{ns}
	Youth	32	31		
	Middle age	28	33		
	Adults	30	35		

ns = Not significant (superscript indicates no significant level on categorical variable)

The respondents in the current survey revealed that adults and middle age groups are mostly involved in the production and consumption of goat milk since they resign and venture into agriculture activities. Meanwhile youth migrates to urban areas in search of employment opportunities. The cultural heritage, awareness on the utility of goat milk as well as ownership of goats maybe associated to the high production and consumption frequencies by the adult class. FAC (2010) reported that youth participation in agriculture especially as farmers is declining in African countries alike. The agriculture sector is not viewed at as a viable sector hence agriculture employment remains highly unappealing to the youth due to the risks, demanding nature and low profitability (FAO, 2009).

3.3.1.3. Income Source

Producer and consumer income sources did not show significant variations with p-values 0.17 and 0.62 respectively. The informal employment sector was the main source (44%) of income for goat producers while the formal employment sector was the second largest income source (34%). The major source of income for the consumer was formal employment (52%) while the informal employment sector contributed 21%. Goat keeping households depending entirely on their farms for livelihoods constituted 22% and 27 % for producer and consumers respectively (Table 3.4).

Table 3.4: Income source characteristics of goat milk consumers and producers in the Gaborone agricultural region of Botswana.

Variables	source of income	Sample no.	Sample %	X^2	P value
Consumers	Formal	115	52	6.44	0.17^{ns}
	Informal	46	21		
	Farming	59	27		
Producers	Formal	31	34	2.63	0.62^{ns}
	Informal	40	44		
	Farming	20	22		

ns = Not significant (superscript indicates no significant level on categorical variable)

In agreement to these results, BIDPA (2001) found that families in Botswana continue to explore and exploit non-agricultural livelihood opportunities alongside farming activities. The author also stated that the agriculture sector is not a very significant source of income for many of the farming households. In contrast to the findings of this study Shivairo *et. al.* (2013) reported that 56.9% of the goat keeping households in Kenya depended entirely on their farms for livelihoods, while 43.1% had supplementary sources of income, mostly from employed member of family. According to BIDPA (2003), formal employment and government support currently contribute more to rural livelihoods than arable and livestock sectors. The proximity of the study area to Gaborone city may justify why high numbers of consumer depend on formal employment for income. Kweneng District Development Plan 6 (2009), reported that Gaborone City is an important source of employment for residents of the three districts (Kweneng, Kgatleng and South East) since they are within reasonable commuting distance and have access to daily transport and housing.

3.3.2. Goat milk value chain actors in the Gaborone agricultural region.

3.3.2.1. Formal Value chain actors

The formal goat milk value chain is composed of foreign input suppliers; foreign producers, distribution companies, formal retailers and purchasing consumers (Figure 3.2). Each of these actors adds value in the process of changing product title. The formal chain is an extension of the South African chain hence, all milk and milk products are imports. Milk production, processing and distribution was performed in South Africa. The chain was completed locally where retailing and consumption is limited to Gaborone. In consent to these findings Debele and Verschuur (2014) and Lie (2011) also found that formal markets and actors are limited to peri-urban areas of Ethiopia and Tanzania respectively.

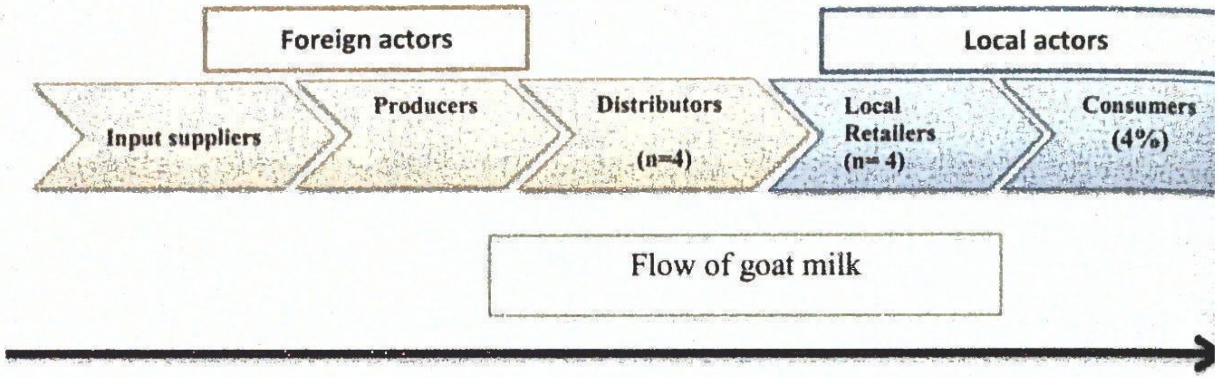

Figure: 3.2: Gaborone agricultural region formal goat milk value chain map.

3.3.2.2. Informal value chain actors

The informal value chain was composed of input suppliers, unlicensed milk producer and consumers (purchasing and non -purchasing) (Figure 3.3). The chain was short and characterized by farm gate trading activities where goat milk and milk products flow directly from producers to the consumers. In contrast to these findings Muriuki (2003) reported that Kenyan informal chains feature more middlemen players in the form of cooperative groups, milk collectors, traditional processors, traders, distributors and retailers thus longer chains. The existence of informal milk trade in Kenya is an outcome of formal system's failure or inefficiency, consumer habits/preferences, and price differences between raw and processed milk (Muriuki, 2001). Meanwhile in the Gaborone agricultural region the informal milk trade is linked to traditional preferences, lack of formal pricing systems, milk standards, and infrastructure to support dairy farming. Furthermore, milk production is a secondary goal driven by surplus milk from home consumption.

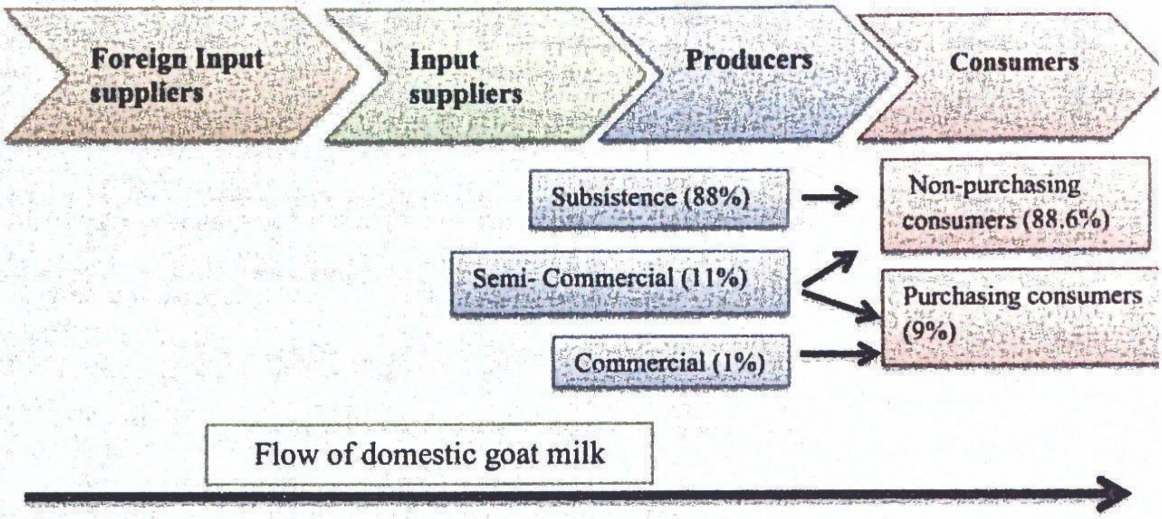

Figure 3.3: Gaborone agricultural region informal goat milk value chain map.

3.3.3. Goat milk production status and constraints

3.3.3.1.0. Goat milk production status

The milk value chain in the Gaborone agricultural region comprised mainly of farmers selling their surplus goat milk after home consumption to neighbours and other consumers in the locality. Eighty-eight percent of respondents were subsistence producers who consumed all milk produced, while 11% were semi-commercial producer who had surplus milk to sell and 1% were commercial milk producers (Figure 3.2). The results were in contrast to findings by Shivairo *et al.* (2013) who reported 60.3% subsistence farmers, 27.6% for farmers who had surplus milk to sell and 18% for farmers who had to purchase additional milk to meet household needs in districts of Kwale and Taveta, Kenya. BIDPA (2001) cited the lack of supply linkages and market-oriented production as key factors influencing the subsistence nature of goat milk in Botswana. Similarly Ogola *et al.* (2009) reported difficulties in marketing as a reason for the large home consumption of goat milk in Kenya.

3.2.3.1.1. Daily milk yield and breeds

The result of the current study exhibited a significant difference of the average daily yield/goat (P> 0.0004), breed (P> 0.0048), milk yield per day (P> 0.001) across the region. The average daily milk yield /goat across the Gaborone agricultural region was 2.84 *L*. Goats yielding on average 0.5 *L* /day constituted the largest share at 62% meanwhile those yielding more than 1.5 *L*/day constituting the least share of 1.1 %. The average farm milk yield/ day was 1.18 *L*. Moreover, the majority (86%) of the respondents had a daily average yield of less than 10 *L* while those producing more than 30 *L*/day constituted the least at 1 %. With regards to goat breeds the indigenous breed was predominantly used (71%) in milk production and yielding on average 0.5 *L* /day. The Saanen breed constituting the least share (1%) nonetheless the highest milk yields at around 4 *L* /day (Table 3.5).

Table 3.5: Milking productivity of goat milk producers in the Gaborone agricultural region.

Variables	Categories	*Sample no.*	%	X^2	*P*	*Mean*
Average yield/goat/ day (*L*)	0.25	9	9	1.2	0.001***	2.84
	0.5	70	62			
	0.50 -1.00	10	26			
	1-1.50	2	2			
	4 .00	1	1			
Milk yield/ day (*L*)	< 10	78	86	1.06	0.001***	1.18
	11-20	11	12			
	21-30	1	1			
	> 30	1	1			
Breeds	Tswana	65	71	15.6	0.048*	n/a
	Saanen	1	1			
	Tswana crosses	21	23			
	Saanen crosses	4	4			

n.a. = not applicable (model did not converge); L =Litres; P-Values with * were significant at (P<0.05), *** were highly significant at (P<0.001).

These results were in disagreement to findings by Kibuuka (2011) and Mpapho (2012) who observed daily milk yields of 1.61 and 2.80 litres respectively for Saanen does. Furthermore Aganga and Moganetsi (1999) and Kibuuka (2011) observed daily milk yields of 0.35 liter and 0.56 liter respectively for Tswana does. Aganga and Moganetsi (1999) also reported contrasting results of 0.94 litres for average production per farm respectively in the Kgatleng and Kweneng districts of Botswana. The low daily yield/goat and low daily milk yield per farm in current study could be attributed to the predominant use of meat goats especially indigenous breed in milk production. Reje (1976) cited the low genetic potential in indigenous tropics breeds as a major constraint to milk production since they are not selected for milking traits. Respondents in current study also attributed the low milk potential to the limited and unaffordable genetic material for dairy selected breeds. Similarly Kenya is faced with challenges of insufficient genetic material for dairy goats hence risks of inbreeding and drop in milk productivity (Mosi, 2010).

3.3.3.1.2. Lactation periods

A significant difference between lactation periods ($P > 0.02$) was observed in the current study. The average lactation period was 5.37 months. Seventy-three percent of the respondents in the current survey adopted a 4-6 months lactation period while longer lactation periods (>6 months) were the least adopted at 10% (Table 3.6). These short lactation periods in the region have influenced milk production to be seasonal than annual. Thus, milk is produced mainly from October-April then declining during the dry season (May-September). CARE- Ethiopian (2009) observed contrasting results with an average lactation length of 3 months in Ethiopian value chain (Borena pastoral areas). Meanwhile an average lactation period of 10 months was reported for goat milking households in Brazil (Vieira *et al.*, 2009). In consent to the findings of the current study Jackson *et al.* (2014) reported lactation periods (months) of 5.4 ± 0.36 and 5.4 ± 0.49 for Toggenburg does in Babati and Kongwa districts of Tanzania. (LSM+SE). The adoption of short lactation periods (≤6 months) is likely to be influenced by the communal system that is characterized by fluctuations in feeding resources and uncontrolled breeding. Studies by Ishag *et al.* (2012) indicated that lactation length was significantly (P<0.05) affected by season, year of kidding and origin of birth. According to Gimenez and Rodning (2007), nutritional status of a flock is the most important factor influencing successful reproduction and lactation. The authors also stated that body condition before and during the breeding season affect reproductive performance in terms of services per conception and kidding intervals.

Table 3.6: Milking management parameter adopted by goat milk producers in the Gaborone agricultural region.

Variables	Categories	Sample no.	%	X^2	P value	Mean
Milking flock size	< 10	66	73	50.91	0.004^{***}	9.26
	11-20	16	18			
	21-30	6	7			
	> 31	3	3			
Milking pattern	Daily	30	60	45.19	0.14^{ns}	n.a
	Frequently	11	21			
	Periodically	27	15			
	Rarely	12	3			
Length of Lactation	< 4 month	16	18	11.58	0.02^{**}	5.37
	4-6 months	66	73			
	>6 months	9	10			

ns = Not significant (superscript indicates no significant level on categorical variable); n.a. = Not applicable (model did not converge; P-Values with ** were significant at (P<0.05), *** were highly significant at (P<0.001)

3.3.3.1.3. Flock sizes

With regards to milking flock sizes (P> 0.004) a significant difference between flock size groups was reported in the current study. The average flock size per household was 32.58 while the milking flock size per household was 9.26. Furthermore, respondent milking less than 10 goats constituted the majority (73%) while those milking more than 30 animals constituted the least share (3%) (Table 3.6). The average flock size reported in the current study was within the range of 1-40 goats per household as reported in Kweneng district of Botswana (Nsoso *et al.*, 2004). Ahuya *et al.* (2003) and Lie (2011) reported contrasting results with an average milking flock size of four and three does in Kenya and Tanzania respectively. Likewise, CARE- Ethiopia (2009) observed that 52.8 % of the goat population in Borana pastoral areas to be is female of which 12.04 % are used for milk. The small milking flock sizes in the current study could be attributed to variation in breeding period, the use of meat breed and flock composition that feature more male animals than females. Aganga *et al.* (2005) indicated that farmers in the Kgatleng and Kweneng regions of Botswana adopted a breeding ratio of 1:60 that tend to overstretch bucks thus resulting in unsynchronized lactating periods and fluctuation in milking flocks sizes.

3.3.3.2. Production constraints

3.3.3.2.1. Input supplies

Shortage of land (79%), feeds and water supply (82%), finances support (68%) were the most constraining factors in the input supply system (Figure 3.4). The shortage of feed and water in the current study was attributed to shortage of land and lack of financial support. Similarly, CARE-Ethiopia (2009), observed that shortage of land impacts negatively fodder supply, grazing and water supply in the Borana milk value chain (Ethiopia). Tariq *et al.* (2008) found that smallholders and resource poor farmers do not have ready access to financial services. Therefore, the absence of these services did not warrant investments and financial recourse at times of emergency. Shortage of land in the Gaborone agricultural region has been attributed mainly to the growth of Gaborone City. Cavric and Keiner (2002) reported that the unpredicted growth of Gaborone effectuates severe stress on its surrounding settlements resulting in loss of agricultural land for residential purposes, falling of water tables and drying up of boreholes and deforestation due to fuel wood needs. CARE-Ethiopia (2009), also reported that undeveloped water harvesting practice, prolonged dry seasons and recurrent drought as core factors aggravating water shortage

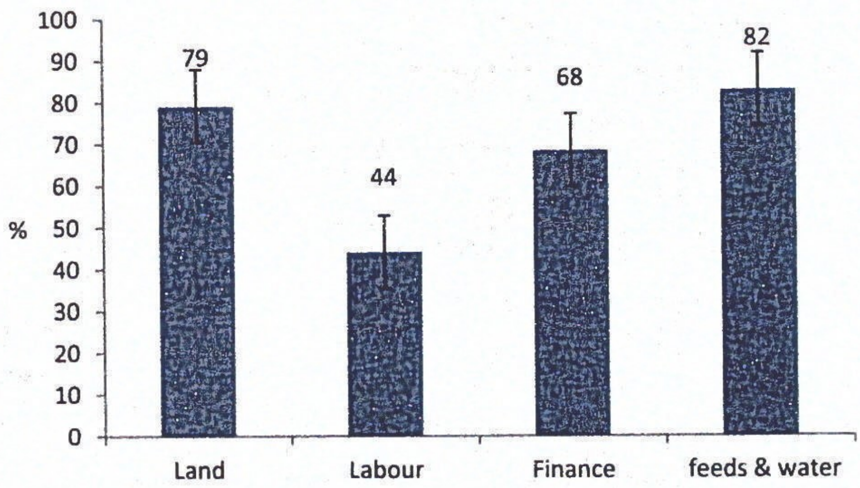

Figure 3.4: Input supplies constraints affecting milk producers in the Gaborone agricultural region.

3.3.3.2.2. Labour

The availability of quality labour is cited as a key concern constituted a share of 44% (figure 3.4). Aganga *et al.* (2005) found contrasting results of 30% for labour constrain in the Kgatleng and Kweneng district of Botswana. The respondents in the current study indicated that labour constraints reached peak during the rainy seasons when much of the required labour for flock management and herding is channeled towards arable activities. In agreement with these results BIDPA (2001) reported that livestock and arable sectors compete for household resources such as labour with other non-agriculture activities. Thus without adequate labour more losses are incurred due to crop damages and stock theft. According to CAR (2005), crop damage by goats is widespread, as many goats are kept in mixed farming areas and most existing arable fences offer little protection against smallstock. Thus without the necessary labour much of the stock is lost due to payments for damages caused by the goats to other farmer.

3.3.3.2.3. Prevalence of livestock Diseases, parasites and mastitis

Disease, parasites and mastitis constraints 88%, 86% and 41.8% of the producers respectively (figure 3.5). Endemic diseases such as heartwater (71%), pasteurelosis (56%) and coccidiosis (43%) were common hence affecting milk production indirectly due to high mortality and low birthrates. According to BIDPA (2001) the health problems in the smallstock sector result from low management inputs and high mortality resulting from disease and external parasites. CAR (2005) also reported that goats are disease prone, with high mortality ranging between 20 to 35% and birthrates that fluctuate between 40 to 50%. The high mortality and low birth rates translates to low replacement rates and low milking flock sizes.

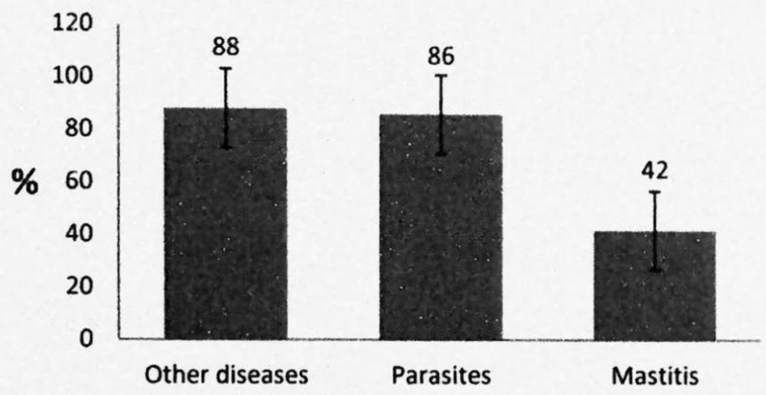

Figure 3.5: Livestock diseases, parasites and mastitis constraints affecting milk producers in the Gaborone agricultural region.

3.3.4.1. Mastitis management in the production stage of the value chain

3.3.4.1.1. Mastitis Diagnosis

The present study has demonstrated a highly significant difference ($P = 0.001$) between mastitis detection methodologies used by the respondents. Subclinical mastitis detection methodologies being the California Mastitis Test (CMT) and Somatic Cell Count (SCC) contributed the least share at 1.1% and 2.2 % respectively. Meanwhile the clinical examinations methodology received the largest share at 27.5%. Respondents diagnosing mastitis through the clinical examination method constituted the highest prevalence of mastitis (27.5%) (Table 3.7). The results were comparable to those by Hussien *et al.* (1997) and Kivaria (2004) who indicated that, subclinical mastitis receives little attention and efforts have been concentrated on the treatment of clinical cases since clinical detection methods are widely adopted in Ethiopia and Tanzania. The respondents in the survey attributed the high utility of clinical examinations methodology to cultural heritage, inadequate financial resources and lack of awareness on the disease. Islam *et al.* (2011) suggested that farmers tend to neglect the sub-clinical forms of mastitis mainly due to lack of awareness. Furthermore, the author indicated that diagnosis of subclinical infection is more problematic since the milk appears normal despite the elevated somatic cell count. Kossabiati *et al.* (1997) reported that timely detection of sub-clinical mastitis may be expensive since test kits come at a cost and may not be affordable for resource poor farmers.

Table 3.7: Critical Control Points and Diagnosis Mastitis methodologies adopted by milk producers in Gaborone agricultural region.

				Mastitis prevalence			
Variables	**Categories**	**Sample No.**	**Sample %**	**Freq**	**%**	**X^2**	**P-value**
	No CCP	58	63.7	10	11	20.08	0.001***
	DM	23	25.3	20	22		
	MHCE	2	2.2	2	2.2		
CCP's	DM+ MHCE	8	8.8	6	6.6		
	CMT	1	1.1	1	1.1	39.84	0.001***
	clinical exam	30	33	25	28		
	CMT & SCC	2	2.2	2	2.2		
Diagnosis	No diagnosis	58	63.7	10	11		

MHCE: morning herd health examination; DM: during milking; Freq: frequency; P-Values with *** were highly significant at ($P<0.001$)

3.3.4.1.2. Critical Control Points for mastitis

The categorical responses of the Critical Control Points (CCP s) displayed a highly significant difference (P = 0.001). The majority (63.7%) of the respondents did not have any Critical Control Points (CCPs) to guide against mastitis. The Critical Control Points (CCPs) that was common to most respondents was during milking (25.3 %). Mastitis cases were high at 22% and 11% for respondents with a CCP during milking and those with no CCP respectively. Furthermore, respondents implementing the CCP during morning herd health examination (MHCE) reported the least frequency of mastitis (2.2%) (Table 3.7). In the local production chain all farmers implemented one CCP. Contrary to the results of the current study findings by Gibbon *et al.* (2011) reported the adoption of six CCPs in European dairy farms, and these were established during: udder preparation, cluster attachment, post-milking teat disinfection, milking machine monitoring, drying off process, and the kidding period. The lack of awareness and insufficient infrastructure to support Hazard Analysis Critical Control Point (HACCP) protocols maybe the major reason why majority of farmers did not have CCP s. Gardner (1997) reported that HACCP protocol could be inadequate and too costly to use on-farm, as it would require costly mastitis and microbial diagnostic tests. This may justify why informed respondents with limited resources opted for one CCP. Ruegg (2003) cited the lack of routine surveillance procedures, effective record keeping, and documentation of standard processes to be a bottleneck in the adoption of efficient HACCP programme.

3.3.4.1.3. Mastitis treatment

There was a significant difference between the respondents who treated and those who did not treat mastitis. Mastitis cases were higher (22%) for respondents who did not employ any treatment compared to those who treated mastitis (19.8%). Twenty-two percent of the respondents did not employ any treatment for mastitis but rather allowed the animal to heal naturally. Indigenous methods of treatment were highly (14.3%) employed compared to antibiotic treatments (6.6%) (Table 3.8). The practice of not treating mastitis may predispose the udder to recurrent infections which may persist to chronic infections. Tomita and Hart (2001) suggested that most instances a spontaneous cure of the intramammary infection occurs, but at the expense of reduced milk production and possible permanent damage to milk secretory tissue. Findings by Islam *et al.* (2011) indicated that the total bacteria count (TBC) in does receiving mastitis treatment decreased between the first day of treatment and day 7 post-treatment, thereafter, it continued to decrease further until day 15 post-treatment. Therefore, treatment of mastitis is essential in prolonging animal productivity and sustaining milk production.

Table 3.8: Mastitis Management practices adopted by milk producers in Gaborone agricultural region.

				Mastitis prevalence			
Variables	Categories	Sample No.	Sample %	Freq	%	X^2	P-value
Treat cases	Yes	19	20.9	18	19.8	27.71	0.001***
	No	72	79.1	20	22		
Treatment	Antibiotics	6	6.6	6	6.6	27.71	0.001***
	Indigenous meds	13	14.3	13	14.3		
	natural healing	72	79.1	20	22		
Culling	Yes	10	11	10	11	15.67	0.001***
	No	81	89	20	30.8		
Isolate infected	Yes	10	11	10	11	15.679	0.001***
	No	81	89	20	30.8		

P-Values with *** were highly significant at ($P<0.001$)

3.3.4.1.4. Culling and isolation

Isolation and culling for mastitis was found to be statistically significant. Culling and isolation of mastitis-infected animals is a practice adopted by 11% of the respondents. Mastitis cases were higher at 30.8% for respondents who did not cull nor isolate mastitis-infected animals (Table 3.8). The lack of awareness, insufficient infrastructure and lack of biosecurity protocols were the major reason for the low practice rates. Since milk production was not a major objective to most of the producers in the chain, goats diagnosed with mastitis were discontinued from milking activities but continued as meat goats. According to Islam (2011), infected animals serve as a reservoir for further infection within the herd, and may shed the organism in milk intermittently. Furthermore Contreras *et al.* (2007) reported that *Staphylococcus aureus* provoked mastitis maybe transmitted from infected does to the rest of the lactating females, by suckling kids that cross suckle from other does. Therefore lack of culling and isolation of infected does may aggravate the prevalence of mastitis cases especially in large flocks.

3.4. Conclusion

Input suppliers, milk producers and consumers were primary player in the informal goat milk value chain. Meanwhile the formal chain was an extension of the South African (foreign) value chain thus based on imported milk. The formal chain players comprised of foreign input suppliers, producers, distribution companies, retailers and purchasing consumers. The average flock size and milking flock sizes was 32.58 and 9.26 animals respectively. Meanwhile the average daily milk yield/goat, production per farm, and lactation periods were 2.84*L*, 1.18*L* /day and 5.37 months respectively. Milk production in the region was constrained by insufficient input supplies, poor marketing prospects, diseases and parasites. The Majority of the respondents did not diagnose mastitis nor employ Critical Control Points in the production process. Thus mastitis was left neither detected nor treated. Mastitis impacted negatively on milk production mainly due to decline in milk yield and kid mortality due to starvation.

3.5. Recommendations

The participation of informal value chain players to formal markets should be promoted through policy development aiming at improving the access to modern inputs, extension and marketing services. Efforts should also be made to strengthen farmer cooperative groups in order to share information, production and marketing costs. Farm productivity per lactation should be increased by introducing improved breeds, increasing milking flock sizes, increased lactation periods (>6 months) and continued access to modern technologies and inputs. Furthermore tailor made animal management systems compatible to local conditions and available resources should be developed in order to increase farmer and animal productivity. Research should also be channeled towards exploring simple cost effective mastitis management practices that adhere to HACCP protocol. Such protocols should feature cost effective CCP's and diagnostic methodologies for mastitis in dairy goats.

CHAPTER 4

OCCURRENCE OF CAPRINE MASTITIS AND ITS ASSOCIATED SELECTED RISK FACTORS IN LACTATING GOATS IN OODI EXTENSION AREA OF KGATLENG DISTRICT OF BOTSWANA.

Abstract

A cross-sectional study was conducted in the Oodi extension area in the Kgatleng district of Botswana in order to determine the prevalence of caprine mastitis in lactating goats. The study was conducted during the winter season from July-August. A total of 163 lactating goats from 17 flocks were purposefully selected for the study based on the stage of lactation (45-60 days post-partum). Milk samples from the examined goats was subjected to Somatic Cell Count Test (SCC) while bulk flock milk sample were subjected to SCC and bacteriological tests for isolation of Staphylococcus aureus. Clinical and subclinical mastitis were prevalent in 4.29% and 13.49% of the studied animals respectively, resulting in an overall prevalence of 17.78% (95% CI). Risk factors; parity class (P=0.0001), previous mastitis history (P=0.0001), injuries on the udder and teats (P=0.0001), breed (P=0.0009), production system (P=0.0076), flock size, (P=0.041) and suckling litter size (P=0.0418) exhibited significant association with the occurrence of caprine mastitis. However no significant association was reported for risk factors; location cluster (P= 0.0652), age (P= 0.2174), parity number (P= 0.5473), body condition score (P= 0.9012), month of kidding (P= 0.0617) and type of housing floor (P= 0.143) to mastitis occurrence. The study suggested the need for the use of risk factors as part of mastitis control and prevention measures so as to improve milk quantity and quality in the value chain.

Key words: Caprine, goats, mastitis, occurrence, odds, prevalence, risk factors.

4.1. Introduction

Mastitis is an inflammatory reaction of parenchyma of the mammary glands that is characterized by physical, chemical and bacteriological changes in milk and pathological changes in glandular tissues (Radostits *et al.*, 2000). It has been established globally that mastitis is the most important disease in the dairy industry irrespective of species of the animal (Bozhilov, 1970). Milk value chain activities and players continue to suffer significant economic losses primarily through its negative effects on milk production, milk quality and longevity of the dairy animals (Nielsen, 2009). Javed *et al.* (2009) reported that the losses due to caprine mastitis might be greater in developing countries where disease prevention, control and reporting systems are not well established.

The etiological complexity of mastitis is linked to associated epidemiological risk factors derived from animal management system employed in farms. Mastitis epidemiological information is applicable in the designing of appropriate animal and food management systems to safeguard animal welfare and public health (Gibbon *et al.*, 2011). Lievaart *et al.* (1999) highlighted several concerns with herd health programmes that lack structure and clear execution and suggested Hazard Analysis Critical Control Point (HACCP)-based programmes as a solution to improve herd health management and quality control measures. Thus accurate up-to-date information on the mastitis occurrences and epidemiological risk factors is necessary to keep HACCP programmes running at optimum levels.

To date many countries including Botswana continue to overlook caprine mastitis since general results obtained from bovine mastitis studies are used to infer on caprine mastitis despite the difference in the species (Contreras *et al.*. (2007). The prevalence and epidemiological profile of caprine mastitis in Botswana remains undocumented due to limited research efforts, poor and/lack of farm reporting and documentation systems and unreliable statistics. This information gap impacts negatively on how caprine mastitis management programs are designed and implemented. This study was therefore designed to investigate on the prevalence of Caprine mastitis and its risk factors in lactating goats in the Oodi extension area of Kgatleng District, Botswana.

4.1.1. The specific objectives of this study were:

1. To estimate the prevalence rates of caprine mastitis in the Oodi extension area
2. To determine the association of selected risk factors to the occurrence of caprine mastitis
3. To determine the probability of mastitis occurrences in relation to risk factors associated with the occurrence of mastitis

4.1.2. Hypothesis

H_o: The prevalence rates of caprine mastitis in the Oodi extension area is not within the international range of 5-30%.

H_A: The prevalence rates of caprine mastitis in the Oodi extension area is within the international range of 5-30%.

H_o: There is no association of selected risk factors to mastitis occurrence in the Oodi extension area.

H_A: There is an association of selected risk factors to mastitis occurrence in the Oodi extension areas.

4.2. Methodology

4.2.1. Description of the Study Areas

The present research work was carried out on selected goat flocks in the Oodi extension area in the Kgatleng district of Botswana (Figure 4.1). The Oodi extension area is located 20 km north-east of Gaborone with Coordinates 24°34'23"South 26°2'2"East Degrees Minutes Seconds (DMS) at an elevation of 926 meters above sea level. The extension area stretches to a radius of about 10 km covering agriculture within Matebeleng, Ruretse, Modipane, Sebele, Glen Valley and Dikwididi. The climate in the area is semi-arid and frost free throughout the year with annual precipitation ranging between 450 -500 mm most of which fall between November and April. The summer and winter temperature range between 21-24°C and 2-20°C respectively (Kgatleng District Development Plan 5, 1997). The vegetation type in most part of the area is *Acacia/Combretum* Tree Savanna. Acacia dominated sites are common on flat terrain while *Combretum* types are associated with rocky outcrops (Aganga and Omphile, 2000). The study was conducted during the cold and dry winter season (July-August). During the period the region recorded no rain fall while environmental temperature ranged between 2-20°C.

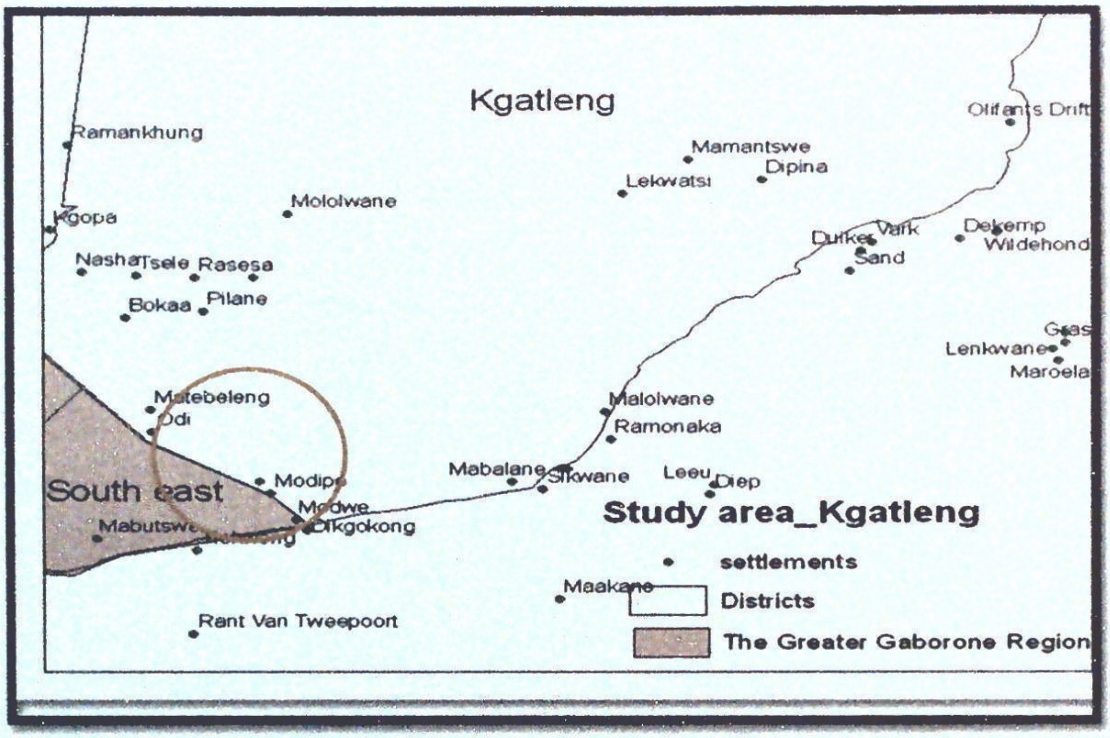

Figure 4.1: A map showing the Oodi extension area radius within the orange circle (Geographic Information System map service, 2008).

4.2.2. Study design and sampling method

The choice of sample size was based on both statistical and non-statistical considerations. The statistical considerations include elements such as required precision of the estimate, expected prevalence, desired level of confidence, and the power to detect real effects in the study (Thrusfield, 2005). However, limitations were set by non-statistical elements; time limitations, financial constraints, availability of study subjects and willingness of farmer to participate. Financial constraints limited the number of observational units (flocks, does, and milk samples), time for observations and analytical methods used.

Prior to sampling a census of farmers was conducted through the assistance of the smallstock extension officers. The census allowed for the use of does in the same lactation stage since lactation stages affect milk Somatic Cell Count (SCC). Farmers willing to participate in the study were consulted and visited in order to assess the state of the animals. The selection of the flocks and animals was purposeful and progressive based on the presence of at least one lactating animal within 45-60 days post-partum. Lactating animals that had not reached the 45-60 days post-partum phase were also included in the list but sampled later when they reached the stage.

A cross-sectional study, methodology involving 17 goat flocks in the Oodi extension area was adopted. The empirical data was based on on-farm experiments carried out from August to October 2013. The sample size was determined by the epidemiological formula $n = \frac{1.96^2 P_{exp}(1-P_{exp})}{d^2}$ given by Thrusfield (2005) by assuming an expected prevalence to be 50% while the statistical confidence level and precision was 95% and 10% respectively. Since the prevalence of caprine mastitis in Botswana is not known nor documented a prior 50% prevalence was assumed (Thrusfield, 2005). From the formula the minimum sample size required was 96. A total of 163 milking goats from the compiled list of flocks and animals were eventually sampled using a purposeful and simple random sampling technique.

- n=required sample size,
- 1.96^2=95% confidence interval
- P_{exp}= expected/assumed prevalence
- d^2 = desired absolute precision

4.2.3. Risk factors

All animals were examined from their respective flock location. Information on risk factors breed, age, parity, kidding month, body score condition, suckling litter size, tick on udder and teats, teat or udder injuries, previous history of mastitis, type of housing floor, production system and flock size was collected through a self-administered questionnaire (Table 4.1).

4.2.4. Milk sample collection

Clinical mastitis was detected by gross signs (lesions) of udder infection during physical examination and abnormal milk whereas subclinical mastitis (SCM) was diagnosed by a somatic cell counts methodology. A total of 163 milk samples were collected from 17 flocks. An aseptic procedure for collecting milk samples as described by Hogan *et al.* (1999) was employed during sampling. Prior to milk collection each teat end was cleaned and disinfected with 70% ethanol swabs and allowed to dry. Milk samples were taken after the first streams (3-4 strips) of milk were discarded. Since mastitis was defined at animal level, milk from the two halves was pooled into a composite sample from each doe. Approximately 5-10 ml of milk was aseptically collected into a horizontally held sterile vial with an identity number. The samples were transported from the field to the laboratory in an ice-cooled box and transferred to a refrigerator at 4°C. Laboratory analysis was performed within 2-3 hour post sampling.

Table 4.1: Selected mastitis risk factors and their description as per individual goat sampled in the Oodi extension area in Kgatleng district, Botswana.

Risk factor	Description
X_1=Breed	Indigenous, crosses, pure exotics
X_2 =Age	Years(1-8)
X_3 =Parity	Primiparous (1) or Multiparous (≥2)
X_4 =Kidding month	July and August
X_5 =Body condition score	Malnourished,(<2.5),Good (2.5-3.5) orObese(>3.5)
X_6 =Suckling litter size	Single (1) or multiple (2 or 3)
X_7 =Location cluster	Matebeleng, Boladu or Oodi
X_8 =Ticks on udder skin or teat	Present (1) or Absent (0)
X9 =Teat or udder injuries	Present (1) or Absent (0)
X_{10}= Previous history of mastitis	Present (1) or Absent (0)
X_{11} = Production system	Intensive, semi-intensive or extensive
X_{12}-Type of housing floor	Concrete, Earth floor or Dung heap
X_{13}- Flock size	(Small 1-30), (Medium 31-60) or (Large ≥61)

4.2.5. Somatic cell count determination using the NucleoCounter SCC-100 System

The NucleoCounter SCC-100 laboratory instrument, NucleoCounter SCC-100 SCC-Cassette and the procedure by Chemometec (2006) were employed in the analysis of the milk samples. Prior to analysis a lysate solution was prepared by dispensing 50 µl of milk sample into a sample vial and adding 50 µl of Reagent C (1:1 dilution). The lysate solution was then loaded into a SCC-Cassette by immersing the tip of the cassette into the solution and pressing the piston to suck the solution. The SCC Cassette was then loaded into the NucleoCounter instrument for microscopic analysis. In the NucleoCounter SCC-100 the stained milk sample automatically transferred to the measuring chamber where the fluorescent image was recorded. The estimated somatic cell count was presented on the instrument display after 30 seconds. After analysis the milk samples contained within the cassette were safely discarded.

4.2.6. Bacteriological Examination of Milk Samples for *Staphylococcus aureus*

Flock composite milk samples were examined following standard procedures using the (ISO 6888-1 (1999) standard technique where about one standard loop full (0.01ml) of each milk was streaked on Baird Parker agar medium preparation. For each bulk sample the duplicate plates were prepared. The plates were incubated anaerobically at 37℃ for up to 48 hours and checked for any bacterial growth. To investigate on the presence and enumeration of *Staphylococcus aureus* a digital colony counter was employed.

4.2.7. Evaluation for milk hygiene

In the current study milk hygiene was defined bases on flock (bulk) milk somatic cell counts and *Staphylococcus aureus* cultures. Due to lack of existing caprine milk standards, analysis was based on the cow's milk standards that are currently used by Botswana bureau of standards and Botswana National Veterinary Laboratory. The bulk somatic cell count data was subjected to milk hygiene reference standards (BOS 64:2003. Raw cow milk) where the somatic cell count threshold is at $5*10^4$ cell/ml. The *Staphylococcus aureus* cultures data was subjected to milk hygiene reference standards

(BOS 92:2003. Raw cow milk) where *Staphylococcus aureus* Colony Forming Units (CFU) should be absent in milk.

4.2.8. Statistical analysis

4.2.8.1. Risk Factors: Chi-square X^2 test

The data for mastitis risk factors was analyzed using the frequency proceduce (proc freq) of SAS (2008) version 9.2. The means were separated using the Chi-square (X^2) test. A probability of P < 0.05 was considered as statistically significant.

4.2.8.2. Risk Factors: Multiple Logistic Regressions

Independent variables having an association with mastitis at P< 0.05 were included in multiple logistic regression models using the SAS procedure of PROC LOGISTIC (Model 1). Odds ratio (OR) calculated determined the risk levels of categories under each risk factor as the ratio of the odds of disease occurring among goat exposed to a factor and the odds of disease occurring among the goats not exposed to a factor. SAS (2008) version 9.2 was employed for analysis and a probability of P<0.05 was considered as statistically significant.

Model 1: $\text{Logit}(Y_{ijk}) = \alpha + \beta_i(x_i) + \beta_j(x_j) + \ldots + \beta_n(x_n) + \varepsilon_{ijk \ldots n}$

Where:

- Y =Probability of occurrence of mastitis,
- α = intercept.
- $X_1 \ldots X_n$ = independent variables: breed, age, parity, kidding month, body condition score, suckling litter size, tick on udder and teats, teat or udder

injuries, previous history of mastitis, type of housing floor, production system, and flock size

- $\beta_1 \ldots \beta_n$ = slope.
- $\varepsilon_{ijk\ldots n}$ = random variation

4.3. Results and discussion

4.3.1. Prevalence of mastitis in the Oodi Extension area

4.3.1.1. Overall Mastitis

The overall prevalence of mastitis from the 163 lactating does examined was 17.79% (n=29) (Table 4.2). This findings is in agreement with that of Ameh and Tari (2000) (17%) in a study done in Nigeria but higher than the findings of 15.5% in an Ethiopian study (Megersa *et al.*, 2010). A greater variability in overall prevalence rates of caprine mastitis has been reported globally. This variability maybe explained by the difference in management of the farms, milking management practices, breed considered or technical knowledge of the investigators (Islam *et al.*, 2011).

4.3.1.2. Clinical Mastitis (CM)

The prevalence of clinical caprine mastitis at animal level was recorded as 4.29% (Table 4.2). The results of the current study were in agreement with findings by Megersa *et al.* (2010) who reported a prevalence of 4.3% in Borana, Southern Ethiopia. However different findings were reported by Ryan and Greenwood (1990), who found lower prevalence less that 1% in New South Wales while Wakwoya (2006) reported a 2.4% in the Southern Rift Valley Region of Ethiopia. The author also stated that the low level of clinical mastitis may be partly associated with the fact that dairy goats with clinically observable mastitis are either treated or culled.

4.3.1.3. Sub-clinical Mastitis (SCM)

The prevalence of sub-clinical mastitis in the current study was reported to be 13.49% (Table 4.2). The results of the current study were in agreement with the summarized results by Contreras *et al.* (2007) who stated a 5 to 30% prevalence range. However the results were in contrast to findings of Gebrewahid *et al.* (2012) and Razi *et al.* (2012) who reported higher prevalence rates of 18.03% in Tigray Regional State, North Ethiopia and 18.64% in Mymensingh Area, Bangladesh respectively. In this study a significantly (P=0.05) high prevalence rate of subclinical mastitis was observed compared to clinical mastitis (Table 4.2). The reasons may be attributed to limited utility of subclinical mastitis detection methodologies. In this case farmers favour the use of clinical/physical examinations hence clinical cases receive attention for detection and treatment. Similar findings were reported in Ethiopia and Tanzania where subclinical mastitis received little attention and efforts were concentrated only on the treatment of clinical cases (Hussein *et al.*. 1997 and Kivaria, 2004).

Table 4.2: Mastitis prevalence rates in the Oodi extension area in Kgatleng district, Botswana.

	Mastitis Prevalence			
Mastitis forms	**Frequency**	**%**	**X^2**	**Pr >X^2**
Clinical mastitis	7	4.29	7.76	0.005**
Sub-clinical mastitis	22	13.49		
Overall mastitis	29	17.79		

*** Categorical levels of mastitis forms highly significant at P<0.001

4.3.2. Risk factors associated with the occurrence of caprine mastitis

4.3.2.1. Parity

The current study indicates that parity of does had a high significant association to the prevalence of mastitis (P=0.0001) (Table 4.3). The risk of mastitis increased with increasing number of parities, thus a higher prevalence rate was reported in multiparous does (21.14%) compared to primiparous does (7.5%). The odds of mastitis occurrence were 0.08 and 0.27 times for primiparous and multiparous does respectively (Table 4.4). Furthermore multiparous does were 0.30 times at risks compared to primiparous does. The number of parity exhibited no significant association (P=0.763) to mastitis occurrences. Nonetheless the risk of mastitis increased linearly with parity number (Figure 4.2). For the parity number the highest prevalence rates (50%) were reported in animals at later stages of their parity (7^{th} and 8^{th} parity), whereas lowest prevalence (7.5%) was at the 1^{st} parity (Figure 4.2).

Table 4.3: Risk factors associated with the occurrence of caprine mastitis in the Oodi extension area of Kgatleng district, Botswana.

			Prevalence			
Risk Factors	**Categories**	**N**	**+No**	**%**	χ^2	**Pr >X^2**
Parity	Primiparous	40	3	7.5	17.52	0.0001***
	Multiparous	123	26	21.14		
History of mastitis	Present	17	10	58.82	21.85	0.0001***
	Absent	146	19	13.01		
Injuries on udder and teats	Present	37	12	32.43	104.88	0.0001***
	Absent	126	17	19.49		
Breed	Meat breeds	139	19	13.67	10.97	0.0018***
	Dairy breeds	24	10	41.67		
Production system	Intensive	22	9	40.49	9.75	0.0076***
	Semi-intensive	53	9	16.98		
	Extensive	88	11	12.5		
Flock size	<30	48	3	6.25	6.37	0.041**
	31-60	39	8	20.51		
	>60	73	18	23.68		
No of suckling kids	Single	95	12	12.63	4.145	0.0418**
	Multiple	68	17	25		

N= sample size; + No= number of positive; P-Values with ** were significant at ($P<0.05$); P-Values with *** were highly significant at ($P<0.001$)

Table 4.4: Association of parity risk factor to the occurrence of caprine mastitis in Oodi extension area of Kgatleng District, Botswana.

		Mastitis Prevalence					
Parity	N	+No	Rate (%)	Odds	OR	95% CI	Pr >X^2
Primiparous	40	3	7.5	0.08	RF	0.086-1.06	0.0501**
Multiparous	123	26	21.14	0.27	0.303		

N= number examined;+ No= number of positive infections; OR = Odd ratio; CI= Confidence of OR; RF = Reference factor; ** Categorical levels significant at P<0.05

In terms of parity the results of the current study are in agreement with research findings by Boscos *et al.* (1996) who reported a significant association ($P < 0.05$) of parity class to mastitis occurrence. The authors indicated that bacteriologically positive samples were (50%) higher in multiparous than in primiparous goats. In relation to parity number the results of the current study are in agreement with findings by Gebrewahid *et al.* (2012) (P= 0.201) and Ndegwa *et al.* (2000) (P= 0.1956) who reported no significant association between parity numbers and mastitis occurrence. Razi *et al.* (2012) reported a higher mastitis prevalence rate of 66.66% in animals that were at later stages of their parity (6^{th} and 5^{th} parity) and lower prevalence rate (11.11%) at the 1^{st} parity stage which is a similar case to the current study.

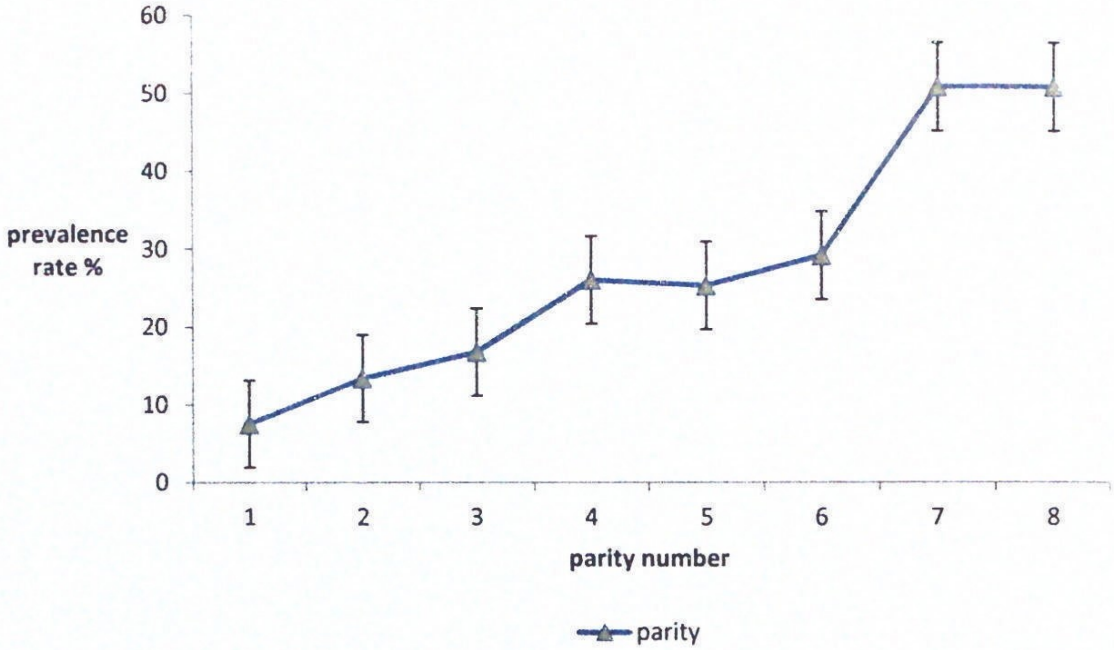

Figure 4.2: Association of parity number to mastitis prevalence in Oodi extension area of Kgatleng District, Botswana.

It is postulated that younger animals are less susceptible to mastitis through a more effective host defence. According to Busato *et al.* (2000) the advancing age and parity are factors relating to immunosuppression that impede the animal's ability to combat mastitis. Ali *et al.* (2010) suggested that older animals with advancing numbers of parity easily become host of infectious agents due to low immunity that is induced by stress and damage to the udder tissue and teat orifice. Dulin *et al.* (1983) indicated that polymorphonuclear leukocyte function which is a defence mechanism is more active in primiparous animals. Reports by Olechnowicz and Sobek (2008) indicated that primiparous goats with five or more lactations produce milk that contains nearly 67% more somatic cells. Therefore high somatic cell count in milk translates to low quality milk despite the lack of mastitis in the milk.

4.3.2.2. Breed

In the current study, breed types exhibited significantly high association (P= 0.009) to mastitis occurrence of (Table 4.3). A prevalence rate of 41.67% was reported for dairy breeds compared to 13.67 for meat breeds. The probabilities of mastitis occurrence were 0.16 and 0.71 times for meat and dairy breeds respectively (Table 4.5). Moreover the odd ratios revealed that the dairy type breeds were 0.22 times more at risk of contracting mastitis compared to meat breeds. Furthermore, a significantly high association (*P*> 0.0016) of individual breeds to the occurrence of mastitis was reported in the current study (Table 4.4). Mastitis was highly prevalent in the Saanen breed at 41.67%, followed by Boer and Kalahari red at 16.67% each and lastly the Tswana breed at 13.68 %. The Saanen, Boer and Kalahari red breeds were 0.22, 0.79 and 0.79 times as likely to contract mastitis compared to the Tswana breed (Table 4.5).

Table 4.5: Association of breed risk factor to the occurrence of caprine mastitis in Oodi extension area of Kgatleng District, Botswana.

		Mastitis Prevalence					
Risk factor	**N**	**+No**	**Rate**	**Odds**	**OR**	**95% CI**	**Pr >X^2**
Breed type							
Meat breeds	139	19	13.66	0.16	RF		
Dairy breeds	24	10	41.67	0.71	0.22	0.086-0.57	
Breeds							
Tswana	95	13	13.68	0.16	RF		
Boer	24	4	16.67	0.2	0.79	0.23- 2.69	0.7098^{ns}
Kalahari	12	2	16.67	0.2	0.79	0.16- 4.03	0.7796^{ns}
Saanen	24	10	41.67	0.71	0.22	0.08- 0.60	0.0032***
Tswana*Boer	8	0	0	0	0	0	0

N= sample size, + No= number of positive; OR = Odd ratio; CI= Confidence of OR; RF = Reference factor; ns = Not significant (superscript indicates no significant level of categorical variable; P-Values with *** were significant at (P<0.001)

Despite the differences in breeds used the results of the current study were in consent with findings by Gebrewahid *et al.* (2012), who reported a significantly high association ($P > 0.009$) between goat breeds (Begait and Abergelle), and mastitis occurrence in Northern Ethiopia. The prevalence rates were 27.6% and 17.7% for the Abergelle and Begait breeds respectively. Ameh and Tari (2000) also found significant differences ($P > 0.05$) for mastitis occurrence in Nigerian goat breeds. The authors reported the highest number of cases for the Borno White (49%) followed by Borno Red (35%) and the Sahelian crosses (15%). Variable mastitis prevalence rates between breeds may be attributed to udder morphology and milk yield. According to Menzies (2001) poor udder morphology in the form of supernumery teats, unconventional teats or poorly shaped udders had a significant, but minor effect on the frequency of mastitis in small stock. Observations in the current study revealed that 13 does had asymmetric udder conformation of which 7 were diagnosed with mastitis. The Saanen breed (85.7%) and Kalahari red breed (14.3%) constituted the group of the infected does. This observation could be explained by the fact that poor conformation of the udder adds to inefficient evacuation of milk from the glands resulting in residual milk. The risk of infections and injury to the udder and teats due to short distances between the teats and the floor has been reported by Anzuino *et al.* (2010). Even though the aspect of teat and floor distances was not covered in the current study it can be inferred that the dairy type breed being the Saanen was more susceptible due to its large sized udder. Ameh and Tari (2000) reported that mastitis prevalence increased with the decrease in teat end to floor distance (observation was not statistically significant ($P > 0.05$).

It has been reported by Watts (1988) that high-yielding goats are at high risk of contracting mastitis, hence milk production potential is a significant mastitis risk factor.

The milk yield of the does may explain the observed order of mastitis prevalence across the breeds. Research by Kibuuka (2011) indicated that daily milk yields (kg/day) from Saanen to be 1.61±0.04 and the Tswana at 0.56±0.04 while Greyling *et al.* (2004) reported a mean milk yield of 0.8 ± 0.7 l kg/per day for extensively maintained Boer goats. Thus mastitis prevalent rates in the current study corresponded to the order of milk yield across the breed. In this case the milking yield potential is also a key factor influencing mastitis since it dictated doe management. The production management of dairy goat breeds alongside other non-dairy breed in the current study may justify the high rate of mastitis in dairy breeds. In this case the poor adoptability of dairy goat breeds to local environments has influenced farmers to adopt intensive management systems meanwhile none dairy breeds are kept in extensive production systems. Moreover the current study reported high mastitis prevalence rates of 40.49% in intensive systems, compared to 12.5% in extensive systems (Table 4.3). Therefore the breed risk factor will always stretch beyond the genetic aspects into environmental and management aspects.

4.3.2.3. Injuries on udder and teats

In the current study udder and teat injuries were strongly associated ($P= 0.0001$) with occurrence of mastitis (Table 4.3). The odd of mastitis occurrence was 0.48 and 0.16 times for does with and without injuries on udder and teats injuries respectively. Moreover the odd ratios revealed that does with injuries were 3.078 times at risk compared to does without injuries. A prevalence rate of 32.43% was reported in does with udder and teat injuries compared to 13.49% in does with no mammary injuries (Table 4.6). The results of the current study are in agreement with those reported by Islam *et al.* (2011) ($P = 0.001$) and Ameh and Tari (2000) ($P = 0.05$) who reported significant associations between teat and udder injuries and mastitis occurrence in Maiduguri, Nigeria. The authors reported prevalence rates of 98.7% and 81.8% for does with udder injuries compared to 14.63% and 14.43% for does without injuries, respectively.

Table 4.6: Association of mammary injuries to the occurrence of caprine mastitis in Oodi extension area of Kgatleng District, Botswana.

			Prevalence				
Risk Factors	**N**	**+No**	**Rate (%)**	**Odds**	**OR**	**95% CI**	**Pr >X²**
Mammary Injuries							
Present	37	12	32.43	0.48	3.078	1.31 -7.25	0.0081**
Absent	126	17	13.49	0.16	RF		
Tick Infestations							
Present	21	4	19.05	n.a	n.a	n.a	0.87^{ns}
Absent	142	25	17.61				

N= sample size; + No= number of positive; OR = Odd ratio; CI= Confidence of OR; RF = Reference factor; ns = not significant (superscript indicates no significant level of categorical variable; n.a. = Not applicable (model did not converge). P-Values with *** were highly significant at (P<0.001)

Respondents in this study attributed udder and teat injuries to bites from suckling kids, abrasion from debris on bedding, housing material and spiky fodder trees (*Dichrostachys cinerea* and various *Acacia species*) (figure 4.3). Therefore, there is a possibility that injuries from the above mentioned factors could predispose animal to mastitis. In support of these observation Togun *et al.* (2003) indicated that the udder could also be exposed to injuries from hard objects like broken bottles and rusty metals in the goat scavenging environments, which make the goats susceptible to mastitis causing organisms.

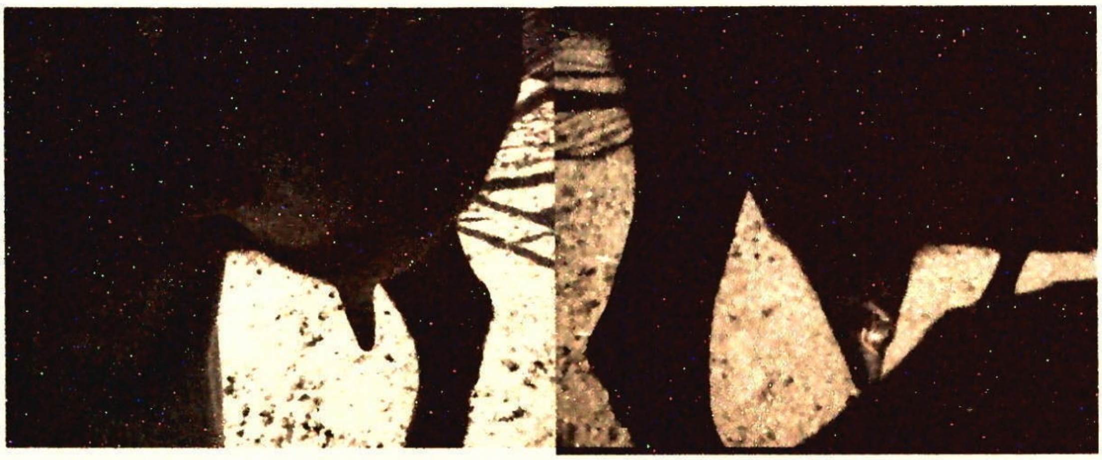

Figure 4.3: Mammary injuries observed on mastitis affected does in the current study.

According to Farnsworth (1996), injuries and lesions affecting the teat end frequently result in increased mastitis problems because of interference with the protective effect of the teat orifice, which is a major barrier preventing bacteria from entering the gland. Teat injuries provide a medium for the growth of the pathogenic bacteria and secondary infections which may induce mastitis and or delay healing of mastitis (Saloniemi, 1980). Damage to mammary epithelial cells initiate somatic cell defensive mechanisms for ingestion and lysis of phagocytosed microbes. Necrosis of epithelial cells hampers the mammary epithelial cells ability to produce inflammatory mediators such as cytokine, chemokines, which are potent activators of leukocytes that enhances the phagocytosis and killing of mastitis pathogens (Kabbur and Jain, 1995). The higher prevalence rates of mastitis in does with teat and udder injuries as evident in the current and previous studies emphasize the need for improved management as a key to reduce mastitis.

4.3.2.4. Suckling litter size

A significant association between suckling litter size to mastitis occurrences was reported in the current study ($P > 0.0451$) (Table 4.3). In this work, the probabilities of mastitis occurrence was 0.33 and 0.15 times as likely for does nursing multiple kids and does nursing a single kid respectively. Meanwhile the probability of mastitis in does nursing multiple kids suckling was 2.3 times greater than does nursing a single kid. Does suckling multiple kids reported a higher prevalence of 25% compared to 12.63% for does suckling a single kid (Table 4.7). The results of the current study are in agreement with findings by Islam *et al.* (2011) who reported a significant association (P<0.05) between suckling litter size to mastitis occurrence. The author reported prevalence rates of 16.7% and 43.0% for does suckling single and multiple litter sizes respectively. In contrast with the current study, Ndegwa *et al.* (2000) reported no significant association (P<0.3668) between litter size to mastitis occurrence. The author also reported higher prevalence rate for does suckling a single kid (44.6%) compared to does suckling multiple kids (41.2%).

Table 4.7: Association of suckling litter size to the occurrence of caprine mastitis in the Oodi extension area of Kgatleng District, Botswana.

			Mastitis Prevalence				
Risk factor	**N**	**+No**	**Rate (%)**	**Odds**	**OR**	**95% CI**	**Pr >X^2**
Litter size							
Single	95	12	12.63	0.15	RF		
Multiple	68	17	25	0.33	2.3056	1.02-5.22	0.0418**

N - sample size; + No- number of positive; OR - Odd ratio; CI- Confidence of OR; RF - Reference factor; P-Values with ** were significant at (P<0.05)

The role of nursing kids in the epidemiology of mastitis has been affiliated to the long-term mechanical damage and irritation of the teat, the streak canal and the entire udder. (Kostelić *et al.*, 2009). Furthermore the nursing stimulus induces migration of fresh neutrophils into mammary tissue that elevates somatic cell counts (Paape *et al.*, 1992). In the current study the high prevalence rates in does with multiple kids may be attributed to udder injuries and lesions that result from vigorous, competitive suckling from their litter and other cross suckling kids. Menzies and Ramanoon (2001), reported positive correlation between the litter size and incidence of intramammary infections. The authors suggested that frequent, vigorous suckling inflicts injuries, trauma and udder damage resulting in stress, intramammary infections and mastitis. The role of suckling kids as reservoir and carriers of mastitis causing microorganisms to lactating does has been reported by Contreras *et al.*, (2007). The author cited the epidemiology of *Staphylococcus aureus* mastitis to be transmitted from infected does to the rest of the lactating flock, by multiple kids that supplement their dams due to insufficient feeding. Therefore higher prevalence rates of mastitis in does suckling multiple litter as evident in the current and previous studies emphasize the need for improved kid feeding management as a key to reducing the spread of mastitis.

4.3.2.5. Previous history of mastitis

A significantly high association (P= 0.0001) of the previous mastitis history to the occurrence of mastitis was reported in the current study (Table 4.3). In this work, the probabilities of mastitis occurrence were 1.428 and 0.1496 times as likely for does with and without a previous mastitis history respectively. Furthermore the probability (Odd Ratio) of mastitis occurrence was 9.549 times as likely for does with a previous mastitis history compared to does with no history. Does with a previous mastitis history reported higher prevalence rate (58.82%) compared to 13.01% for those without history (Table 4.8). Of the does with previous history of mastitis 58.82% of the does had received antibiotic treatment in the previous infection while the remainder was allowed to heal naturally. The results of this study are in agreement with those reported by Elbably (2013) and Megersa *et al.* (2010) who reported a significant association ($P<0.01$) between previous mastitis history to mastitis occurrence. The authors also reported that mastitis was more prevalent in does with previous mastitis history. High occurrences of mastitis on does with previous mastitis history may be linked to recurrent mastitis where the udder acts as a primary reservoir for infection.

Table 4.8: Association of mastitis history to the occurrence of caprine mastitis in Oodi extension area of Kgatleng District, Botswana.

		Prevalence					
Risk Factors	**N**	**+No**	**Rate**	**Odds**	**OR**	**95% CI**	**Pr >X²**
History of mastitis							
Present	17	10	58.82	1.4286	9.549	3.244 -28.10	0.001***
Absent	146	19	13.01	0.1496	RF		

N= sample size; + No= number of positive; OR = Odd ratio; CI= Confidence of OR; RF = Reference factor; P-Values with *** were highly significant at (P<0.001)

According to Bonyata (2011) major risk factors for recurring mastitis are, failure to completely recover from a previous infection due to slow treatment, incorrect treatment, incorrect duration of treatment and antimicrobial resistance. Tiwari *et al.* (2013) r

eported that some antibiotics (penicillin, oxytetracycline, lincomycin and neomycin) used for the treatment of mastitis may affect the phagocytic properties of polymorphonuclear leukocytes (PMN) by altering the oxidative burst property of PMN (141-143) leading to a recurrence of intramammary infections. This recurrent mastitis may result in widespread lesions, irreparable tissue damage, including udder disfigurement and chronic inflammation that are mastitis risk factors (Betzold, 2007). It has been reported by Sharma *et al.* (2011) that bacterial pathogenesis can induce a more aggressive innate or acquired immune response in the udder therefore higher SCC than minor pathogens for first-time in infected udders. Therefore sub-clinical diagnostic methodologies may interpret the high somatic cells as mastitis despite the immune response. Previous mastitis history may result in acquired immunity against mastitis infection or become a chronic problem due to persistent infection and microbial résistance.

4.3.2.6. Production systems and flock sizes

In the current study the production systems had a high significant association (P= 0.0076) to the prevalence of mastitis (Table 4.3). In this work, the odds of mastitis occurrence were 0.692, 0.205 and 0.310 times as likely for does raised in intensive, semi-intensive and extensive production systems respectively. Moreover the odd ratios revealed that does raised in semi intensive and extensive production system were 3.871 and 4.846 times at risk of contracting mastitis as compared to does raised in intensive systems. High prevalence rates (40.49%) were reported in does from intensive systems, followed by semi-intensive (16.98%) and lastly extensive systems (12.5%). The production system parameters, flock size risk and floor types revealed a significant (P=0.0413) and no significant (P=0.143) association to the prevalence of mastitis respectively. Furthermore the probability of mastitis occurrence was 0.832 and 3.871 times as likely in flock sizes of 31-60 and >60 animals as compared to those in flocks with less than 30 animals. High prevalence rates were reported in flock sizes with more than 60 animals (13.68%) meanwhile small herd with less than 30 animals recorded lower rates (6.25%) (Table 4.9).

Table 4.9: Association of flock size, production systems and floor types to the occurrence of caprine mastitis in Oodi extension area of Kgatleng District, Botswana.

			Mastitis prevalence				
Categories	N	+No	Rate	Odds	OR	95% CI	Pr >X^2
Flock size							
<30	48	3	6.26	0.067	RF		
31-60	39	8	20.51	0.258	3.871	0.95 - 15.75	0.0587**
>60	76	18	13.68	0.310	4.655	1.292- 16.789	0.0188**
Production system							
Intensive	22	9	40.91	0.692	RF		
S -intensive	53	9	16.98	0.205	0.295	0.097-0.898	0.0316**
Extensive	88	11	12.5	0.143	0.206	0.072-0.595	0.0035***
Floor type							
Dung heap	95	13	13.68	0.159	n.a	n.a	n.a
Earth floor	35	10	28.57	0.400			
Concrete	33	6	18.18	0.222			

N= sample size; + No= number of positive; OR = Odd ratio; CI= Confidence of OR; RF = Reference factor; n.a. = Not applicable (model did not converge); P-Values with ** were significant at (P<0.05; P-Values with *** were highly significant at (P<0.001)

Razi *et al.* (2012) reported a highly significant association (P <0.0001) between animal production systems and mastitis occurrence. Despite the association the author's findings were in contrast to the results of the current study since a high mastitis prevalence rate was reported for traditional/extensive system (24.4%) while the semi-intensive system had the least occurrences (11.53%). In relation to flock size the results of the current study are in consent with those reported by Jegede and Tekdek (2000) who reported a significant association (P<0.05) between flock size and occurrence of mastitis in Nigerian states of Zamfara, Kebbi and Kaduna. Megersa *et al.* (2010) reported no significant association between the flock size and mastitis prevalence in Borana, Southern Ethiopia.

The high incidences of mastitis in intensive production systems may be attributed to the amount of time the animals spend in contact with pathogens residing in the bedding and other host animals (Contreras *et al.*, 1994). Since intensive system in the current study were characterized by earth floor thus high mastitis incidence (28.57%) was reported (results was not statistically significant (Table 4.3). This observation could be explained by the fact that dirty and wet bedding, which was a common findings on the earthen floors, tends to harbor a wide range of infectious agents, which may contaminate the udder and the teats. According to Ndegwa *et al.* (2000) wet bedding due to new fresh deposits of urine and manure serve as a medium for pathogenic organisms to thrive and multiply in intensive units. Extensive systems in the current study were characterized by dung heap bedding which reported the least mastitis occurrence rate (13.67%). This observation could be explained by the fact that higher temperatures on decomposing manure on dung heaps bedding inactivated most pathogens while maintaining low moisture contents of up to 25-50% (USDA, 2007). Even though this is the case we inferred that dung heap bedding could become an important risk factor for mastitis during wet seasons when high moisture content supports microbial proliferation. The high incidences of mastitis in intensive production systems may also be explained by large flock sizes. The role of flock sizes in the epidemiology of mastitis has been affiliated to stocking density. Najeeb *et al.* (2013) reported that goats reared under high stocking density are susceptible to variety of bacterial infections mainly due to exposure to mastitis pathogens. The spread of mastitis from one udder to the next in large flocks during milking is highly possible especially where environmental hygiene is poor. Findings by Piva (1999) indicated that lower stocking densities resulted in significantly ($P<0.01$) lower concentrations of psychrotrophs, mesophile and feacal coliforms. Thus microbial density is positively correlated to high stocking densities in unhygienic environments.

4.3.2.7. Other risk factors

There was no significant association of the cluster ($P>$ 0.0652, X^2=5.461), age ($P>$ 0.2174, X^2=3.0524), body condition score ($P>$ 0.9012, X^2=0.208), month of kidding ($P>$ 0.0617, X^2=3.49), and type of housing floor ($P>$ 0.143, X^2= 3.88), to the occurrence of mastitis (Table 4.10). Despite the lack of significance high prevalence rates were reported for does in the Matebeleng cluster. Furthermore categorical levels of earth floors, tick infestations, milking and underfeeding reported higher incidences of mastitis.

Table 4.10: Other risk factors not associated with mastitis occurrences in Oodi extension area of Kgatleng District, Botswana.

			Mastitis prevalence			
Risk Factors	**Categories**	**N**	**+No**	**Rate%**	**X^2**	**P-value**
Cluster	Matebeleng	42	12	28.57	5.461	0.065^{ns}
	Oodi	30	6	20		
	Boladu	91	11	12.09		
Age	<2	42	4	9.52	2.957	0.228^{ns}
	3-5	93	18	19.35		
	>5	28	7	25		
Body condition	Malnourished	84	16	19.05	0.208	0.901^{ns}
	Normal	62	10	16.13		
	Obese	17	3	17.65		
Month of kidding	July	52	5	9.62	3.49	0.062^{ns}
	August	111	24	21.62		
Type of doe	Milking	110	20	18.18	0.035	0.8511^{ns}
	Suckling	53	9	16.98		
Tick infestation	Present	21	4	19.05	0.026	0.871^{ns}
	Absent	142	25	17.61		
Floor type	Dung heap	95	13	13.68	3.88	0.143^{ns}
	Earth floor	35	10	28.57		
	Concrete	33	6	18.18		

N= sample size; + No= number of positive; OR = Odd ratio; CI= Confidence of OR; RF = Reference factor; ns = not significant (superscript indicates no significant level of categorical variable;

4.4. Conclusion

The results obtained from the study suggest that the overall prevalence of caprine mastitis in the Oodi extension area was 17.79%. Therefore the prevalence rate was within the international range of 5-30%. Moreover sub-clinical mastitis cases were higher than clinical mastitis. Caprine mastitis occurrence was associated with risk factors; parity class, previous mastitis history, injuries on the udder and teats, breed, production system, flock size and suckling litter size. However, no association was found for risk factors; location cluster, age, parity number, body condition score, month of kidding and type of housing floor. The presence of previous mastitis history and injuries on the udder and teats increased the odds of rates of mastitis occurrences. Furthermore risk factors categories; dairy type breeds (Saanen), intensive production system, large flock size, multiple suckling litter size and multiparous does had high mastitis prevalence rates and increased odds ratios.

4.5. Recommendations

It can be recommended that farmers improve on key management areas of housing, udder health and doe and kid management. Kid and doe management should be improved in order to avoid teat injuries and cross udder contaminations. In this case farmer should consider the early weaning ages to avoid pronged suckling and its effect on udder health. Meanwhile does suckling kids should be monitored to detect any udder infections, injuries or lesion that may persist to recurrent or chronic forms of mastitis. Housing management features that include stocking densities, floor types and infrastructure materials should be planned sufficiently since they add to environmental contaminates, stress and injuries that may affiliate to mastitis occurrence. Milking does should be culled from milking programmes to breeding programmes after 6^{th} parity to reduce mastitis risk in the flock.

CHAPTER 5

5.1. General Discussion

Empirical evidence from the current study revealed that subclinical mastitis (13.34%) is a more severe and unfamiliar problem compared to clinical mastitis (4.29%) (Table 4.2). Similar observations on the dominance of subclinical mastitis were observed in studies by Kerro Dego and Tarek, (2003). The lack of diagnostic capacity (63.7%), treatment (79.1%), culling (89%) and Critical Control Points (CCP's), (63.7%) for mastitis by majority of the value chain farmers played a significant role in the high rates of subclinical mastitis in the region (Table 3.7). Mungube *et al.* (2004) indicted that most smallholder farmers are not well informed about the invisible losses from sub-clinical mastitis and do not normally recognize the condition. Therefore mastitis affected value chain activities and performance negatively in the region.

The major constraint faced by the producers due to mastitis was decline in milk yield which was 58% while kid mortality, cost of treatment and time constraints constituted a share of 25%, 11% and 6 % respectively (Figure 5.1). Milk decline due to mastitis is associated with tissue damage that brings about lowered milk yield or cessation of milk synthesis. Studies have shown that mastitis can cause a 30% reduction in milk yield in goats (Gonzalo *et al.*, 1994, Leitner *et al.*, 2004, Kifaro *et al.*, 2009). This decrease in milk production has been associated to the nutritional demise and mortality of kids. Kid mortality due to mastitis may be linked to poor nursing ability of affected does due to pain as well as lack of milk due to damage from chronic infection. Previous studies by Suffolk (2012) reported an estimated 34% perinatal kid 1mortality which was linked to starvation due to mismothering. Treatment of mastitis is costly in terms of procuring the necessary labour, veterinary requisites and antibiotic withdrawal periods. For commercial enterprises competing in value chains losses due to penalties are possible as a result of antibiotic residues, microbial contamination and inconsistency in milk quality and quantity. The empirical evidence suggests the need to incorporate significant mastitis risk factors in the development of Hazard Analysis Critical Control Points (HACCP) protocols for milk production. This will prove worthy to the control and prevention of the disease within the value chain.

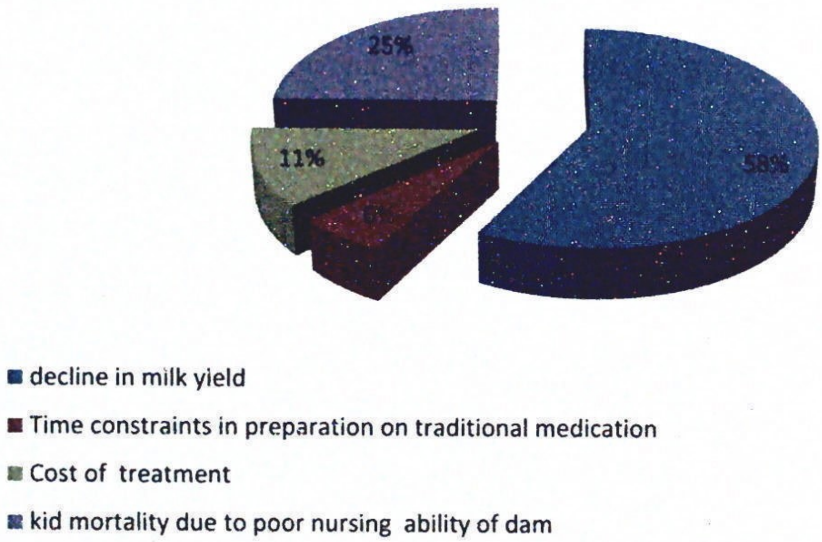

Figure 5.1: Mastitis constraints faced by farmers in the Gaborone agricultural region.

CHAPTER 6

6.1. General Conclusion

The goat milk value chain in the Gaborone agricultural region comprised mainly of farmers selling their surplus goat milk after home consumption to neighbours and other consumers in the locality. Milk was mainly produced from indigenous meat goats thus milk yield per animal and farm output was low. The results also indicated that farmer milked on average 9 animals for an average lactation length of 5 months. Mastitis was a key aspect affecting milk production and was present in 41.8% of the producers. However 36% of the respondents diagnosed and implemented Critical Control Points to manage mastitis. Thus the majority of the producer did not manage caprine mastitis since they were incapable of diagnosing and guarding against it. The overall prevalence of caprine mastitis in the Oodi extension area was 17.79%. Risk factors; parity, previous mastitis history, mammary gland injuries, breed, production system, flock size and suckling litter size exhibited a significant association to the occurrence of mastitis. The risks and rates of mastitis were increased by intensive production system, large flock size, multiple suckling litter size, and high parity numbers and the presence of mammary gland injuries

6.2. Recommendations for Future Research

Mastitis management and value chain functions would most certainly improve if all research results were applied. One major issue is, however, how to communicate results to farmers so they are implemented. Therefore future research should focus on capacity building and exploring the following avenues;

I. Researchers should investigate on efficient ways to disseminate research results to farmers. and other value chain players, as there is a lot of easily applicable results on how to reduce the incidences of mastitis that does not seem to reach the farms.

II. The prevalence of Caprine mastitis should be assessed in different season in order to find out the impact of seasonal variation on the prevalence rates and odd ratios. Longitudinal type of studies should be designed to capture data at varying interval.

III. The prevalence of Caprine mastitis should also be assessed in different management systems in order to capture the effects of management parameter.

IV. An economic analysis of caprine mastitis on the value chain actors, products and processes should be investigated in order to quantify the economic risks associated with the disease.

CHAPTER 7

7.1. References

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APPENDIX 1: GOAT MILK PRODUCER QUESTIONAIRE

Please tick (√) in the boxes where appropriate

SECTION A: DEMOGRAPHIC

1. Location ....
2. District...
3. Age (Year)

1. <18[ ] 2. 18-40[ ] 3. 41-64[ ] 4. 65 Above [ ]

4. Gender
   1. F [ ] 2. M[ ]
5. Marital status

   1. Single[ ] 2. Married [ ] 3. Divorced[ ] 4.widowed [ ]
6. Education level

1. Primary[ ] 2. Junior secondary[ ] 3. Senior secondary[ ]

   4.Tertiary[ ] 5.None [ ] 6. Other others specify ....

7. Sources of income

1. Formal employment	
2. Seasonal employment	
3. Contract employment	
4. Agriculture Specify	
5. Others specify	

8. Monthly Income in Pula.

   1. 500 and less [ ] 2. P501-1000[ ] 3. P1001-2000[ ]

   4. P2001-3000[ ] 5.above 3000 [ ]

9. Type of enterprise

1. Commercial [ ] 2. Semi commercial [ ] 3. Subsistence [ ]

10. Farming experience (years)..

11. Sources of funds for your enterprise?

1. FAP	
2. CEDA	
3. NDB	
4. LIMID	
5. Commercial banks	
6. Family loan	
7. Own(livestock & crops)	
8. Pension	
9. Inheritance	
10. Others (specify)	

SECTION B: PRODUCTION

12. Type of production system?

1. Intensive (zero grazing [ ] 2. Semi intensive [ ] 3. Extensive [ ]

13. Number of milking goats per day.

1. 5 and below	
2. 5-20	
3. 21-40	
4. 41-60	
5. 61-80	
6. 81-100	
7. 101+	

14. Type of breeds used for milk production specify..

15. Average milk yield per goat per day specify the measurement used in production.

16. What do you use the milk for?..

17. Do you add value to the goat milk?

1. Yes [ ] 2. No [ ]

18. If YES how do you add value to milk? ....

19. If yes what produce are obtained from value added milk (specify)....................

20. Why do you add value to the milk in that manner?

21. What constraints do you have in producing milk?

Animal husbandry	1. Other diseases	
	2. Mastitis	
	3. Stock mortality	
	4. Theft/predation	
	5. Drought	
Resources	6. Lack of veterinary requisites	
	7. Finance	
	8. Grazing Land and production land	
	9. Finance	
	10. Labour	
	11. Market	
	12. Theft/predation	
	13. Lack of milking stock	
	14. Milking equipment and infrastructure	
	15. Water, Feeds and supplements	
Production standards	16. Low milk yield	
	17. Low milk quality	
	18. Lack of quality control measures	
	19. Milk hygiene	
Others (specify)	20.	

SECTION C: MARKETING

22. Who market your milk?

1. Yourself[ ]   2. Sales agent [ ]   3. Cooperative [ ]

4. Others (specify)....................

23. Where do you sell your milk?

1. Processors [ ]   2. On farm sales [ ]   3. Consumer [ ]

4. Others (specify).........................

24. Do you have transport for the milk produced?

1. Yes   2. No

25. If no how do you transport your milk to the market?

1. Hired transport   2. Buyers transport   3. Other (specify)

26. How far is the market place from your enterprise in Km?

1. <10 km	
2. 11-20km	
3. 21-30 km	
4. 31-40km	
5. 41-50km	
6. 51+	

27. What type of milk do you sell?

Classes	Litres/month	Price/Litre
1. Raw milk		
2. Pasteurized milk		
3. Processed milk (specify)		
4. Milk product (specify)		

28. Who determines the price for the milk?

1. Myself   2. Buyers   3. Negotiation   4. Others (specify)

29. Are you satisfied with the price/value of your milk?

1. Yes   2. NO

30. If No, please explain

1. Price below production cost   2. Below break-even price

31. How often do you sell goat milk and goat milk products?

1. Every day	
2. Every week	
3. Every three weeks	
4. Every month	
5. Other specify	

32. What constraints do you have in marketing your milk?

Exchange	1. Buying and selling prices	
	2. High cost of marketing	
	3. Lack of market	
Physical	4. Milk transportation	
	5. Milk hygiene	
	6. Distance to markets	
	7. Milk handling and storage	
Facilitating	8. Consumer preference	
	9. unfair quality control standards	
	10. Grading systems	
	11. Marketing skills	

33. What do you think should be done to improve the Marketing of milk and milk products in the Gaborone agricultural region?

Part 2: Mastitis

34. In the past year how many cases of caprine mastitis have u

1. Recorded................ 2. Reported................. 3. Culled.................

4. Mortality ....

35. At which step along the production line do you diagnose or have control checks for caprine mastitis? ....

36. Does this step eliminate or reduce the likely occurrence of the mastitis hazards to an acceptable level? 1. Yes☐ 2. No☐

37. What diagnostic procedure do you use to diagnose caprine mastitis along the production line?

1. California Mastitis Test	
2. Clinical examination	
3. Somatic cell count	
4. Milk microbial cultures	
5. Other (specify)	

38. When you do you use to diagnose caprine mastitis along the production line?

6. Daily basis	
7. Weekly basis	
8. Fortnight basis	
9. Monthly	
10. Annually	

39. Who conduct the above mentioned tests

1. Vet department	
2. Private vets	
3. Self	
4. Milk buyer	
5. Others (specify)	

38. How do you handle any deviations/positively diagnosed stock and mastitis positive milk?

39. Which of the milk management measures do you have in place to guide against caprine mastitis?

milk management measures		Please tick (√)
Milking routine	1. Milking done in a milking parlor	
	2. Separate mastitis infected animals during milking	
	3. Hand wash before milking	
	4. Udder wash	
	5. Pre milking Teat dip antiseptic	
	6. Dry teats	
	7. Strip out foremilk	
	8. Test for mastitis	
	9. Apply teat lubricant	
	10. Apply post milking Teat dip/spray antiseptic	
Milking equipment	11. Programming and calibrating milking pressure systems	
	12. Washing of milking equipment	
	13. Disinfection of milking equipment	

40. Which of the following knowledge and skill do you have?

Knowledge on mastitis	**Please tick (√)**
1. Have Knowledge about mastitis	
2. Have knowledge to diagnose caprine mastitis	
3. Aware of the milk quality control standards	
4. have knowledge on mastitis prevention measure	

5. have knowledge on mastitis control measure	
6. Keep a record on mastitis cases	
7. keep records of treated animals	
8. Reports mastitis cases to the veterinary authorities	
9. Source assistance from extension agents and vets	

41. Which of the flock health management measures do you practice to guide against mastitis?

	Biosecurity measures	Please tick (√)
Biosecurity	1. Hygiene barriers at farm entrance for people, trucks, materials.	
	2. treat mastitis cases in your farm	
	3. Cull mastitis infected animals	
	4. Separate mastitis infected animals	
	5. administer drying therapy	
	6. testing of flocks prior to entry into the herd	
	7. Run periodic flock test on mastitis	
	8. check milk of goats and bulk milk before delivery	
Housing	9. Apply bedding	
	10. Remove excess dung/manure	
	11. Improve drainage of the housing	
Feeding	12. Adequate feeding	
	13. Mineral supplements	

42. In line with your enterprise mandate what constraints you face due to mastitis?

43. Which caprine mastitis prevention measure do you practice to prevent it from recurring?

44. Which caprine mastitis control measure do you practice?

45. What do you think should be done to reduce the prevalence of caprine mastitis and its constraints on goat milk producers?

APPENDIX 2: GOAT MILK CONSUMER QUESTIONAIRE

Please tick (√) in the boxes where appropriate

Location...

District...

1. Age Years

   1. <18 [ ]   2. 18-40 [ ]   3. 41-64 [ ]. 65 and above [ ]

2. Gender   1. F [ ]   2. M [ ]

3. Marital status

   1. Single [ ]   2. Married [ ]   3. Divorced [ ]   4. Widowed [ ]

4. Do you consume goat milk? 1. Yes [ ]   2. No [ ]

5. If No, why?

1. Hygiene issues	
2. Preference	
3. Traditional beliefs	
4. Religious beliefs	
5. Others (specify)	

6. If YES In what form do you prefer goat milk?

1. Fresh milk	
2. Sour milk	
3. Processed produce (specify)	
4. Other (specify)	

7. Where do you get /source your goat milk?

1. Form your own goats	
2. Directly from goat farmers	
3. Retailers	
4. Milk processors	
5. Other (specify)	

5. How often do you consume or use goat milk and milk produce?.......................

6. Do you purchase goat milk 1. Yes☐ 2. No☐

7. If YES at what price do you purchase goat milk P......................./..............

8. How do you use goat milk? ....

9. Do you add value to goat milk? 1. Yes ☐ 2. No ☐

10. If YES how do you add value to milk? ....

11. If YES what produce are obtained from value added milk (specify)...................

12. Why do you add value to goat milk in that manner/or into such products?...........

13. What constraints do you have in sourcing or obtaining goat milk?

1. Limited goat milk distributers	
2. Limited goat milk producer	
3. High price	
4. Distance from home/ locality	
5. Distance from markets	
6. Medical reasons	
7. Veterinary/animal disease reasons	
8. Others specify	

14. Do you receive any information or outreach on the goat milk? 1. Yes☐ 2.No☐

15. If YES how do you get such information?

1. Television	
2. Radio	
3. Private advertising media	
4. Personal encounter	
5. Agric shows and exhibition	
6. Others (specify)	

16. Are you aware of the risk associated with consumption of raw goat milk?

1. Yes ☐ 2. No ☐

17. If YES how do you reduce or mitigate the risk?..

18. What do you think should be done to improve the production and marketing of milk and milk products in the Gaborone agricultural region?..

19. From a consumer perspective what do you think should be done to improve the safety of goat milk and milk products in the Gaborone agricultural region?............