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Estimating the total cost of bovine fasciolosis in Turkey

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The aim of this study was to estimate the total cost of bovine fasciolosis under three different scenarios (expected, optimistic and pessimistic scenarios) in Turkey. The weighted mean prevalence of infection was calculated as 1.9% and the financial losses were estimated in US$ at 2010 current prices. The total costs of bovine fasciolosis per infected beef cattle and dairy cow were estimated as 223.7 US$ (201.3–246.1, under optimistic-pessimistic scenarios) and 430.7 US$ (387.6–473.7), respectively. Total cost of the disease was estimated as 7.4 million US$ (6.1–8.8) for beef cattle and 35.4 million US$ (28.9–42.6) for dairy cows. The nation-wide total cost of the disease in Turkey for 2010 was estimated to be 42.8 million US$ (35.1–51.4). Most of the losses arise from reduced meat yield, fertility and milk yield, and smaller losses are due to condemnation of livers and disease control expenditures. As a result, the quantity of these losses may help the farmers and policy makers to give the better decision for controlling and eradication of the animal diseases in Turkey.

INTRODUCTION

Fasciolosis is a parasitic liver infection of wild and domestic ruminants caused by *Fasciola hepatica* (Trematoda; Fascioliadae) and/or *Fasciola gigantica* which have a world-wide distribution (Soulsby, 1986). Among helminth infections, fasciolosis commonly called as liver fluke disease is of paramount importance due to its wider spectrum of definitive hosts (Rondelaud *et al.*, 2001) causing acute and chronic infections (Sampaio-Silva *et al.*, 1996). Several experimental studies have suggested that there are considerable economic losses due to fasciolosis (Ribbeck and Witzel, 1979; Hope Cawdery, 1984; Wamae *et al.*, 1998).

The total cost (*C*) of a disease is the sum of production losses (*L*) and control expenditures (*E*), in mathematical notation: $C=L+E$ (Otte and Chilonda, 2000). Fasciolosis causes production losses (*L*) in livestock as a result of condemned liver, reductions in weight gain, milk yield and fertility (extended calving interval, additional service). The use of flukucides can be accepted as basic and most popular control expenditure for treatment against fasciolosis. The economic analysis of losses due to animal diseases within the national economy has a degree of uncertainty because of the variability of the losses attributed to infections. In previous studies focused on estimating the losses due to animal diseases, dynamic–stochastic model (Monte Carlo sampling technique) and deterministic–static model (expected, optimistic and pessimistic scenarios) have been used to overcome these uncertainties (Bennett *et al.*, 1999; Schweizer *et al.*, 2005; Sarıözkan and Yalçın, 2009).

In Turkey, reported studies about bovine fasciolosis performed in different regions

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(included five regions and over 10 provinces) showed an estimated prevalence of 0.5% in Thrace region (Gargılı *et al.*, 1999), 1.6–2.2% in Elazığ (Kaplan *et al.*, 2002; Kaplan and Başpınar, 2009), 3.7% in Istanbul (El-Meterawy and Vuruşaner, 1993), 6.0% in Afyon (Sevimli *et al.*, 2005), 15.8–24.5% in Kayseri (Yavuz *et al.*, 2007; Yıldırım *et al.*, 2000; Yıldırım *et al.*, 2007) and 25.0% in Samsun provinces (Celep *et al.*, 1990).

According to review of Köroğlu and Şimşek (2003), under Turkish field conditions, most of the studies only calculated the cost of condemned liver due to bovine fasciolosis at a province level, and ignored the other production losses and control expenditures. However, to the author's knowledge, there have been no attempts to assess the total cost of bovine fasciolosis at national scale in Turkey.

The objective of this study was to estimate the annual (for the current price of 2010) total cost of bovine fasciolosis under different scenarios (expected, optimistic and pessimistic scenarios) in Turkey.

MATERIALS AND METHODS

In the study, total cost (*C*) of bovine fasciolosis calculated by using equation (1) (adapted from Schweizer *et al.*, 2005):

$$(N_1 \times I_1) \times \sum_{x=1}^{5} (P_x U_x) + (P_6 \times U_6) +$$
$$(N_2 \times I_2) \times \sum_{x=4}^{5} (P_x U_x) + (P_6 \times U_6)$$

where N is the population size (number of dairy or beef cattle) with a rate of infection I (prevalence in dairy cows or beef cattle), and a loss parameter P for each of six effects (x_1–x_6) and U represents the unit cost of per parameter (U_1–U_6). The definitions of each symbol (letter) are given in Table 1.

The details of the technical and financial data used in the analyses and their sources were presented in Table 2.

In the analyses, cost of extended calving interval (US$/day) was calculated from Yalçın (2000) and added 3% discount rate for per annum (30% for 10 years).

Due to large variation in the reported prevalence of bovine fasciolosis in Turkey, the total cost of disease on national scale estimated under three scenarios, namely, expected (mean value), optimistic (lowered by 10%) and pessimistic (increased by 10%) scenarios. Similar to Bennett *et al.* (1999), and Sarıözkan and Yalçın (2009), deterministic methods were used to estimate of the annual losses due to bovine fasciolosis in Turkey.

The reported prevalence values of bovine fasciolosis varied from 0.5% to 25.0% in Turkey. Because of higher sample sizes on studies reported lower prevalences (Gargılı *et al.*, 1999; Kaplan *et al.*, 2002; Kaplan and Başpınar, 2009), the weighted mean prevalence was calculated as 1.9%. The weighted mean prevalence of the bovine fasciolosis was calculated from the results of reported studies conducted in different regions (included over 10 provinces) of Turkey (Table 2).

A spreadsheet model detailed in equation (1) was constructed in Microsoft Excel program to estimate annual (for the current prices of 2010) total cost of bovine fasciolosis in Turkey.

RESULTS

The total costs of bovine fasciolosis per infected beef cattle and dairy cow under different scenarios were presented in Table 3.

The total cost per infected beef cattle was estimated as 223.7 US$ (201.3–246.1, under optimistic–pessimistic scenarios) and 430.7 US$ (387.6–473.7) per infected dairy cow. Estimated total cost of fasciolosis in an infected dairy cow is nearly two-fold higher compared to those of beef cattle. Treatment costs were 0.3% and 0.09% of total cost per infected beef cattle and dairy cow, respectively.

The total cost of bovine fasciolosis in Turkey under three different scenarios

TABLE 1. *The definitions of equation* about the total cost of bovine fasciolosis in Turkey*

Effect	Population size (N)	Infection rate (I)	Loss parameter (P)	Unit cost (U)
Loss of milk yield (x_1)	No. of dairy cows (N_1)	Prevalence in dairy cows (I_1)	Loss of milk yield per cow (P_1)	Price of milk (U_1)
Extended calving interval (x_2)	No. of dairy cows (N_1)	Prevalence in dairy cows (I_1)	No. of additional days per cow (P_2)	Cost per day (U_2)
Additional services (x_3)	No. of dairy cows (N_1)	Prevalence in dairy cows (I_1)	No. of additional services per cow (P_3)	Cost per service (U_3)
Loss of meat (x_4)	No. of beef cattle (N_2)	Prevalence in beef cattle (I_2)	Weight loss per cattle (P_4)	Price of meat (U_4)
Loss of livers (x_5)			Condemned liver in kg (P_5)	Price of liver (U_5)
Treatment costs (x_6)			Treated cattle per year (P_6)	Cost per treatment (U_6)

*Equation (1).

TABLE 2. *Technical and financial parameters used in the estimating the total cost of bovine fasciolosis in Turkey*

Parameters used in the analyses	Value	References
TECHNICAL PARAMETERS		
Total number of cattle (2009)	10 723 958	Anon (2010b)
Number of beef cattle (2009)	1 502 073	Anon (2010b)
Number of dairy cows (2009)	4 133 148	Anon (2010b)
Reduction in weight gain (kg/year)	26.0 (23.4–28.6)	Calculated from Bennett *et al.* (1999)
Reduction in milk yield (kg/cow)*	152.5 (137.3–167.8)†	Calculated from Bennett *et al.* (1999)
Extended calving interval (day)	20.0 (18.0–22.0)	Bennett *et al.* (1999)
Additional service	0.5 (0.45–0.55)	Bennett *et al.* (1999)
Weight of condemned liver (kg)	2.7 (2.4–3.0)	Bennett *et al.* (1999)
Mean prevalence (%)	1.9 (1.7–2.1)	Köroğlu and Şimşek (2003)
Number of treated beef cattle (head/year)‡	1 051 451 (946 306–1 156 596)	Anon (2010c)
Number of treated dairy cows (head/year)‡	1 653 259 (1 487 933–1 818 585)	Anon (2010c)
FINANCIAL PARAMETERS§		
Price of meat (US$/kg)	8.0	Anon (2010d)
Price of milk (US$/kg)	0.5	Anon (2010e)
Cost of extended calving interval (US$/day)	5.8	Calculated from Yalçın (2000)
Cost of per service (US$)	30.0	Anon (2010c)
Price of liver (US$/2.7 kg)	15.0	Calculation
Cost of treatment (US$/head/year)	1.0	Anon (2010c)

*Decrease in milk yield was calculated over a 305-day lactation.
†Optimistic and pessimistic values represented in parenthesis.
‡Number of treated beef cattle was calculated as 70% of total beef cattle and number of dairy cows was calculated as 40% of total dairy cows.
§1.5 TL=1 US$ in 2010.

TABLE 3. *The total costs of bovine fasciolosis per infected beef cattle and dairy cow*

	Expected estimation		Optimistic estimation		Pessimistic estimation	
Total cost items	Beef cattle	Dairy cow	Beef cattle	Dairy cow	Beef cattle	Dairy cow
L_{meat}	208.0	208.0	187.2	187.2	228.8	228.8
L_{milk}	…	76.3	…	68.6	…	83.9
$L_{fertility}$*	…	131.0	…	117.9	…	144.1
L_{liver}	15.0	15.0	13.5	13.5	16.5	16.5
$C_{treatment}$	0.7	0.4	0.6	0.4	0.8	0.4
C_{TOTAL}	223.7	430.7	201.3	387.6	246.1	473.7

*Includes cost of extended calving interval and additional service.

(expected, optimistic and pessimistic) were presented in Table 4.

Total cost of bovine fasciolosis was estimated as 7.4 million US$ (6.1–8.8) for beef cattle and 35.4 million US$ (28.9–42.6) for dairy cows. The nation-wide total cost in Turkey in 2010 was estimated to be 42.8 million US$ (35.1–51.4). Estimated total cost of fasciolosis in dairy cows is nearly four- to five-fold higher compared to those of beef cattle in Turkey. Annual treatment costs for both beef cattle and dairy cows were estimated as 5.8–6.9% of total costs. In Turkey, the distributions of total cost for beef cattle and dairy cows were estimated as 17% and 83%, respectively.

DISCUSSION

There are a lot of studies which reported the prevalence of bovine fasciolosis and only estimated the losses due to condemned liver in the world. However, there have been few attempts to quantify the total costs of the infection. In the present study, the total cost of infection for the Turkish economy was estimated under three different scenarios (optimistic, expected and pessimistic). It would have been much better to analyse the total cost of bovine fasciolosis with a 'dynamic stochastic model' such as Monte Carlo Simulation Technique. Such model would have taken account of the knock-on effects (dynamics of the system) and uncertainties over time with and without disease situation much better. However, such advanced model building activities necessitate multidisciplinary team work as done by several developed countries, which is still lacking in Turkey. For this reason, we had to use 'deterministic–static model' to estimate the total cost of the disease and tried to analyse the uncertainties by analysing the

TABLE 4. *Nation-wide total costs of bovine fasciolosis in Turkey under different scenarios*

	Expected estimation		Optimistic estimation		Pessimistic estimation	
Total cost items	Beef cattle	Dairy cow	Beef cattle	Dairy cow	Beef cattle	Dairy cow
L_{meat}	5 936 192	16 334 201	4 808 316	13 230 703	7 182 793	19 764 383
L_{milk}	…	5 987 898	…	4 850 198	…	7 245 357
$L_{fertility}$*	…	10 287 405	…	8 332 798	…	12 447 761
L_{liver}	428 091	1 177 947	385 282	1 060 152	470 900	1 295 742
$C_{treatment}$	1 051 451	1 653 259	946 306	1 487 933	1 156 596	1 818 585
$C_{beef,\ dairy}$	7 415 734	35 440 710	6 139 904	28 961 784	8 810 289	42 571 828
C_{TOTAL}	42 856 444		35 101 688		51 382 117	

*Includes cost of extended calving interval and additional service.

results under pessimistic and optimistic scenarios. We are aware that the analyses do not provide an excellent decision support to the government officials in charge of disease control. However, considering that economic assessments of the livestock disease-induced losses and cost–benefit analysis of alternative control/eradication strategies of animal diseases are almost lacking in Turkey, we believe that the analyses provides at least some information on the magnitude of the cost of fasciolosis at national level.

In this study, the weighted mean prevalence of infection was calculated as 1.9% from the published data in Turkey. However, it could be between 0.5% and 25.0% according to different regions. Although both *F. hepatica* and *F. gigantica* are present in Turkey, *F. hepatica* is more prevalent species in cattle (Yıldırım *et al.*, 2007).

The prevalence of bovine fasciolosis varies among the different countries in the world. The prevalence of infection in cattle reported as 1.1–4.8% in Iran (Ansari-Lari and Moazzeni, 2006), 3.3% in Iraq (Mahdi and Al-Baldawi, 1987), 25.5% in Pakistan (Khan *et al.*, 2009), 10.3% in Brasil (Marques and Scroferneker, 2003), 10.9% in Switzerland (Schweizer *et al.*, 2005), 5.0–8.5% in Scotland (Khaitsa *et al.*, 1994), 6.5% in England and Wales (MAFF, 1980), 3.5–26.0% in Kenya (Kithuka *et al.*, 2002; Mungube *et al.*, 2006), 7.0% in Nigeria (Ogunrinade and Ogunrinade, 1980), 9% in Saudi Arabia (Nasher, 1990), 60.9% in Zambia (Phiri *et al.*, 2005) and 24.3–90.7% in Ethiopia (Yılma and Mesfin, 2000; Berhe *et al.*, 2009).

The large variation of prevalence of bovine fasciolosis in different countries and regions is depending on some factors such as environmental and climatic conditions, snail population, management systems, composition of livestock population, age and sex of cattle, and contamination level of pastures.

In Turkey, total cost of fasciolosis per infected beef cattle was estimated as between 201–246 and 388–474 US$ per infected dairy cow. In Kenya, after an experimental study, both losses of live weight gain and liver condemnations due to *F. gigantica* for Friesian and Boran cattle were reported as 12.1 and 23.4 US$, respectively (Wamae *et al.*, 1998). After a retrospective study in Taveta region of Kenya, Mungube *et al.* (2006) estimated the losses of liver condemnations due to *F. gigantica* infection as 8.9 US$ per infected cattle. The losses of both carcass weight and liver condemnations were estimated as US$ 25.3 per infected cattle in Tigray region of Ethiopia (Behre *et al.*, 2009).

In Turkey, under different scenarios, the estimated cost of fasciolosis for beef cattle and dairy cows varied between 6.1 and 8.8 million US$ and 28.9–42.6 million US$, respectively. Total cost of the disease for Turkish economy could range between 35.1 and 51.4 million US$ annually. This equates the 1.2–1.7% of the reported total losses due to fasciolosis in the world (Spithill *et al.*, 1999) and 0.14–0.19% of the Turkey's total livestock production value in 2009 (Anon, 2010a).

There are some studies performed in different countries/regions about financial losses due to bovine fasciolosis in the world. However, some of these studies were taken into account only the losses due to condemned liver and/or live weight reduction and others estimated the nation-wide total losses of disease as in this study.

For example, in Kenya, Kithuka *et al.* (2002) estimated the annual losses due to bovine fasciolosis for only liver condemnations as 0.2–0.3 million US$. In Greece, loss of condemned liver was estimated as 21.6 US$ per infected cattle (Theodoropoulos *et al.*, 2002). Schweizer *et al.* (2005) estimated the total loss as 72 million US$ and loss per infected cattle as 415 US$ due to bovine fasciolosis in Switzerland. Bennett *et al.* (1999) estimated the low and high annual losses in the UK to be between 12 million and 86 million US$.

Despite the low mean prevalence (1.9%) of bovine fasciolosis, the estimated total cost of disease for Turkish economy and losses of per infected cattle could lead to make some new decisions by government and farmers. In short term, there are some difficulties to eliminate the bovine fasciolosis; however, the following measures could be taken for decreasing the financial impact of disease for Turkish livestock and economy:

- farmers need to inform by government about the disease and prevention methods because of the high quantity of losses and cost of disease;
- drugs (flukucides) should be used in correct time and dose by farmers and veterinarians for preventing the drug resistance;
- disease control expenditures should be increased before the infection, for protecting the herds from fasciolosis;
- cattle faeces should be examined periodically and pastures need to be ameliorated for preventing the contamination.

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