Prevalence of Zoonotic Trematode Metacercariae in Freshwater Fish from Gangwon-do, Korea

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Abstract: The infection status of zoonotic trematode metacercariae was investigated in a total of 2,293 freshwater fish collected from 11 rivers or streams in 9 administrative regions of Gangwon-do, Korea for 5 years (2009-2013). All fish were collected by netting methods and examined using the artificial digestion methods. Clonorchis sinensis metacercariae were detected in 4 fish species, i.e., Pungtungia herzi, Squalidus japonicus coreanus, Acheilognathus rhombeus, and Ladislabia taczanowskii, from only Hantangang in Cheorwon-gun. Metagonimus spp. metacercariae were found in 1,154 (50.3%) fish and their average number per infected fish was 55.8. Among the positive fish species, especially Tribolodon hakonensis from Namdaecheon in Yangyang-gun and Plecoglossus altivelis from Osipcheon in Samcheok-si were most heavily infected. Centrocestus armatus metacercariae were detected in 611 (26.7%) fish and the average metacercarial burden per infected fish was 1,032. Two chub species, Zacco platypus and Zacco temminckii were highly and heavily infected with C. armatus metacercariae in almost all regions surveyed. Echinostoma spp. metacercariae were also found in 24 fish from a few localities, but their numbers per fish infected were very low. From the above results, it is confirmed that the metacercariae of intestinal flukes, especially Metagonimus spp. and C. armatus, were heavily infected, while C. sinensis metacercariae were rarely found in fish from Gangwon-do, Korea.

Key words: Clonorchis sinensis, Metagonimus spp. Centrocestus armatus, metacercaria, zoonotic trematode, freshwater fish, Gangwon-do

INTRODUCTION

Soil-transmitted nematodiases were one of the national health problems in the Republic of Korea (= Korea) in old days, before 1980. However, they are no longer a public health problem these days. On the other hand, the prevalence of zoonotic trematode (mainly fishborne trematodes: FBTs) infections, including clonorchiasis, is maintained high, and they became the most important parasitic diseases in some endemic areas, especially in riverside areas of 7 major rivers, i.e., Han-gang (River), Gumgang, Mangyeonggang, Yeongsangang, Tamjungang, Seomjingang, and Nakdonggang, in Korea [1-4].

Human infections with FBTs are usually caused by habitual consumption of raw fish containing infective larvae, metacercariae. The endemic areas of FBT infections are highly localized depending on the food habits of residents and on the presence of susceptible intermediate hosts [5]. Moreover, FBTs show low host-specificity, and then many kinds of reservoir hosts can contribute to the maintenance of their life cycles. Thus, the infection status of FBT metacercariae in intermediate hosts is one of the important epidemiological indices together with the status of adult worm infections in the definitive and reservoir hosts [6-10].

Gangwon-do (Province) is located at the northeast (between 37°02’ and 38°37’ N; 127°05’ and 129°22’ E) of Korea, and comprised of 7 si (City) and 11 gun (County). The landscape of this province is dominated by Taebaek Mountains, of which mountainous areas occupy the most areas of the province and retained the head streams of Hangang and Nakdonggang [11]. Epidemiological studies have been performed to investigate...
the infection status of FBIs, including *Metagonimus* spp. in Gangwon-do. Most of these studies were performed before an early 1990’s and focused on the infection status with *M. yokogawai* metacercariae in sweetfish, *Plecoglossus altivelis*, from rivers and streams in the east coast of Gangwon-do [12-18]. In addition, metacercarial infections of *Metagonimus* spp. and *Echinostoma hortense* were investigated in some species of freshwater fish from several regions in Gangwon-do [19-23]. However, large-scale surveys on the infection status of FBI metacercariae in a variety of fish species have not been conducted in Gangwon-do. Therefore, in the present study, we investigated the infection status of zoonotic trematode metacercariae in freshwater fish from various regions of Gangwon-do for a period of 5 years.

**MATERIALS AND METHODS**

**Surveyed areas**

The survey was conducted in 13 localities of 9 administrative regions in Gangwon-do, from 2009 to 2013. The surveyed areas (year examined) were as follows: ① Sooipcheon in Yanggu-gun (2009); ② Namdaecheon in Yangyang-gun (2009); ③ Donggang in Yeongwol-gun (2009); ④ Osipcheon in Samcheok-si (2009); ⑤ Gagokcheon in Samcheok-si (2009); ⑥ Hwagang in Cheorwon-gun (2010); ⑦ Hantangang in Cheorwon-gun (2012); ⑧ Hongcheongang in Hongcheon-gun (2010); ⑨ Seomgang in Hoengseong-gun (2011); ⑩ Hantangang in Cheorwon-gun (2012); ⑪ Joyanggang in Jeongseon-gun (2012); ⑫ Hantangang in Cheorwon-gun (2013); ⑬ Pyeongchanggang in Pyeongchang-gun (2013) (Fig. 1).

![Fig. 1. The surveyed areas in Gangwon-do, Korea: ① Sooipcheon in Yanggu-gun (2009); ② Namdaecheon in Yangyang-gun (2009); ③ Donggang in Yeongwol-gun (2009); ④ Osipcheon in Samcheok-si (2009); ⑤ Gagokcheon in Samcheok-si (2009); ⑥ Hwagang in Cheorwon-gun (2010); ⑦ Hantangang in Cheorwon-gun (2012); ⑧ Hongcheongang in Hongcheon-gun (2010); ⑨ Seomgang in Hoengseong-gun (2011); ⑩ Hantangang in Cheorwon-gun (2012); ⑪ Joyanggang in Jeongseon-gun (2012); ⑫ Hantangang in Cheorwon-gun (2013); ⑬ Pyeongchanggang in Pyeongchang-gun (2013).](image-url)
Freshwater fish examined

We collected a total of 865 freshwater fish (32 species) in 5 localities, i.e., Sooipcheon (in Yanggu-gun), Namdaecheon (in Yangyang-gun), Donggang (in Yeongwol-gun), Osipcheon (in Samcheok-si), and Gagokcheon (in Samcheok-si), 2 times in a year, June and October 2009. We also collected 547 freshwater fish (29 species) in Hwagang (in Cheorwon-gun), Hantangang (in Cheorwon-gun), and Hongcheongang (in Hongcheon-gun) 2 times in a year, June and October 2010, and in Seomgang (in Hoengseong-gun) in September 2011. A total of 881 freshwater fish (30 species) were collected in Hantangang (in Cheorwon-gun) and Joyanggang (in Jeongseon-gun) 2 times a year in July and October 2012, and in Hantangang (in Cheorwon-gun) and Yeongchanggang (in Yeongchang-gun) 2 times a year in June and September 2013. The numbers and species of fish examined were shown in Tables 1, 2, and 3. As for fish collection methods, nettings with a Gill net, casting net, and stake net were used in all surveyed areas.

Examination methods

All collected fish were transferred on ice to the laboratory of the Department of Parasitology and Tropical Medicine, Gyeongsang National University School of Medicine, Jinju, Korea. After identification of fish species, fish were individually ground with a mortar with pestle or in 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 x 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 FBT metacercariae was separately collected by the general feature [5], and they were counted to obtain the infection rates and densities by fish species.

RESULTS

Infection status of Clonorchis sinensis metacercariae

The metacercariae of C. sinensis were detected only in 4 fish species, i.e., Pungtungia herzi, Squalidus japonicus coreanus, Acheilognathus rhombeus, and Ladislabia taczanowskii, collected from Hantangang in Cheorwon-gun. The infection rate of fish was 29.8% (28 out of 94 fish), and a total of 56 metacercariae were harvested (2.0 metacercariae per fish). The infection status of each fish species and each year is revealed in Table 4.

Table 1. Freshwater fish collected from streams and rivers in Gangwon-do, Korea (2009)

| Species of fish | No. of fish collected from 5 localities |
|----------------|----------------------------------------|
| Cypriniforms   |                                       |
| Zaccho platypus| 26 30 30 23 19 128                    |
| Zaccho temmincki| 23 30 30 - 20 103                     |
| Coreoluciscus splendidus | 27 - 30 30 8 95 | |
| Pungtungia herzi | 11 15 16 - 17 59 | |
| Tribolodon hakonensis | - 30 - 21 - 51 | |
| Microphysogobio longidorsalis | 25 - 25 - 50 | |
| Rhyncocypris oxycephalus | 10 3 - 1 25 39 | |
| Hemibarbus longirostris | 14 - 16 - 30 | |
| Pseudogobio esocinus | 11 - 10 - 21 | |
| Gobio biloba brevibarba | - - 18 - 18 | |
| Carassius auratus | 14 2 - - 16 | |
| Hemibarbus labio | - - 13 - 13 | |
| Koreocobitis rotundicaudata | - 13 - 13 | |
| Hemibarbus mylodon | 2 - 10 - 12 | |
| Acanthohodeus macropterus | - - 10 - 10 | |
| Orthis tasii | - - 8 - 8 | |
| Opsarichthys uncirostris | 5 - - - 5 | |
| Misgurnus mizolepis | - - 5 - 5 | |
| Ladislabia taczanowskii | - - 3 - 3 | |
| Gobio biloba macrocephala | - - 3 - 3 | |
| Iksookimia koreensis | - - 2 - 2 | |
| Cyprius capio | 1 - - - 1 | |
| Pseudobagrus fulvidraco | - - 1 - 1 | |
| Osmeriformes |                                       |
| Plecoglossus altivelis | - 25 - 29 - 54 | |
| Salmoniformes |                                        |
| Onchorhynchus masou masou | - 5 - 2 3 10 | |
| Siluriformes |                                       |
| Lophius fuscus | 10 - 3 - 13 | |
| Silurus asotus | - - 1 - 1 | |
| Perciformes |                                       |
| Coreperca herzi | 17 10 15 - 42 | |
| Chanaogobius urotaenia | - - 19 8 27 | |
| Tridentiger brevispinis | - - 15 9 24 | |
| Rhinogobius grunius | - - 4 - 4 | |
| Acanthogobius pflaumi | - 4 - - 4 | |
| Total | 196 154 251 155 109 865 | |

*bTotal 865 freshwater fish of 32 species were examined.

Infection status of Metagonimus spp. metacercariae

The metacercariae of Metagonimus spp. were found in 1,154 (50.3%) fish, and their average number per infected fish was 55.8. Among the positive fish species, Tribolodon hakonensis from Namdaecheon in Yangyang-gun and P. altivelis from Osipcheon in Samcheok-si were most heavily infected. The in-
The metacercariae of *Centrocestus armatus* were detected in 611 (26.7%) fish, and the average metacercarial burden per infected fish was 1,032. Two species of chubs, *Zacco platypus* and *Zacco temminckii* were most highly and most heavily infected in almost all regions surveyed. The infection status by each fish species, collection site, and examination year is designated in Tables 5, 6, and 7.

### Infection status of *Centrocestus armatus* metacercariae

The metacercariae of *C. armatus* were detected in 611 (26.7%) fish, and the average metacercarial burden per infected fish was 1,032. Two species of chubs, *Zacco platypus* and *Zacco temminckii* were most highly and most heavily infected in almost all regions surveyed. The infection status by each fish species, collection site, and examination year is shown in Tables 8, 9, and 10.

### Infection status of *Echinostoma* spp. metacercariae

A total of 102 metacercariae of *Echinostoma* spp. were detected in 24 (15.5%) out of 155 freshwater fish (9 species) collected from 5 localities of Gangwon-do. The infection status by fish species, collection site, and examination year is designated in Table 11.
In the present study, *C. sinensis* metacercariae were detected in 28 fish (4 species, i.e., *P. herzi*, *S. japonicus coreanus*, *A. rhombus*, and *L. taczanowski*) from Hantangang in Cheorwon-gun. In our previous study [10], *C. sinensis* metacercariae were also found in 2 fish species, *P. herzi* and *S. japonicus coreanus*, from Hantangang in Cheorwon-gun, Gangwon-do [10]. According to Kim et al. [9], all fish collected from upper regions of Cheongju-si, Chungcheongbuk-do were negative for metacercariae. It is interesting to note that *C. sinensis* metacercariae were detected only in fish from limited areas of Hantangang among various regions surveyed in Gangwon-do. First of all, the presence of snail intermediate host, *Parafossarulus manchouricus*, in this river should be investigated.

Several studies have been performed to investigate on metacercariae of intestinal flukes in fish from Gangwon-do before the early 1990's [12-17,19-23]. Especially, the prevalence of *M. yokogawai* metacercariae was investigated in sweetfish from rivers and streams in the east coast of Gangwon-do [12-18]. Metacercarial infections of *Metagonimus* spp. (*M. miyutai* and *M. takahashii*) were also examined in freshwater fish from Seomgang, Jucheongang, Pyeongchanggang, Hongcheongang, Donggang, and Osipcheon, in Gangwon-do, and also from the upper reaches of Namhangang [21-23]. In addition, epidemiological studies on *E. hortense* infection were performed in some areas of Gangwon-do [19,20].

Ahn and Ryang [21] detected 3-87 *Metagonimus* spp. metacercariae (37.6 in average) in 30 (68.2%) out of 44 *Z. platypus* from Hongcheongang [21]. In the present study, *Metagonimus* spp. metacercariae were found in 71 (39.9%) out of 178 fish (12 species), including *Z. platypus* from Hongcheongang, and their burden per infected fish was 14.3. In case of *Z. platypus*, all of 20 fish examined were infected with them, and the mean burden was 33.4. Therefore, when we compared the infection status of *Metagonimus* spp. metacercariae in *Z. platypus* with that in Ahn and Ryang [21], the prevalence is higher in the present study, although the metacercarial burden is almost similar.

Ahn [22] also detected *Metagonimus* spp. metacercariae in *Z. platypus* from Seomgang, Jucheongang, Pyeongchanggang, Hongcheongang, and Donggang in Gangwon-do [22]. The prevalence by the surveyed area was 75.7% (112/148 fish), 77.1% (37/48), 87.5% (28/32), 63.2% (12/19), and 81.5% (22/27), respectively. The metacercarial burden in total 69 *Z. platypus* ranged 3-1,218 (93.8 in average). In the present study, they were found in all *Z. platypus* from Seomgang (23 fish), Pyeongchanggang (20), Hongcheongang (20), and Donggang (30), and their burdens were 28.8, 13.1, 33.4, and 31.6 metacercariae per fish, respectively. From the above findings, it is indicated that the prevalence is higher in the present study, and the metacercarial burden is higher in Ahn's study [22]. Like in Ahn’s study [22], *Metagonimus* spp. (*M. yokogawai*) metacercariae were also found in 2 fish species, *P. altivelis* (sweetfish) and *T. hakonensis* (sea rundace), from Osipcheon in Samcheok-si in the present study. All fish (2 species) examined were infected with them in both studies. In the present study, the metacercarial burden was 615 in 29 sweetfish and 82 in 21 sea rundace, whereas the burden was 729 in 5 sweetfish and 68 in 10 sea rundace in Ahn [22]. In Namdaecheon,
### Table 5. Infection status of *Metagonimus* spp. metacercariae in fish from streams and rivers in Gangwon-do, Korea (2009)

| Locality (year) and fish sp. examined | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|--------------------------------------|----------------------|--------------------------|-----------------------------|
|                                      |                      |                          | Total | Range | Average |
| ① Sooipcheon in Yanggu-gun           |                      |                          |       |       |         |
| Zacco platypus                       | 26                   | 17 (65.4)                | 53    | 1-16  | 3.1     |
| Zacco temminckii                     | 23                   | 18 (78.3)                | 85    | 1-27  | 4.7     |
| Pseudogobio esocinus                 | 11                   | 2 (18.2)                 | 24    | 11-13 | 12.0    |
| Liobagrus mediadiposalis             | 10                   | 2 (20)                   | 2     | -     | 1.0     |
| Hemibarbus longirostris              | 8                    | 1 (12.5)                 | 1     | -     | 1.0     |
| Subtotal                             | 78                   | 40 (51.3)                | 165   | 1-27  | 4.1     |
| ② Namdaecheon in Yangyang-gun       |                      |                          |       |       |         |
| Tribolodon hakonensis                | 30                   | 27 (90.0)                | 12134 | 2-2250| 449.4   |
| Zacco platypus                       | 30                   | 25 (83.3)                | 223   | 1-58  | 8.9     |
| Zacco temminckii                     | 30                   | 9 (30.0)                 | 66    | 1-47  | 7.3     |
| Plecoglossus altivelis               | 25                   | 20 (80.0)                | 979   | 1-1397| 49.0    |
| Pungtungia herzi                     | 15                   | 10 (66.7)                | 33    | 1-9   | 3.3     |
| Coreoperca herzi                     | 10                   | 1 (10)                   | 1     | -     | 1.0     |
| Onchorhyncus masou masou             | 5                    | 4 (80)                   | 95    | 11-37 | 23.8    |
| Subtotal                             | 145                  | 96 (66.2)                | 13531 | 1-2250| 140.9   |
| ③ Donggang in Yeongwol-gun           |                      |                          |       |       |         |
| Zacco platypus                       | 30                   | 30 (100)                 | 949   | 2-148 | 31.6    |
| Zacco temminckii                     | 30                   | 30 (100)                 | 477   | 2-51  | 15.9    |
| Coreoleuciscus splendidus            | 30                   | 27 (90.0)                | 238   | 1-28  | 8.8     |
| Microphysogobio longidorsalis        | 25                   | 11 (44.0)                | 93    | 1-27  | 8.5     |
| Hemibarbus longirostris              | 16                   | 15 (93.8)                | 727   | 1-260 | 48.5    |
| Pungtungia herzi                     | 16                   | 9 (56.3)                 | 19    | 1-10  | 2.1     |
| Hemibarbus labo                       | 13                   | 12 (92.3)                | 201   | 1-70  | 16.8    |
| Gobiobotia brevibarba                | 11                   | 11 (100)                 | 682   | 6-112 | 62.0    |
| Pseudogobio esocinus                 | 10                   | 10 (100)                 | 1224  | 10-387| 122.4   |
| Hemibarbus mylodon                    | 10                   | 5 (50)                   | 15    | 1-7   | 3.0     |
| Coreoperca herzi                     | 5                    | 1 (20)                   | 1     | -     | 1.0     |
| Liobagrus andersoni                  | 3                    | 2 (66.7)                 | 5     | 1-4   | 2.5     |
| Subtotal                             | 199                  | 163 (81.9)               | 4631  | 1-387 | 28.4    |
| ④ Osipcheon in Samcheok-si           |                      |                          |       |       |         |
| Plecoglossus altivelis               | 29                   | 29 (100)                 | 17820 | 6-3380| 614.5   |
| Zacco platypus                       | 23                   | 23 (100)                 | 303   | 1-75  | 13.2    |
| Tribolodon hakonensis                | 21                   | 21 (100)                 | 1730  | 1-275 | 82.4    |
| Chaenogobio urotaenlia               | 10                   | 1 (10.0)                 | 1     | -     | 1.0     |
| Ladistabia taczanowskii              | 3                    | 3 (100)                  | 16    | 1-12  | 5.3     |
| Onchorhynchus masou masou            | 2                    | 2 (100)                  | 28    | 3-35  | 14.0    |
| Rhynchoocypris oxycephalus           | 1                    | 1 (100)                  | 17    | -     | 17.0    |
| Subtotal                             | 89                   | 80 (89.9)                | 19915 | 1-3380| 248.9   |
| ⑤ Gagokcheon in Samcheok-si          |                      |                          |       |       |         |
| Zacco platypus                       | 19                   | 6 (31.6)                 | 22    | 1-7   | 3.7     |
| Pungtungia herzi                     | 15                   | 7 (46.7)                 | 10    | 1-2   | 1.4     |
| Zacco temminckii                     | 15                   | 2 (13.3)                 | 5     | 1-4   | 2.5     |
| Rhynchoocypris oxycephalus           | 15                   | 2 (13.3)                 | 4     | 1-3   | 2.0     |
| Tridentiger brevispinis              | 9                    | 1 (11.1)                 | 8     | -     | 8.0     |
| Onchorhynchus masou masou            | 2                    | 2 (100)                  | 68    | 20-48 | 34.0    |
| Subtotal                             | 75                   | 20 (26.7)                | 117   | 1-48  | 5.9     |
| Total                                | 586                  | 399 (68.1)               | 38359 | 1-3380| 96.1    |
Yangyang-gun, *Metagonimus* spp. (*M. yokogawai*) metacercariae were detected in 27 (90.0%) *T. hakonensis* in the present study, with their burden being 449 metacercariae per infected fish. By the aforementioned findings, it is confirmed again that 2 fish species, *P. altivelis* and *T. hakonensis*, are highly suitable second intermediate hosts of *Metagonimus* spp. (*M. yokogawai*) in

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**Table 6. Infection status of *Metagonimus* spp. metacercariae in fish from rivers in Gangwon-do, Korea (2010-2011)**

| Locality (year) and fish sp. examined | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|--------------------------------------|----------------------|--------------------------|------------------------------|
|                                      |                      |                          | Total | Range | Average |
| Hwagang in Cheorwon-gun (2010)       |                      |                          |       |       |         |
| *Zacco temminckii*                   | 10                   | 7 (70.0)                 | 103   | 1-47  | 14.7    |
| *Pungtungia herzi*                   | 13                   | 3 (23.1)                 | 5     | 1-3   | 1.7     |
| *Hemibarbus longirostris*            | 12                   | 12 (100)                 | 1,267 | 3-596 | 105.6   |
| *Microphysogobio longidorsalis*      | 8                    | 4 (12.5)                 | 1     | -     | 1.0     |
| *Acheilognathus signifer*            | 4                    | 4 (100)                  | 106   | 18-50 | 26.5    |
| *Zacco platypus*                     | 3                    | 3 (100)                  | 82    | 8-46  | 27.3    |
| *Pseudogobio esocinus*               | 3                    | 3 (100)                  | 2,078 | 78-1,680 | 692.7 |
| *Acheilognathus lanceolatus*         | 2                    | 2 (100)                  | 2     | -     | 1.0     |
| *Coreoleuciscus splendidus*          | 2                    | 2 (100)                  | 11    | 1-10  | 5.5     |
| Subtotal                             | 57                   | 37 (64.9)                | 3,655 | 1-1,680 | 98.8    |
| Hantangang in Cheorwon-gun (2010)    |                      |                          |       |       |         |
| *Zacco temminckii*                   | 30                   | 29 (96.7)                | 342   | 1-56  | 11.8    |
| *Zacco platypus*                     | 30                   | 30 (100)                 | 1,013 | 2-184 | 33.8    |
| *Pseudogobio esocinus*               | 8                    | 8 (100)                  | 383   | 4-125 | 47.9    |
| *Acheilognathus majusculus*          | 6                    | 6 (100)                  | 46    | 3-10  | 7.7     |
| *Acheilognathus rhombeus*            | 5                    | 5 (100)                  | 33    | 1-9   | 6.6     |
| *Hemibarbus mylbobon*                | 3                    | 2 (66.7)                 | 13    | 5-8   | 6.5     |
| *Hemibarbus longirostris*            | 3                    | 3 (100)                  | 160   | 5-85  | 53.3    |
| *Rhynchocypris steidachneri*         | 3                    | 2 (66.7)                 | 68    | 32-36 | 34.0    |
| *Squalidus japonicus coreanus*       | 2                    | 1 (50.0)                 | 3     | -     | 3.0     |
| Subtotal                             | 90                   | 86 (95.6)                | 2,061 | 1-184 | 24.0    |
| Hongcheongang in Hongcheon-gun (2010)|                      |                          |       |       |         |
| *Pungtungia herzi*                   | 25                   | 1 (4.0)                  | 1     | -     | 1.0     |
| *Hemibarbus longirostris*            | 20                   | 7 (35.0)                 | 16    | 1-4   | 2.3     |
| *Pseudogobio esocinus*               | 23                   | 16 (69.6)                | 92    | 1-19  | 5.8     |
| *Coreoperca herzi*                   | 20                   | 1 (5.0)                  | 1     | -     | 1.0     |
| *Coreoleuciscus splendidus*          | 18                   | 4 (22.2)                 | 6     | 1-2   | 1.5     |
| *Zacco platypus*                     | 20                   | 20 (100)                 | 667   | 7-123 | 33.4    |
| *Zacco temminckii*                   | 16                   | 13 (81.3)                | 95    | 1-22  | 7.3     |
| *Microphysogobio longidorsalis*      | 20                   | 1 (5.0)                  | 4     | -     | 1.0     |
| *Siniperca scherzi*                  | 11                   | 4 (36.4)                 | 5     | -     | 1.0     |
| *Odontobutis platycephala*           | 2                    | 1 (50.0)                 | 4     | -     | 1.0     |
| *Opsarichthys uncirostris*           | 2                    | 2 (100)                  | 22    | 8-14  | 11.0    |
| *Hemibarbus labeo*                   | 1                    | 1 (100)                  | 107   | -     | 107.0   |
| Subtotal                             | 178                  | 71 (39.9)                | 1,013 | 1-123 | 14.3    |
| Seomgang in Hoengseong-gun (2011)    |                      |                          |       |       |         |
| *Zacco platypus*                     | 23                   | 23 (100)                 | 662   | 3-122 | 28.8    |
| *Hemibarbus longirostris*            | 20                   | 19 (95.0)                | 1,316 | 1-214 | 69.3    |
| *Pungtungia herzi*                   | 14                   | 2 (14.3)                 | 2     | -     | 1.0     |
| *Pseudogobio esocinus*               | 13                   | 12 (92.3)                | 102   | 1-19  | 8.5     |
| *Gobiobota brevbarba*                | 10                   | 6 (60.0)                 | 23    | 1-12  | 3.8     |
| *Zacco temminckii*                   | 5                    | 5 (100)                  | 116   | 5-75  | 23.2    |
| *Opsarichthys uncirostris*           | 5                    | 5 (100)                  | 13    | 1-12  | 3.8     |
| *Acheilognathus lanceolatus*         | 3                    | 1 (33.3)                 | 3     | -     | 3.0     |
| Subtotal                             | 93                   | 69 (74.2)                | 2,228 | 1-214 | 32.3    |
| Total                                | 418                  | 263 (62.9)               | 8,957 | 1-1680| 34.1    |
Table 7. Infection status of *Metagonimus* spp. metacercariae in fish from rivers in Gangwon-do, Korea (2012-2013)

| Locality (year) and fish sp. examined | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected | Total | Range | Average |
|--------------------------------------|----------------------|--------------------------|-------------------------------|--------|--------|---------|
| **Hantangang in Cheorwon-gun (2012)** |                      |                          |                               |        |        |         |
| Pungtungia herzi                      | 44                   | 6 (13.6)                 | 7                             | 1-2    | 1.2    |
| Zacco temminckii                      | 30                   | 28 (93.3)                | 834                           | 1-135  | 29.8   |
| Zacco platyptus                      | 29                   | 29 (100.0)               | 907                           | 3-115  | 31.3   |
| Achelognathus rhombeus               | 20                   | 17 (85.0)                | 474                           | 1-95   | 27.9   |
| Pseudogobio esocinus                  | 17                   | 17 (100.0)               | 2,389                         | 10-462 | 140.5  |
| Hemibarbus mylodon                    | 12                   | 12 (100.0)               | 601                           | 4-242  | 50.1   |
| Achelognathus signifer                | 11                   | 8 (72.7)                 | 30                            | 1-7    | 3.8    |
| Coreoperca herzi                      | 11                   | 1 (9.1)                  | 2                             | -      | 2.0    |
| Microphysogobio longidorsalis        | 10                   | 1 (10.0)                 | 1                             | -      | 1.0    |
| Hemibarbus labeo                      | 8                    | 6 (75.0)                 | 53                            | 1-22   | 8.8    |
| Pseudobagrus koreanus                 | 6                    | 2 (33.3)                 | 12                            | 2-10   | 6.0    |
| Acanthorhodeus macropterus           | 5                    | 3 (60.0)                 | 8                             | 1-4    | 2.7    |
| Hemibarbus longirostris              | 2                    | 2 (100.0)                | 151                           | 36-115 | 75.5   |
| Ladiapia taczanowskii                | 1                    | 1 (100.0)                | 1                             | -      | 1.0    |
| **Total**                             | 206                  | 133 (64.6)               | 5,470                         | 1-462  | 41.1   |

| **Joyanggang in Jeongseon-gun (2012)** |                      |                          |                               |        |        |         |
| Zacco temminckii                      | 39                   | 38 (97.4)                | 4,939                         | 10-403 | 130.0  |
| Coreoleuciscus splendidus             | 25                   | 25 (100.0)               | 424                           | 1-71   | 17.0   |
| Microphysogobio longidorsalis        | 24                   | 20 (83.3)                | 185                           | 1-42   | 9.3    |
| Pungtungia herzi                      | 24                   | 10 (41.7)                | 23                            | 1-9    | 2.3    |
| Zacco platyptus                      | 20                   | 20 (100.0)               | 1,333                         | 5-169  | 66.7   |
| Liobagrus andersoni                  | 8                    | 3 (37.5)                 | 5                             | 1-3    | 1.7    |
| Pseudopungtungia tenuicorpae         | 2                    | 2 (100.0)                | 2                             | -      | 1.0    |
| Coreoperca herzi                      | 2                    | 1 (50.0)                 | 1                             | -      | 1.0    |
| Hemibarbus mylodon                    | 1                    | 1 (100.0)                | 1                             | -      | 1.0    |
| Hemibarbus labeo                      | 1                    | 1 (100.0)                | 320                           | -      | 320.0  |
| Gobiobotia brevibarba                | 1                    | 1 (100.0)                | 95                            | -      | 95.5   |
| **Total**                             | 147                  | 122 (83.0)               | 7,329                         | 1-403  | 60.1   |
| **Hantangang in Cheorwon-gun (2013)** |                      |                          |                               |        |        |         |
| Pseudogobio esocinus                  | 40                   | 38 (95.0)                | 1,473                         | 1-486  | 38.8   |
| Zacco temminckii                      | 22                   | 18 (81.8)                | 199                           | 2-32   | 11.1   |
| Microphysogobio longidorsalis        | 22                   | 1 (4.5)                  | 1                             | -      | 1.0    |
| Zacco platyptus                      | 16                   | 16 (100)                 | 559                           | 1-67   | 34.9   |
| Hemibarbus longirostris              |                      |                          |                               |        | 10.1   |
| Carassius auratus                    |                      |                          |                               |        | 10.8   |
| Gobiobotia brevibarba                | 4                    | 4 (100)                  | 97                            | 15-29  | 24.3   |
| Hemibarbus mylodon                    | 4                    | 3 (75.0)                 | 224                           | 43-134 | 74.7   |
| Liobagrus andersoni                  | 4                    | 2 (50.0)                 | 3                             | 1-2    | 1.5    |
| Achelognathus majusculus             | 4                    | 2 (50.0)                 | 2                             | -      | 1.0    |
| Rhodeus ocellatus                    | 2                    | 2 (100)                  | 17                            | 7-10   | 8.5    |
| Acanthorhodeus macropterus           | 2                    | 2 (100)                  | 102                           | 38-64  | 51.0   |
| Sarcocheilichthys vanegatus          | 1                    | 1 (100)                  | 1                             | -      | 1.0    |
| Hemibarbus labeo                      | 1                    | 1 (100)                  | 153                           | -      | 153.0  |
| **Total**                             | 140                  | 105 (75.0)               | 2,985                         | 1-486  | 28.4   |

(Continued to the next page)
Table 7. Continued

| Locality (year) and fish sp. examined | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|--------------------------------------|----------------------|--------------------------|-----------------------------|
|                                       |                      |                          | Total | Range    | Average |
|                                        |                      |                          | Total | Range    | Average |
| ⑬ Pyeongchangang in Pyeongchang-gun (2013) |                      |                          |       |          |         |
| Pungtungia herzi | 35 | 2 (5.7) | 5 | 1-4 | 2.5 |
| Zacco temminckii | 34 | 32 (94.1) | 325 | 1-29 | 10.2 |
| Pseudogobio esocinus | 21 | 19 (90.5) | 148 | 1-30 | 7.8 |
| Zacco platypus | 20 | 20 (100) | 261 | 1-53 | 13.1 |
| Coreoleuciscus splendidus | 17 | 15 (88.2) | 213 | 1-63 | 14.2 |
| Hemibarbus longirostris | 17 | 16 (94.1) | 269 | 1-145 | 16.8 |
| Rhynchohypris oxycephalus | 10 | 6 (60.0) | 9 | 1-3 | 1.5 |
| Gobiodota brevbarba | 8 | 7 (87.5) | 32 | 1-9 | 4.6 |
| Pseudopungtungia tenuicorpa | 5 | 1 (20.0) | 1 | - | 1.0 |
| Hemibarbus mylodon | 5 | 1 (20.0) | 1 | - | 1.0 |
| Ladislabia taczanowskii | 4 | 2 (50.0) | 5 | 2-3 | 2.5 |
| Subtotal | 198 | 132 (66.7) | 1,325 | 1-145 | 10.0 |
| Total | 691 | 492 (71.2) | 17,109 | 1-486 | 34.8 |

Table 8. Infection status of Centrocestus armatus metacercariae in fish from streams and rivers in Gangwon-do, Korea (2009)

| Locality (year) and fish sp. examined | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|--------------------------------------|----------------------|--------------------------|-----------------------------|
|                                       |                      |                          | Total | Range    | Average |
|                                       |                      |                          | Total | Range    | Average |
| ① Sooipcheon in Yanggu-gun |                      |                          |       |          |         |
| Zacco temminckii | 23 | 22 (95.7) | 7,231 | 77-1,035 | 329 |
| Zacco platypus | 26 | 25 (96.2) | 3,937 | 1-887 | 158 |
| Opsarichthys uncirostris | 5 | 1 (20.0) | 3 | - | 3.0 |
| Subtotal | 54 | 48 (88.9) | 11,171 | 1-1,035 | 233 |
| ② Namdaecheon in Yangyang-gun |                      |                          |       |          |         |
| Zacco temminckii | 30 | 21 (70.0) | 4,772 | 1-3,687 | 227 |
| Zacco platypus | 30 | 25 (83.3) | 3,533 | 2-809 | 141 |
| Tribolodon hakonensis | 30 | 2 (6.7) | 2 | - | 1.0 |
| Subtotal | 90 | 48 (53.3) | 8,307 | 1-3,687 | 173 |
| ③ Donggang in Yeongwol-gun |                      |                          |       |          |         |
| Zacco temminckii | 30 | 30 (100) | 6,178 | 31-663 | 206 |
| Zacco platypus | 30 | 30 (100) | 10,699 | 54-1,006 | 357 |
| Subtotal | 60 | 60 (100) | 16,877 | 31-1,006 | 281 |
| ④ Osipcheon in Samcheok-si |                      |                          |       |          |         |
| Zacco platypus | 23 | 22 (95.7) | 2,973 | 10-576 | 135 |
| Tribolodon hakonensis | 21 | 5 (23.8) | 16 | 1-10 | 3.2 |
| Rhynchohypris oxycephalus | 1 | 1 (100) | 13 | - | 13.0 |
| Orthrias toni | 8 | 1 (12.5) | 1 | - | 1.0 |
| Subtotal | 53 | 29 (54.7) | 3,003 | 1-576 | 104 |
| ⑤ Gagokcheon in Samcheok-si |                      |                          |       |          |         |
| Zacco temminckii | 15 | 12 (80.0) | 2,421 | 1-1,518 | 202 |
| Zacco platypus | 19 | 18 (94.7) | 8,449 | 1-1,880 | 469 |
| Subtotal | 34 | 30 (88.2) | 10,870 | 1-1,880 | 362 |
| Total | 291 | 215 (73.9) | 50,228 | 1-3,687 | 234 |

In the present study, 1-397 (49 per infected fish) metacercariae were found from 20 (80.0%) out of 25 fish examined. However, no metacercariae were detected in 25 and 22 sweetfish examined by Seo et al. [13] and Ahn et al. [16], respectively. In sweetfish from Osipcheon in Samcheok-si, the infection status of M. yokogawai metacercariae was also surveyed by several workers. Seo et al. [13] reported 100% prevalence and 1,643 metacercariae per fish in 15 sweetfish examined. Ahn [14] and
Song et al. [15] detected 382 and 185 metacercariae per fish in 9 and 10 fish examined, respectively. In the present study, 29 sweetfish from Osipcheon in Samcheok-si were infected with 615 metacercariae per fish. Accordingly, the endemity of *M. yokogawai* metacercariae was much higher in sweetfish from Osipcheon in Samcheok-si than those from Namdaecheon in Yangyang-gun.

As the second intermediate hosts of *Metagonimus* spp. (*M. miyatai* and *M. takahashii*), approximately 48 species of freshwater fish (37 genera) have been listed in Korea [5]. In the present study, *Metagonimus* spp. metacercariae were detected in a variety of fish species in Gangwon-do, from 2009 to 2013. Among the positive fish, 16 species, i.e., *Acanthorhodeus macraperus* (from ③, ④), *Acheilognathus majusculus* (⑦, ⑧), *Acheilognathus signifiger* (⑥, ⑨), *Chaenogobius urotaenia* (⑧), *Hemibarbus myladon* (③, ⑦, ⑨, ⑪, ⑫, ⑬), *Ladislabia taczanowskii* (④, ⑧, ⑫), *Liobagrus andersoni* (③, ⑩, ⑪), *Microphysogobio longidorsalis* (③, ⑥, ⑧, ⑩, ⑫, ⑭, ⑮), *Rhnchocypris steidacheri* (⑦), *Odontobutis platycephala* (⑧), *Onchorhynchus masou masou* (②, ④, ⑤), *Opsarichthys uncirostris* (⑧, ⑨), *Pseudobagrus koreanus* (⑩), *Pseudopungtungia temucorpa* (⑧, ⑫), *Squalidus japonicus coreanus* (⑦), and *Tridentiger brevispinis* (④), have never been listed as the second intermediate hosts of *Metagonimus* spp. in Korea [5]. Therefore, 64 fish species (42 genera) in total are included among the second intermediate hosts of *Metagonimus* spp. in Korea.

To date, 3 *Metagonimus* species, i.e., *M. yokogawai*, *M. takahashii*, and *M. miyatai*, are known to distribute in Korea [24]. As the second intermediate hosts for *M. yokogawai*, 3 fish species, i.e., *P. altivelis*, *Tribolodon taczanowskii* (= *T. hakonensis*), and *Lateolabrax japonicus*, were reported [25-27]. As for *M. takahashii*, 4 fish species, i.e., *Carassius auratus*, *P. altivelis*, *T. taczanowskii* (= *T. hakonensis*) and *L. japonicas*, have been known to be the second intermediate hosts [28-31]. Two species of chubs, *Z. platypus* and *Z. temminckii*, were recorded as the second intermediate hosts for *M. miyatai* [24]. Possible presence of another species of *Metagonimus* in Korea should be investigated in the near future through recovery of adult worms via experimental infection of animals with these metacercariae.

In the present study, the metacercariae of *C. armatus* were

### Table 9. Infection status of *Centrocestus armatus* metacercariae in fish from rivers in Gangwon-do, Korea (2010-2011)

| Locality (year) and fish sp. examined | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|--------------------------------------|----------------------|--------------------------|------------------------------|
|                                      | Total                | Range                    | Average                      |
|                                      |                      |                          |                              |
| ① Hwagang in Cheorwon-gun (2010)    | Zacco temminckii     | 10 (100)                 | 2,208                        | 221                          |
|                                      | Zacco platypus       | 3 (100)                  | 1,149                        | 383                          |
|                                      | Acheilognathus signifiger | 4 (25)                   | 1                            | 1.0                          |
|                                      | Subtotal             | 17 (82.4)                | 3,358                        | 240                          |
| ② Hantangang in Cheorwon-gun (2010) | Zacco temminckii     | 30 (100)                 | 15,637                       | 521                          |
|                                      | Zacco platypus       | 30 (100)                 | 14,650                       | 488                          |
|                                      | Carassius auratus    | 3 (33.3)                 | 1                            | 1.0                          |
|                                      | Subtotal             | 63 (96.8)                | 30,288                       | 497                          |
| ③ Hongcheonang in Hongcheon-gun (2010) | Zacco temminckii     | 16 (100)                 | 53,486                       | 3,343                        |
|                                      | Zacco platypus       | 20 (100)                 | 123,150                      | 6,158                        |
|                                      | Opsariichthys uncirostris | 2 (100)                | 3,750                        | 1,875                        |
|                                      | Pungtungia herzi     | 25 (40)                  | 56                           | 5.6                          |
|                                      | Hemibarbus longirostris | 20 (15)                  | 4                            | 1.3                          |
|                                      | Coreoperca herzi     | 20 (10)                  | 7                            | 3.5                          |
|                                      | Coreodeuciscus splendidus | 18 (16.7)            | 3                            | 1.0                          |
|                                      | Subtotal             | 121 (46.3)               | 180,456                      | 3,222                        |
| ④ Seomgang in Hoengseong-gun (2011)  | Zacco temminckii     | 5 (60.0)                 | 1,755                        | 585                          |
|                                      | Zacco platypus       | 23 (100)                 | 41,599                       | 1,809                        |
|                                      | Opsariichthys uncirostris | 5 (40.0)               | 158                          | 79                           |
|                                      | Subtotal             | 33 (84.8)                | 43,512                       | 1,554                        |
| Total                                | 234 (68.0)           | 257,614                  | 1,13,650                     | 1,620                        |
detected in various fish species from Gangwon-do. Especially in 2 species of chubs, Z. platypus and Z. temminckii, they were highly and heavily infected in almost all regions surveyed. Hong et al. [32] investigated the infection status of C. armatus metacercariae in Z. platypus and Z. temminckii collected from 19 sites in 5 major rivers, Hangang, Geumgang, Yeongsangang, Seomjingang, and Nakdonggang [32]. They could catch Z. temminckii only in 3 regions, Hongcheongang (in Hongcheon-gun), Soyanggang (Inje-gun), and Seocheon (Yanggu-gun), of Gangwon-do. According to them [32], C. armatus metacercariae were detected in 100% (20/20 fish), 35.0% (7/20), and 68.4% (13/19) of Z. temminckii, and their burdens were 65, 2, and 3 metacercariae, respectively. Therefore, it appears that the endemcity of C. armatus is currently much higher than in the past.

Ten species of freshwater fish (8 genera), i.e., Aphyocypris chinensis, C. auratus, C. splendidus, Microphysogobio yaluensis, P. parva, Pseudobagrus fulvidraco, Rhodeus ocellatus ocellatus, R. uyekii, Z. platypus, Z. temminckii, have been listed as the second intermediate hosts for C. armatus in Korea [5]. In the present study, 15 fish species, i.e., Acheilognathyus rhombeus (from ②), Acheilognathyus signifer (⑥), Coreoperca herzi (⑧, ⑫), Gobiobota brevibarba (②), Hemibarbus longirostris (⑧, ⑩, ⑫), Hemibarbus mylodon (⑩), Koreocobitis rotundicaudata (⑪), Liobagrus andersoni (⑪), Microphysogobio longidorsalis (⑧, ⑩, ⑫), Microphysogobio yaluensis (⑧), Pungtungia herzi (⑧, ⑩, ⑫), Orthrias t. uncirostris (①, ⑧, ⑩), Pseudobagrus fulvidraco (④), and Tribolodon hakonensis (②, ④), are newly recorded as the second

Table 10. Infection status of Centrocestus armatus metacercariae in fish from rivers in Gangwon-do, Korea (2010-2012)

| Locality (year) and fish sp. examined | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|--------------------------------------|----------------------|--------------------------|------------------------------|
|                                      |                      |                          | Total                        | Range          | Average |
| Hantangang in Cheorwon-gun (2012)    |                      |                          |                              |                |
| Zacco temminckii                     | 30                   | 30 (100)                 | 17,982                       | 28-2,340       | 599     |
| Zacco platypus                       | 29                   | 29 (100)                 | 28,640                       | 23-6,620       | 988     |
| Pseudogobio esocinus                 | 17                   | 2 (11.8)                 | 3                            | 1-2            | 1.5     |
| Microphysogobio longidorsalis        | 20                   | 1 (5.0)                  | -                            | 1.0            |
| Acheilognathyus rhombeus             | 10                   | 6 (60.0)                 | 45                           | 3-12           | 7.5     |
| Hemibarbus longirostris              | 2                    | 1 (50.0)                 | 4                            | -              | 4.0     |
| Subtotal                             | 108                  | 69 (63.9)                | 46,675                       | 1-6,620        | 676     |
| Joyanggang in Jeongseon-gun (2012)   |                      |                          |                              |                |
| Zacco temminckii                     | 39                   | 39 (100)                 | 40,537                       | 163-3,205      | 1,039   |
| Zacco platypus                       | 20                   | 20 (100)                 | 6,361                        | 53-978         | 318     |
| Liobagrus andersoni                  | 8                    | 2 (25.0)                 | 2                            | -              | 1.0     |
| Coreoperca herzi                     | 2                    | 1 (50.0)                 | 2                            | -              | 2.0     |
| Pseudogobio esocinus                 | 1                    | 1 (100)                  | 10                           | -              | 10.0    |
| Koreocobitis rotundicaudata          | 1                    | 1 (100)                  | 5                            | -              | 5.0     |
| Subtotal                             | 71                   | 64 (90.1)                | 46,917                       | 2-3,205        | 733     |
| Hantangang in Cheorwon-gun (2013)    |                      |                          |                              |                |
| Zacco temminckii                     | 22                   | 22 (100)                 | 14,315                       | 112-2,760      | 651     |
| Zacco platypus                       | 16                   | 16 (100)                 | 29,603                       | 370-3,735      | 1,850   |
| Microphysogobio longidorsalis        | 22                   | 1 (4.5)                  | 2                            | -              | 2.0     |
| Hemibarbus longirostris              | 12                   | 1 (8.3)                  | 2                            | -              | 2.0     |
| Gobiobota brevibarba                 | 4                    | 2 (50.0)                 | 5                            | 1-4            | 2.5     |
| Rhodius ocellatus                    | 2                    | 2 (100)                  | 15                           | 3-12           | 7.5     |
| Subtotal                             | 78                   | 44 (56.4)                | 43,942                       | 1-3,735        | 999     |
| Pyeongchangang in Pyeongchang-gun (2013) |                |                          |                              |                |
| Zacco temminckii                     | 34                   | 34 (100)                 | 148,770                      | 961-11,470     | 4,376   |
| Zacco platypus                       | 20                   | 20 (100)                 | 36,420                       | 240-8,080      | 1,821   |
| Pseudogobio esocinus                 | 21                   | 1 (4.8)                  | 2                            | -              | 2.0     |
| Microphysogobio longidorsalis        | 22                   | 3 (13.6)                 | 3                            | -              | 1.0     |
| Coreobichthys splendidus             | 17                   | 1 (5.9)                  | 2                            | -              | 2.0     |
| Hemibarbus mylodon                   | 5                    | 1 (20.0)                 | 1                            | -              | 1.0     |
| Subtotal                             | 119                  | 60 (50.4)                | 185,198                      | 1-11,470       | 3,087   |
| Total                                | 376                  | 237 (63.0)               | 322,732                      | 1-11,470       | 1,362   |
intermediate hosts. Accordingly, 24 fish species (20 genera) in total are listed as the second intermediate hosts of *C. armatus* in Korea.

In the present study, *Echinostoma* spp. metacercariae (species undetermined) were detected in 9 fish species, i.e., *A. signifer* (from ⑥), *C. herzi* (⑧), *O. platycephala* (⑧), *P. esocinus* (⑧), *P. tenuicorpa* (⑬), *P. herzi* (⑥, ⑧, ⑨, ⑩), *R. oxycephalus* (⑬), *Siniperca scherzeri* (⑥), and *Z. platypus* (⑨). To date, 3 zoonotic *Echinostoma* species, i.e., *E. cinetorchis*, *E. hortense*, and *E. revolutum*, are distributed in Korea [33]. Among them, *E. hortense* is the dominant species and has 8 fish intermediate hosts, i.e., *Misgurnus anguillicaudatus*, *M. mizolepis*, *R. oxycephalus*, *O. interrupta*, *S. japonicus coreanus*, *Rhinogobius brunneus*, *A. macropterus*, and *Acanthogobius flavimanus*, whereas the remaining 2 species take snails as the second intermediate hosts [5]. Moreover, some inland areas, i.e., Eumseong-gun (Chungcheongbuk-do), Yeongwol-gun (Gangwon-do), Cheongsong-gun (Gyeongsangbuk-do), and Geochang-gun (Gyeongsangnam-do), have been reported as the endemic foci of *E. hortense* infection [20,34-36]. Therefore, the metacercariae of *Echinostoma* spp. detected in the present study are presumed to be *E. hortense*.

Conclusively, it is reconfirmed that Gangwon-do is a highly endemic area of intestinal flukes, i.e., *Metagonimus* spp., *C. armatus*, and *Echinostoma* spp., infections rather than clonorchiasis. The inhabitants residing in endemic areas should pay attention to infections with these intestinal flukes, and consumption of raw freshwater fish naturally produced should be avoided. In addition, species differentiation in 2 genera, *Metagonimus* and *Echinostoma*, should be done in the near future through experimental infection of these metacercariae to animal hosts.

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CONFLICT OF INTEREST

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

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