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# Intestinal Trematodes of Humans in Korea: *Metagonimus*, Heterophyids and Echinostomes

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**Abstract:** Ten species of the trematode family Heterophyidae (*Metagonimus yokogawai*, *M. takahashii*, *Heterophyes nocens*, *H. heterophyes*, *H. dispar*, *Heterophyopsis continua*, *Pygidiopsis summa*, *Stellantchasmus falcatus*, *Centrocestus armatus* and *Stictodora fuscatum*), and 3 species of the family Echinostomatidae (*Echinostoma hortense*, *E. cinetorchis* and *Echinochasmus japonicus*) have been found to infect humans in Korea. Biological and epidemiological studies on the above species have shown that *Metagonimus*, heterophyids and echinostomes are all prevalent indigenously in Korea except *H. heterophyes* and *H. dispar*, of which the human cases were infected when they came to the Middle East. Various kinds of fish have been proven to be the source of human infection with these flukes. For example, fresh water fish such as the sweetfish, carp, loach, *etc.*, were found to carry the metacercarial stage of *M. yokogawai*, *M. takahashii*, *C. armatus*, *E. hortense*, *E. cinetorchis* and/or *E. japonicus*. Brackish water fish such as the mullet, perch and goby, were verified to be the second intermediate host of *H. nocens*, *H. continua*, *P. summa*, *S. falcatus* and/or *S. fuscatum*. Among the intestinal flukes, *M. yokogawai* is the most prevalent species in Korea.

**Key words:** Intestinal trematode, *Metagonimus yokogawai*, *M. takahashii*, *Heterophyes nocens*, *H. heterophyes*, *H. dispar*, *Heterophyopsis continua*, *Pygidiopsis summa*, *Stellantchasmus falcatus*, *Centrocestus armatus*, *Stictodora fuscatum*, *Echinostoma hortense*, *E. cinetorchis*, *Echinochasmus japonicus*

## INTRODUCTION

It has long been recognized that the liver fluke (*Clonorchis sinensis*) and the lung fluke (*Paragonimus westermani*), contracted to humans by eating raw or improperly cooked fish, crabs or crayfish, are the most important trematodes of medical importance in Korea, because of their considerably high prevalence and wide geographical distribution. Recently, however, *Metagonimus* and other trematodes infecting the intestinal tract of animals and man, that belong to the family Heterophyidae, Echinostomatidae, Diplostomidae, Plagiorchiidae and Gymnophallidae, became a new important group of trematodes causing fish-borne parasitic zoonoses in this country.

The clinical symptoms and signs reported in metagonimiasis and other intestinal trematodiases have been, unless heavily infected, generally not so severe in the degree and frequently non-specific in their characters; abdominal pain, diarrhea, easy fatigability, weakness, anorexia, *etc.* (Cho *et al.*, 1984; Chai *et al.*, 1984a; Seo *et al.*, 1985a). For this reason, the infection is easily overlooked by the patients and even by the physicians. Attentions, however, should be paid especially to minute-sized intestinal flukes such as heterophyids because fatal extra-intestinal heterophyidiasis was reported in the heart, brain and spinal cord of man, due to the embolised eggs from the intestinal mucosa (Africa *et al.*, 1940). The mechanism and pathogenesis of such fatal embolism of heterophyid eggs has seldom been the subject of intensive study, so that there remains much to be cleared in the future.

According to the epidemiological studies on intestinal trematodes during the past 20 years in Korea, a total of 16 species have been verified to infect the human host. Morphologically they are classified into 5 families; Heterophyidae (10 species), Echinostomatidae (3 species), Diplostomidae (1 species), Plagiorchiidae (1 species) and Gymnophallidae (1 species). Concerning the family Diplostomidae, a comprehensive and very useful review on the responsible species, ***Fibricola seoulensis***, has recently been published (Seo, 1990). For the last two families, the fluke being ***Plagiorchis*** sp. and ***Gymnophalloides*** sp. respectively, studies are now under progress and informations are not yet enough to be reviewed. Therefore, the present paper focused to review briefly on the trematodes of the family Heterophyidae, including ***Metagonimus*** and heterophyids, and the family Echinostomatidae that were reported from humans in Korea.

## FAMILY HETEROPHYIDAE

### *Metagonimus yokogawai* (Katsurada, 1912) Katsurada, 1912

*Metagonimus yokogawai* (Fig. 1; Table 1) is the most prevalent of all intestinal trematode species reported from humans in Korea. This fluke is also known to distribute in Japan, China and Taiwan (Ito, 1964). The presence of human infections with this fluke in Korea was suggested at earlier times by the recovery of *Metagonimus* eggs from fecal examinations (Muta, 1913), but identification of adult worms from such egg positive cases was done much later by Seo *et al.* (1971).

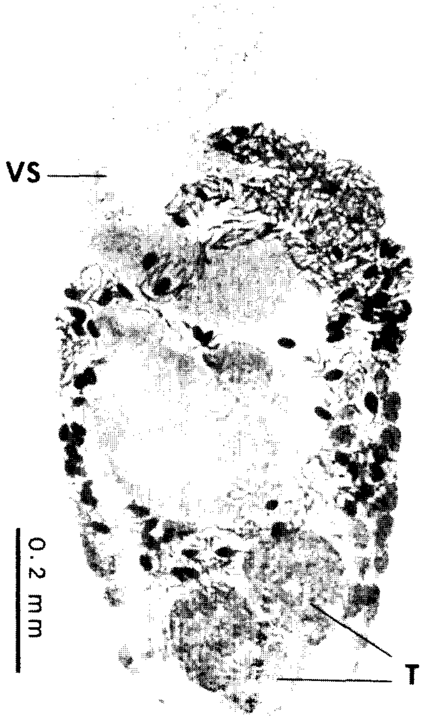


**Fig. 1.** *Metagonimus yokogawai*, ventral view, acetocarmine stained, recovered from a man. Note the location of the ventral sucker (VS) and two testes (T).

At present, almost all of the large and small streams in eastern and southern coastal areas, where the sweetfish (*Plecoglossus altivelis*) are available, have been turned out to be the endemic foci of metagonimiasis (Seo *et al.*, 1982; Song *et al.*, 1985) (Fig. 2). The nationwide egg positive rate of riverside people was once estimated at 4.8% (Seo *et al.*, 1981d). Especially the Sumjin, Tamjin, Boseong rivers, and Keoje Island are the most endemic areas with 10~20% or higher egg positive rate of villagers (Yeo and Seo, 1971; Soh *et al.*, 1976; Chai *et al.*, 1977; Seo *et al.*, 1981d).

**Table 1.** Human intestinal flukes which belong to the family Heterophyidae or Echinostomatidae in Korea

| Family / Species | Second Interm. Host | Egg size(μm) | Adult size(mm) |
|---|---|---|---|
| Heterophyidae | | | |
| *Metagonimus yokogawai* | fresh water fish(sweetfish) | 28～30×16～17 | 1.0～2.0×0.4～0.6 |
| *Metagonimus takahashii* | fresh water fish (carp) | 32～36×18～23 | 0.8～1.5×0.4～0.7 |
| *Heterophyes nocens* | brackish water fish (mullet, goby) | 25～28×14～16 | 0.9～1.6×0.5～0.8 |
| *Heterophyes heterophyes** | brackish water fish (mullet) | 28～30×15～17 | 1.0～1.7×0.3～0.4 |
| *Heterophyes dispar** | brackish water fish (mullet) | 19～25×13～15 | 1.0～1.7×0.5～0.6 |
| *Heterophyopsis continua* | brackish water fish (perch, goby) | 25～27×14～16 | 2.7～2.8×0.5～0.6 |
| *Pygidiopsis summa* | brackish water fish (mullet, goby) | 19～26×12～14 | 0.5～0.8×0.3～0.4 |
| *Stellantchasmus falcatus* | brackish water fish (mullet) | 22～23×11～12 | 0.4～0.7×0.3～0.4 |
| *Centrocestus armatus* | fresh water fish (carp) | 28～32×16～17 | 0.4～0.6×0.2～0.3 |
| *Stictodora fuscatum* | brackish water fish (mullet) | 34～38×20～23 | 0.9～1.0×0.3～0.4 |
| Echinostomatidae | | | |
| *Echinostoma hortense* | fresh water fish (loach, carp) | 105～128×43～68 | 8.2～14.0×0.9～1.6 |
| *Echinostoma cinetorchis* | fresh water fish (loach, large snail) | 95～105×60～68 | 8.6～15.0×2.0～2.4 |
| *Echinochasmus japonicus* | fresh water fish (carp) | 85×56 | 0.5～1.0×0.3 |

* Cases were imported from the Middle East and Sudan.

Morphologically the flukes of the genus *Metagonimus* are characterized by their small body size, laterally located ventral sucker and absence of genital sucker or ventrogenital apparatus. Taxonomically there are some unresolved problems among the genus *Metagonimus*. Until present, more than 5 species including *M. yokogawai* Katsurada, 1912, *M. takahashii* Suzuki, 1930, *M. minutus* Katsuta, 1932, *M. katsuradai* Izumi, 1935 and *M. otsurui* Saito *et* Shimizu, 1968 have been reported in the literature (Saito and Shimizu, 1968). The validity of each species, however, should be re-evaluated. Apart from this taxonomic task, there is another newly raised problem in Japan. That is on the two intermediate forms between *M. yokogawai* and *M. takahashii*, such as *Metagonimus* Miyata type and *Metagonimus* Koga type (Saito, 1984). Also in Korea, the presence of similar intermediate forms has been recognized (Kim *et al.*, 1987; Chai *et al.*, to be published). However, it should be reserved until sufficient works have been done to decide whether they can be treated as distinct species or just regarded as intraspecific variations of *M. yokogawai* or *M. takahashii*.

*M. yokogawai* (Fig. 1) is distinguished easily from *M. takahashii* (Fig. 5), by the different location and arrangement of two testes and different size of the eggs (Saito, 1984). Besides the morphology, *M. takahashii* is differed from *M. yokogawai* in taking different kinds of fish intermediate host; various kinds of fresh water fish other than the sweetfish.

A study on the tegumental ultrastructures of various developmental stages of *M. yokogawai* (Lee *et al.*, 1984d) revealed that their whole tegument was covered with numerous scale-like spines, 7～8 pointed over the anterior body and 2～3 pointed over the posterior one, and cobblestone-like cytoplasmic processes between the spines, together with some groups of type I, type II and type III sensory papillae. It was also observed that the tegument continued to differentiate until they become fully mature (2～4 week old) adults.

The molluscan intermediate host of *M. yokogawai* is a kind of fresh water snail, *Semisulcospira coreana* or *S. libertina* (Cho *et al.*, 1984). The second host includes, besides the sweetfish, the dace (*Tribolodon* sp.) (Choi *et al.*, 1966; Chai *et al.*, to be published) and the perch (*Lateolabrax japonicus*) (Ahn, 1983). Dogs, rats and cats were reported to be

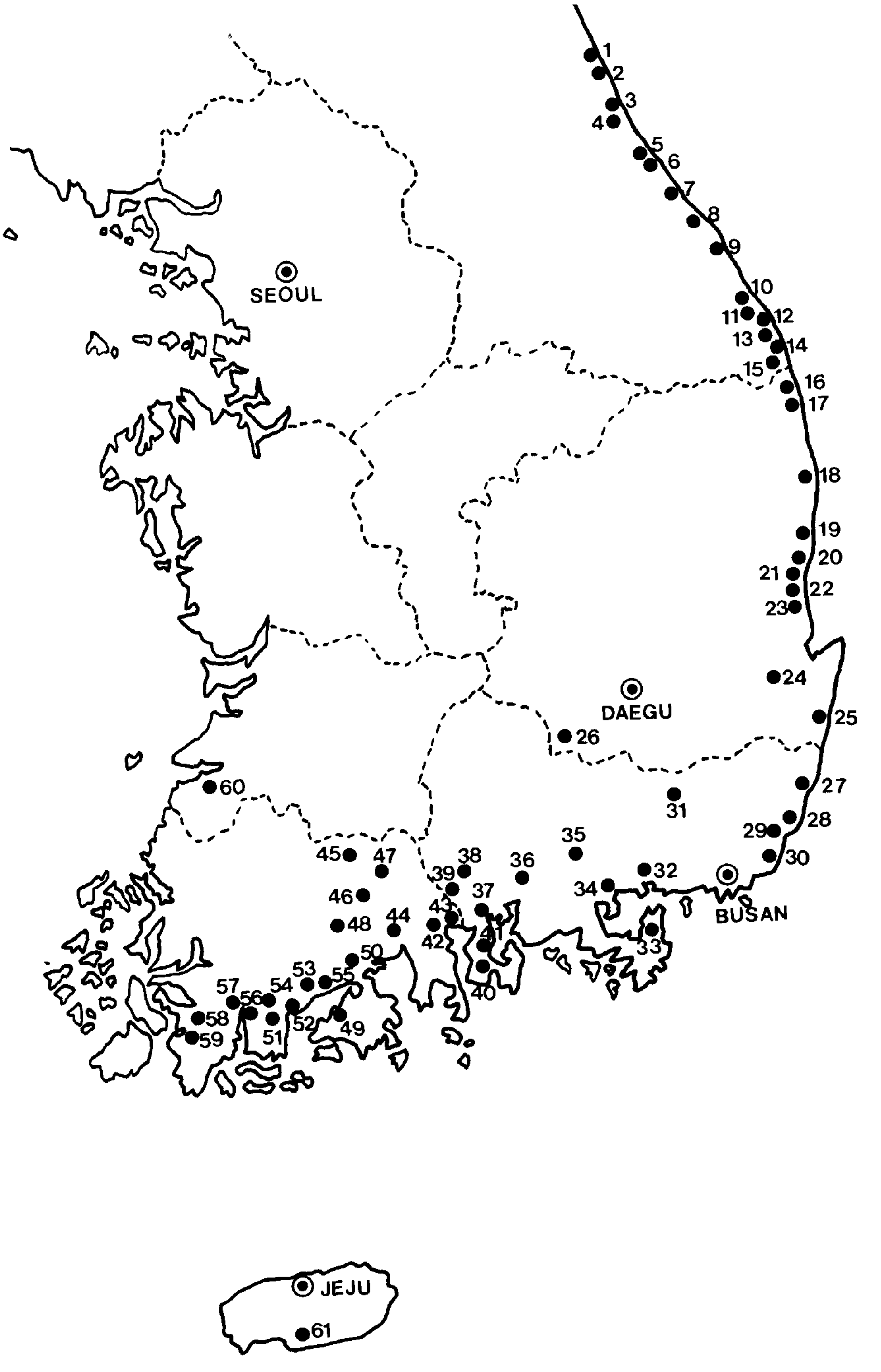


**Fig. 2.** Map of the geographical distribution of *M. yokogawai* in Korea, based on the metacercarial infection in the sweetfish (Redrawn from Seo *et al.*, 1982 & Song *et al.*, 1985).

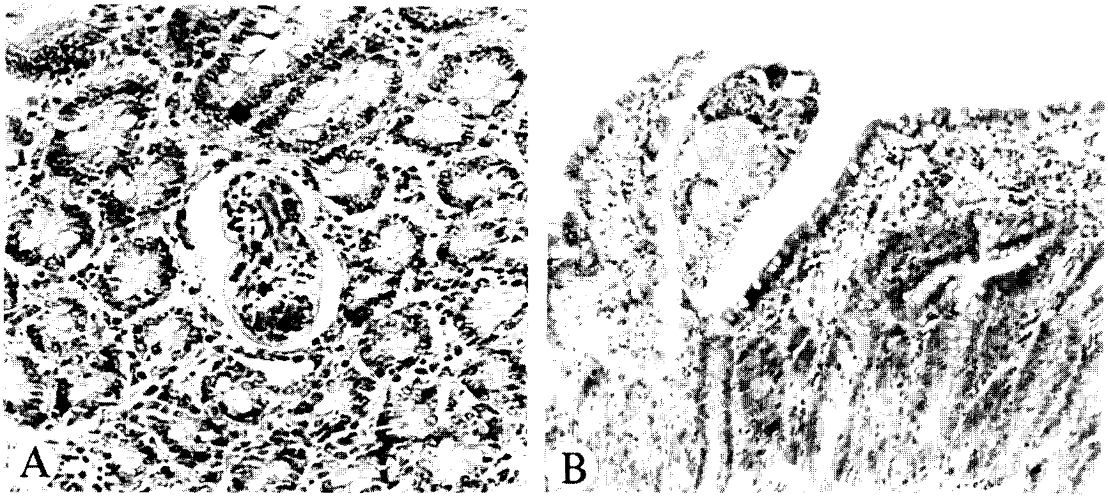


**Fig. 3.** Section of *M. yokogawai* in the jejunum, (A) at an early stage (3-day) of infection in a dog (×200), and (B) at a later stage (2-week) of infection in a rat (×100) (Chai, 1979). Note villous atrophy (B) and crypt hyperplasia (A & B) of the host's jejunal mucosa. H-E stain.

naturally infected (Cho *et al.*, 1981; Seo *et al.*, 1981c), although the significance of these animals as the source of human infection in endemic areas (*i.e.*, reservoir host) has not yet been clarified.

The intestinal histopathology was studied in experimentally infected rats, cats and dogs (Chai, 1979; Lee *et al.*, 1981; Kang *et al.*, 1983) and a naturally infected human (Chi *et al.*, 1988), with very similar findings. The worms were found parasitizing in the middle part of the small intestine; within the crypt of Lieberkühn at early stages of infection (Fig. 3A) or between the villi at later stages (Fig. 3B). The pathological features were characterized by villous atrophy and crypt hyperplasia, with variable degree of inflammatory cell infiltration (Fig. 3A & 3B). The invasion of worms was confined to the lower mucosal level (Kang *et al.*, 1983; Rho *et al.*, 1984; Jang *et al.*, 1985) and the worms were never found from the submucosa in immunocompetent hosts. Prednisolone injection into ICR mice increased the worm recovery rate from the mice after experimental infection with *M. yokogawai* and prolonged the life span of the worms in the same host (Chai *et al.*, 1984b). The extent of worm invasion into the submucosa of such immunocompromised hosts should be studied in the future.

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(←)
**Area Code** (1-61)

**Gangwon-do:** 1-2. Kosung-gun, 3. Sokcho-city, 4-6. Yangyang-gun, 7. Myongju-gun, 8. Kangnung-city, 9. Myongju-gun, 10-15. Samcheok-gun.

**Kyongsangbuk-do:** 16-19. Uljin-gun, 20-23. Yongduk-gun, 24. Yongil-gun, 25. Wolsung-gun, 26. Koryung-gun.

**Kyongsangnam-do:** 27. Ulsan-city, 28. Ulju-gun, 29-30. Yangsan-gun, 31. Milyang-gun, 32. Euichang-gun, 33. Keoje-gun, 34. Kosung-gun, 35. Euiryung-gun, 36. Chinju-city, 37-39. Hadong-gun, 40-41. Namhae-gun.

**Chollanam-do:** 42-43. Kwangyang-gun, 44. Soonchun-city, 45. Koksung-gun, 46-47. Koorye-gun, 48. Seungju-gun, 49. Koheung-gun, 50. Bosung-gun, 51-54. Changhung-gun, 55. Bosung-gun, 56-57. Kangjin-gun, 58-59. Haenam-gun.

**Chollabuk-do:** 60. Kochang-gun.

**Cheju-do:** 61. Seogwipo-city.

The most frequent symptoms complained by the human patients infected with *M. yokogawai* were abdominal pain, diarrhea and lethargy (Cho *et al.*, 1984), and the degree of symptoms seems to be related to the individual worm burden. However, even the most heavily infected case in the Korean literature, a man who is residing in the Tamjin river basin and harbouring as many as 63,587 worms at one time (Seo *et al.*, 1985b), complained only minor troubles such as mild indigestion and epigastric pain. Therefore, the severity of clinical symptoms may not be necessarily correlated to the degree of individual worm burden. It is rather suggested that the severity of symptoms may be dependent upon the susceptibility as well as resistance of the host. Primary infection, to a new comer to the endemic area, for example, seems to evoke severe clinical manifestations (Chai *et al.*, 1989).

The mechanism of diarrhea in metagonimiasis has seldom been the subject of study in contrast to other kinds of enteric helminth infections such as trichinosis, where much progress has been achieved especially on the immunophysiological pathways and pathogenesis of the intestinal pathology and symptoms (Castro, 1989). From a study on the watery content in the small intestine of experimentally infected dogs with *M. yokogawai*, Cho *et al.* (1985) suggested that such watery content may be a product from poor absorption of intestinal secretions from the secretory crypt cells.

The diagnosis of metagonimiasis is usually based on the recovery of typical eggs (Fig. 4) from fecal examinations. However, there will be many false egg negative cases among the light infection cases, for example, with less than 100 worms. Serological test such as ELISA is helpful for such cases (Cho *et al.*, 1987; Chai *et al.*, 1989). The eggs of *M. yokogawai* can be differentiated from other heterophyid eggs by their size range of 26.9~31.6 μm, elliptical shape with length/width ratio of 1.5~2.1, clear shell surface, less prominent operculum, and so on (Lee *et al.*, 1984c).

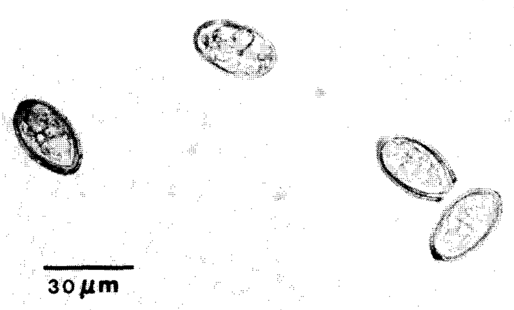


**Fig. 4.** Eggs of *M. yokogawai*, obtained from the uterus of several adult worms.

The drug of choice in the treatment of metagonimiasis is praziquantel. The efficacy of praziquantel by single oral dose of 10~20 mg/kg was reported satisfactory and up to 95~

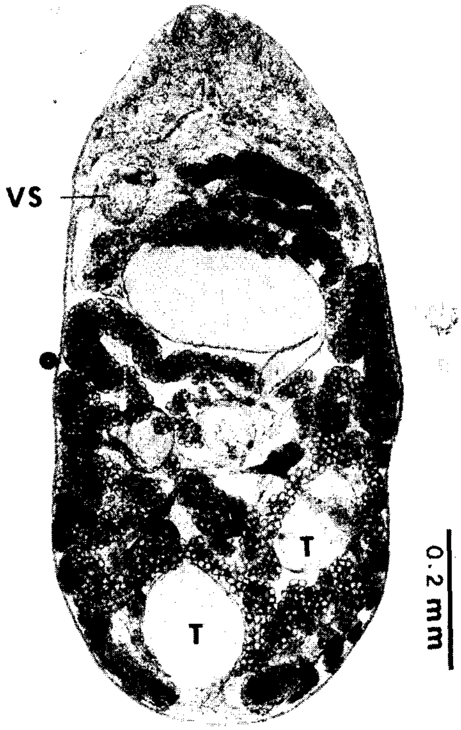


**Fig. 5.** *Metagonimus takahashii*, ventral view, fresh preparation from a man. Note the ventral sucker (VS), two separately located testes (T), uterine tubule crossing over the two testes, and posteriormost extension of vitellaria.

100% in cure rate (Rim *et al.*, 1978; Lee *et al.*, 1984b). Bithionol or niclosamide can be used as a substitute, also with satisfactory therapeutic efficacy.

### ***Metagonimus takahashii*** **Suzuki, 1930**

This fluke was first found by Takahashi (1929a) from the small intestine of mice and dogs experimentally fed the *Metagonimus* metacercariae encysted in several kinds of fresh water fish other than the sweetfish. One year later it was described as a new species, *M. takahashii*, by Suzuki (1930). *M. takahashii* (Fig. 5; Table 1) is morphologically differed from *M. yokogawai* in the position of the anterior testis (separated from the posterior one), the distribution of vitelline follicles (more abundant and extending towards the posteriormost end), and the larger size of the eggs (32~36 μm) (Saito, 1984). However, because of the presence of two intermediate types between *M. yokogawai* and *M. takahashii*, *i.e.*, *Metagonimus* Miyata type and *Metagonimus* Koga type (Saito, 1984), the taxonomic position of *M. takahashii* and two intermediates has to be further studied.

The distribution of *M. takahashii* in Korea was first announced by Chun (1960a) with the adult worms recovered from experimentally infected rabbits, the metacercariae of which were obtained from the scale of the crucian carp (*Carassius* sp.). Human infection cases were reported in 1985 and 1988 (Ahn and Ryang, 1988), however, the diagnosis was not based on a detailed morphological description of the worms, so that there needs a clear elucidation on those human infection cases.

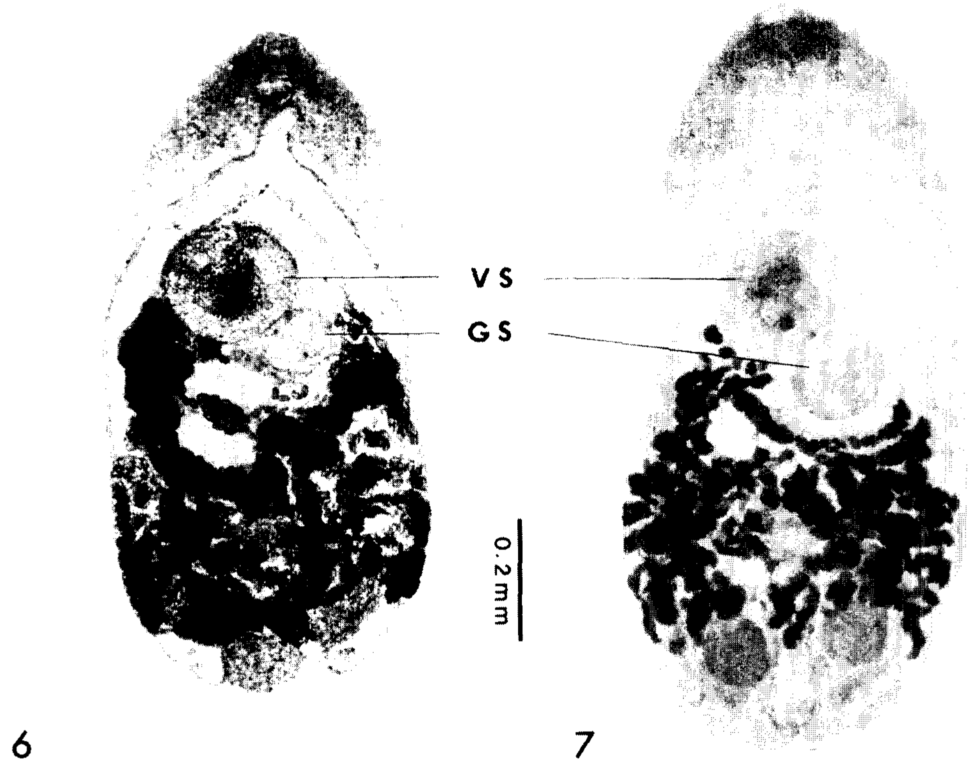


**Fig. 6-7.** *Heterophyes nocens* (Fig. 6) and *H. heterophyes* (Fig. 7), ventral view, fresh preparations from a man (Chai *et al.*, 1985b) and another (Chai *et al.*, 1986a). Note the ventral sucker (VS) and other organs, that show no special difference between the two species, except in the morphology of the genital sucker (GS) (for detail see Fig. 8-9).

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

### *Heterophyes nocens* Onji and Nishio, 1916

Flukes of the genus *Heterophyes* are morphologically characterized by the median location of the ventral sucker and presence of a genital sucker with gonotyl. *H. nocens* (Fig. 6; Table 1), reported from Korea and Japan, is morphologically very close to the type species, *H. heterophyes* (Fig. 7), which is prevalent in Egypt and the Middle East, but differed by the morphology of the genital sucker especially in the number of rodlets on the gonotyl (Figs. 8 & 9); 50~60 in *H. nocens* (Chai *et al.*, 1984a) and 70~85 in *H. heterophyes* (Chai *et al.*, 1986a). After *H. nocens* was described as a new species in Japan (Onji and Nishio, 1916), its validity as a distinct species has sometimes been questioned by several workers (Faust and Nishigori, 1926). However, it is the present authors' firm belief that *H. nocens* should be treated as a distinct one respecting the smaller number of rodlets on the gonotyl as a unique and consistent feature.

In Korea, the metacercariae of *H. nocens* were first found in 1978 from the mullet (*Mugil cephalus*) captured from three southern coastal areas (Seo *et al.*, 1980b). Before 1990, human infections with this fluke were verified in 13 cases who were from scattered areas (Seo *et al.*, 1981b; Chai *et al.*, 1984a & 1985b; Sohn *et al.*, 1989a). In April 1990, however, a highly endemic area of *H. nocens* infection was discovered from a southwestern coastal island, where as many as 42 cases (43%) of the population examined were found infected (Chai *et al.*, to be published).

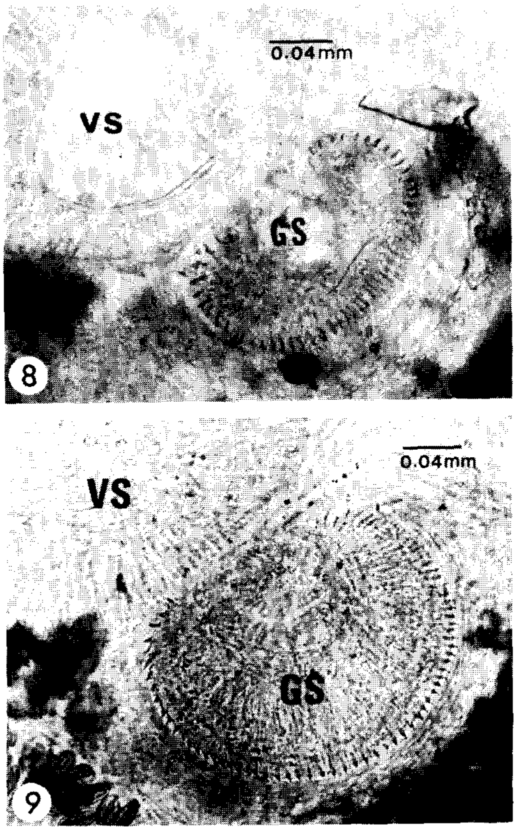


**Fig. 8-9.** Close-up view of the ventral sucker (VS) and genital sucker (GS) of *H. nocens* (Fig. 8) and *H. heterophyes* (Fig. 9). The number of rodlets on the gonotyl (GS) is about 53 for the former (Fig. 8) and about 76 for the latter (Fig. 9).

The first intermediate host is supposed to be a brackish water snail, however, not yet clarified. The second intermediate hosts were reported to be brackish water fish such as the mullet or goby (*Acanthogobius flavimanus*). Domestic cats were found naturally infected with this fluke (Eom *et al.*, 1985a).

### *Heterophyes heterophyes* (v. Siebold, 1852) Stiles and Hassal, 1900

*H. heterophyes* (Fig. 7; Table 1), first found by Bilharz in 1851 at autopsy of a native of Cairo, Egypt, is now well known as a human intestinal trematode in Egypt, Sudan and the Middle East (Tarashewski, 1984), but not yet found to be indigenously distributed in Korea. Total 7 human cases infected with *H. hetero-*

*phyes* were confirmed in Korea by the recovery of adult worms after chemotherapy with

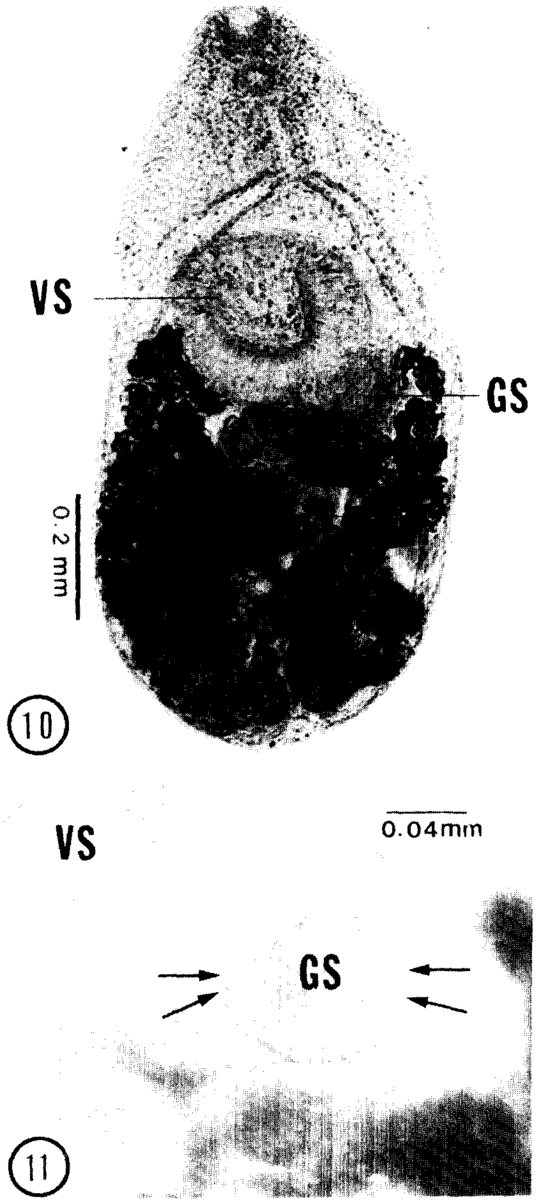


**Fig. 10-11.** *Heterophyes dispar*, ventral view of a whole worm (Fig. 10) and a close-up view (Fig. 11) of the vental sucker (VS) and genital sucker (GS), fresh preparation from a man (Chai *et al.*, 1986a). Note the small size of the genital sucker (GS) (Fig. 10) compared with the large ventral one (VS) and small number (about 30) of rodlets on the gonotyl (Fig. 11).

praziquantel (Chai *et al.*, 1986a; Eom *et al.*, 1985b). They seemed to have been infected, together with *H. dispar* (see below), while they lived in Saudi Arabia or Sudan. The infected persons had the history of consumption of raw mullet, and experienced episodes of epigastric pain and/or diarrhea.

### ***Heterophyes dispar*** **Looss, 1902**

*H. dispar* (Fig. 10; Table 1), was first found from the intestine of dogs and cats in Egypt (Looss, 1902) and has been reported from various carnivorous mammals including foxes and wolves in northern Africa and the Middle East (Taraschewski, 1984). Human infection was not known in the world literature before 1985, when 7 cases of *H. dispar* infection were found concomitantly with *H. heterophyes* infection in Korea (see above), and by this, human infection of this fluke was first verified (Chai *et al.*, 1986a). Morphologically *H. dispar* is distinguished from *H. heterophyes* and *H. nocens* by the smaller sized genital sucker and smaller number of rodlets on the gonotyl; 22～33 in *H. dispar* (Fig. 11).

### ***Heterophyopsis continua*** **(Onji and Nishio, 1916) Yamaguti, 1958**

This species (Fig. 12; Table 1), which was first found from the cats experimentally fed the mullet (*Mugil cephalus*) harbouring the metacercariae (Onji and Nishio, 1916), has been reported to be prevalent in Korea, Japan and China (Seo *et al.*, 1984b). *Heterophyopsis expectans* Africa and Garcia, 1935, reported from the Philippines, seems to be a synonym of *H. continua*. *H. continua* is morphologically differed from other heterophyid flukes in its elongated body, separately located genital sucker from the ventral sucker, and two obliquely tandem testes.

The presence of *H. continua* in Korea was first verified by Chun (1960b) who observed the metacercariae in the flesh of the perch (*Lateolabrax japonicus*) and goby (*Acanthogobius flavimanus*) and obtained adult worms after an experimental infection. Two cases of human infection with this fluke were reported

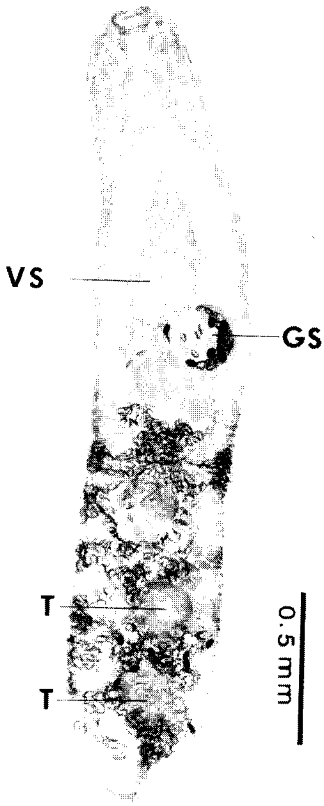


**Fig. 12.** *Heterophyopsis continua*, ventral view, acetocarmine stained, recovered from a man (Seo *et al.*, 1984b). Note the elongated body shape, ventral sucker (VS), genital sucker (GS), and two obliquely tandem testes (T).

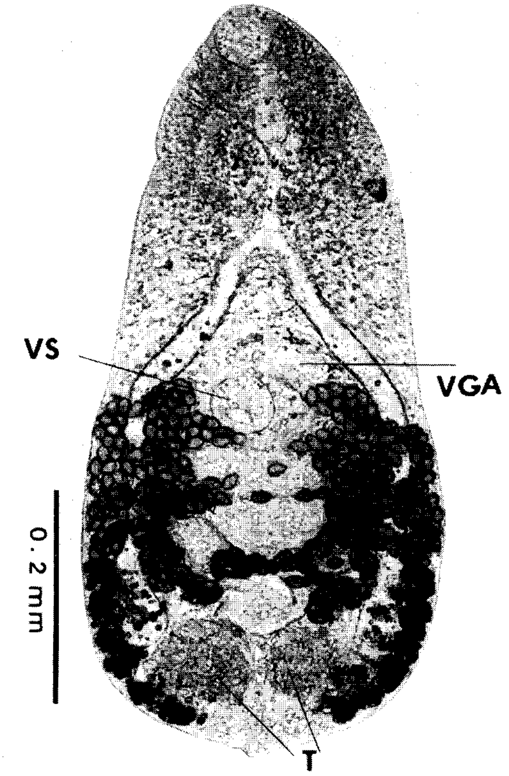


**Fig. 13.** *Pygidiopsis summa*, ventral view, fresh preparation from an experimentally infected rat (10-day old worm) (Chai *et al.*, 1986b). Note the slightly submedian ventral sucker (VS) and associated genital apparatus, forming together a ventrogenital apparatus (VGA). Also see the two side-by-side testes (T).

in Korea by Seo *et al.* (1984b), and two additional cases were described by Hong and Han (1989). Among the available literature, there had been only one paper (Yamaguti, 1939) mentioning the human infection with *H. continua* in Japan.

The first intermediate host is not yet known in Korea. The second hosts are the perch, goby, shad (*Clupanodon punctatus*) (Chun, 1960b) and the sweetfish (*Plecoglossus altivelis*) (Cho and Kim, 1985). Domestic cats were reported to be naturally infected (Eom *et al.*, 1985a). Experimentally dogs (Seo *et al.*, 1984b) and chicks (Hong *et al.*, 1990) were successfully infected with this fluke.

### *Pygidiopsis summa* Onji and Nishio, 1916

This species was first found in Japan from the dogs fed the mullet (*Mugil cephalus*) infected with the metacercariae (Onji and Nishio, 1916), and is now known to be distributed in Korea and Japan. Morphologically *P. summa* (Fig. 13; Table 1) is characterized by the small concave body, median location of the ventral sucker, peculiar morphology of the ventrogenital apparatus, and side-by-side location of two testes. *P. summa* is differentiated from *P. genata*, another species prevalent in Egypt, in the morphology of the ventral sucker, ventrogenital apparatus, and ceca (Chai *et al.*, 1986b).

The presence of *P. summa* in Korea was first described by Chun (1963), who observed the metacercariae from the gill and muscle of the mullet. Human infection was first reported from 8 cases, by the recovery of adult worms after chemotherapy, who were living in a salt farm village and habitually eating the raw flesh of the mullet (Seo *et al.*, 1981b). Seo *et al.* (1983b) further found 9 egg positive cases of *P. summa* during the fecal examination of some seashore villagers, from whom adult worms were recovered later (Hong, unpublished data). In Japan, Takahashi (1929b) detected *P. summa* eggs from the human feces, and the adult worms were identified from humans by Yokogawa *et al.* (1965).

The first intermediate host in Korea is *Cerithidea*(=*Tympanotonus*) sp. (Chai, unpublished data). The second host is the mullet or goby (*Acanthogobius flavimanus*) (Seo *et al.*, 1981c). Natural infection of the domestic cats was reported (Eom *et al.*, 1985a). In experimental rats and mice, the middle part of the small intestine was most frequently infected, and like *M. yokogawai*, the worms caused severe villous atrophy and crypt hyperplasia with inflammation of the mucosa (Seo *et al.*, 1986).

### *Stellantchasmus falcatus* Onji and Nishio, 1916

*S. falcatus* (Fig. 14; Table 1) was first described in Japan as a new species by Onji and Nishio (1916) from the cats experimentally fed the mullet (*Mugil cephalus*) harbouring the metacercariae. This species is morphologically characterized by their slightly deviated location of the ventral sucker and presence of an elongated sac-like seminal vesicle in the opposite side. Human infection cases have been reported from Asia-Pacific countries such as the Philippines (Africa and Garcia, 1935), Hawaii (Alicata and Schattenburg, 1938), Japan (Kagei *et al.*, 1964), Thailand (Kliks and Tantachamrun, 1974; Radomyos *et al.*, 1990), and Korea (Seo *et al.*, 1984a; Hong *et al.*, 1986; Sohn *et al.*, 1989b).

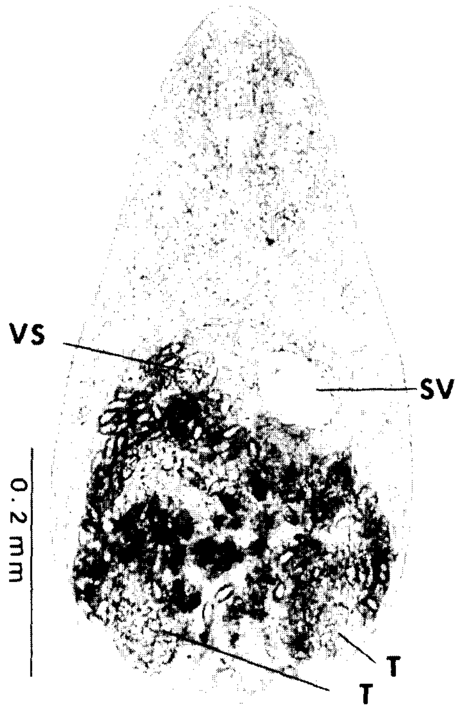


**Fig. 14.** *Stellantchasmus falcatus*, ventral view, fresh preparation from a patient (Seo *et al.*, 1984a). Note the submedian ventral sucker (VS), elongated sac-like seminal vesicle (SV), and two side-by-side testes (T).

The life cycle study has been successfully performed in Hawaii; the first intermediate host is *Stenomelania newcombi* or *Thiara granifera* (Noda, 1959) and the second host is the mullet (Alicata and Schattenburg, 1938). In Korea, the snail host is not known yet. Some of the mullet in Korea were proven to harbour the metacercariae of *S. falcatus* (Chai and Sohn, 1988).

### *Centrocestus armatus* (Tanabe, 1922)

This fluke (Fig. 15; Table 1) was first described by Tanabe (1922) from the dogs, cats, rabbits, rats and mice experimentally fed the cyprinoid fish infected with the metacercariae. The characteristic features of this species are the presence of 42~48 circumoral spines, small number of intrauterine eggs,

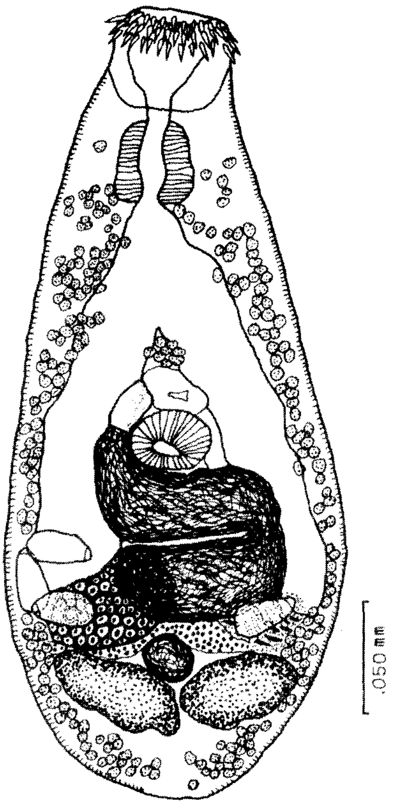


**Fig. 15.** *Centrocestus armatus*, ventral view, drawing from a specimen recovered from a man (Hong *et al.*, 1988). Note the circumoral spines characteristic of this genus.

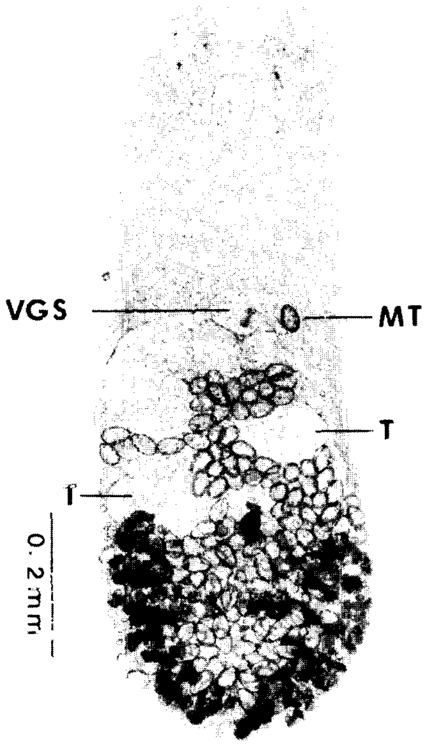


**Fig. 16.** *Stictodora fuscatum*, ventral view, fresh specimen from a patient in a southwestern coastal area (Chai *et al.*, to be published). Note the characteristic features of the ventrogenital sac (VGS), metraterm (MT) containing an egg, two obliquely located testes (T), and distribution of the vitellaria.

median location of the ovary, side-by-side position of two testes, and so on. As for the human infection with *C. armatus*, a successful experimental infection of a human was reported in Japan (Tanabe, 1922), and a natural human infection case was recently reported in Korea (Hong *et al.*, 1988).

The first intermediate host is known to be *Semisulcospira* sp. in Japan (Takahashi, 1929c), but it has not yet been studied in Korea. As for the second host, the fresh water fish such as *Zacco platypus*, *Rhodeus ocellatus*, *Gobius similis*, *Pseudorasbora parva*, *Pelteobagrus fulvidraco* and several other species were reported to harbour the metacercariae of *C. armatus* in Korea (Lee *et al.*, 1983 & 1984a). A recent field survey on metacercarial infection of the fish host revealed that *Z. platypus* and *Z. temminckii* caught at 5 large rivers of South Korea were heavily infected with this fluke (Hong *et al.*, 1989).

### *Stictodora fuscatum* (Onji and Nishio, 1916) Yamaguti, 1958

This species (Fig. 16; Table 1) was originally described by Onji and Nishio (1916) from the cats experimentally fed the infected mullet (*Mugil cephalus*) in Japan. It is morphologically characterized by the presence of an armed gonotyl superimposed on the ventral sucker, the presence of a metraterm, and in the middle field a little obliquely located two testes. A case of human infection with *Stictodora* sp. (*S. fuscatum*) was recently reported from a young Korean who was fond of eating raw mullet or goby (Chai *et al.*, 1988). Thirteen additional human cases were found from a seashore village in a southwestern coastal area of Korea (Chai *et* al., to be published).

## Family Echinostomatidae

### *Echinostoma hortense* Asada, 1926

This species (Fig. 17; Table 1) was first described by Asada (1926) from the small intestine of house rats in Japan, and reported also from the rats in Korea (Seo *et al.*, 1964 & 1981a) and China. *E. hortense* is morphologically differed from other echinostomes in the laterally located ovary, 27～28 collar spines around the oral sucker, and two tandem, slightly lobulated testes. Human infection with *E. hortense* had not been known before 1976, when a first case was found in Japan and the worm was identified as *E. hortense* (Tani, 1976). More than 20 human cases were proven by the recovery of adult worms in Japan (Miyamoto *et al.*, 1983).

The presence of *E. hortense* in Korea was first described by Park (1938) from the rats in Seoul. The first human case was reported rather recently by Seo *et al.* (1983a). After then, total 79 egg or worm-proven cases have been reported in Korea (Lee *et al.*, 1988b; Ryang, 1990). Especially Cheongsong-gun, an inland area located at southeastern part of Korea, was found to be a highly endemic area

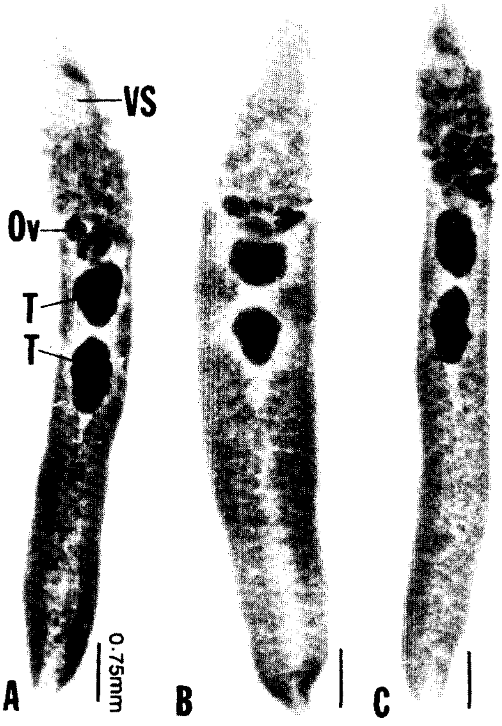


**Fig. 17.** *Echinostoma hortense*, 28-day (A), 42-day (B) and 150-day worm (C) grown in experimental rats, acetocarmine stained (Seo *et al.*, 1985a). Note the large ventral sucker (VS), submedian location of the ovary (Ov), and two slightly lobulated tandem testes (T).

**Fig. 18.** Section of the duodenum of a rat 22 days after experimental infection with *E. hortense* (Lee *et al.*, 1990). Note a worm sucking at a villus with its oral sucker armed with collar spines (arrows). The host mucosa shows villous atrophy and crypt hyperplasia, with inflammatory reactions. H-E stain. ×100.

of human echinostomiasis (*E. hortense*), with 22.4% infection rate of the villagers (Lee *et al.*, 1988b).

The first intermediate hosts reported in Korea are fresh water snails such as *Lymnaea pervia* or *Radix auricularia coreana* (Ahn and Kang, 1988). The fish second hosts are *Misgurnus anguillicaudatus* (Chai *et al.*, 1985a), *M. mizolepis*, *Odontobutis obscura interrupta*, *Moroco oxycephalus*, *Coreoperca kawamebari* (Ryang, 1990), *Squalidus coreanus* (Lee *et al.*, 1988b), and so on. Other than the rat, the dog was found to be another natural final host (Cho *et al.*, 1981). Experimentally mice, rats, and humans were susceptible to this fluke infection (Seo *et al.*, 1985a).

Intestinal pathology (Fig. 18) due to *E. hortense* infection was studied in experimental rats (Lee *et al.*, 1990a). It was revealed that the worms dwell in the lumen of the upper small intestine and pathological changes were chiefly confined to the mucosal layer. However, the changes were very severe accompanying marked destruction of villi and loss of mucosal integrity (Lee *et al.*, 1990a).

### *Echinostoma cinetorchis* Ando and Ozaki, 1923

This species (Fig. 19A & 19B; Table 1), first described by Ando and Ozaki (1923) from the rats in Japan, has been reported from the rats in Korea (Seo *et al.*, 1964 & 1981a). The characteristic morphological features of *E. cinetorchis* include abnormal location (Fig. 19A) and disappearance of one (Fig. 19B) or two testes, and 37~38 collar spines around the oral sucker. Human infection cases were reported at earlier times in Japan (Kawahara and Yamamoto, 1933). Also in Korea, 4 cases of human infection have been reported in the literature (Seo *et al.*, 1980a; Ryang *et al.*, 1986; Lee *et al.*, 1988a).

Life cycle studies in Korea have revealed that *Hippeutis cantori*, the fresh water snail, was experimentally confirmed as the first as well as second intermediate host of *E. cinetorchis* (Lee *et al.*, 1990b). Other fresh water snails

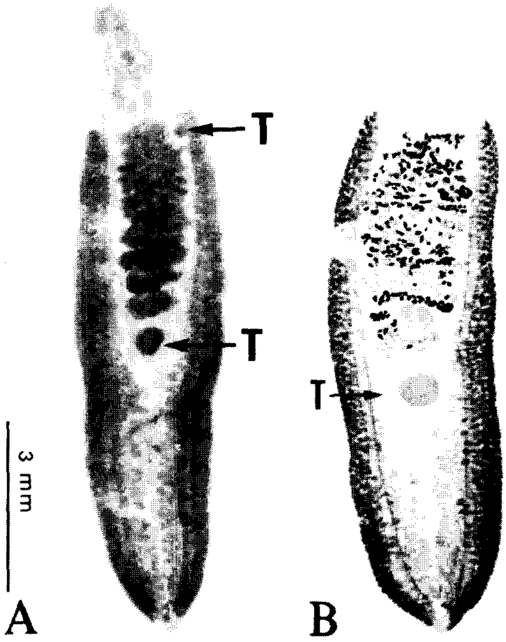


**Fig. 19.** *Echinostoma cinetorchis*, ventral view of two adult worms, grown in experimental rats 16 days after infection, acetocarmine stained (Seo *et al.*, 1984c). Note a worm (A) that has two testes (T) one of which moved to an abnormal location and another that has only one testis (T).

such as *Radix auricularia coreanus*, *Physa acuta* and *Cipangopaludina* sp. (Ahn *et al.*, 1989), or fresh water fish such as *Misgurnus anguillicaudatus* (Seo *et al.*, 1984c) were proven to carry the metacercarial stage of *E. cinetorchis*. Other than the house rat, the dog was found to be another natural final host (Cho *et al.*, 1981). Albino rats were highly susceptible to experimental infection with this fluke (Seo *et al.*, 1984c).

### *Echinochasmus japonicus* Tanabe, 1926

This species (Fig. 20A & 20B; Table 1) was first described by Tanabe (1926) from the small intestine of experimentally infected animals such as the dogs, cats, rats, mice and birds with the metacercariae encysted in the fresh

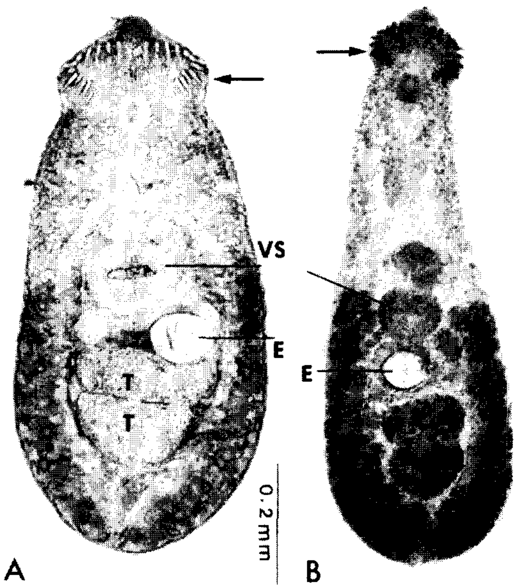


**Fig. 20.** *Echinochasmus japonicus*, ventral view of a fresh specimen (A) recovered from a naturally infected chicken and dorsal view of an acetocarmine stained specimen (B) from an experimentally infected chick. Note the arrangement of 24 collar spines (arrows) which is discontinued dorsally, large ventral sucker (VS), two tandem testes (T) and small uterus with only one egg (E) each.

water fish. The characteristic morphological features are the small and plump body, total 24 collar spines interrupted dorsally, tandem testes, and very small number of eggs in the uterus. *E. japonicus* is known to be distributed chiefly in Far Eastern countries. Experimental human infection was tried by Ujiie (1936) with success in Japan. Recently natural human infection cases were reported in China in 1982 (cited from Zhu *et al.*, 1986) and in Korea (Seo *et al.*, 1985c).

The existence of this fluke was suggested at earlier times in Korea and the metacercarial stage was found from various kinds of fresh water fish (Chun, 1964; Lee *et al.*, 1983). However, successful recovery of the adult worms was first reported from the experimentally infected mice (Chai *et al.*, 1985c) and chicks (Fig. 20B). The first intermediate host reported in Korea is *Parafossarulus manchouricus* (Lee *et al.*, 1983). The second hosts are 18 species of fresh water fish including *Pseudorasbora parva*, *Hypomesus olidus* and *Gnathopogon strigatus* (Lee *et al.*, 1984a). Natural infection of the avian hosts such as chickens (Chai and Sohn, unpublished data (Fig. 20A) and ducks (Eom and Rim, 1984) has been confirmed by the recovery of adult worms from their small intestine.

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