INTESTINAL TREMATODES INFECTING HUMANS IN KOREA

Jong-Yil Chai and Soon-Hyung Lee

Department of Parasitology and Institute of Endemic Diseases, Seoul National University
College of Medicine, Seoul 110-460, Korea.

Abstract. Sixteen species of intestinal trematodes have been recovered from humans in Korea. They include 10 species of the family Heterophyidae (Metagonimus yokogawai, M. takahashii, Heterophyes nocens, H. heterophyes, H. dispar, Heterophyopsis continua, Pygidiopsis summa, Stellantchasmus falcatus, Centrocestus armatus, and Stictodora fuscatum); one species of Diplostomidae (Fibricola seoulensis); three species of Echinostomatidae (Echinostoma hortense, E. cinetorchis, and Echinocystis japonicus); one species of Plagiorchiidae (Plagiorchis sp.), and one species of Gymnophallidae (Gymnophalloides sp.). Biological and epidemiological studies have shown that all of these species are endemic to Korea except H. heterophyes and H. dispar, which were imported from the Middle East, and Plagiorchis sp., which has not been found in Korea. Several fresh water fish were found carrying metacercarial stages of M. yokogawai, M. takahashii, C. armatus, E. hortense, E. cinetorchis and E. japonicus. Brackish water fish were found to be the second intermediate host of H. nocens, H. continua, P. summa, S. falcatus, and/or S. fuscatum. Terrestrial snakes were the second intermediate (or paratenic) host of F. seoulensis. Among these intestinal flukes, M. yokogawai is the most common one in Korea.

INTRODUCTION

Among the trematodes infecting the human host, the liver fluke (Clonorchis sinensis) and the lung fluke (Paragonimus westermani), transmitted by crabs or crayfish, are important parasites because of their relatively high prevalence and wide geographical distribution in Korea. Recently, however, trematodes infecting the intestinal tract of animals and man (intestinal flukes) have become important, because they cause food-borne parasitic zoonoses. There are 16 species that belong to five families (Table 1). This paper reviews the biological and epidemiological aspects of intestinal trematodes affecting humans in Korea.

FAMILY HETEROPHYIDAE

Metagonimus yokogawai (Katsurada, 1912) Katsurada, 1912

This is the most common species of intestinal trematode reported in Korea. The presence of human infection with this fluke was suggested earlier in Korea by the recovery of eggs from fecal examinations, but the identification of adult worms was not made until 1971 (Seo et al., 1971). Streams in eastern and southern coastal areas, where sweetfish (Plecoglossus altivelis) are found, are known to be the endemic foci of metagonimiasis. The overall egg positive rate of riverside people was estimated at 4.8% (Seo et al., 1981c). The Sumjin, Tamjin, and Boseong Rivers, and Geoje Island are highly endemic areas where the villagers have 10-20% egg positive rates (Chai et al., 1977; Seo et al., 1981c).

Morphologically, this species is distinguished from M. takahashii by the location and arrangement of two testes and size of the eggs (Saito, 1984). Fresh water snails, Semisulcospira coreana and S. libertina, are the first intermediate host of M. yokogawai. Second intermediate hosts include the sweetfish, the dace (Tribolodon taczanowskii) (Choi et al., 1966), and the perch (Lateolabrax japonicus) (Ahn, 1983). Dogs, rats, and cats are reported natural final hosts, but their significance as a source of human infection has not been clarified.

The intestinal histopathology was studied in rats, cats or dogs (Chai, 1979; Kang et al., 1983), with the pathology characterized by villous atrophy and crypt hyperplasia, and with variable degrees of inflammatory cell infiltrations. Experi-
Table 1
Intestinal flukes infecting humans in Korea

<table>
<thead>
<tr>
<th>Family species</th>
<th>Second IH</th>
<th>Egg size (μm)</th>
<th>Adult size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heterophyidae</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Metagonimus yokogawai</em></td>
<td>fresh water fish</td>
<td>28–30 x 16–17</td>
<td>1.0–2.0 x 0.4–0.6</td>
</tr>
<tr>
<td></td>
<td>(sweet fish)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>M. takahashii</em></td>
<td>fresh water fish</td>
<td>32–36 x 18–23</td>
<td>0.8–1.5 x 0.4–0.7</td>
</tr>
<tr>
<td></td>
<td>(carps)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Heterophyes nocens</em></td>
<td>brackish water fish</td>
<td>25–28 x 14–16</td>
<td>0.9–1.6 x 0.5–0.8</td>
</tr>
<tr>
<td></td>
<td>(mullets, gobies)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>H. heterophyes</em></td>
<td>brackish water fish</td>
<td>28–30 x 15–17</td>
<td>1.0–1.7 x 0.3–0.4</td>
</tr>
<tr>
<td></td>
<td>(mullets)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>H. dispar</em></td>
<td>brackish water fish</td>
<td>19–25 x 13–15</td>
<td>1.0–1.7 x 0.5–0.6</td>
</tr>
<tr>
<td></td>
<td>(mullets)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Diplostomidae</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Fibricola seoulensis</em></td>
<td>tadpoles and frogs</td>
<td>81–102 x 51–63</td>
<td>0.8–1.2 x 0.4–0.5</td>
</tr>
<tr>
<td></td>
<td>terrestrial snakes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Echinostomatidae</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Echinostoma hortense</em></td>
<td>fresh water fish</td>
<td>105–128 x 43–68</td>
<td>8.2–14.0 x 0.9–1.6</td>
</tr>
<tr>
<td></td>
<td>(loaches, carps)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>E. cinetorchis</em></td>
<td>fresh water fish</td>
<td>95–105 x 60–68</td>
<td>8.6–15.0 x 2.0–2.4</td>
</tr>
<tr>
<td></td>
<td>(loaches, large snails)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Echinochasmus japonicus</em></td>
<td>fresh water fish</td>
<td>85 x 56</td>
<td>0.5–1.0 x 0.3</td>
</tr>
<tr>
<td></td>
<td>(carps)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Plagiorchiidae</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><em>Plagiorchis sp.</em></td>
<td>fresh water fish</td>
<td>32–38 x 20–24</td>
<td>2.9–3.0 x 0.8–1.0</td>
</tr>
<tr>
<td></td>
<td>(?)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gymnophallidae</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><em>Gymnophalloides sp.</em></td>
<td>marine bivalves</td>
<td>20–25 x 12–14</td>
<td>0.4–0.5 x 0.2–0.3</td>
</tr>
<tr>
<td></td>
<td>(oyster)</td>
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</table>

* Cases were imported from Africa and Middle East.

Mental immunosuppression of the host can prolong the survival time of the parasite in the host intestine (Chai et al., 1984b).

The most frequent complaints from humans were abdominal pain, diarrhea and lethargy (Cho et al., 1984). The diagnosis is usually based on recovery of eggs in feces; however, eggs may be absent in light infections with less than 100 worms. The ELISA serological test may be helpful for such cases (Chai et al., 1989). The
drug of choice is praziquantel, a single oral dose of 10–20 mg/kg, which gave an efficacy of 95–100% (Rim et al, 1978). Bithionol and niclosamide are also of therapeutic value.

Metagonimus takahashii Suzuki, 1930

This species differs from M. yokogawai in the position of the anterior testis (more separation from posterior one), distribution of vitelline follicles (more posterior and more abundant), and larger size of eggs (32–36 μm) (Saito, 1984). However, because of the presence of an intermediate type, Metagonimus Miyata type (Saito, 1984), the validity of this needs further clarification. M. takahashii has been reported from Japan and Korea.

The presence of this species in Korea was first reported by Chun (1960a) who recovered adult worms from experimentally infected rabbits fed metacercariae obtained from crucian carps. Human infections were reported in 1985 and 1988 (Ahn and Ryang, 1988), however, they were not based on a detailed morphological diagnosis of worms.

Unlike M. yokogawai, M. takahashii (and/or Metagonimus Miyata type) is distributed along small streams in inland areas of Korea. The snail host is S. coreana or Koreanomelanis nodifila (Cho et al, 1984), and the fish host is Carassius carrasius (Chun, 1960a), Cyprinus carpio, Pseudorasbora parva, or Zacco platypus (for Miyata type). There have been few reports on reservoir hosts.

Heterophyes nocens Onji and Nishio, 1916

This species is morphologically close to H. heterophyes, which is prevalent in Egypt and the Middle East, but it differs by the morphology of genital sucker, especially the number of rodlets on the gonotyl: 50–62 in H. nocens and 70–85 in H. heterophyes. This species has been reported from Korea and Japan.

In Korea, the metacercariae were first found in 1978–1979 (Seo et al, 1980b) from mullets (Mugil cephalus) captured in three southern coastal areas. Before 1990, human infections with this fluke were verified in 13 persons from scattered areas (Seo et al, 1981a; Chai et al, 1984a, 1985b; Sohn et al, 1989). In April 1990, a highly endemic area of H. nocens infection was discovered from a southwestern coastal island, where as many as 42% of the population was found infected (to be published).

The first intermediate host is suspected to be a brackish water snail. The second intermediate host is brackish water fish, such as mullets or gobies (Acanthogobius flavimanus) (Seo et al, 1981b). Domestic cats were found naturally infected (Eom et al, 1985).

Heterophyopsis continua (Onji and Nishio, 1916)

Yamaguti, 1958

This species, first found in cats experimentally fed mullets (Mugil cephalus) harboring metacercariae, and is now known to be distributed in Korea, Japan and China (Seo et al, 1984b).

The presence of H. continua in Korea was first verified by Chun (1960b) who observed metacercariae in the flesh of perch and gobies. Two cases of human infection in Korea were reported by Seo et al (1984b); two additional cases were described by Hong and Han (1989). The first intermediate host is not known in Korea. The second intermediate hosts are perch, gobies, shad (Clupanodon punctatus) (Chun 1960 b), and sweetfish (Cho and Kim, 1985). Domestic cats were reported to be naturally infected (Eom et al, 1985). Dogs (Seo et al, 1984b) and chicks (Hong et al, 1990) have been experimentally infected.

Pygidiopsis summa Onji and Nishio, 1916

This species was first found in Japan in dogs fed mullets harboring metacercariae, and it is now known to be distributed in Korea. P. summa is differentiated from P. genata in the morphology of the ventral sucker, genital apparatus, and ceca (Chai et al, 1986).

The presence of P. summa in Korea was first described by Chun (1963), who observed metacercariae from the gill and muscle of mullets. Human infection was first reported from 8 persons living in a salt farm village who ate raw mullets (Seo et al, 1981a).

The first intermediate host is Cerithidea (= Tympanotonus) sp. (unpublished data). The second intermediate hosts are mullets and gobies.
FOOD-BORNE PARASITIC ZOONOSIS

Seo et al., 1981b). Natural infection of domestic cats was reported (Eom et al., 1985). In experimental rats and mice, the middle intestine is most frequently infected, and like M. yokogawai, the worms cause severe villous atrophy and crypt hyperplasia with inflammation of the mucosa (Seo et al., 1986).

Stellantchasmus falcatus Onji and Nishio, 1916

Human infections with S. falcatus have been reported from several Asian-Pacific countries, including Korea (Seo et al., 1984a; Hong et al., 1986). The life cycle was studied in Hawaii; the first intermediate host is Stenomelania newcombi or Thiara granifera (Noda, 1959) and the second intermediate host is the mullet (Chai and Sohn, 1988). In Korea, the snail host is not yet known.

Centrocestus armatus (Tanabe, 1922)

This fluke was first described by Tanabe (1922) from dogs, cats, rabbits, rats, and mice, fed cyprinoid fish harboring metacercariae. An experimental infection was reported in Japan (Tanabe, 1922) and a natural infection was found in Korea (Hong et al., 1988).

The first intermediate host is Semisulcospira sp. in Japan (Takahashi, 1929). Fresh water fish, such as Zacco platypus, Rhodeus ocellatus, Gobius similis, Pseudorasbora parva, Pelletheobagrus fulvidraco, and several other species, were reported to harbor the metacercariae of C. armatus in Korea (Lee et al., 1984 a, b). A recent field survey on metacercarial infection of fish hosts (Hong et al., 1989b) showed that Z. platypus and Z. temminckii caught in the large rivers of south Korea were heavily infected.

Stictodora fuscatum Onji and Nishio, 1916

This species was originally described by Onji and Nishio (1916) from cats fed infected mullets (M. cephalus) in Japan. Human infection with Stictodora sp. was reported from a young Korean fond of eating raw mullets or gobies (Chai et al., 1988).

FAMILY DICLOPSITOMATIDAE

Fibricola seoulensis Seo, Rim and Lee, 1964

This species was first described by Seo et al., (1964) from the small intestine of house rats captured in Seoul and are now known to be distributed almost all over the country (Seo, 1990). Before 1982, F. seoulensis failed to draw medical attention. In 1982, a human suffering from acute abdominal pain and fever (Seo et al., 1982) had eaten raw snake 7 days prior to admission to the hospital. Later, the snakes, Rhabdophis (= Natrix) tigrina, were found to carry metacercariae (Hong et al., 1982). Twenty-five additional human infections were found among soldiers eating snakes during survival training (Hong et al., 1984; 1986).

Life cycle studies revealed that the first intermediate host is a fresh water snail, Hippeustis cantori, and the second intermediate hosts are tadpoles and frogs (Seo et al., 1988). The terrestrial snake, R. tigrina, is regarded as a paratenic host. Mice, rats, Guinea pigs, and chicks were susceptible to experimental infection (Seo, 1990). In experimental animals, the duodenum is the most favorite site of the worms, and villous atrophy and crypt hyperplasia are the two major histopathological features of the mucosa (Lee et al., 1985).

The diagnosis of fibricolation is based upon recovery of eggs; however, the eggs should be differentiated from those of Echinostomatidae or Fasciolidae. Treatment is successful with a single dose of praziquantel, 10-20 mg/kg (Hong et al., 1984).

FAMILY ECHINOSTOMATIDAE

Echinostoma hortense Asada, 1926

This species was first described by Asada (1926) from the small intestine of house rats in Japan. The presence of E. hortense in Korea was reported by Park (1938) from rats in Seoul and human infection was reported by Seo et al (1983). A total of 77 egg or worm-proven cases were reported (Lee et al., 1988b). Cheongsong-gun, an island area in the southeastern part of Korea, was found to be highly endemic for human echinostomiasis, with an infection rate of 22.4% in the villagers (Lee et al., 1988b).

The first intermediate hosts in Korea are fresh water snails, such as Lymnaea pervia and Radix auricularia coreana (Ahn and Kang, 1988). Fish
hosts are *Misgurnus anguillicaudatus* (Chai et al., 1985a), *M. mizolepis*, *Odontobutis obsura interrupta*, *Morocco oxycephalus*, *Squalidus coreanus* (Lee et al., 1988b). Rats and dogs are natural final hosts (Cho et al., 1984).

**Echinostoma cinetorchis** Ando and Ozaki, 1923

This species was described by Ando and Ozaki (1923) from rats in Japan, and has been reported from rats in Korea (Seo et al., 1964). Human infections are reported from Japan (Kawahara and Yamamoto, 1933); four cases have been reported from Korea (Seo et al., 1980a; Ryang et al., 1986; Lee et al., 1988a).

Life cycle studies in Korea (Seo et al., 1984c; Lee et al., 1990) showed that *Hippeutis cantori*, a fresh water snail, can serve as the first as well as the second intermediate host. Other fresh water snails, such as *Radix auricularia coreana*, *Physa acuta*, and *Cipangopaludina* sp., or fresh water fish, such as *Misgurnus anguillicaudatus* can carry the metacercarial stage. Rats and dogs were found to be a natural final host (Cho et al., 1984). Albino rats were highly susceptible to experimental infection with this fluke.

**Echinostomus japonicus** Tanabe, 1926

This species was first described by Tanabe (1926) from the small intestine of experimentally infected dogs, cats, rats, mice, and birds with metacercariae from fresh water fish. Recently, natural human infections were reported in Korea (Seo et al., 1985).

The existence of this fluke in Korea was suggested when metacercariae were found in fresh water fish (Chun, 1964; Lee et al., 1984a, b), and later the successful recovery of adult worms from experimental mice was reported by Chai et al. (1985c). The first intermediate host in Korea is *Parafossarulus manchouricus* (Lee et al., 1984a, b), and 18 species of fresh water fish, including *Pseudorasbora parva*, *Hypomesus olidus* and *Gnathopogon strigatus* (Lee et al., 1984a, b) are second intermediate hosts. Natural infections are reported in chickens (unpublished) and ducks (Eom and Rim, 1984).

**FAMILY PLAGIORCHIIDAE**

*Plagiorchis* sp.

Three specimens of *Plagiorchis* sp. were recovered from a man after treatment with praziquantel (Hong et al., 1989a). The patient recalled eating raw fresh water fish. The specific diagnosis of worms has been made.

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INTESTINAL TREMATODES IN KOREA


