PREVALENCE AND RISK FACTORS OF BRUCELLOSIS IN GOATS IN SOUTHWEST STATE OF SOMALIA

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DECLARATION

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

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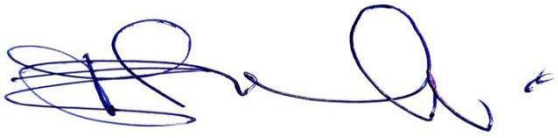
   Sign:  Date: 10/11/2023

DEDICATION

I dedicate this thesis to my wife and children for their support throughout this course of my work.

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I am grateful to Prof. Jackson N. Ombui and Dr. Peter Baaro Gathura, my university supervisors for their mentorship and supervision in this research work. I also appreciate the lecturers at the Department of Public Health, Pharmacology and Toxicology for their dedication. My gratitude is also to the goat herders in Bay and Lower Shabelle regions who participated in the study.

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ABBREVIATIONS

CFT	Complement Fixation Test
ELISA	Enzyme Linked Immunosorbent Assay
FEWS NET	Famine Early Warning Systems Network
FSNAU	Food Security and Nutrition Analysis Unit - Somalia
RBPT	Rose Bengal Plate Test
USD	United States Dollar

ABSTRACT

This study evaluated the occurrence and risk dynamics of Brucellosis, a disease of an infectious nature resulting from intracellular Brucella spp- and Gram-negative coccobacilli bacteria that affect some animals and humans. The disease affects livestock production and human health in developing countries and creates trade barriers and economic losses for the goat industry. The study's aim was estimation of Brucellosis prevalence in goats and to ascertain the risk factors influencing its occurrence in South West Somalia. The area of study was in three districts each in Lower-Shabelle region (Afgoye, Qoryoley and Walaweyn) and Bay region while those in Bay (Baidoa, Diinsor and Burhakaba) of South West state in Somalia. A cross-sectional survey design that involved collecting and managing 207 serum samples of blood from goats and administering a questionnaire to herders with an aim to assess the risk features that led to infection of goat with Brucellosis. Only adult volunteers participated in the study and their privacy and confidentiality were protected. Required sample size was obtained by selecting twenty households from each district using systematic sampling. Serum was obtained from the blood samples collected after allowing it to stand. Analysis of samples was by Rose Bengal Plate test. Data was analyzed using SPSS for statistical analysis, including univariate and multivariate logistic regression models. The study results indicated greater sero-prevalence of brucellosis in females (5.2%) more than male goats (2.9%) and in goats aged 48 months (10%) than in goats aged 13-24 months (2.6%). Afgoi had the highest prevalence (6.45%), followed by Baidoa, Wanlaweyn, Qoryoley and Diinsor. The predisposing factors significant ($p<0.05$) to Brucella infection in goats included cases of abortion (OR = 2.99), and free contact of

goats in communal grazing and drinking water (OR = 1.35). Others are new entries of flock into the farms (OR = 1.33), sharing of communal bucks for breeding (OR = 1.01), knowledge of brucellosis (OR = 1.29) and seeking veterinary services (OR = 1.23). Abortion, free contact of goats in communal grazing and drinking water, new entries of flock into the farms and knowledge of brucellosis were also important risk factors in the multivariate logistic regression. Additionally, the common practices that posed a risk for transmission of Brucellosis to humans were assisting animals during birth, not washing hands with soap after delivery and handling aborted foetuses. The practices of 'sharing of communal bucks for breeding' and 'seeking veterinary services' were not significant due to confounding factors. Failure to wear gear that offers protection including gloves while attending to animals in birth and handling aborted fetuses may increase the infection risk with Brucella organisms. Likewise, poor disposal of aborted foetuses, slaughtering goats at home, consuming raw meat and milk and inadequate knowledge of brucellosis can bring spreading of infection. This study recommends managing livestock migration, doing private grazing and disseminating knowledge to the communities about the disease. New animals should be introduced to household flocks cautiously by ensuring that they are from brucellosis free herds and isolation should be done for screening, while intermingling of herds should be restricted. Control measures such as animal vaccinations and public education on proper handling and disposal of aborted foetuses during birth should be done.

CHAPTER ONE

1.0 INTRODUCTION

Goats and sheep are the main domesticated animals in Somalia that play an important economic function in national food production, employment as well as national revenue through exports (Wanyoike *et al.,* 2015). In 2011, export of goats and sheep worth more than 200 million USD to the Middle East from the port of Barbera, show their importance to the Somalia economy (Wanyoike *et al.,* 2015). Small ruminants are a valuable asset in developing livestock production systems where most of the global production of goats (95%) and sheep (65%) takes place (Guitierrez, 2004). Africa hosts 33% of this population and production is mainly focused in areas that are arid and semi-arid, where other agricultural systems are not possible (Guitierrez, 2004; Herrero *et al.,* 2013).

Small ruminants play a distinctive starring role in protecting livelihoods as they often involve slightly initial investments, have quick growth rates, shorter generation intervals and have better environmental flexibility as paralleled to the larger domestic ruminants (Tibbo and Ayalew, 2006; Nottor, 2012). Even though small ruminants have been demonstrated to be a huge resource in protecting livelihoods in developing countries, production does not recognize its complete potential due to several factors (Shenkute, 2009; Thornton., 2010). Of importance, several infectious diseases for example Brucellosis continue to cause production losses in small ruminant populations and hamper trade.

Brucellosis is a transmissible infectious disease that is zoonotic in nature and seriously jeopardizes livestock production predominantly in developing nations. It is one of the most

common global zoonosis that threatens foods security as well as a source of human health problems. Species of *Brucella* are classified as gram-negative, intracellular, coccobacilli bacteria which after infecting humans and various animals causes Brucellosis disease (Pappas *et al.*, 2005). *Brucella* species that are common in different animal species especially the livestock such as

B. abortus that infect cattle, *B. suis* that infects pigs, and *B. melitensis* that devastate sheep and goats. The most rampant *Brucella* species is *B. melitensis* that cause serious health problem in human beings (Godfroid *et al.,* 2010). Brucellosis is widespread in human beings and small ruminants' species for instance goats and sheep, camel and cattle in Somalia. However, the impact of the disease is largely unclear, especially after the civil war that disrupted most national systems including livestock disease control programmes since the 1990s (Maystadt and Ecker, 2014; Hassan-Kadle, 2015). This study examined the occurrence and risk aspects of Brucellosis occurrence in goats in Somalia. Animal brucellosis creates trade barrier to animal exports as countries reject imports from *Brucella* endemic nations which causes major economic losses in goat industry.

1.1 OBJECTIVES

1.1.1 Overall objective

To evaluate the prevalence and risk dynamics linked to brucellosis in goats in the Southwest State of Somalia.

1.2 Specific objectives

1.2.1 To assess prevalence of goat brucellosis in Southwest state of Somalia

1.2.2 To identify the risk factors of brucellosis occurrence in goats in the Southwest state Somalia

1.3 Hypothesis

H_o: There is a high occurrence of brucellosis in goats in Southwest Somalia.

H_a: There are no risk issues associated with brucellosis occurrence in goats in Southwest Somalia.

1.4 Justification

The civil war in Somalia that erupted in 1991 interrupted many services including veterinary public services and related infrastructures. After the civil war ended, Somalia has set up some institutions that can now enforce law and order, but there are still gaps in disease surveillance especially for infectious diseases like brucellosis. Endemic status of Brucellosis diseases cause health hazards that are serious to human beings and losses that are significant in livestock sector. Goats are the source of the most virulent *B. melitensis* pathogen that causes brucellosis disease in humans. Without a clear picture of the occurrence, incidence and the risk factors associated with the endemic status of brucellosis, it is difficult to device effective mitigation measures for both humans and livestock as this is a public health concern. This study provides the public and the knowledge community and adds to the limited information that is available on the occurrence, incidence and the issues of risk associated with brucellosis disease in Somalia.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Aetiological agent

Brucellosis disease emanates from a bacterium in the *Brucella* genus. In sheep and goats, brucellosis disease is arises from *B.melitensis* which was the first *Brucella* bacteria to be described in the family *Brucellae*. It was first isolated from soldiers in Malta, but it took twenty years to link goats as the source of the pathogen (Wyatt, 2005; Godfroid *et al.*, 2005). *B. melitensis* is non-motile, gram negative and facultative anaerobe bacteria that does not form spores. They measure 0.5 to 0.7 by 0.6 to 1.5 µm (Bandara *et al.*, 2009). Even though *Brucella* species comprise of all motility genes, they lack a system of chemotactic needed to bring together a flagellum that is functional, hence they are non-motile (Fretin *et al.*, 2005). They do not have capsules, plasmid, pili or exotoxins. *Brucella* organisms are usually found individually or sometimes in pairs or small clusters (Nielsen, 2018).

2.2 Epidemiology

2.2.1 Distribution

Brucella spp are found everywhere in the world, except in countries where *B. abortus*, which causes bovine brucellosis, has been eliminated. There has been no documented reports or reliable data on eradication of *B. melitensis* the causal agent for brucellosis disease in a number of ruminants in most countries (Robinson, 2003). Brucellosis is present throughout Sub-Saharan

Africa, but its occurrence and distribution is largely unidentified due to the limited health networks and proper surveillance systems.

2.2.2 Mode of transmission

Brucella melitensis spread in goats and sheep is like the spread of *B. abortus* reported in cattle. It is transmitted through handling of contaminated placenta, infected fetus, fetal fluids and contact with vaginal discharges. Goats can shed vaginal discharges for up to two to three months (Lemu *et al.,* 2014). *B. melitensis* may also be present in semen and milk and infected kids could excrete it in feces (Saxena and Saxena, 2018).

Pastures are more frequently contaminated by infective material and the infective agents are most probably acquired through feeding on that pasture, inhalation and inoculation to the conjunctiva, contamination of the skin and often through udder inoculation during milking (Ashenafi *et al.,* 2007). Nevertheless, sexual spread is the main mode of transmission, and this plays a greater role in maintaining the disease in the flock within *utero* transmission also reported (Godfroid *et al.,* 2011).

Several factors promote the transmission of the disease in flocks; aggregation of flocks during grazing and watering is the main factor that promotes spread among different flocks (Ashenafi *et al.,* 2007 and Godfroid *et al.,* 2011). In addition, animals not screened, especially bucks introduced in a clean flock are a big risk and contribute highly to the introduction of brucellosis disease (Ashenafi *et al.,* 2007). Most herders share breeding bucks among different flocks complicating the situation further (Corbel, 2006).

2.2.3 Clinical and pathological manifestation in goats

Brucellosis in goats has the same clinical manifestation as the disease in cattle; it is characterized by a whole range of reproductive disorders including abortions in the third trimester, still births, weak off springs, reduced fertility, and decreased milk production (Lilenbaum *et al.,* 2007; N Xavier *et al.,* 2010; Godfroid *et al.,* 2010). According to Ebrahimi *et al.* (2014) and Higgins *et al.* (2017), goats abort once but re-colonization and subsequent shedding continues to occur. Animals affected often have retained placenta while arthritis and orchitis may occur in bucks (Nasruddin *et al.,* 2014). When the disease enters a naive herd, abortion rates are excessively high with the inflammatory changes reducing milk production drastically. In males, orchitis leads to damage of testicular tissue and infertility (Matthews, 2016; Ali, 2012).

Although pathological lesions at post-mortem are not pathognomonic for brucellosis, there are often granulomatous lesions on the reproductive system, udder and lymphoid tissue and in some cases in synovial membranes and joints (Fever *et al.,* 2009). The placenta is often inflamed and the cotyledons are either oedematous or necrotic with a thickened and leather-like inter-cotyledon space. Aborted foetus are often autolysed but in some cases may be normal or may be excessively blood-stained within its body cavities with inflamed spleen and liver (Renukaradhya *et al.,* 2002; Al-Majali, 2005; Megersa *et al.,* 2011). Bucks often have orchitis and inflammatory lesions on the epididymis, seminal vesicle and prostate gland (Nasruddin *et al.,* 2014).

2.2.4 Zoonosis

Brucellosis disease poses a risk to people who work with animals, such as farmers and veterinarians (Godfroid *et al.,* 2005). Laboratory workers who handle diseased animals or animal tissues can also be exposed to the infection. People can get the disease from contact with animals, for example, when assisting goat births or handling aborted materials. They can also get infected by eating infected dairy products or meat from infected goats (Corbel, 2006; Assenga *et al.,* 2015; Verraes *et al.,* 2015). It causes a fever that comes and goes in humans, and can become chronic with serious health complications. The main human systems affected by brucellosis disease are the cardiovascular system, central nervous systems and musculo-skeletal (Mantur *et al.,* 2007).

In human, treatment with antibiotics is recommended, however success rates are low as relapses are common even after successful treatment. Mortality in human is usually as a result of meningitis and/or endocarditis. Case fatality rate in untreated animals is less than 5% (Fever *et al.,* 2009).

2.3 Diagnosis

Brucellosis should be considered a tentative diagnosis in flocks of goats with abortion and stillbirths where apparent disease is not evident. Tentative diagnosis of brucellosis involves a stamp modification of Ziehl-Neelsen method stained on microscopic smears. This diagnosis examination is supported by serology (Musa *et al.,* 2008).

Serology is another method for brucellosis diagnosis particularly for monitoring purposes. However, serological tests are not specific enough and can often give false results because just like most bacteria, *Yersinia enterocolitic*a O:9, *B. melitensis* reacts in the same way (Munoz *et al.,* 2005). Currently, the tests for serology used in diagnosis of *B. melitensis* were developed mainly for *B. abortus* diagnosis in cows and bulls. These are considered best serological tests for *Brucella* diagnosis, particularly the Rose Bengal plate (RB) and complement fixation test (CFT),

Even though they are not officially approved for use in small ruminants. Competitive ELISA (enzyme linked immunosorbent assay) has also been used lately (Abuharfeil *et al.,* 1998).

2.4 Economic impact

In spite of the availability of active vaccines for goats, the disease keeps on causing economic losses in goats. Effective control has economic challenges and control in prevalent areas have been unsuccessful due to the ineficiency in vaccine delivery, unreliable infrastructure, and no sufficient funding. Data for annual financial effect of brucellosis in the developing countries related with illness in domesticated animals have the most part been difficult to weight, particularly in Africa (Franco *et al.*, 2007).

It is challenging to estimate the effect of brucellosis diseases on humans because the disability cost caused by the disease is not quantifiable. Moreover, the cost of diagnosis and treatment has to be considered (Schelling *et al.*, 2003). Remarkably, most cases of brucellosis in human especially in countries where the disease endemic are due to patients infected after travelling from endemic regions or import of dairy products. No matter what measures taken, there is high economic impact especially in terms of health and costs caused by brucellosis disease in humans in endemic areas. This justifies establishment of comprehensive, sustained, and efficient efforts in regulation (Roth *et al.,* 2003; Franco *et al.,* 2007).

2.5 Prevention and control

Since treatment of brucellosis is complicated and often nearly impossible in goats, it's more practical and economically feasible to attempt to prevent the flocks from getting the disease (Corbel, 2006). Farmers should exercise caution when introducing animals into their flocks.

Animals introduced should be from brucellosis free herds and isolation of introduced animal should be performed during screening for the disease for at least a month (Samartino, 2002). Farmers should also restrict intermingling of herds if practical and when possible all cases that presents as abortions and still births be exhaustively explored ad the affected animals are separated from the flocks. Infected animals in the herd should be separated and eliminated and proper disposal of contaminated matter like aborted foetus and such by-products by either burning or burial should be done and areas contaminated disinfected thoroughly (Likov *et al.*, 2007; Al-Griw *et al.*, 2017).

To mitigate against human cases, cooperation and coordination with human health is paramount. Surveillance programmes should be instituted nationally to gauge the status of the disease as control of disease in animal has a ripple effect in protecting humans (Pappas *et al.*, 2006; Reddy *et al.*, 2016). Nevertheless, humans should steer away from uncooked meat or unpasteurised milk and avoid contact with aborted material. Protective equipment and garments should be used when handling aborted and other infected material (Cleaveland., 2017; Jia and Joyner, 2015).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study area

This study took place in South West State of Somalia. It is located 3° 51′ 51.12″ N, 43° 25′ 5.16″ E within Somalia. It was founded in the year 2012 and has a population projected at 2.5 million people as of 2015. It is also referred to as *Koonfur-Galbeed Soomaaliya.* The South West State has three regions namely; Lower- Shebelle, Bay and Bakool. Lower-Shabelle is bordered with five regions which are Bay, Middle – Shabelle, Middle –Juba, Hiran and Benadir. It has seven districts which are Afgoye, Marko, Qoryoley, Barawe (capital city of South West State), Sablale, Kurtunwarey, and Walaweyn. Bay also shares the border with five regions which are Lower- Shabelle, Middle-Juba, Hiran, Gedo and Bakool, and has five districts which are Baidoa, Diinsor, Qansahdhere, Berdale and Burhakaba.

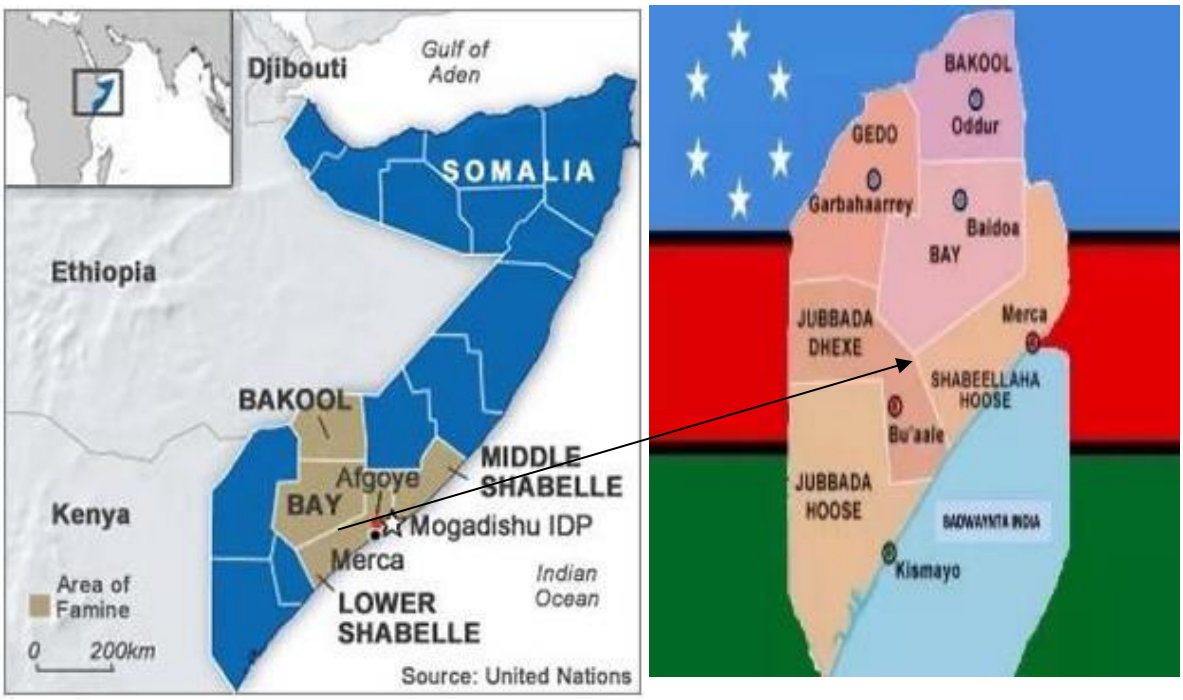


Figure 3.1: Map of South West Somalia region
Source: FEWS NET and FSNAU (2023)

3.1.1 Goat Population in Southwest Somalia

There are about 11 million heads of goats in Somalia goat population with the South West State comprising of a smaller population than the North of Somalia (FAOSTAT, 2020).

3.2 Study design

A cross-sectional design was used for the study. It involved serum samples from goat blood and administering questionnaires to herders during sample collection for evaluating risk issues related to the occurrences of goat *Brucella*.

3.3 Selection of study areas for sampling

The study area was chosen based on its relative political stability, proximity to Somalia's capital

city and availability of a large number of goats. Three districts were purposively selected from each of the two regions, Bay and Lower Shabelle, which are closest to the capital city and have a high population of goats. The selected districts were Baidoa, Diinsor and Burhakaba for Bay region, and Afgoi, Wanlaweyn and Qoryoley for Lower Shabelle region. From each of the six districts 20 households were selected. Ten to eleven goat herds were sampled systematically up

to the required sample size within each selected household. Twenty-four structured questionnaires were also administered to goat herders to identify and evaluate risk factors (including age, sex, species, knowledge, management practices, production system, watering and milking hygiene) that may be associated with the occurrences of brucellosis in goats.

3.3.1 Sample size determination

The formulae by Dohoo *et al. (*2003) assisted to determine sample size;

$n= z_{\alpha}^2 pq /L^2$

Whereby, n = the needed total sample size,

Zα = the normal term providing 95% confidence intervals (1.96)

p = *A priori* estimate of the disease prevalence

q=1-p

L =the acceptable error of the estimate

P= estimated seroprevalence of brucellosis in goat 16.1% in Nigeria (according to Bertu *et al.*, 2010) was used.

$n =1.96^2 \times 0.161 (1-0.161)/ (0.05)^2$

The goat total sample size was 207 that was distributed into households. These households were equally distributed to each of the six districts with approximately 10-11 goats sampled per household.

3.4 Collection of blood samples

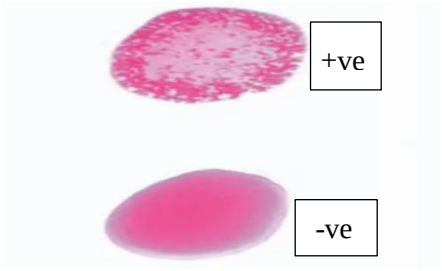
Blood drawn using a disposable syringe of 5ml and a vacutainer tube from the jugular veins of the goats was put into a plain test tube. Blood samples were stored until separation of the serum at normal temperature. The serum was then collected and stored in clean plastic tubes and frozen.

The frozen serum was put into cool boxes containing packs of ice and later transported to the laboratories at the Ministry of Livestock, Forestry and Range in the Department of Animal Health, and Veterinary Service for serological analysis. Serum samples were stored at temperatures of -20ºC in the laboratory until they were analyzed.

3.5 Rose Bengal test

Samples were analyzed using this agglutination test. This test quickly identifies *Brucella* antibodies in serum. It is highly sensitive, easy and fast to use, and it is commonly used in research because of its low cost.

Test Serum (30µL) was mixed with 30µL antigen to form a circle of about 2 cm wide on a white plate. Serum and antigen mixture were shaken gently for few minutes at room temperatures until clumping was detected. A visible reaction or agglutination or a typical rim indicated a positive result (Díaz *et al.*, 2011; Ruiz-Mesa *et al.*, 2005).



RBT reaction for Brucella test.

3.6 Data handling analysis

Data was recorded in research notebooks and entered into Microsoft excel sheets and SPSS for statistical analysis. The results were presented in frequencies, proportions, and means using descriptive analysis. Proportions were used to show categorical response variables and calculation of the bivariate associations was done using chi-square test. Independent variables were created from the pastoralists' population characteristics and their socio-cultural activities to examine their impact on their overall knowledge and the clinical occurrence of brucellosis in herds, while the dependent variables were based on the pastoralists' total answers to questions. The Univariate analysis of the independent and explanatory variable associations also used Chi-square test (Alhaji *et al.,* 2018). For controlling the confounding factors and testing the effect modification, the likelihood stepwise backward multiple logistic regression models was used to further analyze the statistically significant attributes.

Regression analysis method was key for investigating the relation between the independent and explanatory variable.

The model represented the variables below;

$Y = \alpha + \beta_1 X_1 + \varepsilon$

Where:

Y = Prevalence of brucellosis (Explanatory variable),

β_1 is the regression coefficient,

α is the constant,

X_1 = Predisposing factors to Brucellosis (Independent variable)

ε is the error term

3.7 Ethical considerations

Respondents were adult volunteers who consented to be part of this study. Their privacy and confidentiality rights were protected. Approved letter from Southwest State Authorities and Ministry of Livestock Federal Republic of Somalia was received.

CHAPTER FOUR

RESULTS

4.0 Introduction

Study findings and research results based on the study objectives that targeted to evaluate risk factors and prevalence related to sero-positivity of brucellosis in goats are presented in this chapter.

4.1 Demographics of Livestock Species in Southwest State Somalia

Data was obtained from sheep and goat flocks totaling 710 in the Bay and Lower Shebelle regions and out of the flocks sampled, most flocks 45.8% (95/710) or) comprised of below 10 goats followed by flocks comprising between 31-40 goats (51 or 25 %) and between 21-30 goats (43 or 20.8%). Majority of the flocks sampled comprised of between 21-30 sheep (112 or 54.2%) followed by flocks of between 31-40 sheep and below 10 sheep (34 or 16.7% each). Most of the flocks (77 or 37.5%) comprised of between 5-10 male goats followed by flocks comprising between 11 -20 male goats (51 or 25 %) and flocks between 21-30 male goats and between 31-40 male goats (25 or 12.5% each).

A large number of flocks sampled comprised of below 10 female goats (86 or 50%) followed by flocks comprising between 11-20 female goats (51 or 25 %) and flocks between 21- 30 female goats and between 31-40 female goats (35 and 12.5% each). The age group 6 months to 1 year had the highest frequency (57%) then followed by those between 2-3 years (20.9%). Animals 3-4 years and above 4 years had the least frequencies of 16.4% and 5.7% respectively. These results

show that most households owned small herds with more female animals and younger flock preferred for purposes of expanding the flocks faster.

4.2 Sero-Prevalence of brucellosis

Brucellosis infection rate was higher in females at 5.2% (5/95) compared to the rate in males which was 2.9% (3/104) Table 4.1. Older goats (Above 48 months) also had a higher rate of 10% (1/10), followed by goats aged 25 -36 months (4.4%, 4/82) and 37-48 months (3.1%, 1/32). The lowest rate was 2.6% (2/75), found in goats aged 13-24 months. Among the flocks, the highest brucellosis prevalence was 6.45% (2/31) in Afgoi, followed by 5% (2/40) in Baidoa and 4.16% (1/24) in Wanlaweyn. Qoryoley had a prevalence of 4% (2/50) and Diinsor had a prevalence of 2.9% (1/34). No positive results were found in Buurhakabo goats. These results indicate infection rate to be more in female goats, in older goats and in Lower-Shabelle than in Bay region.

Table 4.1: Prevalence of brucellosis in goats in Southwest State

Variables	+ VE	- VE	% positivity
Sex			
Male	3	104	2.9
Female	5	95	5.2
Age			
13mths - 24mths	2	75	2.6
25mths – 36mths	4	82	4.7
37mths – 48mths	1	32	3.1

Above 48mths	1	10	10
District			
Afgoi	2	31	6.45
Qoryoley	2	50	4
Baidoa	2	40	5
Diinsor	1	34	2.9
Buurhakabo	0	45	0

Number of positive 8
Total number of blood examined 207
8/207: 3.86

4.3 Predisposing factors of animal and human infection

The study described the factors that make goats and humans more likely to get *Brucella* infection. About half of the goat herds 50% (103/207 or) in South West Somalia had abortions in their herds during the study period. Most of the herds (83.3%) shared grazing land and water with other animals from different herds. This also led to breeding with common male goats (52.5%). Many herds (164/207) 79.2% had new animals joining them because of migration, buying or gifts. Table 4.2 shows these results. The high incidents of abortions in the goat herds indicate the high brucellosis prevalence. This is explained by presence of factors that predispose to a high extent namely herds with shared water and grazing land with other animals from different herds, breeding with common male goats and mixing of herds with new animals.

Table 4.2: Descriptive analysis of predisposing factors for animal infection with *Brucella* in south west region of Somalia

Predisposing factor to Brucellosis	**Response**	**Frequency (N=207)**	**%**
Abortion in goats	Yes	103	50.0
Communal free grazing	Yes	173	83.3
Communal feeding and watering System	Yes	155	75.0
Extensive production system	Yes	164	79.2
Water from wells	Yes	103	50.0
Communal breeding bucks	Yes	138	52.5
New animal entries into farm in last two years	Yes	164	79.2
Seeking veterinary services	Yes	3	12.5
Knowledge of brucellosis	Yes	14	58.3
Presence of brucellosis signs	Yes	17	70.8
Premature births	Yes	13	54.2

A number of factors were found to be common practices among goat owners and considered as risks in transmission of *Brucella* as shown in Table 3. The respondents that assisted

animals during birth were 75% (18/24), those who washed hands with soap after handling aborted fetuses and in delivery were 83% (20/24) while only 8.3% (2/24) wore protective gear such as gloves in these processes. Those who threw away aborted foetuses in bush were 58.3% (14/24), slaughtered goats at home were 87.5% (21/24), consuming raw meat were 12.5% (3/24) and consuming raw milk were 12.5% (3/24). The goat owners who had knowledge of brucellosis were 58.3 (14/24), those who knew the signs of Brucellosis in sick goats were 70.7% (17/24), while those who sought veterinary services were 12.5% (3/24). All these practices are considered to be contributing towards transmission of Brucella among the herds and humans.

Table 4.3: Descriptive analysis of predisposing factors for human infection with Brucella in south west region

Predisposing factor to brucellosis	**Response**	**Frequency (N)**	**%**
Assisting animals during birth	Yes	18	75.0
Wash hands with soap after handling aborted fetuses	Yes	20	83.3
Wearing protective gear (gloves)	Yes	2	8.3
Throwing away aborted foetuses in Bush	Yes	14	58.3
Consuming raw milk	Yes	19	79.2
Slaughtering goats at home	Yes	21	87.5
Consuming raw meat	Yes	3	12.5
Presence of brucellosis signs	Yes	17	70.8
Managing in affected individuals by treatment	Yes	20	83.3

4.4 Risk factors associated with transmission of brucellosis in goats

Univariate logistic regression was done and six out of eight were discovered as linked significantly to *Brucella* infection in goats. These were abortion history in goats, goats mixing with other animals in shared grazing and water, breeding with common male goats, new animals joining the herds, awareness of Brucellosis and getting veterinary services

4.4.1 Univariate analysis of predisposing factors associated with brucellosis

On univariate analysis of eight factors found six factors that were significantly ($p<0.05$) linked to the *Brucella* positive test. These were abortion (odds ratio (OR) = 2.99; 95% CI), which meant that herds with abortion history had a higher probability (2.99 times) to have a goat that is Brucella positive compared to herds without. Also, herds that mixed with other animals during grazing and drinking (OR = 1.35), herds that had new animals joining them (OR = 1.33), herds that used common male goats for breeding (OR = 1.01), herders that knew about brucellosis (OR = 1.29) and herds that got veterinary services (OR = 1.23) higher probability to have a goat testing positive to Brucella compared to those that did not.

4.4.2 Multivariate regression analysis of risk factors associated with Brucella infection in goats

Out of the six factors linked to brucellosis infections in the univariate analysis, only four factors remained significant in the multiple factor analysis. The factor of ‘using common male goats for breeding’ was not significant in predicting the herd’s Brucella positivity. This meant that this factor was influenced by another factor, probably the factor of ‘herds mixing with other animals during grazing and drinking’ because its OR increased from 0.063 to 0.151. The factor of ‘getting veterinary services’ was also not significant in predicting the herd’s Brucella positivity. This meant that this factor was influenced by another factor, probably the factor of ‘awareness of brucellosis’ because its OR changed a lot.

Table 4: Analysis of risk factors associated with transmission of brucellosis in goats

Variable	Odds Ratio	95% C.I		P-Value
		Lower	Upper	
Common pastures and watering	3.05	0.284	0.323	0.0447
New animal entries into flock	2.52	0.063	0.151	0.0364
Abortion history	2.99	0.281	0.358	0.0326
Knowledge of Brucellosis	1.84	0.323	0.43	0.0182

CHAPTER FIVE

DISCUSSION

The study evaluated risk factors and prevalence related to brucellosis in goat herds in South West State of Somalia. The study found that female goats had a higher brucellosis rate (5.2%) than male goats (2.9%) and those older goats (48 months) had the highest rate (10%) but younger goats (13-24 months) had the lowest rate (2.6%). Afgoi had the most brucellosis cases (6.45%) followed by Baidoa, Wanlaweyn, Qoryoley and Diinsor while Buurhakabo had none. The brucellosis rate in South West State of Somalia is similar to the 5.7% rate reported in Kajiado County by Ogola *et al.* (2014), but different from the 15.48% reported in goats in Baringo county in Kenya. (Lokamar *et al.* 2022) and 2.6% in goats in Ethiopia ((Edao *et al*. 2020). Among the analysed factors, the common practices considered as risks in transmission of *Brucella* to humans were assisting animals during birth, and washing hands with soap after handling aborted foetuses and in delivery. Others are wearing protective gear such as gloves, throwing aborted foetuses in bush, slaughtering goats at home, consuming raw meat and milk and knowledge of Brucellosis.

The predisposing factors significant to Brucella infection in goats from univariate analysis included cases of abortion (OR = 2.99), and free contact of goats in communal grazing and drinking water (OR = 1.35). Others are new entries of flock into the farms (OR = 1.33), sharing of communal bucks for breeding (OR = 1.01), knowledge of brucellosis (OR = 1.29) and seeking veterinary services (OR = 1.23). The same results were found by Lemu *et al. (*2014) who explained modes of infection to include vaginal discharges, shedding in milk and semen and feces. Similarly, a study by Li *et al*. (2021) found recent introduction of new animals, improper disposal of dead goats and poor hygiene during kidding as risk

factors for spreading brucellosis in goats in South China, while Edao *et al* (2020) found herd size and abortion history to be among the risk factors of brucellosis occurrence in a flock of goats and sheep in Ethiopia.

Out of these, four predisposing factors remained significant in the multivariate logistic regression. These are abortion, free contact of goats in communal grazing and drinking water, new entries of flock into the farms and knowledge of brucellosis. This is because the factor of 'sharing of communal bucks for breeding' lost its significance in determining the flock's Brucella positivity due to confounding by the factor of 'flocks that mixed freely during grazing and at drinking points' as evidenced by a notable change of OR. Seeking veterinary services also lost its significance because of confounding by 'knowledge of Brucellosis'.

The communities in South West State of Somalia rely a lot on livestock for their culture and economy. This may help them to control how their goats move and mix with other animals in shared grazing. The goal is to lower infection and its effects on animal and human health. Brucellosis makes female goats release a lot of Brucella germs in milk, placenta and aborted foetuses. This leads to environmental contamination and subsequent infection of other flocks as explained by Saxena and Saxena (2018). At the household level, assisting animals during birth and handling aborted foetuses should be discouraged but conducted while wearing protective gear such as gloves followed with washing hands with soap. Other practices that are risk factors to infection and should be discouraged include throwing aborted foetuses in bush, slaughtering goats at home, consuming raw meat and milk as similarly found by Cleaveland (2017) in a similar study.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

1. The rate of sero-prevalence of brucellosis disease for goats in SW Somalia established was 3.86%. The prevalence was highest in female goats at 4.16% (5/115) than in males at 2.9% (3/104) and in goats aged 48 months at 10% (1/10).

2. The risk factors related to *Brucella* infection in goats were identified as presence of *Brucella* cases causing abortion, communal grazing and watering of goats, entry of new goats to the flock, communal sharing of breeding bucks and limited knowledge of brucellosis among herders.

6.2 Recommendations

- Implementation of strategies, policies for the control of Brucellosis which should include managing livestock migration, private grazing, and dissemination of knowledge to the communities about the disease to reduce infection risk.
- Government to provide rural community with necessary water points and grazing lands to avoid overcrowding to the water points as well as grazing lands
- Caution should be exercised when introducing animals by ensuring that they are from brucellosis free herds and isolation to allow screening of new animals.
- Avoid communal grazing to restrict intermingling of animals from different flocks
- Avoid sharing of breeding bucks by restricting their use to single flocks

- Regular surveillance campaigns and disease reporting in the rural areas as well as suspected animals.
- Regular vaccinations of goats to prevent occurrence of the disease in goat flocks
- Public education and awareness creation on hygiene handling and disposal of aborted foetuses. Disposal of aborted materials to be done through burning or burial and thorough disinfection of contaminated areas.
- Institute a national or regional *Brucella* surveillance Programme to monitor disease occurrence and distribution in the region.
- Where possible, implement a policy to ensure livestock that test positive for *Brucella* are slaughtered and properly disposed to control and eradicate brucellosis disease.

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APPENDICES

Appendix 1; Questionnaires

Dear respondent,

My name is Qassim Abdi, a student at University of Nairobi's Faculty of Veterinary Medicine I the Department of Public Health Pharmacology and Toxicology. I am doing research on Brucellosis in goats in South West State Somalia.

You have been chosen randomly to take part in this study that will help us know how serious brucellosis is in goats in this area. You can choose to join or not and the data you give will be confidential and utilized solely in this study. Your answers are very important.

Please tick the box that matches the statement.

Thank you for your time and help.

GENERAL INFORMATION:

Name of goat owner ____ _____

Date of interview__ _____

Name of the Interviewer_ _____

District: _____ _____ _Sub location: __ _____

Please tick (√) or give numbers where appropriate:

1. Livestock species and numbers:

Goats...No A) 5-10 B) 10-20 C) 20-30 D) 40-50 E) 60 above

Cattle...No A) 5-10 B) 10-20 C) 20-30 D) 40-50 E) 60 above

Sheep. No A) 5-10 B) 10-20 C) 20-30 D) 40-50 E) 60 above

The following information applies to goats only.

2. Sex of goats:

A) Number of males_____ B) Number of females_____

3. Age of goats and number

A) 6 months – 1 year _____ B) 2-3 year's_____ _____

C) 3-4 years_____ D) above _____

4. Grazing system:

A) Private grazing land B) Communal free grazing C) others

5. Breeding system:

A) Own bucks B). Communal bucks C) Others means specify_____

6. Sources of water

1-River 2) Wells 3) Borehole 4) Dam

7. Feeding and watering system:

1) Own 2) Communal

8. What do you do when your goats are sick?

1) Consults Vet-doctors 2) Buys drugs and treats 3) Consults an AHW

9. Production Systems:

1) Intensive 2) Semi intensive 3) Extensive

10. Do you know brucellosis?

1) Yes 2) No

If yes, how do the goats get the disease? _____

11. Tick the signs you see in the sick goats suffering from brucellosis (You can tick one or more)

1) Abortion 2) Orchitis 3) Retained Placenta

12. Ever seen abortions, infertility, or placenta retention in your herd of goats?

1) Yes 2) No

If yes, specify how many goats you have seen this_____

13. Did you introduce new animals into the farm in the last two years?

1). Yes 2) No

14. Have you had goats having premature birth?

1) Yes 2) No

If yes how many goats _____

15. Stage of the pregnancy when abortion occurs?

First trimester B) Second trimester C) Third trimester

16. Do you assist the animals during birth?

1) Yes 2) No

17. How do you handle aborted foetuses?

A) Throw away in the bush B) Give to dogs C) Bury/burn D) Eat

18. How do you handle aborted foetus?

A) Use gloves B) wash hands with soap C) wash hands with disinfectants

D) Others specify_____

19. Do you drink milk from goat?

(A) Yes (B) No

If yes which form do you drink?
A) Raw B) boiled

20. Where do you slaughter your goats?
A) Home B) slaughterhouses

21. Do you eat meat from goat?
A) Yes B) No

If yes which form do you eat?
A) Raw B) cooked

22. Which season do you see these cases of abortion?
1) Rainy season 2) Dry season

23. Do you have knowledge about brucellosis affecting humans and the herd?
1). Yes 2).No

24. Which clinical signs of the disease did you see in affected individuals?
A) Fever and headache B) Body and joints pain C) General weakness D) others

25. How is the disease managed in affected individuals?

A) Treatment B) Vaccination C) Others (specif