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HELMINTHS OF WILD PREDATORY MAMMALS (MAMMALIA, CARNIVORA) OF UKRAINE. TREMATODES

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Helminths of Wild Predatory Mammals (Mammalia, Carnivora) of Ukraine. Trematodes. Korol, E. N., Varodi, E. I., Korniyushin, V. V., Malega, A. M. — The paper summarises information on 11 species of trematodes parasitic in 9 species of wild carnivorans of Ukraine. The largest number of trematode species (9) was found in the red fox (*Vulpes vulpes*). *Alaria alata* (Diplostomidae) appeared to be the most common trematode parasite in the studied group; it was found in 4 host species from 9 administrative regions and Crimea.

Key words: parasites, Carnivora, Trematoda, Canidae, Felidae, Mustelidae, *Alaria alata*, Ukraine.

Introduction

Previous studies on helminths of wild carnivorans in Ukraine were scanty, often limited to particular regions and separate host species. The monograph by A. N. Kadenatsii (1957) deals with the hosts from the Crimean Peninsula only. The article by A. P. Korneev and V. P. Koval (1958) provides more information on helminths of wild mammals from separate regions of Ukraine. An overview of the related publications is given in our previous paper on cestodes of carnivorans (Korniyushin et al., 2011).

Previously gathered information about trematodes of wild carnivorans of Ukraine is allocated in the “Catalogue of helminths of vertebrates of Ukraine” (Iskova et al., 1995). According to this summary, 10 species of trematodes were recorded in carnivorans of Ukraine, namely, *Isthmiophora melis* (Schrank, 1788) (syn. *Euparyphium melis*), *Echinochasmus perfoliatus* (Rats, 1908), *Opisthorchis felineus* Rivolta, 1884, *Metorchis albidus* (Braun, 1893), *Cryptocotyle lingua* (Creplin, 1825), *Metagonimus yokogawai* (Katsurada, 1912), *Dicrocoelium dendriticum* (Rudolphi, 1819), *Alaria alata* (Goeze, 1782), *Troglorema acutum* (Leuckart, 1842), *Euryhelminis squamula* (Rudolphi, 1819). The trematodes were reported from the red fox, raccoon dog, stone marten, weasel, ermine, forest and steppe polecats, and badger. In addition, 17 species of trematodes were reported from domestic dogs and 19 species from cats; 13 species were found to parasitise the both hosts in Ukraine. In the latter group, *Apophallus müehlingi* (Jägerskiöld, 1899), *Cryptocotyle concavum* (Creplin, 1825), *Pygidiopsis genata* Looss, 1907 were also reported from wild mammals in the neighbouring countries (Bowman et al., 2002). In the “Keys to the Helminths of Predatory Mammals of the USSR” (Kozlov, 1977), *Metorchis bilis* (Braun, 1890) (syn. *Metorchis vulpis* Romanov, 1967), *Metametorchis skrjabini* (Morosov, 1939) and *Pharyngostomum fausti* Skrjabin et Popov, 1930 are also mentioned from the neighbouring Eastern European countries.

The present work summarises information on the trematodes of carnivorans based on our investigations on the helminths of this host group in Ukraine.

Material and methods

For the present survey, we used the material collected from 260 individuals of 14 species of carnivorans (table 1). Task-oriented collection of helminths of wild predatory mammals in Ukraine has been carried out since 1998. We have also examined materials provided by helminthologists and mammalogists L. Shevchenko, V. Domnych, A. Yemets, N. Zvegintsova, and others. In addition, we studied the previously collected material stored in the helminthological collection of the Department of Parasitology of the I. I. Schmalhausen Institute of Zoology, NAS of Ukraine (SIZK).

The taxonomy of trematodes follows that in A. Kostadinova, A. Pérer-del-Olmo (2014) and “Fauna Europaea” (<http://www.faunaeur.org>). For identification of trematodes we used “Keys to Helminths of Predatory Mammals of the USSR” (Kozlov, 1977), a monograph by V. Kontrimavichus “Helminth Fauna of the Mustelids and the Ways of its Formation” (Kontrimavichus, 1969), and other publications.

Table 1. Studied hosts and the prevalence of trematode infection

N	Host species	Number of examined individuals	Number of infected individuals	Prevalence of infection, %
1.	Wolf (<i>Canis lupus</i> Linnaeus)	32	11	34.4
2.	Jackal (<i>C. aureus</i> Linnaeus)	1	1	100
3.	Raccoon dog (<i>Nyctereutes procyonoides</i> Gray)	14	10	71.4
4.	Red fox (<i>Vulpes vulpes</i> (Linnaeus))	166	64	38.6
5.	American mink (<i>Neovison vison</i> Brisson)	13	10	76.9
6.	Stone marten (<i>Martes foina</i> Erxleben)	7	1	14.3
7.	Marten (<i>M. martes</i> Linnaeus)	4	0	0
8.	Weasel (<i>Mustela nivalis</i> Linnaeus)	6	1	16.7
9.	Polecat (<i>M. eversmanni</i> Lessin)	2	2	100
10.	Ermine (<i>M. erminea</i> (Linnaeus))	2	0	0
11.	Otter (<i>Lutra lutra</i> Linnaeus)	5	3	60
12.	Badger (<i>Meles meles</i> Linnaeus)	3	0	0
13.	Lynx (<i>Lynx lynx</i> (Linnaeus))	1	0	0
14.	Forest cat (<i>Felis silvestris</i> Schreber)	4	0	0
	Total	260	103	39.6

Results and discussion

In our studies, trematodes were found in 103 individuals of 9 host species (table 1). No trematodes were found in 5 species of Carnivora, namely, the forest cat, the lynx, the marten, the ermine, and the badger.

In the carnivorans of Ukraine we found 11 species of trematodes belonging to 6 families and 10 genera. The information on the trematodes found, their hosts, rates of infection and localities in Ukraine is presented below.

Class TREMATODA

Subclass DIGENEA

Family Diplostomidae Poirier, 1886

1. *Alaria alata* (Goeze, 1782)

Hosts and distribution.

Definitive hosts: *V. vulpes*: P (prevalence) — 38.55 %, I (intensity of infection, mean and range) — 97 (1–570), A (abundance) — 37.32 (Volyn, Zhitomir, Kyiv, Chernigiv, Sumy, Lviv, Cherkasy, Poltava Regions, Crimea). *C. lupus*: P — 31.25 %, I — 353 (2–2124), A — 110 (Chornobyl Exclusion Zone of Kyiv Region, Zhitomir, Chernigiv, Sumy Regions). *N. procyonis*: P — 42.86 %, I — 667 (5–1444), A — 285.86 (Kyiv Region including Chornobyl Exclusion Zone); *C. aureus*: 2 specimens were found in 1 studied host individual in Odesa Region.

Paratenic hosts: *M. nivalis*: P — 16.7 %, I — 19, A — 3.17 (Volyn Region); *M. eversmanni*: P — 50 %, I — 2, A — 1 (Kyiv Region).

2. *Pharyngostomum cordatum* (Diesing, 1850)

Hosts and distribution.

Definitive hosts: *V. vulpes*: P — 0.6 %, I — 85, A — 0.51 (Cherkasy Region).

Family Cyathocotylidae Mühling, 1898

3. *Mesostephanus appendiculatus* (Ciurea, 1916)

Hosts and distribution.

Definitive hosts: *V. vulpes*: P — 1.21 %, I — 97 (83–110), A — 1.16 (Mykolaiv and Kherson Regions).

4. *M. skworzowi* (Petrow, 1950)

Hosts and distribution.

Definitive hosts: *V. vulpes*: P — 0.6 %, I — 88, A — 0.48 (Kyiv Region); *N. procyonis*: P — 14.29 %, I — 257 (10–505), A — 6.79 (Chornobyl Exclusion Zone of Kyiv Region).

Family Echinostomatidae Looss, 1899

5. *Isthmiophora melis* (Schrank, 1788)

Hosts and distribution.

Definitive hosts: *V. vulpes*: P — 1.21 %, I — 3.5 (3–4), A — 0.04 (Lviv, Cherkasy Regions); *N. procyonis*: P — 14.29 %, I — 3.5 (2–5), A — 0.5 (Kyiv Region); *N. vison*: P — 61.54 %, I — 161 (2–500), A — 40.99 (Kyiv Region, including Chornobyl Exclusion Zone, Chernihiv Region); *M. foinea*: P — 1 %, I — 66, A — 9.43 (Kyiv Region); *M. eversmani*: P — 50 %, I — 147, A — 73.5 (Kyiv Region).

6. *Echinochasmus perfoliatus* Ratz, 1908

Hosts and distribution.

Definitive hosts: *V. vulpes*: P — 1.81 %, I — 32 (2–90), A — 0.55 (Rivne, Kyiv, Poltava Regions); *N. procyonis*: P — 14.29 %, I — 14.5 (9–20), A — 2.07 (Kyiv Region); *L. lutra*: P — 33 %, I — 11, A — 36.66 (Kyiv Region); *N. vison*: P — 15.38 %, I — 77.5 (3–152), A — 51.66 (Kyiv Region).

7. *Stephanoprora denticulata* (Rudolphi, 1802)

Hosts and distribution.

Definitive hosts: *V. vulpes*: P — 0.6 %, I — 154, A — 0.93 (Kherson Region).

Family Opisthorchiidae Looss, 1899

8. *Pseudamphistomum truncatum* (Rudolphi, 1819)

Hosts and distribution.

Definitive hosts: *L. lutra*: P — 33.3 %, I — 11, A — 3.67 (Zhitomir Region); *N. vison*: P — 30.77 %, I — 255 (165–346), A — 78.62 (Kyiv Region); *M. eversmani*: P — 50 %, I — 147, A — 73.5 (Kyiv Region).

Family Heterophyidae Leiper, 1909

9. *Apophallus donicus* Skrjabin et Lindtrop, 1919

Hosts and distribution.

Definitive hosts: *V. vulpes*: P — 1.81 %, I — 1, 3 (1–2), A — 0.02 (Kyiv Region); *N. procyonis*: P — 14.29 %, I — 1, A — 0.14 sp. (Kyiv Region); *N. vison*: P — 30.73 %, I — 37 (8–115) (Kyiv Region); *L. lutra*: P — 33.3 %, I — 6, A — 2 (Kyiv Region).

10. *Ascocotyle italica* (Alessandrini, 1906)

Hosts and distribution.

Definitive hosts: *V. vulpes* (Kherson Region; SIZK collection).

Family Plagiorchiidae Lühe, 1901

11. *Plagiorchis elegans* (Rudolphi, 1802)

Hosts and distribution.

Definitive hosts: *L. lutra*: P — 33.3 %, I — 11, A — 3.67 (Zhytomyr Region).

In addition to wild carnivorans examined, we found the trematode *Metorchis albidus* (Braun, 1883) in domestic cat in Sumy Region (1 host infected, out of 6 studied); *A. alata*, *A. donicus* and *E. perfoliatus* were collected from domestic dog.

Generally, trematodes were not very common in carnivorans, comparing to cestodes and nematodes. The overall prevalence of trematode infection in 260 examined host specimens was 39.6 % (table 1).

In our studies, separate regions of Ukraine were not equally investigated. The largest part of the material was collected in the Polissya (forest) region. Six species of trematodes

were registered there, and all those species were found in Kyiv Region. In other regions of Polissya, just 1 or 2 trematode species were found. Six species of trematodes were found in regions close to the Dnieper River (Cherkasy, Poltava, Kherson Regions); and only one species was registered in Crimea.

The trematode *A. alata* appeared to be the most widespread in Ukraine; it was registered in 9 Regions and in Crimea. Four species of the family Canidae: the red fox, wolf, raccoon dog and jackal harboured this parasite. High prevalence and intensity of infection were observed in the former three hosts. Apparently, all of them successfully support the transmission of this parasite in natural ecosystems. The raccoon dog is the most suitable host for *A. alata* due to its ecological particularities, such as food preferences (figs 1, 2). The role of the jackal in the transmission of *A. alata* in the ecosystems of southern Ukraine is yet undefined, since only 1 host specimen was investigated. We identified two species of the family Mustelidae as paratenic hosts of *A. alata*.

The trematode *I. melis* also has comparatively wide host range; it was found in 5 canids and mustelids in 4 regions of Ukraine (Kyiv, Chernihiv, Lviv, Cherkasy Regions). *E. perfoliatus* in Rivne, Kyiv and Poltava Regions, and *A. donicum* in Kyiv Region were each registered in 4 species of the hosts, canids and mustelids. *P. skworzowi* was found in only 2 species of canids in Kyiv Region, and *P. truncatum* parasitised 2 mustelid species in Zhytomyr and Kyiv Regions.

Co-infection of a single individual host by various species of trematodes was rather rare. The following combinations of species were noted. Four species of trematodes were simultaneously observed in the fox: *A. alata* + *E. perfoliatus* + *M. skworzowi* + *A. donicum* and in the raccoon dog: *A. alata* + *M. skworzowi* + *A. donicum* + *I. melis*; each of the simultaneous infections was registered only once. Co-infection with three species of trematodes was observed in the fox (*A. alata* + *S. denticulata* + *M. appendiculatus*) and in the American mink: (*P. truncatum* + *I. melis* + *A. donicum*). Two species of trematodes in a single host individual were found more frequently. There were combinations of the following: *A. alata* + *A. donicum* (in two foxes), *A. alata* + *E. perfoliatus* (in one fox and in two raccoon dogs), *A. alata* + *I. melis* (in one fox and in two raccoon dogs), *A. alata* + *Ph. cordatum* (in one fox), *E. melis* + *A. donicum* (in two raccoon dogs), *P. truncatum* + *I. melis* (in one American mink), *P. truncatum* + *P. elegans* (in one otter), *E. perfoliatus* + *I. donicum* (in one otter). In general, 7 out of 64 examined foxes (10.9 %) harboured more than one trematode species. Trematode co-infection with different species was common in raccoon dogs: 7 out of 10 specimens examined (70 %). There, the occurrence of two or three trematode species was rather a rule than an exception.

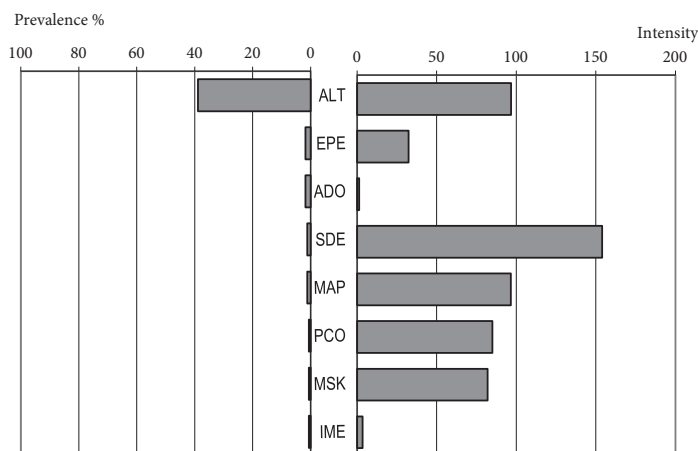


Fig. 1. Structure of the trematode fauna of the red fox in Ukraine (original data): ALT — *A. alata*; EPE — *E. perfoliatus*; ADO — *A. donicum*; SDE — *S. denticulata*; MAP — *M. appendiculatus*; PCO — *Ph. cordatum*; MSK — *M. skworzowi*; IME — *I. melis*.

Table 2. Species of trematodes occurring in wild and domestic Canidae from Ukraine (based on original studies and published records)

N	Trematode species	Fox	Wolf	Raccoon dog	Jackal	Dog
1.	<i>Alaria alata</i>	+	+	+	+	+
2.	<i>Pharyngostomum cordatum</i>	+				
3.	<i>Mesostephanus appendiculatus</i>	+				+
4.	<i>M. skworzowi</i>	+		+		
5.	<i>Echinostoma revolutum</i>					+
6.	<i>Isthmiophora melis</i>	+		+		+
7.	<i>Echinochasmus perfoliatus</i>	+		+		+
8.	<i>Stephanoprora denticulata</i>	+				+
9.	<i>Metagonimus yokogawai</i>	+				+
10.	<i>Opistorchis felineus</i>	+		+		+
11.	<i>Pseudamphistomum truncatum</i>					+
12.	<i>Metorchis albidus</i>	+				+
13.	<i>Cryptocotyle concavum</i>					+
14.	<i>C. lingua</i>	+				+
15.	<i>Apophallus donicus</i>	+		+		+
16.	<i>Ascocotyle italica</i>	+				+
17.	<i>Tauridiana pontica</i>					+
18.	<i>Plagiorchis elegans</i>					+
19.	<i>Dicrocoelium dendriticum</i>	+				+
	Total	14	1	5	1	17

* New original records.

Usually (in 60 examined hosts) trematodes were met in association with others helminths, nematodes and cestodes. Eleven animals were found to be infected with trematodes only.

Wild carnivorans of the Canidae family were the most numerous among the hosts examined; we studied 166 foxes, 32 wolves and 14 raccoon dogs. In foxes, the prevalence of trematode infection reached 38.6 %; 9 species of trematodes were found in these hosts. *A. alata* was a dominant species in trematode communities of the red fox in Ukraine, with infection prevalence 38.55 % and mean intensity 97 (fig. 1). All other trematode species were found in smaller number of host individuals (1–3), infection prevalence was 0.6–1.81 %. The mean infection intensity in those species varied widely, from 1.3 up to 154. Most trematodes found in the red fox (*E. perfoliatus*, *M. appendiculatus*, *M. skworzowi*, *S. denticulata*, *Ph. cordatum*) are rare parasites of this host under the conditions of Ukraine (mean intensity was about 10). The remaining 2 species, *I. melis* (mean intensity 3.5) and *A. donicus* (mean intensity 1.3) are occasional parasites of the host. To date, 14 species of trematodes were registered in foxes in Ukraine, considering the previously published data (table 2).

In the raccoon dog, the prevalence of trematode infection was 71.4 %. Five species of trematodes were found (fig. 2). As in the red fox, *A. alata* predominated (P = 42.86 %, mean intensity 667). The other 4 species had similar occurrence (P = 14.29 %), though *M. skworzowi* was prominent due to comparatively high mean intensity, 256.5. In *E. perfoliatus*, the mean intensity was 14.5. These two species may be considered as common parasites of the raccoon dog. *E. melis* and *A. donicum* were rare parasites of the host; their mean intensity did not exceed 1–3.5.

Prevalence of trematode infection in the wolf was somewhat lower, 34.4 %. *A. alata* is the only species of trematodes registered in the wolf in Ukraine. Some other species of trematodes (table 2) were rarely recorded on the territory of the former USSR (Kozlov, 1977): *O. felineus*, *P. truncatum*, *M. yokogawai*, and *P. truncatum*. In the present study, the latter species was found only in the weasel. Apparently the trematode community in the wolf is depauperated due to feeding preferences of the host, whereas the infection with *A. alata* is ensured by the participation of paratenic hosts, including mustelids, in the transmission.

The only trematode species found in the jackal in the present study was *A. alata*. Two more species were recorded in this host in the former USSR: *Dexiagonimus ciureanus* and *P. elegans* (Kozlov, 1977).

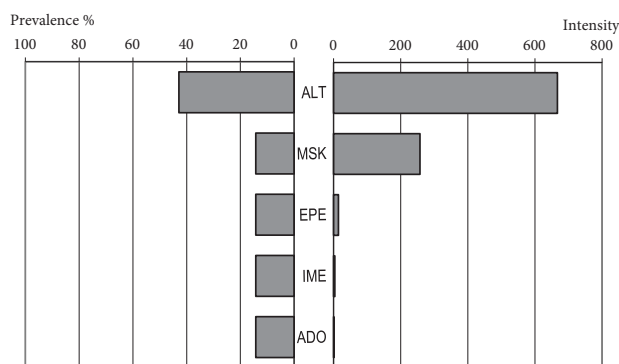


Fig. 2. Structure of the trematode fauna of the racoon dog in Ukraine (original data): ALT — *A. alata*; MSK — *M. skworzowi*; EPE — *E. perfoliatus*; IME — *I. melis*; ADO — *A. donicum*.

The distribution of trematode parasites among canid hosts is presented in table 2.

Our data on trematode infection in Mustelidae are not comprehensive, since only 40 specimens of 8 species were investigated. Eight species of trematodes were found in 5 host species. Four of them parasitised the American mink and the otter, 2 species were found in the weasel; the stone marten and polecat each harboured one species. Two trematode species, *P. truncatum* and *P. elegans*, were specific to mustelid hosts. The former parasite is known also from wild canids in neighbouring regions, and the latter one is an occasional parasite of predatory mammals. The other 6 species are common in other carnivorans in Ukraine. According to the literature (Iskova et al., 1995), two more species, *T. acutum* and *E. squamula*, were registered in the mustelids in the Carpathian Mountains and both are likely specific parasites of these mammals. Mesocercariae of *A. alata* were found in 2 species of mustelids.

Trematodes of mustelids, unlike the cestodes, do not exhibit a narrow specificity to definitive hosts. However, mustelids are apparently more suitable hosts for *I. melis*, *P. truncatum*, and probably, *A. donicum*, as evidenced by higher intensity of infection in this group of hosts.

Information on trematode parasites found in each separate carnivore species is summarised in the list below.

Wolf: 1. *Alaria alata*.

Fox: 1. *Alaria alata*, 2. *Pharyngostomum cordatum*, 3. *Mesostephanus appendiculatus*, 4. *M. skworzowi*, 5. *Isthmiophora melis*, 6. *Echinochasmus perfoliatus*, 7. *Stepanoprora denticulata*, 8. *Apophallus donicus*, 9. *Ascocotyle italica*.

Raccoon dog: 1. *Alaria alata*, 2. *Mesostephanus skworzowi*, 3. *Isthmiophora melis*, 4. *Echinochasmus perfoliatus*, 5. *Apophallus donicus*.

Jackal: 1. *Alaria alata*.

Otter: 1. *Echinochasmus perfoliatus*, 2. *Pseudamphistomum truncatum*, 3. *Plagiorchis elegans*, 4. *Apophallus donicus*.

Stone marten: 1. *Isthmiophora melis*.

Weasel: 1. *Alaria alata*, 2. *Isthmiophora melis*.

Polecat: 1. *Alaria alata*.

American mink: 1. *Isthmiophora melis*, 2. *Echinochasmus perfoliatus*, 3. *Pseudamphistomum truncatum*, 4. *Apophallus donicus*.

General remarks

Helminths of wild carnivorans are actively investigated in the countries neighbouring Ukraine. Trematode parasites, still not numerous, were reported from carnivorans in Belarus (Andreiko, 1973; Shimalov, Shimalov, 1987, 2001; Anisimova, 2002; other publications). For example, 8 species of trematodes are listed in the catalogue "Helminths of Domestic and Wild Animals of Belarus" (Merkusheva, Bobkova, 1981). Only 2 of them (*Fasciola hepatica* L., 1758 and *Strigea strigis* (Schrank, 1788)) have never been registered in these hosts in

Ukraine. In both reported cases that was obviously an accidental infection of the otter and black ferret, respectively. Two trematode species, *O. felineus* and *E. perfoliatus*, were recorded in domestic dogs and cats in Belarus, and both were found in wild carnivorans of Ukraine. Anisimova (2007) first reported on the occurrence of *Isthmiophora inerme* (Fuhrmann, 1904) in American mink in Belarus.

Andreiko (1968) recorded 34 species of helminths in carnivorans in Moldova, including 9 species of trematodes. After fundamental studies on the helminths of Mustilidae in Lithuania (Kontrimavichus, 1969), this group is still being investigated; recent studies reported on 9 helminths species including 2 species of trematodes (Nugaraitė et al., 2014).

In the European part of Russia, studies on helminths of carnivorans were actively carried out in the second half of the XX century (e. g., Karasev, 1963, Troitskaya, 1960, 1967; other publications), and these studies are still in progress now. Recently helminths of wild animals in the Kirov Region were studied by Maslennikova (2005), who found 3 species of trematodes: *E. melis*, *A. alata*, *D. lanceatum* (= *D. dendriticum*). Andreianov (2013) found 6 species of trematodes (*I. melis*, *A. alata*, *E. perfoliatus*, *O. felineus*, *M. albidus*, *P. truncatum*) in 10 species of carnivorans in central regions of Russia (Ryazan, Vladimir, Nizhny Novgorod Regions). According to Kryuchkova (2012), 35 species of helminths occur in carnivorans in the European part of the Russian Federation, including 5 species of trematodes (*A. alata*, *N. salmincola*, *E. perfoliatus*, *S. subtriquetrus*, *O. felineus*). Vlasenko (2007) recorded 100 % helminth infection in 25 species of carnivorans in Krasnodar Region. Helminth community was composed of 13 species including 2 species of trematodes (*A. alata* and *E. perfoliatus*). Trunova et al. (2007) identified 24 species of helminths in wild carnivorans in the south-eastern zone of the North Caucasus, including 3 species of trematodes.

The parasite fauna of wild carnivorans in Poland is rather well investigated (Malczewski, 1961, 1962; Sołtys, 1964, Górsky et al., 2010, and other). Górsky et al. (2006) examined 6 species of carnivorans in Białowieża Primeval Forest. They appeared to be infected with trematodes, the highest prevalence was found in wolves, 42.1 %. According to Borgsteede (1984), 13 helminth species parasitise foxes in the Netherlands, including 4 species of trematodes. Thirteen helminth species were found by Thiess et al. (2001) in raccoon dogs in Germany, including trematodes *A. alata*, *I. melis* and *M. bilis*. The authors noted similarity of helminth communities of the raccoon dog and the red fox. Various authors demonstrated that the trematodes were much rarer than cestodes and nematodes, and *A. alata* was the dominant species.

Among the studied trematodes, only one species, namely *O. felineus*, has epidemiological significance in Ukraine. This diginean is widespread along the Dnipro River and its tributaries (Padchenko, Lokteva, 1990); it is the agent of human opisthorchiasis in the region. People acquire infection by eating poorly-boiled or poorly-fried fish contaminated with metacercariae of the trematode. At high intensity of infection severe liver damage develops, that may lead to death in case of delayed diagnosis and lack of proper treatment. Humans, alike to domestic and wild carnivorans, are the definitive host of *O. felineus*. The transmission of this pathogen can take place in both synanthropic and in natural foci.

Most trematodes of wild carnivorans can also infect domestic dogs and cats, and, therefore, they have a significant veterinary importance. In case of intensive infection, many of them can cause severe diseases with clinical signs of liver or intestine disorders.

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