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Prevalence and Risk factor of Brucellosis in Camels in North Kordofan State, Western Sudan

نسبة الإصابة وعوامل الخطر لمرض البروسيلات في الإبل في ولاية شمال كردفان , غرب السودان

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قال تعالى:

(أَفَلَا يَنظُرُونَ إِلَى الْإِبِلِ كَيْفَ خُلِقَتْ**)**

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DEDICATION

I would like to dedicate this work especially to myparents, Lovely sisters and brothers whomI owe them and to all my friends and Colleagues who supported andmotivated me to continue work for thedegree.

I would also like to dedicate this work to mydeceased friend Dr.Baha_Allden .

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ABSTRACT

Brucellosis is a contagiouszoonotic disease and important disease of animals worldwide (OIE, 2000). The disease causes a decrease in reproductive efficacy and an increased abortion rate in animals.The disease is transmitted from animals to humans by ingestion of infected food products, direct contact with an infected animal, or inhalation of infected aerosols. It is widely distributed in developing countries.

A cross-sectional study was conducted to determine the prevalence of brucellosis in camel in North kordofan State. A total of 230 blood for serum samples were collected from camels, from December2019 to March 2020 at north Kordofan state.The Rose Bengal Plate Test and Buffered Acidified Plate Antigen were used to detect brucellosis infection, the infected camels were 51 of 230 (22.2%) and 33 of 230 (14.8%) respectively. The breed was the significant risk factor associatedwith the disease (X2=10.557: p-value= 0.001). The prevalence of brucellosis was 18.3% in Sheikan, 17.6 in Bara and 9.5% in Umkredem. The prevalence of the disease 18.7% in males and 10.3% infemale. The prevalence of the disease15.3% in adult and 14.3% in old and young. Prevalence of the disease 18.3% in good body condition animal and 13.7% inmoderate and 4.2% in poor. It could be concluded that this study provided necessaryinformation about prevalence and risk factors of the disease in thestudy area which help the decision makers to formulate control measures ofdisease .

الملخص

اجريت دراسة مقطعيةلمعرفة مدى إنتشار داء البروسيلات في الابل في ولاية شمال كردفان وذلك في الفتره من 10ديسمبر2019 الى 3مارس 2020. تم جمع عدد 230 عينة دم للامصال من الإبل، واستخدمت اختبار الروز بنغال ومستضد الصفائح الحمضية المخزنة للكشف عن الداء. كانت معدلات الإصابة 51 من 230 (22.2%) بإستعمال الروز بنغال الحمضي و 33 من 230 (14.8%) بإستعمال مستضد الصفائح الحمضيه المخزنه . كان الانتشار 18.7% في شيكان ، 17.6% في بارا ، 9.5% في ام كريدم.

في الذكور18.7% وفي الإناث 10.3% وفي الحيوانات البالغة 15.3% والإنتشار كان 13.7% في الاجسام جيدة الصحة ، و13.7% في المتوسطه ،و4.2% في الضعيفه.

كانت السلاله عامل المخاطره المعنوي للإصابة بداء البروسيلات (p.value=0.001)

INTRODUCTION

Camels (*Camelus dromedarius)* are important animals. They play an important rolein sustainable agricultural for millions of people in the arid and semi-arid zones. Camels also provide milk, meat, wool and are used for water traction and for bearing burdens. Futhermore, The exportation of camels contributes to foreign currency earnings (Abd-Elmajid, 2000).

According to Food and Agriculture Organization statistics (FAO,2006), the approximate number of camel in the world is about 19 million head, of which 15 million are found in Africa and 4 million in Asia. Moreover, approximately 15 million dromedaries, representing two-thirds ofthe world camel population, are living in the arid areas of Africa, particularly in Northeast Africa.

Sudan has nearly five million camels, the second-largest national herd in the world, after Somalia. Tribal groups in Sudan breed distinctive types of camels, the well-known among these are the Anafi and Bishareen camels(Ali *et al.*,2017).

The camel farming is mainly traditional based on the mobility of the herd. The camel belt in the Sudan includes the states of North and South-Darfur, North and South-Kordofan, Khartoum, Gezira, Kassala, the Red Sea, the River-Nile, Northern Sudan, the White Nile, the Blue Nile and Sennar state(Ali *et al.*,2017). Like other livestock, camelare susceptible different types of diseases. Animal diseases are responsible for great losses in livestock sector. Cost-effective losses incurred by these diseases include reduced animal performance and weight gain, condemnation of whole carcasses or affected organs at slaughterhouses, costs of treatment and mortality in severe cases. Livestock diseases are divided according to pathologic agent whether viral, bacterial, parasitic, and fungal in addition to metabolic diseases.

Bacterial infections of camel cause major problems in the developing world. These diseases are difficult to manage because in some cases they develop resistance to available commercial which is now a common problem worldwide.

One of the main bacterial disease causing severe losses in livestock industry nowadays is *Brucellosis* (undulant fever, Mediterranean fever or Malta fever in humans).

Brucellosis is a zoonosis and the infection is almost always transmitted by direct or indirect contact with infected animals or their products. *Brucellosis* is predominately a disease of domestic animals; however, it is highly transmissible to humans. Cattle, small ruminants, and pigs are among the primary hosts. The disease in these animals is characterized by abortion, orchitis, and chronic shedding of the bacteria. Humans are typically infected by consumption of unpasteurized dairy products or through occupational exposure. Some species of brucellae are extremely infectious with as few as 10 organisms capable of causing disease in humans (Godfroid *at el.*, 2011).Although there has been great progress in controlling the disease in many countries, there still remain regions where the infection persists in domestic animals and, consequently, transmission to the human population frequently occurs. It is an important human disease in many parts of the world especially in the Mediterranean countries of Europe, north and east Africa, the Middle East, south and central Asia and Central and South America and yet it is often unrecognized and frequently goes unreported. There are only a few countries in the world (Canada, Australia, Japan, and nations of northern Europe (Corbel, 1997, EuropeanCommission, 2012), that are officially free of the disease although cases still occur in people returning from endemic countries (FAO,2006).

A disease of numerous manifestations, any organ system can be affected by hematogenous spread of bacteria, leading to the development of debilitating complications. Without proper treatment, chronic or latent infections can develop. Signs of disease nearly30 years after infection have been documented (Ogredici *etal.*, 2010).

According to (OIE, 2006), *Brucellosis* remaining a public health hazard due to expansion of animal industries and urbanization, and the lack of hygienic procedures in animal husbandry and in food handling as well as expansions of international travel which stimulates the taste for exotic dairy goods such as fresh cheeses which may be contaminated, and the importation of such foods into Brucellafree regions, also contribute to the ever-increasing concern over human *Brucellosis*.

Despite advances in veterinary and human healthcare, *Brucellosis* remains an important disease worldwide. *Brucellosis* has not attracted the research and financial resources that other global diseases such as malaria, HIV, and tuberculosis have drawn. In this sense *Brucellosis* has been classified as a "neglected disease" by the World Health Organization (WHO).Economic losses results from *Brucellosis* infection because of the duration of the human illness and its long convalescence as well as a medical problem for thepatient because of time lost from normal activities. In some areas, the animal disease remains a constant threat to humanwelfare, particularly for those in the most vulnerable socioeconomic sections ofthe population, in other words, there are many regions where effective diagnosisor treatment is not available and prevention procedures and sanitation measures for the detection and prevention of the infection in humans and animals are not adequately carried out.

The application of well-controlled laboratory procedures and their careful interpretation can assist greatly in this process because *brucellosis* may present in

many a typical form, for example, in many patients the symptoms are mild and, therefore, the diagnosis may not be even considered, moreover, even in severe infections differential diagnosis can still be difficult.

On the other hand, the prevention and controlof *brucellosis* needs supportive action from various sectors, including thoseresponsible for food safety and consumer education. Inter sectorial cooperation plays an important role in the control of *Brucellosis* and may contribute to the development of appropriate infrastructures in areas of animal production, food hygiene, and health care.The current study was thus; carry out to investigate the sero-prevalence of Camel *Brucellosis,* in different locality in North Kordofan state.

The objectives:

The objectivesof this study were toinvestigate *brucellosis* incamels in North Kordofan State. Determine risk factors associated with *brucellosis* in North Kordofan state by using the RBPT and BABA tests.

Literature Review

Brucellosis is one of the most common zoonotic diseases worldwide (Pappas *et al., 2006)*. Its caused by bacteria of the genus *Brucella*.*Brucella* is gram negative coccobacilli and facultative intracellular organism.*Brucellosis* is predominately a disease of domestic animals; however, it is highly transmissible to humans. The disease in these animals is characterized by abortion, orchitis and chronic shedding of bacteria.

1.1 Classification of Brucella:

1.1.1 The Six Classical Brucella Species:

David Bruce(1887)isolated for the first bacteria of the genus *Brucella*from British soldiers found on the island of Malta who died of a disease then known as undulant fever, which was later named *Brucella*.*melitensis*. Epidemiologicalassociation was noticed between the disease in humans and consumption of milk from infected goats. The incidence of the disease was drastically reduced among British soldiers due to the practice of boiling milk prior to consumption as recommended.

Bernhard Bang (1897) discovered the second member of the genus *Brucella* from cattle suffering from contagious abortion, later named *Brucella*.*abortus*,It also known as Bang's disease (Dalrymple-Champneys, 1950).

The differences in host preference and biochemical properties resulted in the division of the genus into the six classical *Brucella* species (Osterman & Moriyón, 2006) : *B.melitensis*, *B.abortus*, *B*.suis (Huddleson, 1931), B. ovis (Buddle, 1956), *B. neotomae* (Stoenner & Lackman, 1957), and *B. canis*(Carmichael & Bruner, 1968). *B.canis* is typically considered to play a limited role in human disease, although evidence exists that the number of cases may be underestimated (Dentinger *et al.*, 2014, Lucero *et al.*, 2010). *B.ovis* infection has never been reported in humans.

Evidence is accumulating that host specificity may not be as stringent as previously believed. Nevertheless, the primary hosts of *B. melitensis* are sheep and goats, while *B. abortus* primarily infects cattle. *B.suis* has a broader host range. The different biovars of this species are known to infect swine, wild boar (Sus scrofa), European hare (Lepus capensis), reindeer (Rangifer tarandus), and rodents.*B.melitensis, B. abortus,* and *B. suis* are the most pathogenic in humans.

Based on antigenic componentsbrucellae can be divided into smooth (S) and rough (R) strains, this distinction refers to the structure of the lipopolysaccharide (LPS) in the bacterial cell wall. Smooth strains involved natural virulent field strains of *B. melitensis*, *B. abortus*, *B. suis,* and *B. neotomae,*while B. ovis and *B. canis* are naturally rough strains. While S-LPS consists of three components, lipid A, core oligosaccharide, and O-antigen, in R-LPS the O-antigen is either absent or reduced to only a few sugar residues. Smooth strains are generally more pathogenic in humans (Rittig *et al.,* 2003*).*

1.1.2 The NovelBrucella species:

Recent isolation of novel *Brucella* species in wildlife and human hosts has led to considerable changes in*Brucella* taxonomy over the past decade. In 1994 brucellae were isolated from marine mammals,greatly expanding the genus' ecological range, Also, in 2007 two separate species from marine mammals were recognized, *B. ceti* and *B. pinnipedialis*, preferentially infecting cetaceans and pinnipeds, respectively (Foster *et al.,* 2007). The disease manifestations in marine mammals include reproductive lesions (Ohishi *et al.,* 2003),meningoencephalitis (Hernandez-Mora et al., 2008), pulmonary and other abscesses (Cassle *et al.,* 2013), andasymptomatic infections (Nymo *et al.,* 2011).

(Scholz *et al.,* 2008) in 2008recognized a novel *Brucella* species*B.microti* (Microtus arvalis) from voles suffered from a systemic disease characterized by edema of the extremities, skin abscessation, arthritis, lymphadenitis, orchitis, and

peritoneal granulomas during an epizootic affecting the wild vole populationwithin a region of the Czech Republic in 1999-2003.In 2010 another *Brucella* species, *B. inopinata*, was added to the genus (Scholz *et al.*, 2010). Currently, *B.inopinata* is represented by a single isolate (strain BO1) and several "*B. inopinata*-like" bacteria that are yet to beofficially classified. Strain BO1 was isolated from a breast implant infection of a woman from Portland, Oregon(De *etal.*, 2008).

The most recent organism to be added to the genus is *B. papionis* (Whatmore *et al.*, 2014), bringing thenumber of recognized *Brucella* species to eleven with five new species described in the past decade.*Brucella papionis* infection has been associated with two cases of stillbirth and retained placenta in baboons (Papiospp.) (Schlabritz-Loutsevitch *et al.*, 2009). The isolates were from cervical and uterine swabs from two baboons, onewild-caught, one colony-born, at a primate research center in Texas, USA following stillbirth in 2006.

1.2. Clinical signs of Brucellosis:

Brucellosis is a sub-acute or chronic disease which may affect many speciesof animals. In cattle, sheep, goats, other ruminants and pigs the initial phasefollowing infection is often not apparent. In sexually mature animals theinfection localizes in the reproductive system and typically produces placentitisfollowed by abortion in the pregnant female, usually during the last third ofpregnancy, and epididymitis and orchitis in the male. Clinicalsigns are not pathognomonic and diagnosis is dependent upon demonstrationof the presence of *Brucella* spp. either by isolation of the bacteria or detectionof their antigens or genetic material, or by demonstration of specific antibodyor cell-mediated immune responses (OIE, 2006).

1.2.1.Clinical findings of brucellosis in domesticated ruminants:

The severity of the disease depends upon many factors such as previous vaccination, age, sex and management such as herd or flock size and density.

1.2.1.1.Bovine brucellosis:

The most common clinical outcome of *B. abortus* infection in cattle is late-term abortion or full-term birthof weak offspring (Olsen & Tatum, 2010). Abortion typically occurs only during the first parturition followinginfection, with subsequent births often normal, although sometimes accompanied by bacterial shedding. Infectionacquired by calves at birth may be temporary or develop into latent infection. Heifer calves that develop latentdisease remain asymptomatic and serologically negative until first parturition at which time abortion andseroconversion are frequently observed (Wilesmith, 1978, Nicoletti, 1980). While shedding of bacteria in milk is an obvious sequela of infection, overt signs of mastitis are not typically present (Morgan, 1960). Quality of the milkremains high in terms of absence of visible particles and a low leukocyte count (Emminger & Schlam, 1943).Osteoarticular lesions are occasionally associated with *Brucella* infection in cattle. There is evidencesuggesting that differences exist in the frequency of this disease presentation between different geographic locations,potentially due to the presence of different cattle breeds or *B. abortus* biotypes. For example, in western Sudanosteoarticular lesions are more commonly associated with *Brucella* infection; 92% of Zebu cattle (Bosindicus) with hygromas and 62% of Zebu cattle with arthritis were found to be seropositive for *Brucella* (Musa *etal.*, 1990).

In bulls, orchitis is the most common disease manifestation often with an associated seminal vesiculitis andepididymitis. Many bulls will remain asymptomatic, and infertility is not typically observed (Eaglesome & Garcia,1992, Carvalho Neta *et al.,* 2010). *B.abortus* infection of other livestock including

buffalo, bison, yak, andelk resembles infection in cattle (Olsen & Johnson 2011; Kreeger *et al.*, 2000; Jackson *et al.*, 2014; Nicoletti, 1980).

1.2.1.2. Brucellosis in Caprine:

Brucella melitensis infection in goats has been reported to closely resemble disease in cattle infected with*B. abortus*. Sheep are more resistant to infection, and there is great variation in susceptibility between breeds(Alton, 1990). *B.melitensis* is associated with late-term abortion during the first parturition post-infection.Pregnancy can also go full-term with the birth of weak kids, heavily infected but healthy kids, or kids that escapedinfection. Infection of kids may be temporary, as development of latent infection seems to be rare (Alton, 1970).

Following abortion or normal birth large numbers of brucellae are excreted; in goats shedding in uterine discharge can last 2-3 months and resume at subsequent parturitions (Alton, 1990). Sheep are less likely to abort, althoughbreed differences likely exist. In sheep shedding in uterine fluid is of shorter duration and rarely reoccurs duringsucceeding pregnancies. However, shedding in milk over succeeding pregnancies has been observed in sheep(Tittarelli *et al.*, 2005). In male animals, especially in goats, orchitis appears to be a common manifestation of *B. melitensis* infection.

1.2.1.3. Brucellosis in Ovine:

B.ovis causes epididymitis and impaired fertility in male sheep (Buddle, 1956). Althoughexperimental infection of goats is possible, it has not been reported to naturally occur (Burgess *et al.,* 1985, Ridler *etal.,* 2000). Among rams, only 30-50% of serologically or bacteriologically positive animals will have palpablelesions (Van Metre *et al.,* 2012). Shedding of brucellae in semen still occurs in asymptomaticrams, however, and these silent carriers disseminate infection throughout the herd. Fertility of asymptomaticanimals may be normal or reduced. Infection is less common in ewes, but abortion or birth of weak lambs can occur(Poester et al., 2006, Hartley *et al.,* 1955).

1.2.1.4.Brucellosis in camels:

*Brucellosis*inCamels causes considerable economic losses due to abortion and infertility.

Camels are susceptible to *Brucella* infection, exhibiting high seroprevalence in areas where *B.melitensis* or *B. abortus* are endemic. Disease in camels is reportedly more mild than in cattle, but orchitis,epididymitis, abortion, arthritis, hygromas, and shedding in uterine discharge and milk have all been recorded (Gwida *et al.,* 2012).

In pregnant camels, the bacteria localizes in the placenta and are most abundant in abortion material (Millar and Stack, 2012).

In a studyconducted by Mohammed *et al.* (2015)from April to September 2012, to determine the seroprevalence and risk factors for brucellosis infection in camels in Khartoum State, Sudan. The prevalence by RBPT was 5.8% and further investigation for positive results by c-ELISA was87.5%.

A serologicalstudy carried out in Egypt using 1126 blood samples collected from Dromedary camels. The modified Rose Bengal PlateTest (mRBPT) and competitive ELISA (cELISA) were used as screening and confirmatory tests,

respectively. Theoverall sero-prevalence of brucella antibodies was 4.17% and 3.73% as detected by the mRBPT and c-ELISA respectively (Hosein *et al.*, 2016). In Iran (Faham *et al.*,2014), a total of 11.38% of blood samples as positive for *Brucella spp.* and 13.01% of the lymph node samples were positive for *Brucella pp*.

Also, Dawood (2008):carried out a study on the prevalence of camel brucellosisin Jordan during the years 2006 and 2007. The positive samples were subjected to confirmation by complement fixation test. The true prevalence of Brucella seropositive was 15.8%.

1.3. The clinical signs of brucellosis in human:

*Brucellosis*in human isusually marked by an intermittent or remittent fever accompanied by malaise, anorexia and prostration, and which, in the absence of specific treatment, may persist for weeks or months. Typically, few objective signs are apparent but enlargement of the liver, spleen and/or lymph nodes may occur, as may signs referable to almost any other organ system. The acute phase may progress to a chronic one with relapse, development of persistent localized infection or a non-specific syndrome resembling the “chronic fatigue syndrome(Franco *etal.*, 2007).

1.4 Global Distribution, Epidemiology and transmission of brucellosis:

Brucellosis is the most common zoonotic infection worldwide with more than 500,000 people diagnosedeach year. In livestock, the global disease burden is also immense. The disease is endemic in the Middle East, theBalkan Peninsula, Central Asia, and regions of Africa and Latin America.

1.4.1.Brucellosis in Africa:

Brucellosis is considered endemic in North Africa (Pappas et al., 2006) with several studies recentlypublished on disease prevalence in humans and livestock in Egypt (Holt *et al.*, 2011). The predominant *Brucella* species circulating in Egypt is

B.melitensis which is being responsible of infection in small ruminants, cattle, buffalo, and camels in this country and the *B. melitensis* biovar 3 were identifiable isolates in samples collected in 2007 with prevalence rates determined to be 3.6 - 5.4% in goats, sheep, buffalo, and cattle and(Samaha *et al.,* 2008), whereas Holt *et al*., (2011) found that prevalence rates incattle and buffalo were 11%.

Brucellosis has been reported in West Africa(Sanogo *et al.,* 2013), Central Africa (Dean *et al.,* 2012), and East Africa (Megersa *et al.,*2011, Muendo *et al.,* 2012, Crump *et al.,* 2013, Kunda *et al.,* 2007). On a global scale sub-Saharan Africa thus mayhave the largest concentration of human and animal *Brucellosis*, a consequence of extensive disease burden andsheer number of people and animals on the continent (Racloz *et al.,* 2013).

In livestock,*Brucellosis* prevalence has been reported to be 10.6%, 2.2%, and 1.9% in cattle, camel, and goats respectively in Ethiopia(Megersa *et al.,* 2011) and 3.8%, 2.3%, and less than 0.5% in cattle, sheep, and goats respectively in Niger (Boukary *et al.,*2013).

In North Africa, *B. melitensis* predominates even in cattle and buffalo (Samaha et al., 2008). Both *B. melitensis* and *B. abortus* have been isolated from cattle in Kenya (Muendo *et al.,* 2012), while in West Africa and southern Africa *B. abortus* infection of cattle seems to predominate (Sanogo *etal.,* 2013).

The importance of *brucellosis* control, however, was underscored by findings of a study carried out by a group inKenya. Of over 75 diseases affecting livestock, *Brucellosis* was determined to be one of the 10 most important in terms of impact on impoverished people (Perry, 2002).

1.4.2. Brucellosis in livestock in the Sudan:

Brucellosis is widely distributed in Sudan according to many studies.

Abu Damir *et al*., (1984) reported that the prevalence rates were 4.9% while Abbas et al., (1987), Bornstein and Musa (1987), Osman and Adlan (1987) found that the prevalence rates were found to be 3.0%, 5.9%, 8% respectively.

Agab (1993) reported that the prevalence rate was 30% whereas Musa and Shigidi (2001) found the prevalence rate of 1.4%. However Omer *et al.*, 2010 reported seroprevalence of 37.5% of *brucellosis*in camels. Solafa *etal.,* 2014 carried out prevalence of *brucellosis* among herds/flocks of cattle, camel, sheep and goats and the results were 76 %, 20%, 13% and 18% respectively.

1.5. Transmission of brucellosis :

1.5.1. Transmission of brucellosis in domesticated ruminants:

Most infections result from ingestion of bacteria either from diseased animals or contaminated feedstuffs. However, infection may also be acquired by respiratory exposure and by contamination of abraded skin and mucosal surfaces. Natural breeding transmits infection in swine and dogs, to a lesser extent, sheep and goats. (Crawford *et al.*,1990)

In cattle,various routes can transmit *Brucellosis*namely:contact following an abortion,contaminated Pasture, inhalation, conjunctival inoculation,through broken skin contamination or udder inoculation from infected milking cups is also a possibility. Pooled colostrums for feeding newborn calves may also transmit infection.Sexual transmission usually plays little role in the epidemiology of bovineBrucellosis. However, artificial insemination can transmit the disease andsemen must only be collected from animals known to be free of infection.

In sheep and goats, the mode of transmission of *B. melitensis* issimilar to that in cattle but sexual transmission probably plays a greaterrole. Mixed grazing of flocks and herds belonging to different owners and purchasing animals from unscreened sources facilitated the transmission of the disease. The sharing of male breeding stock also promotes transferof infection between farms. Transhumance of summer

grazing is a significantpromoting factor in some areas as is the mingling of animals at markets(Tsend *etal.*, 2014).

1.5.2. Zoonotic of brucellosis :

Brucellosis is not considered a contagious disease in humans, although rare reports of sexual transmission, in utero infection, and nosocomial infection exists (Meltzer et al., 2010, Mesner et al., 2007). Except in these rarecircumstances, *Brucellosis* is contracted via contact with infected animals or animal products. Most cases are causedby *B. melitensis* and *B.abortus*, with *B. suis* is also a highly zoonotic but less widespread. The disease in humans isoccasionally caused by *B. canis* and infection by this species may be underreported (Dentinger *et al.*, 2014, Lucero et al., 2010). Infection with marine mammal strains of brucellae has been diagnosed in four individuals (Sohn *et al.*,2003; McDonald *et al.*, 2006).*Brucellosis*is is typicallya foodborne or occupational origin. Unpasteurized cow, small ruminant, andcamel milk or milk products are most commonly associated with foodborne *Brucellosis*. Brucellae persist in softcheeses, butter, and ice cream to a greater extent than hard cheeses and yogurt due to the low pH of the laterproducts. If sufficiently cooked, muscle and organ meat from infected animals is not a source of human infection.

In some cultures, raw or partially cooked liver, spleen, and fetuses are consumed, however, these can be heavilycontaminated with brucellae (Godfroid *et al.*, 2005). Foodborne exposure is the most common route of infection intravelers as well as in people of endemic countries where milk is not traditionally pasteurized or boiled beforeconsumption. In other endemic areas unpasteurized products are not commonly consumed, and in these casesinfection is primarily occupational. Herders/farmers, abattoir workers, leather makers, veterinarians, hunters, andlaboratory personnel can be exposed to high disease of brucellae. Infection often occurs via inhalation or throughskin lesions.

1.6. Diagnosis of brucellosis:

Diagnostic tests for *brucellosis* fall into two categories: those that demonstrate the presence of the organisms and those that detect an immune response to its antigens.

The isolation and identification of *Brucella* offers a definitive diagnosis of *Brucellosis* and may be useful for epidemiological purposes and to monitor the progress of a vaccination programme in animals.

Concerning the isolation of *Brucella*, notall infected animals give a positive culture and the methods and facilities thatmust be employed are not always readily available. Also, the detection of antibodyor a hypersensitivity reaction provides only a provisional diagnosis. False positivereactions to serological tests can occur through a number of factors, includingvaccination. Similarly,dermal hypersensitivity only indicates previous exposure to the organism, notnecessarily active infection, and may also result from vaccination(CDC, 2006).

1.6.1.Bacteriological methods of brucellosis:

The isolation and identification of *Brucella* offers a definitive diagnosis of*Brucellosis* and may be useful for epidemiological purposes and to monitorthe progress of a vaccination programme.

1.6.1.1. Stained smears examination of brucellosis:

Smears of placental cotyledon, vaginal discharge or fetal stomach contentsmay be stained using modified Ziehl-Neelsen (Stamp) or Kosters' methods.The presence of large aggregates of intracellular, weakly acid-fast organismswith *Brucella* morphology is a presumptive evidence of *Brucellosis*. Care mustbe taken as other infectious agents such as *Coxiella burnetii* or *Chlamydia*may superficially resemble *Brucella* (Quinn *et al.,* 2002; Poiester *et al.,* 2010)

1.6.1.2. Culture examination of brucellosis:

Brucella may most readily be isolated in the period following an infectedabortion or calving, but isolation can also be attempted post-mortem.

Brucella are excreted in large numbers at parturition and can be cultured froma range of material including vaginal mucus, placenta, fetal stomach contentsand milk using suitable selective culture media. It is of the utmost importancethat faecal and environmental contamination of the material is kept to aminimum to give the greatest chance of successfully isolating *Brucella*. If other material is unavailable or grossly contaminated, the contents of thefetal stomach will usually be otherwise sterile and are an excellent source of*Brucella*.

In some circumstances it may be appropriate to attempt the isolation of*Brucella* post-mortem. Suitable material includes supramammary, internaliliac and retropharyngeal lymph nodes, udder tissue, testes and gravid uterus.

Milk samples should be allowed to stand overnight at 4 °C before lightlycentrifuging. The cream and the deposit are spread on to the surface of atleast three plates of solid selective medium. Placental samples should beprepared in the field by selecting the least contaminated portion and cuttingoff pieces of cotyledon. In the laboratory, the portions should be immersedin alcohol which should be flamed off before cutting with scissors or scalpeland smearing the cut surface on three plates of selective medium. Othersolid tissues can be treated in a similar manner, or, ideally, they should bemacerated mechanically following flaming before plating out. The tissuesmay be ground manually or homogenised in a blender or stomacher with asmall proportion of sterile water. Fetal stomach contents are collected, afteropening the abdomen, by searing the surface of the stomach with a hot spatulaand aspirating the liquid contents with a Pasteur pipette or syringe.

Bacterial colonies may be provisionally identified as *Brucella* on the basisof their cultural properties and appearance, Gram staining, and agglutinationwith positive antiserum.If available, a PCR-based molecularidentification method may be used.

1.6.2. Serological methods examination of brucellosis:

The detection of specific antibody in serum or milk remains the most practicalmeans ofdiagnosis of *Brucellosis*. The most efficient and cost-effective methodis usually the screening all samples using a cheap and rapid test which issensitive enough to detect a high proportion of infected animals. Samplespositive to screening are then tested using more sophisticated, specificconfirmatory tests for the final diagnosis to be made.It is absolutely essential that only internationally recognized tests usingantigens standardized against the 2nd International anti-*B. abortus* Serumare used. Appropriate quality control sera should be included with eachbatch of tests, and tests should be repeated if the quality control criteria arenot met.

Serological results must be interpreted against the background of the diseaseincidence, use of vaccination and the occurrence of false positive reactionsdue to infection with other organisms. As with all laboratory based diagnosis, it is imperative to correctly identify the “audit trail” of individual animalidentity, sample number and test result so that there is complete certainty ofthe linkage between animal and result.

1.6.2.1. Rose Bengal Plate test (RBT*)*:

The RBPT is one of a group of tests known as the buffered *Brucella* antigentests which rely on the principle that the ability of IgM antibodies to bind toantigen is markedly reduced at a low pH. The RBPT play a major role inthe serological diagnosis of *Brucellosis* worldwide.

The RBPT is a simple spot agglutination test where drops of stained antigenand serum are mixed on a plate and any resulting agglutination signifies apositive

reaction. The test is an excellent screening test but may be oversensitivefor diagnosis in individual animals, particularly vaccinated ones.The procedure can be automated but this requires custom-made equipment (Godfroid *etal.,* 2010)

1.6.2.2. ELISA tests:

The ELISA tests offer excellent sensitivity and specificity whilst being robust,fairly simple to perform with a minimum of equipment and readily availablefrom a number of commercial sources in kit form. They are more suitablethan the CFT for use in smaller laboratories and ELISA technology is nowused for diagnosis of a wide range of animal and human diseases. Althoughin principle ELISAs can be used for the tests of serum from all species ofanimal and man, results may vary between laboratories depending on theexact methodology used. Not all standardization issues have yet been fullyaddressed. For screening, the test is generally carried out at a single dilution.It should be noted, however, that although the ELISAs are more sensitivethan the RBPT, sometimes they do not detect infected animals which are RBPTpositive. It is also important to note that ELISAs are only marginally morespecific than RBT or CFT (WHO, 2006).

1.6.2.3. Serum agglutination test (SAT):

The SAT has been used extensively for *Brucellosis* diagnosis and, althoughsimple and cheap to perform, its lack of sensitivity and specificity mean thatit should only be used in the absence of alternative techniques(Godfroid *etal.,* 2010).

1.6.2.4.Complement fixation test (CFT):

The sensitivity and specificity of the CFT is good, but it is a complex methodto perform requiring good laboratory facilities and trained staff. If these areavailable and the test is carried out regularly with good attention to qualityassurance, then it can be very satisfactory.It is essential to titrate each serum sample because of the occurrence of theprozone phenomenon whereby low dilutions of some sera from

infectedanimals do not fix complement. This is due to the presence of high levels ofnon-complement fixing antibody istypes competing for binding to the antigen.
At higher dilutions these are diluted out and complement is fixed. Suchpositive samples will be missed if they are only screened at a single dilution.In other cases, contaminating bacteria or other factors in serum samples fixor destroy complement causing a positive reaction in the test, even in theabsence of antigen. Such “anti-complementary” reactions make the test voidand a CFT result cannot be obtained (Godfroid *etal.*, 2010)

1.6.3. Supplementary tests:

1.6.3.1Milk testing:

In dairy herds, milk is an ideal medium to test as it is readily and cheaplyobtained, tests can be repeated regularly and give a good reflection of serumantibody. Milk from churns or the bulk tank can be screened to detect thepresence of infected animals within the herd which can then be identified byblood testing. This method of screening is extremely effective and is usuallythe method of choice in dairy herds (WHO,2006).

1.6.3.1.1. Milk ring test:

The milk ring test (MRT) is a simple and effective method, but can only beused with cow’s milk. A drop of haematoxylin-stained antigen is mixed witha small volume of milk in a glass or plastic tube. If specific antibody ispresent in the milk it will bind to the antigen and rise with the cream to forma blue ring at the top of the column of milk. The test is reasonably sensitivebut may fail to detect a small number of infected animals within a large herd (WHO,2006). The same outher mention that non-specific reactions are common with this test, especially in *Brucellosis*freeareas. The milk ELISA is far more specific than the MRT.

1.6.3.1.2. Milk ELISA:

The ELISA may be used to test bulk milk and is extremely sensitive andspecific, enabling the detection of single infected animals in large herds inmost circumstances (Sekiya, M.*et al.*,2013)

1.6.4. Fluorescence polarization assay:

This technique, which requires special reagents and reading equipment, isclaimed to have advantages in sensitivity and specificity over other methods.

Evaluation has been limited however, and the procedure is not widely available.Further information is required before its overall value can be assessed.

1.6.5. Intradermal test examination of brucellosis:

This procedure, using a standardized antigen preparation such as BrucellinINRA or Brucellergene OCB, can be used for monitoring the status of herdsin *Brucellosis*-free areas. It is sensitive and specific but false positive reactionscan occur in vaccinated animals.

1.7. Prevention and control of animal Brucellosis:

The justificationsfor prevention of the introduction of *Brucellosis* into populationsrepresent in economic benefits and the protection of public health.

1.7.1. Prevention:

The measures of prevention for *Brucellosis*, involve:

Vigilant selection of replacement animals, where should originate from *Brucella*-free herds or flocks, as well aspre-purchase tests are necessary. Isolation of purchased replacements for at least 30 days followed by serologicaltest prior to commingling is necessary.

Prevention of contacts and commingling with herds of flocks of unknownstatus or those with *Brucellosis* and laboratory assistance should be utilized to diagnose causation ofabortions, premature births.

Testing of slaughtered animals with simple screening serological procedures such as the RBPT.And periodic milk ring tests surveillancefor herds and flocks in cattle (at least four times per year), and Disinfection of contaminated areas should be performed thoroughly andproper disposal (burial or burning) of placentas and non-viable (OIE,2006: Wernery, 2014).

1.7.2. Control:

The aim of an animal control programme is to reduce the risk of adisease on human health and the economic consequences. Control programs have an indefinite duration and will needto be maintained even after the "acceptable level" of infection has beenreached, so that the disease does not re-emerge(Thrusfield,2007).

Methodsfor the control of *Brucellosis*must be planed, monitored and appliied by official authorities/legislation.In control Programme certain principlesapply, i.e.: the reduction of exposure to *Brucella* spp. and theincrease of the resistance to infection of animals in the populations. In another words theseprocedures represent in isolation/slaughter, hygiene, control of animal movement, vaccination.

1.8. Test and isolation/slaughter:

Serological tests arethe usual method of identifying possible infected animals because there are no pathognomonic signs of *Brucellosis* in animals at individual level; one ofa strong indicator of infection in naive herds/flocks is the occurrence of abortion storms.

In most cases, test andslaughter of positive animals is only successful in reducing the incidence ifthe herd or flock prevalence is very low (e.g. 2%).

The immediate slaughter of test-positive animals is expensive and requiresanimal owner cooperation. Compensation is usually necessary. Furthermore, the application of test and slaughter policies is unlikely to be successfulwith *Brucellosis* of sheep and goats where the diagnostic tests are lessreliable than in

cattle. Test and slaughter is also unlikely to be successful incattle if the remainder of the herd is unvaccinated, especially in largepopulations. Repeated herd or flock tests are necessary to further reduce theincidence of *Brucellosis* and to confirm elimination.

1.9. Hygiene:

Owners are often poorly informed about disease transmission and recommendations, so the classical procedure in disease control such as the methods of animal husbandry, patterns of commerce, prevalence of clinical signs, type of facilities, and degree of dedication of the owners of animals, is the goal in the application of hygienic methods to the control of*Brucellosis*.

Antibiotic treatment of known infected animals, or of those which are potentiallyexposed to them, has not been commonly used and it should be ruledout as an option in the control of *Brucellosis* (CDC,2006).

1.10. Control of animal movement:

In practice, it is much more difficult to control the movement of camels and small ruminants kept under nomadic or semi-nomadic conditions than that of beef or dairy cattle kept under intensive conditions. The owners of herds and flocks may be accustomed to seasonal migrations which may cross national boundaries, but it is necessary in any programme to bound the spread of *Brucellosis*. Unauthorized sale or movement of animals from an infected area to other areas should be forbidden. As well asimportations into clean areas must be restricted to animals that originatefrom *Brucellosis*-free areas, that have a herd/flock history of freedom fromthe disease and that have given negative reactions to recently performeddiagnostic tests (OIE,2006).

1.11. Vaccination:

Vaccination of animals usually results in elimination of clinical disease and the reduction in numbers of organisms excreted by animals which become infected.

Furthermore, animal owners are more likely to accept vaccination as a method of control since they are accustomed to this form of disease control. In many countries, vaccination is the only practical and economical means of control of animal *Brucellosis*.

There is general agreement that the most successful method for preventionand control of *Brucellosis* in animals is through vaccination. While the ideal vaccine does not exist, the attenuated strains of *B. melitensis* strain Rev.1for sheep and goats and *B. abortus* strain 19 have proven to be superior toall others (Elberg and faunce., 1957). The non-agglutinogenic *B. abortus* strain RB51 has been used inthe USA and some Latin American countries, with encouraging results. Thesource and quality of the vaccines are critical. The dosages and methods of administration, especially with Rev.1, vary and these can affect the results.

Consequently, whole herd or flock vaccination can only be recommendedwhen all other control measures have failed. When applied, the vaccinatedanimals must be identified by indelible marking and continually monitoredfor abortions resulting from the vaccine. Positive serological reactors andsecretors must be removed from the herd on detection.It is often recommended that vaccination with strains 19 and Rev.1 shouldbe limited to sexually immature female animals. This is to minimize stimulationof postvaccinal antibodies which may confuse the interpretation of diagnostictests and also to prevent possible abortions induced by the vaccines. However,field and laboratory studies have demonstrated that conjunctival administrationof these vaccines makes the vaccination of the herd or flock a practical andeffective procedure. Rapid herd immunity is developed and application costsare minimized. The lowered dose results in lower antibody titres and theserecede rapidly. Several diagnostic tests have been developed which are usefulin differentiating antibody classes. Of these, the complement fixation testand ELISA are currently the most widely used (WHO/CDS/EPR/2006).

1.12. Eradication:

Eradication means the elimination of a pathogenic agent from a country or azone. A highly organized effort is needed to reach eradication in either aterritory and in a population. Eradication is conceptually very different fromcontrol,it's based on sanitary measures and on an organization ofactivities completely different from those implemented for a control programme(Thrusfield,2007).

Crucial factors for the success of an eradication programme are the implementationof an effective surveillance system with adequate laboratory support,and the understanding and sharing of objectives for eradication by thedecision-makers, farmers, and all other stakeholders. To keep an unaffectedpopulation free from an infection, prevention measures must be implementedto segregate an infectious organism from a geographical area and its humanand animal populations. Adequate knowledge of the local human and animalpopulations and of the territory is essential (WHO,2006).

On a longterm basis, eradication programmes in general are more economicallyadvantageous compared to control programmes. There is also little doubt that very often failures ofcontrol and eradication efforts are due to the absence of an adequate epidemiologicalsurveillance system sustaining both technical and politicaldecision-making(OIE, WHO, CDC,2006).

1.13. Surveillance of brucellosis in animals:

The unit of reference for animal surveillance is usually the infectedherd or flock rather than the individual animal.

Data from diagnosticlaboratory findings could be used as an animal *Brucellosis* surveillance system as well as outbreak/case investigations and slaughterhouse or animalmarketing tests, or specially commissioned local or national surveys. Thesedata can be used to ascertain flock or herd prevalence of a given populationor area, and in infected flocks or herds, the prevalence of the disease in theflock or

herd and to determine the incidence. An important use of incidencedata is the evaluation of efforts to achieve control or elimination(OIE,2006).

1.14. Intersectoral collaboration:

The zoonotic nature of *Brucellosis* necessitates close interaction between the public health authorities and the veterinary authorities;this collaborationis only the first step in establishing an effective control Programme. For asuccessful outcome, all sections of the community need to be involved inthe process and to lend their support (OIE,2006).

MATERIALS AND METHODS

2.1. The study area:

North Kordofan lies in the arid and semi-arid zones between latitude 11.15-16.45º N and longitude 27-32.15º E. It borders the Northern state in the north, Northern and Southern Darfur states in the west. West and South Kordofan states in the south, and The White Nile and Khartoum states in the east. Soil types are about 55% sand or gouze, 20% gerdud, 15% alluvial land and 10% clay land (Abdallah *et al.,* 2012).

2.2.Design of the study:

Cross sectional study was done for prevalence determination. Sample size was calculated according to the formula described by Thursfiled (2007) based on previous prevalence (%) of *camelbrucellosis* in the Sudan reported by 200 sample with 95% confidence interval and 5% desired absolute precision. To carry out this survey multistage random sampling was used.

2.3. Sample collection and Questionnaire survey:

A total of 230 serum samples were collected from individual animals which selected randomly.Thesamples were kept on ice container and transported as soon as possible to the ElObiedVeterinary Research Laboratory.

A questionnaire was designed to provide information about potential risk factors hypothesized to be associated with *brucella* in camel. The questionnaire included information about age, sex, locality, body condition score and breed of each camel sampled.

2.4. Buffered acidified plate antigen :

The test is prescribed by the OIE for international trade. It's a quick easy presumptive test to start with in order to exclude negative samples from further serological testing.it's a secondary binding qualitative plate agglutination test that uses a colored acidified antigen (pH3.8)to inhibit non-specific reactions due to IgM and enhance the agglutination ability of specific IgG1.

2.4.1.Material needed for the test are:

Standard BAPA test antigen,Control sera (negative, low positive and high positive)., Adjustable pippete, with disposable tips ,Minnesota testing box with glass plate, (illuminator with indirect light source, black back ground, and lid to prevent evaporation of test materials,Stirrer \spreader and Paper towel

2.4.2. The tests procedures:

The samples and antigen were allowed to come to room temperature. 20,40, and 80µl of each sample were measured on the center of the glass plate of the Minnesota testing box. Knownhigh positive, control was included in each day's work. 30 µl of BAPA antigen wasadded to each quantity of serum mixng the antigen bottle thoroughly by gentle shaking and inversion to ensure a homogenous suspension. The sample and antigen were mixed thoroughly using a stirrer enlarging the circle of the mixture to about 2cm in diameter. (the Spreaders was rinsed in water and wiped dry between samples). The glass plate was titled in a circular motion for 4 rotations and were left for 4 min in the Minnesota box with the lid covered and were not switched on . The test was waited until reading. Rotated 4 times again, incubated for another 4 min in the box and finally rotated 4 further rotations.

2.4.3. Reading of the results:

The reactions were red immediately against the illuminated background of the Minnesota box. Any visible agglutination within 8 minuteswas considered positive. No agglutination within 8 min was negative.

Results	Interpretation
No agglutination	-ve
agglutination	+ve

(CVRL, 2014)

2.5. Rose Bengal plate test:

The simple rapid test that prescribed by the OIE for international trade and control campaigns.

2.5.1. Materials:

Rose bengal antigen, Positive and negative control serum, Glass plate, polyethylene plate or enamel, Stirring sticks or tooth picks.

The serum sampls were brought a room temperature.

2.5.2. The test procedure:

Equal volumes (20 µl) of RBPT colored antigen and the test serum were mixed on a clean glass slide with the help of a clean sterile

Shake for 4 minutes and read immediately.

2.5.3. Reading of the results:

No agglutination	-ve
agglutination	+ve

(CVRL, 2014)

2.6. Data management and analysis:

The data were entered into Excel spread sheets, statistical analysis of collected data were carried out with the computer application SPSS version 20 by using

Pearson’s chi-square and to test total prevalence and the existence of differences in prevalence between risk factors.

RESULTS

Overall prevalence of brucellosis in camels by the RBPTwas 51 of 230 (22.2%) serum samples positive by the RBPT (51), by the PABA were subjected to further confirmation using PABA were found positive with an overall prevalence 14.8% .

3.1. Analysis of risk factors:

3.1.1. Age factor:

The result of a different age groups of camelspositive for brucllosis, 12 out of 84 (14.3%) young camel, 18 out of 118 (15.3%) adult camel and 4 out of 28 (14.3%) old camels. By the Chi-squared test, the result showed that there was no association between *camel brucellosis* and the age of animal (x^2= 0.043; P = 0.979) (Table.3)

3.1.2. Sex factor:

Male animals had higher prevalence of23 of 123 (18.7%) than the females 11 of 107 (10.3%).

There was no significant relationship in *brucella*infection between male and female (x^2= 3.219; P =0.07) (table.3)

3.1.3. District factor:

The highest prevalence reported in, Sheikan, Bara and Umkredem was followed 15 of 82(18.3%), 13 of 74 (17.6%) and 6 of 36 (9.5%), respectively.However, camels in umrowaba were negative for brucellosis .No association was found between *brucella* infection and the origin camels (x^2= 4.549; P = 0.20)(table.3).

3.1.4. Breed factor:

The prevalence of *camel brucellosis* in camels in North Kordofan state was20 of 183(10.9%), and 14 of 47 (29.8%) from Darfur breed were positive.

The Chi square test showed there was significant association between *camel brucellosis* infection and breed (X^2=10.557: p-value=0.001)(Table.3)

3.1.5. Body condition score factor:

Regarding body condition score (BCS), 1 of 24(4.2%) camels of poor body condition, 14 of 102(13.7%) camels of moderate body condition and 19 of 104 (18.3%) camels good body condition were positive for brucellosis.

No statistical significant association was observed between categories of body condition and camel brucellosis (x^2= 3.241; P= 0.19) (Table.3).

3.1.6. Grazing factor:

In relation to grazing, 27 of 178 (15.2 %) camels from mixed grazing were positive and 7 of 52 (13.5%) were positive for came *brucellosis*. No association was observed between the grazing factor andcamel *brucellosis* (x^2= 0.093; P= 0.76) (Table.3).

Table: 2: Summary of univariate analysis for risk factors associated with camel brucellosis in North Kordofan State, (n=230) using the Chi-squared test. (RBPT test)

Risk factor	**No. tested**	**No. positive (%)**	**Df**	**x^2**	**p- value**
Age					
Young	84	16(19.0)	2	0.879	0.64
Adult	118	29(24.6)			
Old	28	6 (21.4)			
Sex					
Female	107	21 (19.6)	1	0.753	0.38
Male	123	30 (24.4)			
Locality					
Sheikan	82	26 (31.7)	3	9.737	0.021*
Umrowaba	11	-			
Bara	74	16 (21.6)			
Umkredem	63	9(14.3)			
Grazing					
Mixed	178	35(19.7)	1	2.877	0.09
Non mixed	52	16(30.8)			
BCS					
Poor	24	3(12.5)	1	4.010	0.13
Moderate	102	19 (18.6)			
Good	104	29 (27.9)			
Breed					
Alarabi	183	36(19.7)	1	3.248	0.07
Darfour	47	15 (31.9)			

* = highly significant

Table: 3: Summary of univariate analysis for risk factors associated with camel brucellosis North Kordofan State, Sudan (n=230) using the Chi-squared test. (BAPA test)

Risk factor	No. tested	No. positive (%)	Df	x^2	p- value
Age					
Young	84	12(14.3)			
Adult	118	18(15.3)	2	0.043	0.979
Old	28	4 (14.3)			
Sex					
Female	107	11 (10.3)	1	3.219	0.07
Male	123	23 (18.7)			
Locality					
Sheikan	82	15 (18.3)			
Umrowaba	-	-	3	4.549	0.20
Bara	74	13 (17.6)			
Umkredem	36	6(9.5)			
Grazing					
Mixed	178	27(15.2)	1	0.093	0.76
Non mixed	52	7(13.5)			
BCS					
Poor	24	1(4.2)			
Moderate	102	14 (13.7)	2	3.241	0.19
Good	104	19 (18.3)			
Breed					
Alarabi	183	20(10.9)	1	10.557	0.001*
Darfour	47	14 (29.8)			

* = highly significant

DISCUSSION

Despite the advances made in surveillance and control, the prevalence of *brucellosis* is increasing in many developing countries due to various sanitary, socioeconomic, and political factors (Pappas *et al.,* 2006). In camel, *brucellosis* is common and its prevalence is higher in intensive camel production systems (Abbas and Agab, 2002). The disease circulates in different species of animals including camels due to mixed herding practices, (Al-Majali *et al.,* 2008).

In this study the prevalence of the diseases by two serological camels using the RBPT was 22.2%, while it was 14.8% by use PABA.The RBPT is widely used in Sudan for *brucella* screening for regulatory control and for export requirements. Although the test is very sensitive and is suitable for screening herds, it can give false positive results due to vaccination with *B. abortus* strain 19 vaccine or for cross reactions with other bacteria (OIE, 2004).

Several factors were investigated as potential risk factors at individual level. Those included: locality, age, sex, BCS, breed and grazing. The questionnaire-based information collected during this study indicated that several factors could be considered as potential risk factors for the disease.

The prevalence of Brucellosis in this study was almost similar to that reported by Musa *et al* (2008), who reported a prevalence of 23.8% in camels kept with other ruminant species. Solafa Zein El abdin *et al.,*(2014) reported 20% prevalence in Jabel Aolia Locality. Dawood (2008) reported 19.4% prevalence in Jordan. However El-boshy (2009) in Egypt reported(7.3%) prevalence of brucellosis. Zewold and Haileselassie (2012) examined 768 camel serum samples for *brucellosis* and found 11.9% positive reactors by the RBPT. The differences in the prevalence of *brucella* incamelsfrom different countries may be attributed to different husbandry and management practices.

According to the this study, higher seropositivity was recorded in camels with good BCS (18.3%) followed by moderate (13.7%) and poor (4.2%). This could be attributed to variation in sample sizes.In the present study, the prevalence of *brucellosis* was evident in the male more than female animals, and this contradicted with the result of Bayemi *et al.*,(2009). Females are generally kept for longer period of time than males and this is likely the cause of increased opportunity for exposure to brucella (Mekonnen *et al.*, 2010). Relatively higher vulnerability of female animals could also be that females are more physiologically nervous than male animals (Walker, 1999).

Brucellosis infection may occur in camels of all ages but more persistent in sexually mature animals (Abubakar *et al.*, 2010). The study reveals higher infection rate in adults (15.3%) followed by young and old with prevalence 14.3% in both. Similarly, younger animals have a tendency to be resistant to *brucellosis* and frequently clear infections although latent infections may occur. This can also be attributed to sex hormones that have a propensity to increase in concentration with age and sexual maturity and promote growth and multiplication of *Brucella.*

The camels in Sheikan locality were more seropositive (18.3%) than the camels in the other districts. This may be attributed to the close contact of livestock species, lack of herd health program, disorganized management system, frequent induction of high yielding animals without quarantine, higher population density of livestock and shared grazing and marketing along with poor management practices adopted narrow locality comparing to the rest locality.

In the present study, the animals in mixed grazing had higher prevalence rate (15.2 %) of*brucellosis* than non-mixed grazing (13.5%). it was well documented that the disease is transmitted betweeen species (Dawood, 2008) and these findings are in accord with previous reports of higher prevalence levels in camels kept along with large and small ruminants (Abou-Eisha, 2000; Al-Majali *et al.*, 2008).

CONCLUSION

Based on the result an overall prevalence of *brucellosis*in camelinfection in North Kordofan state by RBPT was 22.2% while by PABA test is 14.8.

Also the study showed high prevalence of *brucellosis* in camels in male than female.

Furthermore, the highest prevalence was recorded in Sheikan,Bara and Umkredem.

A significant correlation was observed between the brucellosis incamel and breed factor in this study.

Recommendation

- A study should beconducted of for a longer period of time to confirm morefacts.
- More studies should be done on brucellosisin different animals in different states to determine the rate of spread of disease.

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