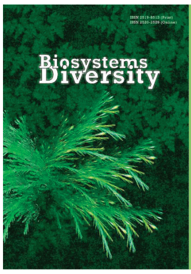

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Contamination of urbanized territories with eggs of helmiths of animals

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The large number of species which cause parasitic infestations and the wide variety of routes and factors of their transmission give great relevance to systematic veterinary-sanitary research into environmental objects, necessarily paying attention to local natural-climatic conditions, social structure and the activities of the population. This problem is most often studied by medical researchers and ecologists, and the extent of studies on this topic from a veterinary-sanitary point of view is insufficient, which conditioned our choice of the current scientific study. Our goal was determining the level of contamination of urbanized territories with exogenous forms of helminths. The research was conducted during 2010–2018 in the territory of Kharkiv Oblast of Ukraine. During the study, we examined 41 samples of soil, extracted both in rural areas, and in urban conditions, and also 100 samples of feces of animals and birds. During the examination of soil from rural areas in Kharkiv Oblast and soil in Kharkiv and Balakleia, we found that it was contaminated with eggs of helminths of different morphotypes. It was determined that mean level of contamination of soil in rural area equaled 12.5%. At the same time, the level of contamination of soil of river banks was 15% at intensity of 52 ± 5 eggs/kg of soil and 10.0% in meadows at intensity of 54 ± 8 eggs/kg of soil. The level of contamination of the soil of park zones of urbanized territories with exogenous stages of helminths was 5–55% and that of residential zones of cities was 20.0–23.3%. In general, in the samples of soil, eggs of Strongilata, Ascaridata, *Trichocephalus* and Cestoda were isolated, and in the soil of rural areas also eggs of Trematoda class. It was proved that cattle and small ruminants discharge feces into the environment which have highest number of eggs of Strongylata spp. helminths (285 ± 3 eggs/g of feces). Excrement of infested birds contaminate the environment with exogenous forms of helminths of Trichocephalata (*Capillaria* spp.) suborder (101 ± 7 eggs/g of feces). In cities, dogs and cats, infested with helminths, discharge into the environment feces with eggs of parasites that belong to *Toxocara* spp. (75 ± 4 eggs/g) and *Dipylidium caninum* (6 ± 1 eggs/g). Droppings of infested birds contaminate the environment with exogenous forms of helminthes of Strongylata spp. (57 ± 2 eggs/g), *Ascaridia* spp. (19 ± 4 eggs/g) and *Capillaria* spp. (11 ± 2 eggs/g).

Keywords: soil; feces; animals; rural area; urban territory.

Introduction

The large number of pathogen species of parasitic diseases and the variety of routes and factors of their transmission give high relevance of systematic veterinary-sanitary studies of environmental objects, with attention necessarily paid to local natural-climatic conditions, the socialstructure and activities of the population (Naish et al., 2004; Brooker et al., 2006; Beugnet et al., 2014). This problem is most often studied by medical researchers and ecologists (Brooker et al., 2006; Pullan et al., 2014; Cholewiński et al., 2015; Wang et al., 2016); the number of studies on this problem from a veterinary-sanitary point of view is insufficient, which conditioned our choice of the research presented here.

Most often the place of accumulation, maintenance and phoresis of eggs and larvae of parasites is soil (Chammartin et al., 2014; Seo et al., 2016; Steinbaum et al., 2016). According to Romanenko (2000), contamination of soil with pathogens of parasitic diseases fluctuates from 3.5% to 24.7%, and in fields irrigated by drainage water and drains of livestock farms – up to 60%. In territory of livestock farms and places for public recreation (parks, park squares, beaches), parasitological contamination reaches 5–40%. It was also determined that food material from kitchen gardens (vegetables, berries, table greens) is contaminated with exogenous forms of helminths at 88% (Romanenko, 2000).

Volochevy (2000) mentioned that the extent of infestation of soil in Moscow with exogenous forms of helminths is 5.3%. At the same time, the highest contamination of soil has been observed in spring (April–May) – 12.9%, and autumn (14.3%). Samples of water from puddles were also contaminated with eggs of helminths of carnivores by 8–20%. Feces of animals, collected in the territory of the city, were found to have 8.2% contamination, at the same time share of eggs of *T. canis* equaled 3.3%. It was also determined that infestation of street carnivores in the city with *T. canis* was 33%. Also, Bekish (2006) reports that contamination of soil with eggs of Ascaridata helminths in the city of Vitebsk was 18.8% whereas in park zone this parameter equaled 55%, and in districts of multi-storey buildings – 42%, and in the river bank zone of the city – 8.3%, and the average amount of eggs of helminths in 100 g of soil equaled 6.5 specimens.

A dependency has been determined between contamination of soil with exogenous forms of parasites and infestation rate of animals which live in the territory (Chiejna & Ekwe, 1986). It has been determined that the structure of soil affects the efficiency of renewal of eggs of helminths; sandy samples led to higher renewal compared to loamy samples (Steinbaum et al., 2017). In urban and urban outskirts territories, in samples of soil, eggs of *Toxocara* dominated. In soil of city outskirt areas, eggs of Taeniidae, *Uncinaria* and cocoons of *Dipylidium caninum* were found more often than in the city, and eggs of *Trichocephalus* were found more often in samples of soils from territories of the city. The highest concentration of eggs of helminths in the studied zones was observed in places for walking animals (Avcioglu & Balkaya, 2011; Karagiannis-Voules et al., 2014; Soares Magalhães et al., 2015). Through analysis of logistic regression, it was determined that age, environment and diet are determining risk factors of infestation of animals with the feline helminth *Toxoplasma gondii* (Lopes et al., 2008).

Viderker (2005) has experimentally determined that 61.2% of the studied objects and 51.2% of the examined samples from the territory of Ulyanovsk Oblast were contaminated with exogenous forms of helminths. Intensity of soil contamination was 42.4 ± 28.6 specimens/kg. In samples extracted from the territories remote from the settlements, no propagative stages of the development of helminths were found; this proves that in urbanized territories, a process of intensification of parasitic contamination of the environment occurs. In the analysis of the helminthofaunistic structure of the contamination, the presence of ten morphotypes of propagative development stages of helminths was determined. These were eggs of *Toxascaris leonina*, *Toxocara* spp., *Ascaris* spp., *Neoascaris vitulorum*, *Metastrongylus* spp., eggs of nematodes of birds, representatives of Trichochephalata suborder, trematodes of the Opisthorchiidae family and *A. alata*, oncospheres of Taenidae spp. The soil was most intensively contaminated with eggs of Nematoda class helminths – 35%; this is related to the fact that representatives of this group are geohelminths and soil is a necessary environment for their development. Propagative stages of representatives of Cestoda class (oncospheres), Taenidae spp., were found in 12.5% of the samples. The source of soil contamination was domestic carnivores. Oncospheres of Cestoda were more often found in soil from private homes and yards of multi-storey buildings. Exogenous forms of helminths, found in soil, indicate that it poses a direct danger for animals and humans. Also, in the Kabardino-Balkar Republic, Zhuravliov (2009) found high level of contamination of rural and urban settlements and pastures with eggs of *Echinococcus granulosus*, where the percentage of invasive samples of soil ranged within 84.1–100.0% with presence of tens and hundreds of eggs of cestodes in 1 kg of soil. Humans are in daily mechanical contact with these contaminated biotopes, which conditions increase in infestation of the population with *Echinococcus*.

According to the results of a study by Masalkova (2015), one can see that the extensive parameter of soil contamination in the northern region of Belarus was 36.5% with content of invasive pathogens of helminthiases of dogs equaling 73.5 ± 5.9 eggs/kg of soil. The level of contamination of urban soil equaled 40.9 ± 3.3%, whereas in rural areas this parameter was 38.5 ± 4.8%. According to the results of the study, 2.7% of contaminated territory was classified as low-contaminated, 24.8% placed in the class moderately-contaminated, and 9.0% classified as highly-contaminated with invasive onset of canine helminths. The helminthological hazard of soil of the studied territory was determined regarding 12 species of helminths of dogs: *T. canis*, *T. leonina*, *D. caninum*, *A. caninum*, *U. stenocephala*, *S. vulpis*, *T. vulpis*, *M. lineatus*, *E. granulosus*, *A. alata*, *C. plica*, *Taenia* spp. The dominating position, according to the results of the study, belonged to *Toxocara canis*, invasive onset of which was found in 37.5% (97 of 259 samples of soil contained eggs of helminths) of soil samples. Eight of the helminths species found were zoonotic and posed a potential threat for humans (Masalkova, 2015).

Pautova (2016) reported that in the Altai, the parameter of contamination of soil with eggs of *Toxocara* spp. was within 3.0 ± 0.2% with fluctuations both by agroclimatic zones of the republic and by years of studies. In the pre-mountain zone, contamination of soil with eggs of *Toxocara* was 2.8 ± 0.2%, low mountain – 3.9 ± 0.6%, middle altitude mountain – 2.9 ± 0.4%, highmountain – 2.6 ± 0.9%. The ovogram of the pathogens of geohelminthiases in the soil of the studied territories of the Altai comprised eggs of *Toxocara* spp. (2.3%), *Ascaris lumbricoides* (0.9%), *Trichocephalus* spp. (0.4%). During examination of samples of vegetables, fruits and greens, selected from commercial facilities of small and medium-sized businesses, and also from markets of settlements in the Altai, in 0.30 ± 0.06% of the samples there found eggs of helminths, including *Toxocara* spp. – (0.06 ± 0.01%), *Ascaris lumbricoides* – (0.10 ± 0.02%), *Trichocephalus* spp. – (0.10 ± 0.02%), *Enterobius vermicularis* – (0.02 ± 0.01%). Eggs of helminths were found most often (80.4%) in soil of the territory of children's playgrounds; Ascarididae (50.4%), *Toxocara* (27.0%), *Trichocephalus trichiura* (23.0%). In soil of the territory of places for recreation, eggs of Ascaridata were found in every second sample.

Increase in the number of dogs in cities, their high level of infestation with toxocariases, on the one hand, and high fertility of *Toxocara*, on the other hand, explain the high level of contamination with eggs of helminths in the soil of parks, children's playgrounds and other places, which creates potentially high threat for humans (Abe & Yasukawa, 1997; Thomas & Jeyathilakan, 2014). According to Peshkov (2006), the number of samples of soil from parks and children's playgrounds, in which invasive eggs of *T. canis* were found, fluctuated from 15% to 78%; in the city of Moscow – 16.6–52.5%, and 10–11% of samples from sand boxes in kindergartens were contaminated with eggs of *T. canis*.

Studying distribution of pathogens of parasitic diseases of animals in the environment in Kyiv, Zhytomyr, Cherkassy and Chernihiv Oblasts, Voloshyna (2008) reported that contamination of water with helminths equaled 0.7%, soil – 10.7%, at the same time eggs of *Neoascaris* were isolated in 16.9% of cases, Ascarididae of swine – 21.0%, Ascaridata of carnivores – 62.1%. According to her data, examination of samples of soil and vegetation from parks and park squares of large cities of Ukraine indicate that contamination with eggs of helminths equals 6.7–87.0%. In rural areas, contamination increases to 93.5%, and is highest near livestock enterprises – 97.2%. According to the results of the conducted studies, contamination of environmental objects in the cities with eggs of Cestoda was 7.3–29.5%, eggs of nematodes – 72.7–84.5%, and in rural areas this parameter equaled 33.5% and 60.0% respectively. Among nematodes, eggs of Strongilata took up the greatest share in the rural area – up to 67.0%, in cities – eggs of Ascaridata (up to 62.1%). According to Pryhodina (2002), contamination of samples of soil from park and accommodation zones of Donetsk with nematodes was 77.5% (*Toxocara* – 45.0%, *Toxascaris leonina* – 18.0%, *Uncinaria* – 9.2%, *Ancylostoma* – 3.2%, *Trichuris trichiura* – 1.4%), Cestoda – 29.5% (*Dipylidium caninum* – 21.2%, Taeniidae – 5.1%).

In Ukraine, intense contamination of soils with exogenous stages of the development of helminths of the Ascarididae order in urbanized territories is related mainly to a number of factors: steep and uncontrolled increase in contamination of specific (domestic predators) and non-specific (human) hosts and their contacts; worsening of sanitary conditions of living of people and keeping animals; absence of specially allocated territories for pasture of animals, lack of culture of removing excrements of animals, access of dogs and cats to rubbish, places of trade with food products, inefficiency of social programs like "Animals in the City", deficiency in number and low effectiveness of functioning shelters for street animals (Bessonov, 2002).

Regarding rural area, in pastures, the most frequently observed parasites have been invasive larvae of Strongilata, gastrointestinal tract parasites, larvae of strongyloidiases and eggs of trematodes of agricultural animals (de Silva et al., 2003; Amoah et al., 2018; Campos et al., 2018).

According to the data of Boyko & Brygadyrenko (2017, 2019), Gugosyan et al. (2019), assessment of the condition of invasive larvae contamination in spring pastures in some regions of Dnipropetrovsk Oblast has confirmed their unsatisfactory condition with regard to helminthiases of large cattle involving five genera of nematodes: *Strongyloides*, *Bunostomum*, *Haemonchus*, *Oesophagostomum*, *Dictyocaulus*. It was proved that larvae of these helminths retain their vital activity in soil over winter. A direct dependence has been confirmed between intensity of infestation of animals and level of contamination of pastures with invasive larvae. At the same time, from territories of pastures of the Oblast, 63 samples of soil were studied, which were extracted from the surface and from different depths (10–25 cm). Various helminthofauna were observed on the surface of soil and at depth of 10 cm. Thus, in Dnipropetrovsk district there were found larvae of *Oesophagostomum radiatum*, *Strongyloides papillosus*, *Dictyocaulus viviparus*; in Piatyhatsky District – *Dictyocaulus viviparus*, *Bunostomum phlebotomum*, *Oesophagostomum radiatum*, *Haemonchus contortus* and eggs of strongyloidiases; in Tsarychansky district – *Oesophagostomum radiatum*, *Haemonchus contortus*. The highest level of contamination of soil was observed in Piatyhatsky District, where five species of helminthiasis pathogens were found. Two species of helminths were found at depth down to 25 cm. Slightly lower was contamination of soil from pastures of other studied districts: in Dnipropetrovsk district – three species of pathogens which were found on the soil surface, and in Tsarychansky District – two species which were found on soil surface and at 10 cm depth. It was determined that larvae of the parasites are viable, because they were active and mobile.

During the examination of pastures of the Caspian region, conducted by Mahomedov (2007), it was determined that in winter and summer pastures from November to Mid-April, eggs and larvae of *Oesophagostomum* and bunostomiases die, and eggs and larvae of other nematodes remain vital. In the study of samples of soil and vegetation from pastures of northern zone of Belarus, Goroveno (2014) found in spring period up to 9.0 spec./kg of eggs of *Strongyloides* of the gastrointestinal tract, up to 4.0 spec./kg – larvae of strongyloidiases, up to 4.7 spec./kg – eggs of *Fasciola*. In summer, their number decreased on average by 60–64%, and increased again in spring. According to her data, the determining coefficient of correlation shows that most relations between intensity of discharge of eggs of Strongilata of the gastrointestinal tract and strongyloidiases with feces of animals and contamination of soil with invasive material are low positive.

Presence of eggs of helminths was determined on raw vegetables, including lettuce, green onion, cucumbers, carrot, cabbage, and tomatoes. At the same time, discovered eggs of helminths included *Taenia* spp. (3.5%), *Toxocara* spp. (1.5%), and eggs of *Ascaris lumbricoides* (1.0%). These results indicate the possibility of transmission of eggs of helminths through unwashed vegetables (Kozan et al., 2005).

Given noncompliance of veterinary-sanitary norms and rules in livestock enterprises, along with problem of endoparasites, the threat of rapid spreading of dangerous endoparasites exists, which in turn requires a complex approach to solving the abovementioned parasitic problems (Paliy et al., 2018). The objective of our study was to determine the level of contamination of urbanized territories with exogenous forms of helminths.

Materials and methods

For determining the level of contamination of soil with eggs of helminths, we extracted samples from the upper layer from an area of 100 cm^2 and at depth of 10 cm, with total mass of 100 g. In laboratory conditions, 25 g samples of soil were put into centrifuged test tubes of 250 mL to which 150 mL of water was added and the mixture was stirred for 5 minutes using a glass stirrer. Then, particles that had floated up were removed, and then centrifugation was conducted for 3 minutes at 1,000 rpm. The liquid above the precipitate was poured out, and 150 mL of saturated solution of sodium nitrate was added, stirred and centrifuged again for 3 minutes. Test tubes were put onto a support stand, and distilled water was poured until a meniscus formed, and then test tubes were covered with defatted glass (6 × 12 cm). After 15 minutes, the glass was taken away, and a few drops of 50% glycerine were added to the humid surface, and analyzed using a microscope. Indication of eggs was carried out in three replications (Piwak et al., 2007).

Veterinary-sanitary assessment of the examined soil by level of its contamination with exogenous forms of helminths (number of eggs of geohelminths per 1 kg of soil) was performed in accordance to normative documents: GOST 17.4.2.01–81 Nature Protection (System of Standards in the Sphere of Nature Protection). Soils. Nomenclature of parameters of sanitary condition; Sanitary rules and 2.1.7.1287-03 "Sanitary-epidemiologic requirements to quality of soil"; Methodological recommendations 2.1.7.730-99 "Hygienic assessment of soil in settlements".

Also, in rural (49.488301 N, 36.810749 E; 49.501994 N, 36.814254 E) and urban (50.007508 N, 36.237193 E; 49.995950 N, 36.164697 E; 49.462124 N, 36.840824 E) areas, we selected samples of feces (50 samples in total from each area). The samples were extracted directly from the soil. Each sample was packed in a plastic bag with a zipper and sent for examination the same day. In laboratory conditions, for floatation, we used a solution of ammonium nitrate, which was prepared by dissolving 1,500 g of ammonia in 1 L of water (density of solution was 1.3) (Kovalenko et al., 1998). From the surface film of each examined sample, we took 3–5 drops of the material using a metal loop, and placed them onto microscope slides for analysis. Species of the discovered eggs of helminths were identified according to morphological (colour, shape, size, number of membranes, presence of the operculums) (Kapustin, 1953) and biological (extent of the development of embryo) features (Daxno & Daxno, 2010).

Extensity of the invasion was determined by ratio of number of samples of feces in which eggs of helminths were found to total number of samples of feces. Intensity of the invasion was determined by number of eggs of helminths in 1 g of feces. From the surface of floatation liquid, we extracted three to five drops using a fecal loop of 0.5 cm diameter and placed them on glass surface for counting. All eggs found in the drops were counted. Then, we counted all eggs in all positive samples. For determining the number of eggs in 1 g of feces, the number of eggs in positive samples was divided by mass of the examined sample (by 5 for examined feces of cattle and swine, by 2.5 for examined feces of small ruminants, and by 1 for poultry) (Trach, 1992). Also the intensity of the invasion was determined according to number of eggs of helminths in 100 g of soil (Romanenko, 2000) and number of eggs in the examined sample from an object (Paliy et al., 2018). Helminthological examinations of the extracted samples were made over 3 days after they had been selected. At the same time, eggs of helminths were found which differed between one another in size, shape and maturity.

Sarzhyn Yar Park is located in Kharkiv and separates Pavlove Pole (in the west) from Nahorny District (in the east) of the city (50.026849 N, 36.231232 E). Today it starts from the forest-park and stretches to the Lopan River. In the past, a stream of the same name flowed along the river bed of the Sarzhyn Yar; it was covered up in 2006. Currently, only few fragments are left from the stream, and the greater part of the slopes of the gully in the central part of the city is being built over with new multi-storey buildings. In the territory of the park, there is a number of relics which attract both locals and tourists. Between the upper part of the park and Oleksiivska Ravine, a reserve tract Pomirky is situated. On the left side of the park, is the Finska Gorka and the Tomb of the Unknown Soldier. On the same slope, the Vidrada Temple of the Mother of God is located, built in 2010. Also, in the territory of the park, there is a bathhouse, a large sports ground, and a play zone for children. Many citizens of Kharkiv arrive here with families, children, and friends for picnics, photo sessions or just recreation outdoors.

Molodizhny city park of Kharkiv is located on Pushkinska street (50.008356 N, 36.251982 E). Its area is 18 ha. The territory of the park has a temple, sport complex of the Polytechnic University, and a children playground. In 2017, a green zone was created in the park, additionally attracting visitors. Molodizhny Park is a quite popular place for the locals for walking domestic animals.

Results

Within our study, we conducted veterinary-sanitary examination of two objects in rural areas – the bank of the Bakaliika River, which flows across Verbivka village (Kharkiv Oblast, Balakliisky district) and the meadows in Verbivka village. During the experiment, we examined samples of soil extracted from the banks of the river (layer by layer from 0–10 cm depth, length of the examined shore was 250 m) and the meadows where cattle from farmyards are grazed. During the examination of soil from the rural site in Kharkiv Oblast, we found that it was contaminated with eggs of helminths of different morphotypes. The results of studying presence of exogenous stages of the development of helminths in soil of the rural site are presented in Table 1.

Table 1
Sanitary level of contamination with exogenous forms of helminths in soil of the rural site (n = 5)

Objects	Positive samples	% contamination	Contamination of samples with eggs of helminths, %				
			Strongylata	Ascaridata	*Trichocephalus*	Cestoda	Trematoda
Shore of the river	3.0	15.0	100.0	33.3	66.6	33.3	66.6
Meadows	2.0	10.0	100.0	–	50.0	–	50.0
Mean	2.5	12.5	100.0	16.6 ± 16.6	58.3 ± 8.3	16.6 ± 16.6	58.3 ± 8.3

Note: "–" contamination with eggs and helminths is absent.

Analyzing data presented in Table 1, it was determined that both studied objects are contaminated with eggs of helminths. The samples of soil from the shore of the river were observed to bear exogenous stages of the development of five morphotypes, and samples from meadows – three. Level of contamination of soil of the river shores equaled 15.0% at intensity of 52.0 ± 5.3 eggs/kg of soil, and 10.0% at intensity of 54.0 ± 8.5 eggs/kg of soil. Eggs were at the early stage of the development. Determination of invasive onset of pathogens of helminthiases according to size and colour of eggs, we determined that eggs of *Trichocephalus* were present in feces of mammals (45.5%), as well as of birds (54.5%), and eggs of Ascaridata (100%) and Cestoda (100%) were present in feces of carnivores. In samples of soil from meadows, 12.8% more larvae of helminths of Strongilata suborder were found than in the samples from near the river. Eggs of Trematoda class were present in feces of birds (100%), and eggs of *Trichocephalus* were present in feces of both mammals (79.4%), and birds (20.6%).The share of nematodes in contamination of soil equaled 99.4%, Trematoda – 0.8%, Cestoda – 0.4%. Mean level of contamination of soil in the rural site equaled 12.5% and according to assessment parameter (GOST 17.4.2.01–81), the soil was contaminated.

Examination of samples of feces of animals and poultry collected in that area revealed that 100% were contaminated with eggs of helminths (Table 2). Analysis determined that cattle and small ruminants infested with helminths discharge with their feces the highest number of eggs of Strongylata spp. helminths (285 ± 3 eggs/g of feces) to the environment. Droppings of infested poultry contaminate the environment with exogenous forms of helminths of Trichocephalata suborder (*Capillaria* spp.) (101 ± 7 eggs in 1 g of feces).

Table 2
Infestation of animals and poultry with helminths (n = 50)

Animals	Number of samples	Contamination with helminths		
		species of helminth	EI, %	number of eggs/g of feces
Cattle	12	Strongylata spp.	100.0	285 ± 2.9
Small ruminants:	16	Strongylata spp.	100.0	114 ± 16.1
goats	14			107 ± 6.4
sheep	2			146 ± 11.0
Carnivores:	5	*Toxocara* spp.	100.0	65 ± 32.7
cats	2	*Toxocara mystax*		26 ± 8.0
dogs	3	*Toxocara canis*		92 ± 3.6
Poultry:	17	*Capillaria* spp.	100.0	101 ± 6.9
geese	9			95 ± 0.7
ducks	8			107 ± 1.5
Total	50	3	100.0	–

The obtained results of the conducted studies show that soil of the rural area was mostly contaminated with eggs of helminths of cattle, small ruminants, and poultry. At environmental contamination of invasive material, this is one of the dangerous links of epizootic chain, due to accumulation of a large amount of eggs (52.0 ± 5.3 eggs/kg of soil) and larvae (18 ± 3.3) of helminths, which can pose a threat of spreading infestations among vulnerable animals.

Circulation of pathogens of parasitoses in cities is related to a number of ecological and sanitary factors, the main one being increase in the population of cities and uncontrolled increase in the number of domestic animals (dogs, cats) and mechanical carriers (rodents, insects). Today, the epidemiological value of yard and street dogs in formation of epizootic and enzootic breeding-grounds of infestations has increased, which is related to absence of timely sanitary catching of dogs, and also as a result of noncompliance in frequency and extent with required dehelminthization measures.

For studying the level of sanitary contamination with exogenous forms of helminths in urban conditions (Kharkiv), we examined three objects: Molodizhny and Sarzhyn Yar Parks, and a place for training dogs in Molodizhny Park. The results of the examinations are given in Table 3. Soil in the examined parks of Kharkiv is contaminated from 5.0% to 55.5%. In Molodizhny Park, sanitary level of contamination of soil equaled 32.5%. Highest level of contamination with exogenous forms of helminths was observed in soil in Sarzhyn Yar Park (55.0% at 46 ± 1.4 spec./kg of soil) at significant contamination with eggs of Ascaridata (30.9 ± 2.4%). Soil from places of training dogs in Molodizhny Park was observed to be contaminated the least – 5.0% at 13 ± 0.1 spec./kg of soil. Determining invasive onset, it was determined that according to the form and colour, eggs of *Trichocephalus* were present in feces of both carnivores (28.5%) and birds (71.5%), eggs of Ascaridata (100%) and Cestoda (100%) – were present in feces of carnivores.

Table 3
Sanitary level of contamination with exogenous forms of helminths in soil from recreation zones in Kharkiv (n = 36)

Objects	Positive samples	Contamination	Contamination of samples with eggs of helminths, %			
			Ascaridata	*Trichocephalus*	Strongylata	Cestoda
Molodizhny Park						
Soil near the alleys	10	50.0	20.0	50.0	80.0	10.0
Soil in the lawn zone	3	5.0	–	33.3	100.0	–
Mean	6.5	2.5	10.0±0.5	41.7 ± 8.4	90.0 ± 10.0	5.0 ± 0.5
Sarzhyn Yar Park						
Soil near the alleys	15	5.0	33.3	46.6	86.6	6.7
Soil in the lawn zone	7	5.0	28.5	57.1	100.0	14.3
Mean	11	5.0	30.9±2.4	51.9 ± 5.3	93.3 ± 6.7	10.5 ± 3.8
Avangard ground, a place for training dogs in Molodizhny Park						
Soil of the territory	1	5.0	–	100.0	100.0	–

Note: "–" – exogenous forms of helminths are absent.

At the next stage, we examined soil samples from a residential district with multi-storey buildings (Kharkiv – Nahorny and Holodnohirsky districts, and also the town of Balakleia (Kharkiv Oblast) – Central district). For this purpose, we selected samples from near five porches, in the territory of children's playgrounds. At the moment of examination near the porches, we saw street animals that were being fed by the locals; nearby various synanthropic birds (sparrows, jackdaws, doves, magpies, and others) were feeding. Taking into account the abovementioned, a conclusion can be drawn that biologic load on the city territory is quite high.

Results of determining the level of soil contamination with exogenous forms of helminths in the area of multi-storey housing buildings are given in Table 4.

Table 4
Sanitary level of contamination with exogenous forms of helminths in soil in the area of multi-storey buildings (n = 40)

Objects	Positive samples	Contamination	Contamination of samples with eggs of helminths, %			
			Ascaridata	*Trichocephalus*	Strongylata	Cestoda
Kharkiv, Nahorny district						
Soil near the porches	7	35.0	28.5	57.1	100.0	14.3
Soil from the territory of the yards	4	20.0	25.0	75.0	100.0	25.0
Soil from children's playgrounds	1	5.0	100.0	100.0	–	–
Mean	4	20.0	51.2 ± 34.5	77.4 ± 17.6	66.6 ± 47.1	13.1 ± 10.4
Kharkiv, Holodnohirsky district						
Soil near the porches	8	40.0	25.0	62.5	87.5	–
Soil from the territory of the yards	5	25.0	20.0	60.0	100.0	20.0
Soil from children's playgrounds	1	5.0	100.0	100.0	100.0	–
Mean	4.7	23.3	48.3 ± 36.6	74.2 ± 18.3	95.8 ± 5.9	6.7 ± 9.4
Town of Balakleia, Central district						
Soil near the porches	9	45.0	22.2	55.6	88.9	11.1
Soil from the territory of the yards	3	15.0	33.3	66.6	100.0	33.3
Soil from children's playgrounds	2	10.0	50.0	100.0	50.0	–
Mean	4.7	23.3	35.2 ± 11.4	74.1 ± 18.9	79.6 ± 21.4	14.8 ± 13.8

Note: "–" – exogenous forms of helminths are absent.

According to the results demonstrated in Table 4, the highest level of sanitary contamination with exogenous forms of helminths was observed in soil near the porches – 35.0–45.0%. The level of contamination with exogenous forms of helminths in soil from the territory of yards of multi-storey buildings in Kharkiv was lower by 15.0% at quantity of 37.0 ± 0.7 eggs/kg of soil, and in Balakleia – by 30.0% at quantity of 32.6 ± 4.1 of eggs/kg of soil, compared to areas near the porches. Most often samples were observed to have eggs and larvae of Strongylata (66.6 ± 47.1% to 95.8 ± 5.9%), and the lowest number was identified for Cestoda. Determining the source of invasive onset, we found that eggs of Ascaridata were present in feces of carnivores and birds, and eggs of Cestoda were present in feces of carnivores.

The level of sanitary contamination with exogenous forms of helminths in soil of children's playgrounds in Kharkiv equaled 5.0% at quantity of 6.0 ± 0.3 in 1 kg of soil: eggs of Strongylata – 33.3%, *Trichocephalus* – 33.3%, Ascaridata – 33.3%, in Balakleia – 10.0% at 8.0 ± 0.1 eggs/kg of soil): eggs of Strongylata – 37.5%, *Trichocephalus* – 37.5%, Ascaridata – 25.0%. It was determined that eggs of *Trichocephalus* were present in feces of birds, Ascaridata – both birds (75.0%) and mammals (25.0%). The level of sanitary contamination of soil with exogenous forms of helminths plays an important part in transmission of helminthiases to the population.

Examination of samples of feces of animals and birds collected in the city showed 100% contamination with helminths (Table 5). Examination of samples of feces revealed that dogs and cats infested by helminths discharge feces with eggs of helminths which belong to *Toxocara* spp. (75 ± 3.7 eggs/g of feces) and *Dipylidium caninum* (6 ± 0.5 eggs/g of feces). Excrement of infested birds contaminate the environment with exogenous forms of helminths Strongylata spp. (57 ± 1.9 eggs/g of feces), *Ascaridia* spp. (19 ± 3.6 eggs/g of feces) and *Capillaria* spp. (11 ± 1.5 eggs/g of feces). The obtained results confirm that soil in cities is mostly contaminated with eggs of helminths of dogs, cats, and synanthropic birds.

Table 5
Infection of animals and birds with helminthes (n = 50)

Animals	Number of samples	Contamination with helminths		
		species of helminth	EI, %	number of eggs/g of feces
Carnivores:	25	*Toxocara* spp. *Dipylidium caninum*	100.0 8.0	75 ± 3.7 6 ± 0.5
– cats	3	*Toxocara mystax* *Dipylidium caninum*	100.0 33.3	48 ± 8.0 3 ± 0.5
– dogs	22	*Toxocara canis* *Dipylidium caninum*	100.0 4.5	104 ± 0.6 9 ± 0.5
Birds:	25	Strongylata spp. *Ascaridia* spp. *Capillaria* spp.	100.0 28.0 36.0	57 ± 1.9 19 ± 3.6 11 ± 1.5
– doves	15	Strongylata spp. *Ascaridia* spp. *Capillaria* spp.	100.0 46.7 33.3	55 ± 0.7 19 ± 3.6 12 ± 1.5
– magpies	3	Strongylata spp. *Capillaria* spp.	100.0 66.6	57 ± 1.5 10 ± 1.5
– sparrows	7	Strongylata spp. *Capillaria* spp.	100.0 57.4	59 ± 1.5 10 ± 1.5
Total	50	5	100.0	–

Generalization of the obtained data demonstrates that soil in park zones of urbanized territories is contaminated with exogenous stages of helminths at 5.0–55.5%, territory of residential zone of cities – 20.0–23.3%, in the rural area – 12.5%. At the same time, soil samples were observed to contain eggs of Strongylata, Ascaridata, *Trichocephalus* and Cestoda whereas in the rural area the soil samples were contaminated also with eggs of parasites of Trematoda class. At comparative characteristic of contamination of objects of the environment with pathogenic parasites in the examined ecosystems, the share of positive samples distributes non-uniformly – 5.0–100.0%.

Discussion

Sources and distribution of different parasitic infections caused by adult and larval stages of different parasites continue to remain an etiological factor of morbidity and mortality not only in underdeveloped, but also industrially developed countries, especially in rural areas (Raether & Hänel, 2003). It was reported that soil in urbanized territories has a leading role in the epizootic process for a number of parasitic diseases. Therefore, in soil in rural areas of Kenya, *Ascaris*, *Trihuris* and *Ancylostoma* are common, at the same time the most abundant were Ascaridata (19.4%) isolated from samples collected near the entrances to the buildings and children's playgrounds (Steinbaum et al., 2016). Over 67% of parks and 1.2% of samples from Murcia city in Eastern Spain were contaminated with eggs of helminths (16.7 ± 20.0 eggs per 100 g of soil), and over 97% of identified eggs were found to be viable (de Ybanez et al., 2001).

The results of our studies, as well as reports by other scientists indicate that domestic dogs and cats can play an important role in transmission of zoonotic agents of helminthiases, such as *Toxocara*, which are directly transmitted from domestic animals to the human environment without any vectors or intermediary hosts. This is facilitated by the high density of feral street dogs and cats, which in turn take part in constant circulation of pathogens of parasitic diseases (Deplazes et al., 2011). Total distribution of cats with endoparasites in a rural area of Western Hungary equaled 39.6%, the most commonly found being: *Toxocara* – 17.4%, *Toxascaris* – 7.2%, *Aelurostrongylus lungworms* – 14.5%, *Capillaria* – 3.8% (Capári et al., 2013). Quite common are infestations with different helminths of dogs (32.2%) and cats (24.3%) in Germany. At the same time, highest number of isolated parasites were representatives of Nematodea class: *Toxocara canis* (22.4%), *Toxascaris leonina* (1.8%), Ancylostomatidae (8.6%), *Trichuris vulpis* (4.0%), *Capillaria* spp. (2.3%), *Crenosoma vulpis* (0.9%), *Angiostrongylus vasorum* (0.3%) (Barutzki & Schaper, 2003). It was reported that 16.9% of samples of dog feces contained eggs of *Toxocara canis*, *Toxascaris leonina*, *Ancylostoma caninum* and *Trichuris vulpis*, and also oocysts of *Isospora canis* (Rinaldi et al., 2006).We should also take into account the possibility of transmission of exogenous forms of helminths by Diptera (Paliy et al., 2018).

The results we obtained on contamination of the environment with eggs of helminths by street animals are confirmed in other publications. Thus, it is reported that street cats live in colonies with high density in city districts and pose a threat to health of domestic cats and humans. It was determined that total distribution of parasites was 90.7%, and 12 species of parasites were determined: *Cystoisospora felis* (14.2%), *C. rivolta* (46.3%), *Sarcocystis* sp. (1.2%), *Ancylostoma tubaeforme* (19.1%), *Toxocara cati* (38.3%), *Ollulanus tricuspis* (30.9%), *Aelurostrongylus abstrusus* (12.4%), *Eucoleus aerophilus* (0.6%), *Taenia taeniaeformis* (3.1%), *Dipylidium caninum* (53.1%), *Joyeuxiella pasqualei* (15.4%) and *Diplopylidium nölleri* (3.7%) (Waap et al., 2014). It was reported that *Capillaria aerophila*, *C. boehmi* and *Trichuris vulpis* are trichuroid nematodes which infest wild and domestic animals around the world (Di Cesare et al., 2012).

Broad distribution of eggs of helminths of *Toxocara* spp. was indicated also by other scientists (Matsuo & Nakashio, 2005; Ozkayhan, 2006; Thomas & Jeyathilakan, 2014). Therefore, eggs of *Toxocara* spp. were found in 30 (75%) out of 40 sandpits in the city of Osaka (Abe & Yasukawa, 1997). According to other data, distribution of *Toxocara* spp. in soil of public parks equaled 64.3%, and average number of eggs was 1.4 per 50 g of sand. Also, soil of parks is contaminated with Taeniid (Avcioglu & Balkaya, 2011). There are data that eggs of *Toxocara* spp. were isolated from 62.5% of children's playgrounds and 15.6% of samples from soil of parks (Aydenizöz Ozkayhan, 2006). At the same time, eggs of *Toxocara* spp. were found in 39 (13.5%) of fecal samples and in 66.7% of samples from public parks (Castillo et al., 2000). According to our studies, among *Toxocara* spp., the largest share belonged to *T. canis*, which coincides with data from other scientists (Masalkova, 2015). Taking into account results of our studies, we have to agree with data of other authors (Dunsmore et al., 1984; Carden et al., 2003; Aydenizöz Ozkayhan, 2006; Avcioglu & Burgu, 2008), that public parks and sandboxes can be sources of toxocariasis. In Argentina 28% of public parks, 5.9% of sandboxes and 2.4% of accommodation buildings were also contaminated with eggs of *Toxocara* spp. Also, distribution of eggs of Ancylostomidae was determined particularly in children's playgrounds in a public park (100%) (Alonso et al., 2001).

It was reported that in Prague, a fairly high level of contamination with eggs of helminths of *Toxocara* spp. was found in parks (20.4%) at average density of eggs of 6.2 per 100 g of soil. Highest level of contamination (45%) was found in yards where feral cats lived. 5% of samples taken from a rural area were contaminated with eggs of helminths (Dubná et al., 2007). However , there were reports that eggs of *Toxocara canis* are rare in public parks in Melbourne (Carden et al., 2003).

From samples of soil in Poznań, the most frequently isolated taxa were *Toxocara* spp. (10%), *Trichuris vulpis* (6%), *Ascaris* spp. (4%) and *Trichuris* spp. Among the studied plots, there were many more eggs of *Toxocara* spp. in the soil of the urban area than in rural territories, and the most contaminated were yards in the center of the city (61% of positive samples) (Mizgajska, 1997).

In rural area, eggs of helminths first of all pose a threat for farmers, who are most often in contact with contaminated objects of live stock (Amoah et al., 2018). Eggs of helminths were experimentally found in 60–100% of field samples, in 20–100% yard samples, in 0–20% samples from gardens and in 10–100% samples of compost. At the same time, the highest average density of eggs of helminths in 100 g of soil was found in compost (44.0) and fields (28.5). In samples taken from cities, average density of eggs equaled 0.4 per 100 g of soil. In soil from fields, eggs of *Ascaris* spp. dominated (87.7%), more rarely *Toxocara* spp. (7.7%) and *Trichuris* spp. (3.5%) were identified. The broadest distribution of eggs with mobile larvae was observed in yards (25.6%) (Blaszkowska et al., 2011).

According to our studies, eggs of *Ascaridia* spp. were isolated from the environment, which in turn area rather dangerous factor for health of people (Nejsum et al., 2005). Also, to the abovementioned, we should add that eggs of helminths are rather resistant to negative environmental factors, which in turn conditions their constant circulation in the environment (Gaspard et al., 1995; Capizzi-Banas et al., 2004), and change in their resistance properties (Boyko & Brygadyrenko, 2017).

The obtained data emphasize the necessity of strategies against parasites, based on demographic control of populations of street cats in cities in order to protect the healthcare of the population (Basáñez et al., 2012; McCarthy et al., 2012; Waap et al., 2014).

Alongside the conducted studies, we have proved that helminthases of animals in livestock farms and complexes are distributed among vulnerable animals due to non-compliance of veterinary-sanitary norms and rules. Examonation of objects of livestock (swine complex, sheep farm, dairy farm, cynological center) in Kharkiv Oblast revealled a significant level of sanitary contamination with exogenous forms of helminths (21.7–45.6%) , which on the soil of their premises was 20.0–36.6% (Paliy et al., 2018).

Understanding of biology and epidemiology of parasites, their epidemiologic and epizootic significance, is necessary for planning and implementing effective scientificantly-based strategies of prevention and control in the general system of veterinary-sanitary measures.

Conclusion

During examination of soil in a rural area in Kharkiv Oblast and soil in cities of Kharkiv and Balakleia, we found that it was contaminated with helminths of different morphotypes. It was determined that the average level of contamination of soil in the rural area equaled 12.5%. Contamination of soil of the river shore equaled 15.0% at intensity of 52.0 ± 5.3 eggs/kg of soil, and in meadows – 10.0% at intensity of 54.0 ± 8.5 eggs/kg of soil. Contamination of soil in park areas of urbanized territories with exogenous stages of the development of helminths was 5.0–55.5%, and in territory of residential areas in cities – 20.0–23.3%.

In general, soil samples contained eggs of Strongilata, Ascaridata, *Trichocephalus* and Cestoda, and soil samples from the rural area were contaminated also with eggs of Trematoda class. It was proved that cattle and small ruminants infested with helminths discharge into environment feces with helminths mostly of Strongylata spp. (285 ± 2.9 eggs/g of feces), excrement of infested birds contaminates environment mostly with exogenous forms of helminths of Trichocephalata (*Capillaria* spp.) suborder (101 ± 6.9 eggs/g of feces).

In cities, dogs and cats infested with helminths discharge into environment feces with helminths mostly of *Toxocara* spp. (75 ± 3.7 eggs/g of feces) and *Dipylidium caninum* (6 ± 0.5 eggs/g of feces). Excrement of infested birds contaminatse the environment with exogenous forms of helminths of Strongylata spp. (57 ± 1.9 eggs/g of feces), *Ascaridia* spp. (19 ± 3.6 eggs/g of feces) and *Capillaria* spp. (11 ± 1.5 eggs/g of feces).

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