INTRODUCTION

Nowadays *Clonorchis sinensis* infection is the most endemic parasitic disease in the Republic of Korea (= Korea). The prevalence of this endemic disease was 1.9%, and about 932,540 residents are estimated to be infected, which is the highest value among the prevalences in the nationwide survey on helminthic infections in Korea [1]. The endemicity of clonorchiasis has maintained at relatively high levels in riverside areas of Korea [2-8]. Especially, in 1981, high prevalences were reported from the riverside residents in 7 major rivers, i.e., Nakdong-gang (40.2%), Yeongsan-gang (30.8%), Seomjin-gang (17.3%), Tamjin-gang (15.9%), Han-gang (15.7%), Geum-gang (12.0%), and Mangyeong-gang (8.0%) [2]. Also in 2006 and 2007, the egg positive rates of *C. sinensis* were surveyed from riverside residents in major 5 rivers of Korea [5,7]. Recently, Jeong et al. [8] reported the prevalence of clonorchiasis from the residents of 5 major rivers as Nakdong-gang (11.7%), Seomjin-gang (9.9%), Geum-gang (6.5%), Yeongsan-gang (3.1%), and Han-gang (1.0%).

On the other hand, many Korean workers surveyed on freshwater fish, the infection sources of clonorchiasis, collected from various endemic riverside areas to estimate the endemicities of clonorchiasis. The results revealed that more than 49 fish species in 7 families have been reported as the second intermediate hosts of *C. sinensis* metacercariae (CsMc). In addition, Cho et al. [14] surveyed the infection status of CsMc in freshwater fish from 3 wide regions, which are tentatively divided by the latitudinal levels of the Korean peninsula. They examined total 136 freshwater fish (16 spp.) from...
Wicheon, the same area in this study, in 2008. Later, in 2014, Cho et al. [16] investigated the prevalence of zoonotic trematode metacercariae in freshwater fish from Gangwon-do (Province), Korea. Recently, Sohn et al. [17] surveyed the infection status of digenetic trematode metacercariae including C. sinensis in freshwater fish from the water systems of Hantan-gang and Imjin-gang in northern regions of Korea. Sohn et al. [18] also investigated the infection status with C. sinensis metacercariae in fish from water systems of Seomjin-gang.

In 2014, total 338 freshwater fish in 24 species, i.e., Z. platypus (60), Z. temminckii (50), P. herzi (47), A. koreensis (29), A. yamatsutae (25), S. japonicus coreanus (14), C. auratus (13), S. gracilis majimae (13), Acheilognathus rhombeus (11), S. variegatus wakiyae (11), A. majusculus (10), Micropterus salmoides (8), C. sinensis (8), C. herzi (7), P. esocinus (7), Misgurnus anguillicaudatus (6), Odontobutis platycephala (4), Pseudorasbora parva (4). L. macrochirus (4), Cobitis lutheri (3), Acheilognathus lanceolatus (2), Microphysogobio jeoni (1), and Microphysogobio loevis (1), were examined. In 2015, total 245 freshwater fish in 19 species, i.e., Z. platypus (50), Z. temminckii (49), P. herzi (41), A. koreensis (29), A. yamatsutae (16), S. japonicus coreanus (15), S. gracilis majimae (11), C. auratus (10), A. rhombeus (7), A. springeri (4), S. variegatus wakiyae (3), O. uncirostris amurensis (3), P. parva (1), Rhynchohyphus oxycephalus (1), A. macropterus (1), P. esocinus (1), C. herzi (1), M. loevis (1), and A. lanceolatus (1), were examined.

In 2016, total 168 freshwater fish in 17 species, i.e., A. koreensis (35), Z. platypus (30), P. herzi (30), A. rhombeus (15), A. yamatsutae (15), Zacco koreensis (14), O. platycephala (6), C. auratus (5), S. japonicus coreanus (4), A. lanceolatus (3), C. herzi (3), P. esocinus (2), S. gracilis majimae (2), Hemibarbus longirostris (1), M. anguillicaudatus (1), Siniperca scherzeri (1), and M. koreensis (1), were examined. In 2017, total 199 freshwater fish in 17 species, i.e., Z. platypus (50), S. japonicus coreanus (31), A. yamatsutae (27), P. herzi (26), A. koreensis (26), Z. temminckii (10), P. parva (7), Acanthorhodeus gracilis (5), S. variegatus wakiyae (3), C. herzi (2), C. auratus (2), Z. koreensis (2), A. rhombeus (2), S. scherzeri (2), M. salmoides (2), C. lutheri (1), and Pseudobagrus fulvidraco (1), were examined.

Examination methods
All collected fish with ice were transferred to the laboratory of the Department of Parasitology and Tropical Medicine, Gyeongsang National University College of Medicine, Jinju, Korea. After identification of fish species, they were individually ground with a mortar or grinder. Each ground fish meat was mixed with artificial gastric juice, and the mixture was incubated at 36°C for 2 hr. The digested material was filtered with 1 × 1 mm of mesh, and washed with 0.85% saline until the supernatant became clear. The sediment was carefully examined under a stereomicroscope. The metacercariae of C. sinensis were separately collected by the general morphological feature [13,15], and they were counted to get hold of the infection rate and density by fish species. The susceptibility indices of

MATERIALS AND METHODS
Fish collection site and freshwater fish examined
We collected total 1,162 freshwater fish in 32 species in Wicheon (a stream of Nakdong-gang), which is located in Wooboo-myeon, Gunwi-gun (gun = county), flows via Gunwi-gun and Eui-seong-gun, and unites with the main stream at Sangju-si (si = city), Gyeongsangbuk-do, the water ecosystem of this stream is more or less healthy but the ecological conditions for fish is not so good [19]. However, it has been known that freshwater fish such as Pungtungia herzi, Squalidus gracilis majima, S. japonicus coreanus, and Pseudogobio esocinus from this stream were heavily infected with CsMc [14]. Therefore, for a period of 7 years, we focused on the infection status of CsMc in fish from a highly prevalent site of Wicheon, Gyeongsangbuk-do, Korea, and analyzed the infection status of CsMc according to the subfamily groups of Cyprinae fish hosts of C. sinensis.

In 2011, total 105 freshwater fish in 13 species (no. of fish examined), i.e., Zacco platypus (49), Squalidus japonicus coreanus (10), Zacco temminckii (10), Squalidus gracilis majimae (8), Pungtungia herzi (5), Acheilognathus majusculus (5), Opsariichthys uncirostris amurensis (5), Carassius auratus (3), Pseudogobio esocinus (3), Acanthorhodeus macropterus (3), Sarcocephalichthys variegatus wakiyae (2), and Acheilognathus koreensis (1), Cobitis sinensis (1), were examined. In 2013, total 107 freshwater fish in 12 species, i.e., P. herzi (20), Z. platypus (20), Acheilognathus yamatsutae (16), Z. temminckii (15), A. koreensis (10), S. gracilis majimae (9), S. variegatus wakiyae (6), Coreoperca herzi (5), Abbottina springeri (2), C. sinensis (2), C. auratus (1), and Lepomis macrochirus (1), were examined.
Table 1. Infection status of *Clonorchis sinensis* metacercariae in fish from Wicheon (a stream of Nakdong-gang) in Gunwi-gun, Gyeongsangbuk-do

| Year and fish species | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|-----------------------|----------------------|--------------------------|------------------------------|
|                       |                      |                          | Total | Range | Average |
| 2011                  |                      |                          |       |       |         |
| *Pungtungia herzi*    | 5                    | 5 (100)                  | 5,216 | 340-2,420 | 1,043 |
| *Squalidus japonicus coranarius* | 10         | 10 (100)                 | 818   | 13-295   | 82    |
| *Squalidus gracilis majimae* | 8           | 8 (100)                  | 4,960  | 9-1,035  | 620   |
| *Sarcocheilichthys vanegatus* | 2           | 2 (100)                  | 1,901  | 2-12     | 951   |
| *Pseudogobio esocinus*  | 3                    | 3 (100)                  | 16    | -       | 5     |
| *Acheilognathus majusculus* | 5           | 1 (20.0)                 | 1     | 2       | 1     |
| *Acanthorhodeus macropterus* | 3           | 3 (100)                  | 91    | 87      | 30    |
| *Acheilognathus koreensis* | 1           | 1 (100)                  | 9     | -       | 9     |
| *Zacco platypus*      | 49                   | 18 (59.3)                | 129   | 1-32    | 7     |
| Subtotal              | 86                   | 51 (59.3)                | 13,141| 1-2,420  | 258   |
| 2013                  |                      |                          |       |       |         |
| *Pungtungia herzi*    | 20                   | 20 (100)                 | 22,790| 27-11,290| 1,140 |
| *Squalidus gracilis majimae* | 9           | 9 (100)                  | 8,687 | 33-2,720 | 965   |
| *Sarcocheilichthys vanegatus* | 6           | 6 (100)                  | 2,545 | 26-1,245 | 424   |
| *Abottina springeri*  | 2                    | 2 (100)                  | 95    | 44-51   | 48    |
| *Acheilognathus koreensis* | 10          | 10 (100)                 | 58    | 1-14    | 6     |
| *Acheilognathus yamatsutae* | 16          | 6 (37.5)                 | 23    | 1-10    | 4     |
| *Zacco platypus*      | 20                   | 8 (40.0)                 | 129   | 1-70    | 16    |
| *Zacco temminckii*    | 15                   | 1 (6.7)                  | 2     | -       | 2     |
| Subtotal              | 98                   | 62 (63.3)                | 34,329| 1-11,290| 554   |
| 2014                  |                      |                          |       |       |         |
| *Pungtungia herzi*    | 47                   | 47 (100)                 | 116,805| 6-31,250 | 2,485 |
| *Squalidus japonicus coranarius* | 14        | 14 (100)                 | 25,291| 140-8,460| 1,807 |
| *Squalidus gracilis majimae* | 13         | 13 (100)                 | 20,285| 20-2,085 | 1,560 |
| *Sarcocheilichthys vanegatus* | 11          | 11 (100)                 | 8,936 | 13-2,730 | 812   |
| *Pseudorasbora parva* | 4                    | 4 (100)                  | 2,911 | 483-1,180| 728   |
| *Microphysogobio jeoni* | 1           | 1 (100)                  | 365   | -       | 365   |
| *Acheilognathus koreensis* | 29         | 29 (100)                 | 1,099 | 1-184   | 38    |
| *Microphysogobio koeensis* | 1           | 1 (100)                  | 12    | -       | 12    |
| *Acheilognathus yamatsutae* | 25         | 25 (88.0)                | 560   | 1-136   | 26    |
| *Acheilognathus rombeus* | 11          | 9 (81.8)                 | 782   | 1-290   | 87    |
| *Acheilognathus majusculus* | 10         | 2 (20.0)                 | 3     | 1-2     | 2     |
| *Acheilognathus lanceolatus* | 2           | 1 (50.0)                 | 283   | -       | 283   |
| *Zacco platypus*      | 60                   | 40 (66.7)                | 447   | 1-66    | 11    |
| *Zacco temminckii*    | 50                   | 1 (2.0)                  | -     | -       | 1     |
| *Carassius auratus*   | 13                   | 1 (7.7)                  | -     | -       | 1     |
| *Microperus salmoicoides* | 8            | 1 (12.5)                 | -     | -       | 1     |
| *Coreoperca herzi*    | 7                    | 1 (14.3)                 | 3     | -       | 3     |
| *Misgurnus anguillicaudatus* | 6         | 2 (33.3)                 | -     | -       | 1     |
| Subtotal              | 319                  | 206 (64.6)               | 178,007| 1-31,250| 864   |
| 2015                  |                      |                          |       |       |         |
| *Pungtungia herzi*    | 41                   | 41 (100)                 | 53,753| 24-7,750 | 1,311 |
| *Squalidus japonicus coranarius* | 15        | 15 (100)                 | 21,164| 359-2,670| 1,411 |
| *Squalidus gracilis majimae* | 11          | 11 (100)                 | 34,255| 146-7,690| 3,114 |
| *Sarcocheilichthys vanegatus* | 3           | 3 (100)                  | 1,632 | 157-1,318| 544   |
| *Pseudorasbora parva* | 1                    | 1 (100)                  | 1,538 | -       | 1,538 |
| *Pseudogobio esocinus* | 1                    | 1 (100)                  | 1,325 | -       | 1,325 |
| *Abottina springeri*  | 4                    | 4 (100)                  | 155   | 10-80   | 39    |
| *Microphysogobio koeensis* | 1           | 1 (100)                  | 139   | -       | 139   |
| *Acheilognathus koreensis* | 29         | 29 (100)                 | 2,454 | 4-678   | 85    |
| *Acheilognathus yamatsutae* | 16        | 4 (25.0)                 | 38    | 1-28    | 10    |
| *Acheilognathus rombeus* | 7                    | 7 (100)                  | 1,081 | 70-295  | 164   |
| *Acheilognathus lanceolatus* | 1           | 1 (100)                  | 245   | -       | 245   |
| *Acanthorhodeus macropterus* | 1           | 1 (100)                  | 79    | -       | 79    |
| *Zacco platypus*      | 50                   | 33 (66.0)                | 965   | 1-420   | 29    |
| *Zacco temminckii*    | 49                   | 4 (8.2)                  | 7     | 1-4     | 2     |
| *Opsariichthys uncirostris* | 3            | 2 (66.7)                 | -     | -       | 1     |
| *Carassius auratus*   | 10                   | 2 (20.0)                 | -     | -       | 1     |
| *Rhyynchocypris oxycephalus* | 1           | 1 (100)                  | 28    | -       | 28    |
| Subtotal              | 244                  | 161 (66.0)               | 118,862| 1-7,750  | 738   |

(Continued to the next page)
CsMc were calculated by the formula, prevalence/100 × mean metacercarial density per fish infected.

Subfamily groups in Cyprinidae fish hosts of C. sinensis

The gobioninid (Gobioninae) group-1 (323 fish) included *P. herzi* (169), *S. gracilis majimae* (43), *S. japonicus coreanus* (74), *S. variegatus wakiyae* (25), and *P. parva* (12). The gobioninid group-2 (24 fish) included *P. esocinus* (13), *A. springeri* (6), *M. koreensis* (3), *M. jeoni* (1), and *H. longirostris* (1). The acheilognathinid (Acheilognathinae) group (296 fish) included *A. koreensis* (130), *A. yamatsutae* (99), *A. rhombeus* (35), *A. gracilis* (7). The rasborinid (Rasborinae) group (403 fish) included *Z. platyurus* (259), *Z. temminckii* (136), and *O. unicirrhus amurensis* (8).

### RESULTS

Infection status of CsMc in overall examined fish

CsMc were detected in 720 (62.0%) out of 1,162 fish in 32 species examined, and their average density was 610 per fish infected. The infection status by fish species and surveyed years is shown in Table 1.

Infection status of CsMc in gobioninid fish group-1

CsMc were detected in all (100%) of 323 fish examined, and their average density was 1,310 per fish infected. The densities were highest in 2014 (1,958), followed by 2015 (1,582), 2016 (1,211), 2013 (972), 2017 (685), and 2011 (516) (Table 2). The infection status of CsMc by fish species, i.e., *P. herzi, S. gracilis majimae, S. japonicus coreanus, S. variegatus wakiyae* and *P. parva*, is revealed in Table 3.

Infection status of CsMc in gobioninid fish group-2

CsMc were detected in 23 (95.8%) out of 24 fish examined, and their average density was 127 per fish infected. The infection status by fish species, i.e., *P. esocinus, A. springeri, M. koreensis, M. jeoni* and *H. longirostris*, is shown in Table 4.

Infection status of CsMc in acheilognathinid fish group

CsMc were detected in 228 (77.0%) out of 296 fish examined, and their average density was 50 per fish infected. The densities were highest in 2015 (972), followed by 2016 (685),

| Year and fish species | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|-----------------------|----------------------|--------------------------|------------------------------|
|                        |                      |                          | Total | Range | Average |
| 2016 Pungtungia herzi | 30                   | 30 (100)                 | 36,686 | 28-9,870 | 1,223 |
| Squalidus japonicus coreanus | 4 | 4 (100) | 3,603 | 210-1,480 | 901 |
| Squalidus gracilis majimae | 2 | 2 (100) | 3,323 | 653-2,670 | 1,662 |
| Pseudogobio esocinus | 2 | 2 (100) | 540 | 36-504 | 270 |
| Microphysogobio koreensis | 1 | 1 (100) | 40 | - | 40 |
| Hemibarbus longirostris | 1 | 1 (100) | 13 | - | 13 |
| Acheilognathus koreensis | 35 | 34 (97.1) | 871 | 2-287 | 26 |
| Acheilognathus rhombeus | 15 | 15 (100) | 3,006 | 64-329 | 200 |
| Acheilognathus yamatsutae | 15 | 8 (53.3) | 25 | 1-9 | 3 |
| Acheilognathus lanceolatus | 3 | 3 (100) | 327 | 4-255 | 109 |
| Zacco platypus | 30 | 19 (63.3) | 192 | 1-30 | 10 |
| Siniperca scherzi | 1 | 1 (100) | 6 | - | 6 |
| Subtotal | 139 | 120 (86.3) | 48,632 | 1-9,870 | 405 |
| 2017 Pungtungia herzi | 26 | 26 (100) | 26,736 | 22-9,950 | 1,028 |
| Squalidus japonicus coreanus | 31 | 31 (100) | 13,161 | 4-2,750 | 425 |
| Sarcocheilichthys variegatus | 3 | 3 (100) | 759 | 156-352 | 253 |
| Pseudorasbora parva | 7 | 7 (100) | 5,260 | 365-2,225 | 751 |
| Acheilognathus yamatsutae | 27 | 15 (55.6) | 45 | 1-2,030 | 7 |
| Acheilognathus koreensis | 26 | 19 (73.1) | 129 | 1-30 | 5 |
| Acanthorhodeus gracilis | 5 | 5 (100) | 26 | 2-12 | 1 |
| Acheilognathus rhombeus | 2 | 1 (50.0) | 1 | - | 16 |
| Zacco platypus | 50 | 21 (42.0) | 345 | 1-205 | 1 |
| Coreoperca herzi | 2 | 1 (50.0) | 1 | - | 5 |
| Micropterus salmoides | 2 | 1 (50.0) | 5 | - | 5 |
| Subtotal | 181 | 120 (66.3) | 46,468 | 1-8,950 |
| Total | 1,067 | 720 (67.5) | 439,439 | 1-31,250 | 610 |
Infection status of CsMc by fish species, i.e., *A. koreensis*, *A. yamatsutae*, *A. rhombes*, *A. majusculus*, *A. macropera*, *A. lanceolatus* and *A. gracilis*, is revealed in Table 6.

### Table 2. Infection status of *Clonorchis sinensis* metacercariae in susceptible gobioninid fish from Wicheon in Gunwi-gun, Gyeongsangbuk-do

| Year examined | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|---------------|----------------------|--------------------------|-------------------------------|
|               |                      |                          | Total | Range | Average |
| 2011          | 25                   | 25 (100)                 | 12,895 | 9-2,420 | 516 |
| 2013          | 35                   | 35 (100)                 | 34,022 | 26-11,200 | 972 |
| 2014          | 89                   | 89 (100)                 | 174,228 | 6-31,200 | 1,958 |
| 2015          | 71                   | 71 (100)                 | 112,342 | 24-7,750 | 1,582 |
| 2016          | 36                   | 36 (100)                 | 43,612  | 28-9,870 | 1,211 |
| 2017          | 67                   | 67 (100)                 | 45,916  | 4-8,950  | 685  |
| **Total**     | **323**              | **323 (100)**           | **423,015** | **4-31,250** | **1,310** |

### Table 3. Infection status of *Clonorchis sinensis* metacercariae by fish species in the gobioninid group-1

| Species of fish          | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|--------------------------|----------------------|--------------------------|-------------------------------|
|                          |                      |                          | Total | Range | Average |
| *Pungtungia herzi*       | 169                  | 169 (100)                | 261,986 | 6-31,250 | 1,550 |
| *Squalidus japonicus coreanus* | 74                  | 74 (100)                | 64,037  | 4-8,460  | 865  |
| *Squalidus gracilis majimae* | 43                  | 43 (100)                | 71,510  | 9-7,680  | 1,663 |
| *Sarcochilichthys variegatus* | 25                  | 25 (100)                | 15,773  | 13-2,730 | 631  |
| *Pseudorasbora parva*    | 12                   | 12 (100)                | 9,709   | 365-2,225 | 809 |
| **Total**                | **323**              | **323 (100)**           | **423,015** | **4-31,250** | **1,310** |

### Table 4. Infection status of *Clonorchis sinensis* metacercariae by fish species in the gobioninid group-2

| Species of fish          | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|--------------------------|----------------------|--------------------------|-------------------------------|
|                          |                      |                          | Total | Range | Average |
| *Pseudogobio esocinus*   | 13                   | 12 (92.3)                | 2,101  | 1-1,325 | 175  |
| *Abbottina springeri*    | 6                    | 6 (100)                  | 250    | 10-80   | 42   |
| *Hemibarbus longirostris* | 1                   | 1 (100)                  | 13     | -       | 13   |
| *Microphysogobio koreensis* | 3                   | 3 (100)                  | 191    | 12-139  | 64   |
| *Microphysogobio jeoni*  | 1                    | 1 (100)                  | 365    | -       | 365  |
| **Total**                | **24**               | **23 (95.8)**           | **2,920** | **1-1,325** | **127** |

### Table 5. Infection status of *Clonorchis sinensis* metacercariae in acheilognathinid fish from Wicheon in Gunwi-gun, Gyeongsangbuk-do

| Year examined | No. of fish examined | No. (%) of fish infected | No. of metacercariae detected |
|---------------|----------------------|--------------------------|-------------------------------|
|               |                      |                          | Total | Range | Average |
| 2011          | 9                    | 5 (55.6)                 | 101   | 1-87  | 20 |
| 2013          | 26                   | 16 (61.5)                | 81    | 1-14  | 5  |
| 2014          | 77                   | 63 (81.8)                | 2,727 | 1-290 | 43 |
| 2015          | 54                   | 42 (77.8)                | 3,897 | 1-678 | 93 |
| 2016          | 68                   | 60 (88.2)                | 4,229 | 1-329 | 70 |
| 2017          | 60                   | 40 (66.7)                | 201   | 1-30  | 5  |
| **Total**     | **296**              | **228 (77.0)**          | **11,372** | **1-678** | **50** |

### Table 6. Infection status of CsMc in rasborinid fish group

CsMc were detected in 147 (36.5%) out of 403 fish examined, and their average density was 15 per fish infected. The densities were highest in 2015 (25), followed by 2017 (16), 2013 (15), 2014 (11), 2016 (10), and 2011 (7) (Table 7). The...
infection status of CsMc by fish species, i.e., *Z. platypus*, *Z. temminckii* and *O. uncirostris amurensis*, is shown in Table 8.

**Susceptibility index of CsMc by fish groups**

The susceptibility indices of CsMc were 412 in the overall positive fish group; 1,310 in the gobioninid group-1, 122 in the gobioninid group-2, 38.5 in the acheilognathinid, and 5.5 in the rasborinid fish group (Table 9).

**DISCUSSION**

By the present study, it was reconfirmed that CsMc are highly prevalent in fish from Wicheon, Gyeongsangbuk-do, Korea. Moreover, the infection status showed a certain tendency ac-
cording to the subfamily groups of fish hosts, i.e., Gobioninae, Acheilognathinae, and Rasborinae, among the Cyprinidae. The prevalences were 100%, 79.7%, and 35.5%, and metacercarial densities were 1,310, 50, and 15 per fish infected in 3 fish groups, respectively. These findings also suggested that the endemicity of CsMc is closely related to the fish group, and this host-parasite relationship may originate from a long-lasting evolutionary process.

The fish sampling is one of the important factors in metacercarial surveys for the epidemiology of fishborne zoonotic trematode infections. Total 1,162 fish in 32 species were collected through 6 years (2011 and 2013-2017) in the same site of Woobo-myeon in Gunwi-gun. Among them, the pale chub (259 Z. platypus: 22.2%) was the most dominant fish species like Sohn et al. [18] in Seomjin-gang, followed by the striped shinner (169 P. herzi: 14.5%), dark chub and/or Korean chub (136 Z. temminckii and/or Z. koreanus: 11.7%), oily bitterling (130 A. koreensis: 11.2%), Korean striped bitterling (99 A. yamatsutae: 8.5%), and short barbell gudgeon (74 S. japonicus coreanus: 6.4%). The number of fish examined was 867 (74.4%) in major 6 species and 298 (25.6%) in the remaining 26 species. The disproportion of the fish number examined was dependent upon the ecological conditions of each fish species, and moreover, we collected all fish only by the casting net in the daytime. If we used together with other methods for fish catching like a netting, we could have collected more various species of fish, including nocturnal ones.

Total 49 fish species (in 34 genera 7 families) have been reported as the second intermediate hosts of C. sinensis in Korea [9-18]. In the present study, CsMc were found in 26 fish species, i.e., Abbottina springeri, Acanthorhodeus macropterus, A. gracilis, Acheilognathus koreensis, A. lanceolatus, A. majuscules, A. rhombetus, A. yamatsutae, Carassius auratus, Coreoperca herzi, Hemibarbus longirostris, Micropterus salmoides, Microphysogobio koreensis, M. jeoni, Misgurnus anguillicaudatus, Opsarichthys uncirostris, Pseudogobio esocinus, Punngungta herzi, Pseudorasbora parva, Rhynchocypris oxycephalus, Sarcoccihelichthys variegates wakiyae, Simiperca scherzeri, Squalidus gracilis majimae, S. japonicus coreanus, Zacco platypus, and Z. temminckii. Among them, 2 fish species, i.e., M. salmoides (Centrachidae) and M. anguillicaudatus (Cobitidae), are newly added in the list of the second intermediate hosts of C. sinensis in Korea [9-18]. Accordingly, total 51 fish species in 9 families are listed as the second intermediate hosts of C. sinensis in Korea.

The large mouth bass, Micropterus salmoides, was imported from USA as an edible fish species in 1973. However, this fish is widely spread in the water systems of the whole country, and then became notorious as an agitating fish species of the ecosystem in Korea [20]. In this study, we examined total 10 M. salmoides and detected 1 and 5 CsMc from 2 fish. Although the number of fish examined and metacercariae detected were not so many, the fact, infection with CsMc in foreign fish species, is highly important. Thus, we should pay attention to the fish species from foreign countries in the metacercarial survey for the fishborne zoonotic trematodes.

Fish species, i.e., Mandarin fish (S. scherzeri), Korean aucha perch (C. herzi), common carp (Cyprinus carpio), and crucian carp (C. auratus), edible in raw conditions practically act as the infection source of clonorchiasis in Korea. Fortunately, these fish species are less prevalent with CsMc. Total 3 (8.8%) out of 34 C. auratus were infected with total 3 CsMc, 2 (11.1%) C. herzi was infected with a total of 4 CsMc, and only 1 (33.3%) S. scherzeri was infected with 6 CsMc, respectively, even in such a highly endemic area, Wicheon. In a survey of the fish from Seomjin-gang, no CsMc was detected in 4 fish species, i.e., C. herzi (57), C. auratus (42), S. scherzeri (11), and C. carpio (2), edible in raw conditions [18].

The striped shinner, P. herzi, is appropriate to be an index fish species to check the endemicity of C. sinensis infection. This fish species broadly lives in the water systems of rivers in Korea and is highly susceptible to CsMc. In the present study, all of 169 P. herzi examined were infected with an average of 1,550 CsMc per fish. The prevalences of CsMc in this fish species were 80.4%, 72.5%, and 30.6%, and metacercarial densities were 15.2, 46.1, and 175.9 per fish infected in the upper, middle, and lower reaches of Seomjin-gang, respectively [18]. The positive rates of CsMc were 6.2%, 31.8%, and 92.9%, and densities were 2.8, 214, and 409 per fish infected in P. herzi from the northern, middle, and southern regions of the Korean peninsula, respectively [14]. Especially, in this fish species from the streams of Nakdong-gang, i.e., Wicheon in Gunwi-gun, Banbyuncheon in Yeongyang-gun, Gyeongsangbuk-do, and Yangcheon in Sancheong-gun, Gyeongsangnam-do, the endemicities of CsMc were much higher like in this study [14].

Conclusively, it has been confirmed that the endemicity of CsMc is much higher in fish from Wicheon, and a strong tendency was shown in the prevalence and intensity of CsMc according to the subfamily groups of fish, i.e., Gobioninae, Acheilognathinae, and Rasborinae, in the family Cyprinidae fish hosts. Among the highly susceptible gobioninid fish, P.
is recommended as a useful index fish to check the endemicity of clonorchiasis in a certain area of Korea.

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CONFLICT OF INTEREST

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

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