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Current Status of Ruminant Theileriosis and Its Economical Impact in Turkey

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SUMMARY: The diagnosis of ruminant theileriosis in Turkey is based on microscopical examination of thin blood and lymph smears, serology, traditional staining methods of the salivary glands of ticks and molecular techniques. Although some investigators reported that *T. mutans* was found in cattle with microscobic examination (7.4%-36.7%) and experimental study, they did not detect this parasite using molecular techniques. On the other hand, the prevalence of *T.buffeli/orientalis* was found to differ between 0.9% and 13.6% using molecular techniques in different regions of Turkey. Tropical theileriosis caused by *T. annulata* is widespread, and constitutes a major health and management problem in cattle in Turkey. The economic losses resulting from the tropical theileriosis were estimated to be US $598,000, $133,000 and $130,000 in the endemic stable zones of Turkey. Microscobic prevalence of *T. annulata* has been reported to be between 0% and 60.5% in different parts of Turkey. The serologic prevalence of *T. annulata* was found to differ between 1.8% and 91.4% by IFAT. In subsequent studies, the prevalence of this parasite was found to differ between 15.4% and 61.2% by molecular techniques. Clinical cases of ovine theileriosis have not been documented in Turkey. The prevalence of *T. ovis /recondita* was found to differ between 0% and 41.3% by microscobic examination of thin blood smears and its seroprevalance was found to be between 8.2% and 63.2% by IFAT. This parasite has also been reported to be present between 41.8% and 67.7% by molecular techniques.

Key Words: Ruminant, theileriosis, economical impact, Turkey

Türkiye'de Ruminant Theileriosis'inin Mevcut Durumu ve Ekonomik Etkisi

ÖZET: Türkiye'de ruminant theileriosis'inin tanısı kan ve lenf frotilerinin mikroskobik muayenesi, seroloji, kene tükürük bezinin boyanması ve moleküler tekniklere dayanmaktadır. Bazı araştırıcılar *T.mutans*'ın varlığını mikroskobik muayene (%7,4 - %36,7) ve deneysel çalışmalara göre bildirsede bu parazit moleküler tekniklerle belirlenememiştir. Türkiye'nin farklı bölgelerinde *T.buffeli/orientalis*'in prevalansı moleküler tekniklerle %0,9 ve %13,6 arasında saptanmıştır. *T.annulata*'nın neden olduğu tropical theileriosis Türkiye'de önemli sağlık ve yetiştiricilik sorunu oluşturmaktadır. Endemik stabil bölgelerde tropical theileriosis'in neden olduğu tahmini ekonomik kayıp 598, 133 ve 130,000 Amerikan dolarıdır. Türkiye'nin değişik bölgelerinde *T.annulata*'nın mikroskobik prevalansı %0 ve %60,5 arasında açıklanmıştır. *T.annulata*'nın serolojik prevalansı IFA testiyle %1,8 ve %91,4 arasında belirlenmiştir. Daha sonraki çalışmalarda, parazitin prevalansı moleküler tekniklerle %15,4 ve%61,2 arasında saptanmıştır. Türkiye'de koyun ve keçilerde theileriosis'e bağlı klinik vakalara rastlanılmamıştır. Kan frotilerinin mikroskobik muayenesine göre *T. ovis /recondita*'nın prevalansı %0 ve %41,3 arasında belirlenmiş ve seroprevalansı IFA testiyle %8,2 ve %63,2 arasında bulunmuştur. Parazitin prevalansı moleküler tekniklerle %41,8 ve %67,7 arasında açıklanmıştır.

Anahtar Sözcükler: Ruminant, theileriosis, ekonomik etki, Türkiye

INTRODUCTION

Turkey covers approximately 780.576 km^2 and lies between 36°-40° North Latitude and 26°-45° East Longitude. Turkey has a great potential for livestock production. Livestock provides approximately 35% of agricultural output, with a population of over 11 million cattle, 25 million sheep and 6 million goats (60). Production from local breeds is low and there is a trend towards importation of high yielding European breeds, particularly dairy cattle. Currently, 71% of cattle are pure-bred, with 18% cross breeds and 11% pure European cattle. Sheep population consists of 98% local breeds, 2% exotic (Merino) and cross-breeds. Goats population includes 15% Angora and 85% local breeds. Despite the high number of sheep, the production per animal is not satisfactory. One of the main factors is considered to be the low productivity potential of local breeds. The current trend is to replace local breeds with Merino.

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In many countries, ticks and tick-borne diseases are the major impediment for the development and improvement of livestock industry. They cause major economic losses, and affect many domestic animals, mainly cattle and sheep, in tropical and subtropical regions (62).

Bovine *Theileria* species are tick-borne intracelular protozoan parasites that cause severe and mild infections in their hosts. Two of them, *Theileria annulata* and *T.parva*, cause lymphoprolipherative disease with high mortality and morbidity in cattle, commonly known as tropical theileriosis and East Coast fever, respectively. *T.sergenti/buffeli/orientalis* cause mild or asymptomatic disease in cattle well-known as bovine benign theileriosis (61).

Ovine theileriosis is a tick-borne hemoprotozoan disease in sheep and goats caused by *Theileria lestoquardi* (*hirci*), *T. ovis (recondita)*, *T. separata* and the newly described *Theileria* sp. China (61). *T. lestoquardi* and *Theileria* sp. China highly pathogenic and cause lymphoprolipherative disease with high mortality and morbidity (34, 66), while *T.ovis* and *T. separata* are low or non-pathogenic species in small ruminants (61).

In Turkey, Although some investigators reported that *T.mutans* was found in cattle according to microscobic examination (18, 22, 47, 59) and experimental study (32), this parasite wasn't dedected by molecular techniques. *T.buffeli/orientalis* was found in cattle by molecular techniques in different parts of Turkey (11, 14, 38, 41, 64). Tropical theileriosis is widespread, and constitute major health and management problems of cattle (42, 53, 55). Mortality in local cattle breeds is approximately 50%, but can be up to 100% in imported animals. Tropical theileriosis control is effected through a cell-line vaccine, of which 170,000 doses per year are prepared (53). Clinical cases of ovine theileriosis have not been documented (35), although *T.lestoquardi* (33) and *T. ovis* have found in Turkey (13, 15, 29, 31).

Geographical distribution and prevalence

Seven geographical areas can be distinguished in Turkey: **i).** The Mediterranean coast; **ii).** The Aegean coast, **iii).** The Marmara coast; **iv).** The Black Sea coast; **v)**. central Anatolia; **vi).** eastern Anatolia; **vii).** south-eastern Anatolia

Studies focusing on distribution of theileriosis in Turkey utilized microscopical examination of blood smears for a long time (Table 1) and serological tests employing IFAT have frequently been used (Table 2). Also, microscopical examination of Methylgreen/Pyronin-stained preparates prepared from salivary glands of the vector ticks was applied to detect the prevalence and intensity of *Theileria* infection. Recently, molecular techniques were performed to diagnose the *Theileria* in Turkey. Molecular techniques seems to be more sensitive and specific for diagnosis of species of *Theileria* when compared with the other methods, and may therefore facilitate determination of latent infections (11, 23, 41, 63, 64). It has been reported that the microscopic prevalence of *T.mutans* was between 7.4% and 36.7% and of *T.annulata* was between 0% and 60.5% in different parts of Turkey (Table 1). In addition, *T.recondita* piroplasm forms have been reported to be present between 0% and 41.3% by microscopic examination (Table 1).

In serological studies carried out in different regions of Turkey, the seroprevalence of tropical theileriosis has been estimated to vary from 1.8 to 91.4% in cattle (Table 2). Recently, *T.recondita* prevalence was detected at a rate of 17.2-63.2% in sheep and 8.2-10.7% in goats by IFAT (Table 2).

The PCR assay was used first time in Turkey for diagnosis of *T.annulata* by Aktas et al. (9). In the subsequently studies, the prevalence of *T.annulata* was determined to differ between 29.1% and 58.4% by PCR (Table 3). Vatansever and Nalbantoglu (63) reported that the prevalence value of *T.annulata* was 61.2% by nested-PCR. *T.annulata* prevalence have also been reported to be present between 15.4% and 44.0% by RLB (Table 3). The prevalence value of *T.buffeli/orientalis* was 0.9-13.6% by RLB and 7.1% by PCR in different parts of Turkey (Table 3). It has been reported that the prevalence of *T.ovis* was between 41.8% and 67.7% by nested-PCR (Table 3).

Natural *Theileria* infection in *H.a.anatolicum, H.a.excavatum*, *H.detritum* and *H.marginatum* ticks collected from cattle and their shelters was reported in Turkey. In Central Anatolia, 8.33-17.49% *H.a.anatolicum*, 0.89-10.8% *H.a.excavatum*, 5.0-5.48% *H.detritum* and 0.51% *H.marginatum* were infected with *T.annulata* (40, 51, 55, 57). In East Anatolia, the prevalence of *Theileria* infection was 10.84-53.7% in *H.a. anatolicum*, 4.6%-6.25% in *H.detritum* and 2.4-7.8% in *H.a.excavatum* (2, 3, 8, 10). In the Mediterranean region, 3.4% of *H.a.excavatum* were positive (49). In the Aegean region, the prevalence of *Theileria* infection was determined to differ between 10% and 50% in *H.detritum* ticks (16). However, traditional staining methods are inadequate in differentiating the species of sporozoites in the salivary glands of tick. More sensitive and specific molecular methods may permit *Theileria* parasites in salivary glands to be differentiated (10). Aktas et al. (12) reported that *T.ovis* was detected by PCR in 37 of 192 (19.27%) *Rhipicephalus bursa* ticks collected from naturally infested sheep and goats in eastern Turkey (12).

Economic aspects of theileriosis

In Turkey, *T.annulata* is considered to be a major threat to the cattle industry since the causative agent cause mortality and economical losses, particularly in imported and crossbred cattle (36, 41, 45, 55). The vaccination programme is aimed at protecting from theileriosis the large number of highly susceptiple cattle being imported into Turkey from Europe and North America with world Bank funds. However despite these efforts to keep the disease under control the importance of tropical theileriosis in Turkey is increasing (15, 51).

Table 1. Microscobic prevalence of theileriosis in domestic ruminants according to geographical areas in Turkey

Geographical region	Reference	Species of *Theileria* (Species of animal)	No. examined	Positive*(%)
Marmara	Tüzer (1981)	*T.annulata* (cattle)	256	23.1
	Tüzer (1981)	*T.mutans* (cattle)	256	14.0
	Sayın et al. (1994c)	*T.annulata* (cattle)	57	0
	Alp (1995)	*T.annulata* (cattle)	67	23.4
	Beyazıt (1997)	*T.annulata* (cattle)	102	0
Aegean	Erkut (1967)	*T.annulata* (cattle)	141	43.2
	Eren (1998)	*T.annulata* (cattle)	100	9.0
	Sayın et al. (1997b)	*T.recondita* (sheep)	96	27.0
Mediterranean	Nalbantoğlu (1996)	*T.annulata* (cattle)	75	9.3
	Sayın et al. (1994c)	*T.annulata* (cattle)	91	8.0
	Öz (1999)	*T.annulata* (cattle)	114	1.8
	Kaya et al. (2006)	*T.annulata* (cattle)	214	2.3
Central Anatolia	Göksu (1959)	*T.annulata* (cattle)	642	43.9
	Zeybek et al. (1995)	*T.annulata* (cattle)	480	5.4
	Yaman (1998)	*T.annulata* (cattle)	86	2.3
	İnci et al. (2002)	*T.annulata* (cattle)	717	59.2
	Vatansever and Nalbantoğlu (2002)	*T.annulata* (cattle)	147	31.3
	Sayın et al. (2003)	*Theileria* sp. (cattle)	198	11.1
	Vatansever et al. (2003)	*Theileria* sp. (cattle)	250	29.6
	İnci et al. (2008)	*T.annulata* (cattle)	554	60.5
	Göksu (1967)	*T.recondita* (sheep)	579	18.2
	İnci et al. (1998)	*Theileria* sp. (sheep)	128	17.9
		Theileria sp. (goat)	66	9.0
	İnci et al. (2003a)	*Theileria* sp. (sheep)	250	18.4
		Theileria sp. (goat)	50	8.0
	Sayın et al. (2009)	*T.recondita* (sheep)	620	38.5
	Sayın et al. (2009)	*T.recondita* (goat)	61	8.2
Black Sea	Mimioğlu (1956)	*T.annulata* (cattle)	70	22.8
	Göksu (1968)	*T.annulata* (cattle)	80	20.0
	Celep (1979-1981)	*T.annulata* (cattle)	95	13.0
	Celep (1979-1981)	*T.mutans* (cattle)	95	7.4
	Celep (1984)	*Theileria* sp. (cattle)	3170	5.4
	Dinçer et al. (1991)	*T.annulata* (cattle)	76	32.8
	Açıcı (1995)	*T.annulata* (cattle)	184	17.4
	Açıcı (2002)	*T.annulata* (cattle)	153	7.2
East Anatolia	Dumanlı and Özer (1987)	*T.annulata* (cattle)	261	2.3
	Dumanlı and Özer (1987)	*T.mutans* (cattle)	261	36.7
	Özer et al. (1993)	*T.annulata* (cattle)	200	32.0
	Özer et al. (1993)	*Theileria* sp. (cattle)	200	16.0
	Özer et al. (1993)	*Theileria* sp. (sheep)	100	3.0
	Özer et al. (1993)	*Theileria* sp. (goat)	100	4.0
	Sayın et al. (1994c)	*T.annulata* (cattle)	130	0
	Aktaş and Dumanlı (1999)	*T.annulata* (cattle)	120	16.6
	Aktaş et al. (2001a)	*T.annulata* (cattle)	741	5.5
	Dumanlı et al. (2005)	*Theileria* sp. (cattle)	1053	14.3
	Aktas et al. (2006a)	*Theileria* sp. (cattle)	252	16.2
	Altay et al. (2007a)	*Theileria* sp. (cattle)	123	11.3
	Altay et al. (2005)	*Theileria* spp. (sheep)	124	19.3
	Altay et al. (2007b)	*Theileria* sp.(sheep and goat)	521	14.2
	Sayın et al. (2009)	*T.recondita* (sheep)	38	18.4
Southeast Anatolia	Özer et al. (1993)	*T.annulata* (cattle)	800	27.2
	Özer et al. (1993)	*Theileria* sp. (cattle)	800	13.3
	Özer et al. (1993)	*Theileria* sp. (sheep)	400	3.2
	Özer et al. (1993)	*Theileria* sp. (goat)	400	3.2
	Dumanlı et al. (2005)	*Theileria* sp. (cattle)	430	33.0
	Altay et al. (2007b)	*Theileria* sp. (sheep and goat)	274	18.2
	Sayın et al. (2009)	*T.recondita* (sheep)	29	41.3
	Sayın et al. (2009)	*T.recondita* (goat)	28	0

*Piroplasmic forms of *Theileria* spp.

Table 2. Prevalence of antibodies to species of *Theileria* in domestic ruminant sera according to geographical areas in Turkey

Geographical region	Reference	Species of *Theileria* (Species of animal)	Test*	No.examined	Positive (%)
Marmara	Sayın et al. (1994b)	*T.annulata*	IFA	57	10.0
	Alp (1995)	*T.annulata*	IFA	67	23.4
	Eren et al. (1995)	*T.annulata*	IFA	105	33.3
	Beyazıt (1997)	*T.annulata*	IFA	102	12.7
Aegean	Eren et al. (1995)	*T.annulata*	IFA	70	40.0
	Eren et al. (1998)	*T.annulata*	IFA	100	31.0
Mediterranean	Çakmak and Öz (1993)	*T.annulata*	IFA	130	10.7
	Öz (1999)	*T.annulata*	IFA	114	1.8
	Sayın et al. (1994b)	*T.annulata*	IFA	91	14.0
	Nalbantoğlu (1996)	*T.annulata*	IFA	75	16.0
	Kaya et al. (2006)	*T.annulata*	IFA	214	11.2
Central Anatolia	Çakmak (1990)	*T.annulata*	IFA	185	6.4
	Sayın et al. (1994a)	*T.annulata*	IFA	223	22.0
	Sayın et al. (1994b)	*T.annulata*	IFA	131	34.3
	Eren et al. (1995)	*T.annulata*	IFA	100	29.0
	Zeybek et al. (1995)	*T.annulata*	IFA	480	8.1
	Yaman (1998)	*T.annulata*	IFA	86	10.4
	İnci et al. (2002)	*T.annulata*	IFA	717	60.6
	Vatansever and Nalbantoğlu (2002)	*T.annulata*	IFA	147	44.9
	Sayın et al. (2003)	*T.annulata*	IFA	198	10.6
	Vatansever et al. (2003)	*T.annulata*	IFA	250	28.0
	İnci et al. (2008)	*T.annulata*	IFA	554	67.5
	Sayın et al. (2009)	*T.recondita* (sheep)	IFA	620	63.2
	Sayın et al. (2009)	*T.recondita* (goat)	IFA	61	8.2
Black Sea	Dinçer et al. (1991)	*T.annulata*	IFA	76	63.1
	Eren et al. (1995)	*T.annulata*	IFA	79	46.8
	Açıcı (2002)	*T.annulata*	IFA	153	1.9
East Anatolia	Sayın et al. (1994b)	*T.annulata*	IFA	130	41.0
	Aktaş and Dumanlı (1999)	*T.annulata*	IFA	120	27.5
	Aktaş et al. (2001a)	*T.annulata*	IFA	741	30.9
	Dumanlı et al. (2005)	*T.annulata*	IFA	1052	21.9
	Sayın et al. (2009)	*T.recondita* (sheep)	IFA	38	44.7
Southeast Anatolia	Eren et al. (1995)	*T.annulata*	IFA	340	91.4
	Dumanlı et al. (2005)	*T.annulata*	IFA	453	65.3
	Sayın et al. (2009)	*T.recondita* (sheep)	IFA	29	17.2
	Sayın et al. (2009)	*T.recondita* (goat)	IFA	28	10.7

*IFAT: Indirect fluorescence antibody test

Table 3. The prevalence of *Theileria* infection by molecular techniques in domestic ruminants according to geograpical areas in Türkey

Geographical region	Reference	Species of *Theileria*	Technique Used*	No.examined	Positive (%)
Central Anatolia	Vatansever and Nalbantoğlu (2002)	*T.annulata*	Nested PCR	147	61.2
	Vatansever et al. (2003)	*T.annulata*	RLB	250	41.6
		T.buffeli/orientalis	RLB	250	13.6
	İnci et al. (2003b)	*T.annulata*	RLB	100	44.0
		T.buffeli/orientalis	RLB	100	12.0
	İça et al. (2007)	*T.annulata*	RLB	337	18.1
		T.buffeli/orientalis	RLB	337	0.9
East Anatolia	Dumanlı et al. (2005)	*T.annulata*	PCR	1101	29.1
	Aktas et al. (2006a)	*T.annulata*	PCR	252	39.2
		T.buffeli/orientalis	PCR	252	7.1
	Altay et al. (2007a)	*T.annulata*	RLB	123	15.4
		T.buffeli/orientalis	RLB	123	9.7
		T.annulata and *T.buffeli/orientalis*	RLB	123	2.4
	Altay et al. (2005)	*T. ovis*	Nested PCR	124	54.0
	Altay et al. (2007b)	*T. ovis*	Nested PCR	541	41.8
Southeast Anatolia	Dumanlı et al. (2005)	*T.annulata*	PCR	460	58.4
	Altay et al. (2007b)	*T. ovis*	Nested PCR	278	67.7

*PCR: Polymerase chain reaction, RLB: Reverse line blotting

Tropical theileriosis is the most important cattle disease in Turkey. Of the 10, 761,000 cattle population, 6.544.000 (60%) pure and cross breed animals are at risk of the disease (55).

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 (55,56). Total economic losses because of tropical theileriosis include three main parameters: **i).** production losses, **ii).** control costs and **iii).** other indirect economic losses. The production losses were composed of direct production losses (morbidity and mortality) and indirect production losses (39). İnci et al.(36) suggested that direct production losses due to tropical theileriosis in Kayseri province located in central Anatolia was consist of milk and meat losses caused by morbidity and mortality. According to these investigators (36), totaly milk and meat losses in imported cattle were 30%, 37% respectively. It has also been reported that the economic losses resulting from the tropical theileriosis were estimated to be 130,000 US $ in the endemic stable zone of Kayseri (36).

It has been reported that morbidity and mortality were significantly higher in the unvaccinated, semi-grazed, pure breed cattle in Cappadocia province located in central Anatolia (40). According to İnci et al. (40) out of 554 cattle, 156 (27.61%) were diagnosed with acute tropical theileriosis and 86 (56.21%) died from the disease. 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%), other losses (9.29%) and control costs (3.45%) (39). In addition to, the overall costs because of tropical theileriosis were estimated to be US $ 598, 133 for 2 years in Cappadocia provinve (39).

CONCLUSION

Theileriosis mainly caused by *T.annulata* in cattle has been extensively studied in Turkey. It is reported that the disease occurs throughout the country. However, small ruminant theileriosis has scarcely been studied and very little is known about their prevalence and distribution. Further studies are needed to obtain more information about ovine theileriosis.

T.annulata is highly prevalent and potentially a major problem in cattle in Turkey, but there is a paucity of information concerning the economic aspects of *Theileria* parasites. Thus, the role of parasite in the livestock industry in Turkey needs to be examined in greater detail.

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