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ORIGINAL ARTICLE

Infection Status with *Clonorchis sinensis* Metacercariae in Fish from Yangcheon (Stream) in Sancheong-gun, Gyeongsangnam-do, Korea

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Abstract: The infection status with *Clonorchis sinensis* metacercariae (CsMc) was examined in freshwater fishes from Yangcheon (a branch of Gyeongho-gang), which is located in Sancheong-gun, Gyeongsangnam-do, the Republic of Korea. Total 2,201 fishes in 26 species were examined by the artificial digestion method through 7 years. CsMc were detected in 1,171 (53.2%) fishes in 21 spp. (80.8%) and their density was 85 per fish infected. Total 532 (99.6%) out of 534 *Pungtungia herzi* (index fish) examined were infected with 147 CsMc per fish infected. Metacercarial densities in this fish were highest in 2015 (179 CsMc), followed by 2012 (168), 2013 (152), 2016 (145), 2014 (114), and 2017 (89) respectively. In the gobioninid fish group, i.e., *P. herzi, Sarcocheilichthys* spp., *Squalidus* spp., *Pseudogobio esocinus*, *Hemibarbus longirostris,* and *Hemibarbus labeo*, 841 (92.7%) fishes were infected with 117 CsMc per fish infected. Total 250 (54.7%) acheilognathinid fish (bitterlings), *Acheilognathus* spp. and *Acanthorhodeus* spp. were infected with 5.8 CsMc. In the rasborinid fish (chubs) group, i.e., *Zacco platypus, Zacco temminckii*, and *Zacco koreanus*, 77 (13.7%) out of 563 fish examined were infected with 2.4 CsMc in average. The susceptibility indices of CsMc were 49.09 in the overall positive fish group, 104.15 in the gobioninid group, 3.17 in the acheilognathinid group and 0.35 in the rasborinid fish group respectively. Only 1 CsMc was detected in 3 fish species, *Coreoperca herzi, Channa argus*, and *Lepomis macrochirus*, respectively. Conclusively, it was confirmed that CsMc are moderately prevalent in fishes from Yangcheon in Sancheon-gun, Gyeongsangnam-do, Korea.

Key words: *Clonorchis sinensis*, metacercaria, susceptibility index, Gobioninae, Acheilognathinae, Rasborinae, Cyprinidae, fish host, Yangcheon

INTRODUCTION

Clonorchiasis, *Clonorchis sinensis* (Digenea: Opisthorchiidae) infection, is most important among endemic parasitic diseases in the Republic of Korea (Korea). Although the prevalence of this endemic disease was 1.86% in the nationwide survey on the helminthic infection in Korea, about 932,540 Korean peoples are estimated to be infected with this endemic trematode. Nowadays, it is the highest value among the prevalences of parasitic diseases in Korea [1]. The prevalence of clonorchiasis has maintained at relatively high levels in the residents of riverside areas in Korea [2-6]. Recently, a team of Korean CDC (Division of Vectors and Parasitic Diseases, Centers for Disease Control and Prevention) [4-6] reported the prevalences of clonorchiasis in the adjacent residents of 5 major rivers, i.e., Nakdong-gang (gang means river), Seomjin-gang, Geum-gang, Yeongsan-gang and Han-gang, in Korea. The riverside area of Gyeongho-gang (a branch stream of Nakdong-gang) in Sancheong-gun, Gyeongsangnam-do has been known as a high endemic area of clonorchiasis [6-10].

Many Korean workers epidemiologically surveyed the freshwater fishes, the human infection sources, to estimate the endemicities of clonorchiasis [11-17]. Especially, Kim et al. [11] widely surveyed freshwater fishes from 34 localities to know the infection status with *Clonorchis sinensis* metacercariae (CsMc) in Korea. Cho et al. [12] investigated the infection status of CsMc in freshwater fish from 3 wide regions, which were tentatively divided by the latitudinal levels of Korean peninsula. Cho et al. [13] also surveyed on the prevalence of zoonotic trematode metacercariae in freshwater fish from Gangwon-do (do = Province), Korea. Sohn et al. [14] investigated the infection status of digenetic trematode metacercariae including *C.*

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sinensis in freshwater fish from the water systems of Hantangang and Imjingang located in relatively northern regions of Korea. Recently, Sohn et al. [15] and Yoon et al. [17] surveyed the prevalence of CsMc in freshwater fishes from the water systems of Seomjin-gang and Tamjin-gang. Sohn et al. [16] also reported the prevalence and intensity of CsMc in freshwater fish from a highly endemic site, Wicheon (a branch stream of Nakdonggang) (cheon means stream), in Gunwi-gun, Gyeongsangbuk-do, Korea.

Gyeongho-gang is one of the branch stream of Nakdonggang, which rise from a mountinous area (Namdeokyu-san) (san means mountain) of Seosang-myeon (myeon = township) in Hamyang-gun (gun = county), flows via Hamyang-gun and Sancheong-gun and into Jinyang-ho (ho means lake) in Jinju-si (si = city), Gyeongsangnam-do. Yangcheon is one of the branch stream of Gyeongho-gang located in the Saengbiryang-myeon, Sancheong-gun [18]. The riverside area of Yangcheon has been reported as a high endemic area of clonorchiasis [7-9]. However, the infection status with CsMc in fish from this area has not been widely and systematically examined yet. Therefore, we intended to investigate the infection status with CsMc in fishes from Yangcheon for 7 years (2011-2017).

MATERIALS AND METHODS

Fish collection site and freshwater fishes examined

We collected total 2,201 freshwater fishes in 26 species in Yangcheon (a branch stream of Gyeongho-gang), which is located in Saengbiryang-myeon, Sancheong-gun (Latitude: 35.37015; Longitude: 128.08025), Gyeongsangnam-do, Korea. The numbers and species of fish by the year examined were as follows.

Total 201 freshwater fish in 14 species were examined in 2011. Fish species (No. of fish) examined were *Zacco temminckii* (27), *Coreoperca herzi* (10), *Odontobutis platycephala* (14), and *Carassius auratus* (1) including 10 ones with CsMc in Table 1. Total 221 freshwater fish in 11 species were examined in 2012. Fish species (No. of fish) examined were *Zacco platypus* (29), *C. herzi* (4), and *C. auratus* (1) including 8 ones with CsMc in Table 1. Total 644 freshwater fish in 20 species were examined in 2013. Fish species (No. of fish) examined were *C. auratus* (20), *C. herzi* (19), *Liobagrus mediadiposalis* (3), *O. platycephala* (3), *Acheilognathus yamatsutae* (1), and *Z. temminckii* (1) including 14 ones with CsMc in Table 1.

Total 291 freshwater fish in 14 species were examined in 2014. Fish species (No. of fish) examined were *O. platycephala* (13) and *Siniperca scherzeri* (1) including 12 ones with CsMc in Table 1. Total 183 freshwater fish in 15 species were examined in 2015. Fish species (No. of fish) examined were *Z. temminckii* (40), *C. herzi* (2), *O. platycephala* (1), *Micropterus salmoides* (1), *C. auratus* (1), and *A. macropterus* (1) including 9 ones with CsMc in Table 1.

Total 253 freshwater fish in 16 species were examined in 2016. Fish species (No. of fish) examined were *C. auratus* (22), *Z. temminckii* (21), *Z. koreanus* (20), *C. herzi* (10), *O. platycephala* (1), and *A. macropterus* (1) including 10 ones with CsMc in Table 1. Total 408 fish in 22 species were examined in 2017. Fish species (No. of fish) examined were *M. salmoides* (36), *C. auratus* (28), *Z. koreanus* (20), *C. herzi* (18), and *O. platycephala* (4) including 17 ones with CsMc in Table 1.

Examination methods

All collected fishes were transferred to the laboratory of the Department of Parasitology and Tropical Medicine, Gyeongsang National University College of Medicine, Jinju, Korea. After the identification of fish species, they were individually ground with a mortar or grinder. Each ground fish meat was mixed with artificial gastric juice and the mixture was incubated at 36°C for about 2 hr. The digested material was filtered with 1×1 mm of mesh and washed with 0.85% saline untill the supernatant is clear. The sediment was carefully examined under a stereomicroscope. The metacercariae of *C. sinensis* (CsMc) were separately collected by the general feature [19,20], and they were counted to get hold of infection rates (No. of fish with CsMc/No. of fish examined × 100) and densities (No. of CsMc/a fish infected) by fish species. The susceptibility indices of CsMc in each fish species were calculated by the formula, prevalence/100 × mean metacercarial density per fish infected.

RESULTS

Infection status with CsMc in overall fishes

The metacercariae of *C. sinensis* were detected in 1,171 (53.2%) out of 2,201 fishes in 26 species examined, and their average density was 85 per fish infected. In CsMc positive fish species, the number of fish examined was 1,827 (83.0%) in 21 species (80.8%), and the positive rate was 64.1%. The infection status by the fish species and surveyed years was detailedly shown in Table 1.

Table 1. Infection status of *Clonorchis sinensis* metacercariae in fishes from Yangcheon (a stream of Gyeongho-gang) in Sancheong-gun, Gyeongsangnam-do

Year and fish sp.	No. of fish examined	No. of fish infected (%)	No. of CsMc detected	
			Range	Average
2011				
Pungtungia herzi	95	95 (100)	4-930	157.2
Zacco platypus	16	1 (6.3)	-	1.0
Squalidus chankaensis	13	13 (100)	14-322	95.1
Squalidus japonicus coreanus	12	12 (100)	7-69	23.3
Pseudogobio esocinus	4	4 (100)	11-167	57.3
Hemibarbus longirostris	4	3 (75.0)	-	1.0
Sarcocheilichthys nigripinnis	2	2 (100)	43-96	69.5
Hemibarbus labeo	1	1 (100)	-	6.0
Sarcocheilichthys variegatus	1	1 (100)	-	512.0
Acheilognathus majusculus	1	1 (100)	-	2.0
Subtotal	149	133 (89.3)	1-930	130.4
2012				
Pungtungia herzi	106	106 (100)	2-1,157	168.0
Zacco temminckii	35	3 (8.6)	1-2	1.3
Hemibarbus longirostris	21	5 (23.8)	1-2	1.4
Sarcocheilichthys nigripinnis	8	8 (100)	7-795	205.1
Acheilognathus majusculus	7	2 (28.6)	7-12	9.5
Squalidus chankaensis	5	5 (100)	18-58	42.6
Acanthorhodeus macropterus	4	1 (25.0)	-	1.0
Squalidus gracilis majimae	1	1 (100)	-	7.0
Subtotal	187	131 (70.1)	1-1,157	150.4
2013				
Pungtungia herzi	142	141 (99.3)	11-742	152.4
Zacco koreanus	94	2 (2.1)	-	1.0
Acheilognathus majusculus	85	40 (47.1)	1-10	2.5
Zacco platypus	55	19 (34.5)	1-13	2.3
Squalidus chankaensis	51	51 (100)	7-183	61.3
Hemibarbus longirostris	34	19 (55.9)	1-3	1.6
Acheilognathus koreensis	31	25 (80.6)	1-20	5.3
Squalidus japonicus coreanus	30	30 (100)	1-134	33.7
Pseudogobio esocinus	20	18 (90.0)	2-23	7.8
Acanthorhodeus gracilis	20	3 (15.0)	-	1.0
Acanthorhodeus macropterus	17	3 (17.6)	-	1.0
Sarcocheilichthys variegatus	8	8 (100)	56-530	227.9
Acheilognathus rhombeus	8	5 (62.5)	1-5	2.6
Sarcocheilichthys nigripinnis	2	2 (100)	21-153	87.0
Subtotal	597	366 (61.3)	1-742	76.8
2014				
Pungtungia herzi	65	65 (100)	1-443	114.3
Acheilognathus majusculus	40	9 (22.5)	1-8	2.9
Zacco koreanus	40	1 (2.5)	-	1.0
Coreoperca herzi	30	1 (3.3)	-	1.0
Zacco platypus	25	13 (52.0)	1-10	2.8
Squalidus japonicus coreanus	25	25 (100)	9-195	86.7
Pseudogobio esocinus	16	16 (100)	1-84	36.8
Acheilognathus koreensis	13	9 (69.2)	1-7	3.2
Acheilognathus yamatsutae	10	6 (60.0)	1-7	2.7
Hemibarbus longirostris	7	5 (71.4)	1-12	5.8
Sarcocheilichthys variegatus	5	5 (100)	2-13	8.0
Sarcocheilichthys nigripinnis	1	1 (100)	-	29.0
Subtotal	277	156 (56.3)	1-443	66.6

(*Continued to the next page*)

Infection status with CsMc in index fish, *Pungtungia herzi*

CsMc were detected in 532 (99.6%) out of 534 *P. herzi* examined and their average density was 147 per fish infected. The densities were most high in 2015 (179), and followed by 2012 (168), 2011 (157), 2013 (152), 2016 (145), 2014 (114), and 2017 (89). The infection status with CsMc in *P. herzi* by

Table 1. Continued

Year and fish sp.	No. of fish examined	No. of fish infected (%)	No. of CsMc detected	
			Range	Average
2015				
Pungtungia herzi	40	40 (100)	9-434	178.8
Zacco platypus	40	18 (45.0)	1-10	2.6
Hemibarbus longirostris	25	2 (8.0)	-	1.0
Sarcocheilichthys variegatus	10	10 (100)	42-362	224.3
Acheilognathus majusculus	9	3 (33.3)	2-6	3.3
Acheilognathus koreensis	7	6 (85.7)	1-5	2.0
Acheilognathus yamatsutae	3	3 (100)	1-5	2.3
Squalidus japonicus coreanus	2	2 (100)	98-194	146.0
Pseudogobio esocinus	1	1 (100)	-	12.0
Subtotal	137	85 (62.0)	1-434	115.0
2016				
Acheilognathus koreensis	40	25 (62.5)	1-9	2.9
Pungtungia herzi	33	33 (100)	23-341	144.8
Zacco platypus	32	14 (43.8)	1-7	2.8
Acheilognathus majusculus	23	13 (56.5)	1-16	2.8
Acheilognathus rhombeus	20	19 (95.0)	6-51	23.1
Acheilognathus yamatsutae	13	9 (69.2)	1-5	1.4
Channa argus	6	1 (16.7)	-	1.0
Squalidus japonicus coreanus	5	5 (100)	25-162	97.0
Hemibarbus longirostris	4	3 (75.0)	1-8	3.7
Pseudogobio esocinus	2	2 (100)	28-35	31.5
Subtotal	277	156 (56.3)	1-443	66.6
2017				
Pungtungia herzi	53	52 (98.1)	6-451	89.0
Zacco platypus	38	5 (13.2)	1-4	2.2
Acheilognathus majusculus	37	18 (48.6)	1-10	2.4
Acheilognathus yamatsutae	31	21 (67.7)	1-12	3.3
Zacco temminckii	30	1 (3.3)	-	1.0
Lepomis macrochirus	25	1 (4.0)	-	1.0
Acanthorhodeus gracilis	21	18 (85.7)	1-59	17.1
Pseudogobio esocinus	18	18 (100)	1-124	34.2
Squalidus japonicus coreanus	15	15 (100)	15-364	133.7
Hemibarbus labeo	8	6 (75.0)	1-6	2.3
Hemibarbus longirostris	7	5 (71.4)	1-8	2.4
Acheilognathus rhombeus	7	6 (85.7)	1-34	11.8
Acheilognathus koreensis	5	3 (60.0)	1-3	2.3
Squalidus gracilis majimae	3	3 (100)	32-195	86.7
Acanthorhodeus macropterus	2	2 (100)	4-7	5.5
Sarcocheilichthys nigripinnis	1	1 (100)	-	172.0
Sarcocheilichthys variegatus	1	1 (100)	-	208.0
Subtotal	302	176 (58.3)	1-451	48.0
Total	1,827	1,171 (64.1)	1-1,157	85.1

the year examined was detailedly revealed in Table 2.

Infection status with CsMc in gobioninid fish group

CsMc were detected in 841 (92.7%) out of 907 fishes in 9 species including *P. herzi* and their average density was 117 per fish infected. The densities were most high in *Sarcocheilichthys* spp. (179), and followed by *P. herzi* (147), *Squalidus* spp. (68), *P. esocinus* (28), *H. labeo* (3), and *H. longirostris* (2). The infection status by the fish species in this group was detailedly shown in Table 3.

Infection status with CsMc in acheilognathinid fish group

CsMc were detected in 250 (54.7%) out of 457 fishes examined and their average density was 5.8 per fish infected. The infection status with CsMc by the fish species, i.e., *A. majusculus, A. koreensis, A. yamatsutae, A. gracilis, A. rhombeus*, and *A. macropterus*, was detailedly revealed in Table 4.

Infection status with CsMc in rasborinid fish group

CsMc were detected in 77 (13.7%) out of 563 fishes examined and their average density was 2.4 per fish infected. The in-

Table 2. Infection status of *Clonorchis sinensis* metacercariae in index fish (striped shinner), *Pungtungia herzi*, from Yangcheon in Sancheong-gun, Gyeongsangnam-do

No. of examined	No. of fish examined	No. of fish infected (%)	No. of CsMc detected	
			Range	Average
2011	95	95 (100)	4-930	157.2
2012	106	106 (100)	2-1,157	168.0
2013	142	141 (99.3)	11-742	152.4
2014	65	65 (100)	1-443	114.3
2015	40	40 (100)	9-434	178.8
2016	33	33 (100)	23-341	144.8
2017	53	52 (98.1)	6-451	89.0
Total	534	532 (99.6)	1-1,157	147.0

Table 3. Infection status of *Clonorchis sinensis* metacercariae by the fish species in the gobioninid group (subfamily Gobioninae)

Species of fish	No. of fish examined	No. of fish infected (%)	No. of CsMc detected	
			Range	Average
Pungtungia herzi	534	532 (99.6)	1-1,157	147.0
Sarcocheilichthys spp.	39	39 (100)	2-795	179.0
S. variegatus wakiyae	25	25 (100)	2-530	193.0
S. nigripinnis morii	14	14 (100)	7-795	153.9
Squalidus spp.	162	162 (100)	1-364	68.4
S. japonicus coreanus	89	89 (100)	1-364	70.1
S. chankaensis tsuchigae	69	69 (100)	7-322	66.3
S. gracilis majimae	4	4 (100)	7-195	66.8
Pseudogobio esocinus	61	59 (96.7)	1-124	27.9
Hemibarbus longirostris	102	42 (41.2)	1-12	2.2
Hemibarbus labeo	9	7 (77.8)	1-6	2.9
Total	907	841 (92.7)	1-1,157	116.6

Table 4. Infection status of *Clonorchis sinensis* metacercariae by the fish species in the acheilognathinid group (subfamily Acheilognathinae)

Species of fish	No. of fish examined	No. of fish infected (%)	No. of CsMc detected	
			Range	Average
Acheilognathus majusculus	202	86 (42.6)	1-16	2.8
Acheilognathus koreensis	96	68 (70.8)	1-20	3.7
Acheilognathus yamatsutae	58	39 (67.2)	1-12	2.7
Acanthorhodeus gracilis	41	21 (51.2)	1-59	14.8
Acheilognathus rhombeus	35	30 (85.7)	1-51	17.4
Acanthorhodeus macropterus	25	6 (24.0)	1-7	2.5
Total	457	250 (54.7)	1-59	5.8

Table 5. Infection status of *Clonorchis sinensis* metacercariae by the fish species in the rasborinid group (subfamily Rasborinae)

Species of fish	No. of fish examined	No. of fish infected (%)	No. of CsMc detected	
			Range	Average
Zacco platypus	235	70 (29.8)	1-13	2.5
Zacco koreanus	174	3 (1.7)	-	1.0
Zacco temminckii	154	4 (2.6)	1-2	1.3
Total	563	77 (13.7)	1-13	2.4

fection status with CsMc by the fish species, i.e., *Z. platypus, Z. koreanus,* and *Z. temminckii,* was detailedly shown in Table 5.

Susceptibility index of CsMc by the fish groups

The susceptibility indices of CsMc were 54.6 in the overall

positive fish group, 108.1 in the gobioninid group, 3.2 in the acheilognathinid, and 0.3 in the rasborinid fish group respectively.

DISCUSSION

By the present study, it was confirmed that CsMc are moderately prevalent in fishes from Yangcheon, in Sancheong-gun, Gyeongsangnam-do, Korea. The infection status was showed with a certain tendency by the subfamily groups, i.e., Gobioninae, Acheilognathinae and Rasborinae, in the cyprinid fish (Family Cyprinidae) hosts of *C. sinensis* like Sohn et al. [16]. The prevalences were 92.7%, 54.7%, and 13.7%, and metacercarial densities were 116.6, 5.8, and 2.4 per fish infected in 3 fish groups respectively. When we compared with those of Sohn et al. [16], prevalences (100%, 79.7%, and 35.5%) and metacercarial densities (1,310, 50, and 15) were much lower in this study. However, we also knew that the endemicity of CsMc is closely related with the subfamily groups in the cyprinid fish hosts of *C. sinensis* from a moderately endemic area, Yangcheon, in Sancheong-gun, Gyeongsangnam-do, Korea.

The water ecosystem of Yancheon is more or less healthy but the ecological conditions for fish is not so good. Total 2,201 freshwater fishes in 26 species were collected through 7 years (2011-2017) in the same site of Saengbiryang-myeon in Sancheong-gun, Gyeongsangnam-do, in this study. Among them, striped shinner (534 *P. herzi*: 24.3%), was the most dominant fish species like Yoon et al. [17] in Tamjingang, and followed by pale chub (235 *Z. platypus*: 10.7%), large stripted bitterling (202 *A. majusculus*: 9.2%), Korean chub (174 *Z. koreanus*: 7.9%), dark chub (154 *Z. temminckii*: 7.0%), long nose barbel (102 *H. longirostris*: 4.6%), and oily bitterling (96 *A. koreensis*: 4.4%). The number of fish examined was 1,497 (68.0%) in major 7 species and 704 (32.0%) in remain 19 species. The disproportion of fish number examined is suggested that the ecological conditions for fish was relatively not so good, and because of all fishes were collected only by the netting in the nighttime. If we used together with other methods for fish catching like a casting net, the more various species of fish including diurnal ones were able to collect.

Total 51 fish species (in 36 genera 9 families) have been reported as the second intermediate hosts of *C. sinensis* in Korea [11,12,15-17,19]. In the present study, CsMc were found in 21 fish species, i.e., *P. herzi, S. variegatus wakiyae, S. nigripinnis morii, S. japonicus coreanus, S. chankaensis tsuchigae, S. gracilis majimae, P. esocinus, H. longirostris, H. labeo, A. majusculus, A. koreensis, A. yamatsutae, A. gracilis, A. rhombeus, A. macropterus, Z. platypus, Z. koreanus, Z. temminckii, C. herzi, Channa argus*, and *Lepomis macrochirus*. Among them, 2 fish species, i.e., *L. macrochirus* (Centrachidae) and *C. argus* (Channidae), are to be newly added in the list of the second intermediate hosts of *C. sinensis* in Korea. Accordingly, total 53 fish species in 38 genera (10 families) are to be the second intermediate hosts of *C. sinensis* in Korea.

The blue gill, *L. macrochirus*, was imported from Japan in 1969 and stocked in the Korean ecosystems in 1975 as the edible fish species. However, this predatory fish was widely spread in the water systems of whole country, and then specified as an agitating fish species of ecosystem in Korea [21]. In this study, no CsMc were detected in 5 (19.2%) out of 26 fish species examined, i.e., *Carassius auratus* (n=73), *Micropterus salmoides* (37), *Odontobutis platycephala* (36), *Liobagrus mediadiposalis* (3), *Siniperca scherzeri* (1), and only 1 CsMc was found in 1 (4.0%) out of 25 blue gills examined. Infections with CsMc in 2 exotic fish species, *L. macrochirus* and *M. salmoides* [16], are meaningful, although the number of fish examined and metacercariae detected were not so many. On the other hand, Choe et al. [22] did not found any other zoonotic trematode metacercariae including *C. sinensis* in 107 large mouth bass (*M. salmoides*) and 244 blue gills (*L. macrochirus*) from 2 sites, Daecheong-ho and Musimcheon, of Chungcheongbuk-do, Korea. However, we should pay attention to the exotic fish species, such as large mouth bass and blue gill, in the metacercarial survey for the fishborne zoonotic trematodes.

Fish species edible in the raw, i.e., Mandarin fish (*S. scherzeri*), Korean aucha perch (*C. herzi*), dark sleeper (*Odontobutis* spp.), common carp (*Cyprinus carpio*), and crusian carp (*C. auratus*), practically act as the infection source of clonorchiasis in Korea. Fortunately, these fish species are less prevalent with CsMc. In even such a highly endemic area, Wicheon, 3 (8.8%) out of 34 *C. auratus* were infected with total 3 CsMc, 2 (11.1%) *C. herzi* were retained with a total of 4 CsMc and only 1 (33.3%) *S. scherzeri* were infected with total 6 CsMc [16]. No CsMc were detected in 4 fish species, i.e., *C. herzi* (n=57), *C. auratus* (42), *S. scherzeri* (11), and *C. carpio* (2), from the water systems of Seomjingang [18]. In this study, only one CsMc were found in only 1 (1.1%) out of 93 *C. herzi* and no CsMc were detected from 73 *C. auratus*, 36 *O. platycephala*, and 1 *S. scherzeri*.

So, the striped shinner, *P. herzi*, broadly live in the water systems of river in Korea and is highly susceptibe with CsMc, it is

appropriate to evaluate the endemicities of *C. sinensis* infection as the index fish species. The number of this fish species examined were 197 (12.3%) in Seomjin-gang [15], 222 (13.5%) in Tamjin-gang [17], 169 (14.5%) in Wicheon [16], and 534 (24.3%) in this study. In the present study, 532 (99.6%) *P. herzi* were infected with 147 CsMc in average. Therefore, the endemicity (susceptibility index) was 146.4 (87.3-178.8 by the year examined). This value is higher than those in Tamjin-gang (103.2) [17] and Seomjin-gang (34.8) [15]. However, it is very low when we compared with that (1,550) in Wicheon [16]. Accordingly, based on the endemicity of CsMc in the index fish, *P. herzi*, we can know that Wicheon is highly endemic, Yangcheon in this study and Tamjin-gang are moderately endemic and Seomjin-gang is more or less low endemic areas.

In a highly endemic area, Wicheon in Gunwi-gun, Gyeongsangbuk-do, the infection tendency with CsMc was observed in positive fish species by the subfamily groups, i.e., Gobioninae, Acheilognathinae and Rasborinae, in the Cyprinidae fish hosts [16]. The endemicites in each group were 1,310.0, 39.9, and 5.3. Meanwhile, in this study performed in the moderately endemic area, they were 130.9, 3.2, and 0.3. The difference of endemicity between 2 regions was about 10 times in gobioninid group, 12.5 times in acheilognathinid and 17.7 times in rasborinid fish group. These findings suggest that the endemicity of CsMc is closely related with the fish groups in the cyprinid fish hosts and the endemicity difference in each fish groups from 2 regions is smaller in the susceptible gobioninid fish group, which is strongly related with host-parasite relationship, such as the infectivity of cercariae and susceptibility of host fish.

Conclusively, it is confirmed that the endemicity of CsMc is the moderate level in fishes from Yangcheon and the infection tendency of CsMc is obviously showed by the subfamily groups, i.e., Gobioninae, Acheilognathinae and Rasborinae, in the family Cyprinidae fish hosts from a moderately endemic site.

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CONFLICT OF INTEREST

The authors have no conflicts of interest concerning the work reported in this paper.

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