

Infection patterns with larval trematodes from fresh-water fish in River Taega, Kyungpook, Korea

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Introduction

Many studies of the biologic and epidemiologic features of larval trematodes from fresh-water fish in Korea and adjacent territories have been carried out extensively. Kobayashi(1910) described for the first time the *Clonorchis* metacercaria from the flesh of several kinds of fresh-water fish. Yokogawa(1913) found a kind of metacercaria from scales of *Plecoglossus altivelis* and obtained a new fluke by a feeding experiment and named it as *Metagonimus yokogawai*.

Metorchis orientalis was found by Tanabe(1920) from the gall bladder of ducks, and he(1920) discovered the metacercaria of this fluke from the flesh of *Pseudorasbora parva*. Kobayashi(1924) made a survey on the second intermediate host naturally infected with *Clonorchis* metacercaria in Kyunggi, Chungnam, Chunpook and Kyungnam Provinces in Korea, and demonstrated that the seven species of fresh-water fish belonging to the family Cyprinidae as the second intermediate host of *C. sinensis*. He also reported that human clonorchiasis was found to be distributed chiefly in the southern part of Korea, especially in the vicinity of major rivers and their tributaries. Little works on the encysted larvae from fresh-water fish were done before the end of Korean War, although only *Clonorchis* metacercaria was

known at that time. After the War, Choi et al. (1964) reported one species, *Centrocestus asadai*, from brackish-water fish, and Lee(1968) found 10 species of the larval trematodes and 4 kinds of unidentified metacercariae from 12 species of fish hosts.

After the establishment of the third "Five-year economic development plan" in 1972, the results of studies on the encysted larvae in fish hosts have been reported by Lee et al.(1979) in river Ossep; by Hwang and Choi(1980) in river Kumho; by Joo et al.(1983) in river Taechong; by Joo(1984) in river Hyungsan; by Rhee et al.(1983 and 1984) in river Mangyeong and river Tongjin; and by Yoo et al.(1984) in river Taehwa. Recently, Joo(1988) studied the changing patterns of infection with digenetic larval trematodes from fresh-water fish in river Taewha, Kyungnam Province, and Joo and Hong(1991) reported that the infection rate of *C. sinensis* from fish hosts in river Ahnseong was relatively high, and the metacercarial burden varied greatly by different fish.

Most of recent reports, however, show a marked decrease in human cases and in the number of *Clonorchis* metacercariae per fish as well as a diminution in distribution areas of the intermediate hosts.

The river Taega is a tributary of the river Nakdong and located in the south-western part of

* The results of this study were presented at the 35th annual meeting of the Korean Society for Parasitology (1993).

Kyungpook Province. In the Taega basin, there are some peculiar houses that would sell raw fresh-water fish to local residents and visitors.

This study has been proceeded as a part of our investigation in the epidemiology and control of human clonorchiasis, since the fresh-water fish was found to play as the main vector of *C. sinensis* prevalent in Korea. This paper deals with the infection rates and intensity for larval trematodes in the fish hosts.

Materials and Methods

1. Geographical conditions of surveyed areas: The river Taega, about 160km in length, has its origin in the eastern range of the Mt. Kaya, Mt. Dokyong and Mt. Hyungjae. The main stream of

the river runs through Seongju and Kolyung counties, and then joins with the river Ahnseong in the southern part of Kolyung town, and then it joins the river Naktong in the Kaeki village of Ugok myun.

There are 10 rivulets in the basin. Eight locations in the river Taega, Habin, Shinan, Sachon, Podong, Yeongdong, Weolsan, Sulyun and Taega, were selected as the study areas because of the abundance of the fresh-water fish (Fig. 1).

The localities are from 80 to 182 meters above sea level and the soil is mainly composed of sand, pebble, and rock with mud (Table 1). The water in the river is fairly constant except 5-6 days after heavy rain. Many types of marsh grasses cover on the river-side and many kinds of fresh-water fish live in the water.

Table 1. Environmental conditions of surveyed areas in the vicinity of river Taega (1993)

Surveyed area			Bottom structure	Mean of water depth(m)
County	Myun*	village		
Kolyung	Kolyung	Habin	pebble and sand	2-3
	Unsu	Weolsan	pebble and sand	1-2
	Gaejin	shinan	pebble and sand	1-2
	Ugok	Podong	sand and pebble	2-4
		Yeondong	sand and pebble	2-3
		Sachon	sand and pebble	2-4
Seongju	Sulyun	Shinpa	pebble and rock	1-2
	Gacheon	Changchon	pebble and rock	1-2

* Myun means the administrative unit in the Province.

2. The fish host survey: Fresh-water fish were caught in the river Taega by netting and fishing with rod and line during the period from April in 1992 to October in 1993. The fish, after removal of their intestinal contents to prevent autolysis, were forwarded to the Department of Parasitology. The specific names of the fish were determined by the keys described by Chung (1977).

In order to determine the distribution of encysted larvae of trematodes, the fish were dissected into their flesh, scales, fins and tail. One

gram of flesh, 50 scales, all fins and tail were taken from each fish using a knife, compressed between two large slides (50 × 90mm) and examined for the presence of metacercariae of digenetic trematodes under a binocular dissecting microscope.

In order to isolate the larval trematodes and to estimate average number of cysts per gram of flesh, the digestion technique was also applied. One gram of flesh, mixed with artificial gastric juice. The juice consisted of 0.2g of diluted hydrochloric acid and 0.3g pepsin per 100ml of

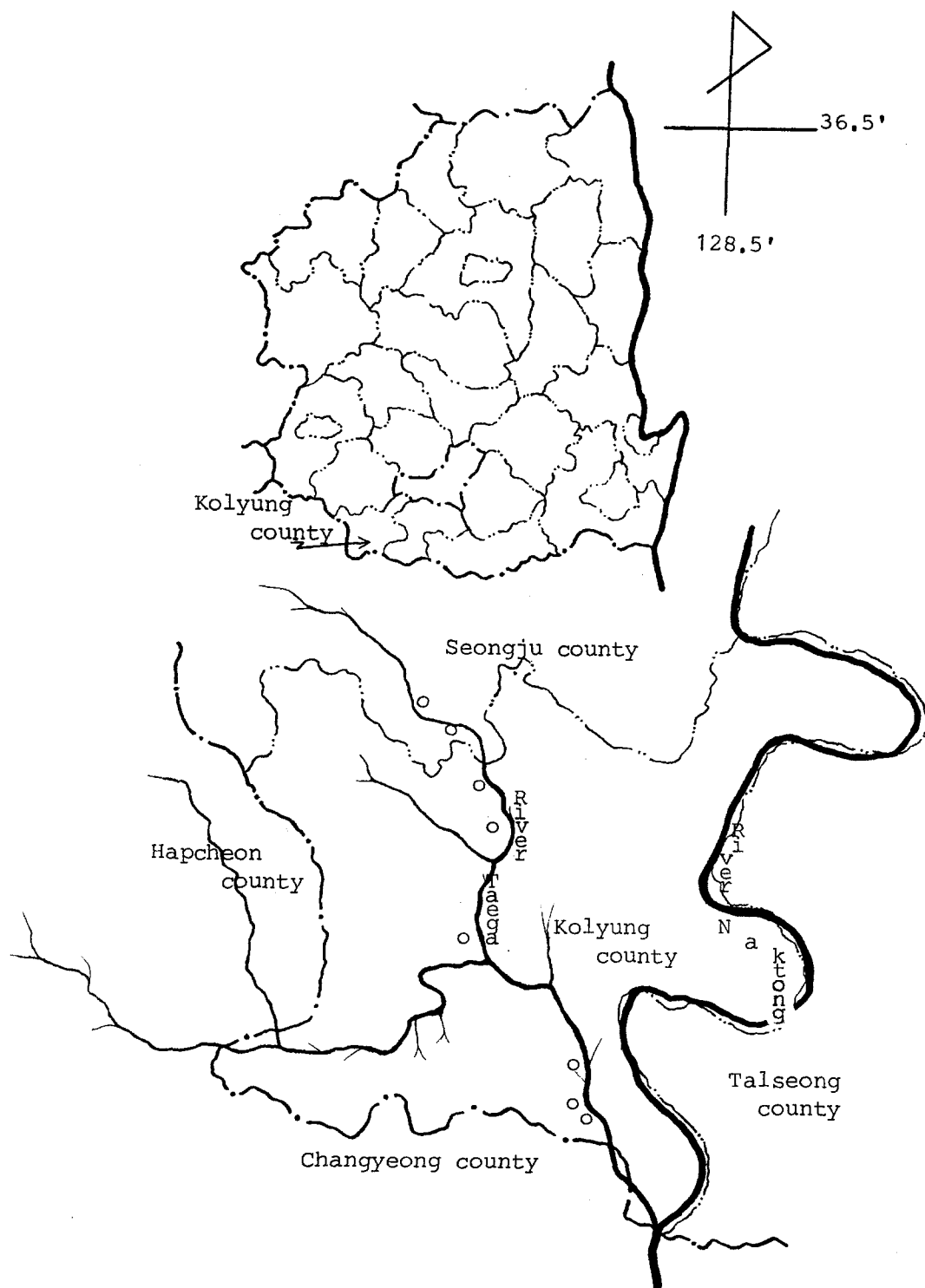


Fig. 1. Surveyed areas(o) in the vicinity of river Taega, Kyungpook Province, Korea.

distilled water. The beakers containing the mixture were incubated under the temperature 37–38 °C for 30–40 minutes. In order to liberate the metacercaria from the cyst, the cysts obtained by digestion technique were washed with physiological NaCl solution thoroughly and then put into the artificial intestinal juice. The juice consisted of 0.2g sodium bicarbonate and 0.5g of trypsin per 50ml of physiological NaCl solution. The beakers containing the mixture were incubated under the temperature 37–38 °C as before for 30–40 minutes.

The excysted larvae stored in a refrigerator were used for observations on the arrangement and number of flame cells. The keys of morphological characteristics of larval trematodes are as follows:

Metacercaria of *Clonorchis sinensis* (Cobbold, 1875)

The mature cyst is oval in shape, measuring $0.12-0.16 \times 0.083-0.16$ mm. The liberated metacercaria is spatula-like in form, tapering slightly towards the posterior part of the body. It measures approximately 0.406×0.121 mm, and makes vigorous leech-like movements. The body surface is beset transversally with the small spines, which extend all over the body surface except for a small area on the dorso-anterior part of the body, mouth opening and acetabulum. On both lateral margin of the body provide with 14 sensory papillae. Numerous masses of brownish yellow pigments are found scattered throughout the body. The oral sucker measures about 0.049 mm in diameter and is smaller than the ventral one, which measures about 0.062 mm in diameter. Following the oral sucker a short prepharynx and oval-shaped pharynx are present. The esophagus bifurcates medianly at a point between the pharynx and anterior margin of the acetabulum into intestinal branches, which run along the side of the body up to its posterior end. The skin glands are found on the surface of the anterior part of the body, numbering about 24 in all: one lateral to the oral sucker, one lateral to the pharynx, six

laterally, in the area between the pharynx and the acetabulum, three near the esophagus and one on the upper margin of the acetabulum, respectively, on each side of the body. They all open ventrally to the exterior. The cephalic glands are found in a group in the triangle formed by the intestinal ceca and the acetabulum. Their ducts, 12 in number, proceed upwards to the dorsal margin of the mouth opening, where they open externally.

The transversal nerve commissure is found medianly under the pharynx. The testes primordia are recognized as small balls obliquely situated, ones on each side of the excretory vesicle. The ovarian complex is found in the midline between the acetabulum and the excretory vesicle. The excretory vesicle occupies the greater part of the posterior part of the body. The main excretory canal starts from the upper lateral corner of the excretory vesicle. It is divided into the anterior and posterior collecting tubes. The former proceeds upwards and then is divided into two branches, each of which has three flame cells with their respective collecting excretory capillaries.

The posterior collecting tube proceeds downwards parallel to the main excretory canal, and after sending one branch upwards at the level of the upper end of the main excretory canal, it is divided into branches. Each of these branches has three flame cells with their respective excretory capillaries. Thus the flame cell formula is $2 \times [(3+3) + (3+3+3)]$. The details of morphological and biological features of the metacercaria were presented by Kobayashi(1912 and 1922), Hsu et al.(1937), Komiya and Tajimi(1940), Watanabe(1942), Komiya and Tajimi(1941), Sakai (1953), Horiuchi(1956), and others.

Metacercaria of *Exorchis oviformis* Kobayashi, 1915

The morphology of *Exorchis oviformis* metacercaria is elliptical in shape, measuring about $0.13-0.23 \times 0.09-0.23$ mm. The liberated metacercaria is pyriformed body, tapering at the anterior

end, bluntly oval at the posterior end of the body. It measures approximately $0.17-0.23 \times 0.11-0.12$ mm, armed with the cuticular spines in the anterior body. No sensory organ present on the lateral sides of the body. No pigment granules scatters in body. It has a pair of the eyespots on the lateral part to the pharynx. The oral sucker is rounded ($50 \times 60 \mu$). The prepharynx, pharynx and esophagus present. The intestinal ceca terminates near the posterior end of the body, and contains the disc-shaped substance. The acetabulum is smaller than the oral sucker, locates medianly anterior to middle of the body. Along its posterior margin transversally elliptical swelling present, on which 3 sensory papillae lying. Around opening of the acetabulum present 6 other sensory papillae. The head glands, more than 20 in number, are found on both lateral sides of the anterior body and open around the oral sucker. The central nerve commissure is found on the posterior to the pharynx. The testes are found symmetrically on another posterolateral to the acetabulum. The uterus starts from the ovary, runs posteriorly, and then anteriorly. It opens near the anterior margin of the acetabulum. The excretory vesicle is V-shaped, its both lateral stems attain anterolateral to the acetabulum. The excretory granules are smaller and less sparsely distributed. The flame cell formula is $2 \times [(2+2) + (2+2)]$.

The details were reported by Kobayashi(1915), Hasegawa(1934), Izumi(1935), Okabe(1936), Komiya and Tajimi(1941), Miyoshi(1948), Yamaguti(1938), Chun(1960) and others.

Metacercaria of *Metagonimus yokogawai* (Katsurada, 1912) and *Metagonimus takahashi* (Suzuki, 1929)

The mature cyst is disc-shaped ($0.14-0.16$ mm in size) or elliptical in form ($0.14-0.18 \times 0.13-0.15$ mm). The liberated metacercaria is flat form, oval tapering anterior end of the body (0.29×0.18 mm), with fairly conspicuous scales in the an-

terior half of the body. The sensory papillae (2-3 in number) are present on the both lateral sides of the body near the anterior end. The head glands present on the postero-lateral to the pharynx, numbering six on each side. They all open on the dorsal margin of the oral sucker arranged in a row. The pharyngeal glands, two on every side lateral to the pharynx, opening near the inner margin of the pharynx. The skin glands are found on every side near the acetabulum and the ceca, numbering ten in all. The yellow brownish pigment granules are scattered in the body, particularly in the area of intestinal bifurcation. The oral sucker measures about 50×35 in diameter.

Following the oral sucker a short prepharynx and an elliptical-shaped pharynx are present. The esophagus is relatively long. The intestinal ceca terminates near the posterior end of the body on the lateral to the excretory vesicle.

The acetabulum ($22 \times 18 \mu$) is markedly smaller than the oral sucker, deflecting to the right of mid-line, with its long axis directed diagonally.

The testes anlagen shows laterally to the excretory vesicle at level of its $1/2$ height symmetrically one another, overlapping partly with the vesicle: small, and rounded.

The ovarian anlage is smaller than the testes and situated in the sinistro-lateral to the acetabulum between this and the excretory vesicle. The excretory vesicle shows flat, V-shaped, being constricted anterolateral owing to presence of the testes. The excretory granules in it are variable in size, the largest being is 49 in diameter. The details were reported by Katsurada(1912), Yokogawa(1913), Izumi(1935), Okabe(1940), Sakai(1954), Chun(1960), Ito(1964), Hong and Seo(1969) and others.

Metacercaria of *Cyathocotyle orientalis* Faust, 1922

The cyst of *Cyathocotyle orientalis* is rounded in shape, measuring about 0.10 mm in diameter, with transparent one layer (18μ in diameter),

surrounded by the outer layer of the connective tissue of the host origin. The layer of the host origin provides frequently with projections on the both pole. The larva in metacercaria is provided with conspicuous W-formed excretory system filling with the excretory granules, giving the characteristic appearance through the metacercaria. The liberated metacercaria is oval shaped (0.23×0.19 mm in size).

The large attached organ is prominently protruded on the ventral surface. The body surface is beset with the cuticular scales densely, particularly in the area of the oral sucker. The sensory papillae are found on the lateral sides of the body, usually 10 or more in number. The subterminal and elliptical oral sucker ($30 \times 43 \mu$ in diameter) and pharynx are well developed. The esophagus is very short. The intestinal ceca is arc-formed and runs downwards. It terminates medianly near the posterior end of the body. A pair of main excretory stems run laterally upto the pharynx, united with each other. Another pair of the excretory branch, starting from the former, also unites with each other and both excretory stems. They are broad, filled with the excretory granules. The most of concretions are oblong in shape ($3.6 \times 1.8 \mu$).

The excretory pole opens somewhat apart from the posterior end of the body.

The main excretory canal starts from the lateral excretory stem at level of its anterior third. The basic form of the flame cell formula is $2 \times [3 + (3 + 3) + \langle (3 + 3) + (3 + 3) \rangle]$. The details of morphological features were reported by Yamaguti(1940), Komiya and Tajimi(1941), Hasegawa(1934), Miyoshi(1948), Sakai(1954) and others.

***Metacercaria hasegawai* Komiya et Tajimi, 1941**

The *Metacercaria hasegawai* is rounded or elliptical, measuring about $0.21 - 0.22 \times 0.25 - 0.29$ mm in size, with the double layers. The outer layer is relatively thin and yellow brownish fine granules found attached on the inner surface of the cyst layer, which makes the appearance of the cyst

is yellowish brown in color. The inner layer is very thin and transparent. The liberated metacercaria is spindle-formed, $0.33 - 0.53 \times 0.23 - 0.27$ mm in size. The several pigment granules are present in the body. On the surface of the body another very minute brown pigment granules are scattered and the body appears brownish in color. The body surface is beset with the cuticular spines, growing less sparsely at the posterior end of the body. A spindle-shaped area without spines is found on the ventral side of the oral sucker. The oral sucker locates subterminal and is rounded ($67 - 98 \mu$ in diameter). The acetabulum locates in the middle part of the body and is smaller than the oral one. The head glands, about 36 pairs in number, are found on the lateral part to the pharynx, and open in the ventral spindle-shaped area without spines. the pharyngeal glands, about 20 in number, are present in the pharyngeal area and open anteriorly to the pharynx. The prepharynx is short and the pharynx is relatively large.

The esophagus is 2 times as long as the pharynx. The intestinal ceca terminates laterally at the level of the anterior margin of the excretory vesicle. The central nerve commissure is found posteriorly to the pharynx. The testes anlagen is found obliquely in both lateral sides of the excretory vesicles. The anlagen of vasa efferentia and vas deferens are well developed. The latter opens medianly on the anterior margin of the acetabulum. The ovarian anlage is rounded and situated median between the acetabulum and excretory vesicle. The oviduct and vitteline duct are well differentiated. The excretory vesicle occupies the large part of the posterior body, and is Y-formed in shape. The flame cell formula is $2 \times [(5 + 6 + 6) + (6 + 6 + 6)]$. The details were reported by Hasegawa(1934), Izumi(1935), Okabe(1939), Komiya and Tajimi(1941 and 1942), Sakai(1954) and others.

***Metacercaria of Metorchis orientalis* Tanabe, 1920**

The cyst is globulous in shape ($0.16 - 0.14$ mm),

with double layers. The liberated metacercaria is elliptical in form, tapering at the anterior end and bluntly rounded at the posterior end of the body. On the both lateral sides of the body are provided with ten or more sensory papillae. The brownish pigment granules are distributed in the body. The skin glands, 3 pairs in number, are arranged in the lateral part to the oral sucker, and other 7 pairs showed the lateral sides of the body. The rounded oral sucker (69μ in diameter) bears 3 sensory papillae around its opening and the acetabulum, of the same size as the oral sucker, situated median between the middle and posterior third of the body, providing with 6 papillae around the opening. The prepharynx and pharynx are present. The esophagus is short, 2-3 times as long as the pharynx.

The intestinal ceca terminates near the posterior end of the body and contains with the disc-like substances. The testes anlagen situate obliquely one another on both lateral sides of the excretory vesicle. The ovarian anlage including female genital anlagen is found from the anterior margin of the acetabulum to its posterior margin along the right margin of the acetabulum. The excretory vesicle occupies the large part of the posterior part of the body and opens the dorsal part at the level of the testes. The flame cell pattern is basically $2 \times [(6+6) + (6+6+6)]$. The details were reported by Tanabe(1920), Yamaguti(1933 and 1934), Hasegawa(1934), Komiya and Tajimi(1941 and 1942) and others.

Metacercaria of *Echinochasmus* species A

The cyst is elliptical in shape, measuring about $92.0-108.0 \times 91.0-97.0\mu$ in diameter, with hyaline and colorless double layers (1.5μ in thickness).

The liberated metacercaria is elliptical in shape, the anterior part of the body is somewhat tapering, $0.18 \times 0.097\text{mm}$ in size. There is no eyespots and pigment in the body. The body surface is beset with the cuticular spines. The head collar is present and provides with 12 spines

around the oral opening, interrupted dorsally on both sides arranging in a row. The oral sucker locates subterminal, and is rounded or elliptical ($40-46 \times 43-53\mu$). The acetabulum is found median at the anterior margin of the posterior third of the body. It is rounded or elliptical. Around its opening provides with minute spines, 30 in number, 2.7μ length, arranged in a row. The head glands are located dorsally anterior to the posterior margin of the oral sucker, their opening being on the dorsal upper margin of the oral sucker.

The prepharynx is somewhat long, and the pharynx is elliptical in shape. The esophagus is short. The intestinal ceca terminates at the posterior end of the body and contains minute ingesta. The genital anlagen are found at the upper and lower margin of the acetabulum as compact masses. The excretory vesicle is irregularly rounded and opens at the end of the body. The flame cell formula is $2 \times [(1+1+1+1) + (1+1+1)]$. The details were reported by Tanabe(1915 and 1919), Hasegawa(1934), Izumi(1935), Okabe(1940), Komiya and Tajimi(1941), Komiya(1951), Kobayashi(1953), Takahayashi(1953) and others.

Metacercaria of *Echinochasmus* species B

The cyst is elliptical in shape and is smaller than *E. perforiatus* ($77-80 \times 54-60\mu$), with transparent, hyaline, and elastic double layers. The liberated metacercaria is elliptical form, measuring about $0.16-0.07\text{mm}$. The head collar has 24 dorsal interrupted head spines arranging 12 on each side in a row. The oral sucker locates subterminal and is rounded (32μ in diameter). The acetabulum locates median on the posterior third of the body and is somewhat smaller than the oral sucker. The prepharynx is long and the esophagus present. The intestinal ceca terminates at the posterior end of the body, and contains minute granule ingesta. The head glands, six in number, locate on the dorsal part to the oral sucker and their ducts open on the dorsal margin

of the oral sucker.

The genital anlagen is recognizable as 2 cell masses on the anterior and posterior margin of the acetabulum. The excretory vesicle is found in the posterior end of the body and is irregularly rounded. It opens at the posterior end of the body. The concretions in the descending part of the main excretory canals, 4-5 in number, show in one side. The flame cell formula is $2 \times [(1+1+1+1+1) + (1+1+1)]$. The ciliae is present in the ascending parts of the excretory canals, 4-5 in number on each side. They are easily taken for flame cells.

The details were reported by Tanabe(1926), Kurisu(1932), Izumi(1935), Okabe(1940), Yamaguti(1939 and 1951), Komiya and Tajimi(1941), Kanemitsu(1953) and others.

Results

A total of 1,239 fresh-water fish or 17 species belonging to families Cyprinidae, Bagridae, Channidae, Serranidae, and Siluridae were collected from the river Taega, Kyungpook Province during the period from 1992 to 1993. The individual numbers and species are shown in Table 2. Of

Table 2. Individual number of fresh-water fish caught in river Taega, Kyungpook Province, Korea (1993)

Species	Common name	Korean	Length (Cm)	No. of fish collected
Family Cyprinidae				
<i>Acanthorhodeus taenianlis</i> Gunter	Korean rose bitterling	큰 납 지 리	5.0-11.0	24 (1.8)**
<i>Carassius carassius</i> Linnaeus	Crussian carp	붕 어	2.8-10.0	92 (7.0)
<i>Coreoleuciscus splendidus</i> Mori	-	쉬 리	7.2-10.5	6 (0.5)
<i>Gnathopogon atromaculatus</i>	Korean shiner	물 개	5.0- 7.5	158(12.0)
Nichols et Pope				
<i>Hemibarbus labeo</i> (Pallas)	Korean barbel	누 치	8.5- 8.5	1 (0.07)
<i>Hemibarbus longirostris</i> (Regan)	Long-nosed barbel	참 마 자	12.5-12.5	26 (2.0)
<i>Moroco oxycephalus</i> (Bleeker)	Fat minnow	버 들 치	6.0-11.5	9 (0.7)
<i>Paracheilognathus rhombea</i> (T et S)*	Fat bitterling	납 지 리	3.0- 8.0	155(11.8)
<i>Pseudogobio esocinus</i> (T et S)	Goby minnow	모 래 모 치	6.0- 9.0	56 (4.2)
<i>Pseudorasbora parva</i> (T et S)	Southern topmouthed minnow	참 붕 어	6.0- 8.0	61 (4.6)
<i>Pungtungia herzi</i> Herzenstein	Striped shiner	돌 고 기	7.5-11.0	166(12.6)
<i>Saurogobio dabryi</i> bleeker	-	두 우 쟁 이	6.5- 8.0	140(10.6)
<i>Zacco platypus</i> (T et S)	Plaie chub	피 래 미	7.5-17.0	203(15.4)
<i>Zacco temminckii</i> (T et S)	Dark chub	갈 견 이	6.5-13.0	166(12.6)
Family Bagridae				
<i>Coreobagrus brevicorpus</i> Mori	Bullhead	꼬치동자개	8.0-10.0	30 (2.3)
Family Channidae				
<i>Channaargus</i> (Cantor)	Spotted serpent head	가 물 치	13.5-13.5	1 (0.07)
Family Serranidae				
<i>Coreoperca herzi</i> Herzenstein	Perch	꺽 지	5.0- 5.5	21 (1.6)
Family Siluridae				
<i>Parasilurus asotus</i> Linnaeus	Catfish	메 기	8.0-13.0	4 (0.3)

* T et S : Temminck et Schlegel.

** Number of parentheses means percent collected.

these, the Korean shiner(*G. atromaculatus*), the flat bitterling(*P. rhombea*), the striped shiner(*P. herzi*), Saurogobio dabryi, the pale chub(*Z. platypus*), and the dark chub(*Z. temmincki*) are the most frequently collected species of fish. Four species, *C. splendidus*, *M. oxycephalus*, *C. argus*, and *P. asotus* are known to be the common species of the river, but in present survey they are less frequently collected.

Table 3 shows the infection rates of encysted larvae of digenetic trematodes according to the species of fresh-water fish collected from the river Taega.

Seven kinds of larval trematodes, *C. sinensis*, *Cyathocotyle orientalis*, *Echinochasmus* species *Exor-*

chis oviformis, *Metacercaria hasegawai*, *Metagonimus yokogawai* and *Metorchis orientalis*, and some unidentified larvae were found in the flesh of the fish hosts.

Of the 10 species of fish with *Clonorchis* metacercaria, *P. parva* was the most highly infected with the positive rates of 86.0 per cent, followed by *P. herzi* with 63.1 per cent, *G. atromaculatus* with 56.8 per cent, and *P. esocinus* with 55.4 per cent. The less frequently infected fish were *A. taenianalis* and *C. brevicorpus*, 12.5 per cent and 16.7 per cent, respectively. From the remaining seven kinds of fish, no *Clonorchis* metacercaria was found.

The encysted larvae of *Metacercaria hasegawai*

Table 3. Infection rates of encysted larvae of digenetic trematodes in flesh of fresh-water fish caught in river Taega(1993)

Species	No. of fish examined	C. s*	C. o	E. s	E. o	M. h	M. y	M. o	Und. s
		No.(%)	No.(%)	No.(%)	No.(%)	No.(%)	No.(%)	No.(%)	No.(%)
<i>A. taenianalis</i>	24	3(12.5)	9(37.5)	1 (4.2)	14(58.3)	4(16.7)	8(33.3)	0	7(29.2)
<i>C. carassius</i>	92	0	16(17.4)	0	0	20(21.7)	9 (9.8)	0	7 (7.6)
<i>C. splendidus</i>	6	0	0	1(16.7)	0	0	0	0	1(16.7)
<i>G. atromaculatus</i>	158	91(57.6)	9 (6.0)	72(45.6)	2 (1.3)	62(39.2)	4 (2.5)	0	33(20.8)
<i>H. labeo</i>	1	0	0	0	0	0	0	0	0
<i>H. longirostris</i>	26	14(53.8)	17(65.4)	5(19.2)	3(11.5)	11(42.3)	0	0	8(30.8)
<i>M. oxycephalus</i>	9	0	0	0	2(22.2)	1(11.1)	0	2(22.2)	5(55.6)
<i>P. rhombea</i>	155	51(32.9)	101(65.2)	42(27.1)	32(20.6)	88(56.8)	8 (5.2)	0	55(35.4)
<i>P. esocinus</i>	56	31(55.4)	30(53.6)	24(42.9)	17(30.4)	29(51.8)	3 (5.4)	1 (1.8)	28(50.0)
<i>P. parva</i>	61	46(75.4)	50(82.0)	13(21.3)	14(23.0)	8(13.1)	1 (1.6)	0	10(16.4)
<i>P. herzi</i>	166	107(64.5)	89(53.6)	38(22.9)	1 (0.6)	55(33.1)	2 (1.2)	1 (0.6)	37(22.3)
<i>S. dabryi</i>	140	57(40.7)	67(47.8)	67(47.8)	68(48.6)	52(37.1)	16(11.4)	16(11.4)	26(18.6)
<i>Z. platypus</i>	203	0	31(15.3)	129(63.5)	10 (4.9)	10 (4.9)	25(12.3)	0	13 (6.4)
<i>Z. temmincki</i>	166	0	39(23.5)	148(88.1)	15 (9.0)	4 (2.4)	34(20.5)	0	26(15.7)
<i>C. brevicorpus</i>	30	5(16.7)	3(10.0)	4(13.3)	1 (3.3)	6(20.0)	1 (3.3)	0	6(20.0)
<i>C. argus</i>	1	0	0	0	0	0	0	0	0
<i>C. herzi</i>	21	6(28.6)	0	0	0	5(23.8)	0	0	1 (4.8)
<i>P. asotus</i>	4	0	0	0	0	0	0	0	0

C. s : *Clonorchis sinensis*

E. o : *Exorchis oviformis*

M. o : *Metorchis orientalis*

C. o : *Cyathocotyle orientalis*

M. h : *Metacercaria hasegawai*

Und. s : Undetermined species

E. s : *Echinochasmus* species

M. y : *Metagonimus yokogawai*

were recovered from 14 species of fish and found in the flesh, ranging in the frequency from 2.6 per cent to 56.0 per cent. Similarly, the larvae of *C. orientalis*, *Echinochasmus* species and *E. oviformis* were found from 12 species of fish, respectively, followed by *M. yokogawai* from 11 kinds of fish, and *M. orientalis* from 4 species of fish.

In the case of *M. yokogawai*, the 11 species of fish harboured the cyst varying in the rate from 1.3 per cent to 33.3 per cent. Of these, *A. taenianalis* was the most highly infected with the infection rate of 33.3 per cent, and *Z. temmincki* was next highly with 21.8 per cent, while *G. atromaculatus*, *P. rhombea*, *P. esocinus*, *P. parva*, *P. herzi*, and *C. brevicorpus* were very lightly infected.

The encysted larvae of digenetic trematodes found on the scales of fresh-water fish are listed in Tabel 4. The *Metagonimus* metacercariae were found in 11 species of fish. The infection rate for

cyst on the scales ranged from 0.6 per cent to 75.0 per cent. The cysts of *M. hasegawai* were found from 9 species of fish, followed by *C. orientalis* and *E. oviformis* from 3 species, *C. sinensis* and *Echinochasmus* species from 2 kinds of fish, respectively. However, the metacercarial rates varied and were generally low.

Table 5 presents the infection rates of encysted larvae of digenetic trematodes on the fins and tail of fresh-water fish. The 6 kinds of encysted larvae were found in the fins and tails of fish. Of these, *Metagonimus* metacercariae were found from 12 species of fish, followed by *M. hasegawai* from 10 species, *Echinochasmus* species from 4 species, *C. orientalis* and *E. oviformis* from 3 species, and *C. sinensis* from 2 species. The infection rates for cysts on the fins and tail showed a similar pattern to the data on the scales of fish.

The infection intensity with the encysted larvae

Table 4. Infection rates of encysted larvae of digenetic trematodes on scales of fresh-water fish(1993)

Species	No. of fish examined	C. s*	C. o	E. s	E. o	M. h	M. y	Und. s
		No.(%)	No.(%)	No.(%)	No.(%)	No.(%)	No.(%)	No.(%)
<i>A. taenianalis</i>	24	0	0	0	0	3(12.5)	18(75.0)	9(37.5)
<i>C. carassius</i>	92	0	3 (3.3)	0	0	4(4.3)	20(21.7)	6 (6.5)
<i>C. splendidus</i>	6	0	0	0	0	0	0	3(50.0)
<i>G. atromaculatus</i>	158	2 (1.3)	0	3 (1.9)	0	2 (1.3)	1 (0.6)	19(12.0)
<i>H. labeo</i>	1	0	0	0	0	0	0	0
<i>H. longirostris</i>	26	0	0	0	0	2 (7.7)	1 (3.8)	11(42.3)
<i>M. oxycephalus</i>	9	0	0	0	0	0	1(11.1)	1(11.1)
<i>P. rhombea</i>	155	0	2 (1.3)	0	0	11 (7.1)	12 (7.7)	73(47.1)
<i>P. esocinus</i>	56	0	0	0	0	0	13(23.2)	28(50.0)
<i>P. parva</i>	61	0	0	0	1 (1.6)	0	0	15(24.6)
<i>P. herzi</i>	166	5 (3.0)	1 (0.6)	1 (0.6)	0	5 (3.0)	2 (1.2)	21(12.7)
<i>S. dabryi</i>	140	0	0	0	1 (0.7)	5 (3.6)	14(10.0)	65(46.4)
<i>Z. platypus</i>	203	0	0	0	0	0	63(31.0)	35(17.2)
<i>Z. temmincki</i>	166	0	0	0	1 (0.6)	0	56(33.7)	31(18.7)
<i>C. brevicorpus</i>	30	0	0	0	0	2 (6.7)	0	0
<i>C. argus</i>	1	0	0	0	0	0	0	0
<i>C. herzi</i>	21	0	0	0	0	0	0	0
<i>P. asotus</i>	4	0	0	0	0	0	0	0

Table 5. Infection rates of encysted larvae of digenetic trematodes on fins and tail of fish(1993)

Species	No. of fish examined	C. s*	C. o	E. s	E. o	M. h	M. y	Und. s
		No.(%)	No.(%)	No.(%)	No.(%)	No.(%)	No.(%)	No.(%)
<i>A. taenianalis</i>	24	0	0	0	0	4(16.7)	18(75.0)	8(33.3)
<i>C. carassius</i>	92	0	2 (2.2)	0	0	12(13.0)	22(23.9)	0
<i>C. splendidus</i>	6	0	0	0	0	0	0	2(33.3)
<i>G. atromaculatus</i>	158	4 (2.5)	0	1 (0.6)	0	4 (2.5)	18(11.4)	16(10.1)
<i>H. labeo</i>	1	0	0	0	0	0	0	0
<i>H. longirostris</i>	26	0	0	0	0	8(30.8)	2 (7.7)	7(26.9)
<i>M. oxycephalus</i>	9	0	0	0	0	0	1(11.1)	3(33.3)
<i>P. rhombea</i>	155	0	0	2 (1.3)	0	18(11.6)	64(41.3)	49(31.6)
<i>P. esocinus</i>	56	0	1 (1.8)	0	1 (1.8)	6(10.7)	38(67.9)	20(35.7)
<i>P. parva</i>	61	0	0	0	0	0	0	18(29.5)
<i>P. herzi</i>	166	9 (5.4)	1 (0.6)	1 (0.6)	0	16 (9.6)	16 (9.6)	14 (8.4)
<i>S. dabryi</i>	140	0	0	0	0	0	71(50.7)	45(32.1)
<i>Z. platypus</i>	203	0	0	0	1(0.5)	5 (2.5)	75(36.9)	4 (2.0)
<i>Z. temmincki</i>	166	0	0	0	0	3 (1.8)	85(51.2)	9 (5.4)
<i>C. brevicorpus</i>	30	0	3(10.0)	3(10.0)	2 (6.7)	0	7(23.3)	4(13.3)
<i>C. argus</i>	1	0	0	0	0	0	0	0
<i>C. herzi</i>	21	0	0	0	0	1 (4.8)	0	1 (4.8)
<i>P. asotus</i>	4	0	0	0	0	0	0	3(75.0)

of digenetic trematodes in flesh of fresh-water fish are shown in Table 6. The metacercarial density in fish, however, expressed in average number of encysted larvae per gram of flesh, was low as a whole. In the case of *C. sinensis*, the 10 species of fish harboured the cyst varying in intensity from 1.7 to 30.9. Of these, the most heavily infected fish was *G. atromaculatus*, being found to be 30.9 cysts, followed by *P. parva*, 20.9 cysts, *S. dabryi*, 10.0 cysts, and *P. rhombea*, 8.0 cysts. While, *A. taenianalis*, and *C. herzi* were very lightly infected. Of the 10 kinds of fish with *M. yokogawai*, *S. dabryi* was the most heavily infected with the larvae and the average number of larvae was 6.0. *P. esocinus* was next with an average of 4.0 cysts. *C. carassius*, *G. atromaculatus*, and *Z. temmincki* were moderately infected, with an average number varying from 2.5 to 3.3 cysts. How-

ever, *A. taenianalis*, *P. rhombea*, *P. parva*, and *P. herzi* were less heavily infected with the larvae, with an average of 1.0, 0.5, 1.0, 1.0 cysts, respectively.

In the case of *M. hasegawai*, the intensity of the cysts in the flesh was lower than that of *C. sinensis*. Of these, *G. atromaculatus* was the most heavily infected, with an average of 12.7 cysts. *P. rhombea* and *C. brevicorpus* were next with 7.7 and 6.8 cysts, respectively. *H. longirostris*, *P. esocinus*, *P. herzi*, *C. carassius*, *M. oxycephalus*, *P. parva*, *S. dabryi*, *Z. platypus*, and *Z. temmincki* harboured around 3.0 cysts per gram of flesh, varying in intensity from 2.0 to 4.0 cysts.

Whereas, *A. taenianalis*, *C. argus*, and *C. herzi* were very lightly infected. As similar pattern was observed in the cases of *C. orientalis* and *E. oviformis*.

Table 6. Infection intensity for encysted larvae of digenetic trematodes in flesh of fresh-water fish (1993)

Species	No. of fish examined	Average number of cyst / g of flesh(ea)							
		C. s*	C. o	E. s	E. o	M. h	M. y	M. o	Und. s
<i>A. taenianalis</i>	24	1.7	23.7	2.4	16.3	1.3	1.0	0	3.3
<i>C. carassius</i>	92	0	6.6	0	0	2.7	2.5	0	1.7
<i>C. splendidus</i>	6	0	0	0.5	0	0	0	0	0.3
<i>G. atromaculatus</i>	158	30.9	4.4	31.1	1.0	12.7	2.5	0	2.5
<i>H. labeo</i>	1	0	0	0	0	0	0	0	0
<i>H. longirostris</i>	26	6.0	4.4	2.6	1.1	4.0	0	0	2.1
<i>M. oxycephalus</i>	9	0	0	0	2.2	2.6	0	1.5	1.4
<i>P. rhombea</i>	155	8.0	20.6	5.5	6.0	7.7	0.5	0	3.5
<i>P. esocinus</i>	56	7.3	3.1	7.4	2.0	3.9	4.0	2.0	3.8
<i>P. parva</i>	61	20.9	23.5	1.9	2.2	2.8	1.0	0	2.2
<i>P. herzi</i>	166	6.1	3.6	1.0	1.0	3.9	1.0	3.0	5.5
<i>S. dabryi</i>	140	10.0	2.5	5.5	4.4	2.5	6.0	4.9	8.6
<i>Z. platypus</i>	203	0	3.6	6.6	1.9	2.4	1.5	0	3.8
<i>Z. temmincki</i>	166	0	3.6	47.8	1.7	2.0	3.3	0	3.4
<i>C. brevicarpus</i>	30	6.8	2.0	1.8	1.0	6.8	0	0	1.5
<i>C. argus</i>	1	0	0	0	0	1.0	0	0	0
<i>C. herzi</i>	21	4.0	0	0	0	1.0	0	0	0
<i>P. asotus</i>	4	0	0	0	0	0	0	0	0

Discussion

Since the first report on the discovery of *C. sinensis* metacercariae from flesh of several kinds of fresh-water fish collected in seven localities of southern Korea (Kobayashi, 1924), the biological, ecological and morphological studies of encysted larvae of digenetic trematodes in the fish hosts have been conducted by many investigators in Korea. As a result, it has been demonstrated that approximately 80 piscine species belonging to 10 families play the important role in transmitting digenetic trematodes in the endemic areas of Korea.

The river Taega is a tributary of river Nakdong and located in the southwestern part of Kyungpook Province. In the Taega basin, there

are many peculiar houses that would sell raw-fish to local residents and visitors. Furthermore, rural and urban residents visit these clear water on weekends and/or holidays, and the majority of residents in the villages along the sides of the river enjoy fishing and also consuming the raw fish with rice-wine and/or distilled spirits.

They are not concerned about infection with intestinal and hepatic flukes, but believe that fresh-water fish collected in this basin are completely free of larval trematodes because the river is clear and running over pebbles and sandy bottoms. However, this traditional concept was found to be false by this study.

The results in this study showed that the infection rates for the encysted larvae in the fresh-water fish varied appreciably from fish to fish, and the intensity of infection with larval

trematodes was relatively low as compared with the earlier reports available.

In the studies of fish hosts with larval trematodes, few works were done before the end of the Korean War, although fresh-water fish belonging to the family Cyprinidae were thought to serve as intermediate hosts of intestinal and/or hepatic flukes in Korea because some studies on the incidence of *C. sinensis* among the residents and its intermediate hosts were conducted by Japanese workers(Matsumoto, 1915; Chung, 1926; Furuyama, 1927; Nishimura, 1943).

After the Korean War, a relatively high infection rates of *Clonorchis metacercariae* have been reported by many investigators, such as Soh (1951) in Chunpook Province, Lee(1956), Kim (1974), Choi(1977), Hwang(1978), and Joo(1980, 1988) in Kyungnam Province, Yun and Chung (1975) in Kyunggi Province, and Kim(1980) in Chungnam Province.

In Kyungpook Province, the detailed reports of larval trematodes from fish hosts have been presented in the vicinity of river Naktong and its tributaries, and the isolated rivers such as, Hyungsan, Ossep, Taechong and Wyangpi rivers.

Lee and Kim(1958) found the metacercaria of *C. sinensis* in 9 of 10 species of fresh-water fish collected in the vicinity of river Kumho, which was followed by Lee(1968) who investigated these again in more details and within a wider area.

According to his survey, 10 species of larval trematodes and 4 kinds of unidentified larvae were found from twelve species of fish.

Of them, the encysted larvae of *E. oviformis* were demonstrated most frequently from all 12 species, followed by the larvae of *Metagonimus* species from 10 species. The metacercaria of *C. sinensis* were found from 9 species, *M. hasegawai* from 8 species, *C. orientalis* from 7 species of fish. He also reported that the rate and intensity of infection with the larval trematodes varied markedly from fish to fish.

Hwang and Choi(1980) in a comparative study

on infection rate of larval trematode in fresh-water fish collected in the same river, with the results reported by Lee(1968), collected 13 species of fresh-water fish and found that they were infected with 10 species of larval trematodes including 3 unidentified larvae A, B and C.

They also reported that *P. parva* was most heavily infected, the average number of *Clonorchis* larvae per gram of flesh being 41.8. Four species of fish, such as *P. herzi*, *P. esocinus*, *G. atromaculatus* and *A. limbata* were moderately infected, the average number varying from 27.1 to 13.3 cysts, and the remaining 8 species of fish were infected with a few cysts only. Similar results in the river Kumho were obtained by Choi(1976) and Park(1978). Thus, the rates and intensity of infection with the larval trematodes, especially *C. sinensis* cysts in fresh-water fish collected in the Kumho river were found to be decreased.

A relative lower rates of infection with the encysted larvae of digenetic trematodes in the fish hosts collected in the river Hyungsan were reported by Joo(1984). He reported that seven species of larval trematodes, including *C. sinensis* and some kinds of undetermined larva were recovered from 10 species of fresh-water fish and 1 kind of brackish-water fish. Of them, *G. atromaculatus*, *P. rhombea*, *P. herzi* and *P. parva* harboured the *Clonorchis* metacercaria, and all the fish were heavily infected with the encysted larvae of *E. oviformis*.

However, 8 species of fish were infected with *Metagonimus* species.

The intensity of infection with the larval trematodes, the average number of *Clonorchis* cysts per gram of flesh in *G. atromaculatus* was the most heavily infected species, being found to be 45.5, followed by *P. herzi* with 11.6, and *P. parva* with 9.7 cysts.

However, the intensity of infection with the *Metagonimus* species in 8 kinds of fresh-water fish was relatively low, and the average number per gram of flesh varied from 0.23 to 9.1 cysts. Similar

results were obtained by Joo et al.(1983) in the river Taechong, by Lee et al.(1979) in the river Ossep, by Joo and Jheon(1990) in the river Wyangpi, and Yoo et al.(1984) in the river Taewha.

From the studies on the larval trematodes from fresh-water fish in the natural and fish-breeding ponds, Kim and Choi(1981) reported that seven kinds of metacercariae, including those of *C. sinensis* and 2 species of unidentified cysts A and B, were found from 10 species of fish hosts. They also found that the infection rates and intensity of the larval trematodes from all the fish in the ponds was lower than from those in the rivers in Kyungpook Province.

In the present study, 18 species of fresh-water fish were collected, from which 7 species of larval trematodes including 3 kinds of unidentified larvae A, B and C were found. Of the fish examined, *G. atromaculatus*, *H. longirostris*, *P. esocinus*, *P. parva* and *P. herzi* were heavily infected with the encysted larvae of *C. sinensis*. Their rates ranged from 53.8 per cent to 75.4 per cent. *A. taenianalis* and *C. brevicorpus* were less frequently infected with rates for the cysts of the fluke being less than 20.0 per cent.

The intensity of *Clonorchis* infection in the 10 species of fish varied markedly from fish to fish. The average number of the cysts was from 1.7 in *A. taenianalis* to 30.9 in *G. atromaculatus*. The results in this study are in agreement with the data reported by Choi(1976), Hwang and Choi(1980) in the river Kumho, Joo and Hong(1991) in the river Ahnseong, but the degree of infection with *Clonorchis* metacercariae is much lower than those by Lee(1968), Hwang and Choi(1980) in the river Kumho, Lee et al.(1992) and Hyun(1992) in the river Naktong and its tributaries.

The main factors contributing to the variant infection densities in different fish were considered to be the ecology of fish, such as habitats and migration, and the changing ecology of the river. As also indicated by Lee et al.(1992), it was shown in this study that the intensity of in-

fection with *Clonorchis* cysts in fish hosts is decreasing recently. It is suggested that newly established factories and apartments near by the river, massive drainage of waste products into the river together with intense pesticide spray to the rice fields and apple farms, and the destruction of natural environment, such as causing the water level to drop, and regulating the construction of many concrete septa across the river to store water for irrigation of the rice fields may have affected the infection rate and density for the larval trematodes in fish.

The assumption is supported by the fact that the scarcity of fish and the low rate of larval trematodes infections in fish hosts would be due to a pesticidal and artificial effects on the water, which would be inhibitory to the survival of both fish and larval trematodes.

Of the fish examined, 11 species including *C. carassius* and *S. dabryi* harboured the metacercariae of *Metagonimus* species and the infection rates varied appreciably from fish to fish.

In the fish host survey of *Metagonimus yokogawai* in the Province, a relatively high incidence of *Metagonimus* metacercariae have been reported by some investigators, such as in the vicinity of the river Ahnseong by Suh and Choi(1979), in the river Hyungsan by Hwang and Choi(1977), in the river Taechong by Roh(1980), and in the river Taewha by Joo and Park(1984) on brackish-water fish, and in the river Hyungsan by Joo(1984), in the river Taewha by Joo(1980, 1988), and Yoo et al.(1984) on fresh-water fish, and in the river Kumho by Hwang and Choi(1980) on fresh-water fish. Seo et al.(1982)'s report on brackish-water fish covered several Provinces in Korea. As a result, it is obvious that in the Province the metacercaria of *Metagonimus* species are widely distributed, in both fresh and brackish-water fish, and in the brackish-water fish the infection rate is far higher than in the fresh-water fish.

As a few papers shown in the river Taewha, the infection rate of *Metagonimus* metacercariae in fresh-water fish, reported by Joo and Park

(1982), was 44.5–100.0 per cent in *C. carassius*, 8.8–67.6 per cent in *G. atromaculatus*, 6.0–50.6 per cent in *Z. temmincki*, 5.5–50.0 per cent in *Z. platypus*, 40.0 per cent in *P. herzi*, 28.6–42.9 per cent in *M. chinensis*, 18.8–25.0 per cent in *P. rhombea*, 7.7–36.5 per cent in *L. macrochirus* and 4.2–8.3 per cent in *C. brevicorpus*, while that in brackish-water fish reported by Lee et al.(1979) was 100.0 per cent in *P. altivelis*, and 86.7–93.3 per cent in *T. hakonensis*.

As for the survey of distribution of encysted larvae of *Metagonimus* species in the fish hosts, Chun(1960) in a study on *M. yokogawai* from *P. altivelis* in the river Miryang reported that 54.0 per cent among 100 sweetfish were infected, and that 45.3 per cent of total metacercariae detected were found on the scales and fins, followed in the subcutaneous tissues with 26.3 per cent, the muscles with 14.3 per cent, and the head part with 14.1 per cent. Subsequently Hong and Seo (1969) reported that 62.8 per cent of all metacercariae could be detected from the muscles, followed by the subcutaneous tissues with 29.3 per cent, and on the scales with 7.7 per cent.

In this study the encysted larvae of *Metagonimus* species were mostly found on the scales, fins and tail with over fifty per cent incidence, whereas in the muscles and subcutaneous tissues were very few in number.

In the basis of the previously reported data and our own figures, it is concluded that in the fresh-water fish such as *C. carassius* and *Z. platypus*, the metacercariae were mostly found on the scales, fins and tail. While in the case of brackish-water fish such as *P. altivelis* and *T. hakonensis*, it was vice versa, therefore the metacercariae were mostly found in the muscles and subcutaneous tissues. Although main reasons for variant infection rates and intensities in different fish hosts can hardly be explained, it is considered to be due to the ecology of fish, such as habitats and migration of fish, and the topical or seasonal conditions. As to the other factors such

as the water temperature, sanil habitats and final hosts with metagonimiasis are to taken into account.

As for the survey of the average number of *Metagonimus* larvae per gram of flesh, our own figures were 6.0 in *S. dabryi*, 4.0 in *P. esocinus*, 3.3 in *Z. temmincki*, 2.5 in *C. carassius* and *G. atromaculatus*, 1.0–1.5 in *P. parva*, *P. herzi* and *Z. platypus*. These fish are apparently neglected by the residents for raw consumption, but are eaten only by residents living near the river basin usually cooked(roasted, boiled, fried, etc.). According to the residents, they eat *C. carpio*nudus and *C. carassius* in a state of raw, cooking them cut in slices and mixed with vinegar or soybean paste. This assumption is supported by the fact that most cases of clonorchiasis and metagonimiasis among the residents of this river basin previously reported by Joo and Hong(1991), Joo and Lee(1992) and Woo and Joo(1993) showed mild infection.

S. dabryi was first reported as the second intermediate host of *C. sinensis* by Kubo and Makino (1941), who made a survey of the fish hosts in Manchuria, China.

In Korea, especially in Kyungpook Province, three reports on *S. dabryi* have been made up-to date, namely by Joo and Hong(1991) in the river Ahnseong, by Lee et al.(1992) in the river Nak-tong and its tributaries, and lately Woo and Joo (1993) in the river Taega basin. In 140 *S. dabryi* examined in this study, 10 species of larval trematodes including some unidentified larvae A, B and C. Of the larval trematodes, *E. oviformis* was found most frequently, the rate being 48.6 per cent, followed by *C. orientalis* and *Echinochasmus* species with the infection rate of 47.8 per cent, *C. sinensis* with 40.7 per cent and *M. yokogawai* with 11.4 per cent. The intensity of infection with the larval trematodes in those fish species, the average number of *Clonorchis* and other encysted larvae per gram of flesh varied from 2.5 to 10.0 cysts. In the basis of previously reported data

and out own figures, it is clear that *S. dabryi* played the second intermediate host as chief vector for the intestinal and/or hepatic flukes in Korea.

As for the survey of *Echinochasmus* metacercaria in the second intermediate hosts in the Province, Lee et al.(1979) found the encysted larvae in one of 101 *C. carassius* and in two of 36 *G. atromaculatus*. Afterwards, Hwang and Choi(1980) reported the infection rate to be 8.0 per cent in *A. limbata*, 3.8 per in *H. labeo*, 33.3 per cent in *P. esocinus*, 2.9 per cent in *P. parva* and 1.7 per cent in *Z. platypus* collected in the river Kumho, and Joo(1984) also reported the rate to be 19.6 per cent in *Z. temmincki* and 8.3 per cent in *P. altivelis* collected the Hyungsan basin. Yoo et al.(1984) conducted a metacercarial study in fish hosts caught along the river Taewha, and reported that the encysted larvae of *Echinochasmus* species were found from 6 species of fish.

They also reported that the average number of encysted larvae of *Echinochasmus* species per gram of flesh was very low, ranging from 0.01 in *C. brevicorpus* and *Z. temmincki* to 0.7 in *P. parva*.

In the present study, 14 species of fresh-water fish belonging to the family Cyprinidae and one species belonging to each families Bagridae, Chan-nidae, Serranidae and Siluridae, were collected in several localities of the river Taega, in which 12 species of the fish harboured the encysted larvae of *Echinochasmus* species.

The rates and density of infection with *Echinochasmus* metacercaria varied markedly from fish to fish. The average number of the cysts was 0.5 in *C. splendidus*, 1.0-2.6 in *A. taenianalis*, *H. longirostris*, *P. parva*, *P. herzi* and *C. brevicorpus*, 5.5-7.4 in *P. rhombea*, *P. esocinus* and *Z. platypus*, and 31.1-47.8 in *G. atromaculatus* and *Z. temmincki*, respectively. The results in this study are in agreement with data obtained by Joo(1988), but the degree of infection with *Echinochasmus* metacercaria is much higher than those reported by Lee et al.(1979), Hwang and Choi(1980), Kim and Choi(1981) and Joo(1984). As to the survey of *M. orientalis* metacercaria belonging to the family

Opisthorchiidae in Korea, Chun(1964) first found from the muscle of 745 *C. carassius* collected in Kimhae, Ulsan, Pohang and Gunsan.

Afterwards, Lee et al.(1979) discovered the metacercariae from the flesh of 3 species of fresh-water fish and one kind of brackish-water fish, *T. hakonensis*, collected in the river Ossep.

Hwang and Choi(1980) also reported the infection rate to be 8.0 per cent in *A. limbata*, 13.3 per cent in *G. atromaculatus*, 11.4 per cent in *P. parva* and 20.0 per cent in *P. herzi*. Similar results were obtained by Kim and Choi(1981), Joo(1980, 1988), Joo et al.(1983) and Yoo et al.(1984).

Of the fish examined in this study, *M. oxycephalus*, *P. esocinus*, *P. herzi* and *S. dabryi* were infected with the metacercaria of *M. orientalis*. Their rates ranged from 0.6 per cent to 22.2 per cent, and the average number of the cysts was from 1.5 in *M. oxycephalus* to 4.9 in *S. dabryi*. In our own figures and all of the previously reported data, it is of interest to note that the degree of infection with *C. sinensis* and *M. yokogawai* have lower been found in the fresh-water fish in spite of the higher density of *Echinochasmus* species, *C. orientalis* and *E. oviformis* from the fresh-water fish collected.

The main factors of higher density of fish hosts with these metacercaria can hardly be explained. However, large amount of pesticides have been widely used on the rice fields and farms in the Taega basin, and it seems quite possible that some cercaria, such as *C. orientalis*, *Echinochasmus* species and *E. oviformis* are resistant to pesticides, whereas, other cercariae such as *C. sinensis* and *Metagonimus* species are pesticide sensitive.

As also indicated by Lee et al.(1992) and Woo and Joo(1993), it was shown in this study that the intensity of *Clonorchis* and *Metagonimus* infections in fish hosts have been decreasing recently. It is suggested that destruction of the natural environment of the rivers may have affected the infection rates and intensity of infection for the digenetic larval trematodes in fish hosts.

Summary

In order to determine the infection patterns with digenetic larval trematodes from fresh-water fish in the river Taega, the fish collected in the 8 localities of the river were examined during the period from April, 1992 to October, 1993.

Of seventeen species of fish, *Clonorchis sinensis*, *Cyathocotyle orientalis*, *Echinochasmus* species, *Exorchis oviformis*, *Metacercaria hasegawai*, *Metagonimus yokogawai*, *Metorchis orientalis*, and some kinds of undetermined larvae were found.

Of these, the encysted larvae of *Metacercaria hasegawai* was found most frequently from 14 species of fresh-water fish, followed by the larvae of *Exorchis oviformis* and *Echinochasmus* species from 12 species of fish, the cyst of *Metagonimus yokogawai* from 11 species, *Clonorchis sinensis* from 10 species and *Metorchis orientalis* from 4 species of fish. In general, the infection rates for the digenetic larval trematodes varied greatly from fish to fish.

In the intensity of *Clonorchis* infection, *Gnathopogon atramaculatus* was the most heavily infected species, the average number of cyst per gram of flesh being 30.9, followed by *Pseudorasbora parva* with 20.9, and *Saurogobio dabryi* with 10.0 cysts. In the intensity of *Metagonimus* infection in 11 species were relatively low, and the average number varied from 0.5 in *Paracheilognathus rhombea* to 4.0 in *Saurogobio dabryi*. In the intensity of the other digenetic larval trematodes showed variations in different fish.

It was found that the rate of infection with digenetic larval trematodes in fresh-water fish was still high, and the metacercarial burden in the fish varied greatly by different fish, and that *Clonorchis* and *Metagonimus* infections are caused by consuming raw fresh-water fish collected in the river Taega, Kyungpook Province.

Key words: Larval trematodes, fresh-water fish, River Taega, Kyungpook, *Pseudorasbora parva*,

Clonorchis sinensis, *Metacercaria*, Family *Cypriidae*, *Metagonimus yokogawai*

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= 국문초록 =

慶北 大駕川 淡水魚에서의 吸蟲類 被囊幼蟲 寄生狀

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大駕川에 棲息하는 淡水魚에서의 吸蟲類 被囊幼蟲 寄生狀을 알아보기 위해 1992年 4월부터 1993年 10월까지 江流域의 8個處에서 投網과 낚시로 淡水魚를 採集하였다.

採集된 魚類는 魚種別로 分類한 다음 魚體 部位別로 吸蟲類 被囊幼蟲의 寄生率을 調査함과 同時に 新魚 魚肉 1g當 被囊幼蟲數를 計算하여 感染程度를 推定하였다.

採集된 17種의 魚類에서 7種의 吸蟲類 被囊幼蟲, *Clonorchis sinensis*, *Cyathocotyle orientalis*, *Echinochasmus species*, *Exorchis oviformis*, *Metacercaria hasegawai*, *Metagonimus yokogawai* 및 *Metorchis orientalis*와 所屬未定幼蟲을 魚肉에서 檢출할 수 있었다. 肝吸蟲 幼蟲은 10種의 魚類에서 檢出할 수 있었고, 요코가와와 吸蟲 幼蟲은 11種의 魚類에서, *Exorchis oviformis*와 *Echinochasmus species* 幼蟲은 12種에서, *Metacercaria hasegawai* 幼蟲은 14種에서, *Metorchis orientalis* 幼蟲은 4種의 魚類에서 檢出할 수 있었으며, 寄生率은 魚種別로 큰 差異를 나타내었다. 魚肉 1g 當 肝吸蟲 被囊幼蟲 平均數는 물개에서 30.9個로 가장 많았고, 큰납지리에서는 1.7個로 가장 적었으며, 참붕어 두우쟁이 및 납지리에서는 各各 20.9個, 10.0個, 8.0個로 中間値를 나타내었다.

요코가와와 吸蟲 被囊幼蟲은 두우쟁이에 있어서는 6.0個로 가장 많았으며 그 다음은 4.0個를 나타내는 모래모치였으며, 납지리에 있어서는 0.5個로 가장 적었다.

Cyathocotyle orientalis, *Echinochasmus species*, *Exorchis oviformis*, *Metacercaria hasegawai* 및 *Metorchis orientalis* 被囊幼蟲의 感染程度는 魚種에 따라 甚한 差異를 나타내었다.

以上の 成績으로 미루어 보아 慶北 大駕川에 棲息하고 있는 淡水魚에 있어서 肝吸蟲을 비롯한 吸蟲類 被囊幼蟲 寄生率은 아직도 높으나 그 寄生程度는 魚種別로 甚한 差異를 나타내고 있음을 알 수 있었으며, 아울러 淡水魚의 膾를 生食하면 肝吸蟲症과 요코가와와 吸蟲症에 感染될 것으로 推定된다.