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Nematode Infections Spread in Slovakia, an European Temperate Region

Ingrid Papajová and Jindřich Šoltys

Abstract

Nematode parasitic infections in the twenty-first century present a serious problem. They occur not only in developing but also in industrialised countries of temperate regions. It is well-known that these infections are common for communities living in poverty. Large numbers of nematode infections are transmitted via the faecal-oral route, where invasive parasitic eggs are excreted into the environments by the definitive hosts. The aim of this chapter is to investigate the occurrence of the most important nematode infections spread in major populations and population living under low hygienic standard conditions in the Slovak Republic territory. The data are compared with data available within European Union countries. The incidence of nematodes in domestic animals increases the health risks in low-privilege population. Contamination of the environment with nematodes as well as proposed countermeasures in urban and rural localities are discussed and suggested.

Keywords: nematodes, Slovakia, temperate region, environment

1. Introduction

Zoonoses are diseases transmitted by its natural way between man and animals pose a serious health risk. Principally, the zoonoses transmission is accomplished through close contact with domestic animals, especially dogs and cats, with whom we share more than 60 parasitic species [1]. Of about more than 370 parasite species, 40 of them are classified as zoonotic. According to the WHO data [2, 3], more than 2 billion people are affected by parasitic zoonoses. This is happening not only within developing but also in the industrialised countries, including Slovakia.

Zoonotic diseases are mainly transmitted through the soil or water. Primarily, they are represented by endoparasites such as protozoa and nematodes [4, 5]. In all of these diseases caused by endoparasites, the most likely route of man infection is oral transmission followed by the contact with infected humans and animals (wild, stray, and domestic), with contaminated food, soil, water, or infected environment. The main sources of the infected environment are faeces from infected animals living in close vicinity with the man. Though the contact with an animal is more intense in the rural than in the urban ecosystems, the likelihood of animal diseases spread is greater between stray animals or in animals without veterinary control.

The prevalence of intestinal parasitic diseases in Slovakia is due to its geographical location and relatively low good hygiene conditions. However, it may be easily

dispensable in socially disadvantaged groups of people. Primarily, these diseases occur in the population of marginalised communities, which as a consequence of various factors are distinct by socio-economic exclusion. In Slovakia, according to the performed studies and governmentally released strategy papers, the group most at risk and living in poverty, which is socially excluded and discriminated, is represented by the Roma people. They are a very specific and the most numerous marginalised group in Slovakia [6]. The Roma population is the population with the progressive age structure, that is, with a high proportion of the younger population and with a low proportion of the population over the age of 60. Life expectancy, which is considered to be a fundamental indicator of the population's health status is within the Roma's men 55.3 and Roma's women 59.5 years, respectively. WHO specified the same numbers for the life expectancies in developing countries. The health status of Roma citizens is much worse when compared with the general (major) population. Particularly, there is a high risk of diseases linked with low hygiene standards. The most affected group are children, who are often exposed to the environmental and anthropogenic risks. Among of aforementioned parasitoses, the soil- and man-transmitted nematodes are the most important. They are represented by ascariasis (*Ascaris lumbricoides*), trichuriasis (*Trichuris trichiura*), ancylostomiasis (*Ancylostoma duodenale*), and necatoriasis (*Necator americanus*), which occur in a chronic form.

The objective of this chapter is to investigate: (i) the incidence of nematodes in domestic animals; (ii) contamination of the environment with nematodes; and (iii) the occurrence of the most important nematode infections spread in major populations and population living under low hygienic standard conditions in the Slovak Republic territory.

2. Material and methods

2.1 Coprological examination of excrements

Totally, 1237 dog faecal samples were collected and examined for the presence of parasite developmental stages. Dog faeces have been collected from around the dwellings, public places, or taken directly by the owners from backyards. After the collections, faecal samples were stored at 4°C and transferred to the laboratory for parasitological examination, which was performed within 24–48 h.

Flotation method with the sucrose flotation solution with specific density of 1.27 was used for coprological examination, where 3 g of faecal sample mixed with water was centrifuged for 5 min at 1200 rpm (Eppendorf 5804, Germany). After pouring out the supernatant, the sucrose flotation solution was added into the test tube. The sediment was then stirred and centrifuged again. After 5 min of sedimentation the test tube was refilled with flotation solution again. Then the top of tube was covered with cover glass to detect the eggs trapped in formed meniscus formed. All samples were further examined under the light microscope at 20× and 40× magnification (Leica Microsystems, DM 5000B light microscope, Germany).

2.2 Parasitological examination of soil samples

In order to identify the presence of parasites in the environment, totally 539 soil samples were collected within the vicinity of human settlements and around the kennels and dog pens. The sand samples were surveyed according to the Kazacos [7]. Briefly, 100 g of pooled sand sample, 100 ml of water, and 0.5 ml of Tween 40 were mixed and decanted for 10 min. Subsequently, the samples were sieved and replenished with 1000 ml of water. After 1 h sedimentation, the soil samples

were centrifuged (Eppendorf 5804, Germany) and then floated with sucrose flotation solution (specific density of 1.3). Samples were examined under the light microscope at 20× and 40× magnification (Leica Microsystems, DM 5000B light microscope, Germany).

2.3 Parasitological examination of stool samples

Totally, 1571 children’s stool samples were collected into the plastic containers. After an informed consent was signed by parents or legal guardians stool containers with unique identifiers were handed out together with the instruction regarding its return. Stool samples (up to 5–15 g of morning stool) were stored in refrigerator without any preservation at 4°C and transferred to the laboratory for examination that was performed within 24–48 h. Samples were examined with commercially available kit (Paraprep L, Mondial, France). Briefly, for each stool sample, 2 ml of ethyl acetate solution and 0.5 g of stool sample were added to 6 ml of 10% formalin in a mixing chamber. The chamber was then connected through filter with a conical collection chamber. Mixed content was incubated for 24 h at room temperature and the tube was centrifuged at 1000 rpm for 1 min (Eppendorf 5804, Germany). The entire samples volumes were collected into the collection chambers.

The supernatant was discarded and the sediment placed on microscope slides and covered with coverslip. The entire area was examined at 20× and 40× magnifications with Leica DM 5000B light microscope (Leica Microsystems, Germany).

2.4 Statistical analysis

Statistical significances were determined using Student t-test, ANOVA, and Dunnett Multiple Comparison test at the levels of significance 0.05, 0.01, and 0.001 (Statistica 6.0, USA) [8].

3. Results

3.1 Incidence of nematodes in dogs

All together, 1237 faeces samples from free living spaces and grass areas were collected within selected urban and rural ecosystems in the Slovak Republic territory for parasitological examinations. Endoparasites were found in 38.56% of all examined samples (Table 1). The most frequent were eggs from the family Ancylostomatidae (20.94%) and *Toxocara canis* (14.31%). Incidence of the other nematode eggs was confirmed in the following order: *Ascaris* spp. (8.08%),

Ecosystems	Negative	Positive	Number of samples	Prevalence (%)
Urban	580	198	778	25.45
Rural	133	89	222	40.09**
Low hygienic standard	46	191	237	80.59***
Overall prevalence	760	477	1237	38.56

Significance at the level $P < 0.05$.
** Significance at the level $P < 0.01$.
*** Significance at the level $P < 0.001$.

Table 1.
Prevalence of parasitic developmental stages in dog faeces.

Trichuris vulpis (7.44%), *Toxascaris leonina* (5.58%), *Capillaria aerophila* (3.72%), strongyloid eggs (1.37%), and larvae of *Angiostrongylus vasorum* (0.40%; **Table 2**).

3.2 Nematode eggs occurrence in dog faeces in the urban ecosystem

Among of 1237 examined faecal specimens, 778 were collected within the urban ecosystem. Samples were collected randomly from the public spaces in seven cities of the Slovak Republic and examined microscopically. In summary, 25.45% of all samples were positive for the occurrence of parasitic nematodes (**Table 1**). Eggs, found in the excrements, were from the family Ancylostomatidae (8.61%), *T. canis* (8.10%), *T. leonina* (4.24%), *T. vulpis* (3.86%), *C. aerophila* (1.67%), and *Strongyloids* origin (1.80%; **Table 3**).

In 146 of positive faecal samples, a simple endoparasitic infection was the most common. Mixed infections with multiple intestinal parasites were detected in 52 cases. The most frequent was *T. canis* infection in combination with eggs from the family Ancylostomatidae, *T. leonina* and/or *T. vulpis* (30 samples). Fifteen samples contained three types of nematodes, where the most often infection was represented by helminths from the family Ancylostomatidae, *T. canis*, *T. leonina*, *C. aerophila*, and *T. vulpis*. Mixed infection consisting of four endoparasites was detected in seven samples. These cases were for the most part represented by the Ancylostomatidae family, *T. canis*, *T. leonina*, *C. aerophila*, and *T. vulpis* and/or *G. duodenalis*.

	Negative (n = 1237)	Positive (n = 1237)	Prevalence (%)
<i>Toxocara canis</i>	1060	177	14.31
<i>Toxascaris leonine</i>	1168	69	5.58
<i>Ascaris</i> spp.	1137	100	8.08
Ancylostomatidae family	978	259	20.94
<i>Trichuris vulpis</i>	1145	92	7.44
<i>Capillaria aerophila</i>	1191	46	3.72
<i>Angiostrongylus vasorum</i>	1232	5	0.40
Strongyloid eggs	1220	17	1.37
n, number of examined samples.			

Table 2.
Occurrence of nematode eggs/larvae in dog faeces.

	Negative (n = 778)	Positive (n = 778)	Prevalence (%)
<i>Toxocara canis</i>	715	63	8.10
<i>Toxascaris leonina</i>	745	33	4.24
Ancylostomatidae family	711	67	8.61
<i>Trichuris vulpis</i>	748	30	3.86
<i>Capillaria aerophila</i>	765	13	1.67
Strongyloid eggs	764	14	1.80
n, number of examined samples.			

Table 3.
Nematode eggs/larvae occurrence in dog faeces collected within urban ecosystem.

3.3 Nematode eggs occurrence in dog faeces from rural ecosystem

Totally, 222 canine faeces samples were collected and coprologically examined from the rural ecosystem. Samples came from both, the public spaces and private land within numerous villages located in Slovakia.

The presence of parasitic intestinal developmental stages was confirmed in 40.09% of collected samples (**Table 1**), where 12 species of nematodes were detected. The most prevalent were the eggs of *T. canis* identified in 19.37% of cases and Ancylostomatidae family (16.67%). The other eggs present were *T. vulpis* (8.11%), *C. aerophila* (5.86%), *T. leonina* (0.45%), Strongyloid eggs (1.37%), and larvae of *A. vasorum* (1.44%; **Table 4**). Moreover, the dog faeces in rural areas contained also the eggs of non-specific parasites such as *Heterakis* spp., *Ascaridia* spp., *Moniezia* spp., and *Eimeria* spp. oocysts.

	Negative (n = 222)	Positive (n = 222)	Prevalence (%)
<i>Toxocara canis</i>	179	43	19.37
<i>Toxascaris leonina</i>	221	1	0.45
Ancylostomatidae family	185	37	16.67
<i>Trichuris vulpis</i>	204	18	8.11
<i>Capillaria aerophila</i>	209	13	5.86
<i>Angiostrongylus vasorum</i>	206	3	1.44
Strongyloid eggs	1220	17	1.37

n, number of examined samples.

Table 4.
Nematode eggs/larvae occurrence in dog faeces collected in rural ecosystem.

Parasitic monoinfection was detected in 58 samples. The most common was *T. canis* infection. Co-infection with two parasite species was observed in 17 cases, where the most common was *T. canis* and/or *T. vulpis* infection mixed with Ancylostomatidae and oocysts of *Isospora* spp. Combination of three endoparasites species was detected in nine samples. These mainly consisted of *T. canis*, *T. vulpis*, *C. aerophila*, and Ancylostomatidae eggs. Collection of four species was identified in three samples. Two samples contained a mixture of eggs similar to previous finding (Ancylostomatidae, *T. vulpis*, and *C. aerophila*), but in remaining samples *H. diminuta* eggs or oocysts *Hammondia/Neospora* spp. were also detected. One faecal sample contained eggs of the family Ancylostomatidae, *T. canis*, larvae of *A. vasorum* and *Sarcocystis* spp. oocysts. Joined co-infection with five endoparasites was found only in two samples (eggs of family Ancylostomatidae, *T. canis*, *T. vulpis*, *H. diminuta*, and *Isospora* spp. oocysts).

3.4 The occurrence of nematode eggs in dog faeces from areas with low environmental hygiene

In addition to the examination within standard urban and rural environment, the occurrence of parasitic eggs was determined in dog faces from areas with low environmental hygiene. Such locations in our region are represented by Roma settlements. Totally, 237 samples of dog faeces from four areas with low environmental hygiene were examined.

About 80.59% of canine faeces collected around houses were found to be positive for parasitic developmental stages (**Table 1**) and 13 different nematode

species were identified. The most common findings were the eggs from the family Ancylostomatidae (65.40%). Despite the fact that the dogs are not host of *Ascaris* spp., the eggs of this nematode was very frequent (42.19%). Another nematodes present in dogs faeces were *T. canis*, *T. vulpis*, *T. leonina*, and *C. aerophila*. The occurrence of *A. vasorum* larvae was sporadic (**Table 5**).

Unlike in the urban and rural ecosystems, only 45 dogs living in areas with low hygiene environment have monoinfections. Multiple co-infections have been confirmed in 146 dogs. Two nematode species were detected in 48 samples and represented primarily by the eggs of the family Ancylostomatidae and *Ascaris* spp. Three nematode species were present in 43 samples, four in 29 samples, and five in 18 cases. Seven examined dogs were infected with six nematodes. Infection with seven nematodes (*T. canis*, *T. leonina*, *Ascaris* spp., Ancylostomatidae, *T. vulpis*, oocysts of *Isospora* sp., and *G. duodenalis*) were confirmed in one sample.

3.5 Contamination of soil by nematode eggs and larvae

The above average occurrence of nematode eggs and larvae in dog faeces poses high risk for environmental contamination. Therefore, their prevalence in the soil was monitored and its effect on population living in the affected areas was analysed.

Totally 539 samples of soil samples from cities in the Slovak Republic were examined to study the risk of environmental contamination. The presence of nematodes was confirmed in 14.47% of all samples. The representation for particular species was as follows: Ancylostomatidae family (7.79%), *Toxocara* spp. (7.24%), *Ascaris* spp. (3.71%), *T. leonina* (2.78%), *Trichuris* spp. (2.23%), and *Capillaria* spp. (0.37%).

In the cities, we focused primarily on the collection of samples from children’s sandpits and public spaces. Together 497 samples were examined and the overall incidence of nematodes in urban environment was 9.86%. The most frequent eggs were of *Toxocara* spp. and eggs of family Ancylostomatidae. Randomly, the eggs of *T. leonina* and *Trichuris* spp. were detected (**Table 6**).

During the sandpits analysis, we sorted them as fenced and unfenced. The unfenced sandpits were found to be contaminated more than fenced. This finding was notable and statistically significant. In comparison with fenced sandpits (4.49%), the prevalence in unfenced sandpits was 12.32% (**Table 6**). The most frequent were the eggs of *Toxocara* spp. eggs from the Ancylostomatidae family. In

	Negative (n = 222)	Positive (n = 222)	Prevalence %
<i>Toxocara canis</i> .	166	71	29.96
<i>Toxascaris leonina</i>	202	35	15.77
<i>Ascaris</i> spp.	137	100	42.19
<i>Ancylostomatidae</i> family.	82	155	65.40
<i>Trichuris vulpis</i>	193	44	18.57
<i>Capillaria aerophila</i>	217	20	8.44
<i>Angiostrongylus vasorum</i>	235	2	0.84

n, number of examined samples.

Table 5.
Nematode eggs/larvae occurrence in dog faeces collected in localities with low hygienic standard.

addition, the unfenced sandpits comprised of *T. leonina*, *Trichuris* spp., and eggs from the family Ancylostomatidae (**Table 6**).

In rural environment, the soil samples were collected from parks, public spaces, and/or from private yards and gardens. In general, significantly higher incidence of parasitic eggs and larvae was found in soil samples collected from rural areas. Up to 44.44% of all examined samples were positive for the occurrence of Ancylostomatidae, *Toxocara* spp., as well as the *T. leonina* and *Trichuris* spp. eggs (**Table 7**).

The highest soil contamination was found in the areas with low environmental hygiene where up to 87.5% of the soil samples contained nematode eggs or larvae at various developmental stages (**Table 7**). The difference, when compared with rural and urban environment, was statistically significant. The soil collected from these sites was contaminated heavily with eggs of Ancylostomatidae family, *Ascaris* spp., *Toxocara* spp., *T. leonina*, and *Trichuris* spp. (**Table 7**).

The differences between the urban, rural and/or with low environmental hygiene examined sites were also compared according to the number of eggs detected per 100 g soil. Soil and sand samples in the urban ecosystem contained 1–10 eggs per 100 g sample. Typically, 1–20 eggs per 100 g sample were found in soil samples from the rural ecosystem. Soil samples collected in low-hygiene areas comprised of 10–1000 eggs per 100 g sample. Moreover, soil samples analysed at these sites contained in general up to 100–200 *Ascaris* spp. eggs per 100 g sample. Also, high numbers of nematode eggs were found for the family Ancylostomatidae (0–100 eggs per 100 g) and *Toxocara* spp. (0–50 eggs per 100 g).

	Sandpits (n = 497) % (p)	Unfenced (n = 341) % (p)	Fenced (n = 156) % (p)
<i>Toxocara</i> spp.	4.43 (22)	5.28 (18)	3.21 (5)
<i>T. leonina</i>	0.80 (4)	1.17 (4)	0
Ancylostomatidae family	3.62 (18)	4.69 (16)	1.28 (2)
<i>Trichuris</i> spp.	0.20 (1)	0.29 (1)	0
Overall prevalence	9.86 (49)	12.32 (42)	4.49 (7)

n, number of examined samples.

Table 6.
Nematode eggs occurrence in sandpits.

	Rural (n = 18) % (p)	Rural with low hygienic standard (n = 24) % (p)
<i>Toxocara</i> spp.	16.67 (3)	58.33 (14)
<i>T. leonina</i>	5.56 (1)	41.67 (10)
<i>Ascaris</i> spp.	0	79.17 (19)
Ancylostomatidae family	27.78 (5)	79.17 (19)
<i>Trichuris</i> spp.	5.56 (1)	41.67 (10)
<i>Capillaria</i> spp.	0	8.33 (2)
Overall prevalence	44.44 (8)**	87.50 (21)***

n, number of examined samples; p, number of positive samples.
Significance at the level $P < 0.05$.
**Significance at the level $P < 0.01$.
***Significance at the level $P < 0.001$.

Table 7.
Nematode eggs occurrence in rural environment and from localities with low hygienic standard.

3.6 Nematode spread in Slovak population

Parasitic nematodal disease incidence in the human population in correlation with environmental contamination and domestic animals was evaluated. Disease monitoring was focused on the most vulnerable children population divided into two groups. First one was represented by kids living satisfactory hygiene condition. Second one was represented by so-called marginalised group living in poor hygienic condition with limited access to the clean water. The living conditions in such settlements are often inadequate and the residents usually live in wooden or brick shacks that often lack basic infrastructural support. Under such conditions, the living space is often shared with a great number of dogs without appropriate veterinary care. As soon as the informed consent was signed by all participants, 1571 randomly selected stool samples from the major and minor (marginalised) population were collected and examined in collaboration with paediatricians and pertinent laboratories. The overall parasitic infections prevalence in children was 12.99%. The most dominant species were *A. lumbricoides* and *T. trichiura* (Table 8). *Hymenolepis nana* and *Hymenolepis diminuta* were detected sporadically. Despite the fact that no perianal examination was performed, *Enterobius vermicularis* eggs were present 26 faecal samples.

All examined children were divided into groups according to the environment where they live. The first group consisted of 851 children from the major population and came from the environment with standard hygiene conditions. The second, marginalised group consisted of 720 children who lived in an environment with low environmental hygiene.

Among of all 851 children who belong to the major population and lived in satisfactory hygiene conditions, only 5 kids were infected with *A. lumbricoides*. A totally different situation was observed in the so-called marginalised group, where the parasitoses incidence was up to 27.64% (Table 8).

A single parasitic monoinfection was observed in 170 children. Co-infection with two nematode species was found in 32 children. The most common infections were of *A. lumbricoides* and *T. trichiura*. Three kids were infected with *A. lumbricoides* and the single-cell parasite *G. duodenalis*. One child was infected with roundworm *A. lumbricoides* and *H. nana*, and one stool sample contained a combination of *T. trichiura* and *H. nana* eggs. Infection with three parasitic species was observed in two cases. The first was combination of *A. lumbricoides*, *T. trichiura*, and *G. duodenalis*. Second case consisted of combination with *T. trichiura* and *H. nana* and *G. duodenalis* cysts.

The incidence of nematodes in children at different ages was also examined. Based on the age, children were divided into three groups: Group 1: Newborn

	Total (n= 1571) % (p)	Marginalised Roma population (n = 720) % (p)	Major non-Roma population (n = 851) % (p)
<i>Ascaris lumbricoides</i>	12.03 (189)	25.56 (184)	0.59 (5)
<i>Trichuris trichiura</i>	2.99 (47)	6.53 (47)	0
Overall prevalence	12.99 (204)	27.64 (199)***	0.59 (5)

n, number of examined samples; p, number of positive samples.

Significance at the level P < 0.05.

**Significance at the level P < 0.01.

***Significance at the level P < 0.001.

Table 8.
Nematodes occurrence in children according the division to Roma or non-Roma population.

	Marginalised Roma population % (n/p)	Major non-Roma population % (n/p)
Newborn	14.17 (127/18)	0.94 (106/1)
Preschool age	29.66 (236/70)	0.63 (315/2)
School attending	28.10 (331/93)	0.48 (420/2)

n, number of examined samples; p, number of positive samples.

Table 9.
Nematodes occurrence in children according to age.

(0–2 years), Group 2: Preschool age (3–5 years), and Group 3: School age (6–18 years). The overall rejection rate between all participants due to incomplete data analysis or non-compliance was 15%.

In children from the marginalised group, the overall parasitic prevalence ranged from 14.17 to 29.66%. The least infected were kids under the age of 2. The most positive stool samples were found in preschool children and kids attending primary school. In opposite to the marginalised group, the overall disease prevalence in children living within major population did not exceed 1% (**Table 9**).

4. Discussion

At the present, it is necessary to create conditions for the co-existence of humans and animals. Man, in the course of domestication, incorporated various animal species into its environment. However, these animals can transfer and can be a source of many viral, bacterial, fungal, and parasitic diseases [9–11]. From this point of view, regarding the spread of parasitic diseases, a significant role is played by domestic animals. Especially, by the dogs and cats which share its living environment with humans. Thus, this co-habitation may represent an important source of contamination by parasites [12–14].

Parasitic status of house held dogs, as well as the other domestic animals, is affected by several factors such as the ecosystem type, breeding, wildlife, dogs use, age, and quality of veterinary care. In an urban ecosystem, the primary roles of the dog (hunting and protection) are diminishing, but its positive psychosocial and emotional influence on humans is on the rise. The town’s infrastructure with flats and apartments impacts the ways how dogs are kept and share their living space with owners. Dogs in cities are in close contact with humans and became part of households. In some cases, the owner takes exaggerated care of their pets what leads to some kind of anthropomorphosis of domestic animals that occasionally could become family members’ substitute [15, 16].

On the other side, such close contact can contribute to the contamination of the nearby human environment. For example, human toxocarosis is traditionally identified as a parasitic disease transmitted by contaminated soil. However, several studies have pointed out on the possibility of transfer through direct contact with the infected animal’s fur. For instance, Wolfe and Wright [17] detected the eggs of *Toxocara* spp. on the coat of 25% examined dogs, where up to 4.20% of eggs were embryonated (capable of infection) and nearly 30% were still developing. Roddie et al. [18] detected *T. canis* eggs in 67% of dogs, and especially in puppies whose contact was limited to its own litter. An alarming discovery was that up to 82.4% of the eggs were viable and either embryonated or under development. In addition to the toxocara eggs, Wolfe and Wright [19] found in dog’s fur, the eggs of *Nematodirus battus*, which usually do not parasite on dogs. It is likely that adult dogs have picked up the parasites from the

other animal species in outside environment by rolling and playing on contaminated soil. Similar findings on the occurrence of infectious parasitic egg in the coat of various dog breeds were also confirmed by Aydenizöz-Özkayhan et al. [20]. The total prevalence of intestinal nematodes in urban localities in Slovakia was 25.45%. In dog excrements, we confirmed the eggs from family Ancylostomatidae, *T. canis*, *T. leonina*, *T. vulpis*, *C. aerophila*, and *Strongyloid* origin. Our results corresponded with those previously published by Antolová et al. [21] and Szabová et al. [22].

In rural ecosystems, the dogs have less companion function and are predominantly kept to guard properties. Usually, the animals do not have access to the interior spaces and are kept loosely on the yards or in the kennels. Under such conditions and in the case of infection, they can spread parasitic germs in surrounding territories. We found that in most municipalities there is no appropriate veterinary care, which may result in insufficient attention to the animal health. Additionally, this is probably also related with poor public health awareness and overall ignorance of the parasitic diseases spread associated with domestic animals. From various reasons, the dog health care very often does not include the prevention against parasitic diseases spread. Especially, in the animals that have no clinical symptoms, a visit to a local veterinarian is not necessary. Another phenomenon is free movement of dogs in villages what is the result of poorly maintained fences and also the owner's negligence. This leads to the spread of parasites into larger areas. The possibility of wandering and close uncontrolled contact with wildlife increases the probability of parasitic infections occurrence in domestic animals. Free living animals that are not under veterinary supervision may be an important source of infection. Many studies have confirmed that there is a higher parasitic of parasites in the population of dogs living in a rural ecosystem than in an urban ecosystem. Fok et al. [23] compared the occurrence of helminths in rural and urban dogs. A higher incidence of helminths was found in rural dogs (56%) when compared with cities (44%). Similar statistically significant difference in domestic animal parasitoses prevalence in the rural and urban ecosystem was reported also by Dubná et al. [24]. The total prevalence of parasites in municipalities around city Prague was 41.7%; meanwhile in the urban ecosystem, it was only 17.60%. Moreover, in a rural ecosystem, the authors found higher prevalence for all 13 detected species. Work of Habluetzel et al. [25] showed that 48.4% of dogs from the rural ecosystem had *T. canis* eggs, while only 26.2% of dogs were infected in the city. A slightly higher prevalence (40.6%) of parasitic eggs in dogs in a rural ecosystem in the Neuquén region of Argentina than in the urban ecosystem (33.4%) was found by Soriano et al. [26]. At the same time, the authors confirmed a statistically significant difference in the prevalence between cestodes and protozoa. In the rural ecosystem, *Taeniidae* ova were found in 44.7% of dogs and sporocysts of *Sarcocystis* spp. in 19.0% of dogs. The prevalence of these parasites in dogs did not exceed 3%. The prevalence of endoparasites in dogs from rural localities in Slovak Republic was 40.09%. *T. canis* and the eggs from family Ancylostomatidae appeared to be the most frequent. Similarly, Szabová et al. [22] confirmed endoparasites in 45.10% of dogs in Slovakia. Our results are similar to the records from neighbouring countries. In Poland, Borecka [27] found parasites in 34.20% of dog excrements and the most frequent were eggs from the family Ancylostomatidae. Dubná et al. [24] reported parasites in 41.7% of dogs examined in Czech Republic, where the most prevalent was *T. canis*.

Among the other important factors affecting the occurrence of parasites within human population is socio-economic status and environmental hygiene quality. In the developing countries, the domestic animals health care is not addressed properly. It is affected by unsatisfactory financial income in large proportion of the population, as well as with low level of health awareness and poor veterinary care. In Nigeria, Ugbomoiko et al. [28] detected 68%, predominantly of *T. canis*, intestinal parasites incidence. The high prevalence of toxocariasis in both dogs and humans was observed by Agudelo et al. [29] within the underprivileged districts of Bogota (Colombia).

Traub et al. [30] found that in Indian community with a low social status 99% of dogs were infected with at least one species of parasite. The most frequent eggs present in the faeces were of family Ancylostomatidae (94.0%), *A. lumbricoides* (31.0%), *T. trichiura* (25.0%), and *Isospora belli* oocysts (2.0%). The occurrence of typically human parasites in a dog's faeces points on the role of a dog as mechanical disseminators of parasitic germs. An increased incidence of parasites may also be found in socially deprived communities living in industrially well-developed countries. In our study, the total prevalence of intestinal parasites among dogs from the areas with low environmental hygiene was 80.59% and 13 different species with predominance of *Ascaris* spp. and family Ancylostomatidae were identified. Rudohradská et al. [31] reported a high parasitic incidence in dogs from segregated Roma settlements in Slovakia. The eggs of at least one parasite were detected in 73.8% of dog faeces samples. The risk of nematode parasites spread in ecosystems may also be increased by lack of owner's interest to perform regular antiparasitic treatment (dehelminthisation).

Increase in the number of dogs over the time in the cities with very limited access to green areas leads to the accumulation of excrement/faeces in public spaces. The pollution of public spaces occurs despite the existence of laws (differs from country to country) regulating the conditions for housing and breeding the animals. For instance, in Slovakia, it is Act No. 282/2002 [32] and paragraph 6, which instructs the owners how to remove biological waste from the environment. The goal of law is to eliminate both factors: the negative aesthetic effect and removal of the endoparasites, which are released into the environment. In particular, dogs and cats are often infected with *Toxocara* spp. and are capable to initiate human toxocarosis. Activities related with the maintenance of urban vegetation, such as lawns and gardens care can contribute to the excrements and parasitic germs dispersal on large areas, where subsequent degradation of excrements leads to the spread parasitic propagative stages in the soil. Such contaminated land is source of further infection and reinfection of animals and poses critical risk to human health. The occurrence of endoparasitic developmental stages is monitored regularly by local health authorities. Mizgajska [33] shows that in Poland, soil contamination by endoparasites in urban development ranges between 38 and 53%, where the most frequent are *Toxocara* spp. and *Trichuris* spp. The high incidence of *Toxocara* spp. (67%) was also detected by Ruiz de Ybanez et al. [34] in the parks of Murcia (Spain). Somewhat lower level of soil contamination (45.5%) was observed by Martínez-Moreno et al. [35] in the urban parks of Cordoba, where *Toxocara* spp. and *T. leonina* were also detected.

Mizgajska-Wiktor and Jarosz (2007) performed a 5-year epidemiological monitoring for parasitic soil contamination in the city of Poznan and its surroundings. Interestingly, there was higher soil contamination within the city (19.8%) than in its rural area (15.6%). Gawor et al. [36] studied the epidemiology of soil contamination and the probability of reinfection in children diagnosed with toxocarosis. After the examination of soil around the households of sick children, it was found that *Toxocara* spp. occurred more frequently in rural settlements (27.5%) than in urban environment (21.1%).

An extensive attention should also be focused on the endoparasitic contamination of children's playgrounds where if not properly fenced the dogs and cats can litter. Children who have not yet developed their hygienic habits and are in direct contact with sand or may have geophagia are at the most risk. Ferre and Dorchie [37] detected *Toxocara* spp. on 38% of examined playgrounds and public parks in Toulouse (France). Talvik et al. [38] in Estonia found higher incidence of *Toxocara* spp. in sandpits (17.8%), which were contaminated by cat excrements, when compared with the soil in the parks (4.2%).

Our results confirmed that the occurrence of endoparasites at children's playgrounds is also affected by the level of protection against house held or free living

animals. Jansen et al. [39] confirmed that fenced sandpits reduced the occurrence of parasitic developmental stages in comparison to the unprotected. This finding was endorsed by the study of Blaszkowska et al. [40] who carried out a survey on parasitic contamination in Lodz (Poland). Fenced sandpits and playgrounds, which were part of schools or kindergartens, contained only 1.4% geohelminths eggs. Meanwhile up to 15.7% of soil samples were found to be positive in unfenced playgrounds. The clear influence of fencing on the reduction of sand and soil contamination has also been confirmed by Dubná et al. [24] and Avcioglu and Balkaya [41].

As we mentioned earlier, younger population is most vulnerable to the nematode infections. Our results show that the total prevalence of nematodes within population with low hygiene standards was 27.64%, while only a small number of infections (0.59%) were observed within major population. *A. lumbricoides* was found to be the leading parasite (25.56%) and results corresponded with those of Rudohradská et al. [42]. Kubiak et al. [43] reported the prevalence of intestinal helminth infections among children in Poland from 3.30 to 46.30% where the most frequent parasite was *E. vermicularis*. In our study, *E. vermicularis* eggs were present in some stool samples. Since no perianal swabs were performed, only heavy infections could be detected. Significant differences in the nematodes prevalence between marginalised population and the major population were constantly confirmed. Based on our results, we can definitely conclude that nematode infections even now in twenty-first century still present a serious health problem.

5. Conclusion

Despite the temperate climatic conditions, nematode infections are still a threat to the public health. The counter measures against diseases spread should be engaged at several levels. Those are represented by appropriate sanitation, disruption of natural parasitic life cycles, soil decontamination, and improvement in hygiene standards. This all should be accomplished through the following actions:

- Perform compulsory surveys regarding the epidemiology, the presence of intermediate, and definitive hosts and soil contamination.
- Approaches such as geographical information systems (GIS) including spatial and environmental analysis should be considered and utilised to reveal biogeographical properties for particular parasitic diseases spread.
- Scrutinise the cultural and social habits from the rural and urban areas and examine the sanitary conditions and hygiene in affected areas.
- Implement appropriate control strategies, for the urban and rural settings, to protect farmers and pet owners.
- Increase public awareness about parasitic diseases spread via community centres, local governmental authorities, veterinary and health care services.

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Author details

Ingrid Papajová* and Jindřich Šoltys
Institute of Parasitology, Slovak Academy of Sciences, Košice, Slovak Republic

*Address all correspondence to: papaj@saske.sk

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