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Economic impact of caprine and ovine brucellosis in Mymensingh district, Bangladesh

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Abstract

Background
Brucellosis is one of the ancient re-emerging zoonotic diseases which play a significant economic impact on public health and livestock sector. Many studies were carried out on the epidemiology of the disease recently but economic importance was not focused on those studies. This study was conducted to determine the true prevalence and economic impact of caprine and ovine brucellosis in Mymensingh district, Bangladesh.

Methods
A cross-sectional epidemiologic study covering all upazilas of Mymensingh district, Bangladesh was conducted during the period from January to December, 2016. The data related to age, sex, abortion record and reproduction disorders were also collected on the sampling day using a questionnaire. Blood samples (n=2593) were collected from randomly selected native goat and sheep where Rose Bengal Test, Rapid *Brucella* AB test kit and MAb-ELISA (Monoclonal antibody based blocking Enzyme-Linked Immunosorbent Assay) were used to identify the positive reactors.

Results
The prevalence of caprine and ovine brucellosis was estimated to be 1.6% whereas it was found to be 1.56% and 1.64 % in goats and sheep respectively. The prevalence data was incorporated to the economic model to quantify the financial loss due to brucellosis. The total losses attributed to the disease was 48436400 taka (605455 US$) annually in the district whereas 46462900 taka (580786.25 US$) and 1973500 taka (24668.75 US$) in goat and sheep respectively.

Conclusions
The study concluded that brucellosis silently constitutes economic loss to the economy of the country and the producers due to insufficient knowledge and inadequate diagnostic facilities, lack of awareness and an effective prevention and control strategy.

Key words: Brucellosis, economic loss, sheep, goat, prevalence, Mymensingh

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Introduction

Brucellosis is enlisted as the second leading zoonotic infection followed by rabies by the Office International des Epizooties and classifies risk group III in laboratory biosafety manual of the World Health Organization. This disease is considered to be an occupational disease that mainly affects slaughter-house workers, butchers, livestock producers, shepherds, farmers, veterinarians, and laboratory technicians (Behzadi and Mogheiseh, 2011; Rahman *et al*., 2012).

Brucellosis causes severe economic losses as result of stormy abortions in small ruminants or reproductive failure, sterility and reduced milk production rates as well as lost trade by denying exportation of sheep to international markets and reduces the Foreign Exchange Earnings (FEE). As a result the disease adds to the burden shouldered by the farmers in developing world (McDermott, 2013; Angara and Ali, 2014). Female goats were considered to be potential source of infections and infected excreted materials are the causes of transmission through contacts following abortion or full-term parturition. Mammary gland may also infected in sheep and goats resulting mastitis, characterized by multinodular firmness with watery, clotted milk commonly observed feature of caprine brucellosis compared with bovine brucellosis (Cutler *et al*., 2005). Goats may responsible for prolong excretion of organisms in milk but less in sheep (Poester *et al*., 2013). It has been reported that intermittent shedding usually observed when infected goats survive as persistent reservoir after one abortion or parturition (ECSCAHAW, 2001). *Brucella ovis* is also an important cause of orchitis and epididymitis in sheep but it is not recognized as a cause of natural infection in goats (Jacques, 1998). Disease transmission chance potentially increases when keeping sheep in contact with goats or get together in parturition or at night as ovine animal's behavior and it is also a risk factor for brucellosis (Coelhoa *et al*., 2013). In relation to age and sex, adults were more positive than young and female were more susceptible than male (3.8%) (Gani *et al*., 2016). In field, a lot of undiagnosed abortion, stillbirth and retained placenta cases are observed due to inadequate diagnostic facilities and thought to be down to brucellosis which could have a significant impact on the development of livestock in Bangladesh (Rahman et al., 2011b).Important factors that contribute to the spread of brucellosis in goat and sheep are existing farming system and practices, farm sanitation, livestock movement, mixing and trading of animals, and sharing of grazing grounds and watering points (Kabagambe *et al*., 2001; Kadohira, 1997; Omer, 2000).

Brucellosis is not a notifiable disease in Bangladesh and was first serologically investigated in goat (1983), in sheep (2007). It is endemic in Bangladesh but yet vaccination and control measure against this disease is not performed (Amin *et al.*, 2005; Rahman *et al*., 2006; Uddin and Rahman, 2007; Das *et al*., 2008; Nahar and Ahmed, 2009; Rahman *et al*., 2009, 2010, 2011; Ahasan *et al.*, 2010; Muhammad *et al*, 2010). A variable seroprevalence ranged from 1.0 to 6.2% were reported (Uddin *et al*., 2007; Islam *et al*., 2010; Rahman *et al*., 2011a; 2013; Akhter *et al*., 2014). Exceptionally higher seroprevalence (14.5%) was reported in just one study in goat (Rahman *et al.*, 1988). The prevalence recorded in sheep were 1.2% to 9.8% (Uddin *et al*., 2007; Rahman *et al.*, 2011a,b; 2013; Ahsan *et al*., 2014; Akhter *et al.*, 2014) of which highest prevalence (9.8%) was recorded in Mymensingh and Netrokona regions (Ahsan *et al*., 2014; Akhter *et al.*, 2014).

Goats and sheep are important livestock resource which give more production per unit of investment, have younger slaughter age and have well established market (Prasad, 2004). Bangladesh has the third highest population of goats among the Asiatic countries which accounts for about 34.5 million heads representing 57% of total ruminant livestock (FAO, 2003) of which 98% is distributed in the rural areas (BBS, 1986). During the last 12 years, sheep population increased 2.5 times, with annual growth rate of 5% (BBS, 2008). Considering the socio-economic and climatic condition of Bangladesh, rearing of Black Bengal goat is more suitable

than other breeds and recognized as best goat breed including fourth largest goat repository in the world (Report KIB, 2018). Each year 127,000 metric ton representing 25% of total red meat in Bangladesh is produced from goat. Mutton export has been started from 2013-14 (Annual report 2016-2017, DLS). In this circumstance, brucellosis may be able to impair the growing economic market. Food and Agriculture Organization of the United Nations (FAO) and the Organization of Animal Health (OIE) considered brucellosis as a barrier to trade of animals and animal products as well as public health implications (WHO, 1997; Fitcht, 2003).

This study was conducted to determine the prevalence and economic impact of caprine and ovine brucellosis in Mymensingh district, Bangladesh.

Material and Methods

Ethical Approval

All essential procedures of sample collections were performed maintaining the human consent and animal welfare.

The Study Area

Mymensingh is 5th largest districts of Bangladesh situated in the north. It is also the largest district of Dhaka division. The Geo position of Mymensingh district is between 24˚02'31'' to 25˚25'56'' North latitudes and between 89˚39' to 91˚15'35' east longitude. The total population is 51,10,272 and population density is 1163/Sq. Km. Currently, Mymensingh district has thirteen upazilas (sub district) containing approximately 2700 Villages where total goat and sheep population is estimated to be 775,249 and 25,591 respectively (Annual report 2016-17, District Livestock Office, Mymensingh, DLS).

Study design and sample size estimation

A cross-sectional study was conducted covering all upazilas of Mymensingh district, Bangladesh during the period from January to December, 2016. Random blood samples were collected from native breeds of female goat and sheep (above one year) and transferred to the Laboratory of Veterinary Medicine, Bangladesh Agricultural University, Mymensingh for serum separation and serological tests. About 5 ml blood was collected from jugular vein of each of the selected goat (n=1847) and sheep (n=746) in separate sterilized test tubes and kept in refrigerator overnight. Then the serum was centrifuged at 2500 rpm for 8-10 min to obtain clear sera free from blood cells. Finally, sera were transferred into a sterilized eppendorf tube and stored at −20°C until used.

Serological tests

Rose Bengal test (RBT) as described by Alton *et al.* (1988) and Rapid *Brucella* AB test kit (chromatographic Immunoassay) were performed as per manufacturer instruction to determine the presence of antibodies against *Brucella* antigens. RBT positive sera were screened by MAb-ELISA (MAb based blocking Enzyme-Linked Immunosorbent Assay, Bru Alert®, TRPVB, CAHS, Tamil Nadu Veterinary and Animal Science University, Chennai) according to the protocol and reading was performed by automated ELISA reader.

Interpretation

All degree of agglutination was considered as positive reaction. In case of brucella AB test kit the presence of two purple color bands within the result window means positive. The prevalence of brucellosis in each Upazila was used for estimating the weighted average of brucellosis in the District (Angara *et al.*, 2016).

Sources of data

Data were collected from both secondary and primary sources. The secondary data were obtained from different sources such as Department of Livestock services Under the Ministry of Fisheries and Livestock (2016-17), record from own upazila veterinary hospital, relevant studies, text books and web sites. The primary data were collected by conducting an epidemiological and economic survey during the period from January to December 2016. A questionnaire was used to collect the economic data and the health status, age, sex and history of abortion and different reproductive disorder for each goat (n=112) and sheep (n=67) from

randomly selected herds (goat=370, sheep=141) containing 3-5 or more small ruminants throughout the district.

The economic model

The simple model was used to estimate the total economic losses in the district is given bellow:

TEL = MT+MD ……(1) (Angara *et al*., 2016).

Where as

TEL=Total Economic Loss, MT (Economic Loss due to mortality) = Number of goats and sheep died due to dystocia/abortion followed by metritis × average price of mature animal……(2)

MD = Economic Loss due to morbidity, MD = BL+CL+LRB+CVI+OC……(3)

Where as

BL (value of body weight loss) = (Number of seropositive animals × cost of body weight loss per animal

CL (value of calves lost) = (Number of mature female × prevalence rate of seropositive aborted animals) × average price of weaning kid……(4)

LRB (Losses due to repeat breeding) = Number of seropositive repeat breeders × cost of repeat breeding per animal ……(5)

CVI (Cost of veterinary intervention) = Number of seropositive aborted animals(include retained placenta+ mastitis + metritis + dystocia) × cost of Veterinary intervention per animal……..(6)

OC (value of opportunity cost) = It is applicable for the surviving infected goats and sheep which included (i) Cost on higher feeding and rearing inputs for weight loss (ii) Decreased milk production which leads to malnutrition of kids and loss in longer rearing-time due to late maturity of young stock, anestrous iii) Cost on permanent infertility or disability (iv)Loss in extra service due to repeat breeding, kidding interval (v) Increased cost on management for transport to veterinary hospital for treatment. These costs were difficult to quantify properly due to absence of suitable data and records. Including other records lacking mentioned above especially estimates on cost of feeding and rearing, were assumed approximately as 15 percent of the total cost of animal, i.e. Taka 1200 per infected surviving animal, i.e. Oc = (Total infected animals – total mortality) × 15% of total cost of animal (Singh *et al*., 2008) ……(7)

Annual losses per head= Total Economic losses / number of goats and sheep population….. (8)

Annual losses per mature female = Total Economic losses / number of mature female goats and sheep…… (9)

Annual losses per seropositive female = Total Economic losses / number of seropositive female. (10)

The parameters used to estimate the economic loss in the model

Most of the necessary data and parameters were obtained from the field survey. Other necessary parameters were estimated from the secondary information or some probable values adapted according to current situation.

In this study, the economic data, information about the effect of the disease on productivity parameters and epidemiological parameters were acquired from the field survey. The secondary information of reproductive and productive parameters were obtained from the Livestock Census, Annual reports of (2016 -17) District Livestock Office, Mymensingh, published relevant publications, Central veterinary Hospital (CVH), Dhaka, Annual Reports (2015-16) of Department of Livestock services (DLS), under the Ministry of Fisheries and Livestock, Bangladesh were as follows:

(i) Number of mature goats in each upazila were obtained by multiplying the total number of goats in each upazila × the ratio of mature female 47% (adapted from Shafy e*t al*., 2016)

(ii) Number of seropositive mature females = Number of mature goats and sheep in each upazila × prevalence rate (the laboratory result).

(iii) Cost of body weight loss per animal = Average body weight loss per infected animal × average price of per kg body weight.

(vi) Number of repeat breeder = Number of mature goats and sheep × prevalence rate of repeat breeding (field data)

(v) (Veterinary Intervention) = Treatment cost of abortion followed by retention of placenta and endometritis of each goat-sheep = 1250 ± .05TK

and treatment cost of mastitis = 2750± .05Tk (obtained from veterinary officer, DLS, 2016)
The probable values used for the different parameters are given below:

Pgs = Average market value of animal = Goat 8000 Tk SD±322.74, Sheep 8000 Tk SD ±355.90 (obtained from field) N.B. Price of animal in village area was lower than urban area in different upazilas of Mymensingh district.
Wt = Average body weight per mature female goat = 20 kg ±1.56 (20-25Kg in Black Bengal goat profile info guide, 23.6±0.81 kg, Jalil *et al.*, 2018) and female sheep 20 kg SD ±1.09 (Field data)
Pb = Average body weight loss per infected animal= Goat 3kg± 0.33 and sheep 3kg ±0.03 (Field data)
Pk = Average price of body weight loss per kg= Goat Tk 400 ± SD±37.80 and sheep Tk 400 SD±29. 01. N.B. Market price of live body weight per kg was higher in urban area than village area and meat of male animal price is higher than female animal during the economic survey of different upazilas.
Kp = Average price of a kid = Goat Tk 1500 SD±81.64 and sheep Tk 1500 SD±37.41 (Field data)
Nk =Average number of kids per kidding = Goat 2 SD±0.43 and sheep 2 SD±0.51 (Field data)
Nc = Delay in next conception (average) = Goat 3 months SD±0.63 and sheep 3 months SD±0.87 (Field data)
ExS = Average number of extra service = 2± 0.02
ExP = Average price of (extra natural) insemination=300 taka (adapted from field data though it varies from100 -1000 taka)
Rb = Cost of repeat breeding per month Tk 550 ± 0.5 obtained from Veterinary hospital, DLS
Oc = 15% of Pgs= Tk1200
1US$ = 80 taka, 1 metric ton =1000 Kg, Tk= Taka, Kg = kilogram

Data Analysis: Data was processed and analyzed by Microsoft excel 2010.

Result

The prevalence of caprine and ovine brucellosis in the upazilas of Mymensingh district: The prevalence rate of caprine and ovine brucellosis was estimated to be 1.6% whereas it was found to be 1.56% and 1.65 % in goats and sheep respectively.

The highest prevalence were observed in Muktagachha 3.16% followed by Mymensingh sardar 2.31% in goat and 3.77 % in Mymensingh sadar followed by 3.33% in Nandail in Sheep respectively (Table 1).

The estimated number of animal losses including economic losses due to caprine and ovine brucellosis

Number of animal losses including economic losses

The number of aborted goat and sheep were estimated at 5891 and 177 where 344 (.09%) and 33 (0.27%) were died respectively as a result of complication of abortion followed by endometritis. The economic loss was estimated at 2752000 taka in goat and 264000 taka in sheep according to equation (2).

Body Weight Loss

The number of seropositive goats were estimated to be { (6918 ×Pb) ×Pk} = 8301600 taka and for 306 sheep = 367200 taka according to equation (3)

Number of kids lost

Kid lost due to brucellosis as a result of abortion in goats and sheep are estimated at yearly 11782 and 354 where the cost was 17673000 taka in goats and 531000 taka in sheep according to equation (4).

Table 1. Estimated Prevalence of brucellosis and the number of mature, seropositive goats and sheep

Name of upazila	Total goats	Collected sample	Mature goats	Preva-lence	Seropositive goats	Total sheep	Collected sample	Mature sheep	Preva -lence	Seropositive sheep
Mymensingh Sadar	95,120	260	44706	2.31	1033	950	53	447	3.77	17
Muktagachha	35,380	95	16629	3.16	526	2,220	70	1043	2.85	30
Fulbaria	57,801	150	27167	1.33	362	523	39	246	2.56	6
Trishal	60,174	147	28282	2.04	577	295	42	139	0	0
Bhaluka	61,740	165	29017	1.81	528	2,000	62	940	1.61	15
Tarakanda	20,319	68	9550	0	0	1,122	59	523	0	0
Gauripur	18,863	55	8866	1.81	161	235	35	110	0	0
Nandail	25,835	70	12143	0	0	8,530	120	4009	3.33	133
Ishwarganj	84,200	225	39574	2.22	879	170	30	80	0	0
Gafargaon	1,86,237	305	87531	2.29	2009	6,670	84	3135	2.38	75
Dhobaura	22,381	72	10519	0		850	46	400	2.17	9
Fulpur	64,781	170	30447	1.76	537	1,618	71	760	2.77	21
Haluaghat	42,418	65	19937	1.53	307	408	35	192	0	0
Total	7,75,249	1847	364368	1.56	6918	25,591	746	12024	1.65	306

Number of repeat breeders and economic loss

Repeat breeding as a result of brucellosis was computed to be 1640 goats and 108 sheep and the cost was 2706000 taka and 178200 taka respectively according to equation (5).

Veterinary intervention

Veterinary intervention was applied in this study in term of diagnosis and treatment. Here the aborted goats and sheep followed by retained placenta and endometritis were estimated to be 4743 goats and 163 sheep and the cost was calculated at 5928750 taka and 2503200 taka respectively. In case of mastitis 441 goats and 37 sheep were computed where 1212750 taka and 101750 taka were estimated respectively as economic loss according to equation (6).

Opportunity cost

The opportunity cost was computed to be 7888800 taka in goats and 327600 taka in sheep according to equation (7).

Calculation of total annual economic losses attributable to the disease in goats and sheep

Total loss attributed to the disease was 46462900 Tk in goat and 1973500 Tk in sheep according to equation (1).

Annual losses per head was estimated to be 59.93 Tk (0.74 US$) in goat and 77.11 Tk (0.96 US$) in sheep according to equation (8) .

Annual losses per mature female goat was 127.51 Tk (1.59 US$) and sheep was 164.13 Tk (2.05 US$) according to equation (9).

Annual losses per seropositive goat was 6716.23 Tk (83.95 US$) and sheep was 6449.34Tk (80.61 US$) according to equation (10).

Table 2. Estimated annual economic loss in different upazilas

Name of upazila	Economic losses for goats	%	Economic losses for sheep	%
Mymensingh Sadar	7349700	15.83	125000	6.333
Muktagachha	3271900	7.04	160500	8.132
Fulbaria	2148650	4.62	57300	2.903
Trishal	3333600	7.18	0	
Bhaluka	3498450	7.53	118500	6.004
Tarakanda	0		0	
Gauripur	1779050	3.83	0	
Nandail	0		840300	42.579
Ishwarganj	6117900	13.17	0	
Gafargaon	12624100	27.17	500050	25.338
Dhobaura	0		74700	3.785
Fulpur	3407700	7.33	97150	4.922
Haluaghat	2931850	6.31	0	
Total	46462900	100	1973500	100

Table 3. Estimated total annual economic losses in Mymensingh district

Cost components	Category of animal	Taka	US$	%
Mortality	Goats	2752000	34400	5.9%
	Sheep	264000	3300	13.38
Morbidity:	Goats	8301600	103770	17.8
Body weight loss	Sheep	367200	4590	18.60
Kid loss	Goat	17673000	220912.5	38.6
	Sheep	531000	6637.5	26.90
Repeat breeding	Goat	2706000	33825	5.8
	Sheep	178200	2227.5	9.02
Veterinary intervention	Goat	7141500	89268.75	15.3
	Sheep	305500	3818.75	15.5
Opportunity cost	Goat	7888800	98610	16.9
	Sheep	327600	4095	16.6
Total	Goat	46462900	580786.25$	100
	Sheep	1973500	24668.75	100

Discussion

In the present study, a large number of small ruminants serum samples were collected randomly using cross-sectional survey from 13 upazila of Mymensingh district and screened with Rose Bengal Test (RBT), Brucella AB kit test and MAb based blocking Enzyme-Linked Immunosorbent Assay (MAb-ELISA). Rose Bengal reagent is highly recommended because of its simplicity and very low cost. In small ruminants, it is highly specific (100%, Diaz, Blasco; 1994) in the absence of vaccination.

The prevalence of caprine and ovine brucellosis was estimated to be 1.6% whereas it was found to be 1.56% and 1.64 % in goats and sheep respectively. The highest prevalence was observed in Muktagachha 3.16% followed by Mymensingh sadar 2.31% in goat and 3.77 % in Mymensingh sadar followed by 3.33% in Nandail in Sheep (Table:1). The prevalence rate was introduced to the economic model for assessment of the financial loss due to the disease. The total losses attributed to the disease was 48436400 (48.4 million) taka yearly where 46462900 (46.4629 million) taka and 1973500 (1.9735 million) taka in goat and sheep respectively (Table: 3). The highest loss observed 12624100(12.6241 million) taka in Gafargaon upazila followed by 7349700(7.3497 million) taka in Mymensingh sadar which were 27.17% and 15.83% of total loss respectively in goat. In sheep, the highest loss was found 840300 (0.8403 million) taka in Nandail upazila followed by 500050 (0.5 million) taka in Gafargaon upazila and the percentage were 42.57 and 25.33 of total loss respectively. The lowest losses showed 1779050 (1.779 million) taka (3.83%) in Gauripur upazila followed by 2148650 (2.14865 million) taka (4.62%) in Fulbaria upazila in goat and in sheep 57300 (0.05 million) taka (2.90%) in Fulbaria upazila followed by 74700 (0.074 million) taka (3.78%) in Dhobaura upazila (Table 2).

Brucellosis is not fatal in animals but mostly affects fertility. Deaths are rare except in the fetus (Saxena et al, 2018) and death usually occur in adults due to complication of abortion followed by secondary infections. The mortality rate of the disease was very low in this study and it was 0.0007% of total economic losses and 0.09% and 0.27% of goat and sheep were died respectively in this study. In morbidity rate, the highest economic loss was attributed to kid loss which was computed 17673000 (17.673 million) taka (38.6%) in goat and 531000 (.531million) taka (26.90%) in sheep annually in Mymensingh district.

The economic impact of brucellosis varies from country to country and from region to region. In this study, the total losses attributed to the disease was 48436400 (48.4364 million) taka annually whereas 46462900 (46.4629 million) taka and 1973500 (1.9735 million) taka in goat and sheep respectively in Mymensingh district and was far less that reported at Uttar Pradesh, India which was estimated to the tune of Rs. 44.02 crore due to brucellosis in small ruminants (Rs. 4.97 crore in sheep and 39.05 crore in goats) in the annual

economic loss (Sinha *et al.*, 2016). This might be happened due to the difference of area and population as known Uttar Pradesh is much bigger in area and population than the district of Mymensingh. The cost of annual losses per head of goat US $ 0 .74 and sheep US $ 0.96 in this study i.e., below 1US$ were almost similar to US $ 0.7 per sheep and US $ 0.5 per goat reported in India (Singh *et al.*, 2015).

Conclusions

The study concluded that brucellosis silently constitutes economic loss to the economy of the country and the producers, due to insufficient knowledge and inadequate diagnostic facilities, lack of awareness and an effective prevention control strategy. Serological test might be a means for identification of brucellosis across the country and measures could have taken to establish a program for control and prevention through proper diagnosis, culling of infected animal from flock by slaughtering or initiate vaccination.

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Competing Interest

The authors declare that they have no competing interests.

References

1. Ahasan MS, Rahman MS, Song H J. A serosurveillance of *Brucella spp*. Antibodies and individual risk factors of infection in cattle of Bangladesh. Korean Journal of Veterinary Service. 2010; 33:121-128.
2. Ahmed M, Elmeshri S, Abuzweda A, Blauo M, Abouzeed Y, Ibrahim A, Salem H, Alzwam F, Abid S, Elfahem A, Elrais A. Seroprevalence of brucellosis in animals and human populations in the western mountains region in Libya, December 2006-January 2008. Euro Surveillance. 2010;15: 30.
3. Akhter L, Islam MA, Das S, Khatun MM. Seroprevalence of brucellosis and its associated risk factors in sheep and goat in the farms and slaughter house in Mymensingh, Bangladesh. Microbes and Health. 2014; 3: 25-28.
4. Ahsan MS, Rahman M, Das GC, Rahman MS, Ali ML. Seroprevalence of brucellosis in sheep in Mymensingh and Netrokona district of Bangladesh. International Journal of Natural and Social Sciences. 2014; 1: 33-40.
5. Amin KMR, Rahman MB, Rahman MS, Han JC, Park JH, Chae JS. Prevalence of *Brucella* antibodies in sera of cows in Bangladesh. Journal of Veterinary Science. 2005; 6: 223-226.
6. Alton GG, Jones LM, Angus RD, Verger JM. Techniques for the Brucellosis Laboratory. Paris: INRA 1988;P: 190.
7. Angara TEE, Ismail AAA, Ibrahim AM, Osman SZ. Assessment of the economic losses due to bovine brucellosis in Khartoum State, Sudan. International Journal of Technical Research and Applications. 2016; 4(2): 85-90.
8. Annual Report (2016-2017) Department of Livestock Services, Ministry of Fisheries and Livestock, Bangladesh.
9. Angara TEA, Ali AA. Socioeconomic aspects of brucellosis in Kuku dairy scheme, Khartoum state, Sudan. Indian Journal of Applied Research. 2014; 4(8): 685 - 687.
10. Blasco JM, Garin-Bastuji B, Marin CM, Gerbier G, Fanlo J, Jiménez de Bagués MP, Cau C. Efficacy of different rose Bengal and complement fixation antigens for the diagnosis of *Brucella melitensis* infection in sheep and goats. Veterinary Record. 1994; 134(16):415-20.
11. Behzadi MA, Mogheiseh A.Outbreak investigation of brucellosis at a kennel in

Iran. Pakistan Veterinary Journal. 2011; 31: 379-380.
12. BBS (1986, 2008). Statistical Yearbook of Bangladesh, Bangladesh Bureau of Statistics. Ministry of planning, Planning Division, Government of the People Republic of Bangladesh.
13. CFSPH: The center for food security and public health. Iowa state university.2009; http://www.cfsph.iastate.edu/Factsheets/pdfs/brucellosis_melitensis.pdf. Accessed 20 July 2018.
14. Cutler S, Whatmore A, Commander N. Brucellosis-new aspects of an old disease. Journal of Applied Microbiology. 2005;98: 1270-1281.
15. Coelho AM, Coelho AC, Rodrigues J. Seroprevalence of sheep and goat brucellosis in the northeast of Portugal. Archivos de Medicina Veterinaria. 2013; 45: 167-172.
16. Díaz-Aparicio E, Marin C, Alonso-Urmeneta B, Aragón V, Pérez-Ortiz S, Pardo M, Blasco JM, Díaz R, Moriyón I. Evaluation of serological tests for diagnosis of *Brucella melitensis* infection of goats. Journal of Clinical Microbiology. 1994; 32(5):1159-1165.
17. Das T, Ershaduzzaman M, Islam KK, Haque MM, Rahman MM, Islam SKBM. Surveillance of *Brucella melitensis* and *Brucella abortus* from aborted Bengal goats in Bangladesh. Research Journal of Veterinary Science. 2008;1:28-36.
18. European Commission Scientific Committee on Animal Health and Animal Welfare (ECSCAHAW, 2001). Brucellosis in sheep and goats.
19. Fitcht TA. Acid tolerance and intracellular survival of Brucella. 2003; Bru Net Pub.http://www.fao.org/ag/aga/agah/id/brunet_main/brunet/public_sub5_p1.html
20. FAO (2003). Production Year Book, Food and Agricultural Organization, Rome, Italy.
21. Gani MO, Munsi MN, Ershaduzzaman M, Rahman AKMA, Sultana S, Alam MS. Seroprevalence of ovine brucellosis in Bangladesh. Asian Journal of Medical and Biological Research. 2016 ; 2 (1): 13-18.
22. Jacques I, Olivier-Bernardin V, Dubray G . Efficacy of ELISA compared to conventional tests (RBPT and CFT) for the diagnosis of *Brucella melitensis* infection in sheep. Veterinary Microbiology. 1998; 64:61-73.
23. Jalil MA, Choudhury MP, KabirM M, Habib MA. Morphometric characterization of Black Bengal Goat under farming condition in Bangladesh. Asian Journal of Medical and Biological Research. 2018; 4(1), 95-104.
24. Kabagambe EK, Elzer PH, Geaghan JP, Opuda-Asibo J, Scholl DT, Miller JE. Risk factors for *Brucella* seropositivity in goat herds in eastern and western Uganda. Preventive Veterinary Medicine. 2001; 52: 91–108.
25. Kadohira M, McDermott JJ, Shoukri MM, Kyule MN. Variations in the prevalence of antibody to *Brucella* infection in cattle by farm, area and district in Kenya. Epidemiology and Infection. 1997; 118: 35-41.
26. McDermott J, Grace D, Zinsstag J. Economics of brucellosis impact and control in low-income countries. Revue Scientifique et Technique (International Office of Epizootics). 2013;32 (1):249-261.
27. Miah G , Das A, Bilkis T, Momin MM, Uddin MA , Alim MA, Mahmud MS, Miazi OF. Comparative study on productive and reproductive traits of Black Bengal and Jamnapari goats under semi-intensive condition. Scientific Research Journal. 2016; 4 (2):1-7.
28. Mohammed MA, Shigidy MT, Al Juboori AY. SeroPrevalence and Epidemiology of Brucellosis in camels, sheep and goats in Abu Dhabi Emirate. International Journal of Animal and Veterinary Advances. 2013; 5(2): 82-86.
29. Nahar A, Ahmed MU. Seroprevalence study of brucellosis in cattle and contact human in Mymensingh. Bangladesh Journal of Veterinary Medicine 2009;7(1): 269–274.
30. Shafy NM. Seroprevalence of caprine and ovine brucellosis in Mymensingh district,

MS thesis. 2017; Department of Medicine, Faculty of Veterinary Science, Bangladesh Agricultural University.

31. Omer MK, Skjerve E, Holstad G, Woldehiwet Z, Macmillan AP. Prevalence of antibodies to *Brucella spp.* in cattle, sheep, goats, horses and camels in the State of Eritrea; influence of husbandry systems. Epidemiology and Infection. 2000; 125 (2): 447- 453.
32. OIE,(http://www.oie.int/en/for-the-media/animal-diseases/animal-disease-information-summaries/). World Health Organization, "Joint FAO/WHO Expert Committee on Brucellosis," Tech. Rep. 6th report,1986; Series no. 740.
33. OIE, 2009. Bovine Brucellosis. In: Manual of diagnostic tests and vaccines for terrestrial animal.
34. Office of International de Epizooties Paris, France. http://web.oie.int/eng/normes/mmanual/A_index.htm. Accessed on 15 April 2017
35. Poester FP, Samartino LE and Santos RL. Pathogenesis and pathobiology of brucellosis in livestock. Revue Scientifique et Technique. 2013; 32: 105-115.
36. Prasad J. Goat, Sheep and Pig production and management. Kalyani Publisher, Delhi-India. 2004; pp: 3-149.
37. Saxena N, Singh BB, Saxena HM. Brucellosis in sheep and goats and its serodiagnosis and epidemiology. International Journal of Current Microbiology and Applied Sciences. 2018; 7 (1):1848-1877.
38. Rahman AKMA, Dirk B, Fretin D, Saegerman C, Ahmed MU, Muhammad N, Hossain A, Abatih E. Seroprevalence and risk factors for brucellosis in a high-risk group of individuals in Bangladesh. Foodborne Pathogens and Disease. 2012;9(3):190-197.
39. Rahman MS, Han JC, Park J, Lee JH, Eo SK, Chae JS. Prevalence of brucellosis and its association with reproductive problems in cows in Bangladesh. Veterinary Record. 2006; 159:180-182.
40. Rahman MS, Alam N, Rahman AKMA, Hague AKMF, Ahasan MS, Song HJ. Seroprevalence of specific Brucella infection of cattle of Bangladesh Agricultural University, Veterinary Clinics and its surrounding area. Korean Journal of Veterinary Service. 2009; 32(3): 219-225.
41. Rahman MS. Brucellosis: a great constraint for development of livestock. Bangladesh Dairy and Poultry. 2010; 5: 18-19.
42. Rahman MS, Hahsin MFA, Ahasan MS, Her M, Kim JY, Kang SI, Jung SC .Brucellosis in sheep and goat of Bogra and Mymensingh districts of Bangladesh. Korean Journal of Veterinary Research. 2011a; 51(4): 277-280.
43. Rahman MS, Faruk MO, Her M, Kim JY, Kang SI and Jung SC .Prevalence of brucellosis in ruminants in Bangladesh. Veterinary Medicine. 2011b; 56 (8): 379–385.
44. Rahman AKMA, Saegerman C, Berkvens D, Fretin D, Gani MO, Ershaduzzaman M, Ahmed MU, Abatih E. Bayesian estimation of true prevalence, sensitivity and specificity of indirect ELISA, Rose Bengal Test and Slow Agglutination Test for the diagnosis of brucellosis in sheep and goats in Bangladesh. Preventive Veterinary Medicine. 2013; 110 (2):242–252.
45. Report (souvenir) of Krishithibid Institution of Bangladesh on 6th National convention, International seminar, Council and Annual general meeting. 2018; P.72.
46. Sinha DK, Singh DK, Quereshi S, Verma MR, Vinodh Kumar OR, Singh BR. "Estimation of economic losses due to brucellosis in small ruminant of Uttar Pradesh, India" an abstract book of Brucellosis, International Research Conference, New Delhi. 2016; Nov 17-19; p 61.
47. Singh BB, Dhand NK, Gill JPS. Economic losses occurring due to brucellosis in Indian livestock populations. Preventive Veterinary Medicine. 2015;119(3–4): 211-215.
48. Shafy NM, Ahmed BS, Sarker RR, Millat KSA, Hasan MT, Bhattacharjee PK,

Chakrabartty A, Paul A, Truong A, Rahman MS. Serological prevalence of caprine ond ovine brucellosis in Bangladesh. Bangladesh Journal of Veterinary Medicine. 2016; 14 (2): 207-212.

49. Singh B, Prasad S. Modelling of Economic Losses due to Some Important Diseases in Goats in India. Agricultural Economics Research Review. 2008; 21: 297-302.
50. Uddin MJ, Rahman MS. Brucellosis of goat in Bangladesh. Journal of the Bangladesh Agricultural University. 2007;5: 287-294.
51. Uddin MJ, Rahman MS, Akter SH, Hossain MA, Islam MT. Seroprevalence of brucellosis in small ruminants in selected area of Bangladesh. Korean Journal of Veterinary Service.2007; 30: 511–525.
52. W.H.O. (1997). Fact sheet N173.Geneva, Switzerland. www.who.int/inffs/en/fact173.html.