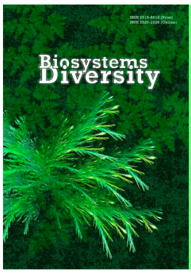

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Contamination of animal-keeping premises with eggs of parasitic worms

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Today, one of the important problems in the cultivation and maintenance of agricultural and domestic animals, both in industrial and private farms, is the spread of ecto- and endoparasites, which cause a significant decline in animal productivity, endanger their health and cause economic losses. The study of the level of distribution and conducting of diagnostic studies on parasitoses of animals in farms with different production orientation is an important and integral part of the overall complex of preventive and health-improving measures. The research was carried out during 2007–2017 in livestock enterprises of Kharkiv Oblast. As a part of the research work, 540 samples were collected from livestock farms, of which 180 were from the premises for keeping pigs, 100 from premises for keeping sheep, 120 from premises for keeping cattle, 80 from premises for dogs and 60 – from the surrounding territories of the livestock enterprises. We found that the objects of livestock rearing (pig complex, sheep farm, dairy farm, cynological center) in Kharkiv Oblast have a significant level of sanitary contamination with exogenous forms of helminths (21.7–45.6%) and the soil of the territories (20.0–36.6%). From samples taken from premises for pigs, eggs of four morphotypes were isolated (*Ascaris suum* – 5.3%, *Trichuris suis* – 14.6%, *Oesophagostomum dentatum* – 60.6%, *Strongyloides ransomi* – 19.4%), from premises for sheep – three morphotypes (*Dicrocoelium lanceatum* – 3.8%, *Trichuris ovis* – 29.3%, Strongylata spp. – 46.9%), from premises for cows – three morphotypes (*Neoascaris vitulorum* – 2.7%, *Trichuris skrjabini* – 12.9%, Strongylata spp. – 34.5%), premises for dogs – four morphotypes (*Toxocara canis* – 6.1%, *Toxascaris leonina* – 5.4%, *Trichuris vulpis* – 20.6%, *Ancylostoma caninum* – 17.5%). It should be noted that the places most contaminated with eggs of helminths were manure gutters (100%) and the floor of livestock buildings (50.0–86.7%). It has also been determined that, in the conditions of the cynological center, the *Musca domestica* was the source of environmental contamination with exogenous forms of *Toxocara canis* and *Trichuris vulpis*, and that the *Muscina stabulans* and *Stomoxys calcitrans* can be the source of spread of larvae of *Ancylostoma caninum* and eggs of *Trichuris vulpis* respectively.

Keywords: pig-breeder; shepherd; cow; cynological center; exogenous stages of development of helminthes

Introduction

The invasion of parasites, when discharged with feces into the environment, pollutes the soil, water, vegetation and can persist for a long time (Paller & de Chavez, 2014; Tun et al., 2015; Dolbin & Khayrullin, 2017). Exogenous forms of helminths in the environment are represented by eggs and free-living invasive larvae (Blaszkowska et al., 2011; Mohd Zain et al., 2013; Steinbaum et al., 2017), posing a serious hygiene problem (Amadi & Uttah, 2010; Shalaby et al., 2010; Ngui et al., 2012). The main goal of veterinary sanitation is prevention of infectious and parasitic diseases of humans and animals, reduction of ecological pollution of the environment, including water, soils, feed and livestock products, elimination of epizootic outbreaks by means of disinfection, disinfestation, disinsection and deratization (Backhans & Fellström, 2012; Paliy et al., 2016; Spanu et al., 2016; Paliy et al., 2018).

The patterns of distribution of exogenous forms of helminths in the environment are determined through studying the distribution of helminthic diseases, identifying the transmission factors of helminthic pathogens, as well as the influence of human economic activity on the species and quantitative composition of parasitic biocenoses (Boyko et al., 2009; Zarlenga et al., 2014). The transition of livestock rearing to an industrial basis has led to the problem of the use and processing of a large amount of waste (manure, bird droppings, wastes from incubation and animal slaughter, etc.). First and foremost, it is biological wastes that pose a threat to the veterinary well-being of farms, as they can be as a source of contamination of air, soil and water through pathogens of infectious and invasive diseases (Hutchison et al., 2005; Graves et al., 2009; Manyi-Loh et al., 2016).

In the circulation of Strongylata larvae in the environment, an important role belongs to water (Van Dijk & Morgan, 2011). It was determined that in the water of the water-troughs in the grazing area, the eggs of Strongylata of the gastrointestinal tract were present in the amount of up to 16.94 specimens/L, and in the water from drinking troughs installed in the premises for animals – up to 6.89 specimens/L. An increase in the content of larvae of *Strongyloides* in the drinking water in pastures was determined in the summer-autumn season – up to 10.80 specimens/L. In the washed off samples from drinking troughs, up to 12.4 specimens/100 cm^2 of eggs of Strongylata of the gastrointestinal tract were found and up to 11.8 specimens/100 cm^2 of *Strongyloides*, larvae and in washings from the floor – up to 14.8 specimens/100 cm^2 of eggs of Strongylata of the gastrointestinal tract, and up to 2.8 specimens/100 cm^2 of *Strongyloides*, larvae and only in winter was the contamination of drinking troughs with the larvae and eggs of helminths absent. In the autumn and winter, in the washings from the walls of livestock premises, no eggs and larvae Strongylata and *Strongyloides* species were found, and in the spring and summer, single specimens were found. In winter, the number of eggs of Strongylata in the washings from the floor was up to 8.0 specimens/100 cm^2, and the larvae of *Strongyloides* were found in the amount of up to 2.0 specimens/100 cm^2. Determination of the correlation coefficient showed that the relationship between the intensity of the excretion of eggs of Strongylata of the gastrointestinal tract and *Strongyloides* and the contamination of the floor was highly positive –

0.74 and 0.77, respectively (Subbotin & Medvedskay, 2013). The conducted research showed a high incidence of contamination of soil of farmland (EI – 8.9%), barnyards (13.3%) and the floor of livestock premises (15.5%). In summer, and especially in autumn, the contamination of the samples increased and equaled: premises – 19.3%, barnyards – 15.3%, pastures – up 6.8% and farm territory – up to 10.9% with contents of 69.3 ± 6.1, 44.5 ± 5.4, 25.2 ± 5.8 and 30.6 ± 5.6 eggs of nematodes respectively in 1 g of feces. Maximum contamination of soil samples of barnyards and pastures was determined in autumn. The autumn rise in contamination level of the environment with eggs of parasitic nematodes occurred as a result of accumulation of invasion and its consolidation on the pastures, as well as in the farm territory and barnyards, causing a threat to the animals throughout the year (Radionov, 2012).

The sources of the invasion of pigs are mostly environmental objects contaminated with eggs of helminths (Tamboura et al., 2006). However, there are significant differences in the degree of contamination of livestock objects in farms with different technologies of keeping animals. Unlike traditional pig farms, in specialized complexes, the livestock facilities are insignificantly contaminated by the eggs and larvae of ascarides, esophagus helminths, *Trochocephalus* and *Strongyloides*. In samples from the stalls where pigs rest, *Ascarida* eggs were found in 9.8% of cases, eggs of esophagus helminths – 6.5%, eggs of *Trichocephalus* – in 5.4%, larvae of *Strongyloides* – in 7.5%. The corresponding infection rates in the samples from floors near feeders and from the feeders were 4.5–8.4%, 3.2–5.1%, 2.6–4.5%, 3.8–6.7% of cases respectively. The equipment of the staff was insignificantly contaminated with eggs and larvae of intestinal nematodes. The highest number of eggs of ascarides, *Trichocephalus*, esophagus helminths and *Strongyloides* larvae in environmental objects and on the skin was found in December – February, the lowest – in September – November (Ivanuk & Bobkova, 2016).

In the study of the samples from pig breeding objects, we found the eggs of *Ascaris suum*, eggs and larvae of *Strongyloides ransomi*, *Oesophagostomum dentatum*, with a degree of contamination of 37.3%, 18.0% and 19.3%, respectively. The largest extent of the invasion of *A. suum*, *S. ransomi* and *Oe. dentatum* was found on the floor of animal stalls – respectively in 31, 20 and 10 samples out of 150. In the study of the walls of the stalls, in 2% cases, the eggs of *Oe. dentatum* were found in small quantities (1 specimen for each sample). Eggs of the helminths were also found in washings of animal care items (brooms, scrapers). Thus, in 13 samples, eggs of ascarides were found, in 1 sample – eggs of *Strongyloides*, in 5 samples – eggs of *Oe. dentatum*. The examination of samples taken from the bottom of the feeders showed the presence of eggs of esophagus helminths in 5 samples. The washings off the udder teats of 100 pig sows showed that eggs of ascarides were present in 8 samples, eggs and larvae of *Strongyloides* in 9 samples, and eggs of esophagus helminths in 3 samples (Antropov & Sidorova, 2007).

Nematodes currently have a leading role in the structure of parasitic contamination of premises and territories where swine are kept (Yadav & Tandon, 1989; Nissen et al., 2011).

During the examination in the kennels of police dogs in Ulyanovsk Oblast, it was determined that they were contaminated with propagative stages of the development of helminths. Overall, 118 samples of 140 (84.3%) were positive. The intensity of soil contamination was 53.4 ± 24.8 specimens/kg. In the soil and premises, the presence of two morphotypes of the propagative stages of the development of helminths, Nematoda (*T. canis*, *T. leonina*) were found. This was related to the fact that the representatives of this group are widespread geohelminths. Eggs of *T. canis* contaminated 78 (66.1%) samples with the presence of 79.1 ± 28.4 specimens/kg, and eggs of *T. leonina* were found in 40 (33.9%) samples with the occurrence of 23.6 ± 5.6 specimens/kg. Correlation analysis of soil contamination and invasiveness of the dogs showed a direct positive relationship (Romanova et al., 2009).

In the study in the police dog kennels, in the washings off the premises, eggs of *T. canis* (5.1 ± 3.5%) were found. Positive samples were found in a vehicle for the transport of police dogs, in the premises for puppies. The samples were observed to contain *T. canis* eggs at the stage of one blastomere ("fresh" contamination) and eggs with moving larvae (Pautova et al., 2012). Nematodes of the Ascaridida order currently take the central place in the structure of parasitic contamination of anthropogenically transformed territories (Trejo et al., 2012). The objective of our research was to determine the level of contamination of livestock biocenoses with exogenous forms of helminths.

Materials and methods

To determine the contamination of the environment with exogenous forms of helminths in premises for animal rearing, we collected samples from feeders, stalls, walls, floors and manure canals after removal of manure. The samples of scraps were taken with a scalpel, put in a plastic bag with a zipper; the time and place of sampling were written on the label. The samples of the washings were collected with cotton or cheesecloth swabs soaked in sterile water, placed in a test tube, and the time and place of sampling were indicated on the label. A total of 10 samples were taken from a single object.

To determine soil contamination, the samples were taken from the surface layer from an area of 100 cm^2 and at the depth of 10 cm with total weight of 100 g (10 samples from one place).

In the laboratory conditions, the scraps were put in glasses with sterile water, carefully stirred, filtered through a cheesecloth layer, transferred to centrifuge tubes. The swabs were thoroughly pressed out, and the obtained liquid after the filtering was also transferred to centrifuge tubes. Centrifugation was carried out at 3000–3500 rpm. for 30 minutes. Subsequently, the supernatant liquid was poured out, and the same amount of distilled water was added to the precipitate, the content was stirred, and again centrifuged for 20 minutes. After centrifugation, the supernatant liquid was poured out, and the precipitate was examined for the presence of eggs of helminths (Kotelnikov, 1984).

For the soil analysis, 25 g samples were put in 250 ml centrifuge tubes and 150 ml of water were added, and then stirred for 5 minutes with a glass rod. After this, the particles that had come to the surface were removed, and the centrifugation was performed again for 3 minutes at 1000 rpm. The supernatant was poured out, 150 ml of saturated solution of sodium nitrate was added to the precipitate, stirred and again centrifuged for 3 minutes. The test tubes were put into support stand, and distilled water was added until a convex meniscus was formed, and then the test tubes were covered with clean glass (6 × 12 cm). After 15 minutes, the glass was removed, several drops of 50% glycerol were added to the wet surface and microscopic examination was performed. Indication of eggs was repeated three times (Piwak et al., 2007).

The veterinary-sanitary assessment of the analyzed soil in relation to the level of its contamination with exogenous forms of helminths (the number of eggs of geohelminths per 1 kg of soil) was carried out in accordance to the current normative documents: GOST 17.4.2.01-81 Nature protection (PSC). Soils. Nomenclature of the indicators of sanitary condition; SanPiN 2.1.7.1287-03 "Sanitary-epidemiological requirements to the soil quality"; MU 2.1.7.730-99 "Hygienic assessment of soil quality of populated areas".

Also, samples of feces were taken from the animals` premises, (at least 10 samples of 25 g each from one object). The samples were taken from the soil, floor or from the transporter. Each sample was packed in a plastic bag with a zipper and transported for the examination on the same day. The accompanying document indicated the name of the farm and the settlement. For the flotation, we used a solution of ammonium nitrate prepared by dissolving 1500 g of nitrate in 1 liter of water (the density of the solution was 1.3) (Kovalenko et al., 1998). From the surface membrane of each experimental sample, using a metal loop, 3–5 drops of the material were taken and put onto the microscope slides and microscopic examination was performed. The eggs of helminths were identified according to morphological (colour, shape, size, number of membranes, the presence of caps) (Kapustin, 1953) and biological (degree of development of the embryo) signs (Daxno & Daxno, 2010).

Extensiveness of the invasion was determined using the formula:

$$\mathrm{EI} = \frac{x}{y} \times 100 ,$$

where EI – extensiveness of the invasion, x – the number of fecal samples in which eggs of helminths were found, y – total number of fecal samples, 100 – coefficient of calculation as a percentage. The intensity of the invasion was determined by the number of eggs of helminths in 1 g of feces (Trach, 1992) and in 100 g of soil (Romanenko, 2000) and by the number of eggs in the experimental sample from an object.

Helminthological studies of the selected samples were performed within three days after the time of their selection. At the same time, eggs of helminths were found which differed from one another in size, form, and maturity.

A veterinary-sanitary inspection of the premises and territory of the intensive pig farm PJSC "Balakliiske Khlibopryimalne Pidpryiemstvo" (Kharkiv oblast, Balakliya district) was conducted. In the intensive pig farm, the pigs were kept in three typical premises. Provision of water, feeding and removal of manure in the complex are automatized. In the first room, there were sows and sows with piglets of up to two months, in the second room – piglets of 2–4 months were kept, and in the third – pigs during fattening. The total number of pigs at the time of the inspection was 420 animals. The territory of the pig farm is fenced off, the manure is systematically removed and disposed of outside the complex.

Also we conducted a veterinary-sanitary inspection of the premises and territory of the sheep farm of PJSC "Balakliiske Khlibopryimalne Pidpryiemstvo". The premises for keeping the sheep on the sheep farm are separated one from another. One section holds ewes with lambs, and the other – the young animals over one year old and rams. The territory is not fenced, adjoins to wasteland and agricultural land, and is separated from Verbivka village by a river. After winter, the premises were not cleaned, the thickness of the litter in the sheepfolds reached 40 cm. At the time of the survey, 315 sheep were kept at the sheep farm.

The next stage of our research was conducting a veterinary-sanitary examination of the dairy farm of the "Verbivskaya" Agricultural Firm (Kharkiv oblast, Balakliya district). The cows are kept in a typical two-row cowshed, the feeding, provision of water, milking and manure removal on the farm are mechanized. The calves, before they become one year old, and heifers of over one year are kept in a separate section. During the warm season, the animals are kept on summer grounds. The territory is fenced, manure is removed and transferred outside the complex. At the time of the survey, 260 cattle were kept at the farm.

Also, we conducted an examination of veterinary-sanitary condition of the center of police dogs of the Ministry of Internal Affairs of Ukraine in Kharkiv oblast, during which we collected and analyzed samples from the premises for the dogs and samples of soil from the territory of the center. The dogs are kept in cages on a wooden floor, which are enclosed with a metal grid, with wooden kennels for resting, the animals are fed and provided with water in individual dishes, feces are removed manually. The collected feces are covered with bleach and stored in a separate fenced place. Once a week, the animals` excrement is taken out for centralized disposal. The cages are cleaned with hot water once a day, and disinfected using a carbolic mixture once a month. At the moment of the study, 63 animals were kept in the center for police dogs.

As part of our research work, we examined 540 samples taken in the livestock farms, of which 180 were from premises for pigs, 100 – from sheep keeping premises, 120 – from premises for cattle, 80 – from premises for dogs and 60 – from the surrounding territories of the livestock enterprises.

Results

Our examination of premises for keeping animals on intensive rearing and traditional farms in Kharkiv oblast revealed the presence of eggs of helminths of various morphotypes. According to the results of the examinations (Table 1), it was determined that the general level of sanitary contamination with eggs of geohelminths in the objects of veterinary control of the pig farming complex was 45.6%, while in 82 positive samples, exogenous stages of the development of helminths of four morphotypes were found *A. suum*, *T. suis*, *Oe. dentatum*, *S. ransomi*. The most common were eggs of *Oe. dentatum*, they were found in the samples 3.1 times more often than eggs of *S. ransomi*, 4.1 times more often than eggs of *T. suis*, and 11.4 times more than eggs of *A. suum*.

It was determined that the level of contamination with exogenous forms of helminths of the manure gutters was 10 times higher than the level of contamination of the walls. The samples from the stalls, floors, manure gutters, and soil from the territory were contaminated with eggs of all mentioned species of helminths, whereas in the samples from the walls only eggs of *Oe. dentatum* (100%) were isolated and 75% of the samples from feeders were contaminated with eggs of *Oe. dentatum* and 25% with eggs of *S. ransomi*.

Table 1
Sanitary level of contamination with exogenous forms of helminths in the pig farming complex (n = 6)

Objects	Positive samples	% of contamination	Contamination of investigated objects with eggs of helminths, %			
			Ascaris suum	*Trichuris suis*	*Oesophagostomum dentatum*	*Strongyloides ransomi*
Stalls	5	16.6	–	20.0	60.0	20.0
Walls	3	10.0	–	–	100.0	–
Floor	26	86.7	11.5	23.1	38.5	26.9
Feeders	4	13.3	–	–	75.0	25.0
Manure gutters	30	100.0	13.3	23.3	40.1	23.3
Soil in barnyards	14	46.7	7.1	21.4	50.1	21.4
Mean value	13.7	45.6	5.3 ± 5.6	14.6 ± 10.4	60.6 ± 21.5	19.4 ± 8.9

Note: "–" – no contamination with eggs of helminths.

In the examined feces of pigs, the extensity of the invasion was 67.7% at the intensity of the invasion of 145 ± 36.1 eggs/g of feces. Eggs of *Oe. dentatum* were found in 64.3% of positive samples, *A. suum* eggs – in 42.9% of the samples, *T. suis* eggs – in 45.2% of the samples, *S. ransomi* eggs – in 35.7% of samples. It should be noted that the animals were found to host mono-and mixed invasions, the average number of eggs in 1 g of feces in cases of monoinvasion was 151 ± 37, in cases of mixed invasion – 139 ± 35.

In the territory, the general level of sanitary contamination of the soil with exogenous forms of helminths was 33.3%, which is 1.4 times lower than in the barnyards. In positive soil samples from the territory, the highest number of the eggs was found in a sample from the place of the outlet of the manure transporter (146 ± 39 eggs/100 g) and at the exit from the complex (97 ± 7 eggs/100 g). In general, by the number of eggs of geohelminths per 1 kg of soil. According to veterinary sanitary assessment of soil (GOST 17.4.2.01-81), it was classified as highly contaminated. Thus, in the barnyard areas, near the outlets of the manure transporters, a significant amount of exogenous forms of helminths accumulate, which could further contaminate the pig farming complex.

The results of determining the presence of exogenous stages of the development of helminths on the sheep farm are presented in Table 2. Analysis of this data demonstrates that the sheep farm, as an object of livestock, was contaminated with exogenous forms of helminths of three morphotypes: *D. lanceatum* (3.8 ± 4.8%), *T. ovis* (29.3 ± 26.9%), as well as the Strongylata (46.9 ± 34.3%) suborder. The general level of sanitary contamination of the premises equaled 34.0%. The extensiveness of the contamination of the floor with exogenous forms of helminths equaled 85%, which was 17 times higher than that of the feeders. In the samples taken from the walls of the premises, no exogenous forms of helminths were isolated. The feeders were contaminated only with eggs of Strongylata spp. helminths at the level of 100% at the intensity of contamination of 14.5 ± 6.1 eggs in one sample.

Table 2
Sanitary level of contamination with exogenous forms of helminths on the sheep farm (n = 5)

Objects	Positive samples	% of contamination	Contamination of investigated objects with eggs of helminths, %		
			Dicrocoelium lanceatum	*Trichuris ovis*	Strongylata spp.
Stalls	2	10.0	–	40.0	60.0
Walls	–	–	–	–	–
Floor	17	85.0	11.7	35.3	53.0
Feeders	1	5.0	–	–	100.0
Soil	14	70.0	7.1	71.4	21.4
Average value	6.8	34.0	3.8 ± 4.8	29.3 ± 26.9	46.9 ± 34.3

Note: "–" – no contamination with eggs of helminths.

The examination of 32 samples of feces of sheep showed that the extensiveness of the invasion was 100%. In sheep' feces, we found eggs of

D. lanceatum in 12.5%, Strongylata spp. – in 100.0%, *T. ovis* – in 53.1%. It was determined that the sheep population, along with monoinvasion, hosted mixed invasion, and the average number of eggs per 1 g of feces was 79 ± 29 and 110 ± 37 specimens respectively.

The level of sanitary contamination of soil in the territory was 40.0%, and soil contamination of the pens exceeded this parameter by 1.75 times. The soil contamination intensity on average equaled 39 ± 15 eggs/100 g. According to veterinary-sanitary assessment of the soil (GOST 17.4.2.01-81), the territory of the sheep farm has been classified as contaminated. Therefore, due to the fact that infected animals graze on the territory near the livestock facilities, they can cause biological contamination with exogenous forms of helminths and their accumulation in the environment.

According to the results of the conducted research (Table 3) it was determined that the examined object was contaminated: in the selected samples, exogenous stages of the development of helminths of three morphotypes were isolated: *N. vitulorum* (2.7 ± 3.6%), *T. skrjabini* (12.9 ± 15.8%) and Strongylata spp. (34.5 ± 34.9%). The general level of sanitary contamination of the premises was 32.5%. The extensiveness of contamination with exogenous forms of helminths in the manure gutters was two times higher than the level of floor contamination. The samples collected from the manure gutters were contaminated with eggs of all abovementioned species of helminths, whereas in the samples from the floor, only *T. skrjabini* (20%) and Strongylata spp. (80%) were isolated.

Table 3
Sanitary level of contamination
with exogenous forms of helminths at the dairy farm (n = 6)

Objects	Positive samples	% of contamination	Contamination of investigated objects with eggs of helminths, %		
			Neoascaris vitulorum	*Trichuris skrjabini*	Strongylata spp.
Stalls	–	–	–	–	–
Walls	–	–	–	–	–
Floor	10	50.0	–	20.0	80.0
Feeders	–	–	–	–	–
Manure gutters	20	100.0	5.0	35.0	60.0
Soil	9	45.0	11.1	22.2	66.7
Average value	6.5	32.5	2.7 ± 3.6	12.9 ± 15.8	34.5 ± 34.9

Note: "–" – no contamination of eggs of helminths.

In the examination of fecal samples of the animals, invasion of *N. vitulorum* was found in 16.8% of calves under 6 months, at intensity of 169 ± 2 eggs/g of feces. In the ewe population, the extensiveness of *T. skrjabini* invasion was 27.5%, while the eggs of Strongylata spp. were found in 57.5% of cows and heifers. The average level of invasion in animals was 39.3%. Therefore, cattle of different age groups hosted both monoinvasions and mixed invasions, and the average number of eggs per 1 g of feces was 174 ± 5 (monoinvasion) and 182 ± 6 specimens (mixed invasion).

The sanitary level of contamination of the soil was 36.6%, at average contamination of 39 ± 38 eggs/kg, which was 8.4% lower than the level of contamination of the soil of barnyards. The highest number of exogenous forms of helminths was found in the soil near the premises for animals: the invasiveness of the samples from the places at the outlet of the manure transporter on average equaled 179 ± 7 eggs/100 g of soil. The eggs were found to be at different stages of development. By the number of eggs of geohelminths per 1 kg, the soil in the territory of the dairy farm was classified under the category "contaminated". Therefore, in case of untimely finding of infested animals and in the absence of conducting preventive disinvasion of the livestock facilities, the level of biological contamination of premises (32.5%) and territory of livestock farms (42.5%) with exogenous forms of helminths increases.

Results of the determination of the presence of exogenous stages of the development of helminths in the premises for dogs are presented in Table 4. It was found that this object was contaminated with exogenous forms of helminths of four morphotypes: *T. canis*, *T. leonina*, *T. vulpis* and *A. caninum*. The sanitary level of contamination was 21.7%. The level of contamination with eggs of *T. vulpis* was 3.4 times than that of *T. canis*. In the samples from the floor and the equipment for animal care, we have isolated the eggs of all abovementioned species of helminths in early stages of the development. At the same time, it should be mentioned that the floor was washed daily.

Table 4
Sanitary level of contamination by exogenous forms of helminths of the premises and the territory of the cynological center (n = 6)

Objects	Positive sample	% of contamination	Contamination of investigated objects with eggs of helminths, %			
			Toxocara canis	*Toxascaris leonina*	*Trichuris vulpis*	*Ancylostoma caninum*
Stalls	–	–	–	–	–	–
Walls	–	–	–	–	–	–
Floor	5.0	50.0	20.0	18.0	40.0	20.0
Equipment	6.0	60.0	16.7	14.2	33.3	33.3
Dishes	–	–	–	–	–	–
Soil	2.0	20.0	–	–	50.0	50.0
Average value	2.2	21.7	6.1 ± 8.7	5.4 ± 8.4	20.6 ± 21.1	17.5 ± 21.6

Note: "–" – no contamination with eggs of helminths.

Along with this, we carried out a coprological study of feces from all animals kept at the center at that time (Table 5). Despite the implementation of veterinary-sanitary measures, 12.7% of the animals were infested with 4 species of helminths. In two samples, mixed invasion (*T. vulpis* and *A. caninum*) was observed. The dogs were infested the most with *T. vulpis* (6.3%), which occurred 1.3 times more often than *T. canis*, and 1.9 times higher than *A. caninum* infestation.

Table 5
Helminthic infestation of dogs of the cynological center (n = 63)

Species of helminth	EI, %	Number eggs in 1 g feces
Toxocara canis	4.8	102 ± 0.7
Toxascaris leonina	1.6	206 ± 4.0
Trichuris vulpis	6.3	85 ± 1,7
Ancylostoma caninum	3.2	68 ± 1.3

The sanitary level of soil contamination was 20.0%, and in general, by the number of eggs of geohelminths per 1 kg of soil, it was classified as contaminated. Therefore, the contaminated floor (50.0%) and the inventory (60.0%) can be the factors of mechanical distribution of exogenous forms of helminths.

The study of the animals in the cynological center revealed that the fly index (the number of insects on an animal before and after treatment) for the dogs was 41. In the cages and in the territory of the police dog center, 312 zoophilous flies were caught. Examination of their species composition revealled the results presented in Table 6. The analysis of the results presented in Table 6 shows that the largest proportion in the entomocomplex of zoophilous flies in the police dogs' center belonged to *M. domestica* – 37.5% and *M. stabulans* – 33.7%, and *S. calcitrans* was also widely distributed – 28.8%.

Table 6
Species composition of zoophilous flies in the cynological center

Species	Quantity	
	number of individuals	%
Musca domestica	117	37.5
Muscina stabulans	105	33.7
Stomoxys calcitrans	90	28.8
Total	312	100.0

At the next stage, we conducted a study to determine the presence of exogenous forms of animal helminths on the surface and the digestive tract of the flies (Table 7). In the premises for keeping the dogs at the police dogs' center, 1.9% of flies carried eggs of helminths of animals on their legs body surface and in the intestine. *M. domestica* have a major role in the distribution of exogenous forms of *T. canis* and *T. vulpis*. The *M. stabulans* and *S. calcitrans* can also be a source of environmental contamination. An egg of *T. vulpis* was found on the body surface of *S. calcitrans* and an *A. caninum* larva was found in the digestive tract of *M. tabulans*. The analysis of the results obtained during the inspection of the livestock objects in Kharkiv oblast shows a significant level of sanitary contamination with exogenous forms of helminths in the objects of animals rearing (intensity – 21.7–45.6%) and the soil of the territories

(20.0–36.6%). Any violations in the complex of treatment and prevention measures in combination with mandatory measures for the protection of the environment from the onset of the invasion of helminths leads to deterioration of the veterinary-sanitary wellbeing of livestock, which is confirmed by the level of the invasion in the animals from 12.7% to 100.0% in these objects.

Table 7
Presence of exogenous forms of helminths of animals in flies

Species	Number	Positive samples	Number of exogenous forms of helminths		
			Species	Eggs, larvae	%
Musca domestica	117	3	*Toxocara canis*	1	0.96
			Toxocara canis+ *Trichuris vulpis*	2	
			Trichuris vulpis	1	
Muscina stabulans	105	2	*Trichuris vulpis*	1	0.64
			Ancylostoma caninum	1	
Stomoxys calcitrans	90	1	*Trichuris vulpis*	1	0.32
Total	312	6	3 species of helminthes	7	1.92

Discussion

The environment acts as one of the driving forces of the epizootic process at helminthiasis of humans and animals. Thus, environmental objects contaminated with an invasive onset of helminths are among the most important factors in the distribution of helminthiases among animals and transmission of the infestations to humans. Sanitary-parasitological monitoring of the natural and anthropogenic environment is of great importance (Christensen, 2001; Chammartin et al., 2013; Salam & Azam, 2017).

Invasive diseases of farm animals are widespread throughout the world (Silver et al., 2018) and have a leading place in the overall morbidity structure, and have a significant impact on herd productivity (Nansen, 1987). The presence of exogenous forms of helminths in environmental objects worsens its veterinary-sanitary condition, and in some cases pose infestation threat to humans. Therefore, it is important to carry out integrated anti-parasitic measures in livestock biocenoses (Eysker & Ploeger, 2000; Charlier et al., 2014; Boyko & Brygadyrenko, 2017).

According to the research conducted by Kochanowski et al. (2017), out of 70 pig farms, 57 were invaded by coccidia (42.9%), *Ascaris suum* (28.6%), *Trichuris suis* (21.4%), and *Strongyloides* spp. (11.4%). The most abundant distribution of coccidia and species of *Strongyloides* was observed among young piglets, eggs of *A. suum* and *T. suis* – among fattening animals, *Oesphagostomum* spp. – in sows. Most of the parasites were found in small rather than average and large farms. Most often, the simultaneous infection of animals with several parasites was observed, which coincides with our data (Kochanowski et al., 2017). The distribution of eggs of helminths in the provinces of China was: *Oesophagostomum* spp. – 86.7%, *Ascaris suum* – 36.7%, *Metastrongylus* spp. – 25.8%, *Strongyloides* spp. – 25.8%, *Trichuris suis* – 15.8%, *Globocephalus* spp. – 6.7%, *Gnathostoma* spp. – 4.2%, *Schistosoma japonicum* – 5.0% and *Fasciola* spp. – 1.3%. The distribution of all helminths, except the species of *Oesophagostomum*, was higher in young pigs (less than 8 months) compared to adult pigs (Boes et al., 2000). However, according to our studies, no infestation of animals with either coccidia or *Fasciola* was found.

According to both our data and the information of other researchers (Armour & Urquhart, 1965; Karshima et al., 2018), the contamination of livestock objects and soil with the exogenous stages of the development of helminths of ruminants is quite common. After being introduced to the environment, eggs of helminths cause a threat of infestation to other animals, which in cases of mass infestations leads to significant economic losses and a 15–20% deficiency in milk (Holzhauer et al., 2011).

Of the environmental objects, the highest intensity of contamination is characteristic of soil which functions as a place for the temporary storage of the invasive onset of helminths, as well as their natural reservoir (Chammartin et al., 2013; Greenland et al., 2015; Salam & Azam, 2017).

Therefore, the distribution of eggs in the soil (*Ascaris*, *Trichuris*) in Bangladesh was 78%, and 37% in Kenya, with the average egg concentration in soil 0.59 and 0.15 eggs/g, respectively. The distribution of eggs of helminths in the soil was significantly higher in Bangladesh than in Kenya (Steinbaum et al., 2017). Other studies have shown that of 1,480 soil samples, 460 (31%) were positive for the presence of eggs of helminths. At the same time, the commonest (77%) were *Toxocara* spp., as well as *Ascaris* spp. (11%), Strongylata spp. (7%), and *Trichuris* spp. (5%). The study revealed that eggs of *Toxocara* spp. are ubiquitous, they prevail in sandy, muddy and loamy soil textures, but are less common in clayey soils (Paller & de Chavez, 2014). In the study of soils in the countryside of Łódź district (Poland), eggs of helminths were found in 60–100% of field samples and 10–100% of compost, and the highest average density of eggs of helminths was recorded in compost – 44 specimens/100 g. The soil from the fields contained mostly eggs of *Ascaris* spp. (87.7%), less commonly *Toxocara* spp. (7.7%) and *Trichuris* spp. (3.5%) (Blaszkowska et al., 2011). However, according to our data, the most common eggs in the soil are those of Strongylata spp. (21.4–66.7%) and *Trichuris* spp. (21.4–71.4%).

The role of dogs as terminal hosts for a number of zoonotic parasites has been widely studied and recognized as an important public health problem worldwide. According to studies by Shalaby et al. (2010), it was determined that out of 25 studied dogs, 14 were infested with *Toxocara canis* (56.0%), two – with *Toxascaris leonina* (8.0%) and two with *A. lumbricoides* (8.0%). One dog was infested with *T. canis* and *T. leonina* at the same time. Therefore, dogs can be reservoir hosts for *A. lumbricoides* and ecological pollutants that increase the risk of human infection. We found that on the territory of the police dogs`center in Kharkiv oblast, the premises and soil were contaminated with exogenous forms of *Trichuris vulpis* and *Ancylostoma caninum* helminths; despite the sanitary measures, 12.7% of dogs were infested with 4 types of helminths: *Toxocara canis*, *Toxascaris leonina*, *Trichuris vulpis* and *Ancylostoma caninum*. In two samples, mixed invasion (*T. vulpis* and *A. caninum*) was observed. Dogs were most infested with *T. vulpis* (6.3%), which was 1.3 times higher than the infestation with *T. canis*. The level of sanitary contamination was 26.7%, and eggs from all mentioned species of parasites in the early stages of the development were isolated from the samples from the floor and the animal care inventory. This confirms the data that dogs are ecological pollutants of the environment.

Our previous studies revealed that the highest number of zoophilous flies in the entomocomplex of a pig farming complex belonged to *Musca domestica*, which has a leading role in the transfer of exogenous forms of helminths (*Ascaris*, *Oesophagostomum*). It has also been proved that *Musca autumnalis* (Paliy et al., 2018) can be the source of environmental contamination with eggs of *Trichostrongylus*. The presented results substantiate the data on the possibility of transfer of pathogens of invasive animal diseases by zoophilous flies, which must be taken into account during of the organization of veterinary-sanitary measures.

The presence of positive samples shows that the complex of antihelminthic measures, performed at the livestock sector (planned dehelminthization, decontamination of wastes, disinfestation of production facilities and the environment) requires further improvement (Charlier et al., 2016; Salam & Azam, 2017). It should also be taken into account the fact that the reason for the infestation of domestic animals may be representatives of the wild fauna, which is supported by the overlapping of the host range of some parasites (Winter et al., 2018).

The results we obtained substantiate the data on the distribution of exogenous forms of helminths in livestock biocenoses, which is proven by the results of other researchers from different countries of the world.

Therefore, the data obtained as the result of our research can be used for raising the awareness among the public, stockbreeders, and especially for pet owners and local healthcare officials, for the purpose of effective prevention and control of parasitoids.

Conclusions

Through the examination of the livestock objects (pig farm complex, sheep farm, dairy farm, police dog center) in Kharkiv oblast, we have found that they have a significant level of sanitary contamination with exogenous forms of helminths (21.7–45.6%) as does the soil of the territories (20.0–36.6%). In the samples from the premises, we isolated eggs of four morphotypes (*Ascaris suum* – 5.3%, *Trichuris suis* – 14.6%, *Oesophagostomum dentatum* – 60.6%, *Strongyloides ransomi* – 19.4%), from sheep – three (*Dicrocoelium lanceatum* – 3.8%, *Trichuris ovis* – 29.3%, Strongylata spp. – 46.9%), cows – three (*Neoascaris vitulorum* – 2.7%, *Trichuris scryabins* – 12.9%, Strongylata spp. – 34.5%), dogs – four morphotypes (*Toxocara canis* – 6.1%, *Toxascaris leonina* – 5.4%, *Trichuris vulpis* – 20.6%, *Ancylostoma caninum* – 17.5%). At the same time, the places most contaminated with helminth eggs were manure gutters (100%) and the floor of livestock buildings (50.0–86,7%).

In conditions of the police dog center, the housefly *Musca domestica* was a source of environmental contamination with exogenous forms of *T. canis* and *T. vulpis* helminths. The species *Muscina stabulans* and *Stomoxys calcitrans* can be the source of distribution of larvae of *A. caninum* and eggs of *T. vulpis*, respectively.

It has been proved that helminthiasiss of animals in livestock farms and complexes are distributed among a susceptible population because of non-compliance with veterinary-sanitary norms and rules, which requires scientifically substantiated application of highly effective measures of dehelminthization and disinfection.

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