More than 50 million people are currently estimated to be infected with intestinal trematodes, including at least 18 million people infected by fishborne trematodes (FBT) around the world. Heterophyid (Heterophyidae) and echinostomatid flukes (Echinostomatidae) are regarded as the most important groups found in the intestinal tract of humans [1,2]. With regard to heterophyids, 10 species in 7 genera, i.e., Metagonimus yokogawai, Meta-gonomimus takahashii, Metagonimus miyatai, Heterophyes nocens, Heterophyopsis continua, Stellantchasmus falcatus, Pygidiopsis summa, Centrocestus armatus, Stictodora lari, and Stictodora spp. have been reported as human-infecting species in the Republic of Korea [2]. Among them, 6 species, namely, H. nocens, H. continua, P. summa, S. falcatus, S. fuscata, and S. lari, are infected by consumption of raw flesh of estuarine fish [1,2]. Among these fish hosts, yellowfin goby, Acanthogobius flavimanus, are sometimes heavily infected with the metacercariae of heterophyid flukes, and are popularly eaten raw by many residents in coastal areas of Korea [3-7]. However, echinostomatid metacercariae have never been reported from yellowfin gobies in the Republic of Korea.

Therefore, we performed an epidemiological survey to know the infection status of FBT metacercariae in yellowfin gobies collected in Shinan-gun and Muan-gun (Jeollanam-do), Korea.

**Echinostoma hortense** and Heterophyid Metacercariae Encysted in Yellowfin Goby, *Acanthogobius flavimanus*, from Shinan-gun and Muan-gun (Jeollanam-do), Korea

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**Abstract:** Fishborne trematode (FBT) metacercariae were investigated in yellowfin goby, *Acanthogobius flavimanus*, collected from Shinan-gun and Muan-gun, Jeollanam-do (province), Korea. All collected fishes were examined using the artificial digestion method. In all of 15 gobies from Aphae-myeon in Shinan-gun, metacercariae of *Stictodora* spp. (334 metacercariae/fish), *Heterophyes nocens* (153/fish), and *Heterophyopsis continua* (20/fish) were detected. In 2 of 14 gobies from Jido-myeon in Shinan-gun, 8 *Echinostoma hortense* metacercariae in total were detected. In 15 gobies from Haeje-myeon in Muan-gun, the metacercariae of *H. continua* were found in 100%, *Stictodora* spp. in 86.7%, and *H. nocens* in 6.7% of fish examined. The average numbers of metacercariae per infected fish were 23.3 (*H. continua*), 416.0 (*Stictodora* spp.), and 2.0 (*H. nocens*), respectively. The metacercariae of *E. hortense* found in gobies were elliptical, with 150 × 138 μm in average size, and had 27 collar spines on the head crown. The above results suggest that yellowfin gobies from 2 localities may be the potential infection sources of FBT. Moreover, it is proved for the first time that the yellowfin goby, *A. flavimanus*, acts as a second intermediate host for *E. hortense*.

**Key words:** Echinostoma hortense, heterophyids, fishborne trematode metacercariae, yellowfin goby, Shinan-gun, Muan-gun

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from Jido-myeon in Shinan-gun, 8 E. hortense metacercariae were detected; however, no other kinds of metacercariae were found in 14 gobies from Jido-myeon. In 15 gobies from Haeje-myeon in Muan-gun, the metacercariae of H. continua were found in 100%, Stictodora spp. in 86.7%, and H. nocens in 6.7% of gobies examined. The average numbers of metacercariae per infected fish were 23.3 (H. continua), 416 (Stictodora spp.), and 2.0 (H. nocens), respectively (Table 2).

The metacercariae of E. hortense found in gobies were elliptical, 140-163 × 130-143 µm (mean 150 × 138 µm) in size, and had 27 collar spines on the head crown, and excretory granules were arranged posteriorly in V-shape from the pharynx level (Fig. 1). Adults of E. hortense recovered from an experimental rat at 2 week after infection were 8.20-9.05 × 1.35-1.63 mm (mean 8.72 × 1.51 mm) in size, had 27 collar spines, and the other morphological characteristics, for example, the right-side deviated round ovary, lobular testes, diffusely distributed vitellaria, and intrauterine eggs, were compatible with previous studies. One adult specimen (Semichon’s acetocarmine stained) of E. hortense is deposited in Invertebrate Research Division, National Institute of Biological Resources, Korea (NIBRIV0000128379).

It has been proved for the first time in this study that the yellowfin goby, A. flavimanus, acts as a second intermediate host for E. hortense. As the second intermediate hosts of this fluke, several species of freshwater fish, i.e. muddy loach (Misgurnus anguillicaudatus), Chinese muddy loach (Misgurnus mizolepis), dark sleeper (Odontobutis interrupta), Chinese minnow (Rhynchoeypris oxycephalus), Japanese aucha perch (Coreoperca kawamebari), short barbel gudgeon (Squalidus japonicus coreanus), and some species of amphibians, frogs (Rana nigromaculata, Rana rugosa, Rana catesbiana), salamanders (Hynobius naevius, Hynobius nebulosus), and toad (Bufo vulgaris japonicus) have been reported in Japan, Korea, and China [8-15].

Human infections with E. hortense have been reported in Japan, Korea, and China [16-18]. Especially in the Republic of Korea, a 22.4% (59/263) egg-positive rate was reported in a survey of residents in Cheongsong-gun, Gyeongsangbuk-do [13], and recently, clinical cases have been diagnosed occasionally by the gastroduodenal endoscopy [19-23].

Table 1. The yellowfin goby, Acanthogobius flavimanus, collected in Shinan-gun and Muan-gun (Jeollanam-do), Korea

<table>
<thead>
<tr>
<th>Locality of fish collected</th>
<th>No. examined</th>
<th>Length (cm) Range</th>
<th>Average</th>
<th>Weight (g) Range</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphae-myeon, Shinan-gun</td>
<td>15</td>
<td>15.0-18.5</td>
<td>16.5</td>
<td>23.7-50.9</td>
<td>34.0</td>
</tr>
<tr>
<td>Jido-myeon, Shinan-gun</td>
<td>14</td>
<td>17.5-27.0</td>
<td>21.6</td>
<td>36.5-124.2</td>
<td>75.0</td>
</tr>
<tr>
<td>Haeje-myeon, Muan-gun</td>
<td>15</td>
<td>14.2-22.7</td>
<td>19.1</td>
<td>22.9-78.4</td>
<td>52.1</td>
</tr>
</tbody>
</table>

Table 2. Infection status of heterophyid metacercariae in gobies from Aphae-myeon, Shinan-gun and Haeje-myeon, Muan-gun (Jeollanam-do), Korea

<table>
<thead>
<tr>
<th>Locality of fish &amp; trematode species</th>
<th>No. (%) infected</th>
<th>No. of metacercariae detected Total</th>
<th>Range</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphae-myeon, Shinan-gun</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stictodora spp.</td>
<td>15 (100)</td>
<td>5,012</td>
<td>12-982</td>
<td>334.1</td>
</tr>
<tr>
<td>Heterophyes nocens</td>
<td>15 (100)</td>
<td>2,298</td>
<td>12-282</td>
<td>153.2</td>
</tr>
<tr>
<td>Heterophyopsis continua</td>
<td>15 (100)</td>
<td>299</td>
<td>3-75</td>
<td>19.9</td>
</tr>
<tr>
<td>Pygidiopsis summa</td>
<td>1 (6.7)</td>
<td>11</td>
<td>-</td>
<td>11.0</td>
</tr>
<tr>
<td>Haeje-myeon, Muan-gun</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heterophyopsis continua</td>
<td>15 (100)</td>
<td>350</td>
<td>1-102</td>
<td>23.3</td>
</tr>
<tr>
<td>Stictodora spp.</td>
<td>13 (86.7)</td>
<td>5,407</td>
<td>9-3,226</td>
<td>415.9</td>
</tr>
<tr>
<td>Heterophyes nocens</td>
<td>1 (6.7)</td>
<td>2</td>
<td>-</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Fig. 1. The metacercariae of Echinostoma hortense detected in an yellowfin goby, Acanthogobius flavimanus, from Jido-myeon, Shinan-gun (Jeollanam-do), Korea. They are elliptical with 150 × 138 µm average size, and had an oral sucker (OS) and 27 collar spines (arrow marks) in the head crown, and excretory granules (EG) located posteriorly in V-shape from the pharynx level. Scale bar = 50 µm.
Endemic foci of heterophyid flukes are scattered around the southwestern coastal areas and islands, especially in Shinan-gun and Muan-gun (Jeollanam-do), Korea. Some species of estuarine fish, including *Lateolabrax japonicus*, *Clupanodon punctatus*, *Mugil cephalus*, and *Acanthogobius flavimanus*, have been reported as sources of human infection in these endemic areas [2]. Among these fish hosts, *Acanthogobius flavimanus* is sometimes heavily infected with heterophyid metacercariae, and are popularly eaten raw by many residents in southwestern coastal areas [3-7].

Several species of heterophyid fluke metacercariae, i.e. *H. nocens*, *H. continua*, *P. summa*, *S. fuscata*, *S. lari*, and *Acanthotrema felis*, were found in the yellowfin gobies in the Republic of Korea [3-7,24]. In the present study, metacercariae of *H. nocens*, *H. continua*, *Stictodora spp.*, and *P. summa* were detected, and especially, high infection rates and intensities were revealed in gobies from Aphae-myeon in Shinan-gun. Metacercariae of *H. continua*, *Stictodora spp.*, and *H. nocens* were detected in 15 gobies from Haeje-myeon in Muan-gun. However, except for *E. hortense*, no other metacercariae were found in 14 gobies from Jido-myeon in Shinan-gun. These findings together suggest that those who consume raw yellowfin gobies, *Acanthogobius flavimanus*, from Shinan-gun and Muan-gun are at a high risk of infection with heterophyid flukes and *E. hortense*.

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