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ZOONOTIC HELMINTHOSIS OF DOMESTIC AND WILD CARNIVORES IN THE EPIZOOTIOLOGIC TERRITORY OF SERBIA

Tamara Ilić[1], Tamaš Petrović[2], Predrag Stepanović[1]*, Danica Bogunović[1], Bojan Gajić[1], Zoran Kulišić[1], Marko Ristić[4], Milan Hadži Milić[5], Sanda Dimitrijević[1]

[1] Department of Parasitology, University of Belgrade, Faculty of Veterinary Medicine, Republic of Serbia
[2] Scientific Veterinary Institute „Novi Sad", Novi Sad, Republic of Serbia
[3] Department of equine, small animal, poultry and wild animal diseases, University of Belgrade, Faculty of Veterinary Medicine, Republic of Serbia
[4] Department of Animal Husbandry and Veterinary Medicine, University of Niš, Faculty of Agriculture in Kruševac, Republic of Serbia
[5] Department of Surgery, Orthopaedic and Ophthalmology, University of Belgrade, Faculty of Veterinary Medicine, Republic of Serbia

Abstract

In the last decade, as the result of climate changes, there have been considerable changes in the parasitofauna of domestic and wild carnivores. The prevalence of the existing parasitic species has varied significantly, showing an increasing tendency, and some parasitic species not present before in this epizootiologic territory have been diagnosed as well. It is thought that the reason for such an epizootiological situation is increased presence of owners with their pet animals in the regions endemic for particular zoonotic helminthoses during summer holidays and touristic visits. This tendency has become especially conspicuous in the last several years characterized by warm winters and very hot summers due to global warming effects, with abundant atmospheric precipitation. Oral vaccination of foxes against rabies, regulated in Serbia by appropriate laws since 2010, has led to an increased number of foxes and rise of prevalence of the parasitic diseases

[1*] Corresponding author: pedja@vet.bg.ac.rs; prstepanovic@gmail.com

for which foxes represent the infection source/reservoir. Continued urbanization of Serbian cities, with the extension of urban belts into the suburbia and recreational ("weekend") settlements, lead to a closer contact of street dogs and owned dogs with foxes, which results in a significant change in the parasitic fauna of dogs. It is an additional factor, which in the chain fox - street dog - owned dog - human increases the risk and tendency for the occurrence of human infections with zoonotic endoparasites of wild and domestic carnivores. In order to reliably predict the degree of spread of particular zoonotic helminthoses in particular regions in Serbia, for which wild carnivores represent the infection source, it is necessary to institute continued monitoring of the parasitic fauna in this type of wild animals.

Key words: carnivores, parasitological screening, zoonoses, endemic parasitoses, Serbia

ZOONOZNE HELMINTOZE DOMAĆIH I DIVLJIH MESOJEDA NA EPIZOOTIOLOŠKOM PODRUČJU SRBIJE

Tamara Ilić[1], Tamaš Petrović[2], Predrag Stepanović[3*],
Danica Bogunović[1], Bojan Gajić[1], Zoran Kulišić[1],
Marko Ristić[4], Milan Hadži Milić[5], Sanda Dimitrijević[1]

[1] Katedra za parazitologiju, Univerzitet u Beogradu, Fakultet Veterinarske Medicine, Republika Srbija
[2] Naučni Institut za veterinarstvo „Novi Sad", Novi Sad, Republika Srbija
[3] Katedra za bolesti kopitara, mesojeda, živine i divljači, Univerzitet u Beogradu, Fakultet Veterinarske Medicine, Republika Srbija
[4] Katedra za stočarstvo i veterinu, Univerzitet u Nišu, Poljoprivredni Fakultet, Kruševac, Republika Srbija
[5] Katedra za hirurgiju, ortopediju i oftalmologiju, Univerzitet u Beogradu, Fakultet Veterinarske Medicine, Republika Srbija

Kratak sadržaj

U toku poslednje decenije u Srbiji je usled klimatskih promena došlo do značajnijih promena parazitofaune domaćih i divljih mesojeda. Prevalencija postojećih parazitskih vrsta je značajno varirala, i pokazala tendenciju povećanja, a dijagnostikovane su i neke vrste parazita koje ranije nisu

bile prisutne na ovom epizootiološkom području. Smatra se da je razlog za ovakvu epizootiološku situaciju, povećana učestalost kretanja vlasnika sa svojim ljubimcima, u endemska područja pojedinih zoonoznih helmintoza, tokom letovanja i turističkih putovanja. Ovaj trend je naročito došao do izražaja poslednjih nekoliko godina, koje su usled globalnog zagrevanja praćene pojavom blagih zima i veoma toplih leta, sa velikom količinom atmosferskih padavina. Oralna vakcinacija lisica protiv besnila, zakonski regulisana u Srbiji od 2010. godine, uslovila je povećanje broja lisica i rast prevalencije parazitoza za koje lisice predstavljaju izvore/rezervoare infekcije. Urbanizacija gradova u Srbiji sa širenjem gradskog pojasa na periferiju i područja vikend naselja, dovodi do bliskih kontakata pasa lutalica i vlasničkih pasa sa lisicama, što je rezultiralo značajnom promenom parazitofaune pasa. To je samo dodatni faktor koji u lancu: lisica - pas lutalica - vlasnički pas - čovek, značajno povećava rizik i tendenciju za nastanak infekcije ljudi zoonoznim endoparazitima divljih i domaćih mesojeda. Da bi se predvidele razmere širenja izvesnih zoonoznih helmintoza u pojedinim regionima Srbije, za koje divlji mesojedi predstavljaju izvore infekcije, neophodno je sprovoditi kontinuiran monitoring parazitske faune ove vrste divljači.

Ključne reči: mesojedi, parazitološki skrining, zoonoze, endemične parazitoze, Srbija

INTRODUCTION

There is a great number of zoonotic endoparasites infesting carnivorous animals which represent a risk for the health of pets or human public health, and the most important among them are the species from the genera *Toxocara*, *Echinococcus*, *Taenia*, *Dirofilaria*, *Dipylidium caninum*, *Capillaria aerophila* and *Thelazia callipaeda* (Overgaauw and van Knapen, 2013; Marino et al., 2018; ESCCAP, 2018).

Special risk factors associated with the infection of carnivores with endoparasites are free roaming, contacts with stray dogs or cats, feeding on carcasses of paratenic hosts, feeding on intermediate host animals, age-related susceptibility, animal hormonal status (gravidity/lactation), contacts with children or immunodeficient individuals and travelling to the regions endemic for particular endoparasitoses (McNamara et al., 2018).

As the consequence of global warming and active migrations of owners with their pet animals into the countries of this region and Europe, there has been an increase in the prevalence of helminths with zoonotic potential in domestic and wild carnivores in the territory of Serbia in the last ten years. Many of the European countries have already been registered as endemic regions for certain zoonotic nematodoses (Wall and Morgan, 2009; ESCCAP, 2018). Such an epizootiologic situation, associated with the action of the above predilection factors, has caused increased occurrence of particular cardiorespiratory, subcutaneous, ocular and intestinal parasitoses, some of which have developed endemic characteristics in the territory of Serbia as well.

Routine treatment and prevention of endoparasitoses affecting carnivores depend on legislation in individual countries and information available to doctors of veterinary medicine, the most important of which are parasite epidemiology, education of pet owners and individual risk estimations. In accordance with the ESCCAP guidelines (2018), it is recommended that every protocol of planned dehelminthization should be implemented after the following: 1) completed clinical examination; 2) coprological examination after the request by the owner; and 3) coprological diagnosis within the preparation for vaccinal immunization, in accordance with the advice given by the doctor of veterinary medicine.

CARDIOPULMONARY AND SUBCUTANEOUS DIROFILARIOSIS

The first research of dirofilariosis in dogs in the territory of former Yugoslavia took place at the end of the last century. Up to then, there were sporadic reports in the literature about the findings of *Dirofilaria immitis* species in the heart of dogs (Dimitrijević, 1999), mostly as incidental autopsy observations (Milosavljević and Kulišić, 1989; Blitva-Mihajlović et al., 1995). After that, some autochthonous cases of cardiopulmonary dirofilariosis in dogs in Serbia were diagnosed (Kulišić and Milosavljević, 1994; Dimitrijević et al., 2007). The study by Tasić et al. (2008) in the territory of Vojvodina confirmed that this region was the northernmost border for cardiopulmonary dirofilariosis in dogs in the Balkans and one of European regions with the highest prevalence of subcutaneous dirofilariosis in dogs. The authors diagnosed *Dirofilaria repens* in 49.2% of dogs, *D. immitis* in 7.2%, and *Acanthocheilonema reconditum* in 2.1% of dogs. Tasić et al. (2012) reported about the occurrence of filariosis in dogs in the territory of Pančevo and Veliko Gradište municipalities, where cardiopulmonary dirofilariosis was found in 12.3%, and subcutaneous dirofilariosis in 42.6% of dogs. The first cases of *D. immitis* in dogs in the territory

of Novi Sad were detected by Savić-Jevđenić et al. (2004). The prevalence of dirofilariosis in dogs in Vojvodina was examined by Savić et al. (2012) and they established the seroprevalence of *D. immitis* of 18% in police dogs, and in the same region in the period 2009-2013, the presence of microfilaria of *D. immitis* was detected in 27.6% of dogs (Savić et al., 2014). Stepanović et al. (2015) reported about their finding of *D. immitis* in 68% of police dogs in the Belgrade municipality, which had been declared endemic for this nematodosis several years before (Jovanović, 2012). *D. immitis* infection was established in 24.2% of non-owned dogs in the Belgrade municipality (Gajić, 2016). Krstić et al. (2016) established the presence of *D. immitis* in 12.7% of tested animals without clinical symptoms. Out of the total number of positive animals, 44% were dogs from dog shelters and 60% were pets.

The prevalence of adult forms of *D. immitis* in wild carnivores in Serbia was monitored by Penezić et al. (2014). In the period 2009-2013 they diagnosed this filaria in 7.32% of golden jackals, in 1.55% of foxes, in 1.43% of wolves and 7.69% of wild cats. Cardiopulmonary dirofilariosis was demonstrated on autopsy in 13.33% of foxes (Gavrilović et al., 2014) and in one wolf (Gavrilović et al., 2015) from the South Banat District.

Microfilaremia established in the above host animals indicated that they represented an infection source for mosquitoes. High prevalence percentages of *D. immitis* of 18.52% in jackals from Romania (Ionică et al., 2016), 9.6% in those from Bulgaria (Kirkova et al., 2011) and 7.4% in animals from Hungary (Tolnai et al., 2014) suggest that this species of wild carnivores has an important role in the maintenance of infection. According to some authors (Otranto and Deplazes, 2019) it is necessary to elucidate the epidemiological role of foxes as well, especially bearing in mind the report on 32.3% of foxes positive to *D. immitis* in some of the irrigated regions in Spain (Gortázar et al., 1998).

The first study of *Dirofilaria spp*. in disease vectors in Serbia was performed by Kurucz et al. (2016). In the period May-August, by way of molecular analysis of grouped samples from 13 municipalities in Vojvodina, 11 species of mosquitoes were identified, and in 60% of samples the presence of *Dirofilaria spp*. was found. *Dirofilaria immitis* was diagnosed in 80% of positive grouped samples of *Culex pipiens, Coquillettidia richiardii and Ochlerotatus caspius* species, while *D. repens* was diagnosed in 20% of positive samples of *Aedes vexans, Cx. pipiens* and *Oc. sticticus* species, without any *D. immitis* and *D. repens* coinfections.

Several factors have influenced the accelerated spread of *Dirofilaria spp*. into European countries in which these nematodes have not been reported before. Increased duration of warm periods due to climatic change is one of

the main factors of impact on the development, activity and seasonal survival of mosquitoes, as well as the development of larval forms of dirofilarios in disease vectors (Farkas et al., 2020). The introduction of the „Pet Travel Scheme" in 2000 has contributed to the spread of dirofilariosis, facilitating the movement of infected, microfilaremic dogs from endemic regions to other parts of Europe (Genchi et al., 2011).

Since the prevalence of dirofilariosis in dogs in hyperendemic regions (northern parts of Serbia) exceeds 60% (Tasić et al., 2008) human infections with the parasite should be expected as well. In the territory of Serbia and Montenegro, individual cases of human infection with *D. repens* have been reported (Kulišić et al., 1989; Kranjčić-Zec et al., 2001; Džamić et al., 2009). In people from different parts of Serbia (Pančevo, Novi Sad, Zaječar, Leskovac, Vranje, Niš, Pirot), Tasić-Otašević et al. (2014) demonstrated seropositivity of 15.4% to dirofilaria antigens. Specific antibodies against *D. repens* were found in 9.7%, against *D. immitis* in 8.1%, while antibodies against both dirofilaria species were found in 2.3% of the examined individuals. Momčilović et al. (2019) diagnosed *D. repens* in buccal mucosa in a man aged 45 years from central Serbia. A striking buccal mucosa edema along the lateral edge of the right maxilla was observed in this patient, followed by leukocytosis. Surgical extirpation was performed, and subsequent histopathological, parasitological, and molecular analysis of the specimen revealed the presence of the *D. repens* nematode. Of the 13 such cases reported so far worldwide, this is the first case analyzed by molecular methods.

RESPIRATORY CAPILLARIOSIS

Considering the available epizootiological data on the distribution of *Capillaria aerophila* species in domestic and wild carnivores in Europe, it is certain that global warming has an important impact on the distribution of this parasite (Traversa and Di Cesare, 2014; Ilić et al., 2015; Otranto and Deplazes, 2019).

Climatic change, animal migrations, destruction of animal habitats by humans, maritime transport of goods, as well as travelling of pets with their owners, all have had a significant role in the spread of this parasitosis and its global distribution (Traversa et al., 2010; Otranto et al., 2013). Changed habitats of wild animals, as the consequence of human activity, have led to a closer contact between wild and domestic animals, which caused this nematode to appear in domestic animals as well (Di Cesare et al., 2014).

The parasite has been diagnosed by way of regular coprological examinations in dogs and/or cats in Spain (Miro et al., 2004), Germany (Epe et al.,

2004), Portugal (Madeira de Carvalho et al., 2009), Romania (Mircean et al., 2010) and Italy (Traversa et al., 2009; Di Cesare et al., 2011; Traversa and Di Cesare, 2016), with evident clinical symptoms of the disease. In the period February-March 2019, in a parasitological examination of dog feces samples taken from three public city parks in Niš, *C. aerophila* nematode was diagnosed with the prevalence of 8-14% (Ristić et al., 2020a).

Di Cesare et al. (2012) have described 15 genetic haplotypes of *C. aerophila*, out of which five were identified in pet animals in Italy and in wild animals in Serbia, and three genetic subtypes were isolated in both domestic cats and foxes in Serbia, Romania and Portugal. It should be emphasized that the genetic haplotypes described in foxes in Serbia were also found in cats and dogs in Italy and Romania. A couple of years later, it was demonstrated that different genetic haplotypes of *C. aerophila* could be simultaneously identified in foxes, beech martens, cats and dogs in European countries, confirming a common pattern of parasite transmission between wild animals and pets (Di Cesare et al., 2014).

The prevalence of respiratory capillariosis in red foxes in Europe is rather high, reaching 97% in Lithuania (Bružinskaitė-Schmidhalter et al., 2012), 88% in Norway (Davidson et al., 2006), 74.1% in Denmark (Saeed et al., 2006), 76.2% in Poland (Karamon et al., 2018), 67-75% in Germany (Schug et al., 2018), 66% in Hungary (Sréter et al., 2003), 46.8% in the Netherlands (Borgsteede, 1984) and 41.8% in Italy (Magi et al., 2015). Otranto et al. (2015) have reported about the finding of *C. aerophila*in European wild cats (33.3%), jackals (5%) and raccoon dogs (32%).

Ilić et al. (2016a) have reported about the prevalence of respiratory capillariosis in foxes in particular areas in Northern, Eastern and Western Serbia, which was 49.02% in the period 2008-2012. The highest prevalence was found in foxes from the hunting grounds in the Districts of Zaječar (74.04%) and Raška (52.63%). Examining the endoparasitic fauna of foxes and jackals in 8 epizootiological regions in Serbia between 2010 and 2014, Ilić et al. (2016b) diagnosed *C. aerophila* in 23.56% of foxes aged above one year. In foxes below one year of age and in jackals, this nematode could not be identified.

There is a close association between the population of foxes and populations of dogs and cats. It is assumed that the process of urbanization and extension of urban belts into the natural habitats of foxes can lead to the opportunities for closer contacts between street dogs and cats, and foxes (Ilić et al., 2017a). The population of foxes thus represents a permanent source of infection for dogs and cats in suburbia, which is especially important for the epidemiology of respiratory capillariosis.

It is supposed that one of the reservoirs of this zoonosis in Serbia are foxes from the territory of Vojvodina, which is additionally confirmed by a case of pulmonary capillariosis diagnosed in an individual from Bačka Palanka (Lalošević et al., 2008). Supporting to this are the results of some authors, who examined the respiratory tract of foxes from different regions of Vojvodina and diagnosed *C. aerophila* nematode in the trachea in 84% (Lalošević et al., 2013) and 30-37.50% of foxes (Ilić et al., 2016a). These epidemiologic data additionally corroborate the hypothesis that wild carnivores represent the principal definitive hosts responsible for the transmission of *C. aerophila* (Otranto and Deplazes, 2019).

OCULAR THELAZIOSIS

After the original report about the finding of this nematode in dogs in Italy (Rossi and Bertaglia, 1989), *T. callipaeda* has swiftly spread across Europe, involving France (Dorchies et al., 2007), Switzerland (Malacrida et al., 2008), Germany (Magnis et al., 2010), Spain (Miró et al., 2011), Portugal (Vieira et al., 2012), Slovakia (Čabanová et al., 2017) and Greece (Papadopoulos et al., 2018).

The first autochthonous cases of ocular thelaziosis in dogs and cats in Serbia have been diagnosed in central, western, and southern parts of the country (Gajić et al., 2014; Tasić-Otašević et al., 2016). The isolated parasites were morphologically identified as *T. callipaeda*, while the molecular analyses of cytochrome oxidase-1 (cox1) gene established the presence of h1 haplotype, so far the only established haplotype of this parasite in Europe (Gajić et al., 2014). Hadži Milić et al. (2016) reported their finding of a relatively high overall prevalence of *T. callipaeda* (35.52%) in dogs in different regions of Serbia. Infected dogs in this study were from the regions in Northern (43.58% from North Banat District and 28.94% from South Bačka District), Central (41.83% from Belgrade suburbia and 21.68% from Braničevo District), Eastern (47.50% from Bor District and 30.92% from Zaječar District) and Southern Serbia (25.00% from Pčinja District). Infection of wolves with *T. callipaeda* has recently been documented, with an overall prevalence of 38.1% (Gajić et al., 2019). This finding suggests the significance of the epizootiological role of wolves as reservoirs of infection for thelazia, although other wild carnivores' role should also be addressed in the studies.

The presence of *T. callipaeda* in this epizootiological area is not surprising for the geographical coordinates of Serbia, positioned between lat 41°53'Nand 46°11'N and long 18°49'Eand 23°00'E, in Southeastern Europe in the central

part of the Balkan Peninsula. Endemic cases of ocular thelaziosis in dogs have been reported in many countries worldwide with similar geographical coordinates (between 39° and 46°) (Otranto et al., 2013). For the most part, Serbia is characterized by moderate continental climate. In the South-Western part the climate varies between subtropical and continental, with the average yearly precipitation of 896 mm, resembling those climatic conditions in the countries with reported thelaziosis cases (Hadži Milić et al., 2016).

According to the literature data, a high prevalence rate of ocular thelaziosis is present in foxes, ranging from 27.71% in Bosnia and Herzegovina (Hodžić et al., 2014), 29.38% in Romania (Ionică et al., 2018) and 49.3% in Southern Italy (Otranto et al., 2009), and cases of the disease have been reported in Portugal as well (Sargo et al., 2014). Furthermore, Pan-European distribution of the vector *Phortica variegata* (*Drosophilidae, Steganinae*) best explains the abilities and spreading potential of *T. callipaeda* (Máca and Otranto, 2014).

Circulation of the nematode across different animal species and its recent appearance in Europe is in accordance with the common genetic haplotype of *T. callipaeda* present in all examined wild and domestic animals (Otranto and Deplazes, 2019). Considering the fact that wild carnivores have a very broad movement area, 10 to 30 km for foxes (Doncaster and Macdonald, 1991) and even up to 800 km for wolves (Mech, 1970), they contribute considerably to the maintenance and spread of the infection. Moreover, they represent a significant infection reservoir for *T. callipaeda*, in both endemic and non-endemic regions (Mihalca et al., 2016), such as Great Britain, where only imported cases of thelaziosis in dogs have been reported (Graham-Brown et al., 2017) despite an endemic vector (Palfreyman et al., 2018).

In the last six years, in the countries nearby Serbia (Romania, Croatia, Bosnia and Herzegovina, Bulgaria, Austria) there have been several reported autochthonous cases of ocular thelaziosis in dogs and cats (Hodžić et al., 2014; Mihalca et al., 2015; Hodžić et al., 2019), and in Bosnia and Herzegovina in foxes as well (Hodžić et al., 2014). In 2016, the zoonotic potential of the parasite in these regions was additionally confirmed by the report of two cases of thelaziosis in humans: one in a 36-year-old man from Serbia (Tasić-Otašević et al., 2016) and one in 82-year-old man from Croatia (Paradžik et al., 2016).

Since *T. callipaeda* has got zoonotic potential and presents a risk for human health, it is necessary that veterinarians, doctors and ophthalmologists should include this nematodosis with ocular manifestations into their differential diagnostic considerations. Such a clinical approach is especially important in regions where ocular thelaziosis has assumed endemic character, such as in Serbia.

INTESTINAL ZOONOTIC HELMINTHOSES

Regarding geographical distribution and clinical relevance, *Toxocara canis*, *Ancylostomatidae* and *Trichuris vulpis* are the most prevalent intestinal helminths affecting dogs, the importance of which is often unacknowledged by doctors of veterinary medicine, medical doctors and general public (Traversa et al., 2014). Depending on the intensity of dog infection, we should not overlook some cestodes (*D. caninum* and *Taenia* spp.), as well as trematodes (*Alaria alata*) and protozoans (*Giardia intestinalis*, *Amoeba* spp., and *Cryptosporidium* spp.) (Möhl et al., 2009; Traversa, 2012; ESCCAP, 2018). From the medical, veterinary, economic and environmental point of view, enzootic infections are the most important, the sources of which are linked to natural sites.

In the last three decades, a large number of authors have studied parasitic fauna of the digestive tract of domestic and wild carnivores from the territory of Serbia (Kulišić et al., 1992; Pavlović and Kulišić, 1994; Antanasijević et al., 1997; Dimitrijević et al., 2005; Nikolić et al., 2008; Pavlović et al., 2010; Ilić et al., 2016b; Ilić et al., 2017b; Ristić et al., 2020a).

In owned dogs, stray dogs and military working dogs in the territory of Belgrade, Nikolić et al. (2008) have found a high prevalence rate of intestinal zoonotic parasites (75.50%). In most of these animals, the infection with *T. vulpis* nematode was diagnosed (47.00%). In dogs and cats aged 1-8 years in the territory of Belgrade, Ilić et al. (2017b) have diagnosed toxocarosis (15.88-16.62%), ancylostomatidosis (1.87-3.80%) and trichuriosis (0.93-4.03%), with the finding of highest prevalence of *Dipylidium caninum* infection, ranging from 21.49% in cats to 24.70% in dogs.

Kostić (2016) has reported on the finding of intestinal parasites in street dogs in the territory of the city of Kruševac. Parasitological studies revealed the predominance of *G. duodenalis* (52.11%) and *D. caninum* cestode (36.61%). *Trichuris vulpis* nematode was found in one third of examined dogs (32.39%), and *T. canis* (22.53%), *Taenia* spp. (5.63%), and *E. granulosus* (2.82%) were diagnosed as well. In the period from September 2017 to June 2018, in a study of endoparasitoses in street dogs aged one year and over from six dog shelters in the Republic of Serbia, the highest prevalence of endoparasitic infections was found in the Shelter for street dogs and cats in Požarevac (69.54%). In dogs below one year of age, most prevalent were toxocarosis (42.85%) and ancylostomatidosis (26.53%) in the Shelter for abandoned dogs in Zemun, while toxocarosis was most prevalent (35.14%) in the Shelter for abandoned dogs in Subotica (Nišavić, 2019).

Monitoring endoparasitic fauna of foxes and jackals from eight different localities in Serbia in the period 2010-2014, Ilić et al. (2016b) have diagnosed as

the most prevalent helminths *A. alata* (49.41% in foxes and 30.00% in jackals), *T. canis* (49.41% in foxes and 23.33% in jackals), ancylostomatids (40.69% in foxes and 33.33% in jackals) and *T. vulpis* (55.23% in foxes and 11.66% in jackals).

Ristić et al. (2020a) have studied the prevalence of zoonotic intestinal parasites in dogs from the public parks in the city of Niš and assessed the health risks they presented for people in public places and children's playgrounds. Endoparasitoses were diagnosed with overall prevalence of 58-70%. Depending on the season of the study, four most common endoparasites were *T. canis* (36.66-38%), ancylostomatids (24.66-32%), *T. vulpis* (20-28%) and *A. alata* (28%). Certainly worth mentioning was the fact that these helminths were identified in soil/sand samples taken from these public parks in Niš. In soil samples, a high and medium degree of contamination with *T. canis* ascaridid was found (14-22%), as well as a low and medium degreeof contamination with ancylostomatids (4-12%), medium degree of contamination with *T. vulpis* species (4-6%), and medium and high degree of contamination with *A. alata* trematode (2%). In sand samples, different degrees of contamination with helminths *T. canis* (26%), ancylostomatids (8%), *T. vulpis* (4%) and *A. alata* (16%) (Ristić et al., 2020b) were established. Based on the results of this parasitological screening, the authors concluded that a large number of street dogs circulated in public parks in Niš, which presented the reservoir of numerous parasitic zoonoses for owned dogs and people (particularly for preschool and school children).

The literature data suggest that *T. canis* is overall the most prevalent helminth in dogs, the prevalence of which varies between European countries from 7.5% (Riggio et al., 2013) to 22.1% (Habluetzel et al., 2003) in Italy; 17.72% in Spain (Martínez-Moreno et al., 2007), from 11.9% (Papajová et al., 2014) to 45.1% (Rudohradská et al., 2011) in Slovakia; and from 0.5% (Ferreira et al., 2017) to 15.8% (Otero et al., 2014) in Portugal. The finding of this ascaridid always involves a high degree of risk for human populations, since after the infection its larvae migrate to individual internal organs, causing the syndrome of visceral and ocular *larva migrans* (Overgaauw and van Knapen, 2013).

In recent years, there has been a growing interest for the infection with *A. alata* trematode, which is very prevalent in Europe, has a potential zoonotic importance since it causes larval alariosis, and is diagnosed in a number of countries nearby Serbia, such as Croatia, Romania and Bulgaria (Lalošević et al., 2014).

A high intensity infection with this trematode has been reported to occur in intermediate hosts (wild pigs) living in the areas with high prevalence of alariosis in definitive hosts (domestic and wild carnivores). In addition to rodents, reptiles and amphibians (Esite et al., 2012), humans as well can be incidental paratenic hosts if they consume insufficiently thermally processed

frog legs, pork (Wójcik et al., 2002; Möhl et al., 2009) or wild goose meat (Kramer et al., 1996) infected with *A. alata* mesocercarias.

In recent years, larval alariosis has been reported in other European countries as well. The first finding in the meat of wild pigs in Bulgaria was reported by Portier et al. (2014), when the overall prevalence of 0.6% was established. The study of the vitality of mesocercarias in products made from infected wild pig meat, prepared in a traditional fashion in Germany, has shown than only fresh products contain living mesocercarias and could be the source of infection for humans (González-Fuentes et al., 2014).

In addition to trichinellosis, wild pig meat can be the source of infection with trematode mesocercarias, so that any preparation of thermally unprocessed products (e.g., sausages) cannot be recommended. Safe for human nutrition is only well cooked wild pig meat. Bearing in mind this information, it is necessary to adjust accordingly the legislation on food safety for human consumption in Serbia (Lalošević et al., 2014).

In view of human population, zoonotic parasites from the feces of carnivores can threaten mostly dog owners or dog breeders who disregard the necessity to perform dehelminthization of their litters, children who do not wash their hands after their contacts with animals, or those with geophagic practices, agricultural workers and greengrocers (especially in semirural and rural areas where dogs freely defecate in the vicinity of vegetables).

In people in Serbia, the cases of a familial epidemic of cryptosporidiosis have been coprologically diagnosed in three immunocompetent patients (Gvozdenović et al., 2012) and there is also the case of 4.5-year-old girl in whom toxocarosis has been detected serologically (Mijatović et al., 2015). A retrospective analysis of the results of examination of feces samples from healthy people in Southern Serbia to detect possible presence of *G. intestinalis* revealed the highest prevalence in 2005 (4.9%), and the lowest in 2014 (0.57%) (Miladinović Tasić et al., 2017). Perić et al. (2017) have reported on their two cases for whom there were no anamnestic data concerning their previous travelling abroad, and in whom cutaneous *larva migrans* was diagnosed in 2016. The first described patient was a 72-year- old man from Western Serbia with changes localized in the chest region, and the other was a 31-year-old man from Central Serbia with changes localized in his right arm.

CONCLUSION

In order to prevent and control zoonotic helminthoses of domestic and wild carnivores it is essential that their occurrence, infection spread and maintenance should be continually monitored in foxes, dogs and humans; that the

problem of abandoned dogs should be effectively resolved in most urban environments; that the measures to control vector populations should be undertaken; that all goods, commodities, services and traffic in international trade should be monitored; that all persons who travel with their pets to the regions endemic for these diseases or who return from these to Serbia should be monitored; that continued education of pet owners is organized; and that synchronized collaboration of appropriate services of veterinary medicine and human medicine is in place.

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Authors' contributions

IT, PT, SP, BD, GB, KZ, RM, HM and DS were participated in the design of the study, conceived of the study, and participated in its design and coordination and helped to draft the manuscript. All authors read and approved the final manuscript.

Competing interests

The author(s) declare that they have no competing interests.

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