ESTIMATES OF BRUCELLOSIS SEROPREVALENCE AND ASSOCIATED RISK FACTORS IN GOATS IN NUGAAL REGION PUNTLAND STATE OF SOMALIA

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DECLARATION

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

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DEDICATION

I dedicate this thesis to both my parents Sahra H. Adowe and Abdullahi Ahmed Olow and my brothers and sisters: Sahardid M.A., Abubakar M.O., Said A. A., Zamzam M.A., Ahmed A.A. and Farhia M.O. for their concerted efforts and sincere concern to see me complete this thesis successfully.

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LIST OF ABBREVIATIONS

ASAL	Arid and Semi-Arid Lands
STAT	Standard Tube Agglutination Test
RBPT	Rose Bengal Plate Test
CFT	Complement Fixation Test
INGO	International Non-Governmental Origination
EU	European Union
USA	United State America
FAO	Food and Agricultural Origination
WHO	World Health Organization
CDFA	California Department of Food and Agriculture
FEE	Foreign Exchange Earnings
MRT	Milk Ring Test
ELISA	Enzyme Linked Immunosorbent assay
PULPA	Puntland Livestock Professional Association
I-ELISA	Indirect Enzyme Immunosorbent Assay
HRPO	Horse Raddish Peroxidase
RAP	Retained After Birth
CAHWS	Community Animal Health Workers
ILRI	International Livestock Research Institute
MOLAH	Ministry of Livestock and Animal Husbandry

ABSTRACT

Brucellosis is a disease of pastoral areas where it causes devastating negative effects on pastoralists livelihoods. Control efforts have been unable to bring the disease to manageable levels.

The objectives of the current research were in to assess the brucella seroprevalence organism in goats in the Nugaal area of Puntland state of Somalia, and to evaluate the potential risk elements for the identification of the disease organisms in goats in Nugaal region of Puntland. The three selected districts, 3 sub-districts from each were selected randomly to compose a total of nine districts. Then families were randomly selected using compiled lists and data were collected through administration systemically to household heads, via personal interviews. Herds were visited systemically until the required number of 182 goats was achieved. Goats to be bled were selected as they entered the *Kraal*. Information collected included herd size, age of goats and sex, production system, water sources and knowledge of brucellosis by the herders. The determination of antibodies to brucella spp. was by the Rose Bengal Plate Test. The logistic regression (Univariate and Multivariate) models were used to assess the risk factors for testing positive to brucella organisms.

Brucellosis seroprevalence was in the study area. The brucellosis seroprevalence was an equivalent to an overall seroprevalence of 7.7%. In the univariate analysis four factors were used as guides for the study organisms including, sex of goats (OR=4.22 for females), production system (OR=2.03 for extensive system), breeding system (OR=0.23 for using own bucks) and handling of aborted fetuses (OR=13.73 for separated aborted fetus). Some of the variables very positively associated, for example handling aborted fetuses with an OR (odds ratio) of 14 impalying that in households where aborted fetuses were handled careless were 14times to have goats testing positive to brucella relative to those where aborted fetuses are not handled reckless. Breeding system was however negatively associated with testing

positive to brucella with an OR=0.23 indicating that brucellosis that used own buck were 4.3(1/0.23) times less likely to have goats testing positive according to individuals that used community bucks. The other variables have similar interoperation. All the four variables retained their significance but the strength of association increased. For example, the OR for handling of aborted fetuses increased from an OR=13.73 to an OR=18 in the multivariate analysis. This was an indication of confounding by either some un measured or measured factors. Three factors were positively associated with brucellosis seropositivity in goats including sex of female goats (OR =5.5) production system, (extensive OR=8.0) and management of abortion in the herd (throwing the birthing material OR=19). The use of own bucks for breeding was negatively associated with brucellosis seropositivity. Indeed, herders who only used their own buck for breeding had an OR=0.223 indicating that they were 4.5(1/0.223) less likely to have goats in their herds testing positive to brucella organisms relative to those who used community bucks for breeding.

In conclusion, this study has identified presence of brucellosis in Nugaal region of Puntland. The identified for risk factors for testing positive to brucella organisms can be for control purposes. For example, avoiding mixing of herds, use of own buck, and proper handling of aborted fetuses. To this, education of the pastoralists would be key. The cooperation sympathy and participation of the pastoralists would be paramount for success of the control programs.

CHAPTER ONE

INTRODUCTION

1.0: Background Information

Most Somalis depend on livestock farming, with the earning from the export of livestock products accounting for more than 80% of the total foreign exchange accrued annually. More than 65% of the Somali population are engaged with livestock farming (FSNU2020).

Brucellosis is caused by zoonotic organisms, and is mainly characterized by the inability of animals in terms of their productivity and activity. As well, the disease is transmissible to humans, where it tends to cause much adverse health effects. The World Health Organization (WHO) indicates that the disease is considered to be one of the least ignored zoonotic diseases, especially in low-income countries (Franc et al., 2018).

The disease is a majorly caused by bacteria and is highly contagious. The bacteria genus *Brucella* is the cause of the contagious disease. It poses serious hazard to both public health and the global livestock economy. The disease has revealed a wide prevalence among the global livestock population (Reddy *et al*., 2014). In livestock, the disease mostly affects the reproductive systems, with more adverse effects experienced in the fetal fluids, the testes as well as the placenta (Wubishet *et al*., 2017).

The economy of Africa has especially been boosted by the rearing of sheep and goats.

Most African countries rely on the livestock rearing to boost their economy (ILRI, 2006). Like in other countries, goats and sheep are the major ruminants kept in Somalia, estimated to be about 27.1 million out of the 39.5 million total estimation of livestock in Somalia (FAO, 2015b). A total estimation of 5.3 million livestock were exported from Somalia, out of which 5 million comprised of goats, 7000 camels, and

300,000 cattle. These exports earned the country a total of $ 384 million (FAO, 2015b). Generally, the Somalia economy is primarily dominated by livestock rearing, contributing to more than 40% to the country's GDP (FAO, 2020). The livestock rearing sector continues to grow, attributed to the focused interventions to increase the exports from the country, the ease of accessibility of markets, government intervention and good prices offered by markets in the Middle East.

Besides, the sheep and goats are a crucial source of income to many households in Somalia. However, some homesteads rear livestock for privilege, and to keep up with tradition. The table below shows the livestock distribution in various areas of Somalia. From the table, it can be clearly seen that sheep and goats are dominating most regions in Somalia.

Table 1.1: Numbers, types and distribution of livestock in various regions of Somalia.

Region	Number of Camel	Number of Cattle	Number of Goats	Number of Sheep	Total Livestock Population Estimate
Awdal	396,890	65,696	2,332,466	1,088,945	3,883,997
Woqooyi Galbeed	564,659	96,567	2,745,465	1,139,224	4,545,915
Togdheer	496,815	5,018	1,952,918	582,689	3,037,440
Sool	236,260	0	1,541,657	1,267,790	3,045,707
Sanaag	233,942	0	2,842,832	2,044,901	5,121,675
Bari	86,649	0	1,496,383	745,638	2,328,670
Nugaal	377,872	0	1,959,593	1,217,801	3,555,266
Mudug	437,672	13,070	2,057,841	881,057	3,389,640
Galgaduud	461,495	33,978	2,031,000	850,953	3,377,426
Hiraan	638,935	347,044	1,995,619	680,917	3,662,515
Shabelle Dhexe (Middle)	156,138	185,540	1,099,778	521,759	1,963,215
Shabelle Hoose (Lower)	286,770	535,447	981,022	464,193	2,267,432
Bay	361,562	800,964	1,171,477	117,007	2,451,010
Bakool	617,905	369,601	1,459,008	408,830	2,855,344
Gedo	770,894	336,629	1,825,849	750,202	3,683,574
Juba Dhexe (Middle)	165,335	520,175	478,247	393,329	1,557,086
Juba Hoose (Lower)	322,042	620,654	732,224	492,673	2,167,593
Benadir region	148000	250000	74526	22264	494,790
Total	**6,759,835**	**4,180,383**	**28,777,905**	**13,670,174**	**53,388,297**

Source: (FGS, 2017).

The germ *Brucella melitensis* is contagious and affects humans and Goats (Chota *at al.*, 2016). In small ruminants the diseases impede their productivity (Mohammed *et al.*, 2017). The organism (*Brucella melitensis* biovars 1, 2 and 3) is ranked as the major cause of ovine and caprine brucellosis (Sintayehu*et al.*, 2015).

Brucella spp is a non-spore, gram-negative, forming, coccobacilli, facultative and non-motile intracellular bacterium with a potential of infecting several species especially humans and animal species. According to Sintayehu *et al.* (2015), the genus *Brucella* is comprised of ten species. Out of the ten species, six are the ‘classical ‘species, namely, *B. melitensis, B. neotomae. B.Suis, B. canis. B.abortus* and *B. ovis*, and are known to cause disease (Atluri *et al.*, 2011).

Brucellosis transmission occur via indirect or direct contact with infected or carrier or convalescence animals. The causal agent is mainly often transmitted through respiratory route, oral route, skin and conjunctival contamination. Venereal and intra-uterine transmissions are other potential routes of organism transmission (Hassan-Kadle, 2015). In humans the organism is transmitted via contact with contaminated or infected animals and their products (*Sharifi et al.*, 2015).

Economic losses due to *B. melitensis* infections are high and comprise productivity losses. This is mainly linked to enhanced abortions weak offspring and reduction in milk production coupled with loss of trade opportunities (Maiyo and Obey, 2016).

The first case of *Brucella* strain isolation in the Somalia was reported as early as 1982 by Andreneani *et al.,* (1982). Since then there has been little or no research in Somalia on brucellosis. In addition, very few bacteriological isolations and serological investigations of *Brucella* have been carried out in the country (Hassan-Kadle, 2015). It is worth noting that due to lack of diseases awareness about the potential of *Brucella* being a zoonosis, the people of Somalia consume raw milk and frequently come in to contact with diseased animals (Hassan-Kadle, 2015).

The most incontrovertible methods of the *Brucella* diagnosis is via detection and isolation of the *Brucella* species. This method has disadvantages such as health risk to laboratory workers, low sensitivity, type of sample collected and time of sample collection. The tests that are accessible for diagnosis of brucellosis includes: Standard Tube Agglutination Test (STAT), Complement Fixation Test (CFT) and Rose Bengal plate Test (RBPT). The (CFT) has been employed in the diagnoses of brucellosis in animals (Reddy *et al*., 2014).

The negative impact of brucellosis in animals and indeed humans may have been great in Puntland state of Somalia. Very sketchy information on brucellosis makes it impossible for policy makers to formulate control measures of the disease. Thus, the current study was designed with the following objectives.

1.1: Problem statement

Brucellosis has been documented in goats, sheep and cattle in different parts of Somalia and is an important trade limiting disease and a major cause of livestock rejection at export.

The common habit of consuming raw milk from goats is a major public health risk, often leading to sickness and loss of manpower. However, there has been little or no research work in Somalia about brucellosis disease in goats. Therefore, the disease status remains largely unknown in Nugaal region, a region with high consumption of dairy products.

1.2: Justification

The purpose of the study is to gather relevant data and collect samples to determine the status of *Brucella melitensis* in Nugaal region with a view of reducing the risk of infection and spread. The data gathered will be used as baseline data for brucellosis in goats in three selected districts of Nugaal region and also as a reference point for other researchers. It will feed into the development of public education programs on brucellosis prevention, and serve as guidance for the local authorities, civil society and NGOs operating in Somalia.

1.3: Objectives

1.3.1: Main Objective

To estimate the Seroprevalence and determine the risk factors of goat brucellosis in Nugaal region Puntland, Somalia.

1.3.2 Specific Objectives

- To assess the Seroprevalence of brucellosis in goats in selected districts of Nugaal region, Puntland state of Somalia
- To evaluate the potential risk-factors brucellosis in Nugaal region, Puntland, Somalia

CHAPTER TWO

LITERATURE REVIEW

2.1 Livestock in the Somali Economy

The export of livestock as well as livestock products is the backbone of the economy of Somalia. The livelihoods of many families are also dependent on livestock rearing, with Somalia exporting more than three million animals each year. Additionally, there is a significant livestock cross-border activity between Somalia and Kenya. Since livestock rearing contributes to over 40% of Somalia's GDP (FAO, 2020), it follows that vaccination programs for livestock is very essential to strengthen the country's livestock sector and to ensure that the citizens have food security. While FAO has significantly contributed to strengthen the country's animal health, the Somalia federal government needs to step up its efforts to ensure that the livestock rearing sector is strengthened. The Somalia government has put considerable efforts to ensure that they boost animal health because most families that rear animals may not be able to cater for treatments and vaccination against common animal diseases by themselves. Therefore, the government has to come tin to help them to ensure that their livelihoods continue as normal.

Because of the arid and semi-arid conditions in Somalia, FAO has been at the front-line to ensure to support pastoralists in Somalia. FAO usually intervenes in rural areas where there is increased insecurity. Goatrearers in Somalia face water and fodder shortage, which consequently increase animal mortality rates, to rates as high as 60% (FAO, 2017). However, through the efforts of FAO, goat farmers in Puntland and other States in Somalia have received significant help. In 2017, FAO reached more than 300000 livestock rearers in Somalia with veterinary care and also offered them with water for their livestock to keep their livestock alive because of the ensuing drought conditions in the country. As such, the livestock was kept healthy and alive to continue reproducing to enable pastoralists to fend for themselves because most of them depend on livestock products and selling the animals themselves. Therefore, FAO has been in the front-line to ensure that the most affected families do not lose the assets that they depend most on. At the same time, the organization has been of significant help in helping livestock farmers to continue farming and to continue rearing their animals for the benefits they receive from them. FAO has done a lot to help the farmers through veterinary care. It would be quite expensive to replace each of the lost animals (FAO, 2017). However, through the veterinary program, FAO has done more than it would have done in replacing the farmers' herds.

2.2: Types of Somalia goats

Two types of goats are reared Somalia, the Arab and short- eared breed of goats especially prevalent in East Africa (Nur, 2005). The short- eared East African type of goats are characterized mainly by white hair coat, although mixed colored goats such as black and brown, are found. Among these types there are a number of sub-types that are distinct and named after the major raring clan or area, for instance, the Tuni goats (Nur, 2005). Other goats bred in Somalia belong to the same species as those bred in Djibouti, Somalia and in Northeast regions of Kenya. The goats bred in the country are popular for their meat. Generally, the Somalia goat are considered to be domestic breeds. However, there are several sub-breeds of the Somalia Goat Breed. Some of these breeds include Degyir and Degeun. Other sub-breeds include Modhugh, Deg yer, Abgal, Galla, Ogaden and Borana (FAO, 2017). The Somali Goat Breed has several advantages to the pastoralists that keep the breed. The breed is popular because it thrives easily in arid and semi-arid areas. Additionally, the breed feeds on a multiple type of vegetation, are easily hand able, are resistant to infectious diseases, has a longer life span, and are tolerant to conditions of drought (FAO, 2017). At the same time, the Somali Goat Breed is known for its quality meat. The health and management of the Somali Goat Breed depends on the type and quality of feeds it has access to. The most common feed of the Somali Goat Feed is grains, hay, browsing and pasture, vitamins, garden scrap and minerals. Besides, the goats are also fed with supplements such as beet pulp, guava, leaves and baking soda. However, forage is the main source of energy for the goats.

2.1.2: Constraints to goat productivity in Somalia

Somalia livestock production systems includes, agro-pastoralism in the Western and Southern regions of the country and pastoralism Central and Northern regions. Sheep, goats, dairy cattle as well as camels are the major livestock types reared in Somalia (Ombui *et al.*, 2014)**.** The arid and semi-arid climate in the larger parts of Somalia supports the rearing of livestock. However, since livestock rearing is dependent on the availability of water and free grass ranges for grazing, the extensive land degradation in Somalia significantly inhibits livestock farming. Additionally, the frequent drought season experienced in Somalia also deters the growing of livestock herds because of lack of access to enough feeds and water (Ombui *et al.*, 2014).

The Ministry of livestock of Puntland has been aggressive in conducting consistent emergency livestock treatment campaigns to address diseases killing goats in the Sool region. In 2016, there was a Caprine Pleuropneumonia outbreak in Sarmaanyo and Boocame, which claimed several animals' lives Ergo, 2016). In the massive treatment campaign carried out by the Ministry of livestock of Puntland in 2016, approximately 35000 goats were treated (Ergo, 2016). The efforts of the ministry were described as an action of emergency. However, several pastoralists lost goats since the start of the outbreak. Fortunately, most of the goats survived and are in a healthy condition. From the treatment exercise, 15,000 goats were treated in Sarmaanyo and 20000 were treated in Boocame.

2.2 Epidemiology of brucellosis

2.2.1: Etiology

Brucella organism causes human and animal Brucellosis. The taxonomic distribution of *Brucella* has been classified based on α-proteobacteria into six classical species, further subdivided in to biovars (Khan and Zahoor, 2018). *B. abortus* is a pathogen of cattle and has 1–6 and 9 biovars, *B. melitensis* effects goats and sheep and has about 1 – 3 biovars. *B.suis* with about 1–3 biovars affect porcine while *B. suis* biovars 4 and 5 are common in small rodents and reindeer infections. Other types include, *B. ovis* in sheep, *B. neotomae* in the desert wood *rattus* and *B. canis* in dogs. Recently *B. ceti* was isolated in dolphins and whales and *B. pinnipedialis* in seals (Khan and Zahoor, 2018).

Brucella bacteria are non-spore-forming, non-motile and Gram-negative coccobacillae (Wernery, 2014). They grow anaerobically and some strains need 5% - 10% carbon (IV) oxide atmosphere. The organism usually grows slowly, however their growth may be enhanced with enriched media, for instances Farrell's medium supplemented with 5% of horse serum and about six different types of antibiotics (Wernery, 2014). *B. abortus* and *B. ovis*, biotype 2 growth requires enriched media with blood or serum incubated at atmosphere of 5% - 10% carbon (IV) oxide (Wernery, 2014).

2.2.2 Geographical distribution of brucellosis

Brucellosis has been documented in 86 countries across the world and thus, it is a threat to both livestock and human health globally (Khan and Zahoor, 2018). The disease causes heavy economic loss, high morbidity in humans and livestock especially in third world countries. Countries in the Near East and North Africa report a high incidence of crossinfections and infection of brucellosis (Khan and Zahoor, 2018). *B. abortus* and *Brucella melitensis* are common in the Middle Eastern countries, Asian and African countries. *Brucella Suis* and *B. abortus* infection is widespread in Central America. In European countries, human Brucellosis has been associated with immigrants and travelers from Middle East countries or privately imported dairy products from endemic regions across the world (Khan and Zahoor, 2018).

Brucella species are widespread in most Asian countries including China, India, Sri Lanka and Pakistan, in humans and animals. In the 1950s, Brucella species were reported in livestock in Malaysia, where eradication strategies were undertaken for bovine, caprine and ovine National Surveillance Program for Animal Brucellosis (NSPLB)1978. (Khan and Zahoor, 2018). A series of studies in Malaysia reported a seropositivity to brucellosis in humans mainly in farmers and veterinary professionals in close contact to animals. In these studies, Brucellosis prevalence was more in males (90%) with age ranging between 20–45 years. More males than females are employed in abattoirs and thus the high risk of contracting brucellosis in male humans.

Although lacking in herd some studies conducted in Egypt and Iraq appears to suggest that socio-economic factors as well as occupation may play a role in the epidemiology of brucellosis. This may explain the high incidence of brucellosis in middle- and low-income countries (Khan and Zahoor, 2018).

In a seroprevalence study in the Banadir region of Somalia by at Jimale,2018) the overall seroprevalence of brucellosis was estimated 4.5%. The prevalence was higher in goats (4.9%) than in sheep (3.6%).

Information on the prevalence of brucellosis on small ruminants in Somalia is quite scanty. A study by Falade and Hussein (1979) examined 250 goat serum samples obtained from

Mogadishu slaughterhouse which employed five tests including: Rivanol test, SAT, RBPT, 2-Mercaptoethanol test (2-ME test) and Cooms Antiglobulin test (AGT). According to the total number of samples examined, the results were 3.6% 2.8%, 2.8%, 5.6% and 1.6% respectively. Another study by Andreani *et al*. (1982) used SAT test and showed 7.2% and 5.3% seropositivity in sheep and goat respectively. 250 sheep and 340 goats from Kismayo and Mogadishu slaughterhouse and small ruminants kept under extensive grazing system in Upper and Lower Jubba and Benadir regions were examined in this study. Prevalence of 1.3% (1 out of 74) in goats of Lower Juba region has also been reported (Wiegand and Marx.,1983). Prevalence of 4%, 3.1% in sheep, and 4.9%, 3.9% in goats using RBPT and i-ELISA tests respectively have been recorded in Awdal, Waqoyi-Galbed and Togdheer: Somaliland (Ghanem *et al*.,2009; Kadle.,2015).

2.2.3 Prevalence of Brucellosis in Africa

Brucellosis is considered an epidemic in the African continent (Franc et al., 2018). Generally, the disease's incidence has been to spread, to a lesser degree, over the entire continent of Africa. The epidemiological spectrum of the disease has especially been seen to be more synonymous with host animals, both in domestic and wild animals.

2.2.4 The prevalence of Brucellosis Among Livestock in Somalia

The average prevalence rate of Brucellosis in the larger part of Somalia is seen to be at 70%, making the state of Puntland at a high risk (Sheik- Mohamed & Velema, 1999). However, the prevalence percentage seems to vary from one region to another. The Gedo region has been observed to have the lowest prevalence, with an average of 7%. The lower Juba region closely follows, with a percentage of 5.8%. These results positively compare to the prevalence rate in other places, such as Northern Somalia, North Eastern Kenya as well as in North Eastern Uganda (Sheik- Mohamed & Velema, 1999). Environmental factors have been attributed to the high prevalence of Brucellosis in some places than others. The environmental factors include the methods of husbandry used by the farmers and the climatic differences in the identified areas.

Since the climatic conditions in Mogadishu are not so much varied from the climatic conditions of Lower Somalia, the anomalies in the rate of infection can be attributed to the differences in the husbandry methods employed by goat farmers. At the same time, most farmers in Puntland state rear their animals in closely compacted sheds, which makes the rate of transmission of disease to be extraordinarily high (Mohamud et al., 2021). With these conditions, the carriers (animals that have already been infected) easily meddle with the healthy animals, easily transmitting the disease to them. Furthermore, the type of animal rearing practice carried out by most farmers provides a perfect ground for the breeding of the Brucella organisms. For example, the excretory products of most animals provide a perfect ground for the breeding of the organisms. This results in a high rate of infection for goats, sheep, and cattle. At the same time, the role of goats and sheep in transmitting Brucellosis to human beings has not been sufficiently investigated (Mohamud et al., 2021).

Traditional types of husbandry are synonymous with reduced rates of transmission compared to the modern methods of animal husbandry. The traditional methods (mostly nomadic) involved the daily movement of animals from one place to another in search of pasture. This nomadic type of animal husbandry was significant in controlling the rate of infection as well as in controlling and curbing the transmission rate of the disease. The daily movement of animals, the exposure of the animals to a large degree of solar radiation and the high chances of reducing the rate of animal interaction played a significant role in reducing the rate of transmission of the Brucellosis among goats, sheep and cattle.

2.2.5 Transmission of Brucellosis

Brucellosis in livestock is transmitted via contact with infected aborted fetus and fetal membranes, contaminated milk and pastures. Venereal transmission may also occur via artificial insemination and even natural mating (Osoro*et al.,* 2015). Infection in goats and sheep happen commonly via the nasopharyngeal route. However, *B. melitensis* can be transmitted vertically through mother to lamb/kid in utero, colostrum or milk (Megid *et al.,* 2010). During high bacteremic phase, *B. melitensis* may settle in the mammary glands of lactating sheep and goat causing acute mastitis resulting in production of watery, clotted milk or drop in milk yield (Megid *et al.,* 2010). Figure 2.1 shows the transmission of *B.Melitensis* in sheep and goats.

Professional health workers are high risk of getting infected with *Brucella*, especially in regions with high prevalence of the disease. This have been documented in about 12% of laboratory professionals in Spain (Khan and Zahoor, 2018). Person-to-person transmission and in utero may occur via organ or tissue transplantation but it's very rare. (Khan and Zahoor, 2018). Aerial bacteria are a major threat of agent transmission and may occur via conjunctiva or inhaling organisms.

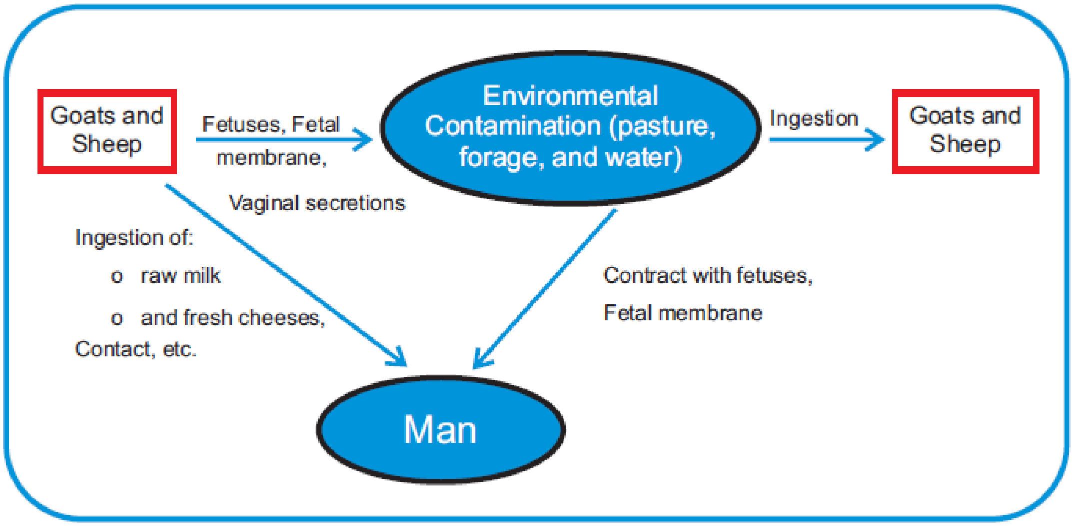

Figure 2.1: Small ruminant brucellosis *(Brucella melitensis*) Mode of Transmission (Alemneh and Akeberegn, 2018)

2.2.6: Human brucellosis

Brucellosis in humans is caused by *B. melitensis* and *B. Abortus*. The mode of transmission is ingestion of *Brucella* contaminated food, for instance meat and milk from infected animals (Faham *et al.*, 2014). The incidence of the disease is high especially in goat rearing regions. Goat farmers in pastoral areas, ingest raw goat milk believing it has medicinal value on intestinal tract infections (Faham *et al.*, 2014).

Human Brucellosis being a multi-systemic disease, may present with wide clinical manifestations and complications can affect most of the body organs with varying prevalence. The fetal case fatality rate may range from 1%–5% especially in untreated cases.

The clinical findings and symptoms usually present with fever, malaise, fatigue, headaches, sweats, myalgia, weight loss and arthralgia (Bano and Lone, 2015). After penetrating into the bacilli's body, there is an increase in the lymphatic system, mostly in the lymph nodes, then break through the defensive barrier and infiltrate numerous organs (Galinska and Zagorski.,2013). The disease is an occupational hazard mostly occurring in a people in close contact with animals and their products including abattoir staff's livestock owners, veterinarians and herders (Musallam *et al.*, 2015).

2.2.7: Brucellosis in Livestock

Brucellosis can present either as sub-acute form or chronic form of the disease which can affect a number of livestock species. In goats, sheep, cattle, pigs and other ruminants the early phase is not apparent following infection (FAO/OIE/WHO/2006). Among sexually mature cattle, the infection localizes in the reproductive system, resulting in placentitis and pregnant female may abort, especial at their last trimester of pregnancy, orchitis and epididymitis in males. Clinically, there are no pathognomonic signs and diagnosis is reliant upon demonstrating occurrence of Brucella spp. either via bacterial isolation, genetic or antigen material detection, demonstrating cell-mediated immune or specific antibody responses to *Brucella species* (FAO/OIE/WHO/2006).

In small ruminants, major productive and reproductive damages as a result of *brucella ovis* and *Brucella melitensis*. However, the disease seroprevalence tends to vary from one country to another, and mainly due to *B. melitensis* which is a disease of significant zoonotic importance (Addis and Desalegn., 2018).

Brucellosis can lead to significant economy burdens and losses, especially reproductive losses because the infected animals cannot give birth normally. Therefore, more animals tend to be wasteful because they cannot reproduce normally. The disease also leads to a reduction in the exportation of animals such as the goats through trade restriction thus, countries have no access to international markets (Addis and Desalegn, 2018).

2.2.8: Zoonotic aspect of brucellosis

The Office International des Epizooties (O1E), the Food and Agriculture Organization (FAO) and WHO consider Brucellosis as the most widely spread zoonotic disease (Alemneh and

Akeberegn, 2018). Incidence of brucellosis in humans reported in endemic regions varies from< 0.01 -> 200 per 100,000 of livestock populations (Alemneh and Akeberegn, 2018). *Brucella melitensis* is the most pathogenic and persistent for long in humans populations compared to the other brucella species which also infect humans. The bacterium is endemic in sheep and goat populations where it occurs. Brucellosis in humans is hazardous and long-lasting (Alemneh and Akeberegn, 2018).

2.2.9: Clinical signs of brucellosis

Animal Brucellosis is characterized by storms of abortions, sterility and to a smaller degree by orchitis and epididymitis (Wernery, 2016). Abortions in breeding camelids are much fewer relative to abortion in small stock and in cattle. Infections can cause retained placenta, stillborn calves, mummification, fetal death, fertility, reduced milk production and delayed service rates have been documented. Retained afterbirth is rarely seen among Camelidae. This could be due to difference in placental attachment in camels own a diffusa placenta in Equidae and not cotyledonary placentation. (Wernery, 2016)

2.2.10 Clinical signs of Human Brucellosis

Brucellosis among humans is one of the most common clinical diseases that happens to affect both humans and livestock. Human brucellosis is associated with various diagnostic challenges since its symptoms are similar to other diseases, such as rheumatic fever, malaria, joint diseases and typhoid. The primary characteristics of the disease include inconsistent fever, weakness, too much sweating, chilling, excessive weight loss, splenomegaly, arthralgia as well as hepatomegaly. Other symptoms do include orchitis, epididymitis and spondylitis (Tumwine *et al.,* 2015)

2.2.11 Brucella Transmission in Small Ruminants in Africa

Larger parts of Africa are synonymous with small ruminants, especially in sub-Saharan Africa. However, large ruminants by far exceed small ruminants. Goats are mostly reared in Kenya, Uganda, Tanzania and Somalia. At the same time, small ruminants are also found in Southern Africa, in countries such as Madagascar, Botswana, Zambia, Angola and Zimbabwe (Tekleghiorghis et al. 2016). While large ruminants are more prevalent than smaller ruminants, small ruminants are found in large densities, especially in African grasslands. More animal farmers are preferring small ruminants because of the unprecedented climatic changes that are extending the arid and semi-arid regions in the Eastern and northern parts of Africa (Tekleghiorghis et al. 2016). This has seen a high dominance of small ruminants among agro-pastoralists and pastoralist systems where farmers have a tendency of rearing both big and small ruminants.

2.2.12 Brucella Sero-Activity of Goats in Somalia

While there are no separate figures for the number of goats and sheep in Somalia, it is believed that Somalia has more goats than sheep (Teshale et al., 2006). The prevalence of brucellosis among goats in Somalia found out that 28% (11.2%) of goats had Brucella antibodies (Teshale et al., 2006). The research involved 250 samples of serum acquired from Mogadishu abattoir, which were consequently examined by serological tests as follows: Rivanol test, 2-Mercaptoethanol test, the Serum agglutination test (SAT), Coombs antiglobulin test (AGT) and the Rose Bengal plate test (RBPT) (Wernery, 2014). Other tests identified the presence of antibodies in the goats as follows: 2.8%, 1.6%, 5.6%, 3.6% and 2.8% respectively (Wernery, 2014). Generally, the results indicated a growing prevalence of brucellosis among goats in Somalis, majorly attributed to the lack of vaccination programs for goats in Somalia. Taking into consideration the large number of unvaccinated goats in the country, the Puntland State accounts for over 25% of the total number of goats reared in Somalia (Mohamud et al., 2021). Therefore, the problem of brucellosis in the Puntland State can be attributed to the failure of the state of Puntland to initiate consistent veterinary programs to help animal farmers in preventing and managing animal diseases.

Additionally, taking into consideration the large number of goats in Somalia, the Somali federal government has not done enough to curb the spread of the disease in the country (Dulo et al., 2015). The existing brucellosis vaccination programs in the country are not enough to serve all goat farmers in the country. With the large number of goats in the entire country, the Somali Federal government must put more attention on the issue of brucellosis among goat farmers in the country. Besides, the spread of the disease, there is another concern of the disease among goats spreading to humans, raising serious public health concerns. The disease is generally associated with adverse socio-economic trends, which requires the Somali government to look into the issue.

2.2.13 Protecting Livestock and Pastoral Livelihoods in Somalia During COVID-19

During the emergence of the Covid-19 pandemic, the animal health campaign was already underway. Despite the Covid-19 restrictions, the animal health campaign continues successfully, taking into consideration all the preventive and precautionary measures put in place to contain the spread of the pandemic. However, it was still a challenge to vaccinate a large number of goats while still observing all the Covi-19 containment measures, especially keeping social distance (FAO, 2020).

Another hindrance to the animal health campaign has been the heavy rains experienced in April in Somalia’s Gu season. The rains make it difficult to continue with the vaccination as well as the animal treatment campaign. More than 400000 people are displaced annually during these floods, according to the report provided by United Nations Office for the

Coordination of Humanitarian Affairs OCHA (FAO, 2020). However, despite these challenges, FAO, through close collaboration with the Somalia government, still managed to treat and vaccinate among most of the pastoralist communities that remained isolate, especially in the Toghdeer, Qardho and Bari regions (FAO, 2020).

Inaccessibility to other areas is another challenge that hinders the progress of the vaccination and treatment campaigns across Somalia. Livestock keepers living in most of the inaccessible areas had to be reached, despite the many hindrances and challenges of reaching them. Plans were made to have livestock from the most inaccessible areas to be brought central points, such as in the accessible neighboring towns and centers. For example, livestock keepers in Middle Juba were organized to bring their livestock to central centers, such as in Gedo an in Lower Juba (FAO, 2020). Another challenge against livestock health campaigns in some areas of Somalia is the threat of terrorist attacks, such as in Middle Shabelle. By the end of 2020, FAO had vaccinated a total of 14.5 million goats in Puntland, Somaliland and Banadir (FAO, 2020). This animal health campaign has significantly helped agro pastoralists and pastoralists inhabiting that could not have afforded to take care of their livestock's health by themselves.

The success of the livestock health campaign has been achieved through the collaboration of various partners and stakeholders. The Somalia's Ministries of Livestock, both at the Federal and State levels, in corporation with FAO's livestock sector, played a great role to reach livestock keepers in the most inaccessible parts of Somalia. In Southern and Central Somalia, the animal health campaign received a major boost from the Livestock Professional Associations, through collaboration with the animal health departments from various states (FAO, 2020). In Puntland and Somaliland, the relevant Ministries concerned with livestock have also implemented the animal health activities (FAO, 2020). More stakeholders that play a critical role in the propagation of the animal health campaigns include the local authorities, agro pastoralists and pastoralists, elders, authorities and good willed NGOs. Additionally, the help of donors has also been very significant in driving the animal health campaign. The DFID from UK donated funds towards the purchase of the 14.5 million CCPP doses of vaccines, which played a significant role towards sustaining the overall cost of the vaccination campaign in central and Southern Somalia (FAO, 2020). Additionally, the USAID, also donated funds that covered the vaccination campaigns in Somaliland and Puntland (FAO, 2020). Furthermore, European Community Humanitarian Office (ECHO) also donated funds towards the running of vaccination campaigns in Central Somalia. Lastly, Germany also contributed to the donations that went into the purchase of field equipment and veterinary medicine.

2.3 Implication of Brucellosis in Goats

The socio-economic effect of brucellosis in animals is dire, Economic and social effects of the disease means that goat farmers cannot do much to grow their animals to bring in the economic value. In Somalia, goats are highly valued because of their meat and milk. Therefore, Brucellosis causes significant losses to farmers, posing a severe public health threat to the consumers of the goats products. Brucellosis prevalence in goats is primarily caused by infection from other infected goats and from poor sanitation on the environment where goats are reared. The main effect of the disease is abortion, which is mainly prevalent during the last state of the animals’ pregnancy, orchitis (especially in male goats) and placenta retention (Megid et al., 2010). A study carried out by Islam et al. (2010) indicated that the Black Bengal breed of goats had a high prevalence of Brucellosis in their milk. As such, it was observed that there was low infection rate of the disease among goats with a reduced history of abortion. At the same time, the seroprevalence of Brucellosis was seen to be high among goats reared in the backyard. On the other hand, intensive and semi-intensive goats manifested less sero-prevalence compared to other goats. This showed that the rate of infection of Brucellosis was higher in pregnant goats compared to the rate of infection in the goats that are not pregnant.

2.3.1 Brucellosis in Somali Ruminants

Somalia is characterized by very little information and sensitization on the existence of Brucellosis. Additionally, very few of the bacteriological and serological investigations of the disease have been carried out in the country. The first cases of the isolation of the strains of Brucella was reported by Andreani et al. (1982), who reported high prevalence of the disease among ruminants in the country. Despite the high prevalence of the disease in the country, most of the Somali citizens are uninformed on the potential of the zoonotic nature of the disease (Teshale et al., 2006). The common habit of consuming raw milk in the country and the close contact of animals in most areas of the country means that the people are highly exposed to the danger of getting infected with human Brucellosis. This state of things in the country has attracted much attention from researchers who have tried to understand the zoonotic potential of the disease and the effect it would have on humans (Höhne, 2007).

Since Brucellosis is a highly transmissible disease among animals, it is prudent that serious measures and courses of action need to be taken to curb its spread, especially in areas where there is a high tendency of animals brooding together. In Puntland state, most animals are kept in sheds together (Höhne, 2007). The rearing of the small ruminants generally takes place in open spaces. The lack of close observation from veterinary experts exposes most of the goats to the risk of infection from Brucellosis. When the zoonotic bacteria from the goats gets access to the sheds where the animals stay, it is highly likely to spread fast. The disease is associated with adverse economic effects, which means that the animals needs to be closely monitored to observed the trends of the disease and to isolate the infected animals. A lack of isolation contributes to more than 60% of the total seroprevalence of animals diseases in Somalia (Ghanem et al., 2009). According to Sheik- Mohamed & Velema (1999), the high spread of infectious diseases among the small-scale farmers in the larger Somali land can be attributed to the lack of education on the common diseases that can affect animals. Therefore, farmers end up incurring significant losses as a result of the death of their animals. While goats tend to have a lower risk of infection from Brucellosis, there need to be effort to generally ensure that farmers are effectively educated and sensitized on how to identify and manage the disease in its various levels.

2.3.2 Seroprevalence of Brucellosis in East African Countries

The infection and transmission of the disease in goats as well as sheep is a worldwide phenomenon, and has been a subject of study by scholars in many regions across the world. The disease is considered an endemic in most Africa countries. The disease seropositivity has been to be generally high in most parts of Nigeria, with the Western, Northern and Eastern parts showing a seropositivity rate of 14.5%, 12.5% and 4.3% respectively of the total number of sheep found in the regions (Cadmus et al 2006; Tijjani et al., 2009; Kaltungo et al., 2013). Studies have also indicated that the seropositivity rate of Brucella *melitensis* in the northern part of Ethiopia are 1.3% for sheep and 1.5% for goats (Tekleye B. and Kasali, 1990). In Tanzania, the seroprevalence rate of the disease is observed to be at 2.2% for sheep and 4.3% for goats (Chota *et.al.*, 2016). Besides, the cases of the disease have also been reported in Kenya, several parts of Uganda, South Africa, Malawi, Zambia, Angola and Zimbabwe (Lughano and Kambarage, 1996). In Kenya, the seroprevalence rate has been observed to be at 12%, indicating that the disease is highly transmissible compared to Somalia. For example, the pastoral areas of Kajiado and northern Kenya have recorded the highest seroprevalence rates (Nakeel 2016) and Marsabit (Kahariri, 2018).

The estimates of brucellosis in Somalia were observed to range from 2.8% to 5.6% (Flade and Hussein, 1979). The rates were especially higher around areas surrounding Kismayo, where the prevalence was 5.3 for goats and 7.2% for sheep.

2.4: Diagnosis of brucellosis

2.4.1 Animal brucellosis

Brucellosis diagnosis is normally through bacteria isolation from various organs depending on the underlining clinical signs (Kaltungo *et al.,* 2014). The placenta is a preferred organ because it contains high concentrations of the bacterium, as well as lymph nodes and milk (Kaltungo *et al.,* 2014*).* However, the disadvantage of the isolation method is that it is time-consuming and complex (Kadle, 2015).

Presumptive diagnosis may be done through serological tests. Serological tests are appropriate method for screening herds and individual animals. They include; Rose Bengal Plate Test (RBPT), Complement Fixation Test (CFT), Standard Agglutination Test (SAT), enzyme Linked Immunosorbent Test Assay (ELISA), Milk Ring Test (MRT), and Immunosorbent Assay: ELISA (Kadle.,2015; Mangen.,2002).

Brucellosis is one of the most difficult diseases to treat. The epidemiology of the disease is one of the most complicated because it can thrive in a wide range number of hosts- from domestic to wild animals. Besides the multi-faceted epidemiology, the disease tends to have several socio-economic implications, as it is not easy to identify the disease because it tends to have a varying picture depending on the type of host and has different manifestations in different population levels (Siembieda et al., 2011). The primary clinical manifestations of the disease in small ruminants includes frequent abortions and infertility. However, these symptoms are not necessarily specific to a particular type of host, nor they generally occurring across a wide range of hosts (Siembieda et al., 2011). The varied nature of the diseases on different hosts makes it difficult to document and monitor the progress of the disease. One of the most common indicators of the disease in a large number of hosts is high likelihood of abortion especially during first pregnancies (Kaltungo et al., 2014). After the first pregnancy, the abortions are likely to recur because of sustained immunity. Additionally, the introduction of infected animals to healthy ones may also lead to increased rate of infections, leading to more abortions within a short period of time (Kaltungo et al., 2014).

2.4.2: Human brucellosis

2.4.3: Rose Bengle Plate Test

An example of card test is the Rose Bengal test (RBT) that is widely used in low-income countries for quick diagnosis and screening of human brucellosis patients due to its simplicity thus ideal in small laboratories. However, this test isn’t perfectly reliable and its results should get confirmed with other tests as recommended by WHO guidelines (Corbel *et al*., 2002; Franco *et al.*, 2007). Some of its downfalls include low capability in sensing especially in long evolution (chronic), quite low specificity in the areas affected by the endemic areas and making strongly positive sera appear as negative (Dıaz *et al.*, 2011; Mizanbayeva *et al.,* 2009; Konstantinidis *et al*., 2007; Muma *et al*., 2008). A combination of RBT with other standard tests is recommended for more credible detection of cut point and to reduce the likelihood of getting false positives (Khan and Zahoor, 2018).

The RBT is used to test the sera that has been diluted to hasten the reduction of the increased number of assenting tests (Ducrotoy *et al.,* 2018).

A well-matched clinical representation is a good match to when determining the effectiveness of the sera obtained from patients with brucellosis (Heukelbach, J. 2018). In case of laboratories lacking modern facilities, the lateral flow assay is another option for rapid field or bedside test (Heukelbach, J., 2018). The advantage of this essay is that its increased accuracy and specificity compared to the SAT in complicated and more chronic cases (Khan and Zahoor, 2018).

2.4.4: Competitive ELISA

The C-ELISA test is used in the testing of Brucellosis by immobilization. After the antibodies have been obtained from the conjugated antigens, they are added to some serum, which is then used to bind to other monoclonal antibodies. The sample of the serum is used to carry out preferential sampling (Deb *et al*.,2013).

2.3.5: Prevention and Control

Human brucellosis prevention and control may depend on the control of livestock brucellosis. The methods that have been employed in a few countries which involve testing, vaccination and test slaughter policy and strictly controlling the movement of livestock. Food and Agriculture Organization (FAO, 2016) recommends a number of control methods of brucellosis in animals depending on the baseline of the sero-prevalence of the flock, estimating prevailing socio-economic status, monitoring and surveillance system available, and the respective countries control policy (Njeru *et al.*,2016).

Brucellosis can be managed by taking some steps of action to reduce the rate of the spread of bacteria. The less the exposure of animals to the brucellosis bacteria, the less the likelihood of infections increasing. This exposure can be controlled by carrying out a number of actions, such as ensuring cleanliness in animal carriages, proper animal management, and regular checking of animals. However, because of the high rate of interaction, it becomes difficult to identify and isolate animals that have become infected (Scott, 1988). This is especially a challenge to the pastoralists, who tend to have large herds of animals and who tend to move a lot. Therefore, the existence of seronegative animal and asymptomatic animals leads to a contagious epidemic as they tend to spread the disease rapidly amongst themselves. However, after the acute stage of the disease has passed, the rate of transmission tends to reduce because the animals tend to develop what is known as herd immunity. The herd immunity ensures that there is a reduced exposure to the challenges associated with bacteria (Scott, 1988). As well, the herd immunity ensures that there is less and less of clinical signs of the disease. However, with time, the disease tends to get "chronic" as there are significant fluctuations between the two extremes of the disease. This is especially caused by high levels of sedentary lifestyles of animal farmers as well as the meddling of typical indigenous animals with exotic breeds that are more unprotected (Scott, 1988).

Control of ruminant brucellosis is the key in diseases prevention in humans. This may be achieved via a combination of vaccination of animals, culling of positive livestock and improving hygienic practices which reduces introduction of disease to disease-free zones in endemic region, such as the Middle East and Africa (Musallam, 2015). Hygiene practices may be of principal importance in reducing risk of spreading the disease from livestock to humans. Animal owners' behavior and, own skills and knowledge should to put into account for sustainable control measures to be implemented. However, inadequate knowledge about Brucellosis, high-risk practices and lack of effective management and prevention strategies resulting in continuous circulation of the disease within the population are key in control (Musallam, 2015).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

The study was carried out in three districts purposively selected from Nugaal region, namely, Burtinle, Garoowe and Dongorayo. (Figure3.1) They were selected because they had the highest concentration of livestock. Garoowe is the capital and administrative capital of the Nugaal region and Puntland state in the Northeastern part of Somalia. The study areas are located in the Nugaal Valley and reaches attitude of 1,650 - 3,300 feet high above the sea level in the West, South and North. The plateaus to the western side are crossed by several dry water courses and valleys. Camel and goat rearing support the economy of Puntland.

Figure 3.1: Map of Somalia showing the location of the Nugaal region (Somalia map 2017).

The study areas have hot climate (Koppenclimate-classification*BWh*) and is characterized by sunny, hot and dry weather. The rains occur in April to June (Gu'u season) and Sep to Dec Dayr season). The rains, however, are inadequate with annual rainfall of 123mm. The average temperatures may reach a maximum of 41℃over the summer season which runs from March to September.

3.2: Study population

Three districts were identified, from which goats were selected using purposive sampling technique. The chosen goats had no history of vaccination against and were 6 months of age and above.

3.3: Study design:

The study was cross-sectional in nature and was applied in the study to evaluate the sero-prevalence of goat brucellosis reared under extensive farming system and also to determine the risk factors of testing positive to brucella organisms in goats.

3.4 Sampling and data collection

The three selected districts, 3 sub-districts from each were selected randomly, totaling to 9 sub-districts. Then in each selected sub-districts other nine families were chosen from the list that had already been combined using the help of the Puntland Livestock Professional Association (PULPA). Data was collected through administration of questionnaires (Appendix1) to household heads via personal interviews. Herds were visited systematically and samples were taken until the expected size was achieved. Goats to be bled were selected systematically as they entered the kraal. Information collected included herd sizes, age, sex, production system, water sources, and the knowledge of brucellosis by the herders. Production systems were categorized as extensive, intensive and semi-intensive. Extensive was defined as when animals spent the day in the field grazing, intensive when they spent all the time fed in stalls and semi-intensive a mixture of the two.

3.5 Determination of the Sample Size

The formula below was used Dohoo *et al*. (2003).

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

Where, n= is expected sample size

Z_{α}^{2}= the normal deviate that provide 95% confidence interval (1.96)

P= this is a *prior* disease prevalence estimation

Q= 1-P

L= the allowable error (5%)

A p value of 13.7% used as it was acquired from Somalia as an estimation in previous studies (Bertu *et al.*, 2010). Thus,

$n= 1.96^{2} \times (0.137 \times 0.86)/ (0.05)^{2}$

The total sample size of goats was 182

3.6: Blood collection

10mls of blood was obtained from the goats using venipuncture methods, after which the serum was separated from the blood before being put in sterilized vials. The blood was then packed in frozen using cool boxes with ice packs to wait for analysis.

3.6.1: Rose Bengal Test

The results of the RBPT carried out in the blood (30µl) showed that the Rose Bangle antigen was present. The serum was divided into two categories- one control and the other for the actual experiment. The plate was allowed to rock for approximately four minutes, after the results were obtained. The results would be positive if agglutination would be observed.

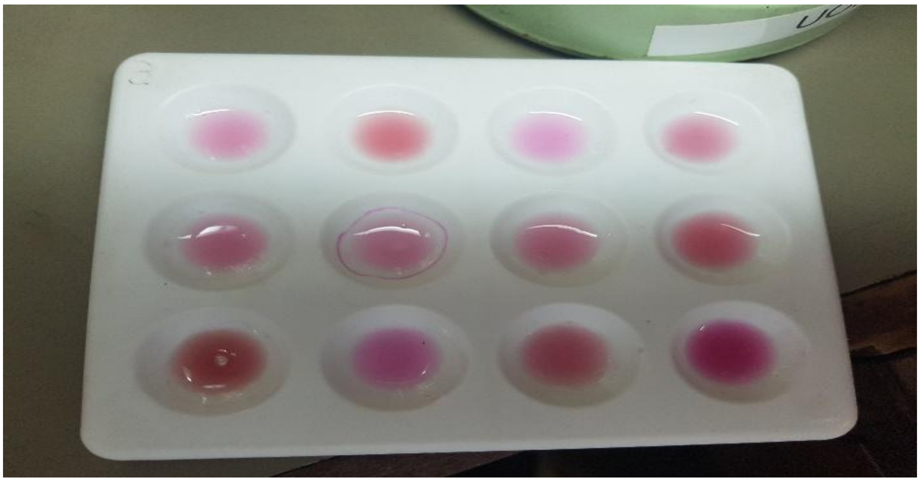

Figure 3. 2: Plate Positive result of RBT.

3.7: Data handling and analysis

The data collected via laboratory findings and questionnaire responses were keyed in to MS Excel (Microsoft Inco., Sacramento, California, USA) for editing and exported to STATA version 14 (Stata Corp LCC, Collage station, Taxes, USA) for statistical analysis. Firstly, the data was sanitized before being analyzed, after which it was coded through the help of descriptive and inferential statistics. Next, proportions were established for analyzing the data using categorical variables, which were then forwarded to be presented using overall numbers, with 95% confidence interval expected to apply where possible.

Mixed-effect logistic regression analysis was performed to control for clustering within herds, to evaluate the relationship between variables and the dichotomized sero-positivity outcome (presence or absence of *brucella spp*. Antiboday). In the first step, univariate logistic regression model was delivered for all the predictors variables and variables with $P<0.2$ were selected. Subsequently all the variables significant in the univariate models were fitted in Multivariate logistic regression model.

CHAPTER FOUR

RESULTS

4.1. Study Farm Characteristics

4.1.1: Livestock population

A total of 81 farms were visited, majority (72.8% 59/81) of the farmers kept goats, and a small proportion kept camels (27.2% 22/81). Garowe district had the largest concentration of goats who relative to the others (figure 4.1) Thus, goats were a popular species with livestock farmers of Puntland. There were more female goats (58.8%) than males in all the three sub-districts as shown in figure 4.1. most of the surveyed goats (75%) were two years old and less. There was a total of (5527) goat's livestock in the 81 households visited.

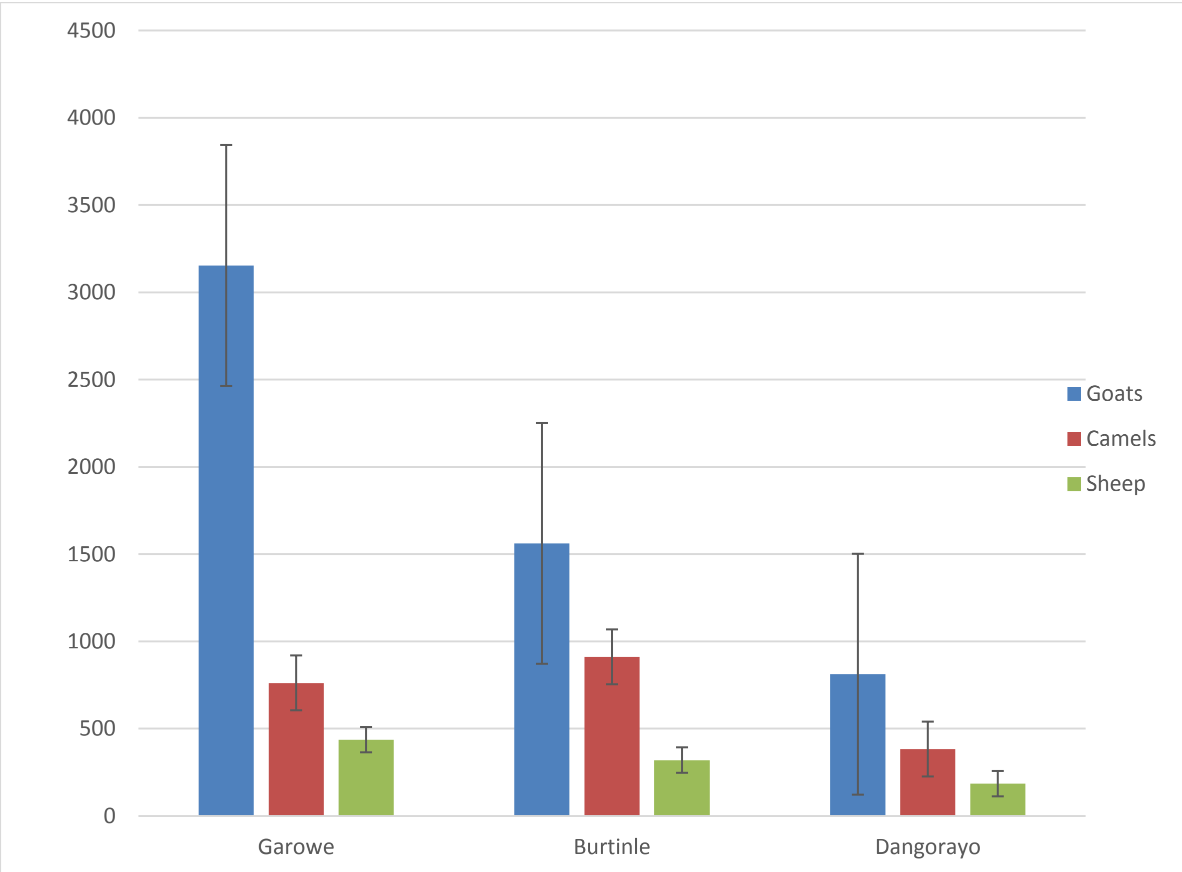

Figure 4. 1: Distribution of livestock species in three sub-districts of Puntland State, Somalia

4.2: Management practices

The majority (63% 51/81) of the respondents were females. They indicated that a huge proportion (74.1% 60/81) of the households practiced extensive grazing of their livestock. Intensive grazing was practiced by 24.7% (20/81) of the respondents and only (1.2%, 1/81) practiced semi-intensive grazing. This implies that goats in the study mixed extensively in the grazing fields, and thus increasing the risk of exposure to brucella organisms.

Use of bucks was the only method for breeding of the goats. The source of the bucks included own bucks (60.5%, 49/81), and neighborhood goats (39.5%, 32/81). All the Livestock was kept in Kraal at night.

Households watered their livestock in separate watering points (69.1%, 56/81) and in communal watering points (30.9% 25/81). More than a half of families acquired stock fro replacing from own herds (56.8% 46/81), purchasing from markets (39.5% 32/81) and from neighbors (3.7% 3/81).

Herders reportedly sought veterinary services from the veterinarians and community-based animal health workers (56.8% 46/81) or purchase drugs directly from drug stores for self-treatment (43.2% 35/81). Thus, drug abuse by the residents of Puntland was likely to have been great.

4.3: Knowledge of brucellosis and associated practices

The knowledge of brucellosis and the associated practices on aborting goats is displayed in Table 4.1. A huge proportion (79%) of the respondents reportedly know about brucellosis. Indeed 30.9% and 69% of the respondents correctly states that night sweats and joint pains respectively were the signs/symptoms of brucellosis in humans (Table 4.1)

However, some of the reported practices with regard to brucellosis e.g. assisting livestock to deliver, disposal of retained after birth increased the risk contacting brucellosis (Table4.1).

In addition, the drinking of raw milk (by 78% of respondents) and handling of aborted fetus (by 75%) of the respondents, also increased the risk of contracting brucellosis.

Table 4. 1: Knowledge of brucellosis and associated practices by the pastoral community of Chosen districts, 2019.

Variable	Level	Frequency	Proportion%
Knowledge of brucellosis	Yes	79	97.5
	No	2	2.5
Clinical signs/symptoms in human brucellosis	Headache	0	0
	Fever	0	0
	Night sweats	25	30.9
	Joint pains	56	69.1
Assisting delivering of livestock	Yes	60	74.1
	No	21	25.9
Use of protection while assisting birthing	Yes	6	7.4
	No	75	92.6
Disposal of retained after birth	Yes	60	74.1
	No	21	25.9
Drinking milk	Raw	63	77.8
	After boiling	18	22.2
Handling aborted fetuses	Throw away	61	75.3
	Give to dogs	19	23.5
	Burn	1	1.2

4.4. Laboratory analysis

A total of 182 goats were bled of which 14 were positive to *Brucella* antibodies. This converts to a point prevalence estimate of (7.7%, 14/182). The distribution of goats testing positive is shown in the Table 4.2. of the 14 seropositive, the majority (20%, 6/30) were from Awr-culus sub-district of Garowe District. Seropositivity was recorded in all three of the study districts.

Table 4. 2: Distribution of goats testing positive for *Brucella* antibodies by study Districts in Nugaal Region, Puntland State, Somalia, 2019.

Districts	Sub-district	No Sera tested	No Positive	Proportion%
Garowe	Xamur	12	0	0.0 (0/12)
	Sinujiif	20	0	0.0 (0/12)
	Awr-culus	68	6	20.0 (6/30)
Burtinle	Jalam	16	3	30.0 (3/10)
	Xaarxaar	15	0	0.0 (0/6)
	Faratooyo	19	2	16.7 (2/12)
Dangorayo	Budunbuto	8	0	0.0 (0/4)
	Libaaxo	12	1	20.0 (1/5)
	Uusgure	12	2	22.2 (2/9)

4.5. Risk factors of Brucellosis seropositivity

4.5.1 univariate analysis

The whole logistic regression is shown in Appendix four variables were associated with testing positive to brucella organisms as P<0.2 as shown in Table 4.3. Female goats were almost 4 times to test positive for brucella relative to male goats (OR=4.22). The other variables have the same meaning. Feeding the goats separately had a negative association with testing positive to brucella organisms (OR=0.23). This meaning those that browsed separately were 4.35(1/0.23) times less likely to test positive for brucella.

Table 4. 3 : **Risk factors of seropositive to Brucella antibodies in univariate analysis in Nugaal region Puntland, state, Somalia,2019.**

Variable	**Level**	**Odds ratio**	**Std. error**	**P. Value**	**95%confi. Interval**
Sex of goat	Female	4.222	2.964	0.040	1.066-16.718
	Male -Cons	0.079	0.0473	0.000	0.024-0.256
Production system	Extensive	2.031	1.295	0.266	0.582-7.089
	Semi-intensive/ intensive	0.154	.0584	0.000	0.731-0.324
Breeding system	Individual buck	0.230	0.186	0.069	0.473-1.119
	Communal back -cons	0.289	0.991	0.000	0.1479-0.566
What happens to aborting animals	Separate aborted animal from the herd	14.667	13.73	0.004	2.341-91.861
	Leave them in the herd-cons	0.136	0.484	0.000	0.679-0.273

4.5.2 Risk factors of Brucellosis in multivariate analysis

In the multivariate analysis, four variables were associated with testing positive to brucella (Table 4.4)

Table 4. 4: Risk factors for seropositive to brucella antibodies in Multivariate analysis in Nugaal region Puntland, state, Somalia, 2019.

Variable	Level	Odds ratio	Std. Error	P<0.05	[95%Confi. Interval]
Sex of goats	Male	5.474	4.691	0.047	1.021- 29.361
Production system	Extensive	7.951	7.029	0.019	1.406-44.965
Breeding System	Own buck	0.1227	0.121	0.033	0.0180.843
What happens to aborting animal	Throws birth material	18.956	20.987	0.008	2.164-166.027

Three of the variables (sex, production system and what happens to the aborted materials) retained their significance with the positivity of foreign antibodies.

The strength of association as determined by the odds ratio increased (Table 4.). However, one of the variables that was significant in the univariate analysis (feeding system) lost its significance in the multivariate analysis (Table 4.) and the breeding system gained significance in the for analysis, loss of significance and gaining of significance, and enhances of OR, are examples of confounding, the detection and control of confounding is a major task in epidemiology as the presence of confounding is known to restart resolves of surveys and observational studies (Dohoo *et al.,*2010).

CHAPTER FIVE

DISCUSSION

Goats were the predominant livestock species in the study area of Nugaal region, Puntland state of Somalia. There were a few camels and sheep Puntland are mostly a desert characterized by scattered scrubs in almost all the country suitable for camels and mostly goats. The pastures are hardly enough for sustain the rearing of cattle and thus the absence of cattle in this study. Goats were targeted in this study because they were the major livestock species for trade with countries in the Middle east (Ombui,2014). But this trade is not without problems.

Exposure to brucella organism was observed in most of the study areas. The seropositive estimates 7.7% was similar to estimate reported from pastoral areas in the East Africa region and the horn of Africa. Abbas (2018) estimate a seroprevalence of 4.5% in goats in the Benadir region of Somalia while Nakeel *et al.*, (2016) had an estimate of 7.3% in goats in Kajiado county and Koagei *et al.,* (2020) estimate a seroprevalence of 10.2% in goats in Baringo County. These results are an indication that brucellosis occurs in pastoral areas with only slight variations. The slight variations in seropositivity have been associated with certain factors such as herd sizes differences, production systems, type of breeding systems, disease control measures differences, and various tests using various testing dimensions (Asheneti *et al.,* 2007).

Some of the risk factors identified in this study that resulted to testing positive to brucella organisms includes: sex, production system, breeding system, and how retained after births are dealt with. Similar risk factors have been identified in studies conducted within the Somali ecosystem and in other pastoral system further afield in Africa (Radostits *et al.*,2000; Mcdermott and Arimi (2002); Osoro *et al.*,2015; Khan and Zahoor 2018; Alemneh and Akeberegn 2018).

Testing positive to brucella organisms was shown to be strongly associated (OR=7.95) with the production system practiced by the pastoralist. In this system goats from different herds mix and since brucella is transmitted through direct and indirect methods (McDermott and Arimi 2002) the risk of transmission from infected to susceptible herds is high. In addition, goats are known to shed the brucella organisms through body fluids subsequently contamination the environment (McDermott and Arimi 2002). This acts a source of contamination to other livestock. All these may perhaps be the reason of the strong association between extensive grazing system and the risk of high positivity.

Female goats were at a high risk of testing positive to brucella organisms than male goats. Brucella is known to be transmitted venereally besides other routes of infection (Radostits *et al.*,2000; Mcdermott and Arimi 2002; Osoro *et al*.2015; Khan and Zahoor 2018; Alemneh and Akeberegn,2018). Thus, the mating of female goats with multiple bucks in the field may increase the risk infection (Sharma *et al*.,2018)

The use of own buck for breeding purposes was associated with seropositivity but in a negative sense (OR=0.223). This indicates that farmers who used their own bucks for breeding were 4.8 times less likely for their goats to test positive to brucella organisms relative to those who used neighborhood bucks.

The way pastoralists managed the aborting goats was strongly associated with seropositivity. Farmers where segregated the aborting animals and handled the aborted fetuses were 19 times more likely to have goats testing positive to brucella organism relative to those who segregated the aborting goats and properly disposal the aborted fetuses.

The placenta from an aborting animal is a rich source brucella organism and if not carefully removed, can contaminate the environment and acts as a source of infection to other animals (Rodostits *et al.*,200; McDermott and Arimi 2002).

Some variables in the univariate analysis changed their Odds ratios (OR) in the Multivariate analysis. For example, the OR for management of aborting animals changed from OR=14.7 to OR=19. This occurs as a result of confounding which distorts results and can give erroneous conclusions (Dohoo *at al.*,2010). In this study confounding was controlled through analysis and therefore multivariate result were adopted as they were adjusted. Thus, these results were the correct ones as confounding was controlled

In conclusion, this study was shown that brucellosis in goats present in the Nugaal region area of Puntland, at a positivity rate of 7.7%. Four factors including sex of goats, breeding methods, production system and handling of aborting animals were associated with testing positive to brucella organisms. There is a need to plan sound control measures of the disease in the area particularly education of the pastoralists in the handling and management of aborting animals. Most of the risk factors could be modified for control purposes. For example, the use of own bucks for breeding, avoid as much a possible the mixing of herd in the field, and proper management of abortion cases.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1: Conclusions

The following conclusions were inferred from the study:

1. Exposure of goats to brucella organisms was widespread in the Nugaal area of Puntland. The seroprevalence of brucellosis was estimated at 7.7%

2. Three risk factors for testing positive to brucella were found to be positively associated including Sex (female OR=5.5), production system (extensive OR=8.0), Management of abortion in herds (Throws birth material in environment (OR=18). The use of their own bucks for breeding purposes was negatively associated with seropositivity with an OR of 0.223 indicating that pastoralists who used their own bucks for breeding were 4.5(1/0.223) times less likely for their herds to test positive to brucella organisms relative to those who used communal bucks.

6.2: Recommendations

1.Since goats are the main stay of the livelihood of pastoralists of Nugaal area of Puntland, brucellosis control is essential. A control strategy that appears attractive is the test and slaughter. However, for this succeed, the government should compensate the farmers.

2. Farmers should be educated on some aspects of flock/herd management. As a first step they should be educated on how to manage abortion in their flocks, e.g. separating from the herd aborting animals and proper disposal of aborted materials. Secondly, they should be taught on the importance of not mixing herds especially at watering points. Thirdly they should be informed on the dangers of using communal bucks for breeding purposes.

3.As a breeding control the farmers should be encouraged to adopt a method of placing a barrier just in front of the penis to present penetration. This method has been used with various degree of success by the Turkana and Maasai pastoralists of Kenya.

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APPENDICES

Appendix 1: Questionnaire Schedule for assessing brucellosis and evaluating risks in three selected districts of Nugaal region Puntland state of Somalia.

Name of respondent: ____

Herder: __________________________

Date: __________________________

District: _______________________**Sub-districts**: ________________

<u>Circle the appropriate answer</u>

Livestock Species Owned

1. Goats No. 1).10-20 2). 20-30 3). 30-40 4). 40 above

2. Sheep No. 1). 10-20 2). 20-30 3). 30-40 4). 40 above

3. Camels No. 1).10-20 2). 20-30 3). 30-40 4). 40 above

No of male goats ____________ Number of female goats _________________

No of male sheep______________ No of female sheep _____________________

No of male camels ____________ Number of female camels________________

Age: 1). 6-month -1 year 2). >1year<2 years 3). >2<5 years

4. Production system

1). Intensive 2). Semi intensive 3). Extensive

5. Do your animals graze together with neighbour animals?

1). Yes 2). No

6. Do your animals drink water together with other animals?

1). Yes 2). No

7. Breeding system

1). Communal buck 2). Individual buck 3). Neighboring buck 4). Others (specify)

8. How do you manage them when feeding, watering at night?

1). Together 2). Separately 3). If others (specify________________

9. Do you know a disease called brucellosis?

1). Yes 2). No

10. What the signs and symptoms of brucellosis in humans?

1). Headache 2). Fever 3). Night sweat 4). Joint paints 5.) Others (specify)

11. Do you assist your animals while delivering?

1). Yes 2). No

If yes,

12. Do you wear protective clothing?

1.) Yes 2.) No

13. How do you drink your milk?

1.) after boiling 2.) Raw 3.) Sack 4.) Others (specify)

14. When did the abortion occur? (What Stage?)

1). 1^{st} tri 2). 2^{nd} Tri 3). 3^{rd} Tri

15. What is the most appropriate thing to be done to an aborted Fetus?

1). Incinerate 2). Discard 3). Bury 4). Others

16. What is the best way to handle a placenta that did not come out wholly?

1). Incinerate 1). Discard 3). Bury 4). Others

17. How would you save an animal with a retained placenta?

1). Abandon them 2). Isolate the aborted animal

18. How do you ensure that your flock is healthy?

1). Use veterinary services 2). Give animals medicine/drugs 3). Other

19. Where do you get your replacement stock?

1). Own stock 2). From neighbours 3.) From the market 4.) Others (please specify)