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REVIEW OF THE HELMINTHS OF CARNIVORA (MAMMALIA) IN UKRAINE: COMPOSITION AND STRUCTURE OF HELMINTH FAUNA

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Review of the Helminths of Carnivora (Mammalia) in Ukraine: Composition and Structure of Helminth Fauna. Kornyushin, V. V., Malega, O. M., Varodi, E. I., Korol, E. M., Kuzmina, T. A., Sokolova, O. A., Kuzmin, Yu. I. — In the present review, we summarised the information on helminths of 14 species of wild carnivorans (a total of 260 individuals examined) from Ukraine based on an investigation of collection materials. Additionally, helminths of the domestic dog, *Canis familiaris* L. (n = 73) and domestic cat, *Felis catus* L. (n = 11) were reviewed. Helminth species and main helminth taxa (Cestoda, Trematoda, and Nematoda) were classified according to their occurrence (prevalence of infection). Helminth fauna composition and structure in host families Canidae, Felidae, and Mustelidae and in separate host species were analysed. Sixty helminth species were found in wild carnivorans in Ukraine, including 18 species of cestodes, 11 species of trematodes, and 31 species of nematodes. In wild Canidae, 45 helminth species were recorded. Nematodes were a predominating group of helminths in the red fox, *Vulpes vulpes* L., cestodes predominated in the wolf, *Canis lupus* L., and trematodes occurred more often in the raccoon dog, *Nyctereutes procyonoides* Gray. Mustelidae (40 specimens of 8 species) harboured 25 helminth species; nematodes predominated by their occurrence and number of species. In the American mink, *Neovizon vison* Brisson, however, trematodes appeared to be the predominating group of helminths. The wolf, the red fox, and the domestic dog showed maximum similarity in the helminth fauna composition. A rather high similarity was observed between the helminth faunae of the raccoon dog and the American mink (I_S = 0.42), both hosts being introduced species in the fauna of Ukraine.

Key words: Carnivora, Canidae, Mustelidae, helminths, Ukraine.

Introduction

Detailed reviews of the studies of particular groups of helminths parasitic in wild predatory mammals in Ukraine were presented in our previous publications (Kornyushin et al., 2011; Korol et al., 2016; Varodi et al., 2017). Therein, we summarised the results of the examination of the material collected from wild carnivorans in Ukraine and stored in the helminthological collections: cestodes, trematodes, and nematodes separately. Several reports on the helminths of domestic carnivorans have been published in recent decades (Kornyushin et al., 1999, 2007, 2008, 2013; Kornyushin & Yemets, 2006, 2016; Kornyushin, 2007, 2010; Kornyushin & Varodi, 2010). On the other hand, few works based on the examination of new collections of helminths of wild carnivorans were published recently (e. g. Zvegintsova, 2003; Zvegintsova et al., 2007, 2018).

In the present work, we summarised the information on the composition and structure of the fauna of all helminths of wild carnivorans in Ukraine, both as a whole and for separate host taxa. Besides, we added the information on the helminth fauna of domestic dogs and cats based on the collection material examined. The material was collected mostly in 1998–2010 in various regions of the country. Additionally, separate samples occasionally collected in earlier years and stored in the Parasitological Collection of the Department of Parasitology, I. I. Schmalhausen Institute of Zoology NAS of Ukraine were examined. Helminths from domestic dogs and cats were collected from homeless animals examined mostly in 1962 and, occasionally, in more recent years.

Material and methods

The entire sample of helminths comprised the material collected from 260 individuals of 14 wild carnivoran species from the families Canidae Fischer de Waldheim, 1817, Mustelidae Fischer de Waldheim, 1817, and Felidae Fischer de Waldheim, 1817 (table 1). The animals were collected mostly by hunters during hunting seasons. Helminths were gathered during the complete investigation of hosts' internal organs and body surfaces; less often, only some systems of organs (digestive tract, respiratory system, kidneys, etc.) were examined. All helminth specimens were fixed in 70 % ethanol and examined on temporary or permanent mounts. Methods of staining and/or clarification of helminths from separate taxa and their identification were described in detail in our previous papers (Kornyushin et al., 2011; Korol et al., 2016; Varodi et al., 2017).

Additionally, we studied the material collected from 73 domestic dogs (*Canis familiaris* Linnaeus, 1758). This material included the samples collected by V. Kornyushin in 1962 and 1989 in Kyiv (32 hosts examined), the samples collected by E. Varodi and N. Vasylyk in 2002–2005 in Kyiv and the Kyiv Region (11 hosts examined), 23 samples collected by O. Yemets in 1977 in the Sumy Region, and the material collected by I. Turyanin in the Transcarpathian Region (7 samples). In the present analysis, we also used the material collected from 11 domestic cats (*Felis catus* Linnaeus, 1758) in various years, mostly in Kyiv (8 hosts), but also in the Kherson Region (in the Black-Sea Nature Reserve, 2 hosts), and the Sumy Region (1 host sampled by O. Yemets). The majority of dog and cat specimens examined were stray animals caught and euthanized by corresponding services. All examined material is stored in the Collection of the Department of Parasitology, I. I. Schmalhausen Institute of Zoology NAS of Ukraine.

Helminth infection was characterised using the infection prevalence (in %) and the infection intensity (in helminth specimens) according to definitions of Bush et al. (1997). In the comparative analysis of taxonomic structure, the percentage of each component was calculated. Based on the infection prevalence (P), we distinguished dominant (P > 50.0 %), subdominant (P 25.0–49.9 %), common (P 10.0–24.9 %), and rare (P < 10.0 %) helminth species and characterised the helminth fauna structure using these categories. All species except rare ones were included in the core of helminth fauna. The estimation of the similarity between helminth faunae of separate hosts based on the Sørensen index and the cluster analysis of the similarity was performed using the PRIMER 6 software (Clarke & Gorley, 2006).

Results and discussion

I. Composition and structure of helminth fauna in separate taxa of Carnivora

In total, 60 helminth species were found in wild carnivorans in Ukraine, including 18 species of cestodes (Platyhelminthes, Cestoda), 11 species of trematodes (Platyhelminthes,Trematoda), and 31 species of nematodes (Nematoda). The richest helminth fauna was recorded in four studied species of Canidae: 16 species of cestodes, 10 species of trematodes, and 19 species of nematodes, i. e. 45 species in total. In eight examined species of Mustelidae, we found 25 helminth species including four species of cestodes, six species of trematodes, and 15 species of nematodes. Twelve helminth species

Table 1. Diversity of helminths in 14 examined species of wild Carnivora in Ukraine

No.	Host species	No. of specimens examined	All helminths		Cestoda		Trematoda		Nematoda	
			Hosts infected	Species found	Hosts infected	Species found	Hosts infected	Species found	Hosts infected	Species found
					Family Canidae					
1.	Red fox (*Vulpes vulpes* L.)	166	164	36	115	11	64	9	134	16
2.	Wolf (*Canis lupus* L.)	32	32	22	28	12	11	1	26	9
3.	Golden jackal (*Canis aureus* L.)	1	1	4	1	2	–	–	1	1
4.	Raccoon dog (*Nyctereutes procyonoides* Gray)	14	14	28	9	3	11	5	9	3
					Family Mustelidae					
5.	American mink (*Neovizon vison* Brisson)	13	13	8	9	1	10	4	6	3
6.	Stone marten (*Martes foina* Erxleben)	7	7	5	–	–	1	1	7	4
7.	Marten (*Martes martes* L.)	4	4	8	2	2	–		4	6
8.	Weasel (*Mustela nivalis* L.)	6	6	7	–	–	1	2	6	5
9.	Polecat (*Mustela eversmanni* Lessin)	2	2	7	1	1	2	3	2	3
10.	Ermine (*Mustela erminea* (L.))	2	2	2	–	–	–	–	2	2
11.	Otter (*Lutra lutra* L.)	3	3	3	–	–	3	4	3	1
12.	Badger (*Meles meles* L.)	3	3	5	1	1	–	–	3	4
					Family Felidae					
13.	Forest cat (*Felis silvestris* Schreber)	6	6	5	6	3	–	–	6	2
14.	Lynx (*Lynx lynx* (L.))	1	1	2	2	1	–	–	1	1
	Total:	260	258	60	165	18	102	11	305	31

were recorded in both canids and mustelids. Wild Felidae are rare and locally distributed in Ukraine. In two examined species of this group, only four helminth species were found: two cestode species also occurring in canids, and two nematode species-specific to felids. Trematodes were not found (table 1).

Family Canidae

Material from four species and 213 individuals of canids was examined in the present study (table 1). The largest host samples were those of the red fox *Vulpes vulpes* (166 individuals) and the wolf *Canis lupus* (32 individuals). The red foxes were examined in all the natural zones of Ukraine, in 15 administrative regions including AR Crimea. The wolves were collected in 10 administrative regions, mostly in the forest zone in the north (Polissia), but also in steppe territories in the Zaporizhzhia and Kherson regions in the south. The raccoon dog *Nyctereutes procyonoides* (14 specimens in total) were collected mostly in the Kyiv Region, few specimens were examined in the south of Ukraine. A single golden jackal *Canis aureus* was collected in the estuary of the Dniester River in the Odesa Region.

Almost all examined canids appeared to be infected with helminths. Only two red foxes (1.2 %) were free from helminth infection. Based on the overall prevalence of infection, nematodes were predominating group of helminths in the red fox, whereas cestodes predominated in the wolf, and trematodes occurred more often in the raccoon dog (fig. 1). Similarly, each group of helminths comprised the largest number of species in the corresponding host (fig. 2). These general parameters influenced the structure and composition of the core of helminth fauna in each host species.

Red fox (*Vulpes vulpes*)

The red fox is a solitary hunter. It feeds mainly on murid rodents and hares. Besides, its diet includes the birds nesting on the ground, reptiles and large invertebrates: beetles, snails, earthworms, etc. Due to the wide range of prey items, the helminth fauna of the red fox is rather rich and diverse and includes a number of rare and occasional species.

Forty helminth species were recorded in the red fox, including 12 species of cestodes, nine species of trematodes, and 19 species of nematodes (table 2; fig. 2). In this host, the

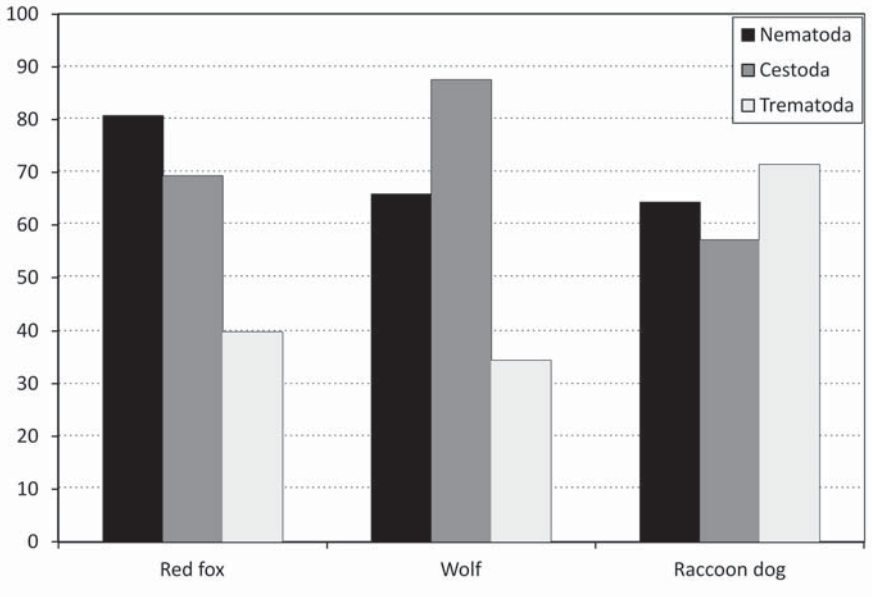

Fig. 1. Prevalence (%) of main groups of helminths in three species of wild Canidae in Ukraine.

Table 2. Infection prevalence of helminth species found in wild Canidae in Ukraine

No.	Species	Red fox, %	Wolf, %	Golden jackal	Raccoon dog, %
	Cestoda				
1.	*Dipylidium caninum* (Linnaeus, 1758)	–	3.1	–	–
2.	*Echinococcus granulosus* Batsch, 1786	–	6.2	–	–
3.	*E. multilocularis* Leuckart, 1863	3.0	–	–	–
4.	*Hydatigera taeniaeformis* (Batsch, 1786)	0.6	–	–	–
5.	*Mesocestoides lineatus* (Goeze, 1782)	40.4	34.4	1/1	14.3
6.	*M. litteratus* (Batsch, 1786)	0.6	–	–	–
7.	*Mesocestoides* sp.	0.6	–	–	–
8.	*Multiceps multiceps* (Leske, 1780)	0.6	15.6	1/1	–
9.	*M. serialis* (Gervais, 1847)	0.6	15.6	–	–
10.	*M. skrjabini* Popov, 1937	0.6	–	–	–
11.	*Spirometra erinaceieuropei* (Rudolphi, 1819)	–	12.5	–	42.9
12.	*Taenia cervi* Christiansen, 1931	0.6	3.1	–	–
13.	*T. crassiceps* (Zeder, 1800)	22.3	12.5	–	14.3
14.	*T. hydatigena* Pallas, 1766	0.6	43.8	–	–
15.	*T. pisiformis* Bloch 1780	–	18.7	–	7.1
16.	*Tetrathyrotaenia polyacantha* (Leuckart, 1856)	27.7	12.7	–	–
	Trematoda				
17.	*Alaria alata* (Goeze, 1792)	39.8	43.7	1/1	57.1
18.	*Apophallus donicus* (Skrjabin & Lindtrop, 1919)	1.8	–	–	21.4
19.	*Ascocotyle italica* Alessandrini, 1906	0.6	–	–	–
20.	*Echinochasmus perfoliatus* (Ratz, 1908)	1.8	–	–	14.3
21.	*Isthmiophora melis* (Schrank, 1788)	1.2	–	–	35.7
22.	*Mesostephanus appendiculatus* (Ciurea, 1916)	1.2	–	–	–
23.	*M. skworzowi* (Petrov, 1950)	0.6	–	–	14.3
24.	*Pharingostomum cordatum* (Diesing, 1850)	0.6	–	–	–
25.	*Plagiorchis elegans* (Rudolphi, 1802)	–	–	–	7.1
26.	*Stephanoprora denticulata* (Rudolphi, 1802)	0.6	–	–	–
	Nematoda				
27.	*Ancylostoma caninum* (Ercolani, 1859)	0.6	6.2	–	–
28.	*Aonchotheca putorii* (Rudolphi, 1819)	0.6	–	–	–
29.	*Capillaria* sp.	1.2	–	–	–
30.	*Crenosoma vulpis* (Dujardin, 1845)	2.4	6.2	–	–
31.	*Eucoleus aerophilus* (Creplin, 1839)	12.0	9.4	–	–
32.	*Heligmosomum costellatum* (Dujardin, 1845)	0.6	–	–	–
33.	*Heligmosomum* sp.	0.6	–	–	–
34.	*Molineus patens* (Dujardin, 1845)	3.6	–	–	–
35.	*Pearsonema plica* (Rudolphi, 1819)	13.2	9.4	–	–
36.	*Pterygodermatites affinis* (Jägerskiöl, 1904)	0.6	3.1	–	–
37.	*Spirocerca arctica* (Petrow, 1927)	0.6	–	–	–
38.	*S. lupi* (Rudolphi, 1809)	0.6	–	–	–
39.	*Strongyloides erschowi* Popowa, 1938	0.6	–	–	21.4
40.	*Syphacia agraria* Sharpilo, 1973	5.4	–	–	–
41.	*Toxocara canis* (Werner, 1782)	22.9	15.6	–	–
42.	*Toxascaris leonina* (von Linstow 1902)	39.2	15.6	–	–
43.	*Trichuris vulpis* Froelich, 1789	4.8	18.7	–	7.1
44.	*Trichinella* cf. *spiralis* (Owen, 1835)	0.6	–	–	–
45.	*Uncinaria stenocephala* (Railliet, 1884)	27.1	65.6	1/1	64.3

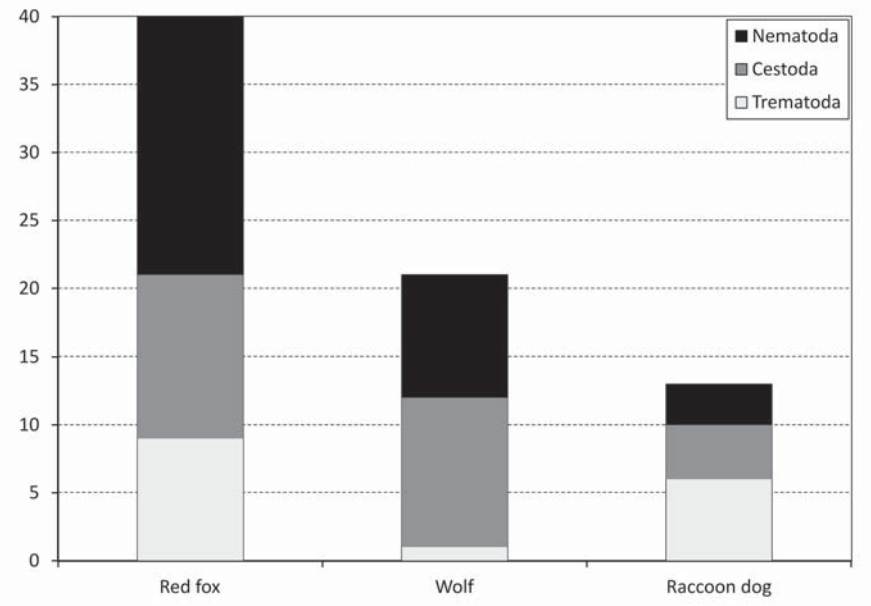

Fig. 2. Number of helminth species found in three species of wild Canidae in Ukraine.

core of helminth fauna was comparatively small and comprised of nine species or 22.5 % of the total number of species recorded. The core included five species of nematodes, three species of cestodes, and one trematode species (fig. 3). Species with an infection prevalence of 50 % and higher (i. e. dominant species) were absent in the core. On the other hand, five core species were considered subdominant, with an infection prevalence of 27.1–40.4 %. The cestode *Mesosestoides lineatus* (Goeze, 1782) (P = 40.4 %), the trematode *Alaria alata* Goeze 1782 (P = 39.8 %), and the nematode *Toxascaris leonina* (Linstow, 1902) Leiper, 1907 (P = 39.2 %) were the most frequently occurring helminths in the red fox. *Mesocestoides lineatus* and *A. alata* had a wide range of intermediate and paratenic hosts, which ensure an active transmission of these parasites under various environmental conditions. *Toxascaris leonina* may actively infect foxes in burrows, where the temperature and humidity are favourable for the development of infective eggs.

Two other subdominant species were less frequent in foxes; each had an infection prevalence of 27.7 %. The cestode *Tetrathyrotaenia polyacantha* (Leuckart, 1856) uses rodents, mostly voles as intermediate hosts; these animals compose a major part of the fox diet, especially in winter. The nematode *Uncinaria stenocephala* (Railliet, 1884) is monoxenous and infects the hosts orally or via skin penetration (Anderson, 2000). Conditions of burrows' floor (constant temperature and high humidity) are favourable for the development of free-living stages of this nematode. Besides, the infective larvae of *U. stenocephala* may be transmitted by transplacental or transmammal ways; the fox-cubs, therefore, are often heavily infected.

Four helminth species were assigned to the group of common parasites of the red fox, for their prevalence of infection reached 12.0 % to 22.9 %. This group included one cestode and three nematode species. The cestode *Taenia crassiceps* (Zeder, 1800) (P = 22.9 %) uses rodents as intermediate hosts. The nematode *Toxocara canis* (Werner, 1782) Stiles, 1905 (P = 22.9 %) is monoxenous, the eggs containing the third-stage larvae are the infective stage. Besides, the prenatal transmission of migrating larvae in pregnant females is also possible (Anderson, 2000). Capillariid nematodes *Pearsonema plica* (Rudolphi, 1819) (P = 13.2 %) and *Eucoleus aerophilus* (Creplin, 1839) (P = 12.0 %) may use earthworms, including those inhabiting fox burrows, as transport (paratenic) or intermediate hosts.

Other 31 helminth species are rare or occasional parasites of the red fox in Ukraine.

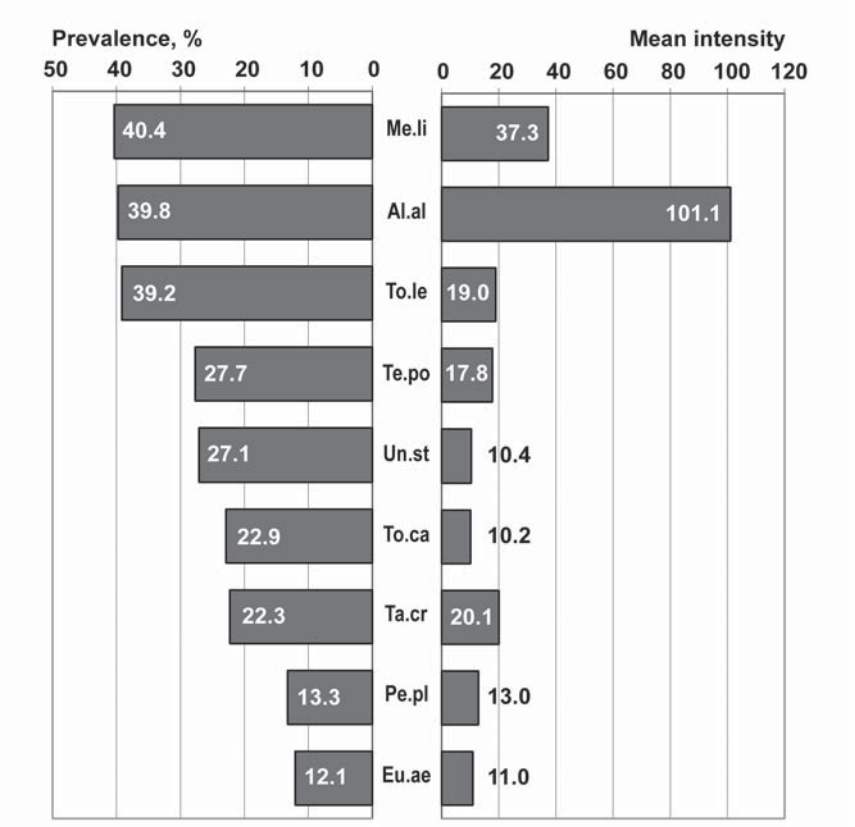

Fig. 3. Infection prevalence and mean intensity of species composing the core of helminth fauna in the red fox; Me.li — *Mesosestoides lineatus*, Al.al — *Alaria alata*, To.le — *Toxascaris leonina*, Te.po — *Taenia polyacantha*, Un.st — *Uncinaria stenocephala*, To.ca — *Toxocara canis*, Ta.cr — *Taenia crassiceps*, Pe.pl — *Pearsonema plica*, Eu.ae — *Eucoleus aerophilus*.

Some of them were found in several host individuals: the cestode *Echinococcus multilocularis* Leuckart, 1863 (P = 3.0 %), the nematodes *Trichuris vulpis* (Froelich, 1789) Smith, 1908 (P = 4.8 %), *Crenosoma vulpis* (Dujardin, 1844) (P = 2.4 %), *Molineus patens* (Dujardin, 1845) (P = 3.6 %), *Pterygodermatites affinis* (Jägerskiöld, 1904) (P = 5.4 %), and the trematodes *Echinochasmus perfoliatus* (Ratz, 1908) (P = 1.8 %), *Apophallus donicus* (Skrjabin & Lindtrop, 1919) Price, 1931 (P = 1.8 %), and *Isthmiophora melis* (Schrank, 1788) Lühe, 1909 (P = 1.2 %). The remaining species were found each in just one host individual (P = 0.6 %). This group included the cestodes *Taenia cervi* Christiansen, 1931, *Taenia hydatigena* Pallas, 1766, *Multiceps multiceps* Leske, 1780, *M. serialis* (Gervais, 1847), *Multiceps skrjabini* Popow, 1937, *Mesocestoides litteratus* (Batsch, 1786), *Mesocestoides* sp., and *Hydatigera taeniaeformis* (Batsch, 1786); the trematodes *Pharyngostomum cordatum* (Diesing, 1850), *Mesostephanus skworzowi* Petrov, 1950, *Stephanoprora denticulata* (Rudolphi, 1802) Odhner, 1910, and *Ascocotyle italica* Alessandrini, 1906; and the nematodes *Aonchotheca putorii* (Rudolphi, 1819), *Trichinella spiralis* (Owen, 1835), *Strongyloides erschowi* Popowa, 1938, *Ancylostoma caninum* (Ercolani, 1859) Hall, 1913, and *Spirocerca arctica* Petrov, 1927. Some of them are usual parasites of other species of carnivorans, and hence they are occasional parasites of the red fox. Three nematode species, namely *Heligmosomum costellatum* (Dujardin, 1845), *Heligmosomum* sp., and *Syphacia agraria* Sharpilo, 1973 are parasitic in rodents and occur in foxes as transit parasites.

Wolf (*Canis lupus*)

In contrast to the red foxes, the wolves normally hunt in groups usually consisting of family members. The core of a wolf's diet is composed of ungulates (roe deer, deer,

wild boars), usually young or weakened individuals. Less often wolves hunt on hares and large rodents. Consequently, the helminth fauna of the wolf is less diverse than that of the red fox. Moreover, the proportion of rare helminth species is smaller, while the occasional species are absent.

The helminth species richness in the wolf is lower than that in the red fox, especially regarding trematodes and nematodes (fig. 2). In the wolf, we recorded 21 helminth species, including 11 species of cestodes, one species of trematodes, and nine species of nematodes (table 2). Cestodes predominated by their occurrence (87.5 % of hosts infected), nematodes were found in 81.2 % of hosts. Trematodes were found in 34.4 % of examined wolves (fig. 1).

The core of the helminth fauna of the wolf was comparatively large and comprised 13 species or 61.9 % of all recorded helminths. It included eight species of cestodes, one species of trematodes, and four species of nematodes (fig. 4). The nematode *U. stenocephala* predominated with the infection prevalence of 65.6 % and a rather high mean intensity of infection (40.2 specimens per host individual). The micro-climate of the wolf's lair is favourable for the development of eggs and larval stages of the nematode, as well as for the survival and transmission of infective larvae.

Four helminth species were assigned to the group of subdominant species. The trematode *A. alata* (P = 43.7 %) and the cestode *Mesocestoides lineatus* (Goeze, 1782) (P = 34.4 %) use a range of intermediate and paratenic hosts in their transmission. Interestingly, these two helminths were among the core species in the helminth fauna of both the wolf and of the red fox. The rate of infection with *A. alata* was similar in both hosts, while *M. lineatus* occurred less frequently in the wolf. The cestode *T. hydatigena* (P = 43.7 %) was

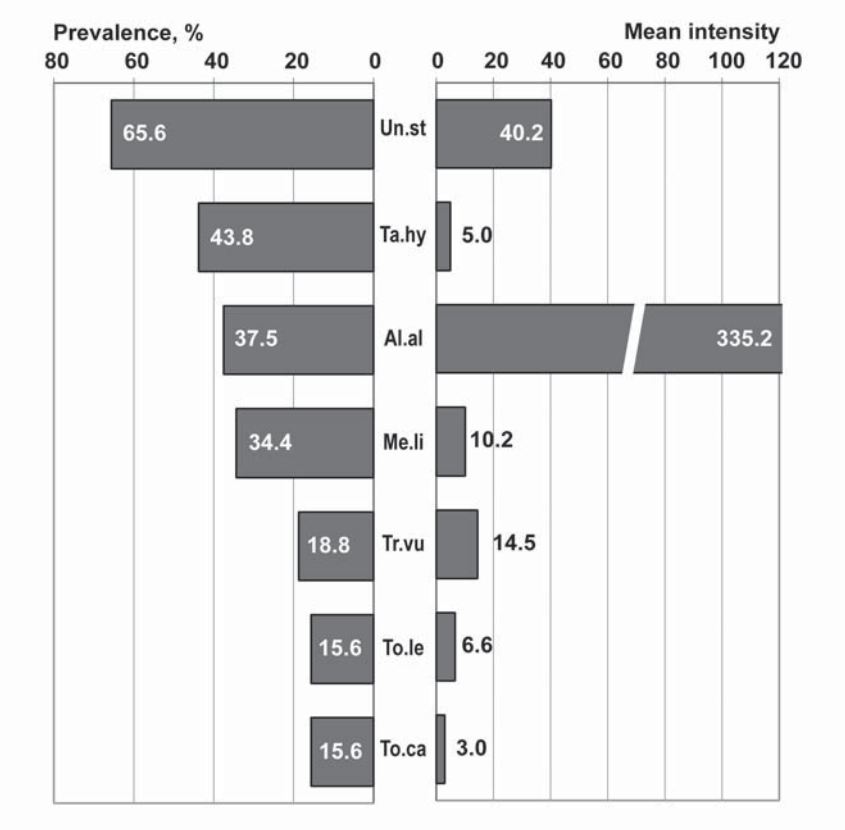

Fig. 4. Infection prevalence and mean intensity of species composing the core of helminth fauna in the wolf; Un.st — *Uncinaria stenocephala*, Ta.hy — *Taenia hydatigena*, Al.al — *Alaria alata*, Me.li — *Mesosestoides lineatus*, Tr.vu — *Trichuris vulpis*, To.le — *Toxascaris leonina*, To.ca — *Toxocara canis*.

another subdominant species. Ungulates, e. g. the wild boar, the roe deer, and the elk, are the intermediate hosts of this parasite, and they are usual components of a wolf's diet. This helminth species was only once found in the red fox.

The group of common species included nine species of helminths. Among them, there were three nematode species: *T. vulpis* (P = 18.8 %), *T. leonina* and *T. canis* (P = 15.6 %), all are monoxenous parasites. Their infective stages (eggs) may develop in the lair floor. Two former species were among the core species in the helminth fauna of the red fox, whereas *T. vulpis* was rather rare (P = 4.8 %) in this host in the examined material. Presumably, the micro-climatic conditions in the wolf's liar are more favourable for the development of eggs of *T. vulpis* than those in the fox's burrow.

Six cestode species were assigned to the group of common species. *Taenia pisiformis* (Bloch, 1780) occurred more frequently (P = 18.7 %); hares are the intermediate hosts of this cestode, they are also a usual component in the wolf's diet. *Multiceps multiceps* and *M. serialis* were less frequent (P = 15.6 %). The latter species also uses lagomorphs as intermediate hosts. Larval *T. pisiformis* and *M. serialis* are known to be usual parasites of rabbits in southern Ukraine. Of these two species, *T. pisiformis* is more common both in hares and in rabbits. Wild and domestic Bovidae (e. g. sheep) are intermediate hosts of *M. multiceps*. Presently, the number of these animals in Ukraine is dramatically decreasing. That was why the prevalence of *M. multiceps* infection in wolves was rather low; this cestode was revealed mostly in old collection material. In some cases, wolves may acquire this infection near the slaughterhouses. Three cestode species from the same group had an infection prevalence as low as 12.5 %. Rodents are the intermediate hosts of *T. crassiceps* and *T. polyacantha*; they compose a less significant part of the wolf's diet. *Spirometra erinaceieuropei* (Rudolphi, 1819) Mueller, 1937 is transmitted to the definitive hosts usually via paratenic hosts: reptiles, birds, and small mammals, often rodents. The wolf is the main definitive host of this parasite; small mammals including carnivorans may be a source of infection. We found plerocercoids of *S. erinaceieuropei* in martens *Martes martes*, American minks *Neogale vison*, and raccoon dogs *Nyctereutes procyonoides* in northern Ukraine. Interestingly, gravid cestodes were also observed in the latter host, but only once.

The group of rare species is rather large (12 species) and may be divided into three subgroups. One of them consists of five species. Two species of capillariid nematodes, *P. plica* and *E. aerophilus,* were found in 9.4 % of wolves. These capillariids are usual parasites of the red fox and the wolf and may reach a higher prevalence of infection in some localities. The cestode *Echinococcus granulosus* (Batsch, 1786) and the nematodes *C. vulpis* and *A. caninum* were found in 6.2 % of wolves. The occurrence of *E. granulosus* was connected to synanthropic foci, though its larval stage occurs also in wild boars.

Three helminth species were found each in only one host individual (P = 3.1 %). The heteroxenous nematode *P. affinis* uses invertebrates (beetles, cockroaches) as intermediate hosts; the red fox is the more usual definitive host of this species. The cestode *T. cervi* is a common parasite of the wolf in Western Europe; in Ukraine, it was found only in the Transcarpathian region (western Ukraine), both in wolves and in red foxes. Various deer species including those widely distributed in the game farms throughout Ukraine are the intermediate hosts of *T. cervi*. The Carpathian Mountains form the eastern border of *T. cervi* distribution. Fleas, common inhabitants of lairs and burrows, are intermediate hosts of the cestode *Dipylidium caninum* (Linnaeus, 1758). Due to this, the parasite usually infects the cubs and rarely the adults. In our material, the wolf cubs were absent. Transit parasites were not found in the studied wolf individuals.

Golden jackal (*Canis aureus*)

In a single studied jackal, four helminth species were found (table 2): the trematode *A. alata*, the cestodes *M. lineatus* and *M. multiceps*, and the nematode *U. stenocephala*. All of them also occurred in other species of Canidae in Ukraine.

Raccoon dog (*Nyctereutes procynoides*)

The raccoon dog, in contrast to the wolf and the red fox, is a "gatherer", almost omnivorous, hydrophilic carnivoran. It feeds on both vertebrates and invertebrates. Its diet includes mammals (mostly rodents), birds (nestlings and eggs), reptiles, amphibians, rarely fish, aquatic and terrestrial molluscs, crustaceans, earthworms, aquatic and terrestrial insects and insect larvae, etc. Consequently, the composition and structure of the helminth fauna of the raccoon dog differ from those in other carnivorans.

Thirteen helminth species were found in this host. The structure of helminth fauna in the raccoon dog significantly differed from that in both the wolf and the red fox. Trematodes predominated by the occurrence (78.6 %), cestodes and nematodes had somewhat lower infection prevalence: 71.4 % and 64.3 %, correspondingly (fig. 1). Similarly, the diversity of trematodes was the highest: six species. Four species of cestodes and three species of nematodes were recorded (fig. 2). The core of helminth fauna in the raccoon dog was composed of ten species (76.9 % of all helminth species recorded). It included three species of cestodes, five species of trematodes, and two species of nematodes (fig. 5). Two species predominated: the nematode *U. stenocephala* (P = 64.3 %) and the trematode *A. alata* (P = 57.1 %). Both are dominant in their definitive hosts, occurring in many carnivoran species; in the present study, they were assigned to subdominant parasites of the wolf the red fox.

Two helminth species were considered subdominant. The cestode *S. erinaceieuropei* (P = 42.9 %) was found mostly at the plerocercoid stage under the skin. Only in one host individual, 25 gravid cestodes were found in the intestine, along with seven subcutaneous plerocercoids. The raccoon dog acquires *S. erinaceieuropei* infection due to predation on

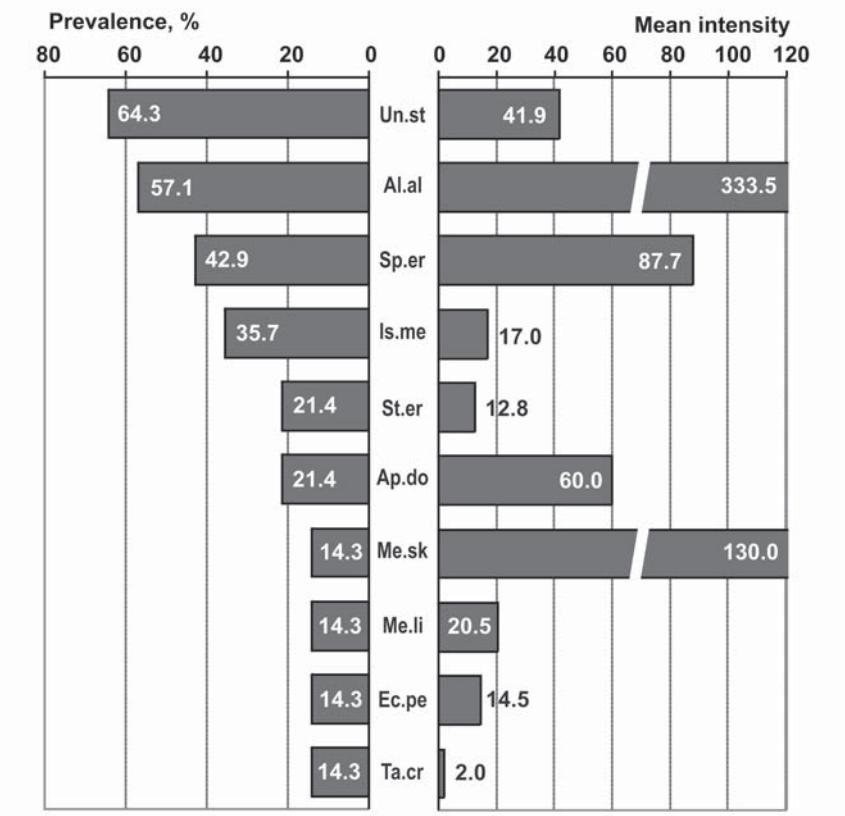

Fig. 5. Infection prevalence and mean intensity of species composing the core of helminth fauna in the raccoon dog; Un.st — *Uncinaria stenocephala*, Al.al — *Alaria alata*, Sp.er — *Spirometra erinaceieuropei*, Is.me — *Isthmiophora melis*, St.er — *Strongyloides erschowi*, Ap.do — *Apophallus donicus*, Me.sk — *Mesostephanus skworzowi*, Me.li — *Mesosestoides lineatus*, Ec.pe — *Echinochasmus perfoliatus*, Ta.cr — *Taenia crassiceps*.

amphibians (second intermediate hosts of the parasite) which are the main subject in the diet of raccoon dogs in northern Ukraine (Polissia). The raccoon dog is an incidental definitive host of *S. erinaceieuropei*. Presumably, under certain circumstances, subcutaneous plerocercoids can return to the host intestine and reach maturity therein. The trematode *I. melis* (P = 35.7 %) occurs in many carnivoran definitive hosts; its transmission involves aquatic molluscs.

Six helminth species were assigned to the category of common parasites with an infection prevalence of 14.3–21.4 %. This group included three species of cestodes, two species of trematodes, and one nematode species. Infective third-stage larvae of nematode *S. erschowi* (P = 21.4 %) develop in moist soil; the burrows of the raccoon dog may be the foci of the infection. This species is specific to the raccoon dog (we found it only once in the red fox) and, presumably, was introduced to Ukraine along with its host. The trematode *Apophallus donicus* (Skrjabin & Lindtrop, 1919) Price, 1931 (P = 21.4 %) is common in a range of fish-eating animals, especially in birds. The trematodes *E. perfoliatus* and *M. skworzowi* (P = 14.3 %) use aquatic molluscs as intermediate hosts and infect carnivorans close to water bodies. In general, a high level of trematode infection found in the raccoon dog is explained by its close relation to aquatic habitats and the presence of aquatic or semi-aquatic animals (molluscs, crustaceans, insect larvae) in its diet. The cestodes *T. crassisceps* and *M. lineatus* were found each in two individuals of the raccoon dog (P = 14.3 %). Rodents are the intermediate hosts of the former one, and it was common in red foxes. *M. lineatus* was a subdominant parasite in the red fox and the wolf.

Three helminth species: the cestode *T. pisiformis*, the nematode *T. vulpis*, and the trematode *Plagiorchis elegans* (Rudolphi, 1802) Braun, 1902 were found each in one raccoon dog examined (P = 7.1 %). They were assigned to the group of rare parasites of this host. Two former species are usual parasites of the wolf. Hares are the intermediate hosts of *T. pisiformis*, they are hardly a common component of the raccoon dog's diet.

Comparatively low helminth species richness in the raccoon dog observed in the present study is caused, at least partially, by the comparatively small area surveyed. The species was collected mostly in central Polissia (northern Ukraine), just two specimens were from the southern part of Ukraine (Zaporizhzhia and Kherson regions).

Domestic dog (*Canis familiaris*)

In an examined sample of domestic dogs, we found 20 species of helminths: nine species of cestodes, three species of trematodes, and eight species of nematodes. We give below the list of recorded helminth species, with their infection prevalence and intensity (mean with the range in parentheses).

Cestodes *D. caninum* — P = 46.6 %; I = 6.53 (1–199); *E. granulosus* s. l. — P = 13.7 %; I = 11.0 (1–23); *T. pisiformis* — P = 13.7 %; I = 6.4 (1–25); *T. hydatigena* — P = 8.2 %; I = 4.3 (1–12); *T. crassiceps* — P = 2.7 %; I = 10.5 (1–20); *H. taeniaeformis* — P = 2.7 %; I = 2.0 (1–35); *M. multiceps* — P = 1.4 %; I = 1.0; *T. polyacantha* — P–1.4 %; I = 6.0; *M. lineatus* — P–2.7 %; I = 29.5 (28–31).

Trematodes *E. perfoliatus* — P = 4.1 %; I = 17.3 (1–345); *A. alata* — P = 2.7 %; I = 5.0 (1–9); *A. donicus* — P = 1.4 %; I = 21.

Nematodes *T. canis* — P = 26.0 %; I = 5.9 (1–36); *U. stenocephala* — P = 23.3 %; I = 30.1 (1–136); *T. leonina* — P = 2.7 %; I = 18.0 (15–21); *T. vulpis* — P = 5.5 %; I = 13.7 (3–19); *A. caninum* — P = 2.7 %; I = 2.0 (1–3); *M. patens* — P = 2.7 %; I = 2.5 (1–4); *Dirofilaria repens* Railliet & Henry 1911 — P = 11.0 %; I = 16.86 (1–98); *Dirofilaria immitis* (Leidy, 1856) — P = 1.4 %; I = 8.

The core of helminth fauna in domestic dogs was comparatively small. It included six species; none of them was classified as dominant species. Two species were subdominant: the cestode *D. caninum* (P = 46.6 %) and the nematode *T. canis* (P = 26.0 %). Fleas are the source of infection of dogs with *D. caninum*; they are abundant in the litter of dogs' kennels

or burrows. Transmission of the nematode *T. canis* is also related to the places where dogs hide and breed; transplacental or transmammal transmission increases the infection rates. In the group of common species, the nematode *U. stenocephala* had the highest infection prevalence (P = 23.3 %). Its transmission is related to the breeding places. Two species of cestodes, *E. granulosus* and *T. pisiformis* (P = 13.7 %) were among the common species. Pigs are the intermediate hosts of the former, rabbits are the intermediate hosts of the latter. Their occurrence in domestic dogs is related to the feeding of dogs on waste and garbage near slaughterhouses. The subcutaneous nematode *D. repens* uses mosquitoes (Culicidae) as vectors in its transmission; it reached a rather high infection prevalence of 11.0 %. Actual prevalence might be even higher than observed, for some dogs delivered for our examination lacked the skin.

In the group of rare species, the cestode *T. hydatigena* (P = 8.2 %) and the nematode *T. vulpis* (P = 5.5 %) occurred more frequently. Fresh-water fishes are the intermediate hosts of the trematode *E. perfoliatus* (P = 4.1 %); they are rarely present in the dogs' diet. Other 11 rare species were found in one or two host individuals (see the list above); all of them are known to parasitize wild canids in Ukraine.

Family Mustelidae

We examined 40 specimens of mustelids in total; all of them appeared to be infected with helminths. Specimens of the American mink composed the largest sample (n = 13). Other species were represented by 2–7 specimens. Most helminth species found in mustelids are known to be specific to this host group. On the other hand, none of them is specialised in parasitism in a single host species; they all occur in various mustelid hosts (Kozlov, 1977). Due to this, we analyse herein a combined sample including the helminth found in all eight examined mustelid hosts (table 3).

A total of 25 helminth species were found in Mustelidae. High helminth species richness reflects a diverse diet of mustelids that includes small mammalians and other terrestrial and aquatic vertebrates, as well as invertebrates. We recorded 15 species of nematodes, six species of trematodes, and four species of cestodes in Mustelidae in Ukraine (fig. 6). Two cestode species use mustelids as paratenic hosts, their definitive hosts are Canidae. Other helminth species may reach maturity in mustelid hosts. Nematodes predominated by their occurrence, they were found in 80 % of hosts. Trematodes were found in 45 % of examined mustelids, cestodes were found in 32.5 % of hosts (fig. 7). In general, the taxonomic structure of the helminth fauna in mustelids is similar to that in the red fox. This is due

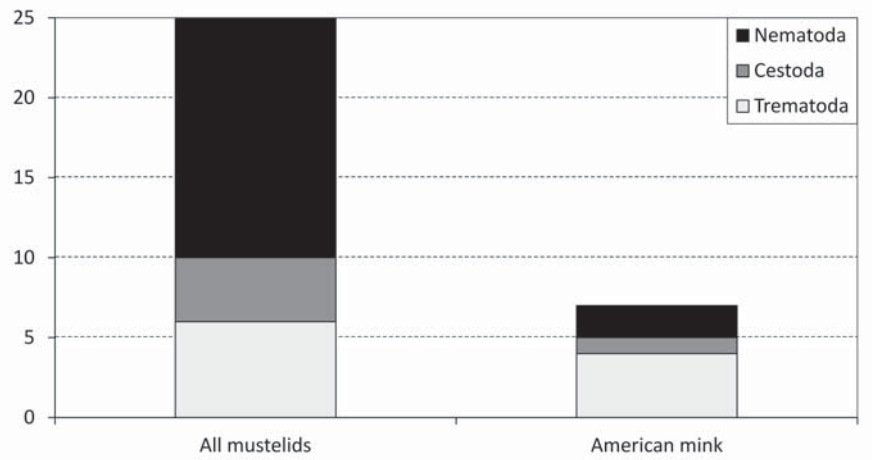

Fig. 6. Number of helminth species found in eight species of Mustelidae (combined sample) and the American mink.

Table 3. Infection prevalence of helminth species found in Mustelidae in Ukraine

No.	Species	American mink (n = 13)	Stone marten (n = 7)	Marten (n = 4)	Weasel (n = 3)	Polecat (n = 2)	Ermine (n = 2)	Otter (n = 3)	Badger (n = 3)
	Cestoda								
1.	*Fimbriataenia martes* (Zeder, 1803)	–	–	1/4	–	–	–	–	–
2.	*Mesocestoides lineatus* (Goeze, 1782)	–	–	–	–	–	–	–	1/3
3.	*Spirometra erinaceieuropei* (Rudolphi, 1819)	69.2 %	–	1/4	–	–	–	–	–
4.	*Versteria mustelae* (Gmelin, 1790)	–	–	–	–	1/2	–	–	–
	Trematoda								
5.	*Alaria alata* (Goeze, 1792)	–	–	–	1/3	1/2	–	–	–
6.	*Apophallus donicus* (Skrjabin & Lindtrop, 1919)	38.5 %	–	–	–	–	–	2/3	–
7.	*Echinochasmus perfoliatus* (Ratz, 1908)	38.5 %	–	–	–	–	–	1/3	–
8.	*Isthmiophora melis* (Schrank, 1788)	61.5 %	1/7	–	1/3	1/2	–	–	–
9.	*Plagiorchis elegans* (Rudolphi, 1802)	–	–	–	–	–	–	1/3	–
10.	*Pseudoamphistomum truncatum* (Rudolphi, 1919)	30.8 %	–	–	–	1/2	–	1/3	–
	Nematoda								
11.	*Aonchotheca putorii* (Rudolphi, 1819)	23.1 %	1/7	1/4	1/3	1/2	2/2	–	–
12.	*Crenosoma vulpis* (Dujardin, 1845)	–	–	–	–	–	–	–	2/3
13.	*Eucoleus aerophilus* (Creplin, 1839)	–	1/7	2/4	–	–	–	–	–
14.	*Filaria martes* Gmelin 1790	–	–	1/4	–	–	–	–	–
15.	*Heligmosomoides* sp.	–	–	–	1/3	–	–	–	–
16.	*Molineus patens* (Dujardin, 1845)	–	–	–	3/3	1/2	–	–	1/3
17.	*Pearsonema mucronata* (Molin, 1858)	38.5 %	6/7	4/4	–	–	–	–	–
18.	*Physaloptera sibirica* Petrov & Gorbunov, 1931	–	–	–	–	–	–	–	1/3
19.	*Skrjabingylus nasicola* (Leuckart, 1842)	–	–	–	–	1/2	–	–	–
20.	*S. petrovi* Bajenov, 1936	–	–	1/4	–	–	–	–	–
21.	*Spirocerca arctica* Petrow 1927	–	1/7	–	–	–	–	–	–
22.	*Strongyloides mustelorum* Cameron & Parnell, 1933	–	–	–	1/3	–	–	–	–
23.	*S. lutrae* Little, 1966	–	–	–	–	–	–	2/3	–
24.	*Syphacia arvicola* Sharpilo, 1973	–	–	–	1/3	–	–	–	–
25.	*Uncinaria stenocephala* (Railliet, 1884)	–	–	1/4	–	–	–	–	2/3
	Number of species found	7	5	6	7	7	2	4	5

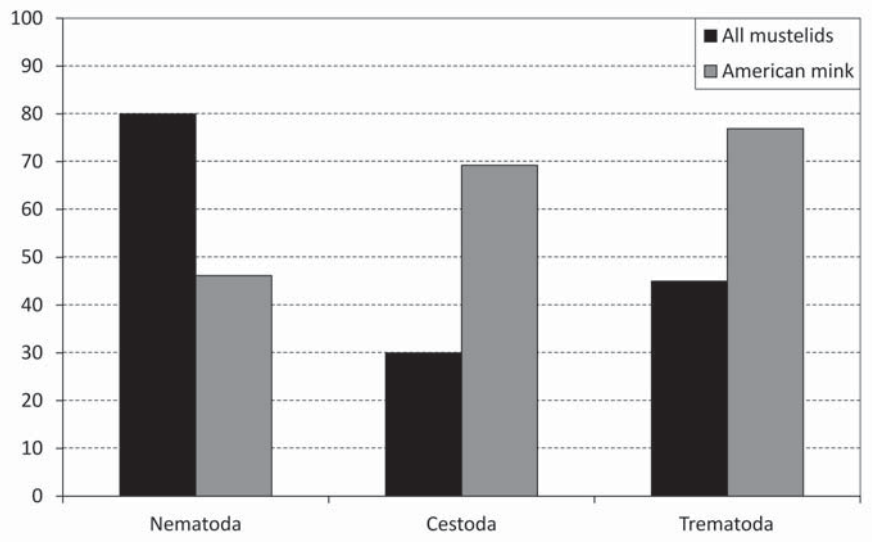

Fig. 7. Prevalence (%) of main groups of helminths in Mustelidae (combined sample) and the American mink.

to the similarity in trophic habits in mustelids and the red fox, and the predomination of rodents in their diet.

The core of helminth fauna in mustelids is comparatively small and includes seven species or 28 % of all species found in this host group (fig. 8). Dominant species were absent; three species were assigned to the group of subdominant species. Capillariid nematode

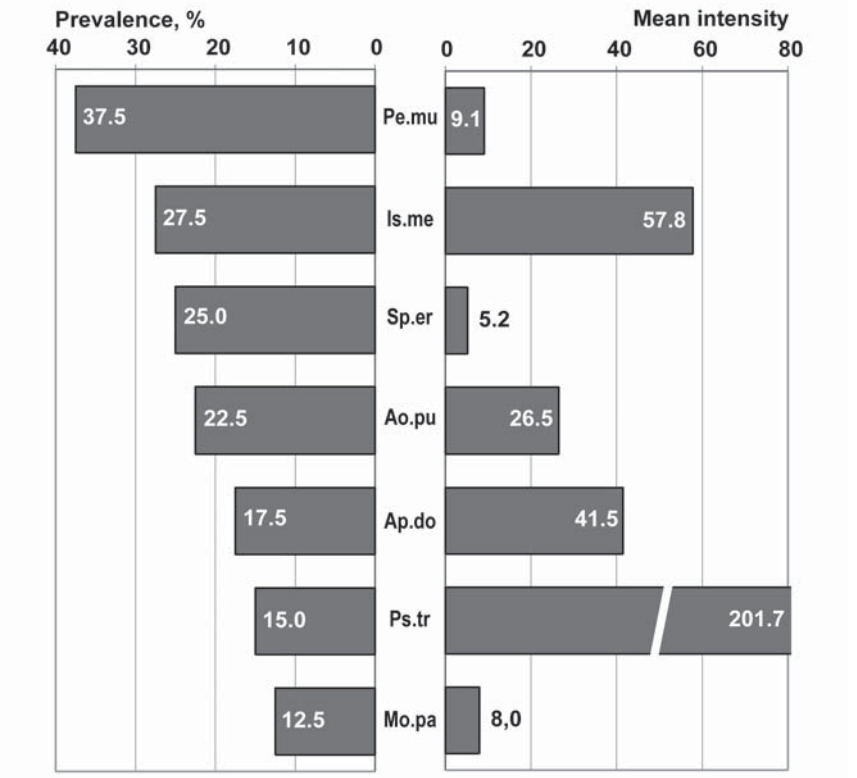

Fig. 8. Infection prevalence and mean intensity of species composing the core of helminth fauna in Mustelidae (combined sample of 8 species); Pe.mu — *Pearsonema mucronata*, Is.me — *Isthmiophora melis*, Sp.er — *Spirometra erinaceieuropei*, Ao.pu — *Aonchotheca putorii*, Ap.do — *Apophallus donicus*, Ps.tr — *Pseudoamphistomum truncatum*, Mo.pa — *Molineus patens*.

Pearsonema mucronata (Molin, 1858) (P = 37.5 %), a specific parasite of mustelids, had the highest prevalence of infection. The trematode *I. melis* occurred in the hosts slightly less frequently (P = 27.5 %); this species parasitizes mostly mustelids, though may occur in canids. The cestode *S. erinaceieuropei* (plerocercoids) was found in 25 % of mustelid hosts; this species has a wide range of paratenic hosts including Mustelidae. The group of common parasites comprised four species. Three of them are specific parasites of mustelid: the nematodes *A. putorii* (P = 22.5 %) and *M. patens* (P = 12.5 %), and the trematode *Pseudoamphistomum truncatum* (Rudolphi, 1819) (P = 15.0 %). The trematode *A. donicus* (P = 17.5 %) is a common parasite of fish-eating birds and mammals. This species was found only in the mustelids occurring near the water bodies, namely the otter and the American mink.

The group of rare and occasional parasites of mustelids included 17 species with an infection prevalence of 2.5–7.5 %. The trematodes *E. perfoliatus* and *P. elegans* (P = 7.5 %) were found only in the American mink and the otter. The trematode *A. alata* had a comparatively higher prevalence of infection, it was found in one out of three examined weasels and in one out of two examined polecats (table 3); mustelids are paratenic hosts of this species. The cestode *M. lineatus* is a common parasite of canids that rarely infects mustelids; it was found only in the badger. The nematode *S. lutrae* (P = 5.0 %) is a specific parasite of the otter found in two examined hosts. Several helminth species specific to mustelids were found each in one host individual (P = 2.5 %): the nematodes *Strongyloides mustelorum* Cameron & Parnell, 1933, *Skrjabingylus nasicola* (Leuckart, 1842), *Skrjabingylus petrovi* Bajenov, 1936, and *Filaria martis* Gmelin 1790; the cestodes *Fimbriataenia martes* (Zeder, 1803) and *Versteria mustelae* Gmelin, 1790. Their low occurrence nowadays is because of the rarity of the hosts and the low density of their populations. The nematodes *E. aerophilus*, *U. stenocephala*, *S. arctica*, *Physaloptera sibirica* Petrov & Gorbunov, 1931, and *C. vulpis* are common parasites of canids and parasitize mustelids, mostly badgers, just occasionally. The nematodes *Syphacia arvicolae* Sharpilo, 1973 and *Heligmosomoides* sp. are the parasites of rodents; their occurrence in mustelids is occasional.

Among all studied species of Mustelidae, the American mink was represented by the largest sample (n = 13) in our material. That allowed performing a separate analysis of the helminth fauna structure in this host species. In general, the helminth species richness in the American mink was low, obviously because it is an introduced species in the Ukrainian fauna. We recorded only seven helminth species: one species of cestodes, four species of trematodes, and two species of nematodes (fig. 6). Trematodes were found in 76.2 % of hosts, cestodes were found in 69.2 % of hosts, nematodes infected the least number of hosts, 46.1 % (fig. 7). All helminth species were included in the core of the helminth fauna of the American mink (fig. 9).

Two species were dominant: the cestode *S. erinaceieuropei* (plerocercoids) (P = 69.2 %) and the trematode *I. melis* (P = 61.5 %). The American mink is the paratenic host for the former species; the latter one is a generalist within carnivorans, more frequently parasitizing mustelids. Three species were assigned to the group of subdominant species: the trematode *A. donicus* (P = 38.5 %), the nematode *P. mucronatum* (P = 38.5 %), and the trematode *P. truncatum* (P = 30.8 %). Two latter species are specific parasites of mustelids. Two species were assigned to the group of common parasites. The nematode *A. putorii* (P = 23.1 %) is specific to mustelids, while the trematode *E. perfoliatus* (P = 15.4 %) occurs in a wide range of carnivoran hosts. Rare and occasional species were not registered.

Most helminth species found in the American mink in Ukraine had high infection intensity (fig. 9). Besides, we found no introduced species of parasites in this host; all the helminth species were local. Interestingly, the structure of the helminth fauna in the American mink was similar to that in the raccoon dog, another introduced species in the Ukrainian fauna. These two carnivorans accepted some trematode species from local carnivoran hosts, apparently due to the low specificity of adult trematodes. Similar

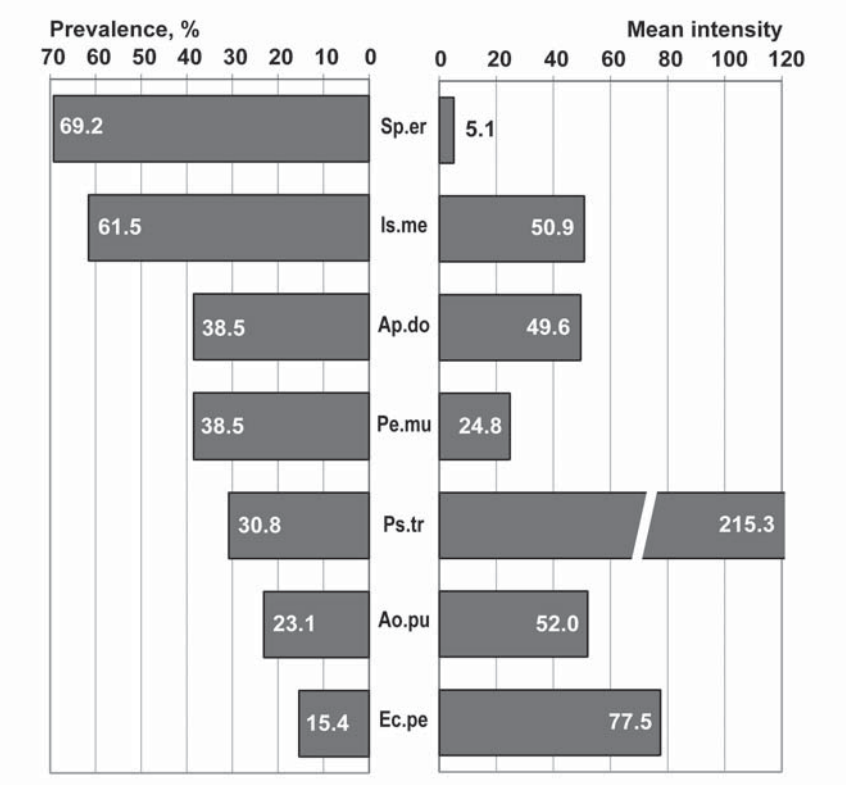

Fig. 9. Infection prevalence and mean intensity of species composing the core of helminth fauna in the American mink; Sp.er — *Spirometra erinaceieuropei*, Is.me — *Isthmiophora melis*, Ap.do — *Apophallus donicus*, Pe.mu — *Pearsonema mucronata*, Ps.tr — *Pseudoamphistomum truncatum*, Ao.pu — *Aonchotheca putorii*, Ec.pe — *Echinochasmus perfoliatus*.

wide specificity is characteristic of some nematode species infecting the American mink and the raccoon dog, as well as other carnivorans in Ukraine. Cestodes are known to be more specialised in the adult stage, therefore, they were found in the introduced hosts mostly at larval stages, e. g. plerocercoids of *S. erinaceieuropei* in the American mink and tetrathyridiae of *M. lineatus* in the raccoon dog. Both helminths use various terrestrial vertebrates as paratenic hosts.

Family Felidae

Two wild species of Felidae occur in Ukraine: the lynx *Lynx lynx* and the forest cat *Felis silvestris*. Both are rare and locally distributed in the country. We studied the helminth material from six forest cats from the Kirovohrad, Transcarpathian, and Odesa regions, and one lynx from the Zhytomyr Region. Helminths were found in all examined host individuals.

Lynx (*Lynx lynx*)

Two helminth species were found in the lynx: a monoxenous nematode *Toxocara mystax* (Zeder, 1800) (2 specimens) and the cestode *Taenia pisiformis* (3 specimens). The latter species occurs also in wolves and domestic dogs and uses hares and rabbits as intermediate hosts.

Forest cat (*Felis sylvestris*)

Five helminth species were recorded in this host: three species of cestodes and two species of nematodes. The cestode *H. taeniaeformis* was found in four cats with an

infection intensity of 6.5 (4–12) specimens. The nematode *T. mystax* was also found in four host individuals with an infection intensity of 33.0 (7–52) specimens. The cestode *M. lineatus* was found in one cat from the Kirovohrad Region (132 specimens). The cestode *S. erinaceieuropei* (3 specimens) was found in a cat from the Odesa Region. Both recorded nematode species are monoxenous parasites of Felidae. The cestode *H. taeniaeformis* uses rodents as intermediate hosts. A wide range of paratenic hosts including rodents is known to be involved in the transmission of *M. lineatus*. Amphibians are the second intermediate hosts of *S. erinaceieuropei*; they are the source of cats' infection with this cestode species.

Domestic cat (*Felis catus*)

All 11 examined domestic cats were found to harbour helminths, from one to three species were found in each host individual. In total, we recorded eight helminth species including three species of cestodes, one species of trematodes, and four species of nematodes. Below is the list of helminths found in domestic cats, with the infection prevalence (P) and intensity (I; given as mean and range in parentheses) indicated for each species.

Cestodes *H. taeniaeformis* — P = 9.1 %, I = 4.0 (3–12); *D. caninum* — P = 9.1 %, I = 1; *M. lineatus* — P = 9.1 %, I = 1.

Trematodes *Metorchis albidus* (Braun, 1893) — P = 9.1 %, I = 1.

Nematodes *T. mystax* — P = 72.7 %, I = 12.9 (1–56); *U. stenocephala* — P = 27.3 %, I = 4.0 (3–12); *Ancylostoma tubaeforme* (Zeder, 1800) — P = 9.1 %, I = 4; *D. repens* — P = 9.1 %, I = 1.

The core of helminth fauna in the domestic cat included two nematode species: *T. mystax* (dominant species), a specific parasite of felids, and *U. stenocephala* (subdominant species), a generalist. All other species were found each in one host individual (P = 9.1 %) and composed the group of rare species. This group included the nematode *A. tubaeforme*, a specific parasite of Felidae, and the trematode *M.* albidus (Opistorchidae), previously not recorded in our studies. Such structure of helminth fauna is typical for small samples of hosts collected in a limited region.

II. Comparison of helminth faunae of separate species of Carnivora

For the comparison, we selected six carnivoran species represented by ten or more individuals in the examined material: the red fox (n = 166), the wolf (n = 32), the raccoon dog (n = 14), the domestic dog (n = 73), the American mink (n = 13), and the domestic cat (n = 11). In total, 52 helminth species were recorded in these hosts. The similarity between the helminth faunae in each pair of the hosts was identified using the Sørensen index (I_S) and is shown in table 4; it was visualised as a dendrogram of cluster analysis in fig. 10.

Expectedly, the highest similarity was observed in the helminth fauna composition of the most closely related carnivorans, the wolf and the domestic dog (I_S = 0.68). These hosts shared 14 out of 27 helminth species. The similarity between the helminth faunae of the wolf and the red fox was also rather high, I_S = 0.56. These two hosts shared 17 out of 34 helminth species; both are widely distributed in Ukraine and often share the same habitats and diet components. The wolf, the red fox, and the domestic dog composed a separate cluster (fig. 10) with the similarity of helminth faunae (Sorensen index) of > 0.5. These three ca-

Table 4. Similarity between the helminths faunae of six carnivoran species based on Sørensen index

	Red fox	Wolf	Raccoon dog	American mink	Domestic dog	Domestic cat
Red fox	–	–	–	–	–	–
Wolf	0.56	–	–	–	–	–
Raccoon dog	0.35	0.36	–	–	–	–
American mink	0.17	0.07	0.42	–	–	–
Domestic dog	0.50	0.68	0.43	0.15	–	–
Domestic cat	0.12	0.21	0.10	0	0.36	–

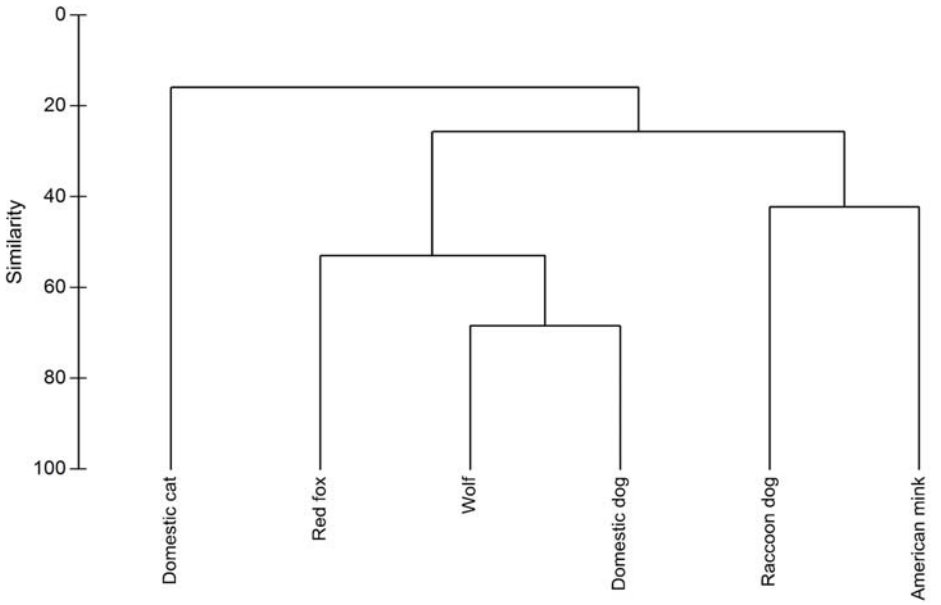

Fig. 10. Cluster analysis of the helminth fauna similarity among six carnivoran species.

nids shared 11 helminth species out of 46 found in these hosts in total. Another cluster was composed of the raccoon dog and the American mink ($I_S = 0.42$). These two hosts shared four out of 16 helminth species: the trematodes *A. donicus*, *E. perfoliatus*, *I. melis*, and the cestode *S. erinaceieuropei*. Possible reasons for the similarity between the helminth fauna of the raccoon dog and that of the American mink were discussed above.

The helminth fauna of the domestic cat showed the lowest similarity with helminth faunae of five other carnivoran hosts. No common helminth species were found in the domestic cat and the American mink (table 4). The highest similarity was observed between the helminths of the domestic cat and the domestic dog, $I_S = 0.36$. The two hosts shared five helminth species: the cestodes *D. caninum*, *H. taeniaeformis*, *M. lineatus*, and the nematodes *D. repens* and *U. stenocephala*.

Conclusions

In the present study, the helminth fauna of Canidae was summarised based on the comparatively largest sample comprising 213 host specimens of four species. We recorded 45 helminth species including 16 species of cestodes, 10 species of nematodes, and 19 species of trematodes. The cestode *M. lineatus*, the trematode *A. alata*, and the nematode *U. stenocephala* were recorded in all four host species. Among the studied species of Canidae, the red fox appeared to be infected with the largest number of helminths: 40 species in total, including 12 species of cestodes, nine species of trematodes, and 19 species of nematodes. Such diversity was recorded apparently due to the large size of the host sample (n = 166). On the other hand, we believe that the helminth fauna of the red fox is rich also due to the wide range of prey animals typical of this carnivoran. Besides, this assumption is confirmed by the fact that only 22.5 % of helminth species found in the red fox compose the core of the helminth fauna. All other species were assigned to rare and/or occasional parasites. The wolf, on the contrary, has a more restricted diet. Presumably, that was the reason for less diverse helminth fauna observed in this host: we found a total of 21 helminth species in the material from 32 wolves examined, including 11 species of cestodes, one trematode species, and nine species of nematodes. Moreover, the core of the helminth fauna in the wolf was rather large, including 61.9 % of all helminth species found, i. e. the proportion of rare and occasional species was much smaller than that in the red fox.

Despite the raccoon dog being known to have a diverse diet including both invertebrates and vertebrates, we found only 13 helminth species in the material from this host. Apparently, this was due to the small sample size (n = 14), but also because the raccoon dog is not a native species in Ukraine, it has been introduced from the Far East of Russia in the middle of the XX century. Most helminth species recorded in the raccoon dog are generalists infecting various carnivoran hosts. On the other hand, trematodes appeared to be more common and abundant among the helminths of the raccoon dog, apparently due to its preference for aquatic habitats.

In the present survey, the taxonomic structure of the helminth fauna of Mustelidae appeared to be similar to that in the red fox, apparently due to the predomination of rodents in the diet of these hosts. Most helminths recorded in mustelids are specific parasites of this host group. In our opinion, all records of helminths of canids occurring in mustelids and felids should be confirmed by the exact identification of helminth species using molecular methods. The same is true for the helminths which are common in domestic dogs and cats. We found 25 helminth species in the material collected from mustelids, including four species of cestodes, six species of trematodes, and 15 nematode species. Presumably, there might be more helminth species infecting mustelids in Ukraine, however, the populations of these carnivorans are decreasing in numbers and scattered. Due to this, we were able to examine only small samples of each species of this group.

Helminth species richness in the material from domestic carnivorans was found to be lower than that in wild species of the group. We recorded 20 species parasitic in the domestic dog and eight species from the domestic cat. Expectedly, the helminth fauna of the domestic dog was most similar to that of the wolf. The helminth fauna of the domestic cat appeared to be distinct from those of all other carnivorans. Two helminth species, namely the trematode *M. albidus* and the nematode *A. tubaeforme* were present only in the material from the domestic cat.

The helminthological material analysed in the present survey included samples collected from the representatives of three carnivoran families: Canidae, Mustelidae, and Felidae. To the best of our knowledge, the overall sample of hosts used in the present study (260 specimens in total) is the largest sample of carnivorans ever examined in Ukraine. The brown bear *Ursus arctos* is the only representative of the Ursidae in the fauna of Ukraine. It is a rare species occurring in Polissia and the Carpathians. Helminths from this species were absent in examined material.

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