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ORIGINAL PAPER

Economical impact of tropical theileriosis in the Cappadocia region of Turkey

Abdullah Inci · Anil Ica · Alparslan Yildirim · Zati Vatansever · Ayse Cakmak · Hasan Albasan · Yucel Cam · Ayhan Atasever · Savas Sariozkan · Onder Duzlu

Abstract This study was initiated to investigate the economical impact of vaccination against tropical theileriosis in cattle in Cappadocia in Turkey. A total of 554 vaccinated and non-vaccinated animals were monitored for *Theileria annulata* infection using microscopic examination serology by measuring the antibody response of the animals by the indirect immunofluorescence antibody test (IFAT). The prevalence of *T. annulata* infection, morbidity and mortality were significantly higher in unvaccinated than in vaccinated cattle, whereas the seropositivity was significantly lower in the unvaccinated group. Acute tropical theileriosis cases were diagnosed in 156 of 554 (27.61%) cattle, and 86 of 156 (56.21%) died from the disease. The total economic losses because of tropical theileriosis were estimated at US$598,133 for 2 years.

A. Inci (✉) · A. Ica · A. Yildirim · O. Duzlu
Faculty of Veterinary Medicine, Department of Parasitology,
Erciyes University,
Baris Manco Cad. No:1,
38090 Kayseri, Turkey
e-mail: ainci@erciyes.edu.tr

Z. Vatansever · A. Cakmak
Department of Parasitology, Faculty of Veterinary Medicine,
Ankara University,
Ankara, Turkey

H. Albasan · Y. Cam
Department of Internal Medicine, Faculty of Veterinary Medicine,
Erciyes University,
Kayseri, Turkey

A. Atasever
Department of Pathology, Faculty of Veterinary Medicine,
Erciyes University,
Kayseri, Turkey

S. Sariozkan
Department of Livestock Economy,
Faculty of Veterinary Medicine, Erciyes University,
Kayseri, Turkey

Introduction

In many countries, ticks and tick-borne diseases (TTBDs) are the major impediment for the development and improvement of livestock industry. They cause economical loss of livestock by decreasing milk production, loosing weight or increasing risk for bacterial and fungal infections, as well as screw-worm attack (Bram 1983). It has been reported that 80% of 1,200 million cattle are at risk for TTBDs causing global annual losses of US $7 billion (McCosker 1979). Tropical theileriosis, caused by the protozoan parasite *Theileria annulata*, is transmitted by several tick species of the genus *Hyalomma* (Robinson 1982). Worldwide, approximately 250 million cattle are at risk of tropical theileriosis (Uilenberg 1981; Norval et al. 1992; Gharbi et al. 2006). The control strategy is based on control or eradication of the vector ticks, immunization of target animals by attenuated vaccines (Brown 1990) and chemotherapy with buparvaquon or long-lasting tetracycline.

Vaccination is an important measure against tropical theileriosis in an endemic area (Brown 1990; Ahmed and Mehlhorn 1999; Pipano and Shkap 2000; Gharbi et al. 2006). Thus, attenuated schizont vaccines have been successfully used for vaccination of susceptible cattle against tropical theileriosis in Israel, Iran, Morocco and Tunisia (Pipano and Shkap 2000; Gharbi et al. 2006). The duration of immunity after sporozoite or schizont infections has not been determined yet but does not appear to be life long, and re-vaccination might be required for cattle in

herds with a low tick infection rate. The attenuated, culture-derived anti-*Theileria* vaccine proved to be a safe and effective method for prevention of field theileriosis in large enzootic areas (Pipano and Shkap 2000).

Tropical theileriosis is also the most important cattle disease in Turkey. Of 10,761,000 cattle, 6,544,000 (60%) pure and cross breeds are threatened by the disease (Sayın et al. 2003). The most susceptible animals are the imported, non-vaccinated cattle, which show a mortality rate of more than 70% in pure breed (particularly Holstein Friesians) and less than 45% in cross breed among indigenous cattle (Sayın et al. 2003, 2004). Annually, approximately 150,000 susceptible cattle are vaccinated against tropical theileriosis in Turkey (Onar 1989).

The objective of this study was to evaluate epidemiological aspects, effectiveness of vaccination and the economic losses because of *T. annulata* in the Cappadocia area in Turkey.

Materials and methods

Study area

The Cappadocia area, comprising the major part of Central Anatolia including the provinces of Nevşehir, Niğde and Kayseri in Turkey was the study area. The climate of the region is defined as cold winter, hot summer, cool-wet spring and autumn with a wide range of temperatures. The altitude of this area ranges from 1,050 to1,600 m. Each village the samples were collected from had a common cattle herd and a common pasture or grassland for grazing from March to December.

The structure of the herds

Of the 554 cattle, 339 were pure breed, 170 cross breed and 45 local breed; 69 were males and 485 females; 135 were 0–1 year old, 53 1–2 years old and 366 greater than 2 years old. Three hundred and forty-six (62%) of sampled cattle were vaccinated against tropical theileriosis by attenuated schizont vaccine at dose of 10^7. The vaccinated cattle were divided into four groups as vaccinated in 1999 (group I), re-vaccinated in 2000 (group II), not re-vaccinated in 2000 (group III) and the first time vaccinated in 2001 (group IV). All vaccinated and also unvaccinated control cattle (group V) were also divided into two sub-groups as grazed and zero grazed. Tick control practices were applied to some of the herds using acaricides.

Visits to villages, sampling of cattle and questionnaire

Field work was conducted from April 1999 to November 2001. Clinical inspection consisted of individual rectal temperature recording (measured temperature≥39.5°C was considered febrile), inspection of vaginal mucosa and conjunctiva for pathological haemorrhages and inspection and palpation of superficial lymph nodes (pre-scapular). Biopsies were taken from enlarged lymph nodes to prepare smear slides, and jugular vein blood was drawn for blood smears and serum samples, to measure packed cell volume, to establish cell lines and for deoxyribonucleic acid (DNA) isolation. Giemsa-stained smears were examined for schizont and piroplasm forms of *T. annulata*. Animals were also examined for tick infestations.

A questionnaire, similar to that described by Thrusfield (1995), was used to collect information on cattle, management, environmental specialties (wildlife, climatic conditions) and risk indicators of tick-borne diseases.

Estimating economic losses because of tropical theileriosis

Total economic losses (TEL) because of tropical theileriosis include three main parameters: (1) production losses, (2) control costs and (3) other indirect economic losses. The production losses were composed of direct production losses (morbidity and mortality) and indirect production losses. Control costs were estimated depending on the

Table 1 Epidemiologic aspects of tropical theileriosis in the Cappadocia region

Variable	Number of cattle (%)	Positive cattle (%)				Morbidity and mortality (%)			
		Microscopy	*p* value	IFAT	*p* value	Cases	*p* value	Deaths	*p* value
Vaccination									
Vaccinated	346 (62.4)	213 (61.6)	0.498	304 (87.9)	<0.001	47 (13.6)	<0.001	10 (21.3)	<0.001
Unvaccinated	208 (37.6)	122 (58.7)		70 (33.7)		106 (51)		76 (71.7)	
Management system									
Semi-grazed	331 (59.7)	269 (81.3)	<0.001	262 (79.2)	<0.001	135 (40.8)	<0.001	81 (60)	<0.05
Zero-grazed	223 (40.3)	66 (29.6)		112 (50.2)		18 (8.1)		5 (27.8)	
Breed									
Pure breed	339 (61.2)	182 (53.7)	<0.001	220 (64.9)	0.099	111 (32.7)	<0.001	69 (62.2)	<0.05
Cross and local breed	215 (38.8)	153 (71.2)		154 (71.6)		42 (19.5)		17 (40.5)	

Table 2 The total economic losses (TEL) because of *T. annulata* infection in the Cappadocia region[a]

	Quantity	Number of cattle	Unit cost (US$)	Total cost (US$)	Percent of total losses
1. Production losses					
Beef loss (kg)					
Morbidity loss	8	67	8	4,288	0.57
Mortality loss	250	86	8	172,000	22.84
Milk loss (l)					
Morbidity loss	250	37	0.3	2,775	0.37
Mortality loss	15,250	85	0.3	388,875	51.62
Calf loss	1.6	85	375	51,000	6.77
Manure loss (ton)	14.6	86	19	23,601	3.13
Hide loss (kg)	28	86	1.5	3,612	0.48
2. Control costs					
Tick control practices					
Avermectins		23	9	207	0.03
Formamidins		92	4	368	0.05
Organophosphates		8	47	376	0.05
Pyrethroids		30	13	390	0.05
Vaccination		47	10	470	0.06
Treatment					
Buparvaquon		153	75	11,475	1.52
Other drugs		153	38	5,814	0.77
Professional fee		153	42	6,426	0.86
3. Other indirect losses					
Credit+insurance costs		85	960	81,600	10.83
4. Losses (L = 1 + 2 + 3)				753,277	100.0
5. Insurance refund (IR)				−155,144	20.60
Total economic losses (TEL = 4 − 5)				598,133	79.40

[a] The prices for February 2006

application of acaricides to tick-infested cattle and the treatment of infected animals. Other indirect economic losses included credit and insurance payments.

Data analysis

The TEL were calculated as described (McInerney et al. 1992; Norval et al. 1992; Bennett et al. 1999) and direct economic losses according to Bennet et al. (1999). TEL was calculated by subtracting the insurance refund from the losses. Chi-squared (χ^2), Mann–Whitney, Kruskal–Wallis and bivariate correlation tests were employed for statistical analysis of the results using SPSS 13.0 statistical software package.

Results

Microscopical examination of Giemsa-stained smears prepared from blood of the cattle was applied to detect the merozoites of *T. annulata.* For further confirmation, polymerase chain reaction (PCR) was used to detect the parasite DNA, and the seroprevalence of tropical theileriosis was determined by IFAT. The obtained results revealed that the infection rate was significantly higher in grazed than in semi-grazed animals. Moreover, the pure breed showed a significantly higher susceptibility to *T. annulata* infection than cross breeds and local breed animals (Table 1).

A positive correlation was observed between protection and antibody response, as the antibody response was significantly higher in vaccinated cattle. This may be due to the fact that the vaccinated animals have been boosted to react with a secondary antibody response after exposure to challenge under field conditions (Table 1).

An interesting finding was that the mortality rate was significantly higher within the non-vaccinated groups, which significantly had a lower antibody response compared to previously vaccinated cattle (Table 1).

TEL because of *T. annulata* infection in cattle in the Cappadocia region is summarized in Table 2. The analysis revealed that most costs (51.62%) were due to the morbidity rate, followed by the costs caused by death of the animals (22.84%). The overall costs because of tropical theileriosis were estimated to be US$598,133 for 2 years in the Cappadocia region of Turkey.

Discussion

There is a clear evidence of variation in susceptibility of different cattle types and breeds to *T. annulata* infection. Both

the prevalence of tick infestation as well as the percentage of piroplasms of *T. annulata* were greater in pure breeds than in cross and local breeds. The reason for this may be that indigenous and cross breed cattle are exposed to *Hyalomma* ticks throughout the theileriosis season, while pure breeds are zero grazed. However, the possibility of genetic differences leading to varied resistance against infection cannot be ruled out and may be explored in future studies.

Parallel to tick infestation, the incidence of disease with severe clinical reactions increased through June and peaked in July (Sayın et al. 2004). It is worth mentioning that the higher prevalence of *T. annulata* in the unvaccinated cattle group correlated to the lower seropositivity, indicating the importance of the antibody response in the control of a superinfection, maybe through neutralization of the sporozoites and, thus, inhibition of the establishment of new infections in host leucocytes. Our results are in agreement with previous studies (Onar 1989; Brown 1990; Norval et al. 1992; Ahmed and Mehlhorn 1999; Pipano and Shkap 2000; Sayın et al. 2004; Gharbi et al. 2006). We also recommend immunization of cattle against *T. annulata* before the onset of the tropical theileriosis season in endemic areas.

In the present study, the economic losses were calculated by using previously published parameters (production losses, control costs and other indirect economic losses, Norval et al. 1992). Based on these analyses, the TEL because of tropical theileriosis was calculated to be US$598,133 for 2 years in the Cappadocia region. The major part of the losses (87.26%) resulted from production loss, followed by the other losses (9.29%) and control costs (3.45%). Similar results were obtained in Tunis (Gharbi et al. 2006).

Based on the results of our study, it is recommended that vaccinated cattle should be grazed during the tropical theileriosis season to achieve a solid immunity and to avoid re-vaccination to reduce costs.

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