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

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Abstract

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. Garissa 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 zoonotic 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 (CO_2) 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

Keywords: Camel milk; north eastern Kenya; brucellosis

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Introduction

The camel (*Camelus dromedarius*) is the dominant livestock in North Eastern province of Kenya where it provides sustenance to many people. About 54% of the national herd estimated at 3 million is kept where camel husbandry has been a major source of livelihood for pastoralists where it provides transport, milk and meat for consumption or sale. The camel's ability to survive and thrive under harsh conditions makes it possible to use marginal and desert ecosystems (Abbas et al., 1992). Recently, camels have also become a national

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export commodity to the Middle East. However, one disease that affects camels remains a major constraint and there is need to investigate and generate valuable information related to the camel in this traditional socio-cultural environment. Brucellosis is a disease caused by varies species of the genus *Brucella* which is the most widely spread zoonosis worldwide (Dawood, 2008). Brucellosis is transmitted from animals to humans by ingestion of raw milk, milk products, raw liver, and close contact with animals through breeding, birth, slaughtering and contaminated dust (Cooper, 1992). Brucellosis is the most important zoonosis in terms of human incidence: almost all human cases are acquired from animals, particularly camels, goats and sheep (Al-Shamahy, 1999). Brucellosis in animals is caused by five recognized species of the genus Brucella. Four species commonly infect man: B. abortus, B. melitensis, B. suis and B. canis (Al-Shamahy, 1997).

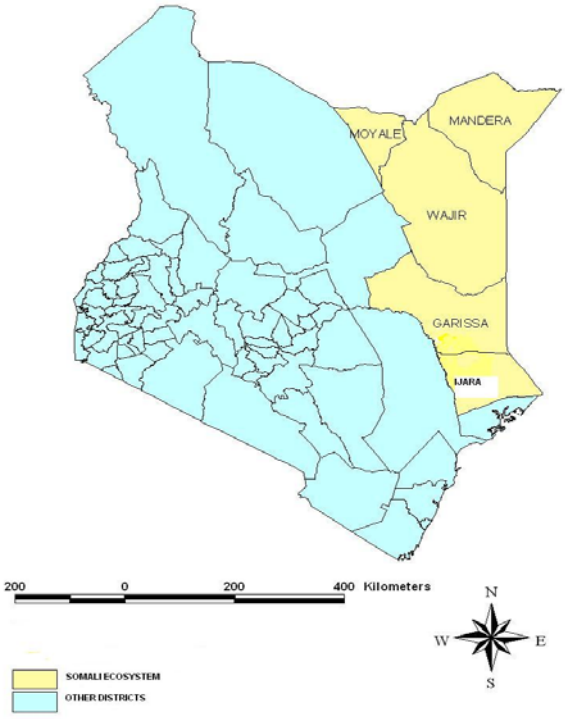

Fig 1: Study area

The disease can affect almost all domestic species and cross transmission can occur between cattle, sheep, goat, camel and other species (Ghanem et al., 2009). These diseases have great impact on economic development by affecting foreign market, apart from direct losses (morbidity and mortality) and indirect losses such as due to the costs of treatment and ineffective control measures (Perry et al., 2001).

Brucellosis has considerable public health importance as owners (Abbas et al., 1987; Gameel et al., 1993) consume raw camel milk and liver considered as delicacies. The prevalence is higher in intensive camel production system where large herd size kept at close proximity in a farm. In extensive management system the prevalence is low (Abbas and Agab, 2002). Infected animals show clinical signs of abortion and stillbirth in female and orchitis and epididymitis in male animals and infertility in both cases (Radostits et al., 1994; Agab, 1997; Straten et al., 1997). In production system where livestock diversification under practice, the disease circulates in sheep, goats and cattle and further spreads to dromedaries (Andreani et al., 1982; Radwan et al., 1992).

Camels are not known to be primary host for any of Brucella organisms but they are susceptible to both *B. abortus* and *B. melitensis* (Musa and Shigidi, 2001). Teshome et al. (2003) has reported 5.7 and 4.2% seroprevalence of brucellosis in camels kept in 3 arid and semi arid region of Ethiopia (Afar, Somali, Borana) using Rose Bengal Plate Test (RBPT) and Complement Fixation Test (CFT), respectively.

As Garissa Provincial medical hospital has recorded many cases of brucellosis in humans, the aim of this study was to investigate the presence of brucellosis in camels and its impact on the livestock rearing system.

Materials and Methods

The study area

The study was done in Garissa and Wajir districts of North-Eastern province, Kenya from October 2008 to March 2009. These are two of the four districts making up the expansive North Eastern province of Kenya. They lie in the Arid and Semi-Arid Lands (ASAL) of the country. The rainfall pattern is erratic and unreliable. It is always less than 600mm annually. Temperature ranges between 22^0C to 42^0C. The districts are flat, covered by trees and shrubs with grass undergrowth. Surface water is a serious problem in the area. Water sources are rivers (permanent and seasonal), pans, boreholes, dams and shallow wells. The mainstream activity of the two districts is livestock keeping. They are kept under pastoralist system. They include cattle, sheep, goats, camels, donkeys and poultry. Nomadic pastoralist communities living in ASAL regions largely depend on milk produced by camels which contribute 80% of the household needs (Schwartz and Dioli, 1992; Guliye, 2006). Animal husbandry is characterized by extensive pastoral production system and seasonal mobility. Camel and cattle herd splitting into mobile *"forra"* and home-based *"herds"* is practiced as strategy to mitigate forage and water shortage. Camel herd movement may be moving the whole herd to water point and to relatively high altitude where green forage is available or partial herd away from home base.

Pastoralist questionnaires

A total of sixty four (64) questionnaires were administered and answered during the study period of seven months (starting from 14th October 2008 to 31st May 2009). Fifty two (52) questionnaires were administered in Garrissa District while twelve (12) questionnaires were administered in Wajir District. Data collected from the questionnaire was entered into Ms-Excel as data package for processing and analyzed with Instat for windows to obtain frequency distribution for various aspects investigated. Descriptive Statistics for some parameters were also done.

Samples

Milk and serum samples from camels were used to test for presence of brucellosis in the camels. Volumes of 200ml – 300 ml of raw camel milk (from the producers or hawkers) was collected into labeled sterile bottles and kept in an ice-box, transported to laboratory for immediate Milk Ring Test (MRT) and bacterio-logical culture (analysis). When not immediately processed, the samples were kept in a refrigerator for a maximum of 24 hours. Volumes of 10 to 15 ml of blood were collected from the jugular vein of camels in plain vacutainer tube after restraining the animal**.** Blood was left to stand for 24 hours at room temperature (15 – 30^0C), to allow for serum separation. Serum was harvested by centrifuging at 3,000 to 3,500 × g or rpm for 10 minutes and decanting into sterile 2ml- vials labeled appropriately and stored in a freezer at $^-20^0$C at the District (Garissa) Veterinary Investigation Laboratory (VIL). The serum was then transported in cool boxes packed with ice to the Microbiology Laboratory (Faculty of Veterinary Medicine, University of Nairobi) for further immunological analysis using the Rose Bengal plate test (RBPT) and Serum agglutination (Micro agglutination) test (SAT) (Alton et al, 1988, Anon, 1986, Brinley,1997).

Identification

Identification of *Brucella* organisms was carried out using Modified (Stamp's) Ziehl-Neelsen method (Holt et al, 1994, Quinn *et al*, 2002, OIE Manual, 2004). A thin camel milk smear was prepared on a microscopic slide and heat fixed. The slide was then flooded with dilute Carbol-Fuchsin for 10 minutes without heating. The slide was washed well with tap water, differentiated with dilute acetic acid (0.5 %) for exactly 10 seconds. The slide was then washed thoroughly with tap water and counter stained with 1 % methylene blue for 0.5 – 1 minute, washed under tap water, blotted dry and heated gently to remove residual moisture. The slide was then examined with the dry objective (× 40) to find a satisfactory area and finally with the oil immersion (× 100) objective).

In a positive test *Brucella* would stain as pink or red coccobacillus (short rods) occurring singly, in pairs or in short chains. Other bacteria would stain blue.

Isolation of *Brucella spp.* Camel milk was first centrifuged at 5900 to 7700xg for 15 minutes, in order to concentrate the bacteria. Culturing through streaking (Laboratory and field handbook on bovine mastitis, 1987; Quinn et al, 1994) was done from the resultant pellet (Walker, 1999) onto Tryptose (Trypcase) Soy agar, to which bovine serum was added at 2-5%; in order to enhance the growth of *Brucella abortus* (Songer and Post, 2005). The inoculated medium was then incubated at 37°C under 5-10 v/v carbon dioxide (CO_2; using a carbon dioxide jar) for up to one week (Songer and Post, 2005) – the primary isolation of *Brucella* done under high CO_2 concentration (8-10%); growth was examined after 72 hours. *Brucella* colonies were generally expected to become visible after cultures were incubated for 3 to 5 days. Colonies are usually small (o.5-1 mm. in diameter), round with entire (smooth) margin, translucent and have a pale honey colour (Gameel et al, 1993; Agab et al, 1994). Older colonies are larger (2-4 mm. diameter) and more brown in colour (Songer and Post, 2005). *Brucella* organisms are gram-negative without bipolar staining (Songer and Post - 2005).

Detection of *Brucella* antibodies in milk and serum
Milk Ring Test (MRT)

The MRT was used to detect *Brucella* antibodies in milk. Stained *Brucella* antigens (cells) were added to the non-homogenised camel milk. *Brucella* antibodies (when present in milk) agglutinated the *Brucella* antigens added forming fat globule-complexes which rose to form a bluish coloured cream layer at the top (Alton et al - 1988, Anon - 1986, Coetzer and Tustin - 2004).

A volume of 2.5 ml of camel milk sample was mixed with 1 drop of *Brucella* stained antigens (Urocel®) in a clean sterile 5 ml test tube. The mixture was then incubated 37^0 C for one hour before reading the results.

Rose Bengal Plate Test (RBPT)

All serum samples collected (n = 200) were initially screened by RBPT using Rose Bengal Plate Test antigen (Rose Bengal-Antigen, Inaktivert, Flussig, Vor Gebrauch Schuttein, Verw, bls, 31: 05: 4000, In Vit, o Diagnost Skikum Zul – Nrb. BGAF – 146. Belgium). Serum samples were kept in refrigerator at 4^0 C before testing. Sera and antigen were left at room temperature for half an hour before the test to maintain to room temperature. Equal volumes (30µ) of test serum and antigen were mixed, shaken for four minutes and viewed. Any degree of agglutination was recorded

Table 1: Results of the Milk Ring Test for Garrissa and Wajir districts, separately and combined

		Garissa n=230		Wajir n=154		Combined n=384	
		Number	%	Number	%	Number	%
Milk Ring Test	Positive	35	15.2	24	15.6	59	15.4
Reaction	Negative	195	84.8	130	84.4	325	94.6

Rose Bengal Plate Test (RBPT)

Table 2: Results of Rose Bengal Plate Test (RBPT) for Garrissa and Wajir districts, separately and combined

		Garissa n=72		Wajir n=128		Combined n=200	
		Number	%	Number	%	Number	%
Rose Bengal Plate	Positive	2	2.8	2	1.6	4	2.0
Test reaction	Negative	70	97.2	126	98.4	198	98.0

Table 3: Results of Serum Micro agglutination Test (SAT) for Garissa and districts, separately and combined

		Garissa n=72		Wajir n=128		Combined n=200	
		Number	%	Number	%	Number	%
Serum Micro-	Positive	13	18.1	8	6.4	21	10.5
agglutination Test reaction	Negative	59	81.9	120	93.8	179	89.5

as positive (Alton et al, 1975; A positive control was run concurrently for every 10 samples tested for comparison.

Microagglutination

This test was carried out according to the method described by Tizard (1996). A range of serum dilutions from ½ to 1/4096 was made (Herr and Brugge, 1985).

Serum Agglutination test

The test used Rose Bengal stained standardized *Brucella abortus* antigens (Central Veterinary Laboratory – CVL- Weybridge, New Haw, Addlestone, Surrey KT 15 3NB, UK). 50 micro liters of PBS were dispensed using a multi channel micropipette in all wells and then the same amount of test serum was dispensed in each first well of the rolls. The serial dilution was done from the first well of the roll to the last transferring 50 µl from the first to the last well and the last 50 µl was discarded and lastly 50 µl of standardized Rose Bengal stained *Brucella abortus* antigens at pre-calculated dilution was dispensed in all wells. A negative control was set consisting of 50 µl of stained antigens and 50 µl of saline for each dilution. The microtitre plate was then shaken well to mix the contents and then left at room temperature overnight (12 – 18 h).

Statistical analysis

Descriptive statistics were used and frequency distributions calculated (Thrusfield and Bertola, 2005). Prevalences of positive animals were determined by dividing the number of positive serum samples by the total number of samples tested. A herd was considered positive for a given serotype if one or more serum samples had antibody titres above 160 in the serotype-specific SPBE.

Data collected in the questionnaire and from serological tests was scored appropriately and recorded in spread-sheet (Ms-Excel) and analysed using Instat for windows. The seroprevalence for animal level was calculated on the basis of Rose Bengal Plate Test (RBPT) and Serum micro-agglutination Test (SAT) positivity, dividing the number of *Brucella* reactors by total number of tested animals. Descriptive statistics was also used for different variables.

Results

Livelihoods

The types of livestock kept by the pastoralists in Garrissa and Wajir Districts included cattle, sheep, goats, camels, donkeys, and domestic chicken. Camels were also kept as a means of transport, especially when the pastoralists were moving from place to place in search for fresh pastures for their livestock Camels were watered every 3 to 5 days (34.4%) or once every week (7 days; 45.3%), depending on the distance to the water source from the pastures. Lactating camels were milked either by herding boys/employed herdsmen (24/64 = 34.4%), women (15/64 = 23.4%), or male owners (27/64 = 42.2%). All the respondents said they practiced what is known as “dry milking”. That is: the udder is not washed with water, but dust is wiped from the udder and teats with the palms of the milker’s hands and milking started immediately. At times, when not being milked, the camel owners tied one or two teats of the camel with a piece of rope from the bark of a tree to serve as an anti-suckling device to prevent calves from suckling. These ropes are untied before milking commences. Containers that the pastoralists use for milking, preservation and transportation of camel milk, included: traditional gourds, used at 48.4%; aluminium/steel, cans at 17.2%; and plastic jerrycans, at

34.4%. All those interviewed said the milk containers belonged to them. Traditional gourds, of approximate capacity of 3 liters, and aluminium/steel cans, of 5 liter capacity, were used for milking. Traditional gourds, of 6 liter capacity, and plastic jerrycans, of varying sizes, were normally used for milk transportation; while traditional gourds, of 10 liter capacity, aluminium/steel cans, of 5 liter capacity, and plastic jerrycans, of varying sizes, were used for milk preservation. The traditional gourds were curved from wood. The traditional gourds of different capacities seemed to be referred to by different terms: "Amel" for one with approximately 3 liter capacity; "Sulma" for one with approximately 6 liter capacity; and "Gilla" for one with approximately 10 liter capacity.

***Brucella* organisms - Direct staining**

None of the 384 milk samples cultured yielded *Brucella* colonies after 72 hours' incubation; not even after a further 96 hours' incubation (4 days).

The same was the case when milk smears were stained with modified Ziehl Neelsen staining technique. No *Brucella* organisms were observed.

Milk Ring Test (MRT)

A total of three hundred and eighty four (384) camel milk samples from Garissa and Wajir Districts were tested using the MRT. The results of the test were as recorded in Table 1 Fifty nine (59) samples (15.36%) tested positive while three hundred and twenty five (325) samples tested negative. When compared at percentage level, the two districts had similar reaction rates.

A total of two hundred camel serum samples from Garissa and Wajir Districts were tested using the RBPT. The results of the test were as recorded in Table 2**.** Four samples (2.0%) tested positive while one hundred and ninety six samples tested negative. When compared at percentage level, Garissa had a higher percentage of reactors (2.8%) than Wajir (1.6%).

Serum Micro agglutination Test (SMT)

The agglutination titre of the serum was recorded as the serum dilution factor (well 1 was recorded as ½ and well 12 as 1/4096).

A total of two hundred (200) camel serum samples from Garissa and Wajir Districts were tested using the SAT. The results of the test were recorded in Table 3. Twenty one (21) samples (10.50%) tested positive while one hundred and seventy nine (179) samples tested negative. When compared at percentage level, Garissa had a higher percentage of reactors (18.1%) than Wajir (6.4%). The range between the two areas, with respect to positive reactors, was much higher than with RBPT.

Discussion

All the milk samples examined were negative for *Brucella* Modified Ziehl- Neelsen's stain meaning that no *Brucella* cells were detected in these samples. Likewise, primary isolation of *Brucella* on Tryptose Soy agar (TSA) under high carbon-dioxide (CO_2) concentration yielded no *Brucella* colonies in all the milk samples tested even after incubation of the TSA plates for 7 days at 37^0C. This could be attributed to the facts that (1) *Brucella* organisms are often present in small numbers in milk and milk products as observed by Walker (1999) and (2) there was a dilution factor since bulk milk was used as samples for culturing. 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 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. Pastoralists in North-Eastern province practiced a high degree of ruminant diversification, i.e., in addition to camels, they kept cattle, sheep and goats. Keeping a mixture of animals is also common in other areas and has economic and ecological advantages (Getahun and Kassa, 2000). While this may be okay economically, in the event that the other animals are infected, such mixing increases the chances of transmission of brucellosis and other diseases to the camels (Andreani et al., 1982; Radwan et al., 1992). This is more so since results showed that large numbers of livestock herds normally congregated at water points, facilitating the spread of disease**.** Traditional wells, ponds/dams and few rivers were also documented as major permanent water sources in the area. Unlike traditional wells where water is raised from deep well by people and added to the trough, animals had direct access to pond/dam water and contaminated it through discharges. However, the exposure rate may not be very high due to the fact that camel herds are mobile; this does not restrict them to a specific category of the water resources (Bekele, 2004). Brucella infection in farm animals is considered a great problem in most countries of the world. Therefore, the early detection of *Brucella* infection in a herd or flock is a pre-requisite for the successful control and elimination of one of the major problems considered to be a predisposing factor leading to infertility and sterility in the herd, along with the possible transmission of infection to man (Wasseif, 1992). Brucellosis exists in stock animals, the disease being an occupational hazard for veterinarians, fur

workers, abattoir workers as well as laboratory workers (Madkour, 1992). More over, other than occupational contacts, there is high-risk of transmission to humans through consumption of milk or milk products of sero-positive animals (Schelling et al., 2003). The disease can also be a health hazard to pastoral households who are exposed to the disease in many ways (Abbas and Agab, 2002). Camel owners (pastoralists) of the study area consume raw camel milk, and do delivery assistance, clean newborns, assist suckling and carry the young from field to home without any protection. Since they have no awareness of Brucellosis, they are at great public health risk. Abou-Eisha (2000) reported 1% (3 out of 330) brucellosis seroprevalence among nomadic people. The disease in man may be misdiagnosed due to the prevailing malaria infections in dry areas (Abou-Eisha, 2000; El-Ansary et al., 2001). A total of two hundred camel serum samples from Garissa and Wajir Districts were tested using the Rose Bengal Plate Test (RBPT). Four (4) samples (2.0%) tested positive. From Garissa 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 Garissa and Wajir Districts were also tested using the Serum Micro-agglutination Test (SAT). Twenty one (21) samples (10.50%) tested positive. For the 21 positive samples, 10 samples had a titre of ½, 3 samples a titre of ¼, 2 samples a titre of 1/8, 1 sample a titre of 1/16, and 5 samples a titre of 1/32. From Garissa District (n = 72), 13 samples (18.06%), were positive while 8 samples (6.25%) from Wajir District (n = 128) were positive.

The seroprevalence finding of the present study (10.50%) is similar to the previous reports from different countries (; Abou-Eisha, 2000; Teshome et al., 2003). However, it is lower than some studies in Ethiopia (Domenech, 1977), Kenya (Waghela et al., 1978), Nigeria (Ajogi and Adamu, 1998), Sudan (Ginawi, 1997; Majid et al., 1999), Somalia (Andreani et al., 1982), Kuwait (Al-Khalaf and El-Khaladi, 1989) and Saudi Arabia (Radwan et al., 1992).

The seroprevalence of brucellosis in camels is low in extensively kept pastoralist camels. Thus, prevalence ranging between 2 and 5% were reported from most countries where camels are produced by pastoralists (Abbas and Agab, 2002; Wernery and Kaaden, 2002). On the other hand, titres as high as 8 to 15% have been reported in intensively kept camels especially in Saudi Arabia (Radwan et al., 1992) and Kuwait (Al-Khalaf and El-Khaladi, 1989). In such production system, large herds, together with overcrowding in restricted area, provide more chances of contact between animals leading to increased likelihood of infection.

Several factors may affect the result of serological findings. Higher seroprevalences of brucellosis have been recorded when multiple serological tests were used in parallel (Waghela et al., 1978; Al-Khalaf and El-Khaladi, 1989) because of sensitivity variations among the tests (Andreani et al., 1982). Majid et al. (1999) reported higher seroprevalence rate (ranging from 14 to 43.9%) using RBPT alone (highly sensitive test). Reported lower prevalence rates by some authors could be a result of using tests with low diagnostic sensitivity (Baumann and Zessin, 1992) or as a consequence of serial multiple tests (Abbas and Agab, 2002). Cross-reacting bacteria such as *Escherchia coli*, *Yersinia enterocolitica and Salmonella serotypes* (Cloeckaert et al., 1992; Garin-Bastuji et al., 1999) have potential to affect serological findings when tests of low specificity are used. *Brucella abortus* may cross-react serologically with *Escherichia coli* sero-group O:157, *Yersinia enterocolitica* serovar O:9, *Salmonella* serotypes of the Kaufmann-white group N, *Francisella tularensis*, *Pseudomonas maltophilia*, and *Vibrio cholera* (Corbel, 1985) because the immunodorminant O-chain of the smooth lipopolysaccharide (S- LPS) of these bacteria contains antigenic motives (epitopes) that may be detected in brucellosis serological tests that use whole *Brucella abortus* cells or S-LPS extracts (Weynants et al., 1996). Such False Positive Serological Reactions (FPSR) induced by these organisms are probably not of great significance in the early phase of eradication campaigns but when the prevalence of the disease has been reduced to a very low level, then this phenomenon may jeopardize the success of the eradication programme (Godfroid et al., 2002).

On the other hand, the immune suppressive effects of trypanosomiasis, which is often prevalent where camels are kept, were reported in vaccinated cattle and goats, implying possible impact on serological findings (Chukwu, 1985). Sample selection bias also might affect serological findings. Ajogi and Adamu (1998) recorded seroprevalence as high as 27.8% from camels slaughtered at three camel rearing regions of northern Nigeria. The sample of animals tested may have been affected by the fact that slaughter of animals kept under extensive pastoral management is normally selective-it is the animals whose production performances have declined substantially that are slaughtered.

It is important to note that slide agglutination test and tube agglutination tests have been shown to have poor diagnostic sensitivity compared to RBPT or card test (Alton et al., 1975; Quinn et al., 2002). Accordingly, RBPT is considered as satisfactory screening test (Nicoletti, 1980; OIE, 2000; Quinn et al., 2002). The highest specificity of Compliment Fixation Test (CFT) deserved it to be used as confirmatory test in serial testing (OIE, 2000). Improvement of test diagnostic specificity is particularly useful in control programs when test and slaughter policy is adopted. In camels there are yet no standards set for the diagnostic test protocol and diagnostic titre for brucellosis;

although OIE (2000) recommends the test procedure outlined for the diagnosis of bovine brucellosis to be applied for camels. It is also not well defined to what extent biochemical and physiological peculiarities of camelids contribute to the test result variability.

Brucellosis remains widespread in domesticated and wild animal populations, and it presents a great economic and public health problem in African countries (Chukwu, 1985, 1987). Brucellosis in camels has been reported in Saudi Arabia, Kuwait, Oman, Iraq, Iran, Sudan, Egypt, Libya, Kenya, Ethiopia, and Somalia (Waghela et al., 1978; Damier et al., 1984; Yogoub et al., 1990; Radwan et al., 1992; Gameel et al., 1993; Refai, 2002; Agab, 1993; Teshome et al., 2003). It has been reported even in racing camels in the United Arab Emirates (Afzal and Sakkir, 1994). *Brucella melitensis* biovar 3 is the most commonly isolated species from animals in Egypt, Jordan, Israel, Tunisia and Turkey. *Brucella melitensis* biovar 2 was reported in Turkey and Saudi Arabia, and *Brucella melitensis* biovar 1 in Libya, Oman and Israel. *Brucella abortus* biovar 1 was reported in Egypt, but most human cases are caused by *Brucella melitensis*, particularly biovar 3 (Radwan et al., 1992; Gameel et al., 1993; Agab et al., 1994; Abou-Eisha, 2000; Hamdy and Amin, 2002). According to Chukwu (1985), the high prevalence of the disease in Africa is probably due to the fact that many African countries have not started control or eradication schemes among the camel herds. Vaccination is limited to cattle and small ruminants (Refai, 2002). Camel herd size has been identified to be the major risk factor for brucellosis to occur in relation to other factors (Bekele, 2004). As herd size increases, the chance of contact between animals increases leading to more chances of infection (Abbas and Agab, 2002), which is particularly more important during calving or abortion, when most of brucellosis contamination occurs (Gameel et al., 1993; Agab et al., 1994). Thus, herd size and density of animal population, together with poor management, are directly related to infection rate (Abbas et al., 1987; Abou-Eisha, 2000; Wernery and Kaaden, 2002). Zoonotic diseases continue to present an important health hazard in most parts of the world, particularly in developing countries (Stohr and Melsin, 1997). Brucellosis is a classical zoonosis and the major sources of infection remain contact with infected animals or the handling of carcasses. Less frequently, it is acquired through food. Camels are not known to be primary hosts of *Brucella* organisms, but they are susceptible to both *Brucella abortus* and *Brucella melitensis* (Cooper, 1991). Consequently, infection rate in camels depends upon the infection rate in primary host animals in contact with them. In the study area of Northeastern province of Kenya, camels are kept in close contact with other animals**.** In Darfur region of western Sudan, which owns over 25% of cattle, sheep and goats in Sudan, brucellosis is widely spread in large and small ruminants, and camels introduced in the area showed high levels of incidence (Mousa, 1995). Mixed herding and frequent contact with small ruminants and cattle are contributing factors to infection rate. There is high chance of brucellosis transmission from these ruminants to dromedaries as they live in free range in promiscuity in the bush and at water points (Andreani et al., 1982). Contact between dromedaries and especially small ruminants were more incriminated for the transmission of brucellosis to camels (Ismaily et al., 1988; Radwan et al., 1992). Abou-Eisha (2000) also observed higher seroprevalence in camels that were in contact with sheep and goats. Moreover, higher frequencies of *Brucella melitensis* isolation from camels (Abbas and Agab, 2002; Wernery and Kaaden, 2002) magnify the role of small ruminants in the transmission of brucellosis to camels. Brucellosis in camels seems to display less clinical signs and antibody levels than in cattle (Mousa, 1987), probably due to a relative resistance of camels to brucellosis. The disease should be controlled by vaccination of camels and primary hosts (cattle and the small ruminants). Improving management practices is one way of attempting to control brucellosis. This would aim to improve hygiene and reduce the chances of contact between infected and non-infected animals. Although it would not be easy under many pastoral circumstances, where resources are lacking and the movement of livestock is difficult to restrict, the following points can be attempted in reducing infection rates (Hunter, 1994, Radostits et al., 1994): (1) Public awareness, which is of vital importance in successful control and prevention of brucellosis , (2) Isolation of infected animals and female at parturition, (3) Proper disposal of aborted fetus, placental tissue and uterine discharge and (4) Disinfection of contaminated areas.

This survey has thus confirmed the presence of brucellosis in the Northeastern province of Kenya, showing a significant prevalence rate in camels (15.36% with the MRT and 10.50% with SAT). There is, therefore need for control programmes for the disease in the camels and other animals, in the area, so as to improve on production and to minimize risk of transmission to humans. As long as the disease persists in the animal reservoir and the pastoralists continue to drink raw camel milk, prevalence of human brucellosis, in the area, is bound to increase.

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