Prevalence of *Clonorchis sinensis* Metacercariae in Freshwater Fish from Three Latitudinal Regions of the Korean Peninsula

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**Abstract:** A large-scale survey was conducted to investigate the infection status of fresh water fishes with *Clonorchis sinensis* metacercariae (CsMc) in 3 wide regions, which were tentatively divided by latitudinal levels of the Korean peninsula. A total of 4,071 freshwater fishes were collected from 3 regions, i.e., northern (Gangwon-do: 1,543 fish), middle (Chungcheongbuk-do and Gyeongsangbuk-do: 1,167 fish), and southern areas (Jeollanam-do, Ulsan-si, and Gyeongsangnam-do: 1,361 fish). Each fish was examined by the artificial digestion method from 2003 to 2010. In northern areas, only 11 (0.7%) fish of 2 species, *Pungtungia herzi* and *Squalidus japonicus coreanus* from Hantan-gang, Cheolwon-gun, Gangwon-do were infected with av. 2.6 CsMc. In middle areas, 149 (12.8%) fish were infected with av. 164 CsMc. In southern areas, 538 (39.5%) fish were infected with av. 159 CsMc. In the analysis of endemicity in 3 regions with an index fish, *P. herzi*, 9 (6.2%) of 146 *P. herzi* from northern areas were infected with av. 2.8 CsMc. In middle areas, 34 (31.8%) of 107 *P. herzi* were infected with av. 215 CsMc, and in southern areas, 158 (92.9%) of 170 *P. herzi* were infected with av. 409 CsMc. From these results, it has been confirmed that the infection status of fish with CsMc is obviously different among the 3 latitudinal regions of the Korean peninsula with higher prevalence and burden in southern regions.

**Key words:** *Clonorchis sinensis*, metacercaria, freshwater fish, prevalence, latitudinal level

**INTRODUCTION**

Recent trends of helminthic infections in the Republic of Korea are characterized by a remarkable decrease of soil-transmitted nematodiases and moderate endemicity of foodborne trematode (FBT) infections. Among FBT infections prevailing in the Republic of Korea, clonorchiasis has been known as the most important endemic disease, and its endemicity has maintained at relatively high levels in riverside areas [1-6]. Especially, in 1981, Seo et al. [1] reported prevalence rates of clonorchiasis among the residents in 7 major rivers, 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 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. Although the Korea Association of Health Promotion (KAHP) and the Korea Center for Disease Control and Prevention (KCDCP) have been performing control programmes of clonorchiasis for more than 20 years, clonorchiasis is still prevalent throughout the country [3,6].

Clonorchiasis is contracted by eating raw or undercooked fish intermediate hosts containing the metacercariae of *C. sinensis*. As the second intermediate hosts of *C. sinensis*, total 40 species of freshwater fishes have been reported in Korea [2,7]. Among them, some species, such as *Pseudorasbora parva*, *Pungtungia herzi*, Sarcocheilichthys spp., *Squalidus* spp., and *Pseudogobio esocinus*, have been known as the more susceptible hosts to cercariae, and they have sometimes enormous amount of...
metacercariae [8-12].

On the other hand, the survey on the infection status of FBT metacercariae in intermediate hosts is one of the important epidemiological indices together with surveys on adult worm infections in the definitive and reservoir hosts. Many Korean workers have investigated the infection status of C. sinensis metacercariae (CsMc) in fishes from various endemic areas to estimate the endemicity of clonorchiasis [8,9,11-17]. Especially, Kim et al. [12] investigated 677 freshwater fish of 21 species to estimate the endemicity of clonorchiosis [8-12].

In the present study, we investigated on the infection status of CsMc in freshwater fish from 3 wide regions, which were tentatively divided by the latitudinal levels of the Korean peninsula. Therefore, in the present study, we investigated on the infection status of CsMc in freshwater fish from 3 wide regions, which were tentatively divided by the latitudinal levels of the Korean peninsula.

**MATERIALS AND METHODS**

**Surveyed areas**

Surveyed areas were largely divided into 3 latitudinal regions of the Korean peninsula (Fig. 1). The northern area was comprised of 7 administrative regions of Gangwon-do, ① Inje-gun, ② Hongcheon-gun, ③ Cheolwon-gun, ④ Yanggu-gun, ⑤ Yangyang-gun, ⑥ Youngweol-gun, and ⑦ Samcheok-si, which are located over 37° North Latitude. The middle area contained 10 regions of Chungcheongbuk-do (⑧ Gum-gang in Okcheon-gun, ⑨ Cheong-cheon in Goseo-mun, and ⑩ Daecheong-ho), and Gyeongsangbuk-do (⑪ Ahndong-si, ⑫ Sangju-si, ⑬ Bonghwa-gun, ⑭ Yecheon-gun, ⑮ Youngdeok-gun, ⑯ Gunwi-gun), which are located between 36° and 37° North Latitude. The southern area was comprised of 8 administrative regions of Jeollanam-do (⑰ Gokseong-gun, ⑱ Gurye-gun, ⑲ Naju-si, ⑳ Gangjin-gun, ⑴ Jangheung-gun, and ⑵ Boseong-gun, Ulsan Metropolitan City (⑶ Taehwa-gang) and Gyeongsangnam-do (⑷ Sancheong-gun), which are located below 36° North Latitude.

**Freshwater fishes examined**

In western parts of Gangwon-do, we collected 678 freshwater fishes (36 species) from 4 localities, Soyang-gang (Inje-gun in October 2003 and April 2004), Hongcheon-gang (Hongcheon-gun in October 2003, and July and October 2010), Hantan-gang (Cheolwon-gun in April 2005 and October 2010), and Hwa-gang (Cheolwon-gun in June 2010) in Gangwon-do. We also collected 865 fishes (32 species) from 5 localities of eastern parts of Gangwon-do, Sooip-cheon (Yanggu-gun), Namdae-cheon (Yangyang-gun), Dong-gang (Youngweol-gun), Osip-cheon, and Gagok-cheon (Samcheok-si) 2 times in June and October 2009. The numbers and species of fish examined are shown in Tables 1 and 2.

In middle regions, a total of 451 fishes (32 species) were collected from 3 sites, Gum-gang (Okcheon-gun in April and September 2006), Cheong-cheon (stream in Goseo-gun on June 2003) and Daecheong-ho (Lake, on June 2003), located in Chungcheongbuk-do. The numbers and species of fish examined are shown in Table 3. To investigate the infection status of CsMc in fishes from the upper reaches of Nakdong-gang, we collected total 716 freshwater fishes (35 species) from 7 loca-
ties, Ahndong-si, Sangju-si, Bonghwa-gun, Yecheon-gun, Youngyang-gun, Youngdeok-gun and Gunwi-gun, Gyeongsangbuk-do in October and November, 2008 (Table 4).

In western parts of southern localities, 452 freshwater fishes (35 species) were collected from 6 localities, Seomjin-gang (Gokseong-gun in September 2004 and May 2005) (Gurye-gun in September 2004), Youngsan-gang (Naju-si in October 2005), Tamjin-gang (Gangjin-gun and Jangheung-gun, in October 2005) and Boseong-gang (Boseong-gun in October 2005), in Jeollanam-do. The numbers and species of fish examined are shown in Table 5. In eastern parts, we also collected 909 freshwater fishes (24 species) from Taehwa-gang (Ulsan Metropolitan City in April and September 2006) and Yangcheon-gang (Sancheong-gun in each October of 2006 and 2007, June

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**Table 1.** Fishes collected from northern regions (Gangwon-do), Korea

| Species of fish                  | No. of fish collected from 6 localities<sup>b</sup> |
|----------------------------------|-----------------------------------------------------|
|                                  | ① | ②-1 | ②-2 | ③-1 | ③-2 | ③-3 | Total |
| Cypriniforms                     |   |      |      |      |      |      |       |
| Zacco platypus                   | 40 | 10   | 20   | 16   | 30   | 3    | 119   |
| Pungtungia herzi                 | 14 | 20   | 25   | 8    | 7    | 13   | 87    |
| Zacco temminckii                 | 6  | -    | 16   | 19   | 30   | 10   | 81    |
| Hemibarbus longirostris         | 5  | -    | 20   | 14   | 3    | 12   | 54    |
| Pseudogobio esocinus             | 10 | 1    | 23   | 5    | 8    | 3    | 50    |
| Coreoleuciscus splendidus        | 5  | 3    | 18   | 19   | -    | 2    | 47    |
| Microphysogobio longidorsalis    | -  | -    | 20   | 4    | -    | 8    | 32    |
| Carassius auratus                | 6  | -    | 2    | 2    | 3    | 5    | 18    |
| Acheilognathus signifer          | -  | 10   | -    | -    | -    | 4    | 14    |
| Hemibarbus laevo                 | 10 | -    | 1    | 2    | -    | -    | 13    |
| Acheilognathus majusculus        | -  | -    | 6    | -    | 6    | -    | 12    |
| Cyprinus capio                   | 5  | -    | -    | -    | -    | -    | 5     |
| Acheilognathus yamatsutae        | -  | -    | -    | 5    | -    | -    | 5     |
| Acheilognathus rhombeus          | -  | -    | -    | -    | 5    | -    | 5     |
| Opsarichthys uncirostris         | 3  | 2    | -    | -    | -    | -    | 5     |
| Pseudopungtungia tenuicorpus     | 1  | 3    | -    | -    | -    | -    | 4     |
| Pseudobagrus fulvidraco         | -  | -    | 4    | -    | -    | -    | 4     |
| Hemibarbus mylodon               | -  | -    | 1    | 3    | -    | -    | 4     |
| Acanthorhodeus gracils           | -  | -    | 3    | -    | -    | -    | 3     |
| Acheilognathus lanceolatus       | -  | -    | -    | 1    | 2    | 3    | 3     |
| Hemicyprinus leucisculus         | 3  | -    | -    | -    | -    | -    | 3     |
| Koreoecobitis rotundicaudata     | -  | -    | 3    | -    | -    | -    | 3     |
| Orthias toni                     | -  | 3    | -    | -    | -    | -    | 3     |
| Rhynchocypsis steidchnneri       | -  | -    | -    | 3    | -    | -    | 3     |
| Rhynchocypsis oxycephalus        | -  | -    | 2    | -    | -    | -    | 2     |
| Squalidus japonicus coreanus     | -  | -    | -    | 2    | -    | -    | 2     |
| Sarcocheilichthys nigripinnis    | -  | -    | -    | 1    | -    | -    | 1     |
| Microphysogobio jaei             | -  | -    | -    | 1    | -    | -    | 1     |
| Abbottina springeri              | 1  | -    | -    | -    | -    | -    | 1     |
| Abbottina revulais               | -  | 1    | -    | -    | -    | -    | 1     |
| Siluriformes                     |   |      |      |      |      |      |       |
| Liobagrus andersoni              | 4  | 10   | -    | -    | -    | -    | 14    |
| Leiocassis usuriensis            | 3  | -    | -    | -    | -    | -    | 3     |
| Perciformes                      |   |      |      |      |      |      |       |
| Coreoperca herzi                 | -  | 15   | 20   | 3    | 5    | 7    | 50    |
| Siniperca scherzeri              | 7  | -    | 11   | -    | -    | -    | 18    |
| Odontobutis platycephala         | -  | 6    | 2    | -    | -    | -    | 8     |
| Total                            | 123| 82   | 186  | 110  | 108  | 69   | 678   |

<sup>a</sup>Total 678 freshwater fishes of 36 species were examined. <sup>b</sup>① Inje-gun (Soyang-gang); ②-1 Hongcheon-gun (Hongcheon-gang, 2003; ②-2 Hongcheon-gang (Hongcheon-gang, 2010); ③-1 Cheolwon-gun (Hantan-gang, 2005); ③-2 Cheolwon-gun (Hantan-gang, 2010); ③-3 Cheolwon-gun (Hwa-gang, 2010).
Examination methods

All collected fishes with ice were transferred to the laboratory of the Department of Parasitology, Gyeongsang National University School of Medicine, Jinju, Korea. After identification of fish species [18], they were individually ground with a mortar with a pestle or a grinder. Each ground fish meat was mixed with artificial gastric juice and the mixture was incubated at 36°C for 2-3 hr. The digested material was filtered with 1×1 mm of mesh, and washed with 0.85% saline until the supernatant is clear. The sediment was carefully examined under a stereomicroscope. The metacercariae of *C. sinensis* were collected based on their general features [7], and they were counted to get hold of the infection densities by fish species.
Table 3. Fishes* collected from middle regions (Chungcheongbuk-do), Korea

| Species of fish                  | No. of fish collected from 3 localitiesb |
|---------------------------------|----------------------------------------|
|                                 | ⑧ Okcheon-gun (Gum-gang); ⑨ Goisan-gun (Cheong-cheon); ⑩ Daecheong-ho (Lake). |
| Cypriniforms                    |                                        |
| Zacco platypus                  | 43 20 2 65                              |
| Acheilognathus lanceolatus      | 49 - 2 51                               |
| Acanthorhodeus gracilis         | 41 - 41                                 |
| Hemibarbus labeo                | 34 - 5 39                               |
| Hemiculter eigenmanni           | 28 - 4 32                               |
| Pungtungia herzi                | 25 6 - 31                               |
| Carassius auratus               | 21 - 10 31                              |
| Opsarichthys unirostris         | 14 - 10 24                              |
| Squalidus japonicus coreanus    | 20 - - 20                               |
| Culter brevicauda               | 20 - - 20                               |
| Pseudogobio esocinus            | 12 5 - 17                               |
| Hemibarbus longirostris         | - 15 - 15                               |
| Cyprinus carpio                 | 6 - 7 13                                |
| Acheilognathus thombeus         | 5 - - 5                                 |
| Sarcocirrhinus variatus         | 2 3 - 5                                 |
| Squalidus salvelinus            | 4 - - 4                                 |
| Acanthorhodeus macroterius      | 4 - - 4                                 |
| Pseudorasbora parva             | 3 - - 3                                 |
| Coreoleucus splendidus          | - 2 - 2                                 |
| Sarcocirrhinus nigripinnis      | 2 - - 2                                 |
| Squalidus maculatus             | 1 - 1 2                                 |
| Pseudadapungtungia nigra        | 1 - - 1                                 |
| Rhyincoryphus oxycephalus       | 1 - - 1                                 |
| Aphoycypris chiniensis          | 1 - - 1                                 |
| Cobitis lutheri                 | - 1 - 1                                 |
| Pseudorasbora parva             | 1 - - 1                                 |
| Pokscuglossus athalae           | 1 - - 1                                 |
| Siluriforms                     |                                        |
| Leiocassis ussuriensis          | 1 - - 1                                 |
| Perciformes                     |                                        |
| Odontobutis platycephala        | 12 - - 12                               |
| Siniperca scherzi               | 2 - 1 3                                 |
| Coreoperca herzi                | 2 1 - 3                                 |
| Total                           | 356 53 42 451                            |

Infection status of freshwater fish from northern areas

The metacercariae of C. sinensis were found in only 2 fish species, P. herzi and Squalidus japonicus coreanus, collected from Hantan-gang in Cheolwon-gun, Gangwon-do. Total 6 CsMc were detected in 3 out of 8 P. herzi examined in April, 2005. They were also detected in 6 (85.7%) of 7 P. herzi and both 2 of S. japonicus coreanus examined in October 2010. The metacercarial densities were 3.2 and 2.0 per infected fish. However, they were not found in fishes from 7 localities, Hongcheon-gang in Hongcheon-gun, Hwa-gang in Cheolwon-gun, Sooipcheon in Yanggu-gun, Namdae-cheon in Yangyang-gun, Dong-gang in Youngweol-gun, and Osip-cheon and Gagok-cheon in Samcheok-si, Gangwon-do.

Infection status of freshwater fish from middle areas

A total of 50 CsMc were detected in 22 (10 species) of 356 freshwater fish (28 species) collected from Gum-gang, and total 27 metacercariae were found in 6 (3 species) of 53 fish from Cheong-cheon. Their infection status by fish species were as shown in Table 7. No CsMc were found in 42 fishes from Daecheong-ho.

CsMc were found in 3 (12.5%) of 24 P. herzi and only 1 (4.8%) Zacco platypus from Ahndong-si, and their average densities were 62 in P. herzi and only 1 in Z. platypus infected. They were also detected in all 6 P. herzi and only 1 of 2 Acanthorhodeus gracilis from Sangju-si, and their average densities were 11 in P. herzi and only 1 in A. gracilis infected. Total 46 CsMc were detected in 10 (35.7%) of 28 Squalidus gracilis majimeae from Youngdeokgun. However, CsMc were not found in other fishes from Bonghwa-gun.

A total of 68 CsMc were found in 9 (15.8%) out of 57 fish of 7 species, Lateslabia taczanowskii, Culter brevicauda, P. herzi, Z. platypus, Pseudogobio esocinus, Hemibarbus longirostris, and Hemibarbus labeo from Yecheon-gun. Total 31 (36.0%) fishes of 6 species, P. herzi, Squalidus chankaensis tsuchigae, Microphysogobio koeensis, Coreoleucus splendidus, Acheilognathus signifer and Z. platypus, out of 86 fish in 12 species from Youngyang-gun, were infected with 1-630 CsMc (av. 126 per fish). Among 136 fishes of 16 species collected from Gunwi-gun, 70 (51.5%) of 14 species were infected with 1-2,105 CsMc (av. 287). The infection status in fishes from Yecheon-gun, Youngyang-gun, and Gunwi-gun were detailed in Table 8.

Infection status of freshwater fish from southern areas

Among 191 fishes (22 species) from Seomjin-gang in Goksung-gun, 42 (13 species) were infected with 2,496 CsMc (av. 59), and 37 fishes (9 species) from Seomjin-gang in Guryung-gun were infected with total 1,390 CsMc (av. 49). Their infection status by fish species were shown in Table 9.

A total of 1,831 CsMc (av. 80) were detected in 23 (9 species) of 65 freshwater fish (11 species) from Youngsan-gang in Naju-
si. Among 58 fishes (11 species) from Tamjin-gang in Gangjin-gun, 39 (9 species) were infected with total 8,020 CsMc (av. 206), and a total of 162 CsMc (av. 32) were detected in 5 (4 species) of 18 freshwater fish (10 species) collected from Boseong-gang in Boseong-gun, Jeollanam-do. Infection status by fish species from 3 aforementioned regions were presented in Table 10. No CsMc were found in 52 fish from Tamjin-gang in Janghung-gun, Jeollanam-do. Total 175 CsMc (av. 22) were detected in 8 (32.0%) of 25 S. chankaensis tsuchigae, and 5 CsMc in 3 (5.0%) Z. platypus collected from Taehwa-gang in Ulsan Metropolitan City. Total 381 (48.2%) of 790 fish from Yangcheon-gang in Sancheong-gun, Gyeongsangnam-do were infected with 1-2,345 CsMc (av. 187). The infection status by fish species and examination year were

### Table 4. Fishes collected from middle regions (Gyeongsangbuk-do), Korea

| Species of fish                                      | No. of fish collected from 7 localities |
|------------------------------------------------------|----------------------------------------|
| Cypriniforms                                         |                                        |
| Zacco platypus                                       | 21 11 26 24 39 37 158                   |
| Pungtungia herzi                                     | 3 11 2 15 14 126 76                    |
| Zacco temmincki                                      | 25 7 8 2 9 51                          |
| Squalidus gracilis majimae                           | 5 - - 28 9 42                          |
| Coreoluciscus splendidos                             | 13 17 8 - 38                           |
| Carassius auratus                                    | 1 3 - 1 14 33                          |
| Squalidus japonicus coreanus                         | - - - 29 29                           |
| Niwaella multifasciata                               | 3 - 10 - 28                           |
| Pseudobagrus esocinus                                | - 3 - 12 - 1 16                        |
| Hemibarbus longirostris                              | - - - 10 - 4 14                        |
| Acanthorhodeus gracilis                              | - 2 - 10 - 2 14                        |
| Acheilognathus signifer                               | 4 - - 2 - 6 12                        |
| Cyprinus capio                                       | - 2 - 10 - 12                        |
| Misgumus anguillicaudatus                            | 8 2 - 1 11                            |
| Hemibarbus labeo                                     | - 6 - 3 - 1 10                        |
| Opsarichthys uncirostris                             | - - 4 - 6 10                          |
| Acheilognathus yamatsutae                            | - - - 9 9                             |
| Pseudobagrus fulvidraco                              | - - 9 - 9                             |
| Koreocobitis naktongensis                            | - 8 - 8 - 8                           |
| Tribolodon hakonensis                                | - - - 6 - 6                           |
| Pseudobagrus koreanus                                | - 3 - 2 - 5                           |
| Microphysofibrio koreanensis                         | - - 1 - 3 - 3                         |
| Iksookimia yongdokensis                              | - - - 3 - 3                           |
| Culter breviceaud                                    | - - 2 - 2                             |
| Squalidus chankaensis tsuchigae                      | - - - 1 - 1                           |
| Ladislabia taczanowskii                              | - - 2 - 2                             |
| Pseudorasbora parva                                  | - - - 1 - 1                           |
| Cobitis sinensis                                     | - - - 1 - 1                           |
| Osmeriformes                                         | - - 10 - 10                           |
| Plecoglossus altivallis                              | - - - - 10                            |
| Siluriformes                                         | - - 15 - - 15                         |
| Liobagrus andersoni                                  | - - 10 - 1 - 11                       |
| Liobagrus obesus                                     | 1 - 8 - 9                             |
| Silurus microdorsalis                                 | - - - 8 - 9                           |
| Perciformes                                          | - - 6 - 3                             |
| Coreoperca herzi                                     | 6 10 6 6 3 42                         |
| Siniperca scherzer                                   | - 1 1 - - 2                           |
| Odontobutis platycephala                            | 7 7 5 3 - 23                         |
| Total                                                | 118 45 97 131 86 103 136 716          |

*Total 716 freshwater fishes in 35 species were examined. ① Ahndong-si; ② Sangju-si; ③ Bonghwa-gun; ④ Yecheon-gun; ⑤ Youngyang-gun; ⑥ Youngdeok-gun; ⑦ Gunwi-gun.
Comparative prevalence and density of CsMc in fresh water fish from 3 regions

Among 1,543 fish from northern areas, only 11 (0.7%) of 2 species, P. herzi and S. japonicus coreanus, from Hantan-gang in Cheolwon-gun, were infected with total 29 CsMc (av. 2.6 per infected fish). Total 149 (12.8%) of 1,167 fish from middle areas were infected with total 24,384 CsMc (av. 163.7). Of 1,361 fish from southern areas, 538 (39.5%) were infected with total 85,428 CsMc (av. 158.8).

In an analysis with an index fish, P. herzi, total 25 CsMc (av. 2.8) were detected in 9 (6.2%) of 146 fishes from northern areas. Among 107 P. herzi from middle areas, 34 (31.8%) were

shown in Table 11.

Table 5. Fishes<sup>a</sup> collected from southern regions (Jeollanam-do), Korea

| Species of fish | No. of fish collected from 6 localities<sup>b</sup> |
|----------------|--------------------------------------------------|
|                | $\sum_1$ | $\sum_2$ | $\sum_3$ | $\sum_4$ | $\sum_5$ | $\sum_6$ | Total |
| Cypriniforms   |          |          |          |          |          |          |       |
| Zacco platypus | 42       | 1        | 20       | 10       | 10       | 1        | 84    |
| Carassius auratus | 13       | 7        | 10       | -        | 2        | 2        | 34    |
| Squalidus chankaensis tsuchigae | 4       | 25       | -        | -        | -        | -        | 29    |
| Acheilognathus yamatsutae | 12       | 7        | 3        | 2        | -        | 3        | 27    |
| Pungtungia herzi | 12       | 1        | -        | 6        | 3        | 2        | 24    |
| Pseudogobio esocinus | 8       | 3        | 3        | 3        | 3        | 2        | 22    |
| Liobagrus mediadiposalis | 21       | -        | -        | -        | -        | -        | 21    |
| Acheilognathus lanceolatus | -        | 1        | 8        | -        | 10       | -        | 19    |
| Zacco temminckii | 8        | -        | -        | 1        | 10       | -        | 19    |
| Sarcocelichthys variegatus | 4        | -        | -        | 15       | -        | -        | 19    |
| Coreoleuciscus splendidus | 17       | 1        | -        | -        | -        | -        | 18    |
| Acanthorhodeus macropterus | -        | -        | -        | 8        | 10       | -        | 18    |
| Hemibarbus longirostris | 2        | 6        | 4        | 3        | -        | -        | 15    |
| Squalidus japonicus coreanus | 12       | -        | 1        | -        | -        | -        | 13    |
| Hemibarbus labeo | 3        | -        | 8        | -        | -        | -        | 11    |
| Sarcocelichthys nigripinis | -        | 10       | -        | -        | -        | -        | 10    |
| Opsianchus uncinorhynus | 3        | -        | 2        | -        | -        | -        | 6     |
| Hemiculter eigentmanni | 5        | -        | -        | -        | -        | -        | 5     |
| Acheilognathus majusculus | 4        | -        | -        | -        | -        | -        | 4     |
| Abbotina springeri | 3        | -        | -        | -        | -        | -        | 3     |
| Gnathopogon strigatus | -        | -        | -        | 3        | -        | -        | 3     |
| Rhodeus ocellatus | -        | -        | -        | 3        | -        | -        | 3     |
| Cobitis lutheri | -        | -        | -        | -        | -        | -        | 3     |
| Ladistaba taczanowskii | 2        | -        | -        | -        | -        | -        | 2     |
| Microphysogobio koreensis | -        | 2        | -        | -        | -        | -        | 2     |
| Pseudorasbora parva | -        | -        | -        | 1        | -        | -        | 1     |
| Cyprinus capio | 1        | -        | -        | -        | -        | -        | 1     |
| Misgurnus anguillicaudatus | -        | -        | -        | -        | -        | 1        | 1     |
| Microphysogobio longidorsalis | -        | 1        | -        | -        | -        | -        | 1     |
| Osmeriformes |          |          |          |          |          |          |       |
| Plecoglossus altivelis | -        | 2        | -        | 6        | -        | -        | 8     |
| Siluriformes |          |          |          |          |          |          |       |
| Liobagrus mediadiposalis | -        | -        | -        | -        | -        | -        | 1     |
| Perciformes |          |          |          |          |          |          |       |
| Coreoperca herzi | 7        | -        | -        | -        | -        | -        | 7     |
| Siniperca scherzi | 5        | 1        | -        | -        | -        | -        | 6     |
| Micropterus salmoides | -        | -        | 5        | -        | -        | -        | 5     |
| Odontobutis platycephala | 3        | -        | 1        | -        | 1        | 2        | 7     |
| Total | 191 | 68 | 65 | 58 | 52 | 18 | 452 |

*Total 452 freshwater fishes of 35 species were examined; \( \sum_1 \) Gokseong-gun (Seomjin-gang); \( \sum_2 \) Gurye-gun (Seomjin-gang); \( \sum_3 \) Naju-si (Youngsan-gang); \( \sum_4 \) Gangjin-gun (Tamjin-gang); \( \sum_5 \) Jangheung-gun (Tamjin-gang); \( \sum_6 \) Boseong-gun (Boseong-gang).
Table 6. Fishes a collected from southern regions (Ulsan Metropolitan City and Gyeongsangnam-do), Korea

| Species of fish | No. of fish collected from 3 localities b | Total |
|----------------|----------------------------------------|-------|
|                | 3 | 1-2 | 3-2 | 3-3 |     |
| Cypriniforms   |   |     |     |     |     |
| Pungtungia herzi | 24 | 44 | 78 | 146 |     |
| Zacco platypus  | 60 | 19 | 44 | 144 |     |
| Pseudogobio esocinus | 34 | 16 | 60 | 110 |     |
| Zacco temmincki | 4  | 34 | 20 | 50 |     |
| Carassius auratus | 5  | 36 | 13 | 82 |     |
| Hemibarbus longirostris | 31 | 15 | 22 | 68 |     |
| Acheilognathus majaecules | 25 | 13 | 10 | 48 |     |
| Squalius chicaenasis tsugicare | 25 | 7  | 2  | 37 |     |
| Acanthorhodeus macropterus | 15 | -  | 15 | 30 |     |
| Squalius gracilis coreanus | -  | 2  | -  | 11 |     |
| Pseudorasbora parva | 5  | -  | 1  | 6  |     |
| Acheilognathus signifer | -  | 6  | -  | 6  |     |
| Hemibarbus labio | 5  | -  | -  | 5  |     |
| Acheilognathus rhombus | -  | 3  | -  | 5  |     |
| Acheilognathus korensis | -  | 4  | -  | 4  |     |
| Culter brevicauda | -  | 2  | -  | 4  |     |
| Sarcoccephalichthys variegates | -  | 2  | -  | 4  |     |
| Hemibarbus eignmanni | 2  | -  | 2  | -  |     |
| Opsiancichthys unicostris | 3  | -  | -  | 3  |     |
| Pseudobagrus koreanus | -  | 2  | -  | 2  |     |
| Sarcoccephalichthys nigripinnis | -  | 1  | -  | 1  |     |
| Perciformes     |   |     |     |     |     |
| Carassius herzi | 2  | 19 | 8  | 30 | 59  |
| Siniperca scherzeri | -  | 2  | -  | 2  |     |
| Odontobutis platycephala | 8  | 8  | 24 | 48 |     |
| Total           | 119| 261| 179| 350| 909 |

a Total 909 freshwater fishes of 24 species were examined; b 3 localities: 1) Ulsan Metropolitan City (Taehwa-gang); 2) Sanchon-sung (Yangcheon-gang, 2006); 3) Sanchon-sung (Yangcheon-gang, 2007).

DISCUSSION

As the second intermediate hosts of C. sinensis, total 102 species of freshwater fishes (59 genera, 15 families) have been reported in China, including Taiwan, and total 40 species (31 genera, 6 families) have been listed in the Republic of Korea [7, 19]. In the present study, CsMc were detected in 36 fish species. Of the 36 positive fish species, 28 have been already known as the second intermediate hosts of C. sinensis. However, 8 species, namely, Pseudopuntungia nigra, Rhynchocypris oxycephalus, Ladislabia taczanowskii, Microphysogobio longidoraisis, Acheilognathus majaecules, Acheilognathus korensis, Acanthorhodeus macropterus, and Odontobutis platycephala, have not been listed in the Republic of Korea [7]. Among aforementioned 8 new fish hosts, R. oxycephalus is the same fish species with Phoxinus (or Moroco) oxycephalus, which has been already recorded. Accordingly, total 47 fish species (34 genera, 7 families) are included among the second intermediate hosts of C. sinensis in the Republic of Korea.

The successful sampling of subjected materials is one of the important factors in epidemiological surveys. A satisfactory fish collection is not easy in surveys like the present study. Fish ecologies are variable by natural conditions, and collected fish species are different by the catching methods (netting, casting net, and trapping) and timings. Although a total of 4,071 freshwater fish were examined in the present study, the fish examined more than 200 in number were only 7 species, i.e. Z. platypus (698), P. herzi (423), Zacco temminckii (344), Pseudogobio esocinus (236), C. auratus (204), Carassius herzi (203), and C. splendidus (200). Among 7 major fish species examined, Z. platypus and P. herzi were predominant, and they were evenly collected in each of 3 regions. Total 247, 223, and 228 Z. platypus and 146, 107, and 170 P. herzi were examined in each of 3 regions, northern, middle, and southern areas of Korea. Therefore, these 2 fish species are good to use as index fish species to compare the endemities of C. sinensis infection in 3 regions of the present study. Until now the susceptible fish host for CsMc, P. parus, has been used as an index species for distribution of C. sinensis at certain areas [10,12,20-22]. However, in this study, their number examined were limited.

By the present study, it is confirmed again that the southern areas are highly endemic for clonorchiasis in Korean peninsula [1-6]. The positive rates and infection densities of CsMc are higher in over all fish examined, as well as in P. herzi, from these southern areas, although they are exceptionally higher in fish species, i.e. P. herzi, P. esocinus, S. gracilis majinmae and S. japonicus coreanus, from Gunwi-gun, Gyeongsangbuk-do. In the analysis with the index fish, P. herzi, the positive rates are relatively proportioned with the average metacercarial density per infected fish. Therefore, the highly susceptible fish species, P. herzi,
Table 7. Prevalence and density of C. sinensis metacercariae in fishes from Chungcheongbuk-do, a middle region of Korea

| Location and fish sp. | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|-----------------------|----------------------|--------------------------|------------------------------|
|                       |                      |                          | Total | Range | Average |
| Gum-gang (River)       |                      |                          |       |       |         |
| Sarcocheilichthys nigripinnis | 2              | 1 (50.0)                | 20    | -     | 20.0    |
| Pungtungia herzi       | 25                  | 1 (4.0)                 | 2     | -     | 2.0     |
| Squalidus gracilis majimae | 20              | 8 (40.0)                | 15    | 1-4   | 1.9     |
| Acanthorhodeus gracilis | 41              | 4 (9.8)                 | 5     | 1-2   | 1.3     |
| Acheilognathus lanceolatus | 49             | 3 (6.1)                 | 3     | -     | 1.0     |
| Hemibarbus laboe       | 34                  | 1 (2.9)                 | 1     | -     | 1.0     |
| Hemiculter eigenmanni  | 28                  | 1 (3.6)                 | 1     | -     | 1.0     |
| Sarcocheilichthys variegatus | 2            | 1 (50.0)                | 1     | -     | 1.0     |
| Pseudopungtungia nigra | 1                  | 1 (100)                | 1     | -     | 1.0     |
| Rhyynchocypris oxycephalus | 1            | 1 (100)                | 1     | -     | 1.0     |
| Subtotal               | 203                | 22 (10.8)              | 50    | 1-20  | 2.3     |
| Cheong-cheon (Stream) in Goisan-gun | |                |       |       |         |
| Pungtungia herzi       | 6                   | 4 (66.7)               | 23    | 2-12  | 5.8     |
| Zacco platypus         | 20                  | 1 (5.0)                | 3     | -     | 3.0     |
| Sarcocheilichthys variegatus | 3            | 1 (33.3)               | 1     | -     | 1.0     |
| Subtotal               | 29                  | 6 (20.7)               | 27    | 1-12  | 4.5     |
| Total                  | 232                | 28 (12.1)              | 77    | 1-20  | 2.8     |

can be the real index fish of clonorchiasis transmission in the natural condition, and the presence of metacercariae in this fish species may suggest the maintaining of C. sinensis life cycle in subjected areas.

On the other hand, in case of Z. platypus, CsMc were not detected in 247 fish from northern areas. Total 17 (7.6%) out of 223 Z. platypus from middle areas were infected with 147 CsMc, and 13 (5.7%) out of 228 fishes from southern areas were infected with 139 CsMc. From the above findings, we could not find any special trend in the endemicity of C. sinensis infection in 3 regions. Therefore, it is confirmed that a less susceptible fish species, like Z. platypus, is unsuitable as an index fish, although they are widely collected in 3 regions as dominant fish species.

CsMc were not found in all fishes from 9 localities in northern areas except 2 species, P. herzi and S. japonicus coreanus, from Hantan-gang in Cheolwon-gun, Gangwon-do. In the study by Kim et al. [12], all the fish from upper regions of Cheongji, Chungeongbuk-doo were negative for CsMc, even though the number of susceptible fishes examined were limited. It is interesting that CsMc were detected only in fishes from Hantan-gang in northern areas. First of all, as an important epidemiologic factor for clonorchiasis, the availability of the snail intermediate host, Parafossarulus manchouricus, should be investigated in the near future in Hantan-gang in Cheolwon-gun, Gangwon-do. There have been few studies on the CsMc infection status of fishes from Gangwon-do, whereas many studies have been performed to investigate the infection status of intestinal flukes, including Metagonimus spp. in fishes from Gangwon-do [23-28]. It is probably due to the reason that Gangwon-do is endemic for intestinal fluke infections rather than clonorchiasis.

Among the 47 fish species listed as the second intermediate hosts of C. sinensis in Korea, Hypomesus olidus (the pond smelt) and Z. platypus are favoritely eaten raw in Korea. Fortunately, they are relatively unsusceptible for CsMc. In our study, CsMc were not found in 247 Z. platypus from Gangwon-do, and in extensive examinations of pond smelts from several lakes in Korea previously by Cho et al. [29]. Moreover, in the present study, they were not detected in 1,532 fishes from Gangwon-do, and in 42 fish from Daecheong-ho. However, Park et al. [30] detected CsMc in H. olidus and Z. platypus from Soyang-ho and Daecheong-ho. Especially, it was remarkable that total 369 CsMc were detected in 100 H. olidus from Daecheong-ho [30]. Judging by aforementioned data and ecological and biological characteristics of C. sinensis, the findings of Park et al. (2004) need further verification.

The positive rates and densities of CsMc were relatively high in fishes from the upper reaches of Nakdong-gang in Youngyang-gun and Gunwi-gun, Gyeongsangbuk-do. Of the 86 fishes from Youngyang-gun, 31 (36.0%) were infected with av. 126 CsMc, and 70 (51.5%) of 136 fishes from Gunwi-gun were infected with av. 287 CsMc. Chung et al. [31] examined 794 fish-
es, including 140 P. herzi from Youngyang-gun, and they detected 2.1 CsMc per gram of muscles from only 10 (23.3%) of 43 Gnathopogon atromaculatus (=Squalidus chankaensis tsuchigae) examined. Kim et al. [32] detected 11.6 CsMc per gram of muscles in 61 (43.9%) of 139 fishes from Wicheon in Uiseong-gun, Gyeongsangbuk-do. Accordingly, we could determine that the endemicity of CsMc in fishes from Youngyang-gun and Gunwi-gun are a little higher in the present study than in previous reports.

There have been few studies that examined the infection status of CsMc in fishes from Jeollanam-do. Kim et al. [12] roughly revealed the distribution of fishes infected with CsMc based on individual fish species. The present study showed a more detailed information on the endemicity of CsMc in fishes from 6 localities, Golseong-gun, Gurye-gun, Naju-si, Gangjin-gun, Jangheung-gun, and Boseong-gun, in Jeollanam-do. The endemicity was relatively higher in fishes from 5 localities except Jangheung-gun. Especially, it is interesting to note that the endemicity of C. sinensis in fishes from Gangjin-gun is high, because Gangjin-gun has been well known as a highly endemic area of metagonimiasis [33,34].

Studies on the CsMc infection status of fishes from Taehwagang in Ulsan Metropolitan City were performed by some workers. Joo [15,35] examined 504 and 697 freshwater fishes from

| Location and fish sp. | No. of fish examined | No. (%) of fish infected | No. metacercariae detected |
|-----------------------|----------------------|--------------------------|----------------------------|
| Yecheon-gun           |                      |                          |                            |
| Ladislabia taczanowskii | 2                    | 2 (100)                  | 33                         | 19-28 | 16.5 |
| Culter brevicauda     | 2                    | 2 (100)                  | 19                         | 2-17  | 9.5  |
| Pungtungia herzi      | 2                    | 1 (50.0)                 | 8                          | -     | 8.0  |
| Zacco platypus        | 26                   | 1 (3.8)                  | 4                          | -     | 4.0  |
| Pseudogobio esocinus  | 12                   | 1 (8.3)                  | 1                          | -     | 1.0  |
| Hemibarbus longirostris | 10                  | 1 (10.0)                 | 2                          | -     | 2.0  |
| Hemibarbus labeo      | 3                    | 1 (33.3)                 | 1                          | -     | 1.0  |
| Subtotal              | 57                   | 9 (15.8)                 | 68                         | 1-28  | 7.6  |
| Youngyang-gun         |                      |                          |                            |
| Pungtungia herzi      | 15                   | 15 (100)                 | 3,736                      | 13-630| 249.1 |
| Squalidus chankaensis tsuchigae | 1 | 1 (100) | 56 | -  | 56.0 |
| Microphysogobio koeensis | 2             | 2 (100)                  | 54                         | 1-53  | 27.0 |
| Coreleuciscus splendidus | 8             | 7 (87.5)                 | 45                         | 1-16  | 6.4  |
| Acheilognathus signifer | 2             | 1 (50.0)                 | 4                          | -     | 4.0  |
| Zacco platypus        | 24                   | 5 (20.8)                 | 13                         | 1-6   | 2.6  |
| Subtotal              | 52                   | 31 (59.6)                | 3,908                      | 1-630 | 126.1 |
| Gunwi-gun             |                      |                          |                            |
| Pseudogobio esocinus  | 1                    | 1 (100)                  | 2,105                      | -     | 2,105 |
| Squalidus gracilis majimae | 9         | 9 (100)                  | 7,463                      | 385-1,875 | 829.2 |
| Pungtungia herzi      | 4                    | 4 (100)                  | 3,279                      | 329-1,180 | 819.8 |
| Squalidus japonicus coreanus | 29   | 29 (100)                | 6,872                      | 9-875 | 237.0 |
| Acanthorhodeus gracilis | 2         | 2 (100)                  | 136                        | 54-82 | 68.0  |
| Zacco platypus        | 37                   | 9 (24.3)                 | 126                        | 1-77  | 14.0  |
| Pseudorasbora parva   | 1                    | 1 (100)                  | 11                         | -     | 11.0  |
| Hemibarbus longirostris | 4               | 4 (100)                  | 34                         | 3-13  | 8.5   |
| Acheilognathus signifer | 6             | 6 (100)                  | 43                         | 2-11  | 7.2   |
| Zacco temminckii      | 9                    | 1 (11.1)                 | 3                          | -     | 3.0   |
| Acheilognathus yamatsutae | 9     | 1 (11.1)                 | 2                          | -     | 2.0   |
| Opsarichthys uncirostris | 6         | 1 (16.7)                 | 1                          | -     | 1.0   |
| Coreoperca herzi      | 3                    | 1 (33.3)                 | 1                          | -     | 1.0   |
| Hemibarbus labeo      | 1                    | 1 (100)                  | 1                          | -     | 1.0   |
| Subtotal              | 111                  | 70 (63.1)                | 20,077                     | 1-2,105 | 286.8 |
| Total                 | 220                  | 110 (50.0)               | 24,053                     | 1-2,105 | 218.7 |
Cho et al. [28]: Prevalence of Clonorchis sinensis metacercariae in fish, Korea

Taehwa-gang, and reported 31 (6.2%) and 126 (18.1%) fish infected with CsMc. Rim et al. [36] also reported 29 (47.5%) CsMc positive fishes, of 2 species, P. parva and S. chankaensis tsuchigae, out of 61 fishes examined in Taehwa-gang. In the present study, we detected total 180 CsMc in 11 (9.2%) fishes of only 2 species, S. chankaensis tsuchigae, and Z. platypus, out of 119 fishes from Taehwa-gang. Therefore, we could determine that the endemicity of CsMc in the present study is much lower than those in the previous studies.

Bae et al. [37] extensively surveyed on C. sinensis infections in the first and second intermediate hosts, definitive hosts, and inhabitants, residing along Nam-gang, in Gyeongsangnam-do. Especially on the second intermediate hosts, they reported that 83 (34.7%) of 239 fishes, including 64 P. parva, were infected with CsMc. In the present study, we examined total 790 freshwater fishes from Yangcheon-gang, a stream of Nam-gang, in Sancheong-gun, Gyeongsangnam-do, and detected av. 187 CsMc from 381 (48.2%) fishes. Until now the endemicity of CsMc in fishes from streams of Nam-gang, including Yangcheon-gang, is as high as in old days. It seems to be one of the reasons why Sancheong-gun is the most highly endemic area of clonorchiasis around the whole country [5]. Therefore, inhabitants residing in endemic areas, like Sancheong-gun, should pay attention to clonorchiasis, and consumption of raw freshwater fish naturally produced in these areas should be avoided.

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Table 9. Prevalence and density of C. sinensis metacercariae in fishes from Seomjin-gang (River), Jeollanam-do, a southern region of Korea

| Location and fish sp. | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|----------------------|----------------------|--------------------------|------------------------------|
|                      |                      |                          | Total | Range | Average |
| Gokseong-gun         |                      |                          |       |       |         |
| Ladislabia taczanowskii | 2              | 2 (100)                        | 604   | 259-345 | 302.0  |
| Sarcocheilichthys variegatus | 4          | 2 (50.0)                        | 379   | 20-359  | 189.5  |
| Zacco platypus       | 42                 | 1 (2.4)                        | 118   | -       | 118.0  |
| Pungtungia herzi     | 12                 | 10 (83.3)                      | 1,139 | 1-275   | 113.9  |
| Squalidus japonicus coreanus | 12     | 3 (25.0)                        | 164   | 20-93   | 54.7   |
| Abbottina spingeri   | 3                  | 2 (66.7)                        | 27    | 2-25    | 13.5   |
| Squalidus chankaensis | 4                 | 3 (75.0)                        | 31    | 4-16    | 10.3   |
| Hemibarbus longirostris | 2             | 2 (100)                        | 7     | 2-5     | 3.5    |
| Cyprinus capio       | 1                  | 1 (100)                        | 2     | -       | 2.0    |
| Acheilognathus majusculus | 4          | 2 (50.0)                        | 4     | -       | 2.0    |
| Coreoleuciscus splendidus | 17     | 11 (64.7)                       | 18    | 1-3     | 1.6    |
| Carassius auratus    | 13                 | 1 (7.7)                        | 1     | -       | 1.0    |
| Hemibarbus labio     | 3                  | 2 (66.7)                        | 2     | -       | 1.0    |
| Subtotal             | 119                | 42 (35.3)                      | 2,496 | 1-359   | 59.4   |
| Gurye-gun            |                     |                           |       |       |         |
| Pungtungia herzi     | 1                  | 1 (100)                        | 377   | -       | 377.0  |
| Squalidus chankaensis tsuchigae | 25 | 19 (76.0)                     | 771   | 1-351   | 40.6   |
| Sarcocheilichthys nigripinis | 10     | 10 (100)                      | 217   | 6-62    | 21.7   |
| Microphysogobio koreensis | 2     | 1 (50.0)                      | 14    | -       | 14.0   |
| Siniperca scherzeri  | 1                  | 1 (100)                        | 4     | -       | 4.0    |
| Hemibarbus longirostris | 6           | 1 (16.7)                       | 3     | -       | 3.0    |
| Pseudogobio escinurus | 3                 | 2 (66.7)                       | 2     | -       | 1.0    |
| Acheilognathus yamatsumae | 7          | 1 (14.3)                       | 1     | -       | 1.0    |
| Microphysogobio longidorsalis | 1      | 1 (100)                      | 1     | -       | 1.0    |
| Subtotal             | 56                 | 37 (66.1)                      | 1,390 | 1-377   | 37.6   |
| Total                | 175                | 79 (45.1)                      | 3,886 | 1-377   | 49.2   |
Table 10. Prevalence and density of *C. sinensis* metacercariae in fishes from rivers in Jeollanam-do, southern regions of Korea

| Location and fish sp. | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|-----------------------|----------------------|--------------------------|------------------------------|
|                       |                      |                          | Total | Range | Average |
| *Youngsan-gang in Naju-si* |                      |                          |       |       |         |
| Squalus japonicus coreanus | 1 | 1 (100) | 815 | - | 815.0 |
| Acheilognathus tanceolatus | 5 | 5 (100) | 730 | 2-460 | 146.0 |
| Hemibarbus longirostris | 4 | 4 (100) | 215 | 23-107 | 53.8 |
| Opsarichthys uncirostris | 2 | 1 (50.0) | 28 | - | 28.0 |
| Pseudologodobius esocinus | 3 | 3 (100) | 24 | 1-12 | 8.0 |
| Acheilognathus yamatsutae | 3 | 2 (66.7) | 10 | 1-9 | 5.0 |
| Zacco platypus | 20 | 1 (5.0) | 2 | - | 2.0 |
| Hemibarbus labeo | 8 | 5 (62.5) | 6 | 1-2 | 1.2 |
| Carassius auratus | 10 | 1 (10.0) | 1 | - | 1.0 |
| Subtotal | 56 | 23 (41.1) | 1,831 | 1-460 | 79.6 |
| *Tami-jang-gang in Gangjin-gun* |                      |                          |       |       |         |
| Pungtungia herzi | 6 | 6 (100) | 2,520 | 95-846 | 420.0 |
| Sarcocheilichthys variiegatus | 15 | 15 (100) | 5,342 | 65-682 | 356.1 |
| Gnathopogon strigatus | 3 | 3 (100) | 122 | 30-52 | 40.7 |
| Pseudorasbora parva | 1 | 1 (100) | 6 | - | 6.0 |
| Acanthorhodeus macropeterus | 8 | 5 (62.5) | 14 | 1-9 | 2.8 |
| Pseudologobius esocinus | 3 | 3 (100) | 6 | 1-3 | 2.0 |
| Acheilognathus yamatsutae | 2 | 2 (100) | 4 | 1-3 | 2.0 |
| Hemibarbus longirostris | 3 | 3 (100) | 5 | 1-3 | 1.7 |
| Zacco platypus | 10 | 1 (10.0) | 1 | - | 1.0 |
| Subtotal | 51 | 39 (76.5) | 8,020 | 1-846 | 205.6 |
| *Boseong-gang in Boseong-gun* |                      |                          |       |       |         |
| Pungtungia herzi | 2 | 2 (100) | 157 | 9-148 | 78.5 |
| Pseudologobius esocinus | 2 | 1 (50.0) | 2 | - | 2.0 |
| Acheilognathus yamatsutae | 3 | 1 (33.3) | 2 | - | 2.0 |
| Zacco platypus | 1 | 1 (100) | 1 | - | 1.0 |
| Subtotal | 8 | 5 (62.5) | 162 | 1-148 | 32.4 |
| Total | 115 | 67 (58.3) | 10,013 | 1-846 | 149.4 |

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Table 11. Prevalence and density of C. sinensis metacercariae in fishes from Yangcheon-gang (River), Sancheong-gun, Gyeongsangnam-do, a southern region of Korea

| Year examined and fish sp. | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|----------------------------|----------------------|--------------------------|------------------------------|
|                            |                      |                          | Total                        |
|                            |                      |                          | Range                        |
|                            |                      |                          | Average                      |

2006

| Pungtungia herzi         | 24                    | 24 (100)                 | 19,044                       |
|--------------------------|-----------------------|--------------------------|------------------------------|
| Squalidus chankaensis    | 7                     | 7 (100)                  | 1,775                        |
| esocinus                 | 34                    | 34 (100)                 | 3,643                        |
| Acheilognathus rhombeus  | 3                     | 3 (100)                  | 187                          |
| Acanthorhodeus macropterus| 15                   | 10 (66.7)                | 335                          |
| Acheilognathus majusculus| 25                   | 18 (72.0)                | 100                          |
| Hemibarbus longirostris  | 3                     | 7 (22.6)                 | 13                           |
| Zacco temminckii         | 34                    | 4 (11.8)                 | 6                            |
| Zacco platypus           | 21                    | 3 (14.3)                 | 3                            |
| Subtotal                 | 194                   | 110 (56.7)               | 25,106                       |

2007

| Pungtungia herzi         | 44                    | 44 (100)                 | 28,294                       |
|--------------------------|-----------------------|--------------------------|------------------------------|
| Squalidus chankaensis    | 2                     | 2 (100)                  | 658                          |
| esocinus                 | 2                     | 2 (100)                  | 551                          |
| Squalidus gracilis       | 2                     | 2 (100)                  | 298                          |
| esocinus                 | 16                    | 13 (81.3)                | 817                          |
| Sarcocheilichthys        | 6                     | 6 (100)                  | 35                           |
| nigripinnis              | 2                     | 2 (100)                  | 14                           |
| Hemibarbus signifer      | 8                     | 1 (12.5)                 | 4                            |
| Coreoperca herzi         | 15                    | 8 (53.3)                 | 23                           |
| Zacco platypus           | 19                    | 1 (5.3)                  | 2                            |
| Acheilognathus koreensis | 4                     | 2 (50.0)                 | 4                            |
| Acheilognathus majusculus| 13                    | 9 (69.2)                 | 16                           |
| Carassius auratus        | 13                    | 1 (7.7)                  | 1                            |
| Odontobutis platycephala| 8                     | 1 (12.5)                 | 1                            |
| Subtotal                 | 155                   | 95 (61.3)                | 30,729                       |

2010

| Sarcocheilichthys        | 2                     | 2 (100)                  | 542                          |
| variegatus               | 78                    | 71 (91.0)                | 13,143                       |
| Pungtungia herzi         | 3                     | 3 (100)                  | 235                          |
| Squalidus chankaensis    | 1                     | 1 (100)                  | 45                           |
| Acheilognathus rhombeus  | 2                     | 2 (100)                  | 51                           |
| Squalidus gracilis       | 9                     | 8 (88.9)                 | 191                          |
| Acheilognathus majusculus| 13                    | 9 (69.2)                 | 16                           |
| Zacco platypus           | 13                    | 1 (7.7)                  | 1                            |
| Hemibarbus longirostris  | 8                     | 1 (12.5)                 | 1                            |
| Subtotal                 | 246                   | 176 (71.5)               | 15,514                       |

Total

| No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|----------------------|--------------------------|------------------------------|
|                      |                          | Total                        |
|                      |                          | Range                        |
|                      |                          | Average                      |

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Table 12. Comparative prevalence* and density† of C. sinensis metacercariae in fishes from 3 latitudinal regions

| Items                                      | Infection status (%) in fishes from | Northern | Middle | Southern | Total |
|--------------------------------------------|-------------------------------------|---------|--------|----------|-------|
| No. (% of fish examined)                   |                                     | 1,543 (37.9) | 1,167 (28.7) | 1,361 (33.4) | 4,071 (100) |
| Total positive rate (%)                    |                                     | 11/1,543 (0.7) | 149/1,167 (12.8) | 538/1,361 (39.5) | 698/4,071 (17.1) |
| Overall metacercarial density/fish         |                                     | 2.6       | 163.7  | 158.8    | 157.4 |
| Positive rate (%) of P. herzi              |                                     | 9/146 (6.2) | 34/107 (31.8) | 158/170 (92.9) | 201/423 (47.5) |
| Metacercarial density in P. herzi          |                                     | 2.8       | 214.7  | 403.3    | 358.2 |
| Positive rate (%) of Z. platypus          |                                     | 0/247 (0)  | 17/223 (7.6)  | 13/228 (5.7)   | 30/698 (4.3)  |
| Metacercarial density in Z. platypus       |                                     | 0         | 8.6    | 10.7     | 9.5   |

*Prevalence: no. of fish infected/no. of fish examined × 100; density: mean no. of metacercariae per infected fish.

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