High Endemicity with *Clonorchis sinensis* Metacercariae in Fish from Yongjeon-cheon (Stream) in Cheongsong-gun, Gyeongsangbuk-do, Korea

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**Abstract:** The infection status with *Clonorchis sinensis* metacercariae (CsMc) was examined in freshwater fishes from Yongjeon-cheon (a branch of Nakdong-gang) located in Cheongsong-gun, Gyeongsangbuk-do, the Republic of Korea (Korea). A total of 750 fishes in 19 species were examined by the artificial digestion method for 2 years (2019 and 2020). CsMc were detected in 378 (51.4%) out of 735 fishes in 14 species (73.7%), and the infection intensity was 666 per fish infected. In 2019, CsMc were found in 172 (68.0%) out of 253 fishes in 10 species, and the infection intensity was 565 per fish infected. In 2020, CsMc were detected in 206 (62.2%) out of 331 fishes in 10 species, and the infection intensity was 751 per fish infected. The other zoonotic trematode, *Metagonimus* spp., *Centrocestus armatus*, *Echinostoma* spp. and *Clinostomum complanatum*, metacercariae were also detected in fishes from the survey streams, but their endemicities were relatively low. Conclusively, it was first confirmed that CsMc are highly endemic in fishes from Yongjeon-cheon in Cheongsong-gun, Gyeongsangbuk-do, Korea.

**Key words:** *Clonorchis sinensis*, Zoonotic trematode metacercaria, Cyprinidae fish host, Yongjeon-cheon, Cheongsong-gun, Korea

Nowadays, clonorchiasis, *Clonorchis sinensis* (Digenea: Opisthorchiidae) infection, is most important as an endemic parasitic disease in the Republic of Korea (Korea) [1]. The prevalence of clonorchiasis has maintained at relatively high levels in the residents of riverside areas in Korea. A team of Korea DCPA (Division of Vectors and Parasitic Diseases, Korea Disease Control and Prevention Agency) has performed the control programs to decrease the prevalence of clonorchiasis in the residents of major river basins in Korea [2-6]. On the other hand, co-working groups of Korea DCPA have epidemiologically surveyed the freshwater fishes, the infection sources, to estimate the endemicities of clonorchiasis [6-11]. Especially, Cho et al. [6] investigated the infection status of CsMc in freshwater fish from various regions of Korean peninsula. Sohn et al. [8] and Yoon et al. [9] investigated the infection status of CsMc in freshwater fishes from the water systems of Seomjin-gang and Tamjin-gang. Recently, Sohn et al. [10,11] also surveyed the infection status of CsMc in freshwater fish from 2 highly endemic areas, Wi-cheon (cheon means stream) and Yang-cheon (branch streams of Nakdong-gang), in Gunwi-gun (gun = county), Gyeongsangbuk-do and Sancheong-gun, Gyeongsangnam-do, Korea.

Yongjeon-cheon is one of the branch stream of Nakdong-gang, which rise from a mountinous area (Guam-san) (san means mountain) of Gunam-myeon (myeon = township), flows via Ju-wangsan-myeon and Cheongsong-eup (eup = town) unites with Banyeon-cheon in Pacheon-myeon, Cheongsong-gun, Gyeongsangbuk-do. This stream flows only in Cheongsong-gun areas as the most big stream in Cheongsong-gun [12]. A riverside area of Yongjeon-cheon was reported as a high endemic area of echinostomiasis [13]. However, the infection status with zoonotic trematode metacercariae (ZTM) including CsMc in fish from this area has not been widely and systematically examined yet. Therefore, we intended to investigate the infection status with CsMc in fishes from Yongjeon-cheon for 2 years, 2019 and 2020.

We collected a total of 750 freshwater fishes in 19 species in 2 sites, midstream (Cheongwoon-ri in Cheongsong-eup: 36.
In the midstream, a total of 382 freshwater fish in 12 species were examined, and the fish species (No. of fish) examined were as follows: Pungtungia herzi (132), Zacco platypus (77), Zacco koreanus (54), Coreoperca herzi (40), Acheilognathus koreensis (34), Odontobutis platycephala (22), Carassius auratus (11), Coreoleuciscus splendidus (6), Opsariichthys uncirostris (2), Siniperca scherzeri (2), Squalidus gracilis majimae (1), Pseudogobio esocinus (1). Total 368 freshwater fish in 18 species from downstream were examined, and the fish species (No. of fish) examined were as follows: P. herzi (102), A. koreensis (60), Z. koreanus (44), Z. platypus (40), Acanthorhodeus macropterus (33), C. herzi (26), Acheilognathus lanceolatus (20), O. platycephala (19), C. auratus (6), Micropterus salmoides (6), P. esocinus (4), O. uncirostris (1), S. gracilis majimae (2), Acheilognathus majusculus (1), Hemibarbus longirostris (1), Hemibarbus labeo (1), Acheilognathus rhombeus (1), S. scherzeri (1).

All collected fishes were transferred to the laboratory of the Department of Parasitology and Tropical Medicine, Gyeongsang National University College of Medicine, Jinju, Korea. After the identification of fish species [14], they were individually examined by the artificial digestion method [15,16]. Collected CsMc were counted to get hold of prevalences (No. of fish with CsMc/No. of fish examined × 100) and infection intensities (No. of CsMc/a fish infected) by fish species.

The metacercariae of C. sinensis (CsMc) were detected in 378 (51.4%) out of 735 fishes in 14 species (73.7%), and the infection intensity was 666 per fish infected. The infection status by the fish species and fish group (subfamilies in Cyprinidae) was shown in Table 1. In 2019, CsMc were detected in 172 (68.0%) out of 253 fishes in 10 species, and the infection intensity was 565 per fish infected. The infection status by the fish species and survey site was detailedly revealed in Table 2. In 2020, CsMc were detected in 206 (62.2%) out of 331 fishes in 10 species, and the infection intensity was 751 per fish infected. The infection status by the fish species and survey site was designated in Table 3 in detail.

Metagonimus spp. metacercariae were found in 304 (42.9%) out of 708 fishes in 11 species (57.9%), and the infection intensity was 14.6 per fish infected. The metacercariae of Centrocestus armatus were detected in 167 (38.7%) out of 431 fishes in 7 species (36.8%), and the infection intensity was 615 per fish infected. Echinostoma spp. metacercariae were found in 310 (42.3%) out of 733 fishes in 13 species (68.4%), and the infection intensity was 29.6 per fish infected.

| Species of fish          | No. of fish examined | No. (%) of fish infected | No. of CsMc detected | Range   | Average |
|--------------------------|----------------------|--------------------------|----------------------|---------|---------|
| Pungtungia herzi         | 234                  | 226 (96.6)               | 1-21,510             | 1,098   |
| Squalidus gracilis majimae | 3                   | 2 (66.7)                 | 31-1,340             | 686     |
| Subtotal                 | 237                  | 228 (96.2)               | 1-21,510             | 1,094   |
| Acheilognathus koreensis | 94                   | 70 (74.5)                | 1-154                | 11.1    |
| Acanthorhodeus macropterus | 33               | 18 (54.5)                | 1-52                 | 6.0     |
| Acheilognathus lanceolatus | 20              | 7 (35.0)                 | 1-357                | 125     |
| Acheilognathus majusculus | 1                  | 1 (100)                  | -                    | 176     |
| Subtotal                 | 148                  | 96 (64.9)                | 1-357                | 20.1    |
| Zacco platypus           | 117                  | 38 (32.5)                | 1-109                | 11.8    |
| Zacco koreanus           | 98                   | 1 (1.0)                  | -                    | 1.0     |
| Opsariichthys uncirostris | 3                   | 3 (100)                  | 1-21                 | 10.0    |
| Subtotal                 | 218                  | 42 (19.3)                | 1-109                | 11.4    |
| Coreoperca herzi         | 66                   | 2 (3.0)                  | -                    | 1.0     |
| Odontobutis platycephala | 41                  | 2 (4.9)                  | 1-3                  | 2.0     |
| Carassius auratus        | 17                   | 1 (5.9)                  | -                    | 1.0     |
| Pseudogobio esocinus     | 5                    | 5 (100)                  | 1-18                 | 10.4    |
| Siniperca scherzeri      | 3                    | 2 (66.7)                 | 1-3                  | 2.0     |
| Subtotal                 | 132                  | 12 (9.1)                 | 1-18                 | 5.3     |
| Total                    | 735                  | 378 (51.4)               | 1-21,510             | 666     |
of *Clinostomum complanatum* were detected in 85 (15.1%) out of 564 fishes in 6 species (31.6%), and the infection intensity was 3.2 per fish infected (Table 4).

By the present study, it was confirmed for the first time that CsMc are highly endemic in fishes from Yongjeon-cheon, in Cheongsong-gun, Gyeongsangbuk-do, Korea. The infection

### Table 2. Infection status of Clonorchis sinensis metacercariae in fishes from Yongjeon-cheon in Cheongsong-gun, Gyeongsangbuk-do (2019)

| Locality and fish sp. examined | No. of fish examined | No. (%) of fish infected | No. of CsMc detected | Range | Average |
|-------------------------------|----------------------|--------------------------|----------------------|-------|---------|
| Midstream                     |                      |                          |                      |       |         |
| Pungtungia herzi               | 62                   | 55 (88.7)                | 1-11,580             | 787   |         |
| Zacco platypus                | 42                   | 19 (45.2)                | 1-109                | 14.6  |         |
| Coreoperca herzi              | 24                   | 2 (8.3)                  | -                    | 1.0   |         |
| Carassius auratus             | 9                    | 1 (11.1)                 | -                    | 1.0   |         |
| Acheilognathus koreensis     | 8                    | 3 (37.5)                 | 1-13                 | 5.0   |         |
| Opsarriichthys uncirostris   | 2                    | 2 (100)                  | 8-21                 | 14.5  |         |
| Subtotal                      | 147                  | 82 (55.8)                | 1-11,580             | 532   |         |
| Downstream                    |                      |                          |                      |       |         |
| Pungtungia herzi              | 39                   | 39 (100)                 | 14-6,950             | 1,301 |         |
| Acheilognathus koreensis     | 20                   | 19 (95.0)                | 1-154                | 13.1  |         |
| Acanthorhodeus macropterus   | 20                   | 11 (55.0)                | 1-11                 | 2.6   |         |
| Zacco platypus               | 19                   | 13 (68.4)                | 1-86                 | 12.3  |         |
| Acheilognathus lanceolatus   | 5                    | 5 (100)                  | 13-357               | 174   |         |
| Squalidus gracilis majimae   | 1                    | 1 (100)                  | -                    | 1,340 |         |
| Acheilognathus majusculus    | 1                    | 1 (100)                  | -                    | 176   |         |
| Opsarriichthys uncirostris   | 1                    | 1 (100)                  | -                    | 1.0   |         |
| Subtotal                      | 106                  | 90 (84.9)                | 1-6,950              | 595   |         |
| Total                         | 253                  | 172 (68.0)               | 1-11,580             | 565   |         |

### Table 3. Infection status of Clonorchis sinensis metacercariae in fishes from Yongjeon-cheon in Cheongsong-gun, Gyeongsangbuk-do (2020)

| Locality and fish sp. examined | No. of fish examined | No. (%) of fish infected | No. of CsMc detected | Range | Average |
|-------------------------------|----------------------|--------------------------|----------------------|-------|---------|
| Midstream                     |                      |                          |                      |       |         |
| Pungtungia herzi               | 70                   | 70 (100)                 | 3-21,510             | 1,759 |         |
| Zacco platypus                | 35                   | 4 (11.4)                 | 1-8                  | 2.8   |         |
| Acheilognathus koreensis     | 26                   | 12 (46.2)                | 1-103                | 23.6  |         |
| Zacco koreanus               | 26                   | 1 (3.9)                  | -                    | 1.0   |         |
| Siniperca scherzi             | 2                    | 1 (50.0)                 | -                    | 1.0   |         |
| Pseudogobio esocinus          | 1                    | 1 (100)                  | -                    | 5.0   |         |
| Subtotal                      | 160                  | 89 (55.6)                | 1-21,510             | 1,387 |         |
| Downstream                    |                      |                          |                      |       |         |
| Pungtungia herzi              | 63                   | 62 (98.4)                | 2-5,250              | 498   |         |
| Acheilognathus koreensis     | 40                   | 36 (90.0)                | 1-26                 | 6.3   |         |
| Zacco platypus               | 21                   | 2 (9.5)                  | -                    | 1.0   |         |
| Acheilognathus lanceolatus   | 15                   | 2 (13.3)                 | -                    | 1.0   |         |
| Odontobutis platycephala     | 13                   | 2 (15.4)                 | 1-3                  | 2.0   |         |
| Acanthorhodeus macropterus   | 13                   | 7 (53.9)                 | 1-52                 | 11.3  |         |
| Pseudogobio esocinus          | 4                    | 4 (100)                  | 5-18                 | 11.8  |         |
| Squalidus gracilis majimae   | 1                    | 1 (100)                  | -                    | 31.0  |         |
| Siniperca scherzi             | 1                    | 1 (100)                  | -                    | 3.0   |         |
| Subtotal                      | 171                  | 117 (68.4)               | 1-5,250              | 267   |         |
| Total                         | 331                  | 206 (62.2)               | 1-21,510             | 751   |         |
status was revealed with a certain tendency by the subfamily
groups, i.e., Gobioninae, Acheilognathinae and Rasboriniae, in
the cyprinid fish (family Cyprinidae) hosts of C. sinensis like in
Sohn et al. [10,11]. The prevalences of CsMc were 96.2%,
64.9% and 19.3%, and infection intensities with CsMc were
1,094, 20 and 11 per fish infected in 3 fish groups respectively.
In this study, prevalences and infection intensities are some-
what lower than those in fish from Wi-cheon [10], but much
higher than those in fish from Yang-cheon [11]. And then, we
can also know that the endemicity of CsMc is closely related
with the subfamily groups, i.e., Gobioninae, Acheilognathinae
and Rasboriniae, in the cyprinid fish hosts from a highly en-
demic area, Yongjeon-cheon, in Cheongsong-gun, Gyeong-
sangbuk-do, Korea.

The ecological conditions for fish was not so good in Yongjeon-
cheon. Total 750 freshwater fishes in 19 species were examined in 2
survey sites of Yongjeon-cheon in this study. Among them, striped shinner (P. herzi: 31.2%), was the most dominant fish
species like in Tamjin-gang [9] and Wi-cheon [10] and in Yang-
cheon [11], and followed by pale chub (C. herzi: 13.5%),
Korean aucha perch (C. auratus: 8.8%), Korean dark
sleeper (O. platycephala: 5.5%), deep body bitterling (A. mac-
ropterus: 4.4%), slender bitterling (A. lanceolatus: 2.7%) and
crusian carp (C. carpio: 2.3%). The number of fish examined
was 720 (96.0%) in major 9 species and 30 (4.0%) in remain
10 species. The disproportion of fish number and a small num-
ber of fish species examined is suggested that the ecological
condition for fish was relatively not so good.

Edible fish species in raw, i.e., Korean aucha perch (C. herzi),
Korean dark sleeper (O. platycephala), crusian carp (C. auratus)
and Mandarin fish (S. scherzeri), practically act as the infection
sources of clonorchiasis in Korea. Fortunately, these fish spe-
cies are less prevalent with CsMc like in such a highly endemic
area, Wicheon [10]. In this study, 2 (3.0%) out of 66 C. herzi
were infected with 2 CsMc, 2 (4.9%) of 41 O. platycephala were
infected with total 4 CsMc, only 1 (5.9%) out of 17 C. auratus
were retained with 1 CsMc and 2 (66.7%) S. scherzeri were in-
fected with a total of 4 CsMc. CsMc were not detected at all in 4
fish species, i.e., C. herzi (n = 57), C. auratus (42), S. scherzeri
(11) and C. carpio (2), from the water systems of Seomjin-gang
[8]. Only one CsMc were found in only 1 (1.1%) out of 93 C. herzi and no CsMc were detected from 73 C. auratus, 36 O. pla-
tycephala and 1 S. scherzeri from Yang-cheon in Sancheong-
gun, Gyeongsangnam-do, Korea [11].

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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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