

The prevalence of *Cryptosporidium* species in diarrhoeic lambs in Kars province and potential risk factors

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Abstract This study was carried out to determine the prevalence of *Cryptosporidium* species in diarrhoeic lambs and investigate some risk factors in Kars province (Northeastern region of Anatolia) in Turkey. Four hundred faecal samples were taken from the rectums of clinically diarrhoeic and aged to 1-month-old lambs from 34 sheep farms in 20 villages in March–April 2007 and examined by using the modified acid-fast staining technique. The prevalence of *Cryptosporidium* species was found as 38.8% (155/400). *Cryptosporidium* oocysts were detected in 90.0% (18/20) of villages and in 76.5% (26/34) of the sheep farms. Infection rates were detected as: 44.4% (67/151) in 1-week-old lambs, 37.5% (39/104) in 2-week-old lambs, 40.0% (38/95) in 3-week-old lambs, and 22.0% (11/50) in 4-week-old lambs. Farms classified according to their zoohygienic conditions and fine, average and bad conditioned farms were contaminated with *Cryptosporidium* with the percentages of 14.7%, 20.6% and 41.2%, respectively. Clinical cryptosporidiosis was determined in 35.0% of the villages (7/20) and in 29.4% of the sheep farms (10/34), *Cryptosporidium* oocysts were found in 81.3% of the lambs (91/112) in these farms.

Cryptosporidiosis may be a major epidemiological significance in lambs in Kars province, and suggests that naturally infected lambs may be reservoirs of Cryptosporidiosis infections for calves even for humans too.

Keywords *Cryptosporidium* · Lamb · Prevalence · Risk factor · Kars · Turkey

Introduction

Cryptosporidiosis is an acute or chronic enteric disease of young or immunosuppressed animals and humans caused by *Cryptosporidium* species in the phylum *Apicomplexa*. *Cryptosporidium* species are the important intestinal protozoans of domestic animals. Cryptosporidiosis is considered to be a serious disease of especially calves and lambs from the economic point of view (De Graaf et al. 1999; Ramirez et al. 2004; Thompson et al. 2005; Smith et al. 2007; Brook et al. 2008).

As well as causing morbidity and mortality in animals, cryptosporidiosis in lambs and calves is considered to be an infection source for humans (De Graff et al. 1999; Ramirez et al. 2004; Thompson et al. 2005; Santin et al. 2007; Smith et al. 2007; Mueller-Doblies et al. 2008).

Cryptosporidium was first seen in the gastric glands of laboratory mice by Tyzzer in 1907 and

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named as *Cryptosporidium muris*. A second species, *Cryptosporidium parvum* was named by Tyzzer in 1912 which was found in the small intestine of laboratory mice (Levine 1985; Fayer, 2004).

Cryptosporidium species are broad-spectrumed protozoans. Sixteen *Cryptosporidium* species are validated to be the cause of infection: (*C. parvum*, *C. muris*, *C. andersoni*, *C. canis*, *C. felis*, *C. suis*, *C. wairi*, *C. bovis*, *C. hominis*) in mammals, (*C. meleagridis*, *C. baileyi*, *C. galli*) in avians, (*C. serpentis*, *C. saurophilum*) in reptiles and (*C. molnari*, *C. scophthalmi*) in fish (Fayer, 2004; Ramirez et al. 2004; Ryan et al. 2005; Thompson et al. 2005; Huber et al. 2007; Smith et al. 2007).

Cryptosporidium parvum is the major species seen in humans and animals. Antroponotic *C. parvum* type I (*C. hominis*) is found in humans, and *C. parvum* type II (*C. bovis*) is found in humans and animals (especially ruminants) zoonotically. *C. parvum* type II causes infection in lambs and it is possible to infect lambs with *C. parvum* type I experimentally (Ebeid et al. 2003; Fayer, 2004; Ramirez et al. 2004; Goma et al. 2007). Additionally it is reported that different genotypes of *Cryptosporidium* agents are found in lambs like *C. suis*, *C. andersoni*, *C. bovis* like genotype, *C. parvum* deer genotype, pig genotype and marsupial genotype (Ryan et al. 2005; Navarro-i-Martinez et al. 2007; Santin et al. 2007).

In sheep, cryptosporidiosis was first described in Australia in 1 to 3-week-old lambs with diarrhoea in 1974 (Barker and Carbonell 1974). However, by the early 1980s its role as a primary aetiological agent of diarrhoea in lambs was approved in studies on experimental and natural infections (Angus et al. 1982). Thereafter, the infection has been reported from different geographical areas; America, Canada, Iran, Trinidad Tobago, Spain, and Italy, with the prevalence varying from 4% to 85% (De Graaf et al. 1999).

Infection causes mild to severe diarrhoea in lambs 5 to 12-day-old, characterized by depression, anorexia, weight loss and the shedding of a large number of oocysts (Angus et al. 1982; Thompson et al. 2005). Clinical course of the disease in lambs is similar in calves, and the development period of the agent is 3–4 days. Disease may be seen in 2-day-old lambs rarely but there are some reports about this case. Outbreaks are usually seen in 7 to 10-day-old lambs with symptoms continuing maximum two weeks. Intermittent diarrhoea and constipation are the frequent symptoms and it was reported that the

infection in lambs is accompanied by the agents like; ETEC-K99, rotavirus, *Giardia* sp. and *Salmonella* (Dubey et al. 1990; Thompson et al. 2005; Ozmen et al. 2006). Mortality, which is usually low, increases with the accompaniment of concurrent infections or deficiencies in nutrition and husbandry (De Graaf et al. 1999; Thompson et al. 2005).

In Turkey, Ozer et al. (1990) conducted the first study about cryptosporidiosis in lambs in Elazığ province, and reported the prevalence 12% in diarrhoeic lambs. Subsequent studies with *Cryptosporidium* oocysts have reported a prevalence of: 23.3% in diarrhoeic lambs and 2% in lambs without diarrhoea in Izmir (Erman et al. 2000), 2% (Handemir et al. 1999) and 2.97% (Sevinc et al. 2005) in Konya, 79.1% in diarrhoeic lambs and 18.2% in lambs without diarrhoea in Aydın (Ulutas and Voyvoda 2004).

Risk factors like such as: farm management, size of herd, farm type and hygiene, bedding type, colostrum nourishment, season, diarrhoea, age and contamination sources (e.g. water) play role in the spread of *Cryptosporidium* sp. in domestic animals (Maldonado-Camargo et al. 1998; Ortega-Mora et al. 1999; Causape et al. 2002; Delafosse et al. 2006; Brook et al. 2008; El-Khodery and Osman 2008).

In this study, it was aimed to determine the spread of *Cryptosporidium* sp. in diarrhoeic lambs in Kars province (one of the important stockbreeding center of Turkey), and to determine some potential risk factors (diarrhoea, age, size of herd, farm hygiene) associated with the spread of this protozoa.

Materials and methods

Study area

Kars is at an altitude of approximately 1,800 meters. The climate in Kars province is cold continental with the annual average temperature about 6 °C and roughly –10 °C average in January and +18 °C in July. The area gets regular rainfall from March through November. In the other months of the year it gets heavy snowfall. The province is the major animal (mainly cattle) breeding area of the country and is relatively underdeveloped when compared to the other parts of the country. In Kars province, 46% of farm animals are sheep. The sheep population in Turkey is estimated to be at 23 millions and farmers

have 296,000 sheep in the province of Kars according to the official records of 2005.

Sampling procedure

Thirty four sheep farms (fold) were visited in the lambing season, between March and April in 2007 at 20 villages in Kars city located in the northeastern Turkey where sheep raising is intensive. Farms were deliberately chosen from villages those are located by the Kars stream and close creek bank beginning from west to the east border of the city (Fig. 1). Stool samples were taken from the recti of 400 clinically diarrhoeic and aged to one month old lambs. The zoohygienic conditions of the sheep farms were classified as; **bad** (Sheep and lambs are all together, no lamb fold, bad hygienic condition), **average** (Sheep and lambs are in the same fold in short periods of time, lamb fold exists and average hygienic condition) and **fine** (Sheep and lambs are in separated and different folds and good hygienic condition).

Collection of data

Informations about breeding conditions, farm management and hygienic factors were collected and recorded for every farm. Size of herd, number of lambs, hygienic conditions of the farms and the age of diarrhoeic lambs were analyzed as potential risk factors.

Detection of *Cryptosporidium* sp.

Freshly obtained stool samples were centrifugated and smears of 20 μ l of the sediment were dried and stained by modified acid-fast technique. In care of fatty

nutrition, faecal specimens were processed with ether. Prepared slides were screened at 40X magnifications, the average numbers of oocysts in 10 different fields were scored as: “+” if the number of oocyst was < 1, “++” for 1–10 oocysts, “+++” for 11–25 oocysts and “++++” if the number of oocysts were > 25. Infection intensity was evaluated as: mild (+ and ++), average (+++) and severe (++++) (Ok et al. 1997; Castro-Hermida et al. 2002).

Statistical analysis

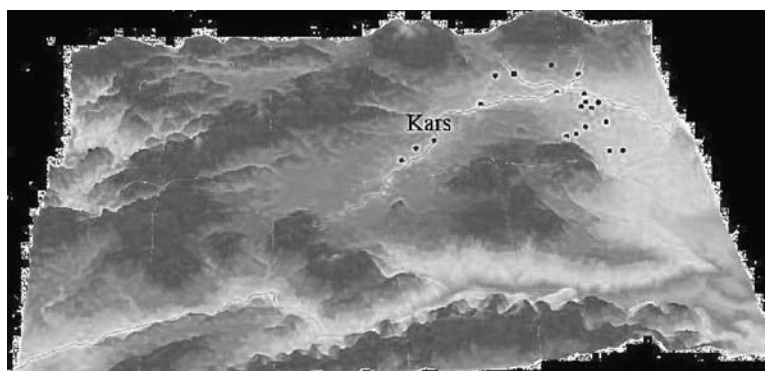
The results from each examined group of animals were analysed by Chi-square test. A value of $P < 0.05$, $P < 0.001$ were required for statistical significance.

Results

The prevalence of *Cryptosporidium* in diarrhoeic lambs in Kars province was found as 38.8% (155/400). In this study it was found that 18 of 20 villages (90.0%) and 26 of 34 sheep farms (76.5%) were infected with *Cryptosporidium* species (Fig. 2).

The prevalence of the infection according to age groups is shown in Table 1. According to age groups, oocyst excretion was found pretty much higher in ≤ 7 -day-old age groups and with lower rates in > 21 -day-old age groups in diarrhoeic lambs infected with *Cryptosporidium* sp. Differences among the ++ oocyst intensity and all age groups were found statistically significant ($P < 0.05$). The prevalence of the infection according to age groups was: 67 (44.4%), 39 (37.5%), 38 (40%) and 11 (22.0%) by MAFT (modified acid-fast technique), in the age groups of ≤ 7 , 8–14, 15–21 and > 21 day, respectively. The highest rate of

Fig. 1 Villages of samples obtained in Kars province



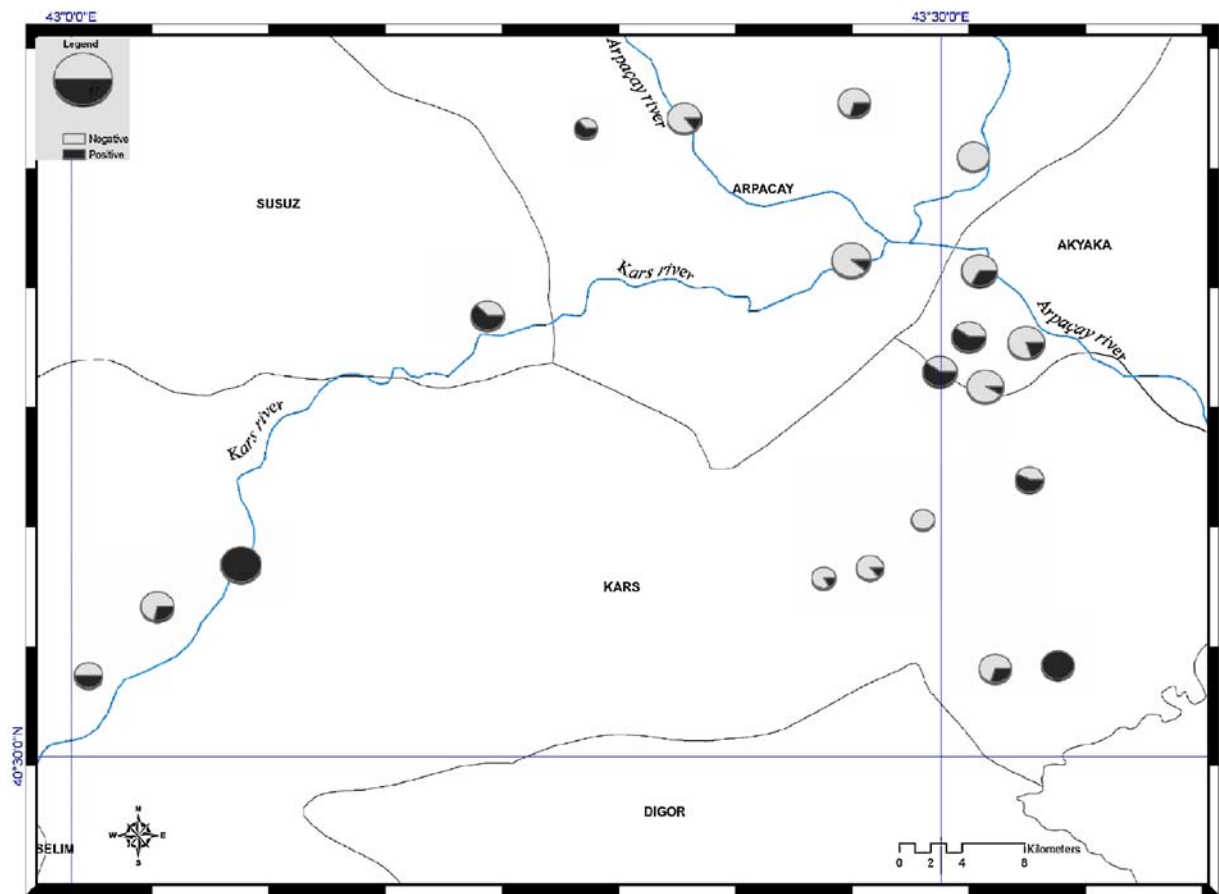


Fig. 2 The distribution of the *Cryptosporidium* infections in diarrhoeic lambs according to localization

Cryptosporidium infection in lambs was the age group of ≤ 7 -day-old age group (Table 1).

The number of infected lambs were found as; +: 42 (%27.1), ++: 48 (%31.0), +++: 29 (%18.7) and ++++: 36 (%23.2) with regard to the intensity of fecal *Cryptosporidium* oocysts. Of the infected lambs,

58.1% had mild infection, 18.7% had average infection and 23.2% had severe infection with a statistical significance (Table 2).

The prevalence of the infection ascended with the increase of the size of the herd and deterioration of the hygienic conditions according to Table 3. But

Table 1 The prevalence of *Cryptosporidium* species and intensity of oocyst excretion in the diarrhoeic lambs according to age groups (%)

Age Group (days)	x/n	Intensity of oocyst excretion			
		+	++	+++	++++
≤ 7	67/151 (44.4) ^a	18 (42.9)	20 (41.7) ^{ab}	14 (48.3)	15 (41.7)
8–14	39/104 (37.5) ^{ab}	9 (21.4)	19 (39.6) ^a	5 (17.2)	6 (16.7)
15–21	38/95 (40.0) ^a	13 (31.0)	7 (14.6) ^b	7 (24.1)	11 (30.6)
>21	11/50 (22.0) ^b	2 (4.8)	2 (4.2) ^{ab}	3 (10.4)	4 (11.1)
Total	155/400	42	48	29	36
P value	P=0.045	P=0.629	P=0.024	P=0.652	P=0.371

^{abc} The differences between the groups at the same column marked with different letters are statistically significant.

x/n: number of infested animal/number of examined animals

Table 2 The intensity of the oocyst and infection in the diarrhoeic lambs infected with *Cryptosporidium* species

Infection intensity	Oocyst intensity	Number of Lambs Infected	% (n=155)	% (n=155)	P value
Mild	+ (<1 oocysts)	42	27.1	58.1 ^a	P=0.000
	++ (1–10 oocysts)	48	31.0		
Average	+++ (11–25 oocysts)	29	18.7	18.7 ^b	P=0.000
Severe	++++ (>25 oocysts)	36	23.2	23.2 ^b	P=0.329

^{ab} The differences between the groups at the same column marked with different letters are statistically significant.

differences among the infection with *Cryptosporidium*, the number of lambs in the farm and the hygienic condition of farm were not found to be statistically significant ($P > 0.05$).

In bad hygienic conditioned sheep farms, oocyst shedding and intensity of the infection was increased (Table 4), and the differences among them were found very significant from the statistical analysis ($P < 0.001$).

During the study, clinical cryptosporidiosis was detected in 35% of the villages and 29.4% of the farms. Ninety one of the 112 samples (81.3%) were found positive. Average and severe infections were seen in 49.5% of lambs due to clinical cryptosporidiosis. According to the field observations, drinking water in the sheep folds and fodder storages are thought to be the contamination source (Tables 5, 6).

Discussion

The results of this study confirm that cryptosporidial infection is widespread in sheep in Kars and *Cryptosporidium sp.* should be considered as one of the major agents in the aetiology of neonatal diarrhoea in lambs.

Studies carried out in different parts of the world about the spread of *Cryptosporidium sp.* in sheep and

lambs have reported a prevalence of 17.2% in sheep in Iran (Nouri and Karami 1991), in rates varying from 14.7% to 45% in diarrhoeic lambs in Spain (Matos-Fernandez et al. 1993; Munoz et al. 1996). Again lately studies in Spain have recorded prevalence rates as 59% in sheep and 84.4% in farms (Causape et al. 2002). According to another study carried out in Australia, Ryan et al. (2005) have reported a prevalence of 2.6% with microscobic tests and 26.2% with PCR. Cryptosporidial infection rates in lambs from other studies were as follows: 12.5% in Zambia (Goma et al. 2007), 3.7% in Brazil (Tembue et al. 2006), 10.1% in Poland (Majewska et al. 2000), 42.1% in Serbia (Misic et al. 2006), 11.2% in Tunisia (Soltane et al. 2007) and 23% in Canada (Olson et al. 1997). Santin et al. (2007) reported 77.4% prevalence of *Cryptosporidium* oocysts in lambs by PCR in America. From these researches it is understood that cryptosporidial infections in lambs are widespread in world including Turkey. It is very important to take into consideration of the zoonotic character of cryptosporidial infections from the point of public health and possible outbreaks of the disease.

Studies in the different geographic locations and climatic zones of Turkey reported the prevalence of *Cryptosporidium* agents in diarrhoeic lambs as follows: 12% in Elazığ (Ozer et al. 1990), 23.3% in Izmir (Erman et al. 2000), 2% (Handemir et al. 1999) and

Table 3 The prevalence of *Cryptosporidium* species in farms according to the size of herd and hygienic condition

		Number of Farms	Number of Farms Infected With <i>Cryptosporidium</i>	Infection Rate (%) n=34	P Value
The Size of Herd (Sheep + Lamb)	<100	5	4	11.8	P=0.735
	100–250	13	9	26.5	
	>250	16	13	38.2	
Hygienic condition	Fine	9	5	14.7	P=0.194
	Average	9	7	20.6	
	Bad	16	14	41.2	

Table 4 The distribution of the intensity of oocyst excretion and the number of diarrhoeic lambs infected with *Cryptosporidium* according to the hygienic condition of the sheep farms (%)

Hygienic condition	x/n (%)	Intensity of Oocyst Excretion			
		+	++	+++	++++
Fine	12/116 (10.3) ^c	4 (9.5)	2 (4.2)	4 (13.8)	2 (5.6)
Average	34/113 (30.1) ^b	12 (28.6)	11 (22.9)	5 (17.2)	6 (16.7)
Bad	109/171 (63.7) ^a	26 (61.9)	35 (72.9)	20 (69.0)	28 (77.8)
Total	155/400	42	48	29	36
P Value	P=0.000	P=0.373	P=0.537	P=0.358	P=0.534

^{abc} The differences between the groups at the same column marked with different letters are statistically significant.

x/n: number of infested animal/number of examined animals

2.97% (Sevinc et al. 2005) in Konya, 79.1% in Aydin (Ulutas and Voyvoda 2004). In this study the infection rate was found as 38.8%. Differences between the results of the studies are probably due to the age of lambs, the number of collected material and diarrhoeic animals.

This research is the first study of cryptosporidial infection in lambs in Kars province and one out of the three diarrhoeic lambs were found to be infected. Early studies in the same province reported 25.7% and 32.9% infection rates in calves (Arslan et al. 2001, 2003), which are similar to the prevalence in lambs in this study.

Age is the major risk factor in the spread of cryptosporidiosis (Causape et al. 2002; Ryan et al. 2005; El-Khodery and Osman 2008; Mueller-Doblies et al. 2008). Disease is seen prevalently in overcrowded farms, especially it is clinically important in the lambs to 1-month-old. Moreover cryptosporidiosis oocysts are mostly seen at the age of 1 to 3-week-old, the incidence decreases when animals get older. In this study the infection rate in 1 to 3-week-old lambs was found pretty much higher (37.5–44.0%), >21 day-old lambs were infected by the rate of 22%.

Cryptosporidiosis is reported to cause serious problems in young livestock like calves, buffalo calves, lambs and goat kids. Risk factors-the size of

the herd, breeding type, hygienic condition, birth time and weaning- were reported to be effective on the spread of *Cryptosporidium* oocysts (Ortega-Mora et al. 1999; Castro-Hermida et al. 2002, Causape et al. 2002; Fayer 2004; Ryan et al. 2005; Delafosse et al., 2006; El-Khodery and Osman 2008). Once again, our study revealed that the herd size and hygienic condition of the sheep farms are the most important risk factors. The correlation among the hygienic conditions and oocyst shedding was found statistically important ($p < 0.001$, Table 4).

Researchers reported that, cryptosporidial oocyst excretion peaks in the period 5 to 25-day-old lambs, calves and goat kids (Maldonado-Camargo et al. 1998; De Graaf et al. 1999; Castro-Hermida et al. 2002; Causape et al. 2002; Delafosse et al. 2006; Brook et al. 2008). In our observations, it was remarkable that the infections from mild to severe were found at high percentages in the ≤ 7 day-old age group and at low percentages in the > 21 day-old age group. Adult sheep being an asymptomatic carrier was shown to increase oocyst excretion in cryptosporidial infections between lambing periods (Xiao et al. 1994; Ortega-Mora et al. 1999). In the current study, oocyst excretion rose with the increase in the number of animals and deterioration of the hygienic conditions of sheep farms.

Table 5 The distribution of clinical cryptosporidial cases in diarrhoeic lambs (%)

Clinical cryptosporidiosis	x/Location	x/Number of farms	Number of infected animal/ Number of samples examined	Possible source of contamination
Observed	7/20 (35.0)	10/34 (29.4)	91/112 (81.3)	Drinking water
Not observed	13/20 (65.0)	24/34 (70.6)	64/288 (22.2)	–

Table 6 Oocyst and infection intensity in lambs due to the clinical cryptosporidiosis

Infection intensity	Oocyst intensity	Number of infected lambs	Infection Rate % (n=91)	Infection Rate % (n=91)	P Value
Mild	+ (<1 oocyst)	17	18.7	50.5 ^a	P=0.000
	++ (1–10 oocysts)	29	31.9		
Average	+++ (11–25 oocysts)	19	20.9	18.7 ^{bc}	P=0.002
Severe	++++ (>25 oocysts)	26	28.6	23.2 ^c	P=0.229

^{abc} The differences between the groups at the same column marked with different letters are statistically significant.

Clinical cryptosporidiosis cases have been seen in domestic animals especially in calves and lambs (Arslan et al. 2003; Ulutas and Voyvoda 2004; Sahal et al. 2005; Navarro-i-Martinez et al. 2007; Mueller-Doblies et al. 2008). In our study clinical cryptosporidiosis was determined in 10 farms in 7 different locations in Kars province of a pretty much higher infection rate (81.3%) from average to severe infections.

As a conclusion the prevalence of *Cryptosporidium* in diarrhoeic lambs was found as 38.8% in Kars. In this province clinical cryptosporidiosis cases are existing and the area is contaminated with *Cryptosporidium* sp. However it is needed to make molecular studies to specify the *Cryptosporidium* sp. and to identify agent genotypes at the source of contaminations.

References

- Angus, K.W., Appleyard, W.T., Menzies, J.D., Campbell, I. & Sherwood, D. 1982. An outbreak of diarrhoea associated with cryptosporidiosis in naturally reared lambs. *Veterinary Record*, **110**, 129–130
- Arslan, M.O., Gicik, Y., Erdogan, H.M. & Sari, B. 2001. Prevalence of *Cryptosporidium* spp. oocysts in diarrhoeic calves in Kars Province, Turkey. *Turkish Journal of Veterinary and Animal Science*, **25**, 161–164
- Arslan, M.O., Erdogan, H.M. & Tanriverdi, S. 2003. Neonatal buzagilarda cryptosporidiosis'in epidemiyolojisi. 13. Ulusal Parazitoloji Kongresi Program ve Ozet Kitabı, SB 6–01, 186 pp, Konya
- Barker I.K. & Carbonell P.L. 1974. *Cryptosporidium agni* sp. n. from lambs, and *Cryptosporidium bovis* sp. n. from a calf, with observations on the oocyst. *Parasitology Research*, **44(4)**, 289–298 doi:10.1007/BF00366112
- Brook, E., Hart, C.A., French, N. & Christley, R. 2008. Prevalence and risk factors for *Cryptosporidium* spp. infection in young calves. *Veterinary Parasitology*, **152**, 46–52 doi:10.1016/j.vetpar.2007.12.003
- Castro-Hermida, J.A., Gonzales-Losada, Y.A. & Ares-Mazas, E. 2002. Prevalence of and risk factors involved in the spread of neonatal bovine cryptosporidiosis in Galicia (NW Spain). *Veterinary Parasitology*, **106**, 1–10 doi:10.1016/S0304-4017(02)00036-5
- Causape, A.C., Quilez, J., Sanchez-Acedo, C., Del Cacho, E. & Lopez-Bernad F. 2002. Prevalence and analysis of potential risk factors for *Cryptosporidium parvum* infection in lambs in Zaragoza (Northeastern Spain). *Veterinary Parasitology*, **104**, 287–298 doi:10.1016/S0304-4017(01)00639-2
- De Graaf, D.C., Vanopdenbosch, E., Ortega-Mora, L.M., Abbasi, H. & Peeters J.E. 1999. A review of the importance of cryptosporidiosis in farm animals. *International Journal for Parasitology*, **29**, 1269–1287 doi:10.1016/S0020-7519(99)00076-4
- Delafosse, A., Castro-Hermida, J.A., Baudry, C., Ares-Mazas, E. & Chartier C. 2006. Herd-level risk factors for *Cryptosporidium* infection in dairy-goat kids in western France. *Preventive Veterinary Medicine*, **77**, 109–121 doi:10.1016/j.prevetmed.2006.07.001
- Dubey, J.P., Speer, C.A. & Fayer R. 1990. *Cryptosporidiosis of Man and Animals*. CRC Press, Boca Raton, Florida
- Ebeid, M., Mathis, A., Pospischil, A. & Deplazes, P. 2003. Infectivity of *Cryptosporidium parvum* genotype I in conventionally reared piglets and lambs. *Parasitology Research*, **90(3)**, 232–235.
- El-Khodery, S.A. & Osman, S.A. 2008. Cryptosporidiosis in buffalo calves (*Bubalus bubalis*): Prevalence and potential risk factors. *Tropical Animal and Health Production*, **40(6)**, 419–426 doi:10.1007/s11250-007-9113-2
- Erman, N., Beyazit, A. & Oz I. 2000. Prevalence of cryptosporidiosis in lambs and goat kids in Izmir province. *Bornova Veteriner Kontrol Arastirma Enstitusu Mudurlugu Dergisi*, **25**, 33–38
- Fayer, R. 2004. *Cryptosporidium*: a water-borne zoonotic parasite. *Veterinary Parasitology*, **126**, 37–56 doi:10.1016/j.vetpar.2004.09.004
- Goma, F.Y., Geurden, T., Siwila, J., Phiri, I.G.K., Gabriel, S., Claerebout, E. & Vercruyse J 2007. The prevalence and molecular characterisation of *Cryptosporidium* spp. in small ruminants in Zambia. *Small Ruminant Research*, **72**, 77–80 doi:10.1016/j.smallrumres.2006.08.010
- Handemir, E., Gozun, H. & Kamburgil, K. 1999. Konya Bolgesi koyunlarinda cryptosporidiosis. *Turkiye Parazitoloji Dergisi*, **23(3)**, 312–316
- Huber, F., Da Silva, S., Bomfim, T.C.B., Teixeira, K.R.S. & Bello, A.R. 2007. Genotypic characterization and phylogenetic analysis of *Cryptosporidium* sp. from domestic animals in Brazil. *Veterinary Parasitology*, **150**, 65–74 doi:10.1016/j.vetpar.2007.08.018
- Levine, N.D. 1985. *Veterinary Protozoology*. First edition. Iowa State Univ Pres Ames

- Majewska, A.C., Werner, A., Sulima, P. & Luty, T. 2000. Prevalence of *Cryptosporidium* in sheep and goats bred on five farms in westcentral region of Poland. *Veterinary Parasitology*, **89**, 269–275 doi:10.1016/S0304-4017(00)00212-0
- Maldonado-Camargo, S., Atwill, E.R., Saltijeral-Oaxaca, J.A. & Herrera-Alonso, L.C. 1998. Prevalence of and risk factors for shedding of *Cryptosporidium parvum* in Holstein Friesian dairy calves in central Mexico. *Preventive Veterinary Medicine*, **36**, 95–107 doi:10.1016/S0167-5877(98)00084-1
- Matos-Fernandez, M.J., Pereira-Bueno, J., Ortega-Mora, L.M., Pilar-Izquierdo, M., Fere, I. & Roje-Vazquez, F.A. 1993. Prevalencia de la infección por *Cryptosporidium parvum* en corderos, cabritos y terneros en la provincia de Leon. *Acta Parasitologica*, **1**, 211
- Misic, Z., Katic-Radojevic, S. & Kulisic, Z. 2006. *Cryptosporidium* infection in lambs and goat kids in Serbia. *Acta Veterinaria Beograd*, **56(1)**, 49–54 doi:10.2298/AVB0601049M
- Mueller-Doblies, D., Giles, M., Elwin, K., Smith, R.P., Clifton-Hadley, F.A. & Chalmers, R.M. 2008. Distribution of *Cryptosporidium* species in sheep in the UK. *Veterinary Parasitology*, **154**, 214–219. doi:10.1016/j.vetpar.2008.03.021
- Munoz, M., Alvarez, M., Lanza, I. & Carmenes, P. 1996. Role of enteric pathogens in the aetiology of neonatal diarrhoea in lambs and goat kids in Spain. *Epidemiology Infection*, **117**, 203–211
- Navarro-i-Martinez, L., da Silva, A.J., Bornay-Llinares, F.J., Moura, I.N.S., del Aguila, C., Oleaga, A. & Pieniazek, N. J. 2007. Detection and molecular characterization of *Cryptosporidium bovis*-like isolate from a newborn lamb in Spain. *Journal of Parasitology*, **93(6)**, 1536–1538 doi:10.1645/GE-1116.1
- Nouri, M. & Karami, M. 1991. Asymptomatic cryptosporidiosis in nomadic shepherds and their sheep. *Journal of Infection*, **23(3)**, 331–333 doi:10.1016/0163-4453(91)93260-J
- Ok, U.Z., Girginkardesler, N., Kilimcioglu, A. & Limoncu, E. 1997. Diski inceleme yontemleri. Ozcel, M.A. and Altintas, N. (Editors). *Parazit Hastaliklarinda Tani. T Parazitol Dern Yay*, Bornova-Izmir, Ege Universitesi Basimevi, 1-61 pp
- Olson, M.E., Thorlakson, C.L., Deselliers, L., Morck, D.W. & McAllister, T.A. 1997. *Giardia* and *Cryptosporidium* in Canadian farm animals. *Veterinary Parasitology*, **68**, 375–381 doi:10.1016/S0304-4017(96)01072-2
- Ortega-Mora, L.M., Requejo-Fernandez, J.A., Pilar-Izquierdo, M. & Pereira-Bueno J 1999. Role of adult sheep in transmission of infection by *Cryptosporidium parvum* to lambs: confirmation of periparturient rise. *International Journal for Parasitology*, **29**, 1261–1268 doi:10.1016/S0020-7519(99)00077-6
- Ozer, E., Erdogmus, S.Z. & Koroglu, E. 1990. Investigation on the incidence of Cryptosporidia of calves and lambs in Elazig vicinity. *Turkish Journal of Veterinary and Animal Science*, **14**, 439–445
- Ozmen, O., Yukari, B.A., Haligur, M. & Sahinduran, S. 2006. Observations and immunohistochemical detection of Coronavirus, *Cryptosporidium parvum* and *Giardia intestinalis* in neonatal diarrhoea in lambs and kids. *Schweizer Archiv fur Tierheilkunde*, **148(7)**, 357–364 doi:10.1024/0036-7281.148.7.357
- Ramirez, N.E., Ward, L.A. & Sreevatsan, S. 2004. A review of the biology and epidemiology of cryptosporidiosis in humans and animals. *Microbes and Infection*, **6**, 773–785 doi:10.1016/j.micinf.2004.02.021
- Ryan, U.M., Bath, C., Robertson, I., Read, C., Eliot, A., McInnes, L., Traub, R. & Besier B. 2005. Sheep may not be an important zoonotic reservoir for *Cryptosporidium* and *Giardia* parasites. *Applied and Environmental Microbiology*, **71(9)**, 4992–4997 doi:10.1128/AEM.71.9.4992-4997.2005
- Sahal, M., Karaer, Z., Yasa Duru, S., Cizmeci, S. & Tanyel, B. 2005. Cryptosporidiosis in newborn calves in Ankara region: clinical, haematological findings and treatment with Lasalocid-NA. *Deutsche Tierarztliche Wochenschrift*, **112(6)**, 203–208
- Santin, M., Trout, J.M. & Fayer, R. 2007. Prevalence and molecular characterization of *Cryptosporidium* and *Giardia* species and genotypes in sheep in Maryland. *Veterinary Parasitology*, **146**, 17–24 doi:10.1016/j.vetpar.2007.01.010
- Sevinc, F., Uslu, U. & Derinbay, O. 2005. The Prevalence of *Cryptosporidium parvum* in lambs around Konya. *Turkish Journal of Veterinary and Animal Science*, **29**, 1191–1194
- Smith, H.V., Caccio, S.M., Cook, N., Nichols, R.A.B. & Tait, A. 2007. *Cryptosporidium* and *Giardia* as foodborne zoonoses. *Veterinary Parasitology*, **149**, 29–40. doi:10.1016/j.vetpar.2007.07.015
- Soltane, R., Guyot, K., Dei-Cas, E. & Ayadi, A. 2007. Prevalence of *Cryptosporidium* spp. (Eucoccidiorida: Cryptosporiidae) in seven species of farm animals in Tunisia. *Parasite*, **14(4)**, 335–338
- Tembue, A.A.M., Alves, L.C., Borges, J.C.G., Faustino, M.A. da G. & Machado, E.L.deC. 2006. *Cryptosporidium* spp. in sheep in Ibimirim District, Pernambuco State, Brazil. *Ciencia Veterinaria nos Tropicis*, **9(1)**, 41–43
- Thompson, R.C.A., Olson, M.E., Zhu, G., Enomoto, S., Abrahamsen, M.S. & Hijawi, N.S. 2005. *Cryptosporidium* and Cryptosporidiosis. *Advances in Parasitology*, **59**, 77–158 doi:10.1016/S0065-308X(05)59002-X
- Ulutas, B. & Voyvoda, H. 2004. Cryptosporidiosis in diarrhoeic lambs on a sheep farm. *Turkiye Parazitoloji Dergisi*, **28(1)**, 15–17
- Xiao, L., Herd, R.P. & McClure, K.E. 1994. Periparturient rise in the excretion of *Giardia* sp. cysts and *Cryptosporidium parvum* oocysts as a source of infection for lambs. *Journal of Parasitology*, **80**, 55–59. doi:10.2307/3283345