Sudan University of Science and Technology

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Prevalence and Risk Factors of Camel brucellosis in ElgadrrIf State of Sudan.

نسبة الاصابة وعوامل الخطر لمرض البروسيلا في الأبل

بولاية القضارف – السودان

By

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Table of contents

List of Table

Acknowledgment

to almighty Allah

to prof. Dr . Mohamed Abdelsalam Abdalla

to prof. Abdelhamid A. M. Elfadil

To my Father's & prof. Ahmed Ali Spirits

to staff of the Gedarrif state laboratory

To my Mother

To my Brothers & Sisters

To my Colleague & To my Friends

Nesreein

Abstract

Across- sectional study was carried from April 2015 to October 2015 to determine the prevalence of, and to identify Risk factor for Brucellosis infection in camels (Camelus dromedarius) in Gadarrif State, Sudan.

A total of 252 camels from 60 camel herds were included in this study, The Study was conducted in four selected locality in Gadarrif State. From Algadarrif (109), Butana (93), Wast Algadrrif (15), and Alshwak (35) Localities. Of these,

8.4 % (215 out of 252), and 13.5% (37 out of 252) were female and male camels respectively.

Atotal of 252 samples were collected and screened by and Rose Bengal Plate Test (RBPT). Among these, 23 were positive giving an individual prevalence rat of (9.2). This Study show that the occurrence of the disease was slightly higher in Algadarrif (89.o %), Butana (89.2%), and Alshwak (92.1%) (P<.25). Seroprevalence of Brucella in male 13.6% relatively higher than that of female camels which was 8.4%. also the disease was slightly higher in Arabi(11.1%) ,Anafi (9.7%) , and Bushari (2.9%) (OR=.270; 95% CI: .034 to 2.160, P=.143) . Immature camels had asignificant higher than adult

, this Study the Seroprevalence of Brucella was higher in Age (1-5 years) 28.0%, (>11 years) 9.1%, and in (6-10 years) 6.2%. there was also significant increasing Seropositivity with respect to increasing herd size (P>0.25) Seropositivity was large herds (>70) 10.6% , in moderate herds(<50) 4.8% ,and small herds (<20) 3.1% .

Mixed camels with other ruminants showed significant of camels Brucellosis (P> o.25). Camels reared with other ruminants showed Seroprevalence of 14.3% which was higher than that in camels kept alone 7.9%. (OR=8.693; 95% CI: .656 to 11.258, P=.162)

Also Study showed Seropositivity of aborted camels were 81.8% which was highest than other one was not aborted camels 2.2% (OR= .002; 95% CI: .000 to.017, P=.000) . and Seropositivity Inbreeding camels 11.2% Compared with the marketing camels 4.9% locality, Body condition were not found significantly associated with brucellosis (P>0.25) in the Univariate analysis.

Multivariate analysis showed that abortion higher significantly (Exp .000 - .017, P-value .000).

The results of the present study provide the status of Seropositivity to Brucella in camels in Algadarrif and the risk factors that contribute to Seropositivity in dromedaries and showed that brucellosis is widely distributed disease among camel herds in Algadarrif State.

ملخص البحث

إجريت دراسة مقطعية من شهر ابريل 2015 الي اكتوبر 2015م ،لتحديد مدى إنتشار مرض البرسيلا في إلابل وتحديد عوامل الخطر للاصابة بداءالبروسيلا في إلابل بولاية القضارف ،السودان.

وقد ادرجت مجموعة 252 من الابل في60 من القطعان في الدراسة من القضارف(109) البطانة(93) وسط القضارف (15)ومن الشواك (35)ومن القطيع اناث (215) بنسبة % 8.4 وذكور(37) بنسبة13.5%.

تم فحص جميع عينات بواسطة الروز بنقال (23 عينه) كانت إيجابية للإختبار . واظهرت الدراسة ان وقوع هذا المرض كان هنالك ارتفاع طفيف في محلية القضارف (89.0) ومحليةالبطانة (89.2) والشوا ك (92.1) (P>0.25) وقد كان الفرق معنويا في الانتشار المصلي في الابل الاناث كانت (8.4%) والذ كور (13.6%) .

وكانت هنالك زيادة في نسبة الاصابة في سلالة الابل العربي 11.1% ويلية العنافي بنسبة 9.7% ثم البشاري 2.9%.

(OR=.270; 95% CI: .034 to 2.160, P=.143)

كمااظهرت الدراسة ايضا ان نسبة الاصابة في الاعمار الصغيره من 1-5 سنوات 28.0%كانت مرتفعه مقارنة مع الاعمار من 11 سنوات كانت 9.1% و في الاعمار 6-10سنوات كانت6.2%.وسجلت القطعان الكبيره نسبة اصابة مرتفعه 10.6% من القطعان المتوسطة 4.8% ثم القطعان الصغيرة 3.1%.

كانت نسبة الاصابة في الابل ذات الحالات الصحية الجيدة 9.8% وفي الحالات الردئة 6.2 وكانت هنالك زيادة كبيرة في الاصابة الابل المخالطة للمجترات الصغيرة 14.3% مقارنة مع الابل الغير مخالطة 7.9%. كما اظهرت الدراسة ان نسبة الاصابة في الاناث المجهضة مرتفعة جدا 81.8% مقارنة مع الاناث الاخري 2.2% (OR= .002; 95% CI:.000 to.017, P=.000) . واثبت الدراسة ان نسبة الاصابة في المواليد لابل من داخل القطيع11.2% وفي الابل خارج القطيع 4.9%.

(OR=1.308; 95% CI: .199 8.591, P=.104)

نتائج هذة الدراسة توضح حالة انتشار مرض البرسيلا في الابل بولاية القضارف وعوامل الخطر التي تسهم في انتشار المرض بين القطعان الابل في ولاية القضارف .

Introduction

Brucellosis is an infectious disease of domestic and wild animals with serious zoonotic and economic implication in humans. The disease is an important public health problem in many parts of the world *(*Pal, 2007; Hadush and Pal, 2013). The disease in dromedary camels can be caused by *Brucella abortus, Brucella melitensis* and *Brucella ovis* (Seifert, 1996). Different studies showed that *B. abortus* and *B. melitensis* are the most frequently isolated from milk, aborted fetus and vaginal swabs of diseased camels (Radwan et al., 1992; Gameel et al., 1993; Agab et al., 1994; Abou-Eisha, 2000; Hamdy and Amin, 2002) and the transmission of brucellosis depends on the *Brucella* species being prevalent in other animals sharing their habitat and on husbandry (Musa et al., 2008).

Camels are not known to be primary hosts of *Brucella*, but they are susceptible to both *B. abortus* and *B. melitensis*. Consequently, the prevalence depends upon the infection rate in primary hosts being in contact with them. Brucellosis may spread from camels to humans, especially via milk. Therefore, the zoonotic risks from camel milk must be considered in view of the traditional African and Arabian preference for raw milk consumption (Cooper, 1991). Groups at high risk for brucellosis are animal health workers, butchers, farmers, and those who habitually consume raw camel milk and come in contact with these animals (Chukwu, 1987).

The uncontrolled movement of camel from infected herds or area to *Brucella* free herds or areas is the major obstacles in brucellosis eradication program (Radostits et al., 2007). Other management factors influencing inter-herd transmission are proximity to infected herds, water ways, and scavengers. Vaccination level, herd size, population density, methods of housing, and use of maternity pens also influence the probability of exposure to the infection (Crawford et al., 1990).

The disease can generally cause significant loss of productivity through late first calving age, long calving interval time, low herd fertility and comparatively low milk production, as in cattle may also happen in camels. The disease can also have an impact on export and import of animals constraining livestock trade (Radostits et al., 2007).

Africa hosts 80% of the world population of dromedary (16.5 million) of which 63% are attributed to East Africa (Wilson, 1998). Camels are a subset of huge livestock resources in Ethiopia with the population estimated to be over one million. This number ranks the country third in Africa after Somalia and Sudan and fourth in the world.

Therefore, the present study was contemplated to determine the seroprevalence and associated risk factors of camel brucellosis in selected districts of Algadarrif State of Sudan.

Objectives of this study

1. To estimate the prevalence of camel brucellosis in Algadarrif State.
2. To Investigate the risk factors association with the disease.

Chapter One

1.1. Literature Review:

1.1.1. Taxonomy and Distribution of the Camels (Dromedaries)

In zoological taxonomy, camelids are classified in the suborder Tylopoda (pad-footed animals) that represents with the suborders Suiformes (pig-like) and Ruminant (ruminants) the order Artiodactyla (even-toed ungulates). This makes obvious that camelids (family Camelidae) as ruminating animals are classified in proximity to ruminants but developed in parallel and are not part of the suborder Ruminant. Some differences as foot anatomy, stomach system and the absence of horns underline this fact (SCHWARTZ & DIOLI, 1992; FOWLER, 1998; WERNERY, 2003).

The family Camelidae is divided into three genera: The old world camels (genus Camelus) and the new world camels (genus Lama with the species L. glama, L. guanicoe, L. pacos and genus Vicugna with the species V. vicugna) (WILSON & REEDER, 2005). In the older literature (e. g. LEGEL, 1990) sometimes only two genera (Camelus and Lama) have been described.Two domesticated species of old world camels exist: the dromedary or one humped camel (Camelus dromedarius, Table 2.1) that has its distribution in the hot deserts of Africa and Asia and the Bactrian or two-humped camel (Camelus bactrianus) that can be found in the cold deserts and dry steppes of Asia. In the desert Gobi there is still a population of wild two-humped camels classified as Camelus ferus (RAO et al., 1970; PETERS, 1997; FOWLER, 1998).

The Bactrian camel was named after the area of Bactrian in Central Asia. The name of the dromedary has derived from the Greek word “dormouse” which means runner or “droma” - running (JASSIM & NAJI, 2002). The one-humped camel was probably domesticated in the region of today’s Yemen and Oman about 3.000 to 4.000 years ago (FOWLER, 1998).

1.1.2. The wild Arabian camel became extinct (LENSCH, 1999).

Table 2.1: Genealogy of the dromedary camel (WILSON, 1984)

Order	Artiodactyla (even-toed ungulates)
Suborder	Tylopoda (pad-footed animals)
Family	Camelidae
Subfamily	Camelinae
Genus	Camelus
Species	*Camelus dromedarius*

Camel breeds are not as differentiated and classified as breeds in other livestock. Systematic selection for productive traits has never been done in camels, except for racing animals (KAPPELER, 1998). Nevertheless, there are different breeds used for different purposes like riding, meat or milk production. Dromedaries for riding are daintier compared to burden dromedaries whose body can vary from small to tall, but is always of heavy weight (BURGEMEISTER, 1974). The breed most common in the UAE is the 'Al-Khawar' breed. It is mainly known for its racing performances but also bred for milk production. (CIRAD, 2006). The weight of a riding or light burden dromedary is given with approximately 400 kg (FARAH, 2004). In the following, the term "camel" without further details will be used exclusively for dromedary camels.

Camel population in the world According to FAO statistics (Global Livestock Production and Health Atlas - GLIPHA, 2006) the world population of camels is about 20 million animals, mainly in arid zones, of which 15 million camels live in Africa and 5 million in Asia (GLIPHA, 2006). In 2001, the total camel population was 19 million of which 17 million were dromedarie (C. dromedarius) and 2 million were Bactrian camels (C. bactrianus) (FARAH, 2004). In most countries, the camel population is increasing after a period of decreasing number due to the introduction of modern transport facilities (FARAH, 2004). An overview is given in Tables(2.2) and (2.3.)

Table(2.2) Development of the dromedary population in some countries in Asia (GLIPHA, 2006)

Count (n)			
Asia			
	1995	1999	2003
Afghanistan	201.000	290.384	175.000
Bahrein	900	915	920
India	1.030.000	820.000	900.000
Iran	143.000	143.000	146.000
Iraq	5.400	8.500	7.600
Israel	5.000	5.300	5.300
Jordan	18.000	18.000	18.000
Kuwait	3.400	3.600	9.000
Lebanon	490	450	440
Oman	94.400	117.000	124.700
Pakistan	1.1000.000	800.000	800.000
Qatar	48.483	50.305	51.000
Saudi Arabia	421.700	255.475	260.000
Syrian Arab Republic	6.711	13.330	13.500
Turkey	2.000	1.400	900
UAE	158.264	207.446	250.000
Yemen	231.000	246.000	264.000

Table(2.3): Development of the dromedary population in some countries in Africa

(GLIPHA, 2006)

Africa	Count (n)		
	1995	1999	2003
Algeria	126,350	220,000	245,000
Burkina Faso	13,300	14,473	15,600
Chad	613,450	715,000	730,000
Djibouti	64,010	67,790	69,000
Egypt	131,000	134,000	120,000
Eritrea	71,000	75,000	75,000
Ethiopia	340,000	527,340	326,500
Kenya	787,700	811,500	830,000
Libyan Arab Jamahiriya	101,000	42,000	47,000
Mali	292,000	466,900	470,000
Mauritania	1,113,000	1,206,000	1,292,000
Morocco	37,000	36,000	36,000
Niger	380,000	404,000	420,000
Nigeria	14,881	18,000	18,000
Senegal	5,000	4,000	4,000
Somalia	6,100,000	6,925,500	7,000,000
Sudan	2,903,000	3,031,000	3,200,000
Tunisia	231,000	231,000	231,000

1.1.1.3. Economical Importance of Camels

As dromedaries are very drought tolerant, they thrive in arid zones of many countries in the world and provide food, hides and transport. Therefore, there has developed an increasing interest in dromedary in arid countries, where other domesticated animals have difficulties to survive. Camels can graze on low productive pastures on which the production of milk is possible and

economically profitable. For this reason, camels may reduce the dependence of pastoralists on other livestock that is usually much more vulnerable to drought than camels (Farah and Fischer 2004).

Camel milk is one of the most valuable food resources for nomads in arid regions and can contribute to a better income for pastoralists, as in the last year's milk consumption among the urban population increased (Farah and Fischer 2004).

Camel milk possesses superior keeping quality to cows' milk due to its high contents of proteins that have inhibitory properties against bacteria. This makes raw camel milk a marketable commodity, even under conditions of high temperatures. Zoonotic risks from camel milk must be considered in view of the traditional preference for raw milk consumption.

Besides milk, meat is one of the most important products of camels. It compares favorably with other livestock in yield and quality of the carcasses but camels are still not systemically bred for meat production in many regions as camels are considered too valuable for this production type. Usually males and infertile female camels are sold as slaughter animals by pastoralists. Nevertheless, saling these animals for meat production can present an important source of income. There has been an increasing demand of camel meat in people and societies that do not breed camels, thus leading to a higher number of camel abattoirs and butcheries in several countries that mainly slaughter young animals (Farah and Fischer 2004; Finke, 2005).

Another important product is camel wool. It is one of the world's most expensive natural animal fibers. In some countries, camels are kept in the backyards of cities to gain wool, besides milk and meat. An adult camel usually produces 2 – 3 kg per shearing (Wernery, 2003). Camel hides are known for their strength and durability. They are used by camel breeders, but also as fashion accessories (Wernery, 2003). Other products used are dung as fertilizer

and source of fuel for pastoralists and bones for production of jewellery or bone-meal for fertilizing purposes.

In spite of its vital importance, studies about camels are very few due to the fact that camel production is in remote, migratory and poor infrastructure condition. Available studies were based on small animal numbers (Schwartz and Dioli, 1992). Published information on diseases revealed that camels may be either carrier, susceptible or suffering from a vast array of infectious and parasitic diseases. Some of these diseases such as brucellosis have considerable public health importance.

Brucellosis was reported in camels as early as 1931 (Solonitsuin, 1949).

1.1.1.5. Brucellosis

1.1.1.5.1. Definition of the disease

Brucellosis is an infectious, contagious , and worldwide spread of an important zoonosis disease caused by bacteria of the genus Brucella . In animals , the disease primarily affects camle , cattle sheep , goats , swine , and doge , and the characterized by abortion or infertility and also affects people and other animals species , the disease is characterized by intermittent fever , chills , sweating , headache , myaliga , arthralgia and adiversity of nonspecific symptoms

(Tun,2007).

1.1.1.5.2. Zoonoses

Five out of the nine Know Brucella species can infect humans and the most pathogenic and invasive species for human is B.melitensis ,followed in descending order by B.suis. B.abortus and B.canis(Acha et al.,2003) The zoonotic nature of the marine brucellae (Brew et al .,1999.,McDonald et al .,2006.,Sohn et al.,2003).

B.melitnsis B. suis and B.abortus are listed as potential bio-weapons by the centers for disease control and prevention in the USA.this is due to the highly

infectious nature of all these species , as they can be readily aerosolized. Moreover ,an outbreak of brucellosis would be difficult to detect because the initial symptoms are easily confused with those of influenza(Chain et al .,2005).

In places where brucellosis is endemic ,humans can get infected via contact with infected animals or consumption of their products,mostly milk and milk products especially cheese made from unpasteurized milk of sheep and goats and rennet from infected lambs and kids .some specific occupationl groups including farm workers, veterinarians ,ranchers, and meat –packing employees are considered at higher risk (Tabak et al ., 2008).B.abortus and B.suis infection usually affect occupational groups, while B .melitensis infections occur more frequently than the other Brucella species in the general population(Acha et al.,2003.,De Massis et al ., 2005).consumption of sheep or goat milk containing B.melitensis is an important source of human brucellosis worldwide and has caused by B melitensis(De M assis et al., 2005.,Wallach et al .,1997).The prevalence of the human brucellosis acquired from dairy products in some countries is seasonal ,reaching apeak usually after kidding and lambing (Dahouk et al.,2007)

In countries where milk and dairy products are always pasteurized befor consumption ,brucellosis principally affect persons who are in close contact with animals and animals products.

Although Brucella is considered highly infectious when encountered via the respiratory rout (e.g 10 bacteria required for infection, in mice), inhalation of Brucella is not a common route of the infection, but it can be significant hazard for people in certain occupational such as those people working in laboratory acquired pathogens ,and they are estimated to account for up to 2% of all laboratory –associated infections (Menseet et al .,2001,. Olle-Goig and Canela-Soler, 1987,. Robichaud et al,m2004)

Table (2 .4) Zoonotic potential and host preference of brucella species

Species	*Zoonotic potential*	*Host preference*
Brucella melitensis	*High*	*Sheep ,goat*
Brucella abortus	*Moderate*	*Cattle*
Brucella suis	*Moderate*	*Pig*
Brucella canis	*Mild*	*Dog*
Brucella ovis	*Absent*	*Sheep*
Brucella neotomae	*Absent*	*Desert wood rat*
Brucella ceti	*Mild*	*Cetaceans*
Brucella pinnipedialis	*Mild*	*Seals*
Brucella microti	*Absent*	*Common voles*

1.1.1.5.3. Economic Importance of Brucellosis

Brucellosis is characterized by abortion, non-viable off spring in female, orchitis and epididymitis in male animals (Seifert, 1996; Radostits et al., 2007). Abortion is the major feature that is manifested in camels (Al-Khalaf and El-Khaladi, 1989). The disease is also associated with infertility and prolonged calving intervals, and has considerable impact on camel production. Epididymitis, chronic inflammation of the joints, tendon sheath and synovial bursa especially at the carpus may also occur in camels (Abbas and Agab, 2002; Wernery and Kaaden, 2002).

The disease can generally cause significant loss of productivity through late first calving age, long calving interval time, low herd fertility and comparatively low milk 10 production (Radostits et al., 2007). The disease can also have an impact on export and import of animals constraining livestock trade.

Abu damir et al. (1989) experimentally infect six camels with two strains of B. abortus, four with S 19 and two with a field bovine strain. They observed that none of the infected camels had any inflammatory reaction at the site of inoculation or any clinical signs during the experimental period. However, camels that inoculated with the bovine field strain showed transient, slight

clinical signs including a reduced appetite, a reluctance to rise in the morning, slight lameness with hot coronets,
bilateral lacrimation and intermittent pyrexia. Furthermore, camels showed very early serological response by RBT, SAT and CFT. They also added that B. abortus had atendency to localize in the lymph node especially those of the head and genital tract.

Afzal and Sakkir (1994) suggested that subclinical brucellosis can pose problems in racing camels by reducing their performance and productivity in the Arabian Peninsula where camel racing is highly popular.

1.1.1.5.4. Public Health Importance of Brucellosis

Brucellosis in humans represents a major public health hazard, which affects social and economic development in various countries. Animal health workers, butchers, farmers, and those who are habitually consume raw milk and come in contact with animals are at high risk for brucellosis (Chukwu, 1987). In man, transmission occurs as a result of ingestion of milk, contact via skin abrasion, mucous membranes and inhalation (Seifert, 1996; Radostits et al., 2007).

Masoumi et al. (1992) recorded a higher prevalence among butchers and people who habitually consume raw milk. Camel keepers consume camel milk as well as liver without heat treatment (Gameel et al., 1993). There is also a close contact between herdsmen and the animal during watering, grooming, riding, nursing sick ones and delivery assistance (Abbas et al., 1987). The isolation of the two major pathogenic Brucella species B. melitensis and B. abortus, from milk and other samples of camel origin (Gameel et al., 1993; Agab et al., 1994; Hamdy and Amin, 2002) clearly indicate the potential public health hazards of camel brucellosis (Straten et al., 1997). The disease in man may be misdiagnosed due to the prevailing malaria infections in dry areas (Abou-Eisha, 2000; El-Ansary et al., 2001).

1.1.1.5.5. Epidemiology of Camel Brucellosis

Brucellosis in animals causes tremendous economic losses due to abortion, premature birth, decreased milk production, reduced fertility and cross transmission to other animal species, the zoonotic potential of the disease in camels should not be overlooked.

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). Brucellosis is caused by Gram negative coccobacilli of the genus Brucella which are facultative intracellular. They can survive within host cells causing a chronic disease that may persist throughout the life time of the animal. Camels can be infected by B. abortus and B. melitensis. The appearance of brucellosis depends on the Brucella species being prevalent in other animals sharing their habitat (cross transmission between species) and on the husbandry system (Musa et al., 2008). A close contact between infected and susceptible camels in a herd promotes the spread of diseases.

The camels are always herded together with sheep and goats and to a lesser extent with cattle and they share the same watering points and pastures, and so it is not surprising to find a higher incidence of the disease among camels (Teshome et al., 2003).

The differences in the prevalence of camel brucellosis from different countries may be attributed to varying husbandry and management practices, the number of susceptible camels, the virulence of the organisms, presence of reactor animals in the region, absence of veterinary service, lack of awareness about the disease in camels and continuous movement of infected camels into a susceptible camel herd (Radostits et al., 2007). Although parturition in she camels is generally occurred in a laying or standing position without extra help (Mugerwa, 1981), they may deliver or abort on the pasture and the aborted material may spread over a wide area of the pasture by stray dogs and foxes

Teshome et al. (2003). Camels may take up bacteria via the alimentary tract from contaminated feed or water, via the respiratory system with contaminated dust or droplets or via the genital system from infected semen (Kudi et al., 1997).

Recently, Musa et al. (2008) reported higher prevalence of brucellosis (23.8%) from camel kept mixed with ruminant species; they suggested that cattle were the possible source of infection for the camels as small ruminants were seronegative. Seroprevalence of camel brucellosis appear to follow two distinct patterns a low prevalence below 5% in nomadic or extensively kept camels and high prevalence 8–15% in camel kept intensively or semi intensively (Abbas and Agab, 2002).The infection is caused by different biotypes of B. abortus and *B. melitensis*. Bitter (1986) examined 948 camels from different herds in eastern Sudan and reported a prevalence of 16.5–32.3%. Musa (1995) examined 416 camels from seven herds from western Sudan owned by nomads he found a 23.3% prevalence rate and concluded that camels ranked second only to cattle in the rate of infection with brucellosis.

Spread of brucellosis in camels depends on the Brucella species prevalent in other animals sharing their habitat and on the husbandry methods of the different species.

Several researchers have evaluated different serological tests (RBT, CFT, Serum Agglutination Test (SAT), Indirect Enzyme Linked Immunosorbent Assay (iELISA), Competitive Enzyme Linked Immunosorbent Assay (cELISA), and Mercapto-ethanol test (2ME) for the diagnosis of camel brucellosis (Azwai et al., 2001; Abdel Moghney, 2004; Alshaikh et al., 2007). With the development of commercial camel dairies in several countries, this disease should be seriously considered because of its impact on human health.

Unfortunately, till now, there are no studies on vaccination or eradication strategies of camel brucellosis (Tibary et al., 2006).

However, the options to control brucellosis included immunization, testing and removal, and improving management practices and movement control (WHO, 1997; Wernery and Kaaden 2002).

Control of camel brucellosis should suite the conditions of the particular country where camels are raised. Vaccination of uninfected animals is generally considered the most effective and economical means of protecting livestock against brucellosis. Consequently, vaccination was performed on all negative reactors immediately after the third serological testing, to avoid the possible presence of carrier animals (Radwan et al., 1995). In most of the developing countries by pastoralists, brucellosis prevalence is low. Thus control by herd immunization and vaccination of calves at 4 to 8 months of age is helpful using S19 or Rev 1 vaccinal strains preceded by blood testing using the SAT or card test on the field. Seropositive animals should be identified and subjected to retesting. Additionally, test and slaughter policy can be followed in countries where intensification is practiced (Abbas and Agab,2002).

In conclusion, camels play an importance role in the epidemiology of brucellosis; the possibility that brucellosis may spread from camels, especially through milk and the lack of current and detailed epidemiological study of the disease in camels strongly calls for a reassessment of the prevalence of the disease. This will allow an effective control program to be designed and serve as a baseline for further research

1.1.1.5.6. Etiology

Brucellae are Gram-negative , facultative intracellular bacteria that can infect many species of animals and man . six species are recognized wihin the genus Brucella : Brucella abortus Brucella melitensis , Brucella suis , Brucella ovis , Brucella canis , and Brucella neotomae (Alton et al., 1988 , Corbel ., et al ., 1984). This classification is mainly based on the difference in host preference and in pahogenicity . Distinction between species and biovars is currently performed by differential laboratory tests (Alton et al., 1988 and Corble ., et al

1984). Although it has been proposed that the Brucella species should be grouped as biovars of a single species based on DNA hybridization studies (Verger et al .,1985) and on the comparison of the genome of B. melitensis (Del Vecchio et al ., 2002), and B. suis (Paulsen et al ., 2002), the current classification of brucellae in species according to differences in host preference and in pathogenicity should be preferred (Cloeckaert et al ., 2001 and Moreno et al ., 2002).

World wide , the main pathogenic species for domestic animals are B.abortus , responsible for bovine brucellosis , B . melitensis , the main etiologic agent of small ruminant brucellosis , and B. suis responsible for swine brucellosis . These three Brucella species may cause abortion in their hosts and because of the presence of brucellosis in a herd (or flock), a region or a country , international veterinary regulations impose restriction on animal movements and trade , which result in huge economic losses (Anonymous FAO/ WHO, Anonymous OIE,2003, Crawford et al ., 1990)

B. ovis and B. canis are responsible for ram epididymitis and canine brucellosis respectively . for B. neotomae only strains isolated from desert rats have been reported . Albit their respective and wildlife has to be considered as a reservoir for zoonotic brucellosis (Davis et ., God froid ,2002, Rhyan ,2000).

The broad spectrum of Brucella isolates has recently been enlarged to marine mammals .

A number of recent reports describe the isolation and characterization of Brucella strains from awild variety of marine mammals (Clavareau et al ., 1998) Ewalt et al ., 1994 and Foster et al., 2002) these strains have been identified as brucellae , however their overall characteristics are not as similarly to those of any of the six recognized Brucella species (Clavareau et al ., 1998 , Cloec kaert et al .,2001, Jahanas et al ., 1997).

Camels can be infected by B. abortus and B. melitensis . Different studies showed that B. abortus and B .melitensis are most frequently isolated from

milk , aborted fetus and vaginal swabs of diseased camels (Radwan et al ., 1992,Gameel et al ., 1993 Agab et al ., 1994, Abou Eisha , et al 2000, Hamdy and Amain .,et al 2002)

The spread of brucellosis depends on the Brucella species being prevalent in other animals sharing their habitat and on husbandary (Musa et al ., 2008)

zoonotic and economic implication in humans. The disease is an important public health problem in many parts of the world (Pal, 2007; Hadush and Pal, 2013). The disease in dromedary camels can be caused by Brucella abortus, Brucella melitensis and Brucella ovis (Seifert, 1996). Different studies showed that B. abortus and B. melitensis are the most frequently isolated from milk, aborted fetus and vaginal swabs of diseased camels (Radwan et al., 1992; Gameel et al., 1993; Agab et al., 1994; Abou-Eisha, 2000; Hamdy and Amin, 2002) and the transmission of brucellosis depends on the Brucella species being prevalent in other animals sharing their habitat and on husbandry (Musa et al., 2008).

Camels are not known to be primary hosts of Brucella, but they are susceptible to both B. abortus and B.melitensis. Consequently, the prevalence depends upon the infection rate in primary hosts being in contact with them. Brucellosis may spread from camels to humans, especially via milk. Therefore, the zoonotic risks from camel milk must be considered in view of the traditional African and Arabian preference for raw milk consumption (Cooper, 1991). Groups at high risk for brucellosis are animal health workers, butchers, farmers, and those who habitually consume raw camel milk and come in contact with these animals (Chuk 1987)

The uncontrolled movement of camel from infected herds or area to Brucella free herds or areas is the major obstacles in brucellosis eradication program (Radostits et al., 2007). Other management factors influencing inter-herd transmission are proximity to infected herds, water ways, and scavengers. Vaccination level, herd size, population density, methods of housing, and use of maternity pens also influence the probability of exposure to the infection (Crawford et al., 1990).

B.Ovis and *B.Canis* are responsible from lam epididymitis and canine brucellosis respectively . for *B.neotomae* only strains isolated from desert rats have been

1.1.1.5.7. Host factors

Animals of all age groups are susceptible to *Brucella* infection but infection persists commonly in sexually mature animals. The seroprevalence of brucellosis was three to four folds higher among adult camels than young ones **(Yagoub *et al*., 1990).**

Various studies showed an equal distribution of *Brucella* antibodies among males and females **(Waghela *et al*., 1978; Abu Damir *et al*., 1984; Abbas *et al*., 1987; Radwan *et al.*, 1992)**.

However, it was mentioned that females are more susceptible to the disease than males **(Agab 1997; Ajogi and Adamu, 1998)**. Female animals have essential epidemiological importance in disseminating the disease via uterine discharge and milk. The role of males in the spread of disease under natural condition is considered to be not important **(Radostits *et al.*, 2007).**

1.1.1.5.8. Pathogenesis and Pathology

Following exposure, the organisms penetrate intact mucosal surface. In the alimentary tract the epithelium covering the ileal Payer's patches are the preferred sites of entry. After penetration, the organisms is engulfed by phagocytic cells and transported to regional lymph nodes (Walker, 1999). Then they proliferate, disseminate haemogenously and localize in the reticuloendothelial and reproductive tract. Various mechanisms are employed by *Brucella* organisms to survive inside the phagocytic cells, inhibiting phagolysosome fusion, blocking bactericidal action of phagocytes andsuppressing the myeloperoxidase H2O2 halide system **(**Frenchick *et al.,* 1985; Harmon *et al.,* 1988; Tizard, 1992; Walker, 1999). In ruminants, *Brucella* organisms by pass the most effective host defense by targeting embryonic and trophoblastic tissue. In cells of these tissues, the bacteria grow not only in the phagosome but also in the cytoplasm and the rough endoplasmic reticulum (Anderson and Cheville 1986). In the absence of effective intracellular microbicidal mechanisms, these tissues permit exuberant bacterial growth, which leads to fetal death and abortion. The presence of erythritol in the placenta may further enhance growth of Brucellae. Products of conception at the time of abortion may contain up to 1010 bacteria per gram of tissue (Anderson *et al*., 1986).

When septic abortion occurs, the intense concentration of bacteria and aerosolization of infected body fluids during parturition often result in infection of other animals and humans.

Only little information is known about the pathological changes in camels.

Gross lesion may be found in the predilection sites uterus, udder, testicles, lymph nodes, joint bursa and placenta. Hydrobursitis was often observed in brucellosis positive dromedaries causing swelling of the bursa (Werney and Kaaden, 2002).

The probable possibilities for the abortion in farm animals may be due to placentitis, direct effect of endotoxins or inflammatory response in fetal tissue (Walker, 1999)

1.1.1.6. Immune Responses

Brucella Ssp. Are facultative intercellular pathogens which resist killing by neutrophilis , replicate inside macrophages and in "non- professional " phagocytes and maintain along lasting interaction with the host cells

(Dornand et al ., 2002).

As intercellular organisms , protection against Brucella infection requires cell – mediated immunity , which includes CD4+ and CD8+ T lymphocytes , The 1- type cytokines such as IFN. And TNF ., and activated macrophages and dendritic cells (D C) (Golding et al ., 2001) . Therefore , host control of infection requires asset of cells and factors wich together promote acomplex response against Brucella abourtus infection .

This protection can be performed by type I cytokine profile . production mainly IFN-, and lysis of Brucella- infected macrophages (Olivera et al ., 1998 , Olivera and Splitter , 1995). Lusis of this macrophages releases the bacteria to the extracellular milieu enabling uptake by other activated macrophages in a IFN- rich microenvironment .

These cells presents augmented antibrucellae mechanisms and are able to destruct the pathogen , inhibiting Brucella spread (Jiang and Baldwin , 1993).

Moreover , the type I cytokines produced by CD8+ T cells in duce down – regulation of Th 2 cytokines and IL -10. (Olivrea et al .,1998 , Olivera and Splitter .1995).

1.1.1.7. Diagnosis of brucellosis

1.1.1.7.1. Diagnostic techniques:

1.1.1.7.1.1. Clinical Finding:

Camels of both species (C. dromedarius and C. bactrianus) are frequently infected with Brucella organisms, especially when they are in contact with infected large and small ruminants (Radwan et al., 1992).

experimentally infected with a field strain of B. abortus developed only mild, transient clinical symptoms including reduced appetite, slight lameness and bilateral lacrimation (Abu Damir et al., 1989). Orchitis and epididymitis have also been associated with brucellosis caused by B. abortus and B. meletensis (Tibary et al., 2006). Other conditions

caused by the disease were retention of placenta, placentitis, uterine infections, fetal death and mummification, delayed maturity and infertility; it also caused

- arthritis and hygroma (Ramadan et al., 1998; Tibary et al., 2006; Ahmad and Nemat, 2007; Musa et al., 2008). As previously mentioned, abortion has been reported in pregnant camels and B. mel- Immunosorbent Assay (cELISA), and Mercapto-ethanol test (2ME) for the diagnosis of camel brucellosis (Azwai et al., 2001; Abdel Moghney, 2004; Alshaikh et al., 2007).

1.1.1.7.1.2. Identification of the agent

the isolation and identification of brucella , but in situation where bacteriological examination is not practicable , diagnosis must be based on serological methods . there is no single test by which bacterium can be identified as Bruccella . A combination of growth characteristics , serological , bacteriological and molecular is usually needed (FAO/2009).

a) Staining methods

Brucella are coccobacilli or short rods measuring from 0.6 to 1.5 μm long and from 0.5 to 0.7 μm wide. They are usually arranged singly, and less frequently in pairs or small groups. The morphology of *Brucella* is fairlyconstant, except in old cultures where pleomorphic forms may be evident. *Brucella* are nonmotile. They do not form spores, and flagella, pili, or true capsules are not produced. *Brucella* are Gram negative and usually do not show bipolar staining. They are not truly acid-fast, but are resistant to decolorisation by weak acids and thus stain red by the Stamp's modification of the Ziehl–Neelsen's method. This is the usual procedure for the examination of smears of organs or biological fluids that have been previously fixed with heat or ethanol, and by this method, *Brucella* organisms stain red against a blue background. A fluorochrome or peroxidase-labelled antibody conjugate based technique could also be used .

The presence of intracellular, weakly acid-fast organisms of *Brucella* morphology or immuno-specifically stained organisms is presumptive evidence of brucellosis. However, these methods have a low sensitivity in milk and dairy products where *Brucella* are often present in small numbers, and interpretation is frequently impeded by the presence of fat globules. Care must be taken as well in the interpretation of positive results in the Stamps's method because other organisms that cause abortions, e.g. *Chlamydophila abortus* (formerly *Chlamydia psittaci*) or *Coxiella burnetii,* are difficult to differentiate from *Brucella* organisms. The results, whether positive or negative, should be confirmed by culture

1.1.1.7.1.3. Serological tests

The sera were screened by Rose Bengal plate test (RBPT) according to the method described by the World Organization for Animal Health (OIE) (16). The modified Rose Bengal Plate test (mRBPT) was performed on the same samples as described previously with the aim of demonstrating that the mRBPT has a greater sensitivity than the RBPT, as documented for sheep in Portugal and Greece (17, 18). Additionally, in order to control for serum samples classified as false negative by the mRBPT

a) Buffered *Brucella* antigen tests (prescribed tests for international trade)

1.1.1.7.1.3. 1. Rose Bengal 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 (52).

 Test procedure

i) Bring the serum samples and antigen to room temperature (22 ± 4°C); only sufficient antigen for the day's tests should be removed from the refrigerator.

ii) Place 25–30 µl of each serum sample on a white tile, enamel or plastic plate, or in a WHO hemigglutination plate.

iii) Shake the antigen bottle well, but gently, and place an equal volume of antigen near each serum spot.

iv) Immediately after the last drop of antigen has been added to the plate, mix the serum and antigen thoroughly (using a clean glass or plastic rod for each test) to produce a circular or oval zone approximately 2 cm in diameter.

v) The mixture is agitated gently for 4 minutes at ambient temperature on a rocker or three-directional agitator (if the reaction zone is oval or round, respectively).

vi) Read for agglutination immediately after the 4-minute period is completed. Any visible reaction is considered to be positive. A control serum that gives a minimum positive reaction should be tested before each day's tests are begun to verify the sensitivity of test conditions.

The RBT is very sensitive. However, like all other serological tests, it could sometimes give a positive result because of S19 vaccination or of false-positive serological reactions (FPSR). Therefore positive reactions should be investigated using suitable confirmatory and/or complementary strategies (including the performance of other tests and epidemiological investigation). False-negative reactions occur rarely, mostly due to

prolonging and can sometimes be detected by diluting the serum sample or retesting after 4–6 weeks.

Nevertheless RBT appears to be adequate as a screening test for detecting infected herds or to guarantee the absence of infection in brucellosis-free herds.

1.1.1.7.1.3.3 Enzyme-linked immune sorbent assays (prescribed tests for international trade)

a) Indirect ELISA
b) Competitive ELISA

No single serological test is appropriate in all epidemiological situations; all have limitations especially when it comes to screening individual animals (31, 64). 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 practised, false-positive reactions may be expected among the vaccinated animals because of antibodies cross-reacting with wild strain infection. For the purposes of this chapter, the serological methods described represent standardised and validated methods with suitable performance characteristics to be designated as either prescribed or alternative tests for international trade. This does not preclude the use of modified or similar test methods or the use of different biological reagents. However, the methods and reagents described in this chapter represent a standard of comparison with respect to expected diagnostic performance. It should be stressed that the serum agglutination test (SAT) is generally regarded as being unsatisfactory for the purposes of international trade. The complement fixation test (CFT) is diagnostically more specific than the SAT, and also has a standardised system of unitage. The diagnostic performance characteristics of some enzyme linked immune sorbent assays (ELISAs) and the fluorescence polarisation assay (FPA) are comparable with or better than that of the CFT, and as they are technically simpler to perform and more robust, their use may be preferred (60, 97). The performances of several of these tests have been compared. For the control of brucellosis at the national or local level, the buffered Brucella antigen tests (BBATs), i.e. the Rose Bengal test (RBT) and the buffered plate agglutination test (BPAT), as well as the ELISA and the FPA, are suitable screening tests. Positive reactions should be retested using a suitable confirmatory and/or complementary strategy.

a- Brucellin skin test

b- Serum agglutination test

c- Native hapten and cytosol protein-based tests

d- Milk tests

An efficient means of screening dairy herds is by testing milk from the bulk tank. It should be borne in mind that in the last period of gestation, pregnant cows are dried and do not participate in the bulk tank sample. Incontrast, these animals, if infected, are most likely to be positive by serological diagnosis. Therefore, immediately after parturition, bulk tank should be re-tested. Milk from these sources can be obtained cheaply and more frequently than blood samples and is often available centrally at dairies. When a positive test result is obtained, all cows contributing milk should be blood tested. The milk I-ELISA is a sensitive and specific test, and is particularly valuable for testing large herds. The milk ring test (MRT) is a suitable alternative if the ELISA is not available.

Milk I-ELISA

As with the serum I-ELISA numerous variations of the milk I-ELISA are in use. Several commercial I-ELISAs are available that have been validated in extensive field trials and are in wide use. In the interests ofinternational harmonization, the three OIE ELISA Standard Sera should be used by national reference laboratories to check or calibrate the particular test method in question. The I-ELISA should be standardized such that the OIE ELISA strong positive standard when diluted 1/125 in negative serum and further diluted 1/10 in negative milk consistently tests positive. Bulk milk samples are generally tested at much lower dilutions than sera, i.e. undiluted to 1/2 to 1/10 in diluents buffer, with the remainder of the assay being similar to that described for serum. The C-ELISA should not be used to test whole milk but may be used with whey Samples.

1. Milk tests

In lactating animals, the MRT can be used for screening herds for brucellosis. In large herds (> 100 lactating cows), the sensitivity of the test becomes less reliable. The MRT may be adjusted to compensate for the dilution factor from bulk milk samples from large herds. The samples are adjusted according to the following formula: herd size < 150 animals use 1 ml bulk milk, 150–450 use 2 ml milk sample, 451–700 use 3 ml milk sample. False-positive reactions may occur in cattle vaccinated less than 4 months prior to testing, in samples containing abnormal milk (such as colostrums) or in cases of mastitis. Therefore, it is not

recommended to use this test in very small farms where these problems have a greater impact on the test results.

1.1.1.8. Treatment of brucellosis

1.1.1.8.1. Chemotherapy:

it is mostly not successful because of intracellular sequestration of the organisms in the lymph nodes, mammary glands and reproductive organs. If it is necessary the treatments often given are, sulphadiazine, streptomycin, chlortetracycline and chloramphenicol 19, 2.

1.1.1.8.2. In human: The most rational approach for preventing human brucellosis is control and eradication of the infection in animal reservoirs. In addition there is a need to educate the farmers to take care in handling and disposing of aborted fetus, fetal membrane and discharges as well as not to drink unpasteurized milk and abattoir workers in transmission of infection especially via skin abrasion 17. The drug recommended is rifampcin at dosage of 600 -900 mg daily combined with doxicycline at 200 mg daily. Both drugs are given in the morning as a single dose and relapse is unusual after a course of treatment continued for at least 5 weeks

1.1.1.9. Control and prevention

1.1.1.9.1. In animals: Prevention and control of brucellosis can be adopted realistically through understanding of local and regional variations in animal husbandry practices, social customs, infrastructures and epidemiological patterns of the disease. The common approaches used to control brucellosis include, quarantine of imported stock, hygienic disposal of aborted fetuses, fetal membrane and discharges with subsequent disinfection of contaminated area. Animals which are in advanced pregnancy should be kept in isolation until parturition 27. Moreover replacement stock should be purchased from herd free of brucellosis, and decide for or against immunization of negative animals. Eradication by test and slaughter of positive reactors is also possible.

1.1.1.9.2. Immunization

vaccines like *B. abortus* strain 19 (S19), which is a live vaccine and is normally given to female calves aged between three and six months as **.**

a single subcutaneous dose of 5-8×10 10 viable organisms. A reduced dose from 3×108 to 3×10 9 organisms can be administered subcutaneously to adult cattle. Alternatively, it can be administered to cattle of any age as two doses of 5-109 viable organisms, given by the conjunctiva route. This reduces the risk of abortion and excretion in milk 29. The protection on a herd basis is much greater due to reduction of clinical symptoms and increased herd resistance 5. There are also Brucella strain 45/20 (Dyphavac) and strain RB51 vaccines 29.

1.1.1.10. Prevalence of brucellosis in different countries

1.1.1.10.1. Abu Dhabi emirate

sero-prevalence of the disease in livestock including sheep and goats and camels In different regions of Abu Dhabi emirate and to identify factors associated with the epidemiology of the disease\7u

A serological study using 61126 blood samples from livestock were obtained from 267 farms (Izaba) during the period from January 2009 to December 2010. The Rose Bengal Plate Test and competitive ELISA were used as screening and confirmatory tests, respectively. The overall sero-prevalence of *Brucella* antibodies was 8.00% and 7.00% detected by the RBPT by c-ELISA respectively. *Brucella* prevalence was 8.3, 5.9 and 4.7% in Alain, Abu Dhabi and Western region. The prevalence of the disease was higher (8.4%) in sheep and goats than (4.4%) in camels respectively. The result showed that, the prevalence of brucellosis was significantly higher in females than male ($p<0.04$) Out of the 267 farms sampled in the study, 147 (55.1%) were infected with *Brucella.* There was strong correlation between herd size and prevalence of the disease, very large herds had significantly higher prevalence when compared with small ones. The study revealed light of a size able prevalence among livestock in Abu Dhabi Emirate and the results reflect the necessity of a control program of the disease is needed to be adopted

1.1.1.10.2. In Ethiopia

1.1.1.10.2.1. Sero-epidemiology of camel brucellosis in the Afar region of Northeast Ethiopia

Camel brucellosis represents a major public health concern, which affects social and economic development in developing countries. A cross-sectional study was conducted in three selected districts of Afar region of Ethiopia to determine seroprevalence of camel brucellosis. A total of 1152 camels from 168 camel herds were included in the study. All serum samples were consequently tested and confirmed serologically using Rose Bengal Plate Test (RBPT) and Complement Fixation Test (CFT). Risk factors analysis was also conducted using multivariable and univariate logistic regression analysis. As a result, 58 (5.0%) were RBPT reactors in which 47 (4.1%, 95% CI: 2.9 to 5.3%) were confirmed to be positive using CFT and at least one reactor camel was found in 37 (22.0%) of the total herds sampled. The statistical analysis indicated that herd size (OR=0.64; 95% CI: 0.42 to 0.98, P=0.04) and contact with other ruminants (OR=0.62; 95% CI: 0.47 to 0.82, P=0.001) were the major risk factors for the presence and transmission of the disease between

animals. In addition, pluriparous (4.7%), abortive (5.7%), pregnant (6.6%) and lactating (4.1%) camels were found with higher seropositivity which contributed in transmission of the disease to calves, other ruminants as well as to humans, but this was not a statistically significant association (P>0.05). In conclusion, camel brucellosis is prevalent in this area of study and there is a need for planning and implementation of joint programs by stakeholders in prevention and control of the disease as well as raising public awareness in decreasing the distribution of the disease in the area.

1.1.1.10.2.2. Seroprevalence and Associated Risk Factors of Camel (*Camelus dromedaries*) Brucellosis in and Around Dire Dawa, Ethiopia

A cross-sectional study of brucellosis was conducted from November 2010 to April 2011 to estimate seroprevalence and to assess potential risk factors of camel (*Camelus dromedaries*) in and around Dire Dawa, Ethiopia. Rose Bengal Plate test (RBPT) was used as a screening test to detect presence of *Brucella* antibodies and CFT to confirm those reactors by RBPT. Thirteen 646 camels (2%) were seroreactive when tested by RBPT, out of which 10 (1.5%) were seropositivity by CFT. Higher seroprevalence was observed in female and in adult camels with seroprevalence of 1.7 and 1.8% than seroprevalence of 1.4 and 0.7% observed in male and young camels, respectively. However, there was no statistically significant difference P < 0.05) in seroprevalence of brucellosis between both groups. Higher seroprevalence of *Brucella* (38.5%) was observed in adult female camels which had history of reproductive problems [abortion, still birth and retained fetal membrane (RFM)] with statistically significant difference (P < 0.05) compared to that of adult female camels which had no history of reproductive problems. Of camels which had these reproductive problems, highest seroprevalence (43%) was observed in camelse which had history of abortion. In conclusion, this level of seroprevalence is enough to be a potential hazard for public health in the study area, therefore, the public especially camel producers should be aware of camels as source of brucellosis.

1.1.1.10.3. In Kenya

1.1.1.10.3.1. The Prevalence of *Brucella spp.* in camel milk marketed from North Eastern Province, Kenya

The camel is the dominant livestock in North Eastern province where it provides sustenance to many people especially during the frequent dry periods when other animals die or are unthrifty. Carissa and Wajir districts in the arid Northern Kenya hosts about 54% of the national camel herd estimated to number over 3 million. Camel milk from North Eastern

Province in Kenya is widely marketed in those areas but is also currently being sold in distant markets in Nairobi and other places. An expanded camel milk market provides an opportunity for increased income that can lead to improved pastoral livelihoods. Most of the milk is collected from individual pastoralists, bulked and then taken by transporters to urban areas. While some milk is boiled before sale, some of the milk however is marketed as raw thus exposing the population to zoontic diseases. In an investigation to find the prevalence of Brucellosis, the main zoonotic agent in milk, samples of milk for marketing were collected as well as serum samples from camels in North Eastern Province A total of three hundred and eighty four (384) camel milk samples from Garrissa and Wajir Districts were tested using the Milk Ring Test (MRT) and out of the total, fifty nine (59) samples (15.36%) tested positive while three hundred and twenty five (325) samples tested negative. From Garrissa District (n = 230), 35 samples (15.22%) were positive for MRT while 24 samples (15.58%) from Wajir District (n = 154) were positive. All the milk samples examined were negative for Brucella Modified Ziehl- Neelsen's stain as well as primary isolation of Brucella on Tryptose Soy agar (TSA) under high carbon-dioxide (CO2) concentration. The results of the milk ring test on the samples tested indicated that 15.36% of the samples were positive for the presence of Brucella antibodies in milk. A total of two hundred (200) camel serum samples from Garrissa and Wajir Districts were tested using the Rose Bengal Plate Test (RBPT). Four (4) samples (2.0%) tested positive. From Garrissa District (n = 72), 2 samples (2.78%), were positive while 2 samples (1.56%) from Wajir District (n = 128) were positive. The two hundred (200) camel serum samples from Garrissa and Wajir Districts were also tested using the Serum Micro-agglutination Test (SAT). From Garrissa District (n = 72), 13 samples (18.06%) were positive while 8 samples (6.25%) from Wajir District (n = 128) were positive. The seroprevalence of brucellosis in camels is low in extensively kept pastoralist camels. Some of the recommendations to avoid the risk of zoonotic diseases include increased awareness on pasteurization of camel milk, proper milk handling and milk testing before pooling

1.10. 5- Cytokine response and clinic pathological findings in Brucella infected camels (Camelus dromedarius)

The present study had the aim of assessing the cytokine response and selected clinicopathological findings associated with brucellosis in camels (Camelus dromedarius) 340 dromedary camels were examined for brucellosis using agglutination and Complement Fixation tests (CFT). Twenty-five camels (7.35%) were positive by both tests; 14 (4.12%) for B. abortus and 11 (3.23%) for B. melitensis. IL-1β and IL-10 interleukin levels in both

B. abortus and B. melitensis infected camels showed significant elevations ($P < 0.05$) compared with controls. Moreover, there was significantly larger increase in IL-1β interleukins in camels infected with B. abortus compared with B. melitensis. TNF-α, IFN-γ and IL-1α levels showed significant decreases ($P < 0.05$) in Brucella infected camels compared with non-infected ones; however, there was non-significant changes in IL-6 levels in Brucella infected camels compared with controls. Lymphopenia was recorded in infected camels but not in controls.

However,normocytic normochromic anemia, hypoproteinemia, hypoalbuminemia and hypoglycemia were recorded in the B. abortus group only. Sorbitol dehydrogenase (SD), aspartate aminotransferase (AST) and alanine aminotransferase (ALT) showed significant increases ($P < 0.05$) in infected camels compared with controls, and in B. abortus infected camels compared with B. melitensis infected animals. This is the first report that describes changes in selected cytokines and various hematological and biochemical parameters associated with brucellosis in dromedary camels. Emphasis should be placed on multidisciplinary research to elucidate the immunomodulatory features of camel brucellosis

1.1.1.10.4. In sudan

- **4 - 6 Seroprevalence of brucellosis in sheep and isolation of *Brucella abortus* biovar 6 in Kassala state, Eastern Sudan**

To study brucellosis in 3413 camels raised in areas of Sudan, where cattle, sheep and goats were intensively bred, bacteriological and serological examinations were performed. Among the camels, 3275 belonged to 110 herds, 35 were reared individually or with cattle, and 103 had been slaughtered at Nyala abattoir. The infection was found in 50 (45.5%) of 110 herds, with prevalence rates ranging from 1.4 to 89.5%; in 72 (7.3%) out of 993 males and in 196 (8.1%) out of 2420 females; 75% of the positive camels were adults over 4 years old and the remaining 25% were younger, from 6 months to 4 years old. In infected herds, abortion rates associated with the disease ranged from 3.1 to 72.7% depending on the location. Other conditions caused by the disease were retention of placenta, fetal death and mummification, delayed service age and infertility. Hygromas and cases of orchitis were not shown to be caused by brucellosis. The disease in camels was found milder than in cattle. *Brucella abortus* antibodies in infected camels ranged from 31 to 1969 IU/ml (2/20 to 2/1280). The milk ring test was improved by adding bovine milk negative for the disease to camel milk. Male camels used for service were negative for the disease implying that they did not play a role in its transmission. Recommendations for brucellosis control were giv

Brucellosis in Camels in Intensive Animal Breeding Areas of Sudan. Implications in Abortion and Early-Life Infections

M.T. Musa1 M.T.A. Shigidi2

Summary

To study brucellosis in 3413 camels raised in areas of Sudan, where cattle, sheep and goats were intensively bred, bacteriological and serological examinations were performed. Among the camels, 3275 belonged to 110 herds, 35 were reared individually or with cattle, and 103 had been slaughtered at Nyala abattoir. The infection was found in 50 (45.5%) of 110 herds, with prevalence rates ranging from 1.4 to 89.5%; in 72 (7.3%) out of 993 males and in 196 (8.1%) out of 2420 females; 75% of the positive camels were adults over 4 years old and the remaining 25% were younger, from 6 months to 4 years old. In infected herds, abortion rates associated with the disease ranged from 3.1 to 72.7% depending on the location. Other conditions caused by the disease were retention of placenta, fetal death and mummification, delayed service age and infertility. Hygromas and cases of orchitis were not shown to be caused by brucellosis. The disease in camels was found milder than in cattle. Brucella abortus antibodies in infected camels ranged from 31 to 1969 IU/ml (2/20 to 2/1280). The milk ring test was improved by adding bovine milk negative for the disease to camel milk. Male camels used for service were negative for the disease implying that they did not play a role in its transmission. Recommendations for brucellosis control were given.

Epidemiological Study of Brucellosis in Camels (Camelus dromedarius) in Khartoum State, Sudan

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Chapter Two

2. Materials and Methods

2.1. Study area

The study area is Butana area, the Northern of Gadarrif State this region far about 160 K.M.Form Gadarrif. Around Four State Eastern Kassala Western East Gezira southern River Nile Khartoum Western El-Showak is a research station that belongs to the Camel Research Centre (CRC).It is a focal point for camel pastoralists in Butana area. Being a collection point, it becomes an important camel market in the region. Butana is situated well within the arid zone of the Eastern Sudan and occupies an area of approximately 120000 km2 and lies between latitude 13° 4' N to 17° 50' N and longitude 32° to 36° E. Most of the Butana is series of flat easily flooded plains interspersed by few hills. The prevailing climate is warm in summer which extends most of the year (March-October) and includes the rainy season(June-September). The vegetation composed of Aristida spp. (Gow) Cymbopong on nervatus (Nal); Acacia mellifera (Kitir); *Calotrop isprocera* (Usher); *Cappar isdeciduas* (Tunduub) and a variety of grasses (Abdalla, 1985).Normally the camels and their owners move /migrate in search for water and grasseseastward to the Ethiopian borders.

2.2.Study Design

Data was collected as part of a study on the Seroepidemiology of Brucella infection in camels herding in ELgadarrif state. Sectional study was carried out during summer season to estimate the seroprevalence of camel brucellosis and to investigate associated risk factors. Multi stage random sampling was designed based on state .governorate ,locality, herd and animal .selection between localities, herds and individual animals based on simple random sampling.

2.3. Sampling Methods

- Samples were collected by probability sampling methods Using multistage sampling methods randomly from locality selection was done from four of the state ,then from each locality two administration units were selected and seven villages were selected from each unit. Lastly .animals were selected by using simple random sampling
- to choice animal from each herd.

Prevalence Rate = No of camel with brucellosis *100

Total No of camel at a particular in time

2.4. Sample size determination

The sample size were calculated by the formula:

$$N = \frac{4P * Q *}{L2}$$

N =sample size ,

P=expected prevalence , Q =(1-P).

L=desired absolute precision. (Martin ,et ,al ,1987)

From the previous studies the samples size was calculated according to the study on prevalence of brucellosis in camel .

The prevalence was estimated about 4.1% so the Sample size estimated was 62.91 .

To increase the precision of the study, the Sample size was multiplied by 4 so the number of sample became 252 sample (Thrusfeild ,2005)

$$N = \frac{4*(0.041)*(0.959)}{(0.0025)} = 62.91 \text{ animals}$$

62.91 x 4 = 252

2.5. Sampling Technique:

Blood samples of about 10 ml were aseptically collected using plain tubes from camels through jugular vein puncture .Serum was separated within 12 hours of collection and transported to the Gadarrif state laboratory using an ice box where they stored Till with tested by RBPT

2.6. Questionnaire survey

Questionnaire execution:-

Information each camel sampled was obtained ,this included its location the individual risk factors , age, sex, previous history of the disease ,history of abortion ,number of parity, body condition, , and other diseases, Selected camel owners were interviewed by using questions . Risk factors that had possible association with brucellosis among herd size, including management type ,production typ,.source of drinking water ,contact with other ruminant species ,contact with other camel herds heath status (history of abortion ,retained placenta)still (birth and infertility) Source of new camel to the herd ,herd man education,

awareness of brucellosis ,awareness of fetus and fetal membrane disposal and veterinary supervision

2.7. Diagnostic Techniques.

RBT:(Rose Bengal plate Test)

All sera samples collected were initially screened by RBPT using antigen(of the Gadarrif state laboratory) the sera samples were kept in refrigerator at 4°C before testing. Sera and antigen were left at room temperature for half an hour before the test to maintain to room temperature.

The test procedure recommended by Alton et al.(1975)was as follow:

30 ul of RBPT antigen was added to each circle on the plate and 30 uI at test serum were placed alongside .the antigen and test serum were mixed thoroughly by wooden applicator

Figure-4. RBPT negative (left) and positive (right)

2.8. Statistical Analysis

Data on tested serum and questionnaire were stored in Micro soft excel spread sheet (Microsoft Corp.1985-2007) as data base.

Statistical Analysis was performed using, Statistical Package for the Social sciences (SSP),version 16.0 soft ware for windows (SPSS Inc.,Chicago,lL,USA).

The seroprevalence for animal level was calculated on the basis of RBPT positivity

,dividing the number of Brucella reactors by total (number of tested animals .similarly ,herd level(prevalence was calculated as the number of the herds with at least one positive animal divided by the total number of herds tested.

Data collected from the questionnaire survey were analyzed using descriptive statistic methods . frequency distribution showed the frequency distribution of the variables comprised the frequency of occurrence of observations in every category.

Cross tabulation was used in 2 X 2 tables and multi way table to measure the degree of association between these tables and related statistics.

Association between the outcome variable (status of brucellosis) and its potential risk factors were first screened in a univariate analysis using chi-square. Potential risk factors with P value 0.25 were considered significant at this level Significant risk factors in the univariate analysis were subjected to multivariate analysis using logistic regression.

EXP B was used to indicate the strength of association with risk factors

Involved in the occurrence of the disease.

All risk factors with P 0.05 were considered significant.

Chapter Three

3.Results

3.1. Overall serological Prevalence:

In this study 252 camels were screened from 60 herds. RBPT (Rose Bengal Plate Test) identified (23) seropositivity reactors out of 252 serum sample (9.2%) (table 5)

Out of 50 examined herds.

.(Table 3-5) Distribution of Brucellosis in 252 camel examined Algadarrif State Sudan examined by RBPT

Result	Frequency	Relative frequency %
Negative	229	90.9
Positive	23	100.0
Total	252	

3.2. Serological Prevalence in Relationship to Risk factors:-

Localities :the study was conducted in four localities in the State , namely:-

Algadarrif, Albutana, Alshwak and Wast algadarrif. Out of the total camels chosen in analysis 34.5% (n=109) , 29.4% (n=93) ,11.1% (n=35) and 4.7% (n =15) . (table 6)

The occurrence of the disease was slightly higher in Algadarrif 11% (n=12) ,Albutana 10.8% (n=10) Alshwak 2.9% (n=1) and Wast Algadarrif 0% (n=0)

.(table 7)

3. 2. Individual Risk factors

3. 2.1.Sex

All breeding male and female above 1 years of were considered in the analysis . from the total camels tested 58.4% (n=215) were female while 14.7% (n=37) were male camels.(table7).

Seroprevalence of Brucella in male animals were 13.6% (n=5) relatively higher than that of the female camels 8.4% (n=18).(table 7)

There was no significant difference obcerved in the analysis (p.value .316)

.(table 8)

3. 2.2. Age

Age was one of the factors observed in the study. Categorization was based on the physiological maturity for breeding purpose from 1 -5, 6 -10 and above 11 years.

Out of the total camels , sampled 10% (n =25), 63.8% (n =161) and 26.2

(n =66)

In this observation Seroprevalence of Brucella was 28% (n=7) in 1 -5 years , 6.3% (n =10) in 6 -10 years and 9.1% (n =6) (Table 7)

There was statistical significance between 3 age groups (p.value.002)

(Table 8)

3. 2.3. Breed

Individual camels selected in this study came from three breeds Arabi , Bushari and Anafi from the total camels screened 67.8% (n =171) were Arabi , 19.8% (n=50)were Bushari and 12.3%(n=3) were Anafi (Table)

There was no statistical significant difference between the three breeds(p.value.14)(Table 8

was one of the factors observed in the study. Categorization in to tow groups good and poor from the total camels screened 81%(n =204) good and 19% (n=45) poor

There was no statistical significant difference between the two group (p.value.442). (Table8)

3.2.5 . Abortion

Camels selected in this study in two groups aborted camels and non aborted from the total camels screened 91.3% (n =230) were non aborted and 8.7% (n =22) were aborted

In this observation Seroprevalence of Brucella was 21.8% (n =5)non were aborted and 78.3% (n =18) were aborted

There was statistical highly significant difference between two groups

(p.value.000) (Table 8)

3.3. Manage mental Risk factors

3.3.1. Herd size

Herds size was classified in to three categories (large >70 ,moderate < 50 and small<20 ,)

Individual camels were 79%(n =199) in larg herds , 8.3% (n =21) in moderate and 12.7%

(n-=32) in small herds(Table)

Seroprevalence were 91.3% (n=21) in large herds ,4.3% (n=1) in moderate and 4.3% (n=1) in small

There was no statistical significant difference between three groups

(p.value .307) (Table 8)

3.3.2. Contact with other camels

Contact with other camels herds was considered of putative risk factors .Individuals within herds in contributed 19.5% (n=49) while the other not in contact 80.6% (n=203)

The distribution of the disease in the first group (in contact)

Was 14.3% (n 49) while the other not contact 7.9% (n=203) (Table 7)

There was no statistical significant difference between two groups

(p.value .162) (Table 8)

3.3.3. Source of animals

Owner obtained their camels form own herds or bought from the market. Most of the camels tested had been obtained from the herds 67.5% (n=82)

(Table 6)

The higher seroprevalence brucellosis was seen in camels obtained from the herds 11.2% (n=82) (Tables 3-6)

Risk factor	Frequency	Percent	Cumulative Percent
Locality			
Algadarrif	109	34.5	43.3
Albutana	93	29.3	80.2
Alshwak	35	11.1	94.0
Wsat algadarrif	15	4.7	100.0
Breed			
Arabi	171	54.1	67.9
Bushari	50	15.8	87.7
Anafi	31	9.8	100.0
Age of animals			
1-5	25	7.9	9.9
6- 10	161	50.9	73.8
<11	66	20.9	100.0
Body condition			
Good	204	64.6	81.0
Poor	48	15.2	100.O
Herd size			
Large	199	63.0	79.0
Moderate	21	6.6	87.3
Small	32	10.1	100.0
Sex of animals			
females	215	68.3	85.3
males	37	11.7	100.0
Aborted animals			
No	230	72.8	91.3
Yeas	22	7.0	100.0
No	203		
Yeas	49	64.2	100.0
Source of animals		15.5	
Inbreeding	170		100.0
Marketing	82	53.8	
		25.9	

Table (3-7) cross tabulation of prevalence of brucellosis an associated Risk factor in 252 camels examined by RBPT in Algedarif State.

Risk factor	Number test	Number positive	Percentage(%)
Locality			
Algadarrif	109	12	11.0%
Albutana	93	10	10.8%
Alshwak	35	1	2.9%
Wsat algadarrif	15	0	0%
Breed			
Arabi	171	19	11.1%
Bushari	50	1	2.0%
Anafi	31	3	9.7%
Age of animals			
1-5	25	7	28.0%
6- 10	161	10	6.2%
>11	66	6	9.1%
Body condition			
Good	204	20	9.8%
Poor	48	3	6.2%
Herd size			
Large	199	21	10.6%
Moderate	21	1	4.8%
Small	32	1	3.1%
Sex of animals			
females	215	18	8.4%
males	37	5	13.5%
Aborted animals			
No	230	5	2.2%
Yeas	22	18	81.8%
Contact with other animals			7.9%
No	203	16	14.3%
Yeas	49	7	
Source of animals			
Inbreeding	170	19	11.2%
Marketing	82	4	409%

Table (3-8)

Univarite analysis of prevalence of brucellosis an associated Risk factor in 252 camels examined by RBPT in Algedarif State using the Chi square

Risk factor	Number tested	Number positive	(%)	Degree of freedom	X	P- value
Locality						
Algadarrif	109	12	11.0%			
Albutana	93	10	10.8%			
Alshwak	35	1	2.9%	3	3.927	.269
Wsat algadarrif	15	0	0%			
Breed						
Arabi	171	19	11.1%			
Bushari	50	1	2.0%	2	2.885	.143
Anafi	31	3	9.7%			
Age of animals						
1-5	25	7	28.0%			
6- 10	161	10	6.2%	2	12.38	.002
<11	66	6	9.1%			
Body condition						
Good	204	20	9.8%			
Poor	48	3	6.2%	1	.592	.442
Herd size						
Large	199	21	10.6%			
Moderate	21	1	4.8%	2	2.360	.307
Small	32	1	3.1%			
Sex of animals						
females	215	18	8.4%	1	1.006	.316
males	37	5	13.5%			
Aborted animals						
No						
Yeas	230	5	2.2%	1	1.536	.000
	22	18	81.8%			
Contact with other animals						
No						
Yeas	203	16	7.9%	1	1.952	.162
	49	7	14.3%			
Source of animals						
Inbreeding						
Marketing				1		
	170	19	11.2%		2.646	.104
	82	4	409%			

The significant level < 0.25

3 .4. Logistic Regression

The univariate analysis by Chi-square on camels risk factors revealed 5 variable with p<0.25 (breed P=0.143 ,age P=0.002 , abortion P=0.000 .contact with other P=0.162 and source of animals P=0.104)which were subjected to the multivariate logistic model table(8)

Abortion was only identified as risk factors for camels brucellosis (P<0.05 , OR 0.002 and 95% CI :0.00 – 0/017)(Table 9) .

Locality P=.269 ,herd size P =.307 and sex P =.316 were not significant with Seroprevalence of camel brucellosis in Algadarrif State(Table 8) .

Table(3-9) Multivariate analysis for the positive risk and risk factor associated with camel brucellosis in 252 camels examined by RBPT in Gadarrif State using logistic regression.

Risk factors	Number tested	Number positive (%)	Exp (B)	95% CL for Exp(B)	P. value
Breed					
Arabi	171	19	.270	.034 -2.160	
Boshary	50	1	.078	.002- 2.963	.143
Age					.002
1-5	25	7	2.888	.216 _38.564	
6- 10	161	10	.558	.091 – 3.431	
Abortion					.000
Yeas	22	18	.002	.000 -.017	
Contact with other animals					.162
Yeas	203	16	8.693	.656–115.258	
Source of animals					
Inbreeding	170	19	1.308	.199 – 8.591	
					.104

Table(3-10) Final logistic regression for positive risk factors associated with camel brucellosis

Risk factors	Number tested	Number positive	Exp (B)	95% CL for Exp(B)	P-value
Breed					
Arabi	171	19	.270	.034 -2.160	.143
Bushari	50	1	.078	.002 – 2.963	
Age of animals					
1-5					
6- 10	25	7	2.888	.216 -38.564	.002
	161	10	.558	.091 – 3.431	
Aborted animals Yeas					
Contact with other animals Yeas	22	18	.002	.000 -.017	.000
Source of animals	203	16	8.693	.656 –115.258	.162
Inbreeding					
	170	19	1.308	.199 – 8.591	.104

Chapter Four

4.Discussion

The disease is known to cause abortion and birth of non-viable off spring in female ,and orchitis and epididmitis in male animals and infertility in both cases (Rradostits et al ., 1994 ,Agab , 1997, Straten et al ., 1997)

In production system where livestock diversification is practiced ,the disease circulates in sheep ,goats and cattle ,and further spreads to dromedaries

(Andreani et al., 1982, Radwan et al ., 1992)

Five out of the nine known Brucella species can infect humans and the most pathogenic and invasive species for human is *B.melitensis*, followed in descending order by *B.suis.*

B. abortus and *B.canis* (Acha et al ., 2003). The zoontic nature of the marine Brucella

(B.ceti) has been documented (Mc Donald et al .,2006).

.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 this study and based on the results of RBPT, the prevalence of Brucellosis of examined camels was (9.2%) . this result is not different from other studies carried out by Musa (1995) who examined 416 camels from seven herds in western Sudan. the prevalence was 7.9, 9.32, 5.03 and 8.06 %, from 1985 to 1989. The author suggested that camels are the second most affected animal species besides cattle .

However. Higher prevalence was recorded in Sudan (Musa and shigidi 2001 and omer et al .,20100) in (, Jordan(AL. Majali et al ., 2008 and Dawood 2008) , and in Nigeria (Sadiq et al ., 2011)

Epidemiology of the prevalence of camel brucellosis from different countries depend on the lack of exact camel population concerning detailed demographic data , besides lack of cattle ,sheep and goats Brucella of control program including vaccination , may be attributed to varying husbandry and management practices and The number of susceptible camels , the virulence of the organisms ,presence of reactor animals in the region, absence of veterinary service ,lack of awareness about the disease in camels and continuous entry of infected camels in to a susceptible camels herd

(Rodostits *et al* .,2007)

By the univariate analysis, the presence of seropositivity camels was significantly associated ($P<0.25$) with the variables: breed, age, abortion, contact with other animals and

source of animals.

The breed of camels showed significant association with the prevalence of Brucella infection (P=.143) the occurrence of the disease was slightly higher in Arabi 11%(=19),Anafi 9.7% (n=3) Bushari 2.0%(n=1) that is result could be due to it breed used for transportation and worker than other breed.

Age of animals was also found to affect significantly the seropositivity of Brucella on animals level (P=.002) the occurrence of the disease was higher in age (1-5) year28% (n=7), above 11year 9.1% (n =6) and (6 -10) 6.2% (n =10) .these result may be to the vertical transmission of the disease These result agree with

Abortion was found with higher risk factor significantly associated seropositivity which contributed in transmission of the disease to camels, other ruminants as well as to humans, but this was highly a statistically significant association regression (OR = .000 , 95 % CL .000 - .O17)(P< 0.05). This result agree with (Ismail Warsame, Sefinew Alemu, Wudu Temesgen and Wassie 2012) who found that Female Camels which had history of abortion with a statistically significant different (p-<0.05) compared to that female which had no history of abortion.

contact with the other animals was also found to affect significantly the seropositivity of Brucella on animals level (P=.162) the disease was higher in camels witch contact with the other animals 14.3% (n =7) and the other with no contact 7.9% (n=16) These result agree with (Angesom Hadush, , Mahendra Pal1, Tesfu Kassa and Fikre Zeru., **2013)** who found that different (p-<0.05) between Contact with other animals and the other with no contact was statistical significant association exists between camel groups in contact with small ruminants and without contact with ruminants. A contributing factor to the spread of the disease may be the movement of animals for grazing and watering during the dry season; aggregating animals around a watering point will increase the contact between infected and healthy animals and thereby facilitate the spread of the disease.

Source of the camels showed significant association with the seropositivity of Brucella infection (P=.104) the disease was slightly higher in breeding a camels 11.2% (n =19) and the marketing camels 4.2% (n=4) these result show the bad hygiene management

Conclusion and Recommendations

Conclusion

The current study has shown the overall prevalence of Brucella as (9.2) of the tested dromedaries in Algadarrif State.

The fact that the overall seroprevalence of brucellosis in this study was higher this makes the animals and family member of those infected herds are all at risk .

In univariate analysis breed, age, abortion, contact with other animals and sources of animals categories have shown significant association with seroprevalence of camels brucellosis.

In multivariate analysis of presumed risk factors in dictated that age and abortion as a major risk factors associated with camels brucellosis.

Results of the present study clarified the status of camels brucellosis in Gadarrif state .and the risk factors that contribute to the occurrence of the disease in dromedaries as well as the possible zoontic implications inhuman being .

Recommendations

1- Although the prevalence of brucellosis in camel population is probably related to husbandry practice, there is lack of information regarding the pathogenesis and epidemiology of diseases, modern management practices and sanitary measures could be by a major role in lowering the prevalence of the disease.

2- Isolation and identification of species and biotypes of Brucella involved in camel brucellosis are needed .

3- A routine vaccination for cattle ,sheep and goat should be considered in areas where camels are kept together with these animals .

4- In the future, study is necessary to investigate the risk factors and the public health issues related to camels brucellosis.

5- The need for governmental and non- governmental organizations to enhance their capabilities in camel research, veterinary services and to establish adequate veterinary infrastructures concerning camel dairy production.

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Angesom Hadush1, 2*, Mahendra Pal1, Tesfu Kassa3, and Fikre Zeru2 (2013) **Sero-epidemiology of camel brucellosis in the Afar region of Northeast Ethiopia** ***Full Length Research Paper***

-M. El-Boshy1, H. Abbas2, S. El-Khodery1, S. Osman3(2009)
Cytokine response and clinic pathological findings in Brucella infected camels (Camelus dromedarius) *Veterinarni Medicina,* 54, 2009 (1): 25–32

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M.T. Musa1 M.T.A. Shigidi2(2001)
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M.M. Gumaa (1)*, H.M. Osman (2), M.M. Omer (1), E.M. El Sanousi (2), J. Godfroid (3, 4)# & A.M. Ahmed (2) (2014)
Seroprevalence of brucellosis in sheep and isolation of Brucella abortus biovar 6 in Kassala state, Eastern Sudan *Rev. sci. tech. Off. int. Epiz.*, 2014, 33 (3

Sero-Prevalence and Epidemiology of Brucellosis in Camels,

Elamir Gafar Saad Mohamed1, Abdelhamid Ahmed Mohamed Elfadil2 and Enaam Mohamed El Sanousi 3(2014)

Epidemiological Study of Brucellosis in Camels (Camelus dromedarius) in Khartoum State, Sudan, Veterinary Research Institute, Amar.

Distribution of 252 camels examined for brucellosis in Algadarrif State according to potential risk factors .

Table 1: Distribution of Camels in Governorates of Algadarrif State

Table (11)name of locality

locality	Frequency	Percent	Cumulative Percent
algadarrif	**109**	**34.5**	43.3
Albutana	93	29.4	80.2
Alshwak	35	11.1	94.0
wsat algadarrif	15	4.7	100.0
Total	252	79.7	
Total	316	**100.0**	

Table (12)number of infected animals

	Frequency	Percent	Cumulative Perce
-ve	**229**	72.5	90.9
+ve	23	7.3	100.0
Total	252	79.7	
Total	316	**100.0**	

Table (13)Distribution of Breed among tasted camels

	Frequency	Percent	Cumulative Percent
Arabi	171	54.1	67.9
boshary	50	15.8	87.7
alanafiy	31	9.8	100.0
Total	252	79.7	
Total	316	100.0	

Table (4)Distribution of age among tasted camels

		Frequency	Percent	Cumulative Percent
	1-5	25	7.9	9.9
	6-10	161	50.9	73.8
	>11	66	20.9	100.0
	Total	252	79.7	
Total	316	100.0		

Table (15)Distribution of body condition among tasted camels

		Frequency	Percent	Cumulative Percent
	good	204	64.6	81.0
	modrat	48	15.2	100.0
	Total	252	79.7	
Total		316	100.0	

Table (16)Distribution of herd size among tasted camels

		Frequency	Percent	Cumulative Percent
Valid	large	199	63.0	79.0
	modrat	21	6.6	87.3
	small	32	10.1	100.0
	Total	252	79.7	
Total		316	100.0	

Table (17)Disterbution of sex among tasted camels

		Frequency	Percent	Cumulative Percent
	female	215	68.0	85.3
	male	37	11.7	100.0
	Total	252	79.7	
Total		316	100.0	

Table (18) Distrbution of aborted camels among tasted camles

	Frequency	Percent	Cumulative Percent
no	230	72.8	91.3
yeas	22	7.0	100.0
Total	252	79.7	
Total	316	100.0	

Table (19) Disterbution of contact with other animals among tased camels

	Frequency	Percent	Cumulative Percent
no	203	64.2	80.6
yeas	49	15.5	100.0
Total	252	79.7	
Total	316	100.0	

Table (20)source of camels

	Frequency	Percent	Cumulative Percent
in breeding	170	53.8	67.5
marcting	82	25.9	100.0
Total	252	79.7	
Total	316	100.0	

Appendix 2

Across tabulation for the prevalence of brucellosis and associated risk factors in 252 Camels examined by RBPT in Algadarrif State

Table (21) number of infected animals * name of locality

number of infected animals	name of locality				Total
	algadarrif	Albutana	Alshwak	Wast algadarrif	
-ve Count	97%	93%	34%	15%	225
% within number of infected animals	42.4%	36.2%	14.8%	6.6%	100.0 %
% within name of locality	89.0%	89.2%	97.1%	100.0%	90.9%
% of total	38.5%	32.9%	13.5%	6.0%	90.9%
+ ve count	12%	10%	1%	0%	23%
% within number of infected animals	52.2%	43.5%	4.3%	.0%	100.0%
% within name of locality				.o%	9.1%
% of total	4.8%	4.0%	.4%	.o%	9.1%
Total count	109%	93%	35%	15%	252
% within number of infected animals	43.3%	36.9%	13.9%	6.0%	100.0%
% within name of locality	100.0%	100.0%	1oo.o%	100.0%	100.0%
% of total	43.3%	36.9%	13.9%	6.0%	100.0%

Table (22) number of infected animals * breed Crosstab

			Breed			Total
			Arabi	Boshary	Anafi	
number of infected animals	-ve	Count	152	49	28	229
		% within number of infracted animals	66.4%	21.4%	12.2%	100.0%
		% within breed	88.9%	98.0%	90.3%	90.9%
		% of Total	60.3%	19.4%	11.1%	90.9%
	+v	Count	19	1	3	23
		% within number of infacted animals	82.6%	4.3%	13.0%	100.0%
		% within breed	11.1%	2.0%	9.7%	9.1%
		% of Total	7.5%	.4%	1.2%	9.1%
Total		Count	171	50	31	252
		% within number of infracted animals	67.9%	19.8%	12.3%	100.0%
		% within breed	100.0%	100.0%	100.0%	100.0%
		% of Total	67.9%	19.8%	12.3%	100.0%

Table (23) number of infacted animals * age of animals **Crosstab**

			age of animals			Total
			1-5	6-10	>11	
number of infracted animals	-ve	Count	18	151	60	229
		% within number of infracted animals	7.9%	65.9%	26.2%	100.0%
		% within age of animals	72.0%	93.8%	90.9%	90.9%
		% of Total	7.1%	59.9%	23.8%	90.9%
	+ve	Count	7	10	6	23
		% within number of infracted animals	30.4%	43.5%	26.1%	100.0%
		% within age of animals	28.0%	6.2%	9.1%	9.1%
		% of Total	2.8%	4.0%	2.4%	9.1%
Total		Count	25	161	66	252
		% within number of infracted animals	9.9%	63.9%	26.2%	100.0%
		% within age of animals	100.0%	100.0%	100.0%	100.0%
		% of Total	9.9%	63.9%	26.2%	100.0%

Table (24)number of infected animals * body condition

Crosstab

			body condition		
			Good	modrat	Total
number of infected animals	-ve	Count	184	45	229
		% within number of infected animals	80.3%	19.7%	100.0%
		% within body condition	90.2%	93.8%	90.9%
		% of Total	73.0%	17.9%	90.9%
	+ve	Count	20	3	23
		% within number of infracted animals	87.0%	13.0%	100.0%
		% within body condition	9.8%	6.2%	9.1%
		% of Total	7.9%	1.2%	9.1%
Total		Count	204	48	252
		% within number of infected animals	81.0%	19.0%	100.0%
		% within body condition	100.0%	100.0%	100.0%
		% of Total	81.0%	19.0%	100.0%

Table(25)number of infected animals * herd size

			herd size			
			larg	modrat	small	Total
number of infected animals	-ve	Count	178	20	31	229
		% within number of infracted animals	77.7%	8.7%	13.5%	100.0%
		% within herd size	89.4%	95.2%	96.9%	90.9%
		% of Total	70.6%	7.9%	12.3%	90.9%
	+ve	Count	21	1	1	23
		% within number of infected animals	91.3%	4.3%	4.3%	100.0%
		% within herd size	10.6%	4.8%	3.1%	9.1%
		% of Total	8.3%	.4%	.4%	9.1%
Total		Count	199	21	32	252
		% within number of infected animals	79.0%	8.3%	12.7%	100.0%
		% within herd size	100.0%	100.0%	100.0%	100.0%
		% of Total	79.0%	8.3%	12.7%	100.0%

Table (26) number of infected animals * source of animals

Crosstab

			sex of animals		
			female	male	Total
number of infected animals	-ve	Count	197	32	229
		% within number of infected animals	86.0%	14.0%	100.0%
		% within sex of animals	91.6%	86.5%	90.9%
		% of Total	78.2%	12.7%	90.9%
	+ve	Count	18	5	23
		% within number of infected animals	78.3%	21.7%	100.0%
		% within sex of animals	8.4%	13.5%	9.1%
		% of Total	7.1%	2.0%	9.1%
Total		Count	215	37	252
		% within number of infected animals	85.3%	14.7%	100.0%
		% within sex of animals	100.0%	100.0%	100.0%
		% of Total	85.3%	14.7%	100.0%

Appendix 3

Univariate analysis for risk factors in 252 camels tasted in

Algadarrif ,Sudan using Chi-square

number of infected animals * name of locality

Table (27)Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.927[a]	3	.269
Likelihood Ratio	5.807	3	.121
Linear-by-Linear Association	2.984	1	.084
N of Valid Cases	252		

a. 2 cells (25.0%) have expected count less than 5. The minimum expected count is 1.37.

Table (28) Number of infected animals* breed

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.885[a]	2	.143
Likelihood Ratio	5.138	2	.077
Linear-by-Linear Association	1.004	1	.316
N of Valid Cases	252		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 2.83.

number of infected animals * age of animals

Table (29)Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.387[a]	2	.002
Likelihood Ratio	9.153	2	.010
Linear-by-Linear Association	3.202	1	.074
N of Valid Cases	252		

a. 1 cells (16.7%) have expected count less than 5. The minimum expected count is

Table(30)number of infected animals * body condition

b. Computed only for a 2x2 table

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.592[a]	1	.442		
Continuity Correction	.241	1	.624		
Likelihood Ratio	.644	1	.422		
Fisher's Exact Test				.583	.326
Linear-by-Linear Association	.589	1	.443		
N of Valid Cases	252				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.38.

Table (31)number of infected animals * herd size

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.360[a]	2	.307
Likelihood Ratio	2.864	2	.239
Linear-by-Linear Association	2.259	1	.133
N of Valid Cases	252		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 1.92.

Table (32)number of infected animals * sex of animals

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.006[a]	1	.316		
Continuity Correction	.482	1	.488		
Likelihood Ratio	.910	1	.340		
Fisher's Exact Test				.351	.234
Linear-by-Linear Association	1.002	1	.317		
N of Valid Cases	252				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 3.38.

b. Computed only for a 2 x 2 table

Table (33)number of infacted animals * aborted animals

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.536E2[a]	1	.000		
Continuity Correction	144.114	1	.000		
Likelihood Ratio	84.916	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	152.957	1	.000		
N of Valid Cases	252				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 2.01.

b. Computed only for a 2x2 table

Table (34) number of infacted animals * contact with other animals

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.952[a]	1	.162		
Continuity Correction	1.256	1	.262		
Likelihood Ratio	1.759	1	.185		
Fisher's Exact Test				.171	.133
Linear-by-Linear Association	1.944	1	.163		
N of Valid Cases	252				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.47.

b. Computed only for a 2x2 table

Table (35)number of infected animals * source of animals

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.646[a]	1	.104		
Continuity Correction	1.941	1	.164		
Likelihood Ratio	2.926	1	.087		
Fisher's Exact Test				.159	.078
Linear-by-Linear Association	2.635	1	.105		
N of Valid Cases[b]	252				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.48.

b. Computed only for a 2x2 table

Appendix 4

Questionnaire to Salivary Epidemiology study of Brucellosis in camels (Camelus Dromedarius) in Algadarrif state – Sudan .

(A) General characteristics

Date---------- serial NO----------

(1) Owner Name---------- ---------- (2) Phone No

(3)Location---------- (4)Locality

(5)Education level :

Illiterate Primary Secondary graduate

(6) Herd Size :

<10 10 – 20 > 20

(7) Camels sex :

All male All female mixed

(8) History of Brucellosis

Yeas No

(B) Individual Camels factors

(1) Age:

> 5 (menthes) 5- 10 year > 10year

(2) sex:

Male ( ) female ( )

If male :

Orchitis ( ) Hygroma ( )

If female :

Hostory of abourtion Yeas ( ) No ( )

(3) Berrd:

Boshari ( ) Anafi ( ) Alarabi ( )

(4) Boody condition :

Good ( ) Bad ( )

(C) Manage mental factors:

(1) Operation type :

Intensive ( ) Semi- intensive ( ) extensive ( )

(2) Production type :

Milk ( ) Meat ( ) both ( ) racing ( )

(3) Housing :

Open ( ) closed ( ) semi- closed ( )

(4) Water source :

Tap water ( ) Underground ( ) Surface water ( )

(5) Wariness of fetus and fetal membranes disposal :

Yeas ( ) No ( )

(6) Presence of dogs ;

Yeas ( ) No ( )

(7) Source of new Camels :

Herd ( ) Purchase ( )

(8) History of herd abortion:

Yeas ( ) No ( )

(9) History of herd mastitis:

Yeas ( ) No ( )

(10) Previous Brucellosis:

Yeas ( ) No ( )

(11) Veterinary Supervision:

Yeas ( ) No ( )

(12)Trust in vets :

Yeas ( ) No ( )

(13) Ethical treatment :

Yeas ( ) No ( )

(14) Wariness of Brucellosis:

Yeas ( ) No ( )

(15) Herd orchitis and Hygroma:

Yeas ( ) No ( )

(16)Reproductive Disorders (retained placenta ,stillbirth , in fertility

Yeas ( ) No ( )

(17) contact with other ruminant :

Yeas ( ) No ( )

(18) contact with other Camel herds:

Yeas ( ) No ( )

(19) Type of Breeding:

Within herd ( ) from out side ( )

(20) Milking man :

Private ( ) Common ( )