The Mean Prevalence, Abortion Rate and Estimating the Economic Costs of *Brucella abortus* in Dairy Cows in Turkey

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ABSTRACT

The aim of this study was to estimate the economic cost of *Brucella abortus* in Turkey. According to present literatures, the mean prevalence of infection has been estimated as 6.21%. The positivity rate of *B. abortus* in aborted cows has been found to be 21.16%. The financial costs were estimated in US$ according to 2020 prices. The production cost of brucellosis was estimated in US$ as 1.464 per a cow. In this study, the percentage of production losses caused by brucellosis per cow were determined as 32.65% abortion, 10.77% prolonged calving interval, 9.7% milk loss, 29.88% replacement of culled cow and 17.01% costs for treatment, respectively. The annual production losses were estimated as US$208 million of the *B. abortus* for Turkey. The annual economic costs have been estimated as US$301 million for prevention and control of the *B. abortus*. In general studies that have been conducted so far on Brucellosis are focused on the prevalence and the diagnosis of the disease in Turkey. In this study, we attempted to determine the economic costs due to *B. abortus* and attempted to attract attention on the economic impacts of the disease. As a result, *B. abortus* in Turkey results in major economic costs to the livestock industry with significant impact on dairy cattle.

Key words: *Brucella abortus;* Bovine Brucellosis; Reproductive Losses; Economic Costs; Dairy Cows; Turkey.

INTRODUCTION

Brucellosis is one of the zoonotic disease causing economic losses both in the meat and milk industry worlwide. Abortion, infertility, elongation in carving interval, decrease in milk yield, replacement of culled cows and mortality due to Brucellosis in dairy cattle causes significant production losses on the farms. The disease causes significant economic losses not only in cattle farms but also to the country's economy. These include the practices to control the disease such as quarantine, vaccination, compensated slaughter/culling or destruction, treatment and tools, material, labor and transportation costs used in the field and in the laboratory and also obstacles for the international trade (1).

Although the data giving full implications due to *Brucella* infection which have changed the losses estimated to reach million to billion of Dollars. In an epidemiologic study, annual economic cost in India was declared to be approxiately US$3.4 billion (2). To best of knowledge of the authors, studies so far conducted on the subject of direct and indirect economic costs caused by Bovine Brucellosis in Turkey have been found to be inadequate (1, 3).

The rational usage of sources used in the prevention and control of animal diseases, and economic analyses of the diseases are very important. In this concept, the purpose of the study was to determine the mean prevalance and abortion rate of the infection depending on the studies conducted between 1972-2018, estimate overall economic cost depending on up-to-date data and determine the economic importance of this disease in Turkey.

MATERIAL AND METHODS

In the calculation of estimated economic costs due to *B. abortus* infection in bovines in Turkey, the data about the number of animals under risk and the prevalence of Brucellosis according to regions were used. SPSS 16 package program and 2020 current dollar rates were used in the generated modeling.

For this study, permission was obtained from the Ministry of Agriculture and Foresty, Food and General Control Directorate (15.05.2020/71037622-325.06-E.1367969).

The true prevalance of *B. abortus* is not known for the reasons such as insufficient disease reporting and the existence of subclinical cases. For this reason, the mean prevalance was calculated in the performed study by examining studies conducted between 1972-2018 on this subject in Turkey. Furthermore, the overall prevalence of Bovine Brucellosis in Turkey was determined according to the current literatures by using the PubMed, WOS and Google schooler browsers. The data are presented in Table 1.

Within the bounds of this research, Delphi questionnaire was carried out with an expert veterinarian (3 people) and public veterinarians (3 people), as expert opinion for obtaining diverse information and data was needed to determine the economic cost and consequences (4).

In this study, economic costs caused by *B. abortus* was reviewed under 2 sections. In the first part, estimated Brucellosis prevalance calculated in line with litrature data with the calculation of the number of dairy cows that could be infected was interpreted. According to these, estimated loss of production due to disease per infected cow and total production losses in Turkey was calculated (Table 2 and Table 3). In the second part, using with data obtained from the Delphi questionnaire, estimated annual expenditures for the prevention-control of *B. abortus* was calculated. In the study, the effects of *B.abortus* related production losses in nation-wide and per infected cow were estimated under three scenarios; expected (mean value), optimistic (minimum value), and pessimistic (maximum value) values with the resulting economic costs were calculated (Table 4). While the costs caused by infection in dairy cows was emphasized in Table 2, the formula used to determine the estimated expenditures depending on the disease in Turkey was presented in Table 3. In this study, the production losses of *B. abortus* was calculated.by using the below mentioned formula (adapted from 4, 58). The technical and financial parameters used in determining the estimated economic cost due to Brucellosis are presented in Table 4.

In the optimistic scenario, in accordance with the literature evidence (Table 1), the economic losses caused as a result of the disease was calculated over the lowest prevalence rate of 1.43%. In the expected scenario, the prevalence of the disease was calculated on the average value of 6.21%, and in the pessimistic scenario, the maximum value was 81.7%.

RESULTS

To best of knowledge of the authors, the incidence of *B. abortus* varied from region to region even from city to city. Particularly, it was found more frequently in the east of the country (40, 51). According to the data obtained, the prevalence of the disease was determined to be in a range of minimum 1.43% and maximum 81.7%, with mean of 6.21%. However, when the samples from the aborted cases were examined, the rate was determined to be 21.16% (7,989/37,749) (Table 1). Taking into consideration the mean of 6.21% *B.abortus* prevalence among 7,261,966 dairy cows in 2019, estimated 450,663 cows might be infected by *B.abortus*, and 4,679 pregnant cows were calculated as candidates of abortion as a result of *B.abortus* The estimated production loss in a dairy cow exposed to *Brucella* infection is presented in Table 5.

When Table 5 was examined, the economic cost per cow was calculated as a mean of US$1.464. In Turkey, for a cow with an annual mean milk yield of 3.161 liters/cow an annual mean 474.2 liters per cow (15% reduction) milk loss was estimated.

When Table 5 was examined, the most important loss caused by *B.abortus* was abortion (32.65%), followed by the loss due to the replacement of culled cow (29.88%) after abortion and infertility. Besides, if an infected cow was not

Table 1. Literature about *B. abortus* in Turkey.

Province of Turkey	Date	Sample	Diagnostic test*	Brucella agent	No. tested	No. positive	% Positive	Abortion No. tested	Abortion No. positive	% Abortion rate	Reference
Erzurum	1972	Serum	SAT	*B. abortus*	337	40	11.7	--	--	--	(5)
Turkey's Different Cities and Towns	1987	Serum	SAT	*B. abortus*	1620	194	11.9				(6)
Ankara, Adana	1995	Serum	ELISA	*B. abortus*	976	49	5.02				(7)
Ankara Univ Vet Fac.	1999	Serum	SAT	*B. abortus*	430	135	31.0				(8)
Van	1999	Serum	SAT	*B. abortus*	116	24	20.68	56	36	64	(9)
		Serum	RBPT	*B. abortus*	56	34	60.71				
Turkey	2000	Serum	RPBT/CFT	*B. abortus*	34.458	493	1.43				(10)
Van	2002	Serum	RBPT	*B. abortus*	320	20	6.25				(11)
Van	2003	Serum	SAT	*B. abortus*	129	28	21.7				(12)
Burdur	2003	Milk	MRT	*B. abortus*	101	12	3.0				(13)
Kars	2004	Abortion, Foetus	TISSUE	*B. abortus*				25	22	20.68	(14)
Kars, Ardahan	2005	Serum	SAT	*B. abortus*				163	107	65.6	(15)
Samsun	2006	Milk	MRT	*B. abortus*	50	10	20.0				(16)
Kirikkale	2007	Serum	RPBT	*B. abortus*	301	8	2.67				(17)
Marmara Region	2007	Aborted Foetus	Biotyping Tests	*B. abortus*	41	8	19.5				(18)
North East Turkey	2008	Serum	SAT	*B. abortus*	626	221	35.3	160	92	57.50	(19)
Kars	2008	Serum	SAT	*B. abortus*				407	141	34.64	(20)
Kirikkale	2008	Milk	MAT	*B. abortus*	100	19	19				(21)
Artvin	2009	Serum	SAT	*B. abortus*				250	26	1.04	(22)
Etlik	2009	Foetus Stomach Content	PCR	*B. abortus*	31	15	48.4				(23)
Kayseri	2009	Serum	SAT	*B. abortus*				200	22	11	(24)
Kirikkale, Izmir Tokat	2009	Serum	MAT	*B. abortus*	557	77	13.8	234	38	16.23	(25)
Ankara Univ Vet Fac.	2010	Serum	MAT	*B. abortus*	524	8	1.5				(26)
Different Regions; Kars, Ardahan, Samsun	2010	Serum	RBPT	*B. abortus*	597	73	58.4	265	52	19.62	(27)
Samsun	2010	Milk	ELISA	*B. abortus*	70	15	21.4				(28)
Burdur	2011	Serum	SAT	*B. abortus*				2869	194	6.8	(29)
Afyonkarahisar	2011	Milk	SAT	*B. abortus*	120	6	5				(30)
Kars	2011	Serum	ERIFA$^{LPS/LYS}$	*B. abortus*	420	212	50.47				(31)
Kars	2011	Serum/Swap	PCR	*B. abortus*	250	27	5.4				(32)
Kars	2011	Milk/Swap	PCR	*B. abortus*	623	106	17.01				(33)
Marmara Region	2011	Serum	ELISA	*B. abortus*	38	8	21.1				(34)
Trakya	2011	Milk	PCR	*B. abortus*	75	14	22.66				(35)
Van	2011	Serum	RBPT	*B. abortus*	55	8	14.5				(36)
Burdur	2012	Serum	ELISA	*B. abortus*				932	236	25.3	(37)

Table 1. Literature about *B. abortus* in Turkey (continued)

Province of Turkey	Date	Sample	Diagnostic test*	Brucella agent	No. tested	No. positive	% Positive	Abortion No. tested	Abortion No. positive	% Abortion rate	Reference
Kars	2012	Vaginal Swab	Immunoperoxidase Technique	*B. abortus*				261	25	9.57	(38)
Kayseri	2012	Aborted Foetus	PCR	*B. abortus*	61	17	27.9				(39)
Erzurum	2013	Milk	PCR	*B. abortus*	334	273	81.7				(40)
Kirikkale	2013	Milk	RBPT	*B. abortus*	100	43	43				(41)
Adana	2014	Serum	MAT	*B. abortus*	132	4	3.03				(42)
Afyonkarahisar	2014	Serum	RBPT	*B. abortus*	756	33	4.37				(43)
Ankara, Corum, Kirikkale, Yozgat	2015	Serum	RBPT	*B. abortus*				656	45	6.86	(44)
Ankara, Kırıkkale, Kırşehir, Nevşehir, Kayseri, Yozgat, Çankırı, Eskişehir, Bolu, Karabük, Zonguldak, Bartın, Kastamonu	2015	Serum	RBPT/ SAT/ CFT	*B. abortus*				30.944	6.913	22.34	(45)
Kars	2015	Serum	RBPT	*B. abortus*	100	26	26.0				(46)
Sanliurfa	2015	Serum	RBPT	*B. abortus*	68	35	51.4				(47)
Edirne	2016	Milk	PCR	*B. abortus*	99	2	2.02				(48)
Kars	2016	Milk	PCR	*B. abortus*	215	4	1.86				(49)
Sanliurfa	2017	Milk	iELISA	*B. abortus*	48	8	16.6				(50)
Southeast Region	2017	Serum	RBPT	*B. abortus*	487	396	81.3				(51)
Kars	2017	Serum	RBPT	*B. abortus*				270	22	8.14	(52)
Kars	2017	Serum	RBPT	*B. abortus*				20	10	50	(53)
University of Harran	2018	Milk/Aborted Foetus	LAMP	*B. abortus*	20	5	25	37	8	21.6	(54)
University of Harran	2018	Serum	LFT	*B. abortus*	91	34	37.4				(55)
Konya	2018	Serum	RBPT	*B. abortus*	560	89	15.89				(56)
Central Anatolia Region	2018	Milk	RBPT	*B. abortus*	202	35	17.32				(57)
Total					46.521	2.887	6.21	37.749	7.989	21.16	

* SAT: Serum Agglutination Test; ELISA: Enzyme linked Immunosorbent Assay; RBPT: Rose Bengal Plate Test; CFT: Complement Fixation Test; MRT: Milk Ring Test ; MAT: Microtube Agglutination Test; PCR: Polymerase Chain Reaction; ERIFA: Enzymatic Rapid Immunofiltration Assay; iELISA: Indirect Enzyme-Linked Immunosorbent Assay; LAMP: Loop Mediated Isothermal Amplification; LFT:Lateral Flow Testi.

Table 2. The estimated losses of production calculation method of *B. abortus* in dairy cows (4).

Loss of milk production (X1)	Estimated number of infected dairy cows x Annual milk production (kg/cow) x Reduction in milk yield (%) x Price of milk ($/kg)
Cost of extended calving interval (X2)	Estimated number of infected dairy cows x Extended calving interval (day) x Cost of extended calving interval ($/day)
Cost of abortion (X3)	Estimated number of infected abort cows x (Pregnant dairy cow value ($)- Slaughtered cow value ($))
Replacement of culled cow (X4)	Estimated number of infected dairy cows x Rate of reform x Price of dairy cow ($/head) x ¼
Estimated cost of treatment and drug (X5)	Cost of treatment and drug ($/head) x Estimated number of treated dairy cows + Relapse rate of the infection (%) x Estimated number of treated dairy cows
Total production losses	X1+X2+X3+X4+X5

Table 3. The estimated expenditures for the prevention-control of *B.abortus* in Turkey.

Compensation payment (X6)	Estimated number of infected dairy cows x Culling rate (%) x Avarage compansation paid per cow ($/head)
Cost of diagnostic test and laboratory analysis (X7)	Estimated number of samples examined x Cost of diagnostic test and laboratory analysis per cow ($/head)
Vaccination cost (X8)	Estimated number of dairy cows x Vaccination rate (%) x Cost of one dose of vaccine ($/head)
Total expenditures for the prevention-control	X6+X7+X8

Table 5. The estimated production loss of *B.abortus* per cow ($/head).

Variable	Production loss per cow (US$/head)	(%)
Loss of milk production	142.0	9.7%
Cost of extended calving interval	157.7	10.7%
Cost of abortion	478.0	32.65%
Replacement of culled cow	437.5	29.88%
Estimated cost of treatment and drug	249.0	17.01%
Total production loss	1464.2	100%

Table 4. Technical and financial parameters of the economic loss due to *B.abortus* in Turkey.

Variable	Value (mean, min-max)	Reference
1. Technical parameters		
– Total number of dairy cattle	7.579.493	(59)
– Annual milk production (kg/cow)	3161	(60)
– Mean abort rate in Turkey (%)	4.7 (0.43-8.90)	(61)
– Mean Brusella prevalence in abort (%)	21.16 (1.04-65.6)	Calculated
– Extended calving interval (day)	95 (70-120)	(1)
– Rate of reform (%)	20 (15-25)	Expert opinion*
– Reduction in milk yield (%)	15 (10-20)	(62); Expert opinion
– Vaccination rate (%)	60 (40-80)	Expert opinion
– Estimated rate of treated dairy cows (%)	20 (10-30)	Expert opinion
– Culling rate (%)	80 (70-90)	Expert opinion
– Relapse rate of the infection (%)	50 (25-51)	(1)
2. Financial parameters		
– Price of milk ($/kg)	0.30	(63)
– Price of dairy cow ($)	1.750	(59)
– Cost of extended calving interval ($/day)	1.66	(64)
– Cost of abortion ($/per cow)	478 (348-696)	Calculated of TUİK (59)
– Cost of treatment and drug($/head)	249	Expert opinion
– Avarage compansation paid ($/head)	750	Expert opinion
– Diagnostic test and laboratory analysis ($/head)	20	Expert opinion
– Cost of one dose of vaccine ($/head)	2.5	Provincial Agriculture and Forestry Directorate

6.03 Turkish Lira (TRY) = 1 US$ in 2020 year.

* Delphi survey results

killed but remains in the herd, treatment and medication resulted in costs averaging of US$250 /per a cow (17.01%).

In this study, the estimated production losses ocurred in total for infected dairy cows due to *B. abortus* evaluated in 3 different senarios as optimistic, expected and pessimistic are presented in Table 6.

When Table 6 was examined, it was seen that the total production loss was US$207 million according to the average prevalence of the disease (6.21%) and abortion rate (21.6%) in line with the literature data (Table 1). However, in the optimistic scenario where the prevalence and abortion rate is kept low (1.43%; 1.04%), the production loss was US$ 32 million, in the pessimistic scenario where the prevalence and abort rate are kept high (81.7%; 65.6%) estimated loss was found to be US$3 billion.

According to expert opinions (4), the estimated average

Table 6. The estimated production loss in US$ due to *B.abortus* in Turkey.

Variable	Expected scenario	Optimistic scenario	Pessimistic scenario
Loss of milk production (US$)	66.796.189	10.261.213	941.448.397
Cost of extended calving interval (US$)	74.177.056	12.594.540	990.451.764
Cost of abortion (US$)	2.236.406	1.687	197.116.607
Replacement of culled cow (US$)	41.157.212	7.112.880	543.828.623
Estimated cost of treatment and drug (US$)	23.471.370	2.701.540	372.180.150
Total production loss (US$)	207.838.234	32.671.861	3.045.025.540

Table 7. The prevention and control of *B .abortus* in Turkey (US$)

Cost	Expected scenario	Optimistic scenario	Pessimistic scenario
Compensation payment	282,220,885	56,903,044	3,356,199,500
Cost of diagnostic test and laboratory analysis	7,525,890	1,517,414	89,498,653
Vaccination cost	11,369,240	7,579,493	15,158,986
Total cost	301,116,014	65,999,951	3,460,857,140

values of annual expenditures for the prevention and control of brucellosis in Turkey are presented in Table 7.

When the Table 7 was examined, the estimated annual mean cost for the prevention and control of according to expected scenario was found to be US$ 301 million. These expenditures were composed of compensated payments, vaccine costs, and diagnostic costs with the rate of 93.7%, 3.8% and 2.5%, respectively.

In this study, according to the average prevalence value calculated in the overall estimate, was calculated as the number of infected dairy cows per 470,368 for 2019. According to the expert opinion, it was culling rate of 80% of animals infected in Turkey. Accordingly, the compensation of dairy cows infected 376,294 (US$750/head) to Turkey was determined that the estimated cost were US$282 million.

The cost of *B. abortus* analysis (Diagnostic tests and laboratory analyses) was US$20/head per cow, and the diagnostic cost of 376,294 animals determined to be infected was calculated as US$7,525,890. In addition, according to the results of expert option (Delphi survey), 60% (4,547.695) of cows are vaccinated every year in Turkey. Average 2.5US$/head per cow was determined to be 11,369,240US$ vaccine costs per year.

DISCUSSION

Brucellosis, is very common in many different regions of the world, especially in developing countries, causing substantial economic costs in terms of both animal and public health (65).

While economic loss in *B. abortus* only creates parameters that reduce benefits (reduction in milk yield, low fertility rate, replacement of culled cow), the economic cost of the disease is made up of the costs spent on treatment and control.

The most important symptom of *B.abortus* in dairy farms is abortions usually seen after the second trimester of pregnancy. In addition, decrease in milk yield, loss of progeny, prolongation of calving interval and increase in the rate of replacement of culled cows cause significant economic losses at the enterprise level. On the other hand, various practices such as routine vaccination, testing, treatment, culling and compensation payments made on a national level for the eradication of the disease enhances the economic losses caused by the disease (1).

In the study, the prevalance of *B. abortus* in dairy cows was calculated as 6.21%. *Brucella* prevalance in Turkey has been found to be higher than USA and Iran, with the rate of 0.014% (66), and 0.034% (67), respectively, but closer to Ethiopia (3.1-12%) (68), and lower than Brazil and India with the rate of 15% (69) and 17% (70), respectively. The prevalence of Brucellosis was observed higher in the provinces close to the border in the Eastern and Southeastern Anatolia regions where pasture-breeding is implemented. Similiar to our results, although the prevalance was declared to be 1.9% in China in a meta-analysis study, it was reported that it had increased up to 31.5% in Jilin province where pasture and water are shared (71). This difference in the prevalence rate might be thought to be due to sample size, whether samples were taken randomly or not and differences in the cattle breeding management systems (68). Another important reason for the high level prevalence of the infection in Turkey may be that the majority of the studies published in Turkey were performed with non-randomised samples. Thus, the high rate of prevalence of infection with the rate of 21.16% in abortion cases in Turkey was attributed to bovine brucellosis.

While the abortion rate was determined as 25-50% according to the severity of the disease in one study (72), this rate has been reported to vary between 10% and 50% in many other published studies (1, 73, 74, 75, 76, 77, 78). The abortion rate was declared to be 10.2% in Bishoftu, Ethiopia (68), 12% in Bangladesh (79), and 6.6-60% in India (80). This has created an important economic burden for the livestock industry. Therefore, in this study, the loss due to abortion was estimated to be US$478 per cow and mean of US$2,236,406 across the country.

Other economic losses caused by Brucellosis were the reduced milk production (81). Annual milk yield loss in an infected cow caused by Brucellosis was reported to be ranging from 10% to 25% (1, 72-77, 81). In this study, according to the data obtained from the Delphi questionnaire, the total milk production loss was calculated as 15% (10-20%), therefore relying on this data, an average of 474 liters of milk was lost per cow, was calculated. Unlike our study, Panchasara *et al.* (81) reported 231 liter of milk loss per infected cow as half of the milk loss detected in our study. In our conducted study, estimated production loss to the milk industry due to *Brucella* infection was calculated as US$207 million. Considering other studies conducted in Turkey, while financial loss was declared to be US$20.4 million by Yurtalan (3), Can (1) reported it as approximately US$23.9 million. The main reason for the difference between the results was thought to have originated from the estimated prevalences being in low level as 1.43%-3% and the differences in the applied methodological methods. Singh *et al.* (65) reported that Brucellosis in India caused mean losses of US$3.4 billion for the dairy industry.

Reproductive performance is an important component of milk production, and cows must become pregnant at regular intervals after each calving to enhance the business profit. In this study, period of conception was determined to be taken as an average of 15.2 months (83). In our study, it was calculated that the calving interval (CI) was extended by an extra 95 days and mean cost of US$157.7 per cow. Prolonged calving interval occurring after abortion in an infected cow due to Brucellosis was declared to be on average more than 63 days by Hugh-Jones *et al.* (73) and Emebet and Zeleke (84) reported this period as less than 17.8 months. These differences might be due to reproductive management, poor care-nutrition and poor management practices and other environmental stress diversities in herds.

The rate of replacement of culled cows and heifers due to disease was reported to be 20%, 15%, and 23%, by Can (1), Hugh-Jones *et al.* (73) and Carpenter (74) respectively. This rate was found to be 20% (15-25%) on average from the Delphi expert opinion surveys. In this study, infection-related replacement of culled cowwas estimated as an average of US$437.5/cow.

In a study (1), it was determined that the average financial loss for an infected bovine compared to the weighted average was US$385 (1). In our study, total loss per cow was calculated as US$1464/cow. The difference between these two studies could possibly be explained by the fact that the loss due to abortion was not calculated directly in the study of Can (1). In present study it was determined that the most important loss from an infected cow originated from abortion, and its ratio within the total loss was calculated as 32.7%. However, in our study, prevalence of Bovine Brucellosis in Turkey was determined to be higher where the cow prices and veterinary-treatment costs had increased due to the economic crises over the past 10 years.

It had been stated that the cost of mandatory testing in the USA for producers could be between US$1.5-11.5 per animal, and also, the loss of employment due to infection was stated to reach significant levels. According to the worst-case scenario, the annual cost of the test implementation for the state was estimated to range from a minimum US$495,000 to a maximum US$3,795,000. In this study, according to Delphi expert surveys, the exact diagnosis cost was determined as approximately US$20/cow, and the cost for the whole country was estimated to be minimum US$1,517,414 to maximum US$89,498,653.

The cost of the control strategy related to Brucellosis was calculated as US$75 million in a study conducted in USA (85) and US$8.3 million in another study conducted in Mongolia (86). In this study, the estimated cost of the annual expenditure for the prevention and control in Turkey was estimated to be US$301 million. The high cost of protection-control were as a result of the high disease prevalence and increasing cow prices due to supply shortage in livestock sector in Turkey. In addition, in the analysis, compensation payments constituted 93.7% of the expenses related to Brucellosis. In addition to this, Yurtalan (3) declared that in certain cases no feasible strategy was implemeted, Turkey's total financial losses has been calculated to be US$762 million in a 20-years' period. Considering the development levels of countries and the advantages they have reached to combat against Brucellosis in their regions and countries where the disease is endemic and herd prevalence ≥5-10%, it had been reported that the only way to control and eliminate this zoonosis was through vaccination of all sensitive animals routinely and eliminatation of infected animals (10). Yurtalan (3), calculated the financial losses of Brucellosis originated from *B. abortus* occured in animal production system, and out of 4 different control strategies in order to control and eradicate of the disease, he decided that most rational strategy in terms of economic means was 'solely the vaccination method for 20 years'. However, despite those vaccination programs and practices of elimination of infected animals, the most significant reasons why Brucellosis occured from time to time and particularly in the Eastern Regions of Turkey was due to uncontrolled animal border movements, and grazing all together in the pastures.

Amosson *et al.* (85), examined production losses due to Bovine Brucellosis and alternative control programs in their modeling study. As a result of this study, it had been determined that all alternative programs reduced the prevalence of Brucellosis and created a positive net benefit between a minimum of US$294.9 million and maximum of US$768.9 million annually (1).

In this study, the estimated total economic cost due to disease in Turkey was calculated to be US$508 million, consisting of loss of production US$207 million and protection-control costs of US$301 million.

When the total losses caused by Brucellosis on the national economies were analyzed the annual economic losses were as follows: US$3.2 million in Nigeria (87), US$7 million in Egypt (1, 88), US$3-25 million in Switzerland (85), US$20 million in the Czech Republic (89). The loss of US$26.6 million in Mongolia (86) was lower than our country; in Brazil (US$448 million) (90) the lossses were determined to be similar to those in our country, and in India with US$3.4 billion (2) was found to be higher than in Turkey. In the studies carried out here, while calculating the economic costs related to the disease, it was determined that terms such as economic impact/loss/cost were used by some researchers in general or interchangeably. Therefore, studies on the economy of Brucellosis showed differences in estimated total economic costs as well.

Consequently, particularly in Eastern regions of Turkey, Bovine Brucellosis causes serious economic costs in livestock industry. In line with these data, appropriate prevention-control programs, monitoring animal movements, veterinary biosecurity measures, and regular vaccination of calves at the age 3 months until the target prevalence values are reached will have a direct positive impact on the economic cost of the disease. In addition, awareness among the breeders concerning the epidemiology, control and eradication of bovine Brucellosis should be increased; coordination between the relevant institutions and organizations should be ensured and the further spread of the disease should be prevented.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest: The authors declare that they have no conflict of interest.

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