


Intestinal Parasites of Red Foxes (*Vulpes vulpes*) and Their Zoonotic Importance for Humans in Kars Province

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Summary

During 2004-2007, 20 carcasses of red foxes, found dead mainly due to road accidents in Kars province of Turkey, were collected and examined helminthologically. Fifteen of (75%) 20 necropsied foxes were infected with various helminth species. According to the results of intestinal wash examinations, the helminth community of the red fox in the necropsy is composed of 10 helminths and 1 arthropod species. The recovered species were *Alaria alata* (30%), *Mesocostoides lineatus* (60%), *Taenia multiceps* (10%), *T. pisiformis* (10%), *T. taenuiformis* (5%), *Taenia* spp. (10%), *Echinococcus granulosus* (5%), *Toxascaris leonina* (65%), *Toxocara canis* (20%), *Capillaria* spp. (5%) and *Linguatula serrata* (40%). This article appears to be the first report of the presence of both the adults and nymphs of *Linguatula serrata* in the intestines of fox. According to the results of fecal examinations, helminth eggs were found in 13 of 20 (65%) fox fecal samples. Revealed helminth species were as follows; *Mesocostoides lineatus* (55%), *Toxascaris leonina* (40%), *Alaria alata* (30%), *Toxocara canis* (15%), *Capillaria* spp. (15%), *Taenia* spp. (15%).

Keywords: Fox, Helminth, *Linguatula serrata*, Kars, Turkey

Kars İlinde Kırmızı Tilkilerde Bağırsak Parazitleri ve İnsanlar için Zoonotik Önemleri

Özet

Kars ve çevresindeki yollarda, 2004-2007 yılları arasında kaza sonucu ölmüş 20 tilkinin helmintolojik muayeneleri gerçekleştirilmiştir. Nekropsileri yapılan 20 tilkinin 15 (%75)'i çeşitli helmint türleri ile değişik şiddetlerde enfekte bulunmuştur. Nekropsi yapılmış kırmızı tilkilerde helmintlerin tespiti için bağırsak içerikleri incelendiğinde 10 helmint ile 1 artropod türü görülmüştür. Tespit edilen türler *Alaria alata* (%30), *Mesocostoides lineatus* (%60), *Taenia multiceps* (%10), *T. pisiformis* (%10), *T. taenuiformis* (%5), *Taenia* spp. (%10), *Echinococcus granulosus* (%5), *Toxascaris leonina* (%65), *Toxocara canis* (%20), *Capillaria* spp. (%5) ve *Linguatula serrata*'dan (%40) oluşmaktadır. Bu makale tilki bağırsaklarında *Linguatula serrata*'nın hem larvalarının hem de erişkinlerinin bildirildiği ilk vaka olması özelliği taşımaktadır. Dışkının muayenesi ile de, 20 tilkinin 13 (65%) ünde çeşitli helmint yumurtalarına rastlanmış olup, 11 örnekte *Mesocostoides lineatus* (55%), 9 örnekte *Toxascaris leonina* (45%), 6 örnekte *Alaria alata* (30%), 3 örnekte *Toxocara canis* (15%), 3 örnekte *Capillaria* spp. (%15) ve 3 örnekte de *Taenia* spp. (%15) yumurtası teşhis edilmiştir.

Anahtar sözcükler: Tilki, Helminth, *Linguatula serrata*, Kars, Türkiye



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INTRODUCTION

Foxes have importance for carrying some parasites whose larvae can infect both human and domestic animals. Therefore, presence of foxes and their roles in zoonotic infections in rural and urban areas in western world have been well documented¹⁻¹⁰. Unfortunately in Turkey, very few epidemiologic studies were conducted on foxes^{1,11}. Merdivenci¹¹⁻¹³ reported first time the parasitic records from foxes in Turkey. According to his reports, *Mesocostoides lineatus*, *Echinococcus* spp., *Dipylidium caninum*, *Toxocara canis*, *Toxascaris leonina*, *Uncinaria stenocephala*, *Trichuris vulpis*, *Capillaria aerophila*, *C. plica*, *Taenia crassiceps*, *T. hydatigena*, *T. psiformis*, *Thominx aerophila*, and *Crenosoma vulpis* were the recovered and identified parasites from the foxes.

The more detailed study was performed by Mimioğlu et al.¹ in Ankara province, where *Alaria alata* (1.9%), *Joyeuxiella echinorhynchoides* (1.9%), *Mesocostoides lineatus* (78.4%), *Taenia polyacantha* (13.6%), *Capillaria aerophila* (19.6%), *C. linearis* (3.9%), *C. plica* (5.8%), *Pyhsaloptera rara* (%7.8), *Rectularia cahirensis* (27.4%), *Spirocerca lupi* (27.4%), *Toxocara canis* (35.2%), *Toxascaris leonina* (11.1%), *Uncinaria stenocephala* (5.8%), and *Macracanthorhynchus huridinaeus* (43.1%) were found in 51 examined foxes.

Burgu and Guclu¹⁴ carried out necropsies in a mink and fox farm in Ankara, and they identified *Heterophyes heterophyes*, *H. dispar*, *Phagicola longa*, and *Sticodora sawakinesis*. Ayaz et al.⁴ necropsied a fox in Van province and reported *M. lineatus*, and its' larvae (tetratridium), *T. leonina*, and *C. vulpis*.

Foxes live in all around the world in different climates in even in the North Pole. Interestingly *Echinococcus* spp., *Toxocara* spp., and *D. caninum* etc. were very common in high percentages in foxes in different regions and climates of the world including Turkey, and the fox parasites have vital zoonotic importance for both human and domestic animals^{5-7,9,15-18}. The present study describes the prevalence and the helminth parasite community of the red foxes and partly potential risk factors for humans in Kars, Turkey.

MATERIAL and METHODS

• Materials

Foxes mostly hit by cars were collected and brought to the Parasitology Laboratory of our school by farmers and drivers from 2004 through 2007. The numbers of foxes were 20, and 9 of them were males and 11 of them were females.

• Examination of the animals

Individual data for each fox as regards of killing site, date of the death, sex, and age was recorded. For safety precautions against parasitic diseases such as cystic echinococcosis, all carcasses were frozen at -20°C at least for 3 weeks before the gastrointestinal tract was examined as previously described^{7,10,19,20}.

Frozen animals were thawed overnight and complete parasitological necropsies were performed on a sub sample of 20 carcasses. Body parts were systematically checked for helminthes. Trachea, lung, heart, digestive tract, liver, gallbladder, renal pelvis and urinary bladder were examined by routine techniques²¹. The intestines were opened up along their entire lengths and repeatedly washed with tap water to collect all the contents which afterwards were examined under a stereomicroscope. Not to overlook small helminthes such as *Echinococcus* spp., some trematods, and *Capillaria* spp., the intestinal mucosae were removed carefully by vigorous rubbing. All the material obtained were diluted and transferred to Petri dishes to be examined in the dissection microscope and recovered parasites stored in 70% alcohol containing 5% glycerin for identification.

During necropsies, fecal samples extruded from the recti of 20 carcasses were examined for helminth eggs by using saturated ZnSO₄ flotation. Identifications for both helminthes and their eggs were based on the descriptions of Ryan², Thienpont et al.²², Skirnisson et al.¹⁷, Willingham et al.³, Papadopoulos et al.²³, Gortazar et al.²⁴, Wolfe et al.⁵, Vervaeke et al.²⁰, Dalimi et al.⁸ and Saeed et al.¹⁰.

RESULTS

Of 20 foxes, 15 (%75) were infected with one or more intestinal helminth species. In total, ten helminth species were identified, including one trematoda species, six cestoda species and three nematode species (Table 1). The following parasite

taxa were found; trematoda *Alaria alata* (%30 of foxes); cestodes *M. lineatus* (%60), *T. multiceps* (10%), *T. pisiformis* (10%), *T. taeniaformis* (5%), *Taenia* spp. (10%), *E. granulosus* (5%), and nematodes *T. leonina* (65%), *T. canis* (20%), and *Capillaria* spp. (5%). The percentage of parasites was 72.7% in males, and 77.8% in female animals. The prevalence was 90.9% in adult and 55.6% in juvenile foxes.

The parasites found and the range of worms in infected foxes are given as follows; fourteen foxes (93.3%) harbored cestodes, 13 foxes contained

One to 6 helminth species were encountered in infected animals. Parasite burden was between 14 to 789 in individual hosts with mean of 183.4 parasites. The most prevalent species were *T. leonina* (65%), *M. lineatus* (60%), and *L. serrata* (40%).

The results of fecal examinations are shown in Table 2. Helminth eggs were found in thirteen (65%) of 20 fecal samples. *Mesocostoides lineatus* eggs were found in 11 (55%), *Toxascaris leonina* in 9 (45%), *Alaria alata* in 6 (30%), *Toxocara canis* in 3 (15%), *Capillaria* spp. in 3 (15%), and *Taenia* spp. in 3 samples (15%).

Table 1. Parasite fauna of foxes (*Vulpes vulpes*) in Kars and vicinity (intestinal examination)
Tablo 1. Kars ilinde kırmızı tilkilerde (*Vulpes vulpes*) parazit faunası (bağırsak muayenesi)

Species	Examined foxes					
	Infected/ Examined number	%	Male	Female	Young	Old
Trematoda						
<i>Alaria alata</i>	6/20	30	3	3	2	4
Cestoda						
<i>Mesocostoides lineatus</i>	12/20	60	8	4	5	7
<i>Taenia multiceps</i>	2/20	10	-	2	-	2
<i>T. pisiformis</i>	2/20	10	1	1	1	1
<i>Taenia</i> spp.	2/20	10	2	-	-	2
<i>T. taeniaeformis</i>	1/20	5	1	-	-	1
<i>Echinococcus granulosus</i>	1/20	5	-	1	-	1
Nematoda						
<i>Toxascaris leonina</i>	13/20	65	8	5	5	8
<i>Toxocara canis</i>	4/20	20	2	2	-	4
<i>Capillaria</i> spp.	1/20	5	-	1	-	1
Arthropoda						
<i>Linguatula serrata</i>	8/20	40	6	2	4	4

Table 2. Fecal flotation results of fox feces
Tablo 2. Tilki dışkılarının flotasyon sonuçları

Species	Infected number/ Examined number	Infection rate (%)
Trematoda		
<i>Alaria alata</i>	6/20	30
Cestoda		
<i>Mesocostoides lineatus</i>	11/20	55
<i>Taenia</i> spp.	3/20	15
Nematoda		
<i>Toxascaris leonina</i>	9/20	45
<i>Toxocara canis</i>	3/20	15
<i>Capillaria</i> spp.	3/20	15

(86.7%) nematodes and 6 foxes (40%) harbored trematods. Eight of the foxes (53.3%) also harbored the arthropod *L. serrata*.

DISCUSSION

Several intestinal helminth species reported in this study are potential causative zoonotic agents. Infection with *E. multilocularis* results in alveolar echinococcosis which is usually fatal. Alveolar echinococcosis was reported from humans several times in Turkey especially from Erzurum and Kars provinces ²⁵⁻²⁹. It is contradictory that we have not found *E. multilocularis* in our present study. This parasite was also not encountered in a previous study Umur and Arslan ³⁰ in dogs of Kars. Now, It brings in mind that previously there may be wrong diagnosis for alveolar echinococcosis in Erzurum and Kars. There is a need for more extensive parasitological surveys of the red foxes of the region.

Echinococcus granulosus was found at rate of 5% in this study. The prevalence of this zoonotic parasite in the fox population may be accompanied by a spread and increasing prevalence of this parasite so that may spread very rapidly in dog populations causing cyst hydatid diseases in humans. The prevalence of *E. granulosus* in dogs in Kars province was reported as 40.5% by Umur and Arslan³⁰. And also Gicik et al.³¹ reported that the prevalence of hydatid disease in sheep and cattle in the same region was 63.85% and 31.15% respectively. In Erzurum which is a neighboring province to Kars, hydatid disease in sheep and cattle were reported as 70.91% and 46.41%³². The seropositivity against hydatid disease in Kars was reported as 34.6% by using IHA and IFAT³³. Gundogdu et al.²⁹ also reported that surgical operations for hydatid disease in humans were quite higher between 1999 and 2004 in Erzurum-Kars provinces comparing to the other parts of Turkey. Depending to data about *E. granulosus* and hydatid disease, it seems that fox may not be important factor transmitting the parasite and its' larvae to animals or humans in Kars province.

Larvae of *Toxocara canis* may cause visceral and ocular larval migrans in humans. This parasite was reported from foxes at rates between 2.0% and 73.7%^{1,3,8,10,16,17,20,23,24,34-36}. The prevalence of *T. canis* was 20% in this study indicating that the red fox may play a reservoir role for dogs and also somewhat for humans.

When the rectal contents of foxes were examined for helminth eggs, there were some differences between the prevalence for trematods and cestodes recorded by intestinal washes and fecal flotation. It is reported that flotation technique can lead to an underestimation of infection with cestodes and sometimes trematods³. In our study, when the results of intestinal washes and flotations are compared the prevalence of trematoda, nematodes, and *Mesocostoides* spp. were similar to each other except *Taenia* spp. The reason for this for flotation method could be due to suppressing and crushing the feces carefully and patiently during the examination.

Infections in adults were more prevalent than juveniles. It is widely accepted that adult hosts are more resistant to helminth infections than young host due to immune mechanisms, which may be

related to prior exposure to infection^{37,38}.

Although this study was aiming to investigate for helminth fauna, we have to report *Linguatula serrata* which is not a helminth. Although there are some reports about *L. serrata* in foxes in Turkey or other countries^{6,21,31,36,39,40}, this parasite is rarely reported from foxes. This parasite is a wormlike arthropod, the adults of which inhabit the nasal fossae or paranasal sinuses of vertebrates especially carnivores, the larvae are found in the lungs and other internal organs such as intestines. Acariform larvae of *L. serrata* in intermediate hosts (especially cattle, sheep, goat, buffaloes, rabbit etc.) bores through bowel wall, it is then carried out in the lymphatic or blood stream to the mesenteric lymph nodes or to the viscera particularly the liver, lungs, spleen, and kidneys where it encysts. Interestingly in this study, the adults of *L. serrata* were found in 8 of 20 (40%) foxes and nymphs of that were only in one fox (5%). After searching all databases and according to the authors' knowledge it is decided that this is the first documented report for both adults and nymphs of *L. serrata* were seen in the intestines of the final host which is a fox. We think that this arthropod could be confused with tetra-tridiums of *Mesocostoides* spp. To prevent confusing with the larvae of this parasite, both adults and acariforms of *L. serrata* were left in lactophenol solution for a long time and were carefully examined all morphological characteristics of the parasite and seeing the eggs inside of adults. Therefore, this methodology could be good advice for researchers who want to eliminate the possibly of overlooking the parasite because of not doing good clearing. There is another possibility that seeing the adults of *L. serrata* in the intestines could be due to swallowed worms via pharynx coming from the lungs of fox or other animals which were eaten by fox.

This study presents that the red fox in Kars province is a host to a range of intestinal helminth species including the arthropod *L. serrata*. Previous studies on foxes^{1,4,11-14} in Turkey were case reports in general. Therefore, the information about fox parasites was limited. We believe that this study contributes valuable information for fox parasites. By this study, *E. granulosus*, *T. multiceps*, *T. taeniaformis*, and *L. serrata* (adult and nymphs) were first time reported from foxes in Kars province.

REFERENCES

1. **Mimioğlu MM, Güralp N, Tolgay N, Sayın F:** Ankara civarında tilkilerde (*Vulpes vulpes*) bulduğumuz helmintler. *Ankara Univ Vet Fak Derg*, 12, 164-190, 1965.
2. **Ryan GE:** Helminth parasites of the fox (*Vulpes vulpes*) in New South Wales. *Aust Vet J*, 52, 126-131, 1976.
3. **Willingham AL, Ockens NW, Kapel CMO, Monrad J:** A helminthological survey of wild red foxes (*Vulpes vulpes*) from the metropolitan area of Copenhagen. *J Helminthol*, 70, 259-263, 1994.
4. **Ayaz E, Değer S, Gül A:** Van ilinde bir tilkide (*Vulpes vulpes*) bulunan helmintler. *T Parazit Derg*, 25, 163-165, 2001
5. **Wolfe A, Hogan S, Maguire D, Fitzpatrick C, Vaughan L, Wall D, Hayden TJ, Mulcahy G:** Red foxes (*Vulpes vulpes*) in Ireland as hosts for parasites of potential zoonotic and veterinary significance. *Vet Rec*, 149, 759-763, 2001.
6. **Razavi SM, Shekarforoush SS, Ghafari Red H:** Prevalence of *Linguatula serrata* nymphs in goats in Shiraz, Iran. *Small Rum Res*, 54, 213-217, 2004.
7. **Barbosa AM, Segovia JM, Vargas JM Torres J, Real R, Miquel J:** Predictors of red fox (*Vulpes vulpes*) helminth parasite diversity in the provinces of Spain. *Wildl Biol Pract*, 1, 3-14, 2005.
8. **Dalimi A, Satri A, Motamedi GH:** A study on intestinal helminths of dogs, foxes and jackals in the western part of Iran. *Vet Parasitol*, 142, 129-133, 2006.
9. **Eira C, Vingada J, Torres J, Miquel J:** The helminth community of the red fox, *Vulpes vulpes*, in Dunas de Mira (Portugal) and its effects on host condition. *Wildl Biol Pract*, 2, 26-36, 2006.
10. **Saeed I, Maddox-Hyttel C, Monrad J, Kapel CMO:** Helminths of red foxes (*Vulpes vulpes*) in Denmark. *Vet Parasitol*, 139, 168-179, 2006.
11. **Merdivenci A:** Türkiye'de tilki (*Vulpes vulpes*)'lerde ilk helmintolojik araştırma ve ilk *Echinococcus multilocularis* (Leuckart, 1866), Vogel. *Türk Vet Hek Dern Derg*, 33, 290-296, 1963.
12. **Merdivenci A:** Türkiye'de tilkide *Alveococcus multilocularis* olgusu ve yurdumuzda *Alveococcus* (alveolar kist)'in epidemiyolojisi ve epizootolojisi. *T Hidatid Derg*, 1, 6-29, 1965.
13. **Merdivenci A:** Son 30 yıl (1952-1982) içerisinde Türkiye'de varlığını ilk kez bildirdiğimiz parazitler. *Türk Mikrobiol Cem Derg*, 13, 23-37, 1983.
14. **Burgu A, Güçlü F:** Bir tilkide bulunan trematod türleri. *Ankara Univ Vet Fak Derg*, 58, 27-241, 1991.
15. **Dibble ED, Font WF, Wittrock DD:** Helminths of the red fox, *Vulpes vulpes* L., in West Central Wisconsin. *J Parasitol*, 69, 1170-1172, 1983.
16. **Borgsteede FHM:** Helminth parasites of wild foxes (*Vulpes vulpes* L.) in the Netherlands. *Z Parasitenkd*, 70, 281-285, 1984.
17. **Skirnisson K, Eydal M, Gunnarsson E, Hersteinson P:** Parasites of the arctic fox (*Alopex lagopus*) in Iceland. *J Wildl Dis*, 29, 440-446, 1993.
18. **Zanini F, Laferrara M, Bitsch M, Perez H, Elissondo MC:** Epidemiological studies on intestinal helminth parasites of the patagonian fox (*Pseudalopex griseus*) in Tierra del Fuego, Patagonia Argentina. *Vet Parasitol*, 136, 329-334, 2006.
19. **Richards DT, Haris S, Lewis JW:** Epidemiological studies on intestinal helminth parasites of rural and urban red foxes (*Vulpes vulpes*) in the United Kingdom. *Vet Parasitol*, 59, 39-51, 1995.
20. **Vervaeke M, Dorny P, Bruyn LD, Vercammen F, Jordaens K, Berge KVD, Verhgen R:** A survey of intestinal helminths of red foxes (*Vulpes vulpes*) in northern Belgium. *Acta Parasitol*, 50, 221-227, 2005.
21. **Soulsby EJJ:** Helminths, Arthropods and Protozoa of Domesticated Animals. Bailliere, Tindall, London, 1982.
22. **Thienpont D, Rochette F, Venparijs DFL:** Diagnosis of Helminthiasis by Coprological Examination. 2nd ed., Janssen Research Foundation, Belgium, 1986.
23. **Papadopoulos H, Himonas C, Papazahariadou M, Antoniadou-Sotiridou K:** Helminths of foxes and other wild carnivores from rural areas in Greece. *J Helminthol*, 71, 227-231, 1997.
24. **Gortazar C, Villafuerte R, Lucientes J, Fernandez-de-Luco D:** Habitat related differences in helminth parasites of red foxes in the Ebro valley. *Vet Parasitol*, 80, 75-81, 1998.
25. **Merdivenci A:** Türkiye'de Hidatik Kist Hastalığı. İstanbul Üniversitesi Cerrahpaşa Tıp Fakültesi Yayınları, İstanbul, 1976.
26. **Özbek A:** Erzurum'da unilokuler ve multilokuler hydatid tanısı konmuş hastaların Ocak 1997-Nisan 1999 yılları arasında dağılımı ve 1998 yılı için Erzurum Et Balık Kurumu'nda kesim yapılan hayvanlarda tespit edilen *Echinococcus hydatidosis* oranı. XI. Ulusal Parazitoloji Kongresi, YM 3, 82, Sivas, 1999.
27. **Polat KY, Balık AA, Celebi F:** Hepatic alveolar echinococcosis: Clinical report from an endemic region. *Can J Surg*, 45, 415-419, 2002.
28. **Korkmaz M, Inceboz T, Celebi F, Babaoglu A, Uner A:** Use of the losses produced by hydatidosis immunoblot markers, em70 and em90, for diagnosis of alveolar echinococcosis. *J Clin Microbiol*, 42, 3350-52, 2004.
29. **Gündoğdu C, Arslan R, Arslan MÖ, Gıcık Y:** Erzurum ve çevresinde insanlarda kistik ve alveolar ekinokokkozis olgularının değerlendirilmesi. *T Parazit Derg*, 29 (3): 163-166, 2005.
30. **Umur Ş, Arslan MÖ:** Kars yöresi sokak köpeklerinde görülen helmint türlerinin yayılışı. *T Parazit Derg*, 22, 188-193, 1998.
31. **Gıcık Y, Arslan MÖ, Kara M, Köse M:** Kars ilinde kesilen sığır ve koyunlarda kistik ekinokokkozisin yaygınlığı. *T Parazit Derg*, 28, 136-139, 2004.
32. **Arslan MÖ, Umur Ş:** Erzurum mezbahalarında kesilen koyun ve sigirlarda hidatidozun yayılışı ve ekonomik onemi. *Kafkas Univ Vet Fak Derg*, 3, 167-171, 1997.
33. **Karaman Ü, Miman Ö, Kara M, Gıcık Y, Aycan OM, Atambay M:** Kars bölgesinde hidatik kist prevalansı. *T Parazit Derg*, 29, 238-240, 2005.
34. **Schoffel VI, Schein E, Wittstadt U, Hentsche J:** Parasites of the red fox in Berlin (West). *Berl Münch Tierarztl Wochr*, 104, 153-157, 1991.
35. **Wessbecher H, Dalchow W, Stoye M:** The helminth fauna of the red fox (*Vulpes vulpes*) in German Federal Administrative area of Karlsruhe-Part 2: Nematodes. *Dtsch Tierarztl Wochenschr*, 101, 322-326, 1994.
36. **Criado-Fornelio A, Gutierrez-Garcia L, Rodriguez-Caabeiro F, Reus-Garcia E, Roldan-Soriano MA, Diaz-Sanchez MA:** A parasitological survey of wild red foxes

- (*Vulpes vulpes*) from the province of Guadalajara, *Spain Vet Parasitol*, 92, 245-251, 2000.
37. **Grenfell BT, Dobson AP:** Ecology of infectious diseases in natural populations. University of Cambridge, Downing Street, Cambridge, UK, 1995.
38. **Rodríguez A, Carbonell E:** Gastrointestinal parasites of the Iberian lynx and other wild carnivores from central Spain. *Acta Parasitol*, 43, 128-136, 1998.
39. **Güralp N:** Helmintoloji. 2. Baskı. Ankara Univ Vet Fak Yayın No: 368/266, Ankara, 1981.
40. **Arroyo R, Vargas M, Santamaría S:** Pentastomiasis in Costa Rica caused by *Linguatula serrata* and its differential diagnosis from *L. recurvata*. *Rev Latinoam Microbiol*, 28, 157-166, 1986.