Sudan University of Science and Technology
College of Graduate Studies

Economic effect of Bovine Brucellosis in some Dairy Farms in AlSilate Complex- Sharge Elnile Locality

الاثر الاقتصادي لبروسيلا الابقار في بعض مزارع الالبان بمجمع السليت- محلية شرق النيل

A Dissertation Submitted in Partial Fulfillment of the Requirements for the degree of Master in Tropical Animal Production

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Dedication

For the Soul of my father

My beloved mother and my husband

For my brothers and Sister

To my friends who gives happiness and Joy

For all person who helped me the throughout my Study

I dedicate this work with love

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At the beginning and at the end praise at Allah for helping us achieve this work.

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Abstract

This study was conducted in Alsilate dairy cattle farms in East Nile locality, Khartoum State during the period (Oct– 2018/ (April- 2019) with the objective of estimating the economic loss due to bovine brucellosis.

The necessary data was collected by conducting field survey in which the epidemiological and economic data were collected. Also, the study relied on secondary data. To determine the disease situation, a total of 340 serum bloods from 16 farms were collected and tested using RBPT and the positive sample were confirmed by (I- Elisa). The study revealed that the prevalence rate was 23.52% based on RBPT while it was 18.7% based on I- Elisa. According to the confirmatory test the economic loss was estimated. The losses in the milk production were found to be SDG 1520402.4 (USS 466 38.10), losses in calf's harvest were SDG1861200 (USS 57092.024), losses due to repeat breeding was SDG 2939.868 (USS 90.8), losses due to veterinary intervention was SDG33000 (USS 1012.289) and losses due to mortality at SDG 26400 (USS 809.815). The total financial losses due to brucellosis Alsilate farms was SDG 344942.268 (USS 105642.4). Each farmer losses SDG 215246.391 (SUS 6602.650) annually as a result of brucellosis.

The study concluded that brucellosis in Alsilate adversely impacts the farmer income as well as the quantity of milk supply and recommended adoption of brucellosis control program as well as raising the awareness of the producers to the negative impact of the disease on public health, income generation and food security.

ملخص الأطروحة

أجريت هذه الدراسة بمجمع مزارع السليت بمجلية شرق النيل بولاية الخرطوم للأبقار الحلوب في الفترة من 10/ 2018 إلى 2019/4 كان الغرض من الدراسة الأثر والفقد الاقتصادي لمرض البر وسيلا نتيجة (الإجهاض والخصوبة وإنتاج الألبان وموت العجول والأبقار).

شملت الدراسة 16 مزرعة من 208 مزرعة واخذت 340 عينه دم وتم فصل السيرم في المعمل المركزي (سويا) تم فحص كل العينات بانتجين روز بنقال كانت النتيجة 80 عينه (+) من 340 عينه تم تأكيد الفحص باختبار الاليزا تم الحصول على 55 عينه (+) من 80 عينه وكانت نسبة انتشار المرض باالاليزا 17 .16 % والروز بنقال,52 ,23% و كانت نسبة انتشار المرض في كل مزرعة كما يلي، مزرعة رقم (1) 50 % مزرعة رقم (2) 1، 23% مزرعة رقم (16,17% مزرعة رقم (4) 8,7% , مزرعة رقم (5) 27,2 مزرعة رقم (6)33,3 % أما المزارع (7) (8) (15) 0.0% لا توجد , مزرعة (9) 6% مزرعة (10) 4,5% مزرعة(11) 17,4% مزرعة (12) 42,9 مزرعة (14) 16,7% , مزرعة (16)26,7%

ثم اجري استبيان للمزارع ال 16 تم جمع البيانات والمعلومات عن المرض وأمراضيته وعدد الحيوانات ألمنتجه والتي يحدث لها إجهاض والتي تعاني من قلة الخصوبة ومشاكل العقم وتكلفة علاج مضاعفات المرض.

تم تقدير الخسارة والفقد الاقتصادي نتيجة المرض كالاتي:

الفقد في إنتاج اللبن نتيجة المرض1520402,4 جنيه سوداني (46638,15 دولار، الفقد في العجول نتيجة الإجهاض وطول الفترة بين الولادات 1861200 جنيه سوداني (570920524 دولار)، الفقد نتيجة مشاكل الخصوبة والعقم وإعادة التلقيح

29390868 جنيه سوداني (5590,8دولار) والفقد نتيجة علاج مضاعفات المرض 33000 جنيه سوداني (1012,260دولار))، الفقد نتيجة موت الأبقار 26400 جنيه سوداني (809,815)

وكان إجمالي الفقد الاقتصادي نتيجة المرض 268و3443942 جنيه

استدلت هذه الدراسة بان تأثير البروسيلا على مزارع السليت وعلى نحو معاد على الدخل بالاضافه الى كمية اللبن المعروضة والتوصيات المتبعة فى برنامج السيطرة والتحكم على البروسيلا ورفع الوعي بين المنتجين بالتأثير السلبي على مرض البروسيلا وعلى الصحة العامة والدخل وعلى المواليد والامن الغذائى

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CHAPTER ONE
1. INTRODUCTION

1.1. Background

Brucellosis is a serious zoonotic disease affecting man and all domestic animals (Redistric*etal.*, 2007). This disease causes abortion, infertility, economic losses in livestock production. Brucellosis in cattle is an important zoonotic disease that has existed since antiquity (Cutler *et al.*, 2005).Itconstitutes a zoonosis of worldwide public health and economic importance (Whatmore, 2009). Twelve species of Brucella have been identified so far (Rajala, 2016). Most species of Brucella can infect multiple species of animals, including humans (Zinsstag*et al*., 2005). In cattle, the infection is predominantly caused by *B. abortus*, less frequently by *B. melitensis* and occasionally by *B. suies* (OIE, 2016). In sexually mature female cattle, infection localizes in the reproductive system and produces placentitis followed by abortion, causing production losses (Ul-Islam, 2013). Most infected animals abort only once in their lifetime, but may remain infected throughout their entire life (Godfroid,2010). The disease is often asymptomatic in non-pregnant female and after the first abortion. Adult male may develop orchitis, and brucellosis may cause infertility in both sexes. Hygromas can occur in leg joints and are a common manifestation of brucellosis in some tropical countries (OIE, 2009). Bovine brucellosis can also occur in buffaloes, bison and yak and clinical manifestations in these animals are similar to those in cattle (OIE,2009). Economic importance of the disease in cattle farming in many countries of the world is well known. The disease was not described in detail until Bang in 1897 who established that *B. abortus* was the cause of abortion in cattle (Nielsen, 2002). It is perhaps the most widespread and economically important zoonotic diseases in

tropical and subtropical regions (Nicoletti, 1980). Although the disease is endemic in Sudan, countrywide estimates of the economic impact of the disease arenotavailable. However, considerable number of exported animals are rejected annually because of the disease (Musa and Shigidi.2001).

1.2The Statement of the Problem.

Khartoum state is the largestmilk market in Sudan, the demand for milk exceeds its supply, so the establishment of commercial dairy farms and projects around the city becomes a necessity.Alsilatecomplexwas established to provide Khartoum with agricultural products including milk. Highly producing cross breed cattle were used to ensure high supply and high profits to the farm. Unfortunately, the state was proved to be endemic with brucellosis which causes economic losses as a result of abortion, reduced milk production, infertility,and stillbirthandcalves' mortality. To what extend do the profit of the farmer is affected because his herd being infected with bovine brucellosis. This is the concern of this study.

1.3. The Research Objectives.

The main objective of the research is to estimate the economic losses due to bovine brucellosis in some selected farms in Alsilatecomplex.

Specific objectives

1. To estimate the prevalence rate of bovine brucellosis based on serological tests.
2. To assess the awareness, perception and attitudeof in contact persons.
3. To calculate the economic loss due to bovine brucellosis.

1.4. The Research Hypothesis.

1. The prevalence rate of bovine brucellosis is more than 20% based on I-Elisa test.

2. The awareness of in contact persons is fair, but the perception and attitude are poor.

3. The annual loss of farmer as a result of brucellosis is more than that reported SDG (33, 548, 189, 5)$US (7, 293, 084, 6) in Khartoum State.

1.5. TheOrganization of the Research.

The research is organized in four chapters:

CHAPTER ONE: Provides an introduction to research which includes; background, the statement of the problem, objectives, hypotheses of research and the research layout.

CHAPTER TWO: Reviews the related literature and the relevant studies.

CHAPTER THREE:Describes the material and methods used to achieve the objectives of the research.

CHAPTER FOUR: Presents the results obtained and theirdiscussion.

CHAPTERS FIVE: Concludethe research and set recommendations.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Brucellosis

Brucellosis is a disease caused by bacterium of the genus Brucella. *Brucella* spp. Arecoccobacilli, aerobic, facultative intracellular,non-capsular, gram negative, non-spore forming,non-acid-fastandnon-motile bacteria. The cells vary form 0.4-1.5mm in length and 0.4-0.8 mm in width. Young colonies are pin point in size, translucent and glistening (Spink, 1986). According to Garritty*et al*., (2005); Foster *et al*., (20070; Scholz *et al*., 92008), there are nine distinct species which include: *B. abortus, B. melitensis, B. suis, B. canis* and *B. ovis, B. neotomae, B. microti, B. ceti* and *B. pennipedials*. Each of thesebrucellahavea preferred natural host that include cattle (*B. abortus*); goats and to a lesser extent sheep (*B. melitensis*); pigs (*B. suis*); dogs (*B. canis*) and sheep (*B. ovis*)respectively (Quinn *et al*., 1999). *B. ceti* and *B. pennipedials* have cetaceans (whales and dolphins) and seals (pinnipeds) respectively, as their preferred natural hosts (Garritty*et al*., 2005; Foster *et al*., 2007). *B. neotomae* that was originally isolated from a desert wood rat (Neotomalepida) is believed to be non-pathogenic to cattle, sheep, goats and pigs (Garritty*et al*., 2005), while *B. Microte* has been recently isolated from a vole, Microbusarvalis (Scholz*et al.,* 2008).

Brucellosis severely hinders livestock productivity and human health worldwide. The burden that the disease places specifically on low-income countries has led the World Health Organization (WHO) to classify it as one of the world's 'neglected zoonotic diseases.In animals, brucellosis is highly contagious and cross-species transmission of certain *Brucella* spp. can occur (Olsen,2014). The disease is one of most frequent bacterial zoonoses in low-income countries, where the control programs have not succeeded in eradicating it. The disease acts as an impediment to trade and

exportation.Bovine brucellosis is usually caused by Brucella abortus, less frequently by *B. melitensis*, and occasionally by *B.suis*(Bishop *et al.*, 1994). Infection is widespread globally. Clinically, the most common clinical manifestation of brucellosis in natural hosts is reproductive loss resulting from abortion, birth of weak offspring, or infertility (Olsen and Tatum, 2010).

2.2. Epidemiology of Brucellosis

Worldwide, brucellosis remains a major source of disease in human and domesticanimals.Although reported incidence andprevalence ofthe diseasevary widely from country to country, bovine brucellosis caused mainly by *B.abortus* is still the most widespread form. In Ovine/caprine brucellosis caused by *B. melitensis is* by farther most important clinically apparent disease. The disease has limited geographic distribution, but remains a major problem in the Mediterranean region,western Asia,and parts of Africa and Latin America. Recent reemergence in Malta and Oman indicates thedifficulty of eradicating this infection (Corbel, 1997). Sheep and goats and their products remain the main source of infection, but *B.melitensis* in cattle has emerged as an important problem in some south East European countries, Israel, KuwaitandSaudiArabia (Corbel1997). Thus bovine *B.melitensis*infection is emerging as an increasingly serious public health problem in some countries.A related problem has been noted in some south American countriesParticularlyBrazil and Colombia where*B. suisbiovar*1 have become established in cattle (Corbel,1997). While some area, such as Peru,Kuwait and SaudiArabia,haveavery high incidence reported of acuteinfections (Corbel, 1997). Higher productivity losses are associated with higher prevalence. Seropositive animals have higher rates of abortion, stillbirth, infertility and calf mortality, as well as reduced growth and longer calving intervals. Often, infected females will abort only once, although they may remain infected their entire life. Older literature in high-income countries found that aborting cows kept for milking produced 20% to 25% less milk,

while seropositive non-aborting cows produced 10% below potential(ILRI,2012). Several studies in Africa have shown an association between seropositivity and abortions: around one fifth of cows may abort where seroprevalence is high (>30%) compared to less than 5% of cows in low –prevalence (< 5%) areas or non-affected herds (Matope*et al.*,2011). In a herd in which disease is endemic, an infected cow typically aborts only once after exposure; subsequent gestations and lactations appear normal. After exposure, cattle become bacteremic for a short period and develop agglutinins and other antibodies; some cattle resist infection, and a small percentage of infected cows spontaneously recover. A positive serum agglutination test usually precedes an abortion or a normal parturition but may be delayed in ~15% of cows. The incubation period may be variable and is inversely related to stage of gestation at time of exposure. Organisms are shed in milk and uterine discharges, and the cow may become temporarily infertile. Bacteria may be found in the uterus during pregnancy, uterine involution, and infrequently, for a prolonged time in the non-gravid uterus. Shedding from the vagina largely disappears with the cessation of fluids after parturition. Some infected cows that previously aborted shed brucellae from the uterus at subsequent normal parturitions. Organisms are shed in milk for a variable length of time—in most cattle for life. Bovine brucellosis is widespread and endemic in most countries in the world, especially where disease control is lacking. However, most parts of Northern and Central Europe, Australia, New Zealand and Japan are believed to be free from the disease (OIE, 2004). In these countries, the disease was eradicated through implementation of disease control strategies that included test and slaughter policies.

2.3.Transitionof Brucellosis

Inanimals' infection is transmitted through ingestion orinhalation of organisms that are present in fetal fluids or other birth products. In the herd animals, the infection can be due to introduction of an infected animal that subsequently

gives birth or aborts a fetus, whereupon pasture or water becomes contaminated by these excretions. Transient disease such as abortion can also develop following administration of a live Brucellavaccine, particularly the *B. abortus*vaccinestrain19.Mucosal contents with aborted fetuses and fetal membranes, which contain large amounts of the bacteria, is an important means of transmission in livestock (Pestered *al.,* 2013). Infection spreads rapidly and causes many abortions in unvaccinated cattle. The organisms have been recovered from fetal and manure samples that remained in a cool environment for longer than two months. However, exposure to sunlight kills the bacteriumwithina few hours, and the organism is susceptible to many common disinfectants (McDermott*et al*., 2013). The transmission of the organisms is mainly by direct or indirect contact of the mucous membranes with infective execrators (Quinn *et al.,* 1999). Although cattle have been infected experimentally by conjunctiva, vaginal and via mammary routes, the main route of infection in the field is the oral route (Cunningham, 1977). Thus, most cattle acquire infection by licking infected material, grazing on infected pasture or consuming other feedstuffs and drinking water contaminated by aborted material or uterine discharges from an infected animal (Blood and Radostits, 1989).

2.4. Diagnosis of Brucellosis

The purpose is to search for brucella infection, to reveal prevalence and distribution, andor to monitor freedom from reinfectionin countries where eradication has been achieved. Techniques employed are serological andallergic tests, isolation of the agent by bacteriological methodsand recently Polymerase Chain Reaction (PCR).

2.4.1Serological diagnosis

No single serological test is appropriate in all epidemiological situations; all have limitations especially when it comes to screening individual animals (Godfroid*et al*., 2002; Nielsen *et al*., 2006). Consideration should be given to

all factors that impact on the relevance of the test method and test results to a specific diagnostic interpretation or application. In epidemiological units where vaccination with smooth Brucella is practiced, false-positive reactions may be expected among the vaccinated animals because of antibodies cross-reacting with wild strain infection.

2.4.1.1. Rose Banal Test.

This test is a simple spot agglutination test using antigen stained with Rose Bengal and buffered to a low pH, usually 3.65 ± 0.05 (Morgan *et al*., 1969).

2.4.1.2. Enzyme linked immune sorbent assays (Prescribed tests for international trade) Indirect ELISA

Numerous variations of the indirect ELISA (I-ELISA) have been described employing different antigen preparations, ant globulin-enzyme conjugates, and substrate/chromogens. Several commercial I-ELISAs using whole cell, smooth lipopoly saccharide (sLPS) or the O-polysaccharide (OPS) as antigens that have been validated in extensive field trials are available and are in wide use. In the interests of international harmonization, the three OIE ELISA Standard Sera should be used by national reference laboratories to check or calibrate the particular test method in question (OIE, 2009). These assays should be calibrated such that the optical density (OD) of the strong positive OIE ELISA Standard Serum should represent a point on the linear portion of a typical dose–response curve just below the plateau. The weak positive OIE ELISA Standard Serum should consistently give a positive reaction that lies on the linear portion of the same dose–response curve just above the positive/negative thresholds (OIE. 2009). The negative serum and the buffer control should give reactions that are always less than the positive/negative threshold (Wright *et al*., 1993). Finally, the cut-off should be established in the test population using appropriate validation technique (OIE, 2009).

2.5. Control of Brucellosis

To control Brucellosis in thirty-two countries the detectionofbrucellosis has been made compulsory throughout the country or in specified parts of it (provinces or natural regions). In the sixteen other countries itispartial, usuallydepending on voluntary effort orapplication to certain zones (dairying areas close to large towns, state farms or experimental farms). A scheme for disease-free status, defining the criteria which have to be sful filled before a herd can be recognized as free from the disease, is in operation in twenty-sixcountries. Inmostcountriesallcasesofabortion haveto be notified, and are followed up by arrange of diagnostic and disease control measures.

General methods of control of Brucellosis in animals are on farm: 1) test and slaughter.2) hygienic measures and3) vaccinations (Nicolette,2010). The most effective strategy when they are combined. Test and slaughter of seropositive animals is usually apart of organized governmental programmers when the goal is eradication. The purpose of hygienic practices such as isolation ofaborted animals is to reduce or prevent exposure of susceptible animals. Pre-movement tests at local or international levels are parts of control efforts. These procedures are often difficult to administer and to gain acceptance. Livestock owners are reluctant to accept controls for long periods and usually they respond onlyforemergency disease. Proper disposal (burial or burning) of placentas and non-viable fetuses, disinfectionof contaminated areas should be performed thoroughly.Cooperation with public health authorities to investigate human cases. Animal brucellosis, especially when caused by *B.melitensis*,can often be identified through cases in human (FAO, OIE, WHO, 2006).

2.6. Treatment of Animal Brucellosis

Because of intracellular location of the bacteria, prolonged course treatments (3month) are needed(Mims*et al.,* 2009) and the effective treatment often difficult (Boyd*et al.,* 1991). There is no practical treatment for infected cattle or pigs, but long-term antibiotic treatment is sometimes successful in infected

dogs. Some dogs relapse after treatment.Fertility may remain low even if the organism is eliminated.In horse with fistulous withers or poll evil, the infected bursa may need to be surgically removed (OIE,2009). Due to intracellular ocalization encountered in its replicative niche e.g macrophage. Treatmentof an infected cattle has not widely used, onlyvaluable breeding animals were sometimes treated (Seleem*et al.*, 2008). Many research workers have tried chemotherapy of bovine Brucellosis. Tetracyclines are the most effective and inhibit 95% of strains in aconcentration of 0.02mg/ml. A single intra peritoneal injection of oxytetracycline (10g) to all cows soon after the first abortion in aherd prevented future abortion in non-pregnant cows and about half of the already pregnant ones (Fenterbank,1976).

2.7Economic Impact of Brucellosis

Brucellosis,one among most importantdiseases that cause heavy economic losses in animal production resulting in abortion, neonatal losses reduced fertility decreased milk production and emergency slaughtering of infected animal in addition,the disease is an impediment to free animal movement and export(Coelho*et al*.,2004).To estimate the financial loss caused brucellosis, it depend mainly on the type of cattle farming,herd size,losses in production of meat and milk due to abortion.Non aborting dairy cows produce 10% below potential and aborting20% (Crawford.*et al*.,1979).The main point in quantification of financial effects of animal disease is to make decision on to the best way of disease control measures based on cost and benefits (Chiolonda andHaylentorok,2001). Infected livestock exhibit clinical signs of great economic significance to stakeholders (i.e., small scale livestock farmers, meat and milk industry, human communities, etc.), including reduced fertility, abortion, and a substantial decline in milk production over an animal's lifespan (McDermott *et al*., 2013). The disease can generally cause significant loss of productivity through first to late calving age,long calving interval time, low herd fertility and comparatively low milk production, as

in cattle may also happen in camels(Radostits*et al*.,1994).The disease can also have an impact on export and import of animals constraining livestock trade (Afzal and Sakkir,1994).In Latin America annual losses were estimated at $600 million and the losses for Argentina were estimated at US$ 60 million per year or US$1.20 per bovine considering prevalence around 5%(Seleem*et al*.,2010). In U.S.A. the cost of abortion and reduced milk production in 1952 alone were put at $400 million (Acha*et al*., 2003) and in Nigeria losses were estimated at US$ 575,605 per year or US$3.16 per bovine based of prevalence rate ranging between 7% to 12%(Ajogi *et al.*, 1998). Food and Agriculture Organization of the United Nations (FAO) and the Organization of Animal Health (OIE) consider brucellosis as has not only direct public health implications , it also poses a barrier to trade of animals and animal products(Fitcht,2003) and has a wide socioeconomic impacts especially in countries where people in rural areas rely to a large extent on livestock breeding and dairy products as a source of income (Zinsstag*et al.*, 2005).The economic loss from brucellosis in developed countries arises from the slaughter of cattle herds that are infected with brucellosis and all the cost of eradication and control program. In developing countries farmers suffer from the actual abortion of calves and the decreased in milk yield, birth of weak calves that die soon after birth, retention of placenta, impaired fertility and sometimes arthritis or bursitis and all the cost of tests and samples, death of mature as result of acutemetritis (GarinBastuju,2003). The estimation of the financial loss caused by brucellosis depends mainly on the type of cattle farming, herd size, and loss in reproduction in meat and milk due to abortion. The infected non-aborting dairy cows produced 10% below potential and the aborted ones at 20% and the percentage of abortion in infected cows annually is 41.0-35% (Shepherd*et al*.,1979). Several studies in Africa have shown an association between sero positivity and abortions: around one fifth of cows may abort where seroprevalence is high (>30%) compared to less than 5% of

cows in low-prevalence is (<5%) areas.Studies on the economic production losses of bovine brucellosis are reasonably consistent across a range of production systems in Africa, with losses estimated at 6% to 10% of the income per animal (Mangen*etal*.,2002).At the end of the last century, economic losses for Argentina were estimated at US$60 million per year or US$1.20 per bovine when the prevalence was around 5% (Samartino, 2002) and in Nigeria losses were estimated at US$575,605 per year or US$3.16 per bovine (prevalence 7% to 12%(Ajogi,1998). Productivity losses resulting from *B. melitensis* infection are less well documented in tropical Asia and Africa. One study in India estimated the annual economic loss at Rs.1180 and Rs.2121.82 (current exchange rate US$1 = Rs.56) per infected sheep and goat respectively (Sulima and Venkataraman, 2010). The disease has considerable impact on the economy through loss of milk, meat and by diminished animal working power (Unger, 2003). The worldwide economic losses due to brucellosis are extensive, not only in terms of animal production but also in terms of human health. However, when the incidence of brucellosis is controlled in the animal reservoirs, there is a corresponding and significant decline in the incidence in humans (Seleem*et al*., 2010).

CHAPTER THREE

3 MATERIALS AND METHODS

3.1 Study area

TheEast Nile locality is one of the seven of KhartoumStatelocalities. The locality is bounded by Blue Nile River from south and West, Bahry locality from North, River Nile State from the West. The climate is similar to the climate of whole statesemi-desert,dry and hot in summer (maximum temperature of 47.1 and min. temperature of 22.7) the average rain fall is 150mm per year.The animal population in the locality consists of ruminants and poultry. Ruminantsincludemainly cattle, goats, sheep and camel.Alsilatecomplex is located in the East Nile locality.Thecomplex has an area of about (4-6) km2 it involved 554farms out of which 208 farms raise dairy cows. The total number of cows accounts to 4571 head.

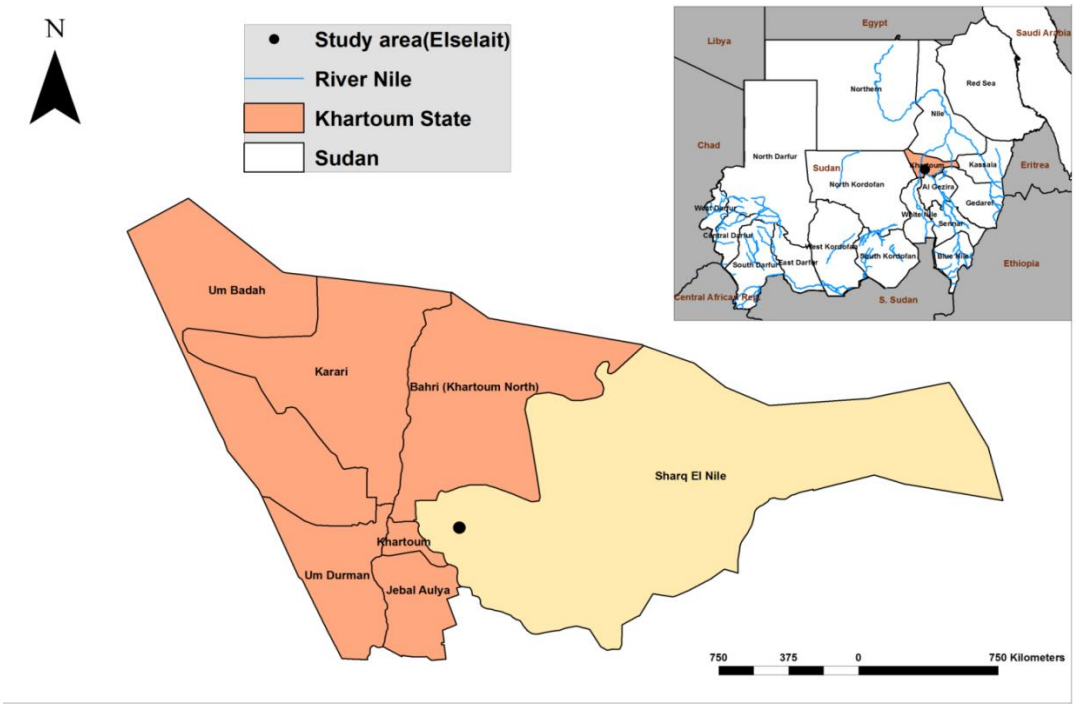

Figure 1: MapofEastern NileLocalitySource: Produced by Dr.Selma Kamal (2020)

3.2. Data Collection

Data were collected from two sources; secondary and primary sources.

3.2.1 Secondary sources of data

Secondary data was obtained from the most relevant sources of information such as journals, thesis, meeting proceedings, technical and administrative reports.

3.2.2The Primary source of data

The primary data for this study include both economic and epidemiological data. Thesewereobtainedby conducting fieldsurvey. A total of 16 dairy farms were selected and covered in this survey. The required data was collected using structuredquestionnaires which were completed by direct interviewing the respondents throughout the period Oct 2018-April 2019.This method was used because most of respondents were illiterates and unable to fill the questionnaire themselves, also because some questions needed explanation.

3.2.2.1. The economic data

The economic data were collectedduring the survey using a questionnaire (Appendix 1).

3.2.2.2. The epidemiological data

The epidemiological data was carried out to determine the prevalence rate of the diseaseSelected.

3.2.2.2.1. Blood samples Collection

A total of 340 blood sample were collected from mature females randomly. The blood samples were withdrawn and processed as described by Alton *etal.,* (1975). The skin over the jugular vein was rubbed with 70% alcohol and disinfected by the application of tincture of iodine. Then 7ml of blood was withdrawn using a labeled vacationer. The samples were placed in a wire basket under shade, before taken to the Brucella laboratory in Veterinary Research Institute (VRI), Sobawith minimum possible shaking. These samples were kept overnight at 4°C for separation of sera. These sera were then

separated from the whole blood by centrifugation, placed in sterile bijou bottles labeled and stored frozen until they were examined.

3.3 Laboratory diagnosis

3.3.1 Serological tests:

Atotal of 340 serum samples collected were subjected Rose Bengal Plate Test (RBT) as screening test.Positive samples in RBT test were further reconfirmed with indirect Enzyme Linked Immune sorbent (I-ELISA).

3.3.1.1.Roes Bengal Plate Test (RBPT)

The 340 blood samples were examined as described **by** Alton*etal*. (1988). The sera and the antigen were brought to room temperature before testing. The test was doneby dispensing 0.03ml of each serum to an enamel plate and equal amount of RBPT antigen was added to each serum sample and both were mixed together, rocked by hand for four minutes, after which the test was immediately read.

The result was read as follows: -

Negative when there was no agglutination or clumping, or showing a pattern of dispersed particles without clumps.Positive when there was agglutination, with moderate to large clump.

3.3.1 .2. I-Elisa 'Enzyme Linked Immune SorbentAssay (ELISA)

3.3.1 .2. 1. Material needed

-Precision pipettes

- Disposable pipette tips

- Distilled, deionize dormancy similar high-quality water

-Wash bottle, multi-channelpipetteor plate washer

-Container: 1 to 2 liters for PBS-Tween

- Micro plate photometer, 450 nm filter.

3.3.1.2.2. Preparation of reagents

PBS-Tween Buffer: The PBS-Tween Solution 20x concentrate 1/20 was diluted in distilled water and 500 ml per plate was prepared by adding 25mlPBS-Tween solution to 475 ml distilled water and mixed thoroughly.

- Anti-Bovine HRP IgG Conjugate:
- The lyophilized HRP Conjugate was reconstituted with 115 ml PBS. -TweenBuffer. Thebuffer wascarefullyadded to the bottle. the solution was left for one minute and mixedthoroughly.
- The remaining reconstituted conjugate was stored -20 ^{C0} and thawed and refrozen up to 3time.

3.3.1.2.3 Procedure

-All reagents wereequilibrated to room temperature 18-25 C^0 (64-77F) before use. Each strip was labeled with a number.

-samples were added

The provided negative and positive control sera were used for serum testing.

-Serum samples using 0.10ml sample volume.

Add 0.90ml of sample Dilution Buffer to each well that will be used for serum sample and serum controls. Added 0.10ml of positive control serum (reagent A) and 0.10ml of negative control serum (Reagent) respectively to selected wells coated with *Brucella abort*santigen. For conformation purpose it is recommended to run the control sera in duplicates. Added 0.10ml of serum sample to a selected well coated with Brucella. abortus antigen.

- The plate was shakenthoroughly. Then the plate was sealed and incubated at37C^0 (98.6F) for 1 hour.

-the plate was rinsed 3 times with PBS-Tween Buffer:

- 100µof HRP Conjugate was added to each well. Then the plate was sealed and incubatedat 37℃ for hour.

- 100 µ Substrate Solutionwas added to each well and incubated for 10 minutes at room temperature.
- The reaction was stopped by adding50µof stop solution to each well and mix thoroughly.
- The optical density (OD) of the controls and samples were measure at 50nm in a micro plate photometer within 15 minutes after the addition of stop solution to prevent fluctuation in OD values.
- **3.3.2.1.4Calculation of percent positivity values(pp)**

Percent positivity values (PP) were calculated.All OD Value for the test samples as well as the Negative control (Neg. C) were related to the Positive control as follows:

$$PP = \frac{\text{End sample or Negative control}}{\text{Ex positive control}} \times 100$$

OD Positive control > 1.0

PP Negative control < 1

3.4 The Economic Model

The following model was used to estimate the total economic losses.

TEL = MT+ MD (1)

Whereas:

TEL = Total economic loss. (2)

MT (Economic loss due to mortality) = number of cows died due to maturities x average price of mature cow. (3)

MD = Economic loss due to morbidity MD = (ML + CL+LRB+ CVI)(4)

Whereas:

ML (value of milk lost) =

(Milk losses of aborted cows + milk losses of non-aborted cows) x price of milk/kg(5)

CL (value of calves lost) =

(Number of mature females x abortion rate of seropositive)

x average price of weaning calf(6)

LRB (Losses due to repeat breeding) =

Number of repeat breeders x cost of repeat breeding per cow (7)

Cost of veterinary intervention (CVI)= number of seropositive aborted cows x cost of veterinary intervention/cow(8)

Annual losses per head = total economic losses/number of cattle population (9)

Annual losses per mature female =

total economic losses/ number of maturefemale cattle(10)

Annual losses per seropositive female =

total economic losses/ number of seropositive female (11)

3.4. 1oss of the Parameters of the model and their sources

The estimates ofeconomic losses were obtained fromfield survey. Production and reproduction parameters were based on previouslypublished sources with some adaptations as in table (3-1).

Table (3-1)The Parameter of the economic model and their sources

Parameter	Value	Source
Numberof mature cows	564	Field data
Numberof seropositive abortedmature females	33	Lab. result
Number of seropositivenormallydelivered mature females	22	Lab. result
Mortality rate	1%	(Santos,*et al.*, 2013)
loss of the total milk yield of infect normallydelivered cow	10%	(Shepherd, el *al.*, 1979)
loss of the total milk yield of infected aborted cows	20%	(Shepherd, el *al.*, 1979)
Annual milk yield (Kg/cow)	7678.8	Obtained from field.
Price of milk (SDG)	22.5	Obtained from field.
Average price of weaning calf (SDG)	10064.51	Obtained from Field
Average price of cow	SDG 169.52	Obtained from Field
Cost of repeat breeder (SDG) per cow	163.326	adapted from (Angara and Elfadil,2014)
Cost of veterinary intervention SDG per cow	1000	Obtained from field
The average price of (U$)	SDG = 32.6	(htteps:fex top.com historical-exchange .ratesphp?AM-I)

3.5Data Analysis:

The collected data was organized and summarized coded and fed in software. Data analysis was carried out by using the computerized Statistical Packages for Social Science (SPSS) version 17 (Samaria et al., 2010).

CHAPTER FOUR

4 RESULTS AND DISCUSSION

4.1 Managementof the investigated Farms inAlsilate

The result of frequency distribution of the 16 farmsfromAlsilatecomplex revealed that all (100%) of the investigated animals were cross bred animals with foreign blood ranges between 70%-75% (Table 4-1).

It worthmentioning that 75% of the farmers used to vaccinate their animals by the vaccines described by the veterinary authorities (Anthraxvaccine, B.Q.vaccine,H.S. vaccine,C.B.P.P.vaccine,render best), while the other 25% of farmers donotused to vaccinate their animals.

Allfarmers (100%) used to separate theiranimals according to age. Animal feed come from two sources, 93.8% of the feed was purchased from outside the complex and 6.2% of feed was produced within the farms. All animals were watered inside the farms.Abortion occurred repeatedly in 50% of the investigated farms and it occurred sometimes in by 18.8% of the herds, 31.2%of respondents claimed that abortion was not found in their animals absolutely.

Table (4-1) Management of the Investigated Farms

Item	Description	%
Breed of animals	**Cross breed**	100.0
Foreign blood	less than70 %	18.8
	Between (70- 75%) 81.2	
Housing animal	Separate according age	100.0
Type of breeding adopted	Natural insemination	100.0
source of feed	Purchased	93.8
	Produced in the farm	6.2
Source of water	Within the farm	100.0
Routine vaccination	Yes	75.0
	No	25.0
Occurrence of abortion	Repeatedly	50.0
	Some time	18.8
	Not found	31.2

4.2 The Prevalence of Bovine Brucellosis in the Investigated Farms inAlsilate

4.2.1. The prevalence ratebased on Rose Bengal Plate Test(RBPT)

The laboratory examination of 340 serum samples by RBPT revealed 80positivesamples. The detailed result of the 16 farm is presented in Table (4-2).The herd prevalence was 81.25% while the individual animal prevalence was 23.52%
(80/340). The prevalence rate in 16 farms indicate thatfarm (1)has the highest prevalence of 50% whereas threefarms, (farm number 7, 8 and 15) were free from of brucellosis (0.0%)

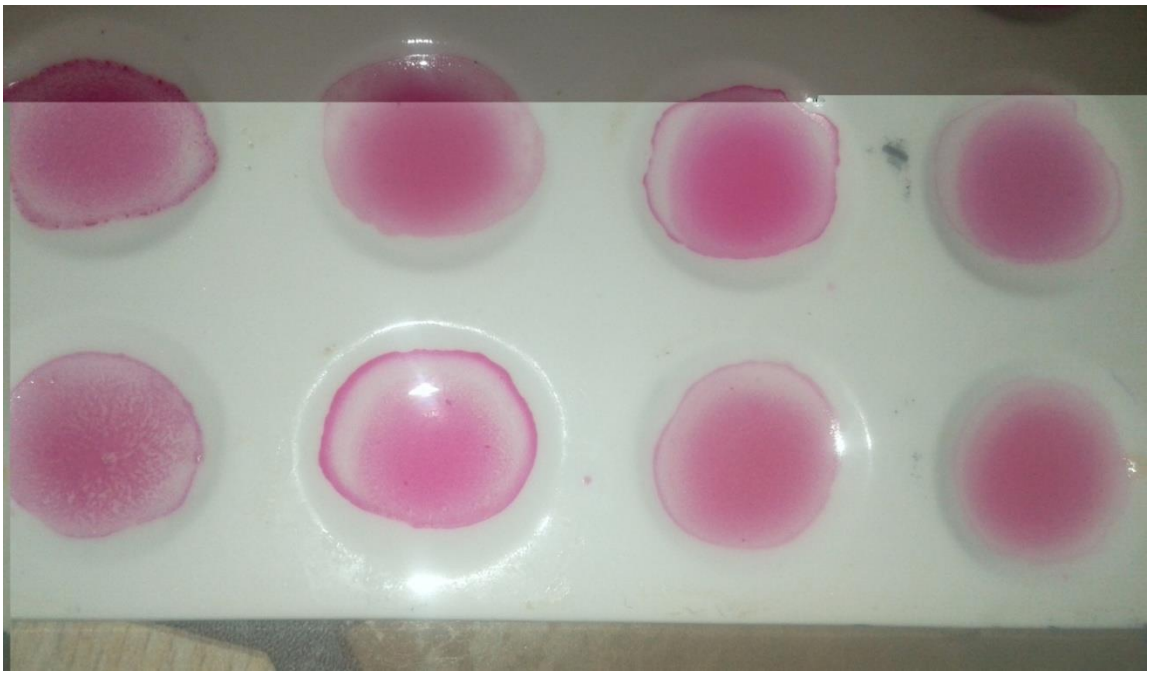

Figure (2) Result ofRose Bengal Test (R B T)

4.2.2 The prevalence rate based on Enzyme Linked Immune Sorbent Assay (I ELISA).

The positive 80 serum samples in RBPT were confirmed by I-Elisa. From 80 samples 55 samples were found positive.While 25samples were found negative. Accordingly,theprevalence according toI-Elisa was16.17% (55/340). The highest prevalence rate was 50% in farm number 1. Whereas farm number 7, 8 and 15 were proved to be free from the disease.

RBTTwasused for primary diagnoses of brucellosis in the Sudanas screening test because itissensitiverapid, cheap, available, produced locallyand it is recommended forinternational trade(Anon, 2014).Butstill therewascross reaction with some infection (OIE,2004). Our findings ensured that I ELISA is a confirmatory test.

The results in table(4-2)revealedthat there was large difference between RBTT and I-ELISA in the detection of the brucella antibodies. In this study area ourresults showed that the prevalenceratewas 23.52% byRBTT. This result is higher than whencomparedwith the result of 2.77% reported in dairy farming inEritrea(Massimo*et al.*, 2009).On the other hand, this result is lower than that found by Solafa, (2015) of 35% in Jebel Aulia locality and that of 25.1% reported by Angara*et al*., (2016) and by Ibrahim (2013)of 25.7% in Khartoum State.

Table (4-2) Prevalence rate of brucellosis inAlsilate basedon (RBT) and (1 ELICA) Test

Number Farm	No Samples	(RBTT) Positive	Percentage%	(I Elisa) Positive	Percentage %
1	6	3	50	3	50.0
2	13	4	30.8	3	23.1
3	26	5	19.2	4	15.4
4	15	4	26.7	2	8.7
5	11	4	36..4	3	27.3
6	6	2	33.3	2	33.3
7	11	0	0.0	0	0.0
8	8	0	0.0	0	0.0
9	16	2	12.5	1	6.2
10	67	6	9.0	3	4.5
11	35	10	30.3	8	24.2
12	7	4	57.1	3	42.9
13	23	8	34.8	4	17.4
14	36	10	27.8	6	16.7
15	14	0	0.0	0	0.0
16	46	17	37.8	13	28.3
Total	340	80	23.2	55	18.7

This result indicates high herd prevalence rate which comes in agreement with (Solafa,2014). Also, the individual animal prevalence rate is high this confirms the result reported by Ibrahim (2013). The high prevalence rate is attributed to the high foreign blood, less interest of vaccinating animal against brucellosis and the poor extension services.

Table (4-3). Brucellosis seropositive aborted and non-abortedcows in each of the investigated farms

Number offarms	Cattle populatio	Mature cows	Prevalenc rate %	Seropositive	Sero non aborted	Sero aborte	% sero-aborte
1	45	7	50.0	3	1	2	2/3
2	41	3	23.1	3	1	2	2/3
3	72	4	13.4	4	1	3	3/4
4	32	2	8.7	2	1	1	1/2
5	75	1	27.3	3	2	2	2/3
6	2	2	33.3	2	2	0	0
7	19	2	0.0	0	0	0	0
8	25	8	0.0	0	0	0	0
9	58	0	6.2	1	0	1	1
10	76	9	4.5	3	1	2	2/3
11	90	6	24.2	8	4	4	1/2
12	27	6	42.9	3	1	2	2/3
13	53	0	17.4	4	1	3	3/4
14	106	3	16.7	6	2	4	2/3
15	32	7	0.0	0	0	0	0
16	71	1	26.7	13	5	7	7/13
Total	844	61	18.7	53	20	33	33/53

Table indicates that only 3 out of the 16 farms investigated are free from brucellosis. Only one seropositivefarmhas no abortion.Most 62.3% (33/53) of the seropositve cows aborted and 37.3% (20/53) of them did not abort.

4.3Losses due to brucellosis.

1. Number of cows died due to brucellosis

The number of aborted cows was estimated at 33 head out of which 3 cows died as a resultof metritis.

2. Losses of milk due to brucellosis

Quantity of milk lost due to seropositive aborted cows was found to be at 151,113.2 Kg/year. The milk lost by seropositive normally delivered was found to be 50371.2 Kg/year. Accordingly, the totalannual amount milklost due to brucellosis in the 16 farms was found to 201,484.8 Kg/year.

3. Number of calves lost.

Calves lost due to brucellosis as result of abortion and increased calvinginterval period was estimated at186 calves annually.

4.Numberof repeat breeder.

Repeat breeding as result ofbrucellosis was estimated to be 18 cows

5. Cost of veterinary intervention.

The aborted cows required veterinary intervention interms of examination and treatment which costed SDG330.00.

4.4. Estimated Economic lossin monetary term

From table (6) the annual economic losses due to bovine brucellosis are estimated in both Sudanese pound (SDG) and the equivalent toUnited States Dollars (US$) the calculation of the total economic losses due to brucellosis was done according to (Ahmed, 2006).

4.4.1Economic losses due to mortality

The losses due to death of 3 cow died as result of metritis was estimated at SDG240,000equivalent to US$6000.equ (3) and table (3-1).

4.4.2Economic losses due to morbidity

4.4.2.1. Economic losses due to reduction in milk production

Reduction in milk production was SDG 1,520,402.4equevelent to U$3335.2(eqn,(5) and table (3-1).

4.4.2.2Economic losses due to repeat breeding.

The cost of repeatbreedinglosses was estimated atSDG2, 939.868that amount about US$90.18.eqn (7) andtable (3-1).

4.4.2.3 Economic loss of calves' harvest.

Due to abortion and increased inter- calving periods the losses in calves harvest wereto be about 1861200SDG which equivalentto US$57092.024.eqn (6) and table (3-1), of the aborted cows was SDG33, 000about US$.825eqn (8) and table (3-1).

4.4.2.4 Total economic losses

4.4.2.4 The totalCost of Veterinary intervention.

The cost of veterinary examination and treatment economic losses due to brucellosis in the study areawerethe sum of the economic losses due to mortalityand that due to morbidity. It was calculated to beDG26, 400Splus SDG 3,417,542.268equal to 3,4439,42.268 the total economic losses wereequivalent toUS$105,642.400.

Table (4-5) Estimated total economiclosses due to brucellosis dairyfarms

Item	Total(SDG)	Total(US$)	%
Losses due to mortalityofabortedseropositive cow	26,400	809.815	0.8
Losses due to morbidity	3,417,542.268	104,832.584	99.2
Milk losses	1,520,402.4	46,638.110	44.1
Losses in calves harvest	1861200	57,092.024	54.0
Losses repeat breeding	2,939.868	90.8	0.1
Costof veterinary intervention	33,000	1,012.269	1.0
Total economic losses in Alsilatecomplex	3,443,942.268	105,642.400	100.0

Although Sudan was proved to be endemic with brucellosis, few studies wereconducted in the field of the economic impact of the animal diseases.The current studyestimated the financial loss in dairy sector namely the lossin dairy farms becausecattle were important sourcesof milk, reservoir and suffered from brucellosis beside that they play an important role in food security and income generation.According to our findingsthe bulk loss was due to losses in calves harvest as a result of increased abortion followed by the losses in milk that production.

In this study the least items in economiclosses are losses due to repeat breeding followed by the losses resulting from veterinary intervention. Wasminor. Studies of economic production losses of bovine brucellosis are reasonably consistent across a range of production systems in Africa. Seleem, *etal.*, 2010in Nigeria estimated the losses due to brucellosis and their result was at US$ 575,605 peryear. Their findings were lower than our results.

Table (4-6) Estimated economic losses dueto brucellosisper head

Item	SDG	US$
Economic loses / head	4,080.5	125.169
Economic loses / mature female	6,138.934	188,310
Economic loses /seropositive	62,617.132	1,920.77
Economic loses / per farm	215,246.391	6,602.650

Conclusion

This study concluded that as a result of the lack of control measures, bovine brucellosisinAlsilatedairy farms is high but it varies between farms to farm. Individual animal prevalence rate varies from 50% to 0%. Economic losses due to brucellosis in this study is considered to be mainly attributed to the losses in calves harvest followedby losses inmilk production. Economiclosses due to repeat breeding is negligible andlosses due to cost veterinary intervention low. The study proved that brucellosis causes high financial losses to dairy sector andadversely impact the farmers' income and consequently the national income.

Recommendation

In this study recommends:

-Raising the awareness of the owners towards the public health significant of the disease.

-Application of brucellosis vaccination program.

-Animals health biosecurity needs to be improved.

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Appendix (1)

Questionnaire Sheet.

Date……23-10-2018 SerialNo. (1)

Name of respondent:

Personal data of the farm owner:

Farm No.

Name (farm owner) ….; Addle AhmedElshfeei.

1 Occupation. …. II Sex

III Age….47 Year

Marital Status: … Tribe

Address:

b- Herd data:

1. Number of animals raised 2. Breed

3. Breed source:

4. Foreign blood %(if known}:

a.> 75%

b. between (65- 75) %

c. ≥ 60%an

5. Herd structure:

Age Item	Less than o year	Calves mo than one year	Mature cows	Gran total
Number				

C. Animal Health Data:

1. Do you vaccinate your animals?

A. Yes B. No.

3. If yes, what diseases you vaccinate your animals against?

4. Do you have abortion cases in your farm?

a. yes b. No

5. If yes how does it occur?

a. Repeatedly

b. Sometimes

10. Doyou vaccinate your animals against brucellosis?

Yes No

d. Herd management data:

1.How do you keep your herd?

a. Mixed b. Separated according to age

c. Separated according to age and sex

2. What type of breeding do you adopt?

a. Natural insemination b. Artificial insemination

3. In case of natural insemination, do you have your own bull {} or borrow one from other farms { }

4. How do you feed and water your animals?

5. What are the sources of food and water that you provide to you herd?