

Prevalence of *Clonorchis sinensis* Metacercariae in Fish from Water Systems of Seomjin-gang (River)

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Abstract: The prevalence of *Clonorchis sinensis* metacercariae (CsMc) was examined in freshwater fish from the water systems of Seomjin-gang (River), the Republic of Korea. Total 1,604 fish from 7 local sites of Seomjin-gang were examined by artificial digestion methods. The metacercariae of *C. sinensis* were detected in 102 (39.8%) out of 256 fish (14 species) from the upper reaches of Seomjin-gang, i.e., Osucheon (22.3% in 6 fish species) in Imsil-gun, and Seomjin-gang (63.9% in 9 fish species) in Sunchang-gun, Jeollabuk-do. Their average density was 9.0 per infected fish. They were also found in 132 (48.0%) out of 275 fish (12 spp.) from the middle reaches of Seomjin-gang, i.e., Songdaechon (58.9% in 4 fish species) in Namwon-si, Jeollabuk-do, and Seomjin-gang (45.2% in 10 fish species) in Gokseong-gun, Jeollanam-do. Their average density was 21.0 per infected fish. CsMc were detected in 77 (56.6%) out of 136 fish (11 species) from the lower reaches of Seomjin-gang, i.e., Seomjin-gang (73.3% in 11 fish species) in Gurye-gun, Jeollanam-do, and Nam-sancheon (8.6% in 1 fish species) in Hadong-gun, Gyeongsangnam-do. Their average density was 64.9 per infected fish. The metacercariae of *Metorchis orientalis* were also detected in 6 fish species from 4 sites of Seomjin-gang. Conclusively, it has been confirmed that CsMc are more or less prevalent in fish from some water systems of Seomjin-gang in Korea.

Key words: *Clonorchis sinensis*, *Metorchis orientalis*, metacercaria, freshwater fish, Seomjin-gang

INTRODUCTION

Nowadays, *Clonorchis sinensis* is the most important helminth in aspects of the prevalence and clinical significance in the Republic of Korea (= Korea). The endemicity of this trematode infection, clonorchiasis, has maintained at relatively high levels in riverside areas [1-8]. Seo et al. [1] reported the prevalence of *C. sinensis* infection among the riverside residents in 7 major rivers, i.e., Nakdong-gang (River) (40.2%), Youngsan-gang (30.8%), Seomjin-gang (17.3%), Tamjin-gang (15.9%), Han-gang (15.7%), Gum-gang (12.0%), and Mangyeong-gang (8.0%). In 2008, Cho et al. [5] reported the egg positive rates of residents living in 4 major river basins, Nakdong-gang (17.1%), Seomjin-gang (11.2%), Youngsan-gang (5.5%), and

Gum-gang (4.6%), located in southern parts of Korea. Recently, the prevalence of *C. sinensis* infection in adjacent residents of 5 major rivers, i.e., Nakdong-gang (11.7%), Seomjin-gang (9.9%), Gum-gang (6.5%), Youngsan-gang (3.1%), and Han-gang (1.0%), were reported by Jeong et al. [8]. By the nationwide survey on helminthic infections in Korea (2012), the prevalence of clonorchiasis was 1.9%, and 932,540 residents with this endemic disease were estimated to be infected, which is the highest value among the prevalences of helminthiasis in Korea [7].

On the other hand, freshwater fish, the source of infections, collected from various endemic riverside areas were examined by many Korean workers to estimate the endemicities of clonorchiasis. More than 48 fish species have been reported in Korea as the second intermediate hosts of *C. sinensis* [9-15]. Especially, in 2008, Kim et al. [12] widely surveyed 677 freshwater fish (21 species) from 34 localities to know the infection status with *C. sinensis* metacercariae (CsMc) in Korea. They examined fish from 2 sites, Imsil-gun (29 fish of 4 species), Jeollabuk-do, and Gokseong-gun (45 fish of 10 species), Jeolla-

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nam-do, as the fish from water systems of Seomjin-gang. In 2011, Cho et al. [14] investigated the infection status of CsMc in freshwater fish from 3 wide regions, which were tentatively divided by the latitude levels of the Korean peninsula. They also examined fish from 2 sites, Gokseong-gun (191 fish of 22 species) and Gurye-gun (68 fish of 14 species), Jeollanam-do, as the fish from Seomjin-gang. Cho et al. [15] surveyed on the prevalence of zoonotic trematode metacercariae in freshwater fish from Gangwon-do, Korea. Recently, Sohn et al. [16] investigated the infection status of trematode metacercariae, including *C. sinensis*, in freshwater fish from the water systems of Hantan-gang and Imjin-gang located in relatively northern regions of Korea. However, freshwater fish from the water systems of Seomjin-gang has not been widely and systematically examined. It is seriously needed to reveal the infection status of CsMc in fish from water systems of Seomjin-gang. Therefore, we performed the present study to investigate the prevalence of CsMc in freshwater fish from 7 local sites of Seomjin-gang.

MATERIALS AND METHODS

Fish collection

We collected total 1,604 freshwater fish from 7 local sites of Seomjin-gang, i.e., Osucheon (“cheon” means stream) (latitude: 38.43268; longitude: 127.4375) in Imsil-gun, Seomjin-gang (38.23047; 127.2179) in Sunchang-gun, Songdaechon (38.23047; 127.2179) in Namwon-si, Jeollabuk-do, Seomjin-gang (38.23047; 127.2179) in Gokseong-gun, Seomjin-gang (37.94375; 127.07142) in Gurye-gun, Jeollanam-do, and Hoengcheon (38.0855; 127.07264) and Namsancheon (38.01408; 127.2088) in Hadong-gun, Gyeongsangnam-do, for 5 years (2012-2016) (Fig. 1).

Fish examined from upper reaches of Seomjin-gang

Total 236 freshwater fish in 11 species (no. of fish examined) were collected from Osucheon in Imsil-gun, Jeollabuk-do (2012 and 2013), which included *Zacco platypus* (80), *Hemibarbus labeo* (56), *Squalidus chankaensis tsuchigae* (35), *Opsariichthys uncirostris amurensis* (21), *Squalidus japonicus coreanus* (20), *Microphysogobio jeoni* (6), *Acanthorhodeus gracilis* (6), *Pseudogobio esocinus* (5), *Carassius auratus* (3), *Rhodeus ocellatus* (3), and *Hemibarbus longirostris* (1).

Total 310 freshwater fish in 29 species were collected from Seomjin-gang in Sunchang-gun, Jeollabuk-do (2014 and 2015), which included *Pungtungia herzi* (56), *Z. platypus* (51), *P.*

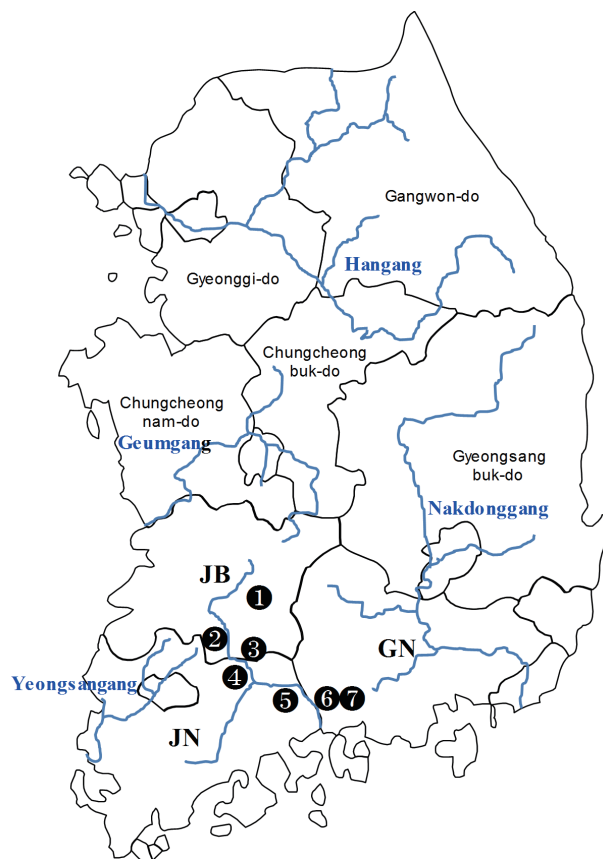


Fig. 1. The surveyed areas in the water systems of Seomjin-gang (River). ① Osucheon (latitude: 38.43268; longitude: 127.4375) in Imsil-gun, ② Seomjin-gang (38.23047; 127.2179) in Sunchang-gun, ③ Songdaechon (38.23047; 127.2179) in Namwon-si, Jeollabuk-do (JB), ④ Seomjin-gang (38.23047; 127.2179) in Gokseong-gun, ⑤ Seomjin-gang (37.94375; 127.07142) in Gurye-gun, Jeollanam-do (JN), ⑥ Hoengcheon (38.0855; 127.07264) and ⑦ Namsancheon (38.01408; 127.2088) in Hadong-gun, Gyeongsangnam-do (GN), Korea.

esocinus (32), *Coreoperca herzi* (19), *Zacco coreanus* (15), *O. uncirostris amurensis* (14), *C. auratus* (14), *Acheilognathus koreensis* (12), *Sarcocheilichthys variegatus wakiyae* (12), *S. japonicus coreanus* (11), *Acheilognathus rhombeus* (10), *Siniperca scherzeri* (10), *Odontobutis platycephala* (9), *Squalidus gracilis majimae* (6), *A. gracilis* (6), *Gnathopogon strigatus* (5), *H. longirostris* (5), *H. labeo* (4), *Coreoleuciscus splendidus* (4), *Plecoglossus altivelis* (3), *Acheilognathus yamatsutae* (3), *Abbottina springeri* (3), *Cyprinus carpio* (2), *Cobitis tetralineata* (2), *Acheilognathus lanceolatus* (1), *Acanthorhodeus macropterus* (1), *Hemiculter leucisculus* (1), *Cobitis lutheri* (1), and *Misgurnus anguillicaudatus* (1).

Fish examined from middle reaches of Seomjin-gang

Total 196 freshwater fish in 14 species collected from Song-

daecheon in Namwon-si, Jeollabuk-do were examined in 2012 and 2013. They included *Z. koreanus* (57), *P. herzi* (47), *Z. platypus* (46), *Rhynchocypris oxycephalus* (21), *C. herzi* (6), *Microphysogobio koreensis* (5), *C. auratus* (3), *G. strigatus* (2), *S. gracilis majimae* (2), *Pseudorasbora parva* (2), *A. springeri* (2), *P. esocinus* (1), *Iksookimia longicorpus* (1), and *Lepomis macrochirus* (1).

Total 289 freshwater fish in 15 species collected from Seomjin-gang in Gokseong-gun, Jeollanam-do were examined in 2015 and 2016. They included *Z. koreanus* (52), *Z. platypus* (43), *C. splendidus* (37), *S. variegatus wakiyae* (31), *S. japonicus coreanus* (27), *P. herzi* (22), *H. longirostris* (20), *P. esocinus* (16), *M. koeensis* (16), *C. herzi* (11), *Acheilognathus majusculus* (6), *P. altivelis* (3), *H. labeo* (2), *O. uncirostris amurensis* (2), and *Ladislavia taczanowskii* (1).

Fish examined from lower reaches of Seomjin-gang

Total 183 freshwater fish in 21 species were collected from Seomjin-gang in Gurye-gun, Jeollanam-do (2014), which included *Z. platypus* (24), *P. herzi* (21), *Z. koreanus* (14), *S. japonicus coreanus* (15), *Sarcocheilichthys nigripinnis morii* (14), *O. uncirostris amurensis* (13), *A. rhombeus* (11), *C. herzi* (10), *H. labeo* (10), *S. gracilis majimae* (8), *M. koeensis* (6), *C. auratus* (5), *A. rivularis* (5), *A. gracilis* (5), *O. platycephala* (4), *P. parva* (3), *P. altivelis* (3), *A. lanceolatus* (3), *H. longirostris* (1), and *S. scherzeri* (1).

Total 156 freshwater fish in 13 species were collected from Hoengcheon in Hadong-gun, Gyeongsangnam-do in 2014 and 2016, which included *Z. koreanus* (35), *A. koreensis* (27), *Z. platypus* (27), *P. herzi* (16), *C. herzi* (11), *Zacco temminckii* (10), *H. longirostris* (8), *P. esocinus* (8), *A. springeri* (7), *C. splendidus* (4), *S. gracilis majimae* (1), *C. auratus* (1), and *O. platycephala* (1).

Total 234 freshwater fish in 12 species were collected from Namsancheon in Hadong-gun, Gyeongsangnam-do in 2015 and 2016, which included *Z. koreanus* (57), *P. esocinus* (46), *Z. platypus* (41), *P. herzi* (35), *C. auratus* (16), *H. longirostris* (14), *Z. temminckii* (11), *A. koreensis* (7), *S. gracilis majimae* (3), *A. gracilis* (2), *C. splendidus* (1), and *O. platycephala* (1).

Examination methods

All collected fish with ice were transferred to the laboratory of the Department of Parasitology and Tropical Medicine, Gyeongsang National University School of Medicine, Jinju, Korea. After identification of fish species, they were individually ground with a mortar or a grinder. Each ground fish meat was mixed with artificial gastric juice, and the mixture was incubated at 36°C for 2 hr. The digested material was filtered

with 1 × 1 mm of mesh, and washed with 0.85% saline until the supernatant became clear. The sediment was carefully examined under a stereomicroscope. Each species of zoonotic trematode metacercariae were separately collected by the general feature [1,2], and they were counted to get hold of infection rates (%) and densities (no. of metacercariae per infected fish) by fish species.

RESULTS

Infection status of fish from upper reaches of Seomjin-gang

The metacercariae of *C. sinensis* were detected in 102 (39.8%) out of 256 fish in 14 species from the upper reaches of Seomjin-gang, i.e., Osucheon in Imsil-gun, and Seomjin-gang in Sunchang-gun, Jeollabuk-do. Their average density was 9.0 per fish infected. Among 236 freshwater fish in 11 species collected from Osucheon, 33 (14.0%) in 6 species (54.6%), i.e., *Z. platypus*, *S. chankaensis tsuchigae*, *O. uncirostris amurensis*, *M. jeoni*, *P. esocinus*, and *H. longirostris*, were infected with CsMc. Total 69 (22.3%) freshwater fish in 9 species (31.0%), i.e., *P. herzi*, *S. variegatus wakiyae*, *S. japonicus coreanus*, *A. rhombeus*, *S. gracilis majimae*, *H. longirostris*, *H. labeo*, *A. yamatsutae*, and *H. leucisculus*, out of 310 fish in 29 species collected from Seomjin-gang in Sunchang-gun were infected with CsMc. Their infection status with CsMc by the fish species and surveyed areas was shown in Table 1.

Infection status of fish from middle reaches of Seomjin-gang

The metacercariae of *C. sinensis* were detected in 132 (48.0%) out of 275 fish in 12 species from the middle reaches of Seomjin-gang, i.e., Songdaecheon in Namwon-si, Jeollabuk-do, and Seomjin-gang in Gokseong-gun, Jeollanam-do. Their average density was 21.0 per infected fish. Among 196 freshwater fish in 14 species collected in Songdaecheon, 33 fish (16.8%) in 4 species (28.6%), i.e., *P. herzi*, *M. koreensis*, *G. strigatus*, and *S. gracilis majimae*, were infected with CsMc. Total 99 (34.3%) freshwater fish in 10 species (66.7%), i.e., *Z. platypus*, *C. splendidus*, *S. variegatus wakiyae*, *S. japonicus coreanus*, *P. herzi*, *H. longirostris*, *M. koeensis*, *P. esocinus*, *A. majusculus*, and *L. taczanowskii*, out of 289 fish in 15 species collected from Seomjin-gang in Gokseong-gun were infected with CsMc. The infection status with CsMc by the fish species and surveyed areas are shown in Table 2.

Table 1. Infection status of *Clonorchis sinensis* metacercariae in freshwater fish from the upper reaches of Seomjin-gang (River)

Locality detected and fish sp.	No. of fish examined	No. (%) of fish infected	No. of metacercariae		
			Total	Range	Average
Osucheon in Imsil-gun, Jeollabuk-do					
<i>Zacco platypus</i>	80	1 (1.3)	5	-	5.0
<i>Squalidus chankaensis</i>	35	27 (77.1)	133	1-24	4.9
<i>Opsariichthys uncirostris</i>	21	2 (9.5)	2	-	1.0
<i>Microphysogobio jeoni</i>	6	1 (16.7)	2	-	2.0
<i>Pseudogobio esocinus</i>	5	1 (20.0)	1	-	1.0
<i>Hemibarbus longirostris</i>	1	1 (100.0)	3	-	3.0
Subtotal	148	33 (22.3)	146	1-24	4.4
Seomjingang in Sunchang-gun, Jeollabuk-do					
<i>Pungtungia herzi</i>	56	45 (80.4)	685	1-79	15.2
<i>Sarcocheilichthys variegatus</i>	12	7 (58.3)	46	1-17	6.6
<i>Squalidus japonicus coreanus</i>	11	6 (54.6)	20	1-5	3.3
<i>Acheilognathus rhombeus</i>	10	1 (10.0)	1	-	1.0
<i>Squalidus gracilis majimae</i>	6	6 (100.0)	12	1-3	2.0
<i>Hemibarbus longirostris</i>	5	1 (20.0)	1	-	1.0
<i>Hemibarbus labeo</i>	4	1 (25.0)	1	-	1.0
<i>Acheilognathus yamatsutae</i>	3	1 (33.3)	1	-	1.0
<i>Hemiculter leucisculus</i>	1	1 (100.0)	2	-	2.0
Subtotal	108	69 (63.9)	769	1-79	11.1
Total	256	102 (39.8)	915	1-79	9.0

Table 2. Infection status of *Clonorchis sinensis* metacercariae in freshwater fish from the middle reaches of Seomjingang (River)

Locality and fish sp.	No. of fish examined	No. (%) of fish infected	No. of metacercariae detected		
			Total	Range	Average
Songdaechon in Namwon-si, Jeollabuk-do					
<i>Pungtungia herzi</i>	47	28 (59.6)	499	1-92	17.8
<i>Microphysogobio koeensis</i>	5	2 (40.0)	8	1-7	4.0
<i>Gnathopogon strigatus</i>	2	1 (50.0)	28	-	28.0
<i>Squalidus gracilis majimae</i>	2	2 (100.0)	15	2-13	7.5
Subtotal	56	33 (58.9)	550	1-92	16.7
Seomjingang in Gokseong-gun, Jeollanam-do					
<i>Zacco platypus</i>	43	1 (2.3)	1	-	1.0
<i>Coreoleuciscus splendidus</i>	37	6 (16.2)	7	1-2	1.2
<i>Sarcocheilichthys variegatus</i>	31	28 (90.3)	246	1-50	8.8
<i>Squalidus japonicus coreanus</i>	27	18 (66.7)	132	1-46	7.3
<i>Pungtungia herzi</i>	22	18 (66.7)	1,805	1-348	86.0
<i>Hemibarbus longirostris</i>	20	11 (55.0)	16	1-3	1.5
<i>Microphysogobio koeensis</i>	16	7 (43.8)	11	1-3	1.6
<i>Pseudogobio esocinus</i>	16	4 (25.0)	4	-	1.0
<i>Acheilognathus majusculus</i>	6	2 (33.3)	4	1-3	2.0
<i>Ladislabia taczanowskii</i>	1	1 (100.0)	1	-	1.0
Subtotal	219	99 (45.2)	2,227	1-348	22.5
Total	275	132 (48.0)	2,777	1-348	21.0

Infection status of fish from lower reaches of Seomjin-gang

The metacercariae of *C. sinensis* were detected in 77 (56.6%) out of 136 fish in 11 species from the lower reaches of Seom-

jin-gang, i.e., Seomjin-gang in Gurye-gun, Jeollanam-do, and Namsancheon in Hadong-gun, Gyeongsangnam-do. Their average density was 64.9 per infected fish. Among 183 freshwater fish in 21 species collected in Seomjin-gang in Gurye-gun,

Table 3. Infection status of *Clonorchis sinensis* metacercariae in freshwater fish from the lower reaches of Seomjingang (River)

Locality and fish sp.	No. of fish examined	No. (%) of fish infected	No. of metacercariae detected		
			Total	Range	Average
Seomjingang in Gurye-gun, Jeollanam-do					
<i>Pungtungia herzi</i>	21	19 (90.5)	3,531	1-1, 580	185.8
<i>Squalidus japonicus coreanus</i>	15	13 (86.7)	278	1-125	21.4
<i>Sarcocheilichthys nigripinnis</i>	14	11 (78.6)	85	1-41	7.7
<i>Acheilognathus rhombeus</i>	11	9 (81.8)	231	2-179	25.7
<i>Hemibarbus labeo</i>	10	2 (20.0)	2	-	1.0
<i>Squalidus gracilis majimae</i>	8	8 (100)	189	10-47	23.6
<i>Microphysogobio koreensis</i>	6	2 (33.3)	2	-	1.0
<i>Acanthorhodeus gracilis</i>	5	2 (40.0)	15	2-13	7.5
<i>Abbottina rivularis</i>	5	4 (80.0)	18	4-6	4.5
<i>Pseudorasbora parva</i>	3	3 (11)	307	67-128	102.3
<i>Acheilognathus lanceolatus</i>	3	1 (33.3)	1	-	1.0
Subtotal	101	74 (73.3)	4,659	1-1, 580	63.0
Namsancheon in Hadong-gun, Gyeongsangnam-do					
<i>Pungtungia herzi</i>	35	3 (8.6)	339	1-336	113.0
Total	136	77 (56.6)	4,998	1-1, 580	64.9

Table 4. Infection status of *Metorchis orientalis* metacercariae by the species of fish caught from water systems of Seomjingang (River)

Locality and fish sp.	No. of fish examined	No. (%) of fish infected	No. of metacercariae detected		
			Total	Range	Average
Seomjingang in Sunchang-gun, Jeollabuk-do					
<i>Pungtungia herzi</i>	56	5 (8.9)	8	1-4	1.6
<i>Misgurnus anguillicaudatus</i>	1	1 (100.0)	1	-	1.0
Subtotal	57	6 (10.5)	9	1-4	1.5
Songdaecheon in Namwon-si, Jeollabuk-do					
<i>Pungtungia herzi</i>	47	1 (2.1)	2	-	2.0
<i>Microphysogobio koreensis</i>	5	1 (20.0)	1	-	1.0
<i>Gnathopogon strigatus</i>	2	1 (50.0)	1	-	1.0
Subtotal	54	3 (5.6)	4	1-2	1.3
Seomjingang in Gurye-gun, Jeollanam-do					
<i>Pungtungia herzi</i>	21	3 (14.3)	4	1-2	1.3
<i>Pungtungia herzi</i>	5	1 (20.0)	1	-	1.0
<i>Pseudorasbora parva</i>	3	1 (33.3)	1	-	1.0
Subtotal	29	5 (17.2)	6	1-2	1.2
Hoengcheongang in Hadong-gun, Gyeongsangnam-do					
<i>Pungtungia herzi</i>	5	1 (20.0)	1	-	1.0
Total	275	132 (48.0)	2,777	1-348	21.0

74 fish (40.4%) in 11 species (52.4%), i.e., *P. herzi*, *S. japonicus coreanus*, *S. nigripinnis morii*, *A. rhombeus*, *H. labeo*, *S. gracilis majimae*, *M. koreensis*, *A. rivularis*, *A. gracilis*, *P. parva*, *P. altivelis*, and *A. lanceolatus*, were infected with CsMc. No metacercariae were detected in total 156 freshwater fish in 13 species collected from Hoengcheon in Hadong-gun, Gyeongsangnam-do. Total 339 *C. sinensis* metacercariae were found in only 3 *P. herzi* among 234 freshwater fish in 12 species collected from Namsancheon in Hadong-gun, Gyeongsangnam-do. Their in-

fection status by the fish species and surveyed areas are shown in Table 3.

Infection status of *Metorchis orientalis* metacercariae in fish from Seomjin-gang

The metacercariae of *M. orientalis* were detected in fish from Seomjin-gang in Sunchang-gun, Songdaecheon in Namwon-si, Seomjin-gang in Gurye-gun, and Hoengcheon in Hadong-gun. Their infection status by the fish species and surveyed ar-

Table 5. Comparison of the infection status^{a)} of *Clonorchis sinensis* metacercariae in fishes from 3 reaches of Seomjingang

Items	Infection status of <i>C. sinensis</i> metacercariae in fishes from			
	Upper	Middle	Lower	Total
No. (%) of fish examined	546 (34.0)	485 (30.2)	573 (35.7)	1,604 (100)
Total positive rate (%)	102/546 (18.7)	132/485 (27.2)	77/573 (13.4)	311/1,604 (19.4)
Total metacercarial density	9.0	21.0	64.9	27.9
No. (%) of <i>P. herzi</i> examined	56 (10.3)	69 (14.2)	72 (12.6)	197 (12.3)
Positive rate (%) in <i>P. herzi</i>	45/56 (80.4)	50/69 (72.5)	22/72 (30.6)	117/197 (59.4)
Metacercarial density in <i>P. herzi</i>	15.2	46.1	175.9	58.6
No. (%) of <i>Z. platypus</i> examined	131 (24.0)	89 (18.4)	92 (16.1)	312 (19.5)

^{a)}Positive rate: No. of fish infected/No. of fish examined x100; metacercarial density: mean No. of metacercariae per fish infected.

eas are shown in Table 4.

DISCUSSION

By the present study, it has been confirmed that CsMc are more or less prevalent in fish from Seomjin-gang. The total positive rate, 19.4%, and average metacercarial density, 27.9 per infected fish, were not so high (Table 5). However, the infection status was revealed with a certain trend in positive fish groups according to the surveyed localities tentatively divided; upper, middle, and lower reaches. The prevalences were 39.8%, 48.0%, and 56.6%, and metacercarial densities were 9.0, 21.0, and 64.9 per fish infected, respectively. Metacercarial densities in fish from upper to lower reaches, i.e., Osucheon in Imsil-gun, Seomjin-gang in Sunchang-gun, Songdaechon in Namwon-si, Seomjin-gang in Gokseong-gun, and Seomjin-gang in Gurye-gun, were 4.4, 11.1, 16.7, 22.5, and 63.0 per infected fish, respectively. These findings suggested that the endemicity of CsMc is much higher in fish from lower reaches of Seomjin-gang.

The sampling of fish is one of the important factors in the successful metacercarial surveys to determine the epidemiology of trematode infections. Total 1,604 fish were collected from 7 localities in the water systems of Seomjin-gang in this study. The fish were tentatively grouped according to the surveyed areas, those of upper (546 fish: 34.0%), middle (485: 30.2%), and lower (573: 35.7%) reaches. The number of fish examined in each of these 3 reaches was relatively even. The pale chub (312: 19.5%), *Z. platypus*, was the most dominant fish species, and followed by the Korean chub (230: 14.3%), *Z. koreanus*, and the striped shinner (197: 12.3%), *P. herzi*, among the fish species examined in this study. The numbers of the pale chub examined in 3 reaches were 131 (upper: 42.0%), 89 (middle: 28.5%), and 92 (lower: 29.5%). Those of the Korean

chub were 15 (6.5%), 109 (47.4%), and 106 (46.1%), and of the striped shinner were 56 (28.4%), 69 (35.0%), and 72 (36.6%). According to the above findings, the pale chub was collected more in the upper than in the middle and lower reaches, The Korean chub was collected more in the middle and lower reaches than in the upper reaches, and the striped shinner was relatively evenly collected in 3 reaches.

Total 48 fish species (in 34 genera, 7 families) have been reported as the second intermediate hosts of *C. sinensis* in Korea [9-15]. In the present study, CsMc were found in 24 fish species, i.e., *A. rivularis*, *A. gracilis*, *A. lanceolatus*, *A. majuscules*, *A. rhombeus*, *A. yamatsutae*, *C. splendidus*, *G. strigatus*, *H. labeo*, *H. longirostris*, *H. leucisculus*, *L. taczanowskii*, *M. koreensis*, *M. jeoni*, *O. uncirostris*, *P. esocinus*, *P. herzi*, *P. parva*, *S. nigripinnis morii*, *S. variegates wakiyae*, *S. chankaensis tsuchigae*, *S. gracilis majimae*, *S. japonicus coreanus*, and *Z. platypus*. They all had been listed as the second intermediate hosts of *C. sinensis* in Korea [9-15]. The striped shinner was used as an index fish species to compare the endemicities of *C. sinensis* infection in 3 reaches in the present study. However, the metacercarial positive rates (prevalence) in this fish species were 80.4%, 72.5%, and 30.6%, whereas the metacercarial densities were 15.2, 46.1, and 175.9 per infected fish in the upper, middle, and lower reaches, respectively (Table 5). In the distribution pattern of CsMc in another susceptible fish, *P. parva*, the prevalence is proportionally correlated with the metacercarial density in certain areas [17-20]. This reverse phenomenon is questionable, and it should be solved in the near future.

Kim et al. [12] detected CsMc in 3 fish species, *P. parva*, *Acheilognathus intermedia* and *Odontobutis interrupta*, from Imsil-gun, Jeollabuk-do and also in 3 fish species, *P. parva*, *Zacco temminckii*, and *O. interrupta*, from Gokseong-gun, Jeollanam-do in the examination of the fish from water systems of Seomjin-gang (total 74 fish of 11 species). Their infection rates and

densities were not so high except for *P. parva* from Imsil-gun, Jeollabuk-do, when we compared them with our findings of Imsil-gun and Gokseong-gun. Fish from Seomjin-gang in Gokseong-gun (191 fish in 22 species) and Gurye-gun (68 fish in 14 species), Jeollanam-do were also examined in Cho et al. [14]. The prevalences were 35.3% and 66.1%, and densities were 59.4 and 37.6 per fish infected in fish from above 2 regions, respectively. However, the prevalences were 45.2% and 73.3%, and densities were 22.5 and 63.0 per fish infected in this study. From the above comparisons, it was confirmed that the metacercarial endemicity in fish from Gurye-gun is much higher in this study than in Cho et al. [14].

According to recent studies, CsMc were found in fish from the water system of Imjin-gang and Hantan-gang located in the northern part of Korea, although their prevalences and densities were very low [14-16]. However, CsMc were not detected in fish from the water systems of Han-gang in Gangwon-do [14,15]. In fish from Geum-gang, the prevalence and density of CsMc were also revealed in low levels [14]. They showed moderate levels in fish from Yeongsan-gang and Seomjin-gang in Jeollanam-do [14] like those in this study. However, fish from Tamjin-gang in Gangjin-gun, Jeollanam-do and Nakdong-gang in 3 localities of Gyeongsangbuk-do, and Sancheong-gun, Gyeongsangnam-do were highly infected with CsMc [14]. By the present study, it has been confirmed that CsMc are more or less prevalent in fish from some water systems of Seomjin-gang in Korea.

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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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