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ASSESSMENT OF THE ECONOMIC LOSSES DUE TO BOVINE BRUCELLOSIS IN KHARTOUM STATE, SUDAN

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Abstract— **Brucellosis is an important re-emerging zoonotic disease. Apart from the public health hazard significant it has a great economic impact on both health and agricultural sectors. In health sector the burden of the disease is usually quantified in monetary and non –monitory terms. In agriculture the disease affects a range of domesticated animals resulting a huge economic loss in term of production and reproduction evolvement also the disease acts as trade impeder. This paper deals with the economic impacts of bovine brucellosis in Khartoum State, Sudan. Khartoum State as well as the country at large was proved to be endemic with both human and animal brucellosis. Many studies were carried out on the epidemiology of the disease, yet few studies were focused on the economic significant of the disease. In this work a comprehensive epidemiological survey covering the seven localities of the State was held to determine the situation of bovine brucellosis. A multi stage cluster sample was used to determine the prevalence rate in each locality where Rose Bengal Plate Test was used to identify the positive reactors. A weighed average of 25.1% prevalence rate was introduced to the economic model for assessment of the financial loss due to the disease. Accordingly the loss attributed to the disease was estimated at State, Locality and animal levels. Moreover, the cost due to reproduction, production and veterinary intervention was also quantified. The paper concluded that the disease constitutes a serious economic burden to the economy of the State and the producer in the absence of a formal control strategy. The paper recommended that there was an urgent need to formulate and implement livestock brucellosis control strategy in the State and the whole country for the benefit of both agriculture and health sectors.**

Index terms- ***bovine brucellosis; economic assessment, economic modelling, Khartoum State*.**

I. Introduction

A part from securing food, generating income, providing employment opportunities, livestock serve as store of wealth and is utilized in traction and transport. Among Arab and African countries Sudan occupies the first rank in terms of livestock resources. As estimated in 2011 by MARFR [1] the total number of livestock population accounted to 29,618, 39,296, 30,649 and 4,715 thousand head of cattle, sheep, goats and camels respectively. Livestock production has vast potential and provides about half of agricultural earnings. In spite of the rich resource endowment Sudan is considered one of the least developed countries. The potentialities of livestock subsector in particular are affected by many impeders; Animal diseases are not an exception. Although, Khartoum State has the lowest numbers of cattle compared with other states, yet the major modernized dairy production is centred in Khartoum State which specialized in commercial milk production [2].

Brucellosis is a worldwide zoonosis that affects variety of host range. The disease is caused by a number of species of the genus brucella. The organism is gram negative facultative intra cellular coco bacillus, acid fast non spore forming. The genus *Brucella* tends to infect specific animal species but most of *brucella* species can infect other animal species and some are zoontic [3]. Since Brucella spp. have distinct host preferences [4], seven species of the genus were identified; these are *brucella abortus, brucella melitensis, brucella ovis, brucella suis, brucella canis, brucella pepedialis and brucellaa maris.* Brucellosis is still a major problem, widely distributed throughout the world, mainly in developing countries due to traditional feeding habits and the failure to maintain standards of hygiene because of socio-economic conditions [5].

Brucellosis in cattle is usually caused by biovars of *B.abortus*. Infection can also be caused by *B. Melitensis* [6]. *B. suis* may cause a chronic infection in the mammary gland of cattle, but it has not been reported to cause abortion or spread to other animals [7]. In cattle the infection is characterized by abortions during the last trimester of gestation, perinatal mortality, and infertility, whereas bulls can develop orchitis [8].

Seroprevalence of bovine brucellosis were reported in Eastern Ethiopia and Guto Gida District East Wollega Zone as (3.5%) & (1.97 %), by Bekele *et al* [9] and Moti *et al* [10] respectively. In Kampala individual animal prevalence was 5.0% [11].

In Sudan animal brucellosis was discovered early in 1904 and was first reported by Bennet [12] in Khartoum. Later many researchers surveyed the disease in different animal species in different localities in Sudan. In Khartoum State the rates of positive reactors in cattle was estimated at 30.1% in Kuku scheme [13].

Food and Agriculture Organization of the United Nations (FAO) and the Organization of Animal Health (OIE) consider brucellosis as has not only direct public health implications , it also poses a barrier to trade of animals and animal products [14,15] and has a wide socioeconomic impacts especially in countries where people in rural areas rely to a large extent on livestock breeding and dairy products as a source of income [16, 17, 18, 19].The economic loss from brucellosis in developed countries arises from the slaughter of cattle herds that are infected with brucellosis and all the cost of eradication and control program. In developing countries farmers suffer from the actual abortion of calves and the decreased in milk yield, birth of weak calves that die soon after birth, retention of placenta, impaired fertility and sometimes arthritis or bursitis and all the cost of tests and samples,death may occur as a result of acute metritis [20, 21].

The estimation of the financial loss caused by brucellosis depends mainly on the type of cattle farming, herd size, and loss in reproduction in meat and milk due to abortion. The infected non aborting dairy cows produced 10% below potential and the aborted ones at 20% [22]. The percentage of abortion in infected cows annually is 10-35% [23].

The economic impact of brucellosis varies from country to country and from region to region. In Latin America annual losses were estimated at $600 million and the losses for Argentina were estimated at US$ 60 million per year or US$1.20 per bovine considering prevalence around 5% [24, 25]. In the U.S.A. the cost of abortion and reduced milk production in 1952 alone were put at $400 million [26] and in Nigeria losses were estimated at US$ 575,605 per year or US$3.16 per bovine based of prevalence rate ranging between 7% to 12% [24].

The current work was carried out to estimate the economic losses due to bovine brucellosis in Khartoum State based of sero- prevalence survey.

II. . MATERIAL AND METHODS

A. The Study Area.

Khartoum State, the capital State is one of the eighteen states of the Sudan. It is the smallest State area wise (22,142 km^2), yet it the most populous state with approximately 5,274,321 inhabitants with growth rate of 8.9% annually. The state lies between longitudes 31.5 to 34 ^{0}E and latitudes 15 to 16 ^{0}N [27]. Livestock population was estimated at 1,348,676 heads of which 244,688 were cattle [28]. The breeds of cattle found in the State are local breeds mainly Butana, and crossbred between local breed and Friesian with different percent mostly less than 75% [29].

B. Sources of Data

Data were collected from both secondary and primary sources. The secondary data were obtained from different sources such as Ministry of Agriculture, Animal Resources and Irrigation -Khartoum State, relevant studies, text books and web sites. The primary data were collected by conducting an epidemiological and economic survey during the period from April to October 2012. A multi stage cluster sample [30] was used to select the investigated herds. The number of clusters (herds) was calculated using the following formula according to Bennett *et al* [31].

$$C = P \quad (1-P) \quad D/SE^2 \quad n \tag{1}$$

Where C is the number of clusters to be sampled, P is the expected prevalence [32], D (= 4) the design effect of using cluster sample instead of simple random sample, SE (0.05) is the standard error of the estimate and n is the average cluster size. According to previous prevalence the clusters were calculated for each locality.

A pre-tested structured questionnaire was used to collect the economic data from 103 selected herds. A total of 2068 blood samples from mature females were collected for the estimation of prevalence rates after the serological examination. The blood samples were transferred to the College of Veterinary Medicine-Sudan University of Science and Technology where serum was separated and conserved in cryotubes. The serum was transferred to Veterinary Research Institute (VRI) at Soba for serological testing. All sera samples were kept at -20 C until they were tested using Rose Bengal plate test (RBPT) for the presence of antibodies against *Brucella* antigens as described by Alton *et al* [33]. All degree of agglutination was considered as positive reaction. Accordingly the prevalence rate of brucellosis in each locality was estimated and the weighted average for the State was calculated.

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C. The Economic Model

The following model was used to estimate the total economic losses in the State;

TEL = MT+ MD (2)

Whereas;

TEL = Total economic loss

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

MD = Economic loss due to morbidity

MD = ML + CL+LRB+ CVI (4)

Whereas;

ML (value of milk lost) = (Milk losses of aborted cows + milk losses of non aborted cows) x price of milk/kg. (5)

CL (value of calves lost) = (number of mature females x abortion rate of seropositive) x average price of weaning calf. (6)

LRB (Losses due to repeat breeding)
= number of repeat breeders x cost of repeat breeding per cow. (7)

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

Annual losses per head = total economic losses/

number of cattle population (9)

Annual losses per mature female = total economic losses/ number of mature female cattle (10)

Annual losses per seropositive female = total economic losses/ number of seropositive female. (11)

D. The Parameters fitted in the model

The epidemiological parameters and economic data were obtained from the field survey. Reproductive and productive parameters were based on the previously published indicators with minor adaptations as follows:

(i) Number of mature cows in each locality and the state were obtained by multiplying the total number of cattle in each locality and the state [28] x the ratio of mature female 58.8% [13].

(ii) Number of seropositive mature females = Number of mature cows x prevalence rate (the laboratory result).

(iii) Number of seropositive aborted females = Number of seropositive mature females x 0.07% incidence of abortions in infected cows (the field data).

An incidence rate of repeat breeding of 0.08 (adapted from 0.15 infertility rate due to brucellosis [16] – 0.07 abortion rate of seropositive (field data).

(iv) 1% mortality risk for seropositive aborted cows [36].

(v) 10% loss of the total milk yield of infected non aborted cows [22].

(vi) 20% loss of the total milk yield of infected non aborted cows [22].

(vii) Annual milk yield of 2,614 Kg/cow [37].

(viii) Price of milk SDG 3 obtained from field.

(ix) Average price of weaning calf of SDG 900 obtained from field.

(x) Cost of repeat breeding per cow of SDG 11.3 based on Angara and Elfadil [34].

(xi) Cost of veterinary intervention per cow of SDG 53.141 according to Elfadil [35].

(xii) 1$US= 4.6 [38].

E. Data Analysis

Microsoft excel was in the analysis.

III. RESULTS

A. *The prevalence rates of bovine brucellosis in the localities of Khartoum State*

Table 1 presents the prevalence rate of bovine brucellosis in each locality in Khartoum State based on Rose Bengal Plate Test. The average rate for the State was found to be 27.5% and the weighted average was 25.1%.

Khartoum locality has the highest prevalence rate (36.1%) followed by Jebel Aolia, (35%) while Omdurman locality has the lowest prevalence rate(19.1%) followed by Umbeda (20.6%).

Table 1.The number cattle, mature cows, prevalence rates and brucellosis seropositive cows In Khartoum State localities

Locality	Cattle population	Mature cows	Prevalence rate %	Seropositive cows
Karrari	13,660	8,032	27.6	2,217
Omdurman	13,343	7,846	19.1	1,495
Umbeda	28,944	17,019	20.6	3,506
Bhri	27,531	16,188	30.5	4,937
East Nile	135,674	79,777	23.4	18,668
Khartoum	5,529	3,251	36.1	1,174
Jabel Aolia	20,007	11,764	35.0	4,117
Khartoum State	244,688	143,877	25.1	39,566

Based on the above prevalence rates and the Livestock estimates in the Khartoum State, the numbers of seropositive animals are shown in table1. The number of the total seropositive cows in the State (39,566) cow was based on the weighted average prevalence.

B. Losses due to bovine brucellosis

1. Number of cows died due to brucellosis

The number of aborted cows is estimated at 2528 head out of which 25 cows died as a result of metritis.

2 Quantity of milk lost due to brucellosis

The quantity of milk lost from seropositive aborted cows is found to be 1,321,591.8 kg/year and that lost form seropositive non aborted cows is 8,779,145.575 kg/year. Accordingly the total annual amount of milk lost due to brucellosis in the State is 10,100,737.38 Kg/year.

3 Number of calves lost.

Calves lost due to brucellosis as a result of abortion and increased inter-calving period are estimated at 3,084 calves yearly

4. Number of repeat breeders

Repeat breeding as a result of brucellosis was estimated to be 2889 cow.

5. Veterinary intervention

The aborted cows require veterinary intervention in term of examination and treatment.

C. Economic losses due to bovine brucellosis

In table 2 the annual economic losses due to bovine brucellosis in Khartoum State are estimated in both domestic currency; the Sudanese pound (SDG) and the equivalent international currency ($US) the calculation of the total economic is done using eqn, (2). It was found that Khartoum State loses SDG 33,548,189.5 ($US7, 293,084.6) annually as a result of the disease.

Table 2: Estimated annual economic losses due to brucellosis in Khartoum State

Cost components	SDG	Total (SDG)	Total (US$)	%
Losses due to mortality of aborted seropositive		303,349.3	65945.5	1.0
Losses due to morbidity		33,244,840.2	7,227,139.1	
Milk Losses (SDG) Milk Losses ($US)	30,302,212.2 6,587,4			90.3
loss in calves harvest (SDG) loss in calves harvest ($US)	2,775,646.1 603,401.3			8.2
losses due to repeat breeding (SDG) losses due to repeat breeding ($US)	32,646.2 7,097.0			0.1
cost of veterinary intervention cost of veterinary intervention	134,335.7 29203.4			0.4
Total economic losses		33,548,189.5	7,293,084.6	100

1 Economic loss due to Mortality

The loss due to the death of 25 cow died as a result of metritis was estimated at SDG 303,349.3 equivalent to $US 65945.5. using eqn, (3).

2 Economic losses due to Morbidity

The morbidity of the disease deprived the state about SDG 33,244,840.2 ($US 7,227,139.1) as computed by eqn, (4).

2.1 Economic losses due to reduction in milk production. The state lost a

total of SDG 30,302,212.2 ($US 6, 587, 4) from both seropositive aborted and

non aborted cows (eqn,5).

Table 3: Estimated annual economic loss due to brucellosis in each Locality

Locality	Economic losses (SDG)	Economic losses ($US)	%
Karrari	1,872,867.8	407,145.2	5.6
Omdurman	1,829,405.2	397,696.8	5.5
Umbeda	3,968,395.6	862,694.7	11.8
Bhri	3,774,664.9	820,579.3	11.2
East Nile	18,601,717.5	4,043,851.6	55.4
Khartoum	758,059.0	164,795.4	2.3
Jabel Aolia	2,743,079.5	596,321.6	8.2
Khartoum State	33,548,189.50	7,293,084.6	100

E. Economic loss per animal

Considering the loss per head it was found that each animal loses about $US 30,

each mature cow loses about $US 51 and each seropositive cow loses $US 202 as a result of brucellosis based on eqn (9), (10) and (11) respectively (table 4).

Table 4: Estimated economic losses due to brucellosis per head

Item	SDG	$US
Economic loss /head	137.1	29.8
Economic loss /mature female	233.2	50.7
Economic loss / seropositive female	929.0	202.0

IV. Discussion

In the present study the prevalence rates of individual animal were estimated in each locality of Khartoum State using a cross-sectional study based on a probability sampling framework and the highly sensitive Rose Bengal Plate Test.

2.2 Economic loss of calves harvest. A total of SDG 2,775,646.1 ($US 603,401.3) is the cost of the calves lost due to abortion and increased inter-calving period. (eqn, 6)

2.3 Economic loss due to repeat breeding. The product of equ, (7) indicated that repeat breeding accounted to SDG 32,646.2 ($US7, 097.0).

2.4 Cost of Veterinary intervention The cost of examination and treatment of the aborted cows was SDG 134,335.7 ($US 29203.4.) using eqn (8).

Mortality accounts to only 1% of the total economic losses the remaining 99% is due to the morbidity of the disease. Milk losses only constitute 90% of the cost components, while the loss due to repeat breeding is the least cost components.

D. Economic loss according to locality

Based on locality Eastern Nile locality is the prime loser from brucellosis it loses $US 4,043,851.6 annually which accounts to more than half the total loss in the State. followed by Umbeda, Bhri, Jebel Aolia, Karrari and Omdurman respectively. Khartoum Locality is least loser among Khartoum State localities (table 3).

RBT was used for screening individual animals because it was cheap, rapid, highly sensitive and is recommended for control of brucellosis at local, national levels or for the purpose of international trade of livestock [38]. It was observed that the prevalence rate differs from locality to another with the two localities of Khartoum district (Khartoum and Jebel Aolia) had the highest prevalence rate 36.1% and 35 % respectively, while two localities in Omdurman district (Omdurman, Umbeda) had the lowest prevalence rates 19.1% and 20.6% respectively. A previous study was conducted in Kuku dairy Scheme located in Eastern Nile locality revealed 31.0% prevalence rate using the same test. The higher prevalence in Kuku Scheme revealed by Angara et al., [13] compared to that obtained in Eastern Nile Locality in this study may be attributed to the high foreign blood cattle breeds kept in high stocking density in Kuku. The weighted average prevalence obtained in Khartoum State in the current work (25.1%) far exceeds that reported in Eastern Ethiopia and Guto Gida District East Wollega Zone in Ethiopia (3.5%) & (1.97 %) respectively [9] [10] and that of 5.0% in Uganda [11].

The disease is well known to be not fatal but mostly affect animal fertility [21] that is why the losses due to mortality is very low about 1% of the total economic losses. The high morbidly rate resulted in high economic losses $US7, 227,139.1 per year most of which is attributed to reduction in milk production because cattle in Khartoum state are mostly cross and local (Butana) dairy breeds. The cost of milk lost is estimated at $US 6, 587, 400. The quantity of milk lost (10,100,737.38 Kg/year) could have contributed in securing food to Khartoum State inhibitors and act to fill the gap in milk supply.

Apart from the financial loses of the calves lost due to abortion and increase inter calving period which accounted to $US 603,401.3, meat lost and cross bred animals used to upgrade local breed in the country at large are other consequences of brucellosis.

Although the prevalence rate in Eastern Nile locality is not higher than in other localities yet, the locality is the most one that shoulders the cost of the disease. The locality has the largest animal population and encompasses kuku dairy scheme with high production potentialities.

The total economic losses due to bovine brucellosis in the current study US$ 7,293,084.6 per year exceeds that reported in Argentina, U.S.A. and Nigeria which were e estimated at US$ 60 million $400 million and US$ 575,605 per year respectively [24 , 25, 26]. The cost per head was US$1.20 per bovine in and US$3.16 per bovine in Nigeria [24] both are far less than in this study ($US 29.8) this is attributed to the high prevalence in Khartoum State.

The Federal Ministry of Animal Resources & Fisheries through its Directorate of Animal Health and Epizootic Diseases Control classified brucellosis as apriority disease but little effort was directed to the control of the disease in the country at large due to budgetary constraints, Khartoum State was not an exception. Apart of controlling the disease because of its zoonotic nature, financially it looks very sound to control the disease in Khartoum State if we compare the losses per head obtained in this study($US 29.8) with the cost of vaccinating 1000 head of SDG 705 ($US 261) [39].

V. Conclusion

Our study showed that bovine brucellosis adversity affect dairy sector in Khartoum state mainly due to reduction in milk production. Khartoum locality has the highest prevalence rate while Eastern Nile locality shoulders the maximum financial burden. The cost of brucellosis per head far excesses the cost of control, so it is advisable to formulate and implement brucellosis control strategy.

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