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▣ ORIGINAL ARTICLE

Zoonotic Intestinal Trematodes in Stray Cats (*Felis catus*) from Riverside Areas of the Republic of Korea

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Abstract: The present study was performed to survey the infection status of zoonotic intestinal trematode (ZIT) in stray cats from 5 major riverside areas in the Republic of Korea. Total 400 stray cats were captured with live-traps in riverside areas of Seomjingang ('gang' means river) (203 cats) from June to October 2010, and of Yeongsangang (41), Nakdonggang (57), Geumgang (38), and Hangang (61 cats) from June to October 2011, respectively. Small intestines resected from cats were opened with a pair of scissors in a beaker with 0.85% saline and examined with naked eyes and under a stereomicroscope. More than 16 ZIT species were detected in 188 (92.6%) cats from Seomjingang areas, and the number of worms recovered was 111 per cat infected. In cats from riverside areas of Yeongsangang, Nakdonggang, Geumgang, and Hangang, more than 9, 8, 3, and 5 ZIT species were recovered, and the worm burdens were 13, 42, 11, and 56 specimens per infected cat, respectively. As the members of family Heterophyidae, more than 10 species, i.e., *Metagonimus* spp., *Pygidiopsis summa*, *Heterophyes nocens, Stellantchasmus falcatus, Heterophyopsis continua, Acanthotrema felis, Centrocestus armatus, Procerovum varium, Cryptocotyle concava,* and *Stictodora lari,* were recovered. More than 5 species of echinostomes, i.e., *Echinostoma hortense, Echinochasmus japonicus, Echinochasmus* sp., *Echinoparyphium* sp., and unidentified larval echinostomes, were collected. *Plagiorchis* spp. were detected in cats from areas of Seomjingang and Yeongsangang. From the above results, it has been confirmed that stray cats in 5 major riverside areas of Korea are highly infected with various species of ZITs.

Key words: *Metagonimus* spp., *Pygidiopsis summa, Heterophyes nocens, Stellantchasmus falcatus*, zoonotic intestinal trematode, stray cat, riverside area, Korea

INTRODUCTION

The stray cat (*Felis catus*), a powerful predator, actively consumes the wide-ranged foodstuff, which originated from various kinds of prey animals. That's why this predator animal is highly infected with various species of parasites, and act as the important reservoir hosts of human and veterinary parasites. Surveys on intestinal parasite infections in stray or feral cats have been conducted in various regions of the world including the Republic of Korea (Korea) [1-14]. Especially, in Korea, more than 21 species of zoonotic intestinal trematodes (ZITs) from cats have been reported in the literatures [7,8,11-14].

On the other hand, soil-transmitted nematodiases are no longer public health problems in these days in Korea. Meanwhile, infections with zoonotic trematodes including *Clonorchis sinensis* are important parasitic diseases in endemic areas, especially in riverside areas [15-18]. Moreover, these trematodes show the low host-specificity, and then many kinds of reservoir hosts can contribute to the maintainance of their life cycles. Therefore, we have been trying to survey on the infection status of ZITs in stray cats from the riverside areas of 5 major rivers in Korea, and to estimate these predator animals as the potential reservoir hosts for ZITs.

MATERIALS AND METHODS

We captured total 203 stray cats with live-traps in riverside areas of Seomjingang ('gang' means river) from June to October 2010. We also collected with the same manner 41, 57, 38, and 61 stray cats in riverside areas of Yeongsangang, Nakdonggang, Geumgang, and Hangang from June to October 2011 respectively. Their small intestines were isolated and longitudi-

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nally opened with a pair of scissors in a beaker with 0.85% saline, and washed with saline until the supernatant is cleared. The sediment of intestinal content was carefully examined with naked eyes and under a stereomicroscope. The collected worms were fixed with 10% neutral buffered formalin under the slight pressure of cover glass, stained with Semichon's acetocarmine and observed under a light microscope with a micrometer (OSM-4, Olympus Co.). The stained specimens of ZITs were identified based on the appropriate systematic keys with morphological characteristics and dimensions. Then, each ZIT species identified was counted to get hold of infection rates and densities per cat infected.

RESULTS

Overall infection status of ZITs

Among the total 400 cats examined, 178 (44.5%) were negative for ZITs, and 222 (55.5%) were positive for more than 1 ZIT species (Table 1). Among the positive cats, 121 (30.0%) was infected with 1 species of ZIT. Only 1 cat from a riverside area of Nakdonggang was infected with more than 7 species of ZIT. The ZIT prevalence by the surveyed area is presented in Table 1.

Infection status of ZIT in cats from Seomjingang areas

More than 16 species of ZIT were recovered in 188 (92.6%)

Table 1. Recovery of intestinal trematodes by the number of species detected in cats from riverside areas of 5 major rivers, Korea

No. of species detected	No. (%) of cats positive from riverside areas of					
	SJG	YSG	NDG	GG	HG	Total
Negative	94 (46.3)	16 (39.0)	25 (43.9)	20 (52.6)	23 (37.7)	178 (44.5)
1 sp.	59 (29.1)	13 (31.7)	15 (26.3)	14 (36.8)	20 (32.8)	121 (30.0)
2 spp.	35 (17.2)	5 (12.2)	7 (12.3)	4 (10.5)	7 (11.5)	58 (14.5)
3 spp.	9 (4.4)	5 (12.2)	5 (8.8)	-	7 (11.5)	26 (6.5)
4 spp.	5 (2.5)	-	2 (3.5)	-	2 (3.3)	9 (2.3)
5 spp.	-	1 (2.4)	-	-	2 (3.3)	3 (0.75)
6 spp.	1 (0.5)	1 (2.4)	2 (3.5)	-	-	4 (1.0)
7 spp.	-	-	1 (1.8)	-	-	1 (0.25)
Total	203 (100)	41 (100)	57 (100)	38 (100)	61 (100)	400 (100)

SJG, Seomjingang (= Seomjin River); YSG, Yeongsangang; NDG, Nakdonggang; GG, Geumgang; HG, Hangang.

Table 2. Results of worm recovery in the small intestines of 203 stray cats from riverside areas of Seomjingang (=Seomjin River)

Trematode recovered	No. (%) of cats positive	No. of worms recovered		
		Total	Range	Average
Total	188 (92.6)[a]	20,821	1-9,591	110.8
Metagonimus spp.	61 (30.0)	6,446	1-1,380	105.7
Pygidiopsis summa	33 (16.3)	2,734	1-1,885	82.8
Heterophyes nocens	29 (14.3)	375	1-150	12.9
Stellantchasmus falcatus	6 (3.0)	216	1-106	36.0
Heterophyopsis continua	5 (2.5)	37	4-10	7.4
Acanthotrema felis	5 (2.5)	15	1-9	3.0
Centrocestus armatus	4 (2.0)	35	2-19	8.8
Cryptocotyle concava	2 (1.0)	2	-	1.0
Stictodora lari	1 (0.5)	1	-	1.0
Echinochasmus spp.[b]	19 (9.4)	10,768	1-9,591	566.7
Echinostoma hortense	2 (1.0)	28	12-16	14.0
Echinoparyphium sp.	1 (0.5)	63	-	63.0
Unidentified larval echinostome	9 (4.4)	85	2-35	9.4
Plagiorchis spp.	8 (3.9)	11	1-3	1.4
Unidentified spp.	3 (1.5)	5	1-3	1.7

[a]Cumulative positive rate.
[b]Mixed-infection including a dominant species, *Echinochasmus japonicus*.

Table 3. Results of worm recovery in the small intestines of stray cats captured from riverside areas of 4 major rivers, Korea

Locality trematode	No. (%) of cats positive	No. of worms recovered		
		Total	Range	Average
Yeongsangang (n=41 cats)	25 (61.0)[a]	313	1-190	12.5
Heterophyes nocens	8 (19.5)	60	1-28	7.5
Metagonimus spp.	5 (12.2)	19	1-10	3.8
Pygidiopsis summa	3 (7.3)	193	1-190	64.3
Procerovum varium	3 (7.3)	32	1-29	10.7
Heterophyopsis continua	2 (4.9)	4	1-3	2.0
Stellantchasmus falcatus	1 (2.4)	2	-	2.0
Centrocestus armatus	1 (2.4)	1	-	1.0
Echinostoma hortense	1 (2.4)	1	-	1.0
Plagiorchis muris	1 (2.4)	1	-	1.0
Nakdonggang (n=57)	45 (79.0)[a]	1,897	1-740	42.2
Heterophyes nocens	12 (21.1)	77	1-33	6.4
Pygidiopsis summa	10 (17.5)	1,603	2-740	160.3
Metagonimus spp.	10 (17.5)	135	1-77	13.5
Heterophyopsis continua	5 (8.8)	9	1-3	1.8
Stellantchasmus falcatus	3 (5.3)	5	1-3	1.7
Centrocestus armatus	1 (1.8)	1	-	1.0
Procerovum varium	1 (1.8)	1	-	1.0
Echinostoma hortense	3 (5.3)	66	2-59	22.0
Geumgang (n=38)	3 (7.9)[a]	33	-	11.0
Metagonimus spp.	1 (2.6)	25	-	25.0
Echinochasmus japonicas	1 (2.6)	7	-	7.0
Unidentified sp.	1 (2.6)	1	-	1.0
Hangang (n=61)	22 (36.1)[a]	1,230	1-632	55.9
Metagonimus spp.	13 (21.3)	1,119	1-632	86.1
Stellantchasmus falcatus	2 (3.3)	80	9-71	40.0
Heterophyes nocens	1 (1.6)	7	-	7.0
Pygidiopsis summa	1 (1.6)	5	-	5.0
Unidentified larval echinostome	5 (8.2)	19	1-7	3.8

[a]Cumulative positive rate.

cats from Seomjingang areas. The number of worms recovered was 111 per cat infected. *Metagonimus* spp. (30.0%) were the most prevalent, followed by *P. summa* (16.3%), *H. nocens* (14.3%), and *Echinochasmus* spp. (9.4%). A cat was extraordinarily infected with about 9,600 *Echinochasmus* spp. The infection status of each ZIT species is shown in Table 2.

Infection status of ZIT in cats from riverside areas of 4 major rivers

More than 9 species of ZIT were recovered in 25 (61.0%) cats from Yeongsangang areas. The average number of worms recovered was 12.5 per cat infected. *H. nocens* was most highly prevalent and recovered from 8 (19.5%) cats. Total 45 (79.0%) cats from Nakdonggang areas were infected with ZITs (more than 8 species), and the average number of specimens recovered per cat was 42.2. *H. nocens* (21.1%), *Metagonimus* spp. (17.5%), and *P. summa* (17.5%) were prevalent in cats from Nakdonggang areas. Only 3 cats (7.9%) from Geumgang areas were infected with a total of 33 ZIT specimens. More than 5 species of ZIT were recovered in 22 (36.1%) cats from Hangang areas. The number of worms recovered was 56 per infected cat. *Metagonimus* spp. was most highly prevalent and recovered from 13 (21.3%) cats. The infection status of each ZIT species by surveyed areas is shown in Table 3.

DISCUSSION

Studies on ZIT infections in cats have been done by several workers in Korea. Lee [7] reported 5 species of ZIT, i.e., *H. nocens*, *M. yokogawai*, *Centrocestus* sp., *Echinochasmus perfoliatus*, and *Echinoparyphium* sp., from cats captured in Gyeongsangbuk-do. Eom et al. [8] described 3 species of ZIT, *H. continua*,

H. nocens, and *P. summa*, collected in domestic cats from Seoul. Sohn et al. [11] recorded *Acanthotrema felis*, as a new species, from the small intestines of stray cats from a market in Busan. Sohn and Chai [12] added more than 15 species of ZITs in the fauna of cat trematodes, and Shin et al. [13] reported *Gymnophalloides seoi* found in feral cats from Shinan-gun, Jeollanam-do. Chai et al. [14] clarified species names of some ZITs recorded by Sohn and Chai [12] in the faunistic point of view. Thus far, more than 23 species, i.e., *Metagonimus* spp., *Heterophyes nocens, Heterophyopsis continua, Pygidiopsis summa, Stellantchasmus falcatus, Stictodora fuscata, Stictodora lari, Acanthotrema felis, Centrocestus armatus, Procerovum varium, Cryptocotyle concava, Echinostoma hortense, Echinostoma revolutum, Echinochasmus japonicus, Echinochasmus perfoliatus, Echinochasmus* sp., *Echinoparyphium* sp., *Stephanoprora* sp., *Neodiplostomum seoulense, Plagiorchis muris, Plagiorchis* sp., *Gymnophalloides seoi*, and *Eurytrema pancreatitum*, have been reported as the ZITs recovered from cats in Korea [7,8,11-14].

In the present study, 178 (44.5%) out of 400 stray cats examined were negative for ZIT, while the remaining 222 (55.5%) were infected with 1-7 species of ZITs. The cumulative positive rate of ZIT was the highest in cats from Seomjingang areas (92.6%), and lowest in cats from Geumgang areas (7.9%). The worm burden (intensity of infection) was also the highest in cats from Seomjingang areas (about 111 worms per cat infected), and lowest in cats from Geumgang areas (11 worms). However, direct comparison of ZIT endemicity by the surveyed areas in the present study seems unreasonable. The survey in the Seomjingang areas was performed from June to October 2010, and a total of 203 stray cats were captured and examined. Whereas, the surveys in the adjacent areas of 4 rivers, Yeongsangang, Nakdonggang, Geumgang, and Hangang, were conducted from June to October 2011, and only 38-61 cats (total 197) were captured and examined. The number of cats examined was relatively high in the areas of Seomjingang, but it is considered not enough in the other 4 river areas for evaluation of the ZIT endemicity.

More than 9 species of heterophyid flukes, i.e., *Metagonimus* spp., *P. summa*, *H. nocens, S. falcatus, H. continua, A. felis, C. armatus, C. concava*, and *S. lari*, were detected in 146 (72.0%) cats from Seomjingang areas. Among these, *Metagonimus* spp. were the most frequently detected (in 61 cats: 30.0%), and *P. summa* and *H. nocens* were found from 33 (16.3%) and 29 (14.3%) cats, respectively. These findings are in accordance with those of previous studies; the adjacent areas of Seomjingang and the coastal areas of Namhae (the southern sea) are endemic areas of heterophyidiases including metagonimiasis [19-22]. Sohn and Chai [12] surveyed stray cats from a local market of Busan and found that *H. nocens* was the most prevalent ZIT (from 24.2% cats), and *P. summa*, *Metagonimus* spp., and *H. continua* were detected in 21.0%, 17.8%, and 13.2% of cats, respectively. The most prevalent ZIT, *Metagonimus* spp. comprised 3 species, i.e., *M. yokogawai, M. takahashii*, and *M. miyatai*, distributed in Korea [23]. Although the distribution pattern of the uterine tubule of *M. yokogawai* is different from those of the latter 2 species, they are difficult to distinguish from each other in fresh worm samples.

Three species of heterophyid flukes, *A. felis, C. concava*, and *S. lari*, were found only in cats from Seomjingang areas. *P. varium*, described with only 2 adults by Chai et al. [14] for the first time in Korea, was detected in cats from the areas of Yeongsangang and Nakdonggang. Whereas, *Metagonimus* spp. were found in cats from all surveyed areas. *P. summa*, *H. nocens*, and *S. falcatus* were detected in cats from 4 surveyed areas except Geumgang areas.

An echinostomatid fluke, *E. hortense*, the dominant species in Korea, was found in cats from the areas of Seomjingang, Yeongsangang, and Nakdonggang. Also *Echinochasmus* spp. (including *E. japonicus*), *Echinoparyphium* sp., and unidentified larval echinostomes were detected in a small number of cats. Extraordinarily, about 9,600 *Echinochasmus* spp. specimens (including *E. japonicus*) were recovered in a cat from Seomjingang area, and 63 *Echinoparyphium* sp. were collected in another cat from Seomjingang area. Two species of *Echinochasmus*, i.e., *E. japonicus* and *E. perfoliatus*, and *Echinoparyphium* sp. were already reported as cat trematodes in Korea [7,12,14]. However, *E. perfoliatus* and *Echinoparyphium* sp. were poorly and erroneously described with 2 and 1 worm samples, respectively, and the genus- and/or species-specific characteristics are not obvious to approve their taxonomic validities. Therefore, in faunistic points of view, these obscure problems should be solved in the near future with the worm samples of *Echinochasmus* spp. and *Echinoparyphium* sp. recovered in the present study.

Nowadays, fishborne trematode (FBT) infections are the most important parasitic diseases in the riverside areas of Korea. People in the endemic areas have been subjected to the control projects by the Korea CDCP (Centers for Disease Control and Prevention), and human excrements have been hygienically dealt with in the sewage disposal plant in Korea [15-

17]. However, the endemicity of FBT infections is continuously maintained in these areas. If it is so, what kind of animals (definitive hosts) are acting as the egg-supplier in the ecological environment? In the present study, we could confirm that stray cats from riverside areas are infected with various species of ZITs. It is suggested strongly that stray cats play an important role of a reservoir host for ZITs.

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CONFLICT OF INTEREST

We have no conflict of interest related to this work.

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