

## Dogs from public city parks as a potential source of pollution of the environment and risk factor for human health

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### ABSTRACT

A study was undertaken to determine the prevalence of zoonotic parasites in faeces of dogs who were visiting the public parks and to evaluate the risk they represented for the people and children visiting the same places. Parasitological analysis was performed on 300 samples of faeces, collected from public parks of the city of Niš (Tvrdava Park, Čair Park, Sveti Sava Park); from autumn 2018 and spring 2019. Using standard qualitative and quantitative methods of coprological diagnostics, the presence of protozoa (*Cystoisospora* spp.), nematodes (*Toxocara canis*, *Toxascaris leonina*, *Ancylostoma caninum* / *Uncinaria stenocephala*, *Trichuris vulpis* and *Capillaria aerophila*), cestodes (*Dipylidium caninum*, *Taenia* spp.) and trematode *Alaria alata* was determined. The prevalence of endoparasitoses were 58–70%, and the most prevalent were those of medium intensity. Depending on the research period, the four most frequent endoparasites were *T. canis* (36.66–38%), ancylostomatidae (24.66–32%), *T. vulpis* (20–28%) and *A. alata* (28%).

**Keywords:** Dogs, Endoparasites, Faeces, Niš, Public parks, Zoonoses

According to the latest studies related to public health, a large number of dogs are infected by zoonotic parasites whose different developmental forms are eliminated by faeces into the environment and represent a permanent danger for people, especially children of preschool and school age (Thomas and Jeyathilakan 2014).

In cities, parks are the main locations where children play, people rest and dog owners bring their pets for stroll. In these places, a close cohabitation of owners' pets with stray dogs occurs, which makes owners' dogs more exposed to new parasitic infections. The presence of a large number of these animals on a limited area of the city causes constant contamination of public areas, especially streets, parks and sand pools with developmental stages and adult stages from dog faeces (Pavlović *et al.* 2010, Sprenger *et al.* 2014).

Larger systematic studies conducted in certain Serbian cities, such as Belgrade (Pavlović *et al.* 2008), Po•arevac and Kostolac (Pavlović *et al.* 2003), indicated that there was contamination of green surfaces, parks and sand pools in kindergartens, with zoonotic nematodes and cestodes of dogs. Diagnosed cases of parasitic zoonoses on the territory of Serbia (Gvozdrenović *et al.* 2012, Mijatović *et al.* 2015, Perić *et al.* 2017) and city of Niš (Miladinović Tasić *et al.* 2017), indicate that this tendency continued in Niš. One of the important moments and risk factors in the process of the contamination of soil and sand in the public parks of the city of Niš are also the imported parasitic zoonoses. They arrive in Niš with the migration of pets, which come with their owners who are tourists and who regularly visit city parks.

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Due to a justified assumption that on the territory of public parks in urban environments, besides owners' dogs, a large number of stray dogs also circulate and live there, the aim of this paper was to examine and determine the prevalence of zoonotic parasites in the faeces of dogs which stay in the parks of the city of Niš, to evaluate the representation of stray dogs on the basis of the results of performed parasitic screening and to assess the risk they represent for the health of humans in public places and children's playgrounds.

### MATERIALS AND METHODS

*Study design:* The parasitological examination included 300 samples of faeces, which were collected from three public parks of the city of Niš, viz. Tvrdava Park (Park 1), Čair Park (Park 2) and Sveti Sava Park (Park 3). The aforementioned parks represent the urban part of Niš with high population density and a high frequency of pet dogs and stray dogs. The examined material from the parks was sampled during September to October 2018 (150 samples) and February to May 2019 (150 samples). Sampling was conducted on the basis of indicators of bio-climate conditions, taking into account the method of bioclimatogram by Uvarov, which contains the average values of temperature and humidity for the given area.

Coprological diagnostics was done by a qualitative method without the concentration of parasitic elements – a native wet mount according to Pataki (Soulsby 1986) and qualitative methods with the concentration of parasitic elements - the method of gravitational flotation with a

saturated aqueous solution of NaCl with specific weight of 1.200 and a saturated aqueous solution of ZnSO<sub>4</sub> with the specific weight of 1.400 at the temperature of 20°C (Urquhart *et al.* 1996), the method of sedimentation (Hansen and Perry 1994) and the method according to Fülleborn (Euzéby 1982).

The results were quantified by applying the method according to McMaster (Kochanowski *et al.* 2013). The diagnosed eggs of helminths (EPG, eggs per gram) and oocysts of protozoa (OPG, oocysts per gram) were categorised according to the intensity of the established infection in three levels, viz. low (50–100 EPG/OPG), medium (101–500 EPG/ OPG) and high (101–500 EPG/ OPG).

Parasites developmental forms were determined by a morphometric analysis on the basis of morphological keys given by Soulsby (1982) and Euzéby (1982).

All parasitological methods applied in this research that are related to the diagnostics of parasitic diseases are in accordance with the recommendations by ISID (International Society for Infectious Diseases), OIE (World Organisation for Animal Health), WHO (World Health Organization) and WAAVP (World Association for the Advancement of Veterinary Parasitology).

**Study area:** Niš is the largest city in south-eastern Serbia, the seat of the Nišava Administrative District, an industrial and tourist centre of national importance. Over 260,237 residents live on the territory of the city, which makes it the third largest city in Serbia (Census 2011). It is located in

the centre of the basin of Niš, on both sides of the Nišava river, at an altitude of 194 m and it occupies the territory of 596.73 km<sup>2</sup>, including Niška Banja (resort) and 68 suburban neighbourhoods and villages (Fig. 1).

As the traffic crossroads of the most important Balkan and European roads, with its airport, Niš is easily reachable from all directions. Two important directions of the European transport network, viz. Corridor X (Salzburg - Ljubljana - Zagreb - Belgrade - Niš - Skopje - Veles - Thessaloniki) and Corridor VII (a waterway along the Danube which connects Germany with the Black Sea), directly or indirectly connect Niš with a wider, European surrounding territories. According to the European nomenclature, the city of Niš belongs to the category of NUTS3. Niš has a humid continental climate (warm summers and moderately cold winters), with the average annual temperature of 12.08°C, average annual precipitation of 577.79 mm/m<sup>2</sup> (most in October and least in February) and average annual relative humidity of 70.4% (highest in January and lowest in August).

**Samples:** The faeces of dogs were collected in the form of individual and group samples, from the locations where the concentration of faeces was the largest and where it was determined by a macroscopic insight that it was freshly defecated. The number of collected samples was conditioned by the size of the locality and the level of visible contamination by dog faeces. The samples of dog faeces were packed in plastic bags and adequately labelled (date of sampling, location, number and type of sample). They



Fig. 1. Geographic position of the city of Niš and the parks included in the research.

were stored in the portable fridge at 4°C and transported to the laboratory of the Department of Parasitology of the Faculty of Veterinary Medicine University. Coprological diagnostics was performed during the first 24 to 48 h after the arrival of samples.

The statistical analysis was performed using the SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). The statistical analysis of the data included the application of descriptive tests and analytical non-parametric tests (Chi-square test). The descriptive statistics were performed to report the analysis of the data that are presented as mean and standard deviations. The categorical variables are shown as frequency and percentages. The statistical significance was set at  $P < 0.05$ .

## RESULTS AND DISCUSSION

In the examined samples of dog faeces, the presence of 10 endoparasites was diagnosed, whereby 6 of them were at the level of species and 4 of them at the level of genus. During both seasons, protozoa from the genus *Cystoisospora*, nematodes (*Toxocara canis*, *Toxascaris leonina*, *Ancylostoma caninum* / *Uncinaria stenocephala*, *Trichuris vulpis*) and cestodes (*D. caninum*, *Taenia* spp.) were observed. During February–May 2019, it was determined that a nematode *Capillaria aerophila* and a trematode *A. alata* (Table 1) were present in the public parks of Niš.

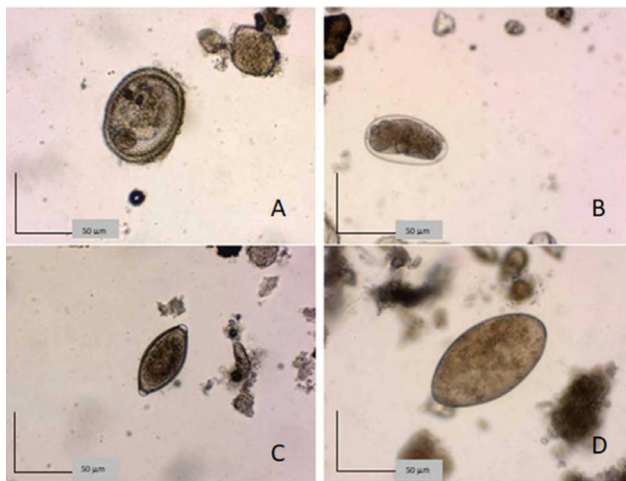


Fig. 2. Most common parasites in Niš city parks. A) egg of *T. canis* 100×; B) egg of ancylostomatidae 100×; C) egg of *T. vulpis*; D) egg of *A. alata* 100×.

The four most frequent endoparasites were *T. canis* (36.66–38%), ancylostomatidae (24.66–32%), *T. vulpis* (20–28%) and *A. alata* (28%) (Fig. 2).

During September–October 2018, the oocysts of protozoa and the eggs of helminths were found in 60% (30/50) of the samples of faeces from Tvrdava Park (Park 1), 64% (32/50) of samples from Èair Park (Park 2) and 70% (35/50) of the samples from Sveti Sava Park (Park 3). The most prevalent intestinal parasites in the three examined parks were *T. canis*, ancylostomatidae and *T. vulpis* (Table 1).

The highest prevalence of *Cystoisospora* spp. (16%; 8/50) was observed in Park 1, *T. canis* (42%; 21/50) in Park 2, *T. leonina* (10%; 5/50) in Parks 2 and 3, *A. caninum* / *U. stenocephala* (44%; 22/50) in Park 3, *T. vulpis* (24%; 12/50) in Park 1, *D. caninum* (8%; 4/50) in Park 2 and *Taenia* spp. (4%; 2/50) in Park 1. Out of coinfections, the most prevalent were a double infection of nematodes of two species in the samples from Park 1 (18%; 9/50) and Park 2 (14%; 7/50), and a triple infection of nematodes of three species (20%; 10/50) in the samples from Park 3 (Table 1). A Chi-square independence test for the observed period did not show a statistically significant correlation between these three parks and the number of positive findings of the total number of endoparasitoses [ $\chi^2$  (2, n=150) = 1.11;  $P = 0.57$ ].

During February–May 2019, developmental forms of endoparasites were determined in 66% (33/50) of the samples of faeces from Park 1, 58% (29/50) of the samples from Park 2 and 70% (35/50) of the samples from Park 3. The most prevalent intestinal parasites were *T. canis*, *T. vulpis* and *A. alata* (in Park 1); *T. canis*, ancylostomatidae and *T. vulpis* (in Park 2) and *T. canis*, ancylostomatidae and *A. alata* (in Park 3). The following largest prevalences were determined: *Cystoisospora* spp. of 22% (11/50) in Park 3, *T. canis* 42% (21/50) in Park 1, *T. leonina* 18% (16/50) in Park 3, *A. caninum* / *U. stenocephala* 28% (14/50) in Park 2, *T. vulpis* 36% (18/50) in Park 1, *D. caninum* 4% (2/50) in Parks 1 and 3, *Taenia* spp. 4% (2/50) in Park 1, *C. aerophila* 14% (7/50) in Parks 2 and 3 and *A. alata* 38% (19/50) in Park 3. Out of coinfections, the most prevalent were a double infection of nematodes of two species (Park 2) - 12% (6/50) and triple infection of nematodes of two species - trematode (Park 1) - 18% (9/50) (Table 1).

For the observed period, a Chi-square independence test did not show a statistically significant correlation between these three parks and the number of positive findings of the total number of endoparasitoses [ $\chi^2$  (2, n=150) = 1.63;  $P = 0.44$ ].

The analysis of the number of positive findings in the examined intervals during September–October 2018 showed that the three most prevalent intestinal parasites were *T. canis* (38%; 57/150), ancylostomatidae (32%; 48/150) and *T. vulpis* (20%; 30/150). In the autumn period, *C. aerophila* and *A. alata* were not diagnosed. The three most frequent endoparasitoses during February–May 2019 were toxocarosis (36.66%; 55/150), trichuriasis (28%; 42/150) and alariosis (28%; 42/150) (Table 1). A Chi-square independence test (with Yate's correction for continuity) did not show a significant correlation between the seasons of research (autumn and spring) and the existence of the number of positive findings for *T. canis* [ $\chi^2$  (1, n=300) = 0.014;  $P = 0.91$ ], *A. caninum* / *U. stenocephala* [ $\chi^2$  (1, n=300) = 1.64;  $P = 0.20$ ] as well as *T. vulpis* [ $\chi^2$  (1, n=300) = 2.21;  $P = 0.14$ ].

The quantitative results show that during the autumn of 2018, the positive samples were dominated by parasitic infections of medium intensity - *T. canis* in Park 2 (57.14%;

Table 1. Results of coprological examination in the autumn 2018 and spring 2019

Endoparasites	Public parks in Niš												χ <sup>2</sup>	p		
	September to October 2018						February to May 2019								Autumn 2018 N=150 n (%)	Spring 2019 N=150 n (%)
	Park 1 N=50		Park 2 N=50		Park 3 N=50		Park 1 N=50		Park 2 N=50		Park 3 N=50					
n	%	n	%	n	%	n	%	n	%	n	%	n	%			
<i>Cystoisospora</i> spp.	8	16	3	6	6	12	5	10	5	10	11	22	21	(14)		
<i>Toxocara canis</i>	16	32	21	42	20	40	21	42	18	36	16	32	55	(36.66)	0.0142	.904987
<i>Toxascaris leonina</i>	3	6	5	10	5	10	2	4	4	8	9	18	15	(10)		
<i>Ancylostoma caninum</i> / <i>Uncinaria stenocephala</i>	16	32	10	20	22	44	10	20	14	28	13	26	48	(32)	1.6416	.200108
<i>Trichuris vulpis</i>	12	24	8	16	10	20	18	36	13	26	11	22	30	(20)	2.2113	.137007
<i>Dipylidium caninum</i>	3	6	4	8	3	6	2	4	-	-	2	4	10	(6.66)		
<i>Taenia</i> spp.	2	4	1	2	1	2	2	4	-	-	1	2	4	(2.66)		
<i>Capillaria aerophila</i>	-	-	-	-	-	-	4	8	7	14	7	14	-	-		
<i>Alaria alata</i>	-	-	-	-	-	-	12	24	11	22	19	38	-	-		
Total positive	30	60	32	64	35	70	33	66	29	58	35	70	17	(11.33)		
Mixed endoparasitic infection	n	%	n	%	n	%	n	%	n	%	n	%				
Protozoa and Nematode	5	10	1	2	5	10	1	2	2	4	2	4	3	(2)		
Protozoa and Cestode	1	2	1	2	-	-	-	-	-	-	-	-	18	(12)		
Nematode and Trematode	-	-	-	-	-	-	-	-	-	-	-	-	42	(28)		
Nematodes of two species	9	18	7	14	5	10	3	6	6	12	3	6	4	(2.66)		
Nematode and Cestodes	3	6	2	4	3	6	3	6	-	-	2	4	3	(2)		
Cestodes and Trematode	-	-	-	-	-	-	-	-	-	-	1	2	-	-		
Nematodes of three species	6	12	4	8	10	20	1	2	5	10	1	2	18	(12)		
Protozoa and Nematodes of two species	-	-	-	-	-	-	1	2	-	-	4	8	42	(28)		
Protozoa, Nematode and Trematode	-	-	-	-	-	-	-	-	-	-	1	2	-	-		
Nematodes of two species and Cestode	-	-	-	-	-	-	1	2	-	-	-	-	-	-		
Nematodes of two species and Cestodes	1	2	2	4	1	2	-	-	-	-	-	-	-	-		
Nematodes of two species and Trematode	-	-	-	-	-	-	9	18	3	6	4	8	-	-		
Nematodes of four species	1	2	1	2	2	4	1	2	1	2	2	4	-	-		

(Table 1. contd...)

Endoparasites	Public parks in Niš												χ <sup>2</sup>	p		
	September to October 2018						February to May 2019								Autumn 2018 N=150 n (%)	Spring 2019 N=150 n (%)
	Park 1 N=50		Park 2 N=50		Park 3 N=50		Park 1 N=50		Park 2 N=50		Park 3 N=50					
	n	%	n	%	n	%	n	%	n	%	n	%			n	%
Protozoa and Nematodes of three species	1	2	-	-	1	2	1	2	1	2	1	2				
Protozoa, Nematodes of two species and Cestodes	1	2	-	-	-	-	-	-	-	-	-	-				
Protozoa, Nematodes of two species and Trematode	-	-	-	-	-	-	1	2	2	4	1	2				
Nematodes of three species and Cestode	-	-	1	2	1	2	-	-	-	-	-	-				
Nematodes of three species and Trematode	-	-	-	-	-	-	1	2	1	2	2	4				
Protozoa, Nematodes of three species and Trematode	-	-	-	-	-	-	1	2	-	-	2	4				
Nematodes of four species and Trematode	-	-	-	-	-	-	1	2	4	8	2	4				

12/21), 60% - 12/20 in Park 3 and 68.75% - 11/16 in Park 1) (Table 2).

During spring 2019, the parasitic infections of low and medium intensity were present equally in the examined parks, and infections of high intensity were more prevalent in relation to the previous season. The most numerous were the samples of faeces with the medium intensity of infection by a nematode *T. canis* [47.62% (10/21) in Park 1; 50% (9/18) in Park 2 and 68.75% (11/16 in Park 3)], followed by ancylostomatidae (71.43%, 10/14) in Park 2, *T. vulpis* (81.81%, 9/11) and *A. alata* (57.89%, 11/19) in Park 3 (Table 2).

The obtained results arose out of the need for a more systematic research of parasitic infections of dogs in public parks of the cities on the territory of the Republic of Serbia. The geographic position of the city of Niš, which is a traffic crossroads of the most important Balkan and European roads, ascribes to this study a special epidemiological significance.

In the faeces of the examined dogs, there were 80% zoonotic endoparasites (8/10), which represent possible contaminants of public areas of the city of Niš. Developmental forms of endoparasites were determined in 60–70% of the samples collected in spring, and 58–70% of those collected in autumn. In both seasons, the eggs of *T. canis* (32–42%) and ancylostomatidae (28–44%) were the most frequently diagnosed, mostly as infections of medium intensity. The contact of humans with the soil is one of the possible ways of spreading parasitic carriers which reach the soil through the excrement of dogs and remain in the soil for a long time, thus making it a potential source of infection (Tudor 2015). The ones that can survive the longest in the soil are the developmental forms of geohelminths, which get inside the organism of a vulnerable individual through injuries on the skin or visible mucosa (ancylostomatide and rhabditide) causing cutaneous *larva migrans* - CLM (Reichert *et al.* 2016, Jaleta *et al.* 2017) or by ingestion (*T. canis*), in which case visceral - VLM or ocular *larva migrans* - OLM occur, which can persist in the tissues of humans even for several years (Overgaauw and van Knapien 2013).

Coccidiosis was diagnosed with a highest prevalence of 16% in autumn (mainly medium-intensity infections) to 22% in the spring (predominantly low-intensity infections). Since toxocarosis and coccidiosis are predominantly diseases of puppies, such a finding could be explained by the fact that young animals are only occasionally taken to public places or spaces for dog socialisation, because they are not yet completely vaccinated. The studies conducted in other cities of Europe such as Portugal (0–5%) (Ferreira *et al.* 2017), central Italy (7.5%) (Riggio *et al.* 2013) and Spain (10.2%) (Martinez-Moreno *et al.* 2007) indicate a lower prevalence of *T.*

*canis* and *Cystoisospora* spp.

Toxascariasis was the most prevalent (10%) in autumn in the form of infections of medium intensity and 18% in spring in the form of infections of low intensity. According to the data from the literature, *T. leonina* is always present in dogs with the lower prevalence in relation to *T. canis*, which can partially be a consequence of endogenic development (histotrophic phase) and the inability to transmit this nematode transplacentally and lactogenically (Traversa 2012).

The diagnostic significance of the determined prevalence of the following should not be neglected - nematode *T. vulpis* (16–24% in autumn and 22–36% in spring), which causes human trichuriasis - accompanied by disorders of the gastrointestinal tract, anaemic and neurasthenic syndromes (Dunn *et al.* 2002); cestodes *D. caninum* (6–8% in autumn and 4% in spring), a potential carrier of human dipylidiosis, which is accompanied by the abdominal pain, anal itching, diarrhoea, indigestion and loss of appetite (Jiang *et al.* 2017), as well as the eggs of taeniidae (2–4% during both seasons of the research). As a precaution, in veterinary medicine, the finding of eggs of *Taenia* spp. in dog faeces has always been stated as the finding of the eggs of *Echinococcus granulosus* – the cause of cystic echinococcosis (hydatidosis) in humans (Vaidya *et al.* 2018).

Relatively high prevalence of trichuriasis was determined, mostly in the form of infections of low and medium intensity can be a consequence of the geographic distribution of carriers or the origin of the examined samples (stray dogs, dogs from breeding kennels). The eggs of *D. caninum* and *Taenia* spp. were not diagnosed in Park 2 during the spring of 2019, which can be a consequence of the lowered circulation of stray dogs in this park. It can also be explained by the fact that there is an enclosed section for pet dogs in Park 2, which is, therefore, visited more intensively by owners' dogs, which are regularly treated against helminths and ectoparasites.

It is assumed that the samples of faeces were positive for the presence of nematode *C. aerophila* (8–14%) which originates from stray dogs, which live in the parks of the city of Niš. This parasite circulates among wild carnivores and it is diagnosed in foxes in suburban neighbourhoods on the territory of Serbia (Lalošević *et al.* 2013, Ilić *et al.* 2016), which represent the source of infection for domestic carnivores. There were also reported cases of pulmonary capillariosis in humans in Serbia (Lalošević *et al.* 2008), which manifests in infected people by the occurrence of acute bronchitis and bronchiolitis, asthma and a productive cough.

In examined dogs, another potential zoonosis – alariosis (22–38%), which is not to be neglected in urban conditions. Over the last few years, there has been a growing interest in the infection by trematoda *A. alata*, which is very widespread in Europe and which causes larval alariosis in humans and is diagnosed in many states bordering Serbia (Croatia, Romania and Bulgaria). Lalošević *et al.* (2014) report on the first finding of mesocercaria of *A. alata* in

Serbia by a routine trichineloscopy of the wild boar's meat which was intended for human consumption. The high intensity of alariosis was reported in wild pigs, which live on territories where a high prevalence of *A. alata* in dogs as true hosts was diagnosed (Esite *et al.* 2012).

We believe that one of the risk factors for dogs which stay in the parks of the city of Niš is the proximity of the rivers, which makes the examined locality a biotope necessary for living and reproduction of transient hosts of this trematoda (Esite *et al.* 2012). Stray dogs which run uncontrollably around parks can be constant carriers of this parasite and they can have an important role in maintaining the chain of infection.

*Capillaria aerophila* (mostly infections of low intensity) and *A. alata* (mostly infections of high intensity) were diagnosed only during February - May 2019, and this seasonality in their occurrence can be explained by the rise in temperatures, which is not common for this period of the year, and it is the consequence of the global warming.

On the territory of Serbia, the research on these problems has so far been conducted only on the territory of Belgrade (Pavlović *et al.* 1997, Pavlović *et al.* 2008, Pavlović *et al.* 2012), Po•arevac and Kostolac (Pavlović *et al.* 2003), when it was determined that there was the contamination of green areas, parks and sand pools within kindergartens with the eggs of *T. canis*, *A. caninum* and *D. caninum*. The results of the conducted epidemiological study indicate that this tendency continued in Niš as well, which is why we suggest that a synchronised cooperation between veterinary and medical occupations in Serbia is necessary. Additional reasons are also diagnosed cases of parasitic zoonoses on the territory of Serbia, whose carriers are eliminated by dog faeces. There have been cases of respiratory capillariosis in humans (Lalošević *et al.* 2008), family epidemics of cryptosporidiosis (Gvozdenović *et al.* 2012), toxocarosis (Mijatović *et al.* 2015), giardiasis (Miladinović Tasić *et al.* 2017) and cutaneous *larva migrans* (Perić *et al.* 2017).

Since humans and dogs share their living spaces and establish a very close contact, and many owners do not take care properly of their pets, there is a possibility of transmitting parasitic diseases from dogs to humans. That is why it is necessary to raise citizens' awareness about the necessity of conducting zoohygienic measures in the breeding of dogs, about the importance of regular coprological tests on the presence of parasites (four times a year), and on the significance of the causal planned dehelminthisation and antiectoparasitic treatment.

The greatest threat to the health of people are stray dogs, which move freely around the parks of the city of Niš. Hence it is necessary to find a long-term solution for this problem by developing a strategy for the regulation of the number of abandoned dogs, with the mandatory parasitological control of public areas. It can be assumed that a more intensive process of the urbanisation of the city of Niš will bring an expansion of the city area onto the natural habitats of foxes, which will enable a more intimate contact of stray dogs and foxes. Since foxes represent a source of numerous

parasitic zoonoses for stray dogs and owners' dogs, an appropriate socio-medical approach is necessary for solving this current medical and ecological problem of urban environments.

On the basis of the results of performed parasitological screening and determined high prevalences of endoparasitoses in the examined samples of faeces, it is estimated that a large number of stray dogs circulate on the territory of city parks in Niš. They uncontrollably defecate on the soil, grass and sand of public parks, thus representing sources/reservoirs of infection for owners' dogs and humans. This information is of special importance for children of preschool and school age, who actively walk and play in parks, where they are continually exposed to potential infections and reinfections by developmental forms of zoonotic parasites.

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