Opis przypadku *Case report*

Spirometra erinaceieuropaei infection in a cat imported into Poland from South Korea

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Summary

***Spirometra* tapeworms are causative agents of sparganosis, an emerging zoonosis in Europe. Many mammal species in Poland, such as wild boar and American mink, are among its paratenic hosts. Red foxes and raccoon dogs are recognized as both intermediate and definitive hosts. Very little is known about the prevalence of *Spirometra* among dogs and cats. Only a few cases of infection in cats have been described worldwide. The aim of this paper was to describe a very important aspect of long distances parasite migration. In March 2023, a mixed breed cat was brought from South Korea to Poland. In fecal examination, eggs similar to those of tapeworms from the Diphyllobothridae family were found. Molecular identification of the tapeworm showed a 100% similarity to *Spirometra erinaceieuropaei* deposited in GenBank®. One dose of praziquantel was effective against infestation. This case of the cat imported into Poland without previous deworming or vaccination highlights the problem of potentially dangerous parasites entering countries along with pets.**

Keywords: *Spirometra erinaceieuropaei*, sparganosis, cat, imported infection, Poland

The tapeworm *Spirometra erinaceieuropaei* (Rudolphi 1819) belongs to the Diphyllobothriidae family. It requires two intermediate hosts to complete its life cycle (17). The first group of intermediate hosts are crustaceans, most often cyclops, and the second are small rodents, birds, amphibians, and reptiles (17). Dogs, wild canids, cats, and Eurasian lynx (*Lynx lynx*) are considered its definitive hosts (8, 19, 24). Many mammal species in Poland are recognized as paratenic hosts of the *Spirometra* tapeworm. Plerocercoid larvae were found subcutaneously in European badgers (*Meles meles*), wild boars (*Sus scrofa*), raccoon dogs (*Nyctereutes procyonoides*), American minks (*Neovison vison*), and European polecats (*Mustela putorius*) (16-18). Red foxes (*Vulpes vulpes*) and raccon dogs (*Nyctereutes procyonoides*) can be both intermediate and definitive hosts (8, 31, 32). *S. erinaceieuropaei* is a highly zoonotic agent and the cause of sparganosis in humans (25). In humans, plerocercoid larvae can be located under the skin, in the lungs, liver, eye sockets, brain, and spinal cord (22, 25, 35). The first case of human sparganosis in Poland was described in 2019 in a 60-year-old woman living in Hajnówka, north-eastern Poland (5). Humans become infected after consumption of raw or undercooked tissues or derivatives of mammals, birds, snakes, or amphibians (34, 20).

Case description

Mixed breed cat of unknown age living near households in Ulsan in South Korea was imported into Poland in March 2023. The animal was a stray cat that fed on free-living rodents and birds. After the journey, the cat was examined, vaccinated, and dewormed with milbemycin and praziquantel (Milbemax, Elanco GmbH). No significant abnormalities were noted in blood tests except low folic acid (1.5 µg/L) and high amylase (2153.17 U/L) levels (Tab. 1, 2).

Two days after deworming, the cat excreted whitish fragments with feces. They were difficult to identify, soft and easy to crush between fingers. Fecal samples were collected and sent to a veterinary laboratory, where they were examined by fresh fecal smear and centrifugal fecal flotation with sucrose solution. Additionally, a rapid one-step immunochromatographic test (Simple Crypto-Giardia, OPERON, S.A.) for the detection of *Cryptosporidium* and *Giardia* antigens in stool samples was performed.

The morphology of eggs detected in the fecal samples was similar to that of tapeworm eggs from the Diphyllobothriidae family. The eggs identified under the microscope were brownish, ovoid, operculate, and easy to confuse with trematode eggs. The eggs (n = 20) were, on average, 72 (59-79)

Tab. 1. Complete blood count values

Parameter	Result	Unit	Reference range	
			min.	max.
RBC	9.44	10^{12}/L	6.5	10.0
HGB	139.0	g/L	80.0	150.0
HCT	0.40	L/L	0.24	0.45
MCV	42.4	fL	39.0	55.0
MCH	0.9	fmol	0.8	1.05
MCHC	21.5	mmol/L	13.7	25.4
RDW-CV	23.5 ↑	%	16.0	23.0
WBC	6.31	10^9/L	5.5	19.0
Neutrophils	2.62	10^9/L	2.3	9.8
Eosinophils	0.59	10^9/L	0.0	1.8
Basophils	0.0	10^9/L	0.0	0.2
Limphocytes	3.03	10^9/L	0.9	5.5
Monocytes	0.07	10^9/L	0.0	0.8
Neutrophils	41.5	%	35.0	75.0
Eosinophils	9.3	%	2.0	12.0
Basophils	0.0	%	0.0	1.0
Limphocytes	48.0	%	20.0	55.0
Monocytes	1.2	%	1.0	4.0
PLT	227.0	10^9/L	150.0	600.0
MPV	11.4	fL	10.0	16.0
PDW	14.7	(10GSD)	12.0	17.5

Fig. 1. Eggs of a tapeworm from the Diphyllobothriidae family found in cat feces. Sucrose flotation method, SG of flotation solution = 1.31. Lens magnification 40×

µm in length and 36 (32-43) µm in width (Fig. 1). No other parasites or protozoan antigens were found in the feces.

The tapeworm eggs were rinsed off the cover slide with distilled water and centrifuged. The sediment obtained was frozen. Manual DNA extraction from the frozen sediment

Tab. 2. Serum biochemistry values

Parameter	Result	Unit	Reference range	
			min.	max.
AST	13.84	U/L	6.0	44.0
ALT	48.23	U/L	20.0	107.0
ALP	38.2	U/L	11.0	49.0
Urea	10.9	mmol/L	4.2	11.7
Creatinine	0.15	mmol/L	0.1	0.16
Total protein	67.8	g/L	60.0	79.0
Albumin	40.6 ↑	g/L	25.0	39.0
Globulin	27.2	g/L	26.0	51.0
Alb/Glo ratio	1.49 ↑	A:G	0.5	1.1
Glucose	5.3	mmol/L	3.3	6.7
Amylase	2153.2 ↑	U/L	550.0	1465.0
DGGR lipase	26.77	U/L	25.0	251.0
Cholesterol	4.3	mmol/L	2.0	5.2
Triglicerydes	0.38	mmol/L	0.2	1.5
CK	128.34	U/L	70.0	400.0
LDH	125.63	U/L	70.0	405.0
GGTP	4.02	U/L	0.0	10.0
GLDH	1.95	U/L	1.0	10.0
Bilirubin total	0.003	mmol/L	0.002	0.02
Chlorides	123	mmol/L	112	129
Sodium	159 ↑	mmol/L	145	158
Potassium	5.0	mmol/L	3.7	5.4
Calcium	2.4	mmol/L	2.0	2.7
Phosphorus	1.56	mmol/L	1.0	2.0
Magnesium	0.86	mg/dL	0.5	1.2
Vitamin B12	713	pmol/L	214.0	738.0
Folic acid	3.4 ↓	nmol/L	22.0	49.0

was performed according to the manufacturers' instructions (Genomic Mini AX Stool, A&A Biotechnology). The DNA obtained was frozen for further tests.

Molecular identification of *Spirometra*. PCR was performed in a 25 µl of reaction mixture containing 12.5 µl StartWarm HS-PCR Mix (A&A Biotechnology), 1.25 µl of each primer: JB3 (5'-TTTTTTGGGCATCCTGAG-GTTTAT-3'), JB4.5 (5'-TAAAGAAAGAACATAAT-GAAAATG-3'), 7 µl dd H_2O and 1 µl of genomic DNA to amplify a partial mt-CO1 gene for sequencing (1). PCR was carried out by an initial denaturation at 95°C for 3 min, followed by 45 cycles of denaturation at 95°C for 30 s, annealing at 50°C for 60 s, extension at 72°C for 60 s, and a final extension at 72°C for 15 min in a PCR thermocycler (MultiGene optiMAX, Labnet International, Inc.). Amplified products were analyzed on 2% agarose gel. A 446bp PCR product was sequenced and aligned, analyzed with MEGA11 (Molecular Evolutionary Genetics Analysis Version 11), and compared with the GenBank® database. A 373-bp product was 100% homologous to cytochrome c oxidase subunit 1 (COX-1) of *Spirometra erinaceieuropaei* gene sequences in GenBank® (eg. MK085883.1, MK085880.1, MK085875.1). The sequence obtained in this publication has been submitted as OQ733387.

Discussion

The cat imported into Poland without any preventive measures (vaccination and deworming) or prior veterinary examinations was adopted at the beginning of 2023 as a stray cat. Stray cats play a significant role as definitive hosts for many tapeworm species belonging to the genera *Taenia*, *Mesocestoides*, *Echinococcus*, *Dibothriocephalus*, and *Spirometra* (3, 13, 14, 23, 27, 28). Dogs and cats are recognized as the most important animal hosts in endemic and urban areas. Little is known about the prevalence of *S. erinaceieuropaei* in cats and dogs worldwide. Two studies from Italy showed a prevalence of 0.9% and 1.4% among 116 and 139 cats, respectively (15, 28). In Portugal, *Spirometra* infection was found in 0.3% of 301 dogs examined (2). A fecal flotation test of 1322 cats from two shelters in New York, USA, showed only 0.4% of positive results for the *Spirometra* tapeworm (21). The highest prevalence of *Spirometra* in definitive hosts was described in Australia. Among 146 feral cats and red 147 foxes, the prevalence reached 61% and 5.4%, respectively (20, 29). In Poland, *Spirometra* infection was described in Eurasian lynx – originally, *Spirometra janickii* in 2008 (33) and then *Spirometra* sp. in 2018 (19). No data on *Spirometra* infections among dogs and cats in Poland are available.

Sparganosis caused by the *Spirometra* genus in humans and animals is well known in Korea (11, 14). In contrast to two cats living in the cities of Yangsan and Daegu in South Korea (14), the cat described in this study showed no clinical signs of parasitic infection, such as diarrhea, vomiting, weight loss, or anemia. No abnormalities were noted in blood morphology or typical serum biochemistry, except for a low folate level.

Praziquantel is a drug of choice in the treatment of tapeworms and trematode infections (12, 30). The dose of the drug in both dogs and cats varies from 5 to 40 mg/kg (4, 23, 30) and is well tolerated (7). In our case, the cat was treated with a single dose of milbemycin oxime (16 mg)/praziquantel (40 mg) tablets, Milbemax (Elanco GmbH). The treatment was repeated after 14 days, and no tapeworm eggs were detected in a control fecal flotation.

Global transport and tourism make the transfer of new parasite species very likely. In 2017, three cases of *Thelazia callipaeda* in dogs traveling from continental Europe to the United Kingdom were described (9). Two years later, an imported infection by the same nematode species was described in a German Pointer dog in Poland (10). A British study performed between 2015 and 2017 demonstrated the potential risk of tapeworm infection among illegally transported animals due to the absence of vaccination and/or deworming with praziquantel against *Echinococus multilocularis* infection (6).

The case of the cat from South Korea described in this study highlights the potential risk of zoonotic infection. It seems important to implement measures aimed at preventing similar situations by increasing the awareness of animal owners, veterinarians, and border guards.

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