

Larval Trematodes from *Semisulcospira* Snails in Kyungpook Province, Korea

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Paragonimiasis is prevalent among the residents in the mountainous districts of Korea and is a nation-wide problem. However, Kyungpook Province has a number of endemic areas.

It has been well known that *Paragonimus westermani* has a distribution among mammals and has the principal host in man and reservoir hosts in dogs, cats, tigers, and wild rats.

The results of early studies of *P. westermani* in Korea revealed that the first intermediate host of the fluke is the fresh-water snail, *Semisulcospira* species (Miyairi, 1917; Hara, 1916; Inemoto, 1916; Moriyasu, 1916; and Ohoki, 1916), and the second intermediate host in the inland areas is the fresh-water crayfish, *Cambaroides similis*, and that in Quelpart Island, the carabs, *Eriocheir japonicus* and *E. sinensis* (Kobayashi, 1918 and 1934; and Lee *et al.*, 1957).

Recently, two species of lung fluke, *P. westermani* (Kerbert, 1878) Brown, 1899, and *P. iloktsuenensis* Chen, 1940 are known to be existed in Korea. Of these, *P. westermani* is the unique species of human lung fluke and *P. iloktsuenensis* a newly found species of lung fluke in Korea (Yokogawa *et al.*, 1971; and Seo and Koo, 1971).

Park and Choi (1974) conducted a survey on the distribution of *P. westermani* metacercaria in the second intermediate host of *P. westermani* in Kyungpook Province, and they found many

crayfish in the sixty-five mountain streams in the Province, and then isolated the majority of the metacercariae in the cephalothorax, gills and liver, and very rarely in the heart. Kim, Choy, and Choi (1974) canvassed 6 counties (gun) and one city in Kyungpook Province, and they reported that the prevalence rate for *P. westermani* was 4.3 per cent of the residents examined.

Almost all of the surveys on *Semisulcospira* snails in Korea have been done by Kobayashi (1918a and b, 1919, 1921a and b, 1922, 1926, and 1927) and Miyanaga (1938). In recent years, there has been no previous report concerning the infestation of larval trematodes from *Semisulcospira* snails, the first intermediate host of the fluke, in Kyungpook Province, since Han and Chun's report (1963) in the Kim-Hae plain, Kyungnam Province.

This paper reports observations on the infestation pattern of larval trematodes in *Semisulcospira* snails in one of the endemic areas of *P. westermani*.

MATERIALS AND METHODS

The locality selected in the present study was Judong stream, Kachang myun, Dalseong county, Kyungpook Province, Korea (Fig. 1) where the

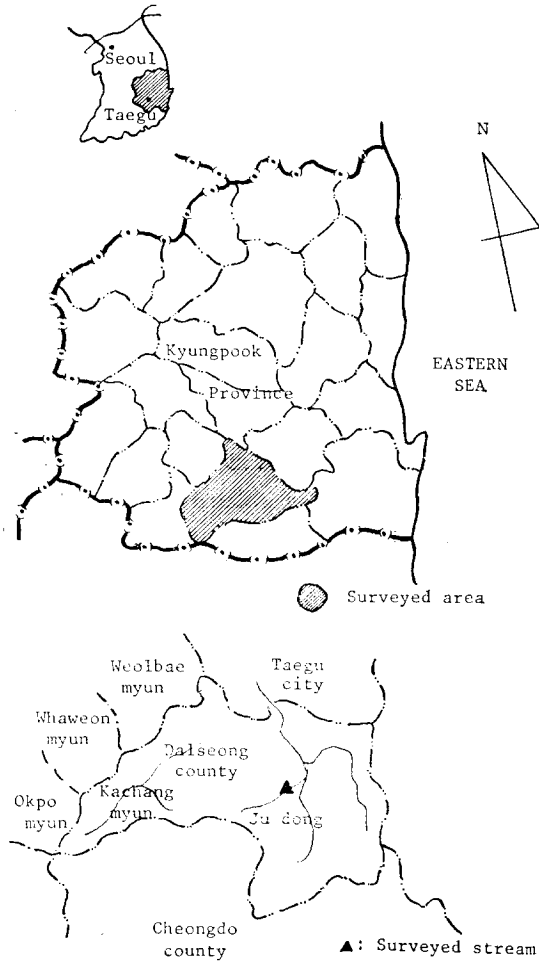


Fig. 1. Map of Judong stream surveyed in Kachang myun, Dalseong county, Kyungpook Province, Korea

crayfish, *A. similis*, infested with the metacercaria of *P. westermani*, was found (Park and Choi, 1974).

Collections of *Semisulcospira* snails were made for fifteen years, from 1965 to 1980.

The snails collected by hand were put into damp plastic baskets with water grass and forwarded to the Parasitology laboratory, where kept in a refrigerator, they remained alive for weeks.

These snails were examined for the presence of the cercariae of digenetic trematodes using both immersing and crushing techniques (Miya-

zaki, 1961; and Hamajima and Ishii, 1963). Ten snails were isolated in petri-dishes containing 40ml of tap water for 48 hours and observations were made on the liberation of cercariae. All snails in a dish revealing larval flukes were crushed to determine the total percentage infestation.

The cercariae liberated from the snails were studied in the living state under a microscope. Neutral red was used *intra vitam* staining since it differentiates the germinal materials. Some of the cercariae shed from the snails were stained with Semichon's acetocarmin or 0.001 per cent neutral red and the observations made supplemented those made on living material.

To determine the arrangement and the total number of flame cell in a cercaria, the living specimens stored in a refrigerator were put on the slide glasses and the cover glass slipped on. All the edges of the cover glass were then sealed with paraffin-vaseline mixture. Observations were made under the oil immersion lens.

The morphological characteristics of larval flukes are as follow:

Cercaria incerta (Kobayashi, 1922) Faust, 1924

The cercaria is a sort of microcercous cercariae. The body is cylindrical in shape and light yellow in color (Microphotograph 1). The body measures $260 \sim 280 \times 80 \sim 95 \mu\text{m}$. The tail is short and $60 \sim 70 \mu\text{m}$ in length and $40 \sim 50 \mu\text{m}$ in width. The oral sucker ($45 \sim 52 \times 39 \sim 41 \mu\text{m}$), the stylet ($13 \times 9 \mu\text{m}$), the long prepharynx ($35 \times 45 \mu\text{m}$), the pharynx ($19 \times 20 \mu\text{m}$), the acetabulum ($50 \sim 52 \times 40 \sim 45 \mu\text{m}$) and the intestinal ceca are distinct. There is a stylet on the dorsal side of the oral sucker. The anterior one third of the stylet is pointed and the posterior two thirds thickened. The 3 pairs of penetrating glands lie on the lateral side of the pharynx. The body surface has 7 pairs of sensory hairs but no spines. The genital primordia, consisting of two compact masses, occupy both the anterior and posterior borders of the acetabulum.

The excretory bladder is I-shaped and $80 \sim 90 \times$

50~56 μ m in size. The flame cell formula is $2[(2+2)+(2+2)]=16$.

The details of morphological features were reported by Kobayashi (1918a and 1918b), Kobayashi (1922), Faust (1924), Yokogawa and Wakeshima (1934), Ito (1953), Hamajima and Ishii (1963), and Han and Chun (1963).

***Cercaria nipponensis* (Ando, 1915)**

Faust, 1924

The cercaria belongs to virgula group of xiphidocercaia. The oval body is 140~145 \times 50~65 μ m in size (Microphotograph 2). The oral sucker is large (40~50 \times 38~50 μ m) and has a large virgula organ. The stylet (14 \times 4 μ m) and pharynx (10 \times 12 μ m) are distinct, but the ventral sucker and intestine are not fully developed. Minute spines and sensory hairs are present on the surface. The penetration glands consisting of 3 pairs are fine granular. The small tail is one half of the body length. The excretory bladder is cup-shaped, and the flame cell formula is $2[(2+2+2)+(2+2+2)]=24$.

The details were reported by Kobayashi (1917), Faust (1924), Yokogawa and Wakeshima (1934), Ito (1952), Shimizu (1958), and Hamajima and Ishii (1963).

***Cercaria yoshidae* (Osafune, 1898)**

Cort et Nichols, 1920

The cercaria, belonging to cystophorous group, has peculiar organs, the bulbous and the excretory projection (Microphotograph 3). The body is ellipsoidal in shape and measures 160~230 \times 50~55 μ m. The slender tail is flat laterally at the posterior one third to form a fin, 290~350 \times 18~20 μ m in size. The oral sucker (30~32 \times 35~36 μ m), the acetabulum (33~35 \times 34~36 μ m), and the intestinal ceca are fully developed, but no penetrating and encysting glands are present.

The bulbous, situating between the body and the tail, is a large globular cavity 85 \times 92 μ m in size. The excretory projection is a slender tube with a canal in it, and 150~360 \times 16~20 μ m in size. It originates from the anterior corner of the bulbous and protrudes anterio-bliquely. The distal end of the tube is thickened. No minute spines and sensory hairs are present on the body surface. The body and

the excretory projection of the mature cercaria are frequently invaginated in the cavity of the bulbous.

The flame cell formula is $2(2+2)=8$.

The details were reported by Yoshida (1917), Cort and Nichols (1920), Faust (1924), Ito (1952), Shimizu (1958), Hamajima and Ishii (1963), and Han Chun (1963).

Cercaria of Centrocestus armatus

(Tanabe, 1922) Yamaguti, 1933

The cercaria is relatively small and ellipsoid in shape, tapering anteriorly and rounded posteriorly. The body is somewhat transparent and has a pair of minute eye spots which lie in the lateral anterior third of the body (Microphotograph 4). It measures 100~120 \times 50~65 μ m, the tail 80~120 \times 12~17 μ m, and the oral sucker 30 \times 37 μ m. The acetabulum is small (13 \times 13 μ m) and not fully developed. Four pairs of penetration glands contain fine granular materials. The body surface is covered with spines and eight pairs of sensory hairs. The oral spines consisting of 9 spines are arranged in 2 rows on the mouth. The number of sensory hairs and oral spines varies from cercaria to cercaria. The oral sucker and prepharynx is distinct, but the pharynx is faintly outlined and no intestinal ceca is found. The excretory bladder is large and thick walled. The tail is 120~180 \times 12~17 μ m and has no spine and fin. The flame cell pattern is $2[(2+2)+(2+2)]=16$.

The details were reported by Kobayashi (1922), Takahashi (1929), Yamaguti (1933 and 1938), Ito and Watanabe (1958), and Hamajima and Ishii (1963).

Cercaria of Metagonimus species

The cercaria is a sort of lophocercous cercaria, its body (180~230 \times 60~75 μ m) is elongated pyriform and it has a pair of pigmented eye spots (Microphotograph 5). The body is light yellow in color and has a relatively thin cuticle. The oral sucker is oval (43 \times 35 μ m) and has about thirty specialized spines around the antero-ventral mouth. The acetabulum is small (19 \times 20 μ m) situated in the middle of the body. The esophagus and intestinal ceca are not fully developed. Seven pairs of penetrating glands have a pair of clustered openings dorsal to the mouth. The excretory bladder is clover shaped and

occupies the posterior part of the body. The tail is 350~400 μ m in length and 33~35 μ m in width and has a dorso-ventral fin, which joins at the end of tail.

The flame cell formula of the cercaria of *Metagonimus yokogawai* is represented as $2[(3+3+3)+(3+3+3)]=36$ by Komiya (1966). However, the excretory pattern of the cercaria of *M. takahashii* reported by Takahashi (1929) is $2[(2+2+2)+(2+2+2)]=24$. The differentiation of the excretory pattern of *M. yokogawai* from that of *M. takahashii* is very difficult and time-consuming. In the present study, *Metagonimus* species includes these two species.

The details of morphological and biological features of this cercaria were presented by Muto (1917), Kobayashi (1918), Takahashi (1929), Yokogawa and Wakeshima (1934), Shimizu (1958), Ito, Mochizuki and Noguchi (1959), Hamajima and Ishii (1963), and Han and Chun (1963).

***Cercaria of Notocotylus magniovatus* Yamaguti, 1934**

The larva is a sort of monostomous cercaria. The body is ellipsoidal in shape and has three eye spots (Microphotograph 6). The body length is 270~330 μ m, width 130~145 μ m. The tail is 250~450 μ m in length and 60~80 μ m in width, and the excretory canal opens in the middle of the tail. The oral sucker is oval and 28~35 \times 30~37 μ m in size. The body surface has 5 pairs of sensory hairs, but no spines. The postero-lateral margin of body is transformed to a so-called adhesive organ. The body is opaque due to the coarse granules in the body. The excretory bladder is small and occupies the posterior part of the body.

The flame cell formula is $2[(2+2)+(2+2)]=16$.

The details were reported by Kobayashi (1922), Ueno, Ishii, and Abe (1930), Yamaguti (1938), and Ito (1959).

***Cercaria of Paragonimus westermani* (Kerbert, 1878)**

The larval fluke is microcercous cercaria. The body is ellipsoidal in shape and entirely transparent. The body surface is covered with several groups of sensory hairs and spines. The body length is 260~310 μ m, and width 100~110 μ m. The tail is knob-

shaped and 25~35 μ m in length and 16~20 μ m in width. The oral sucker (60~65 \times 50~60 μ m) is larger than the ventral sucker (25~35 \times 45~55 μ m). The pharynx (13 \times 15 μ m) and the stylet (35 \times 6 μ m) are small. The intestinal ceca is fully developed and runs in a zigzag to the posterior end of the body (Microphotograph 7).

The penetrating glands consisting of seven pairs are divided into two groups. The outer four pairs contain coarse granules, whereas the inner three pairs fine granules.

The large I-shaped excretory bladder occupies the posterior part of the body reaching behind the ventral sucker. The main collecting canal originates at the anterior-lateral corner of the bladder and runs upwards in a zigzag to midbody, where the canal divided into anterior and posterior collecting tubes. Both anterior and posterior tubes divide again into five tertiary collecting tubes, each connecting with three flame cells by their collecting capillaries. The flame cell formula is $2[(3+3+3+3+3)+(3+3+3+3+3)]=60$.

The details of morphological and biological features of this cercaria were presented by Yoshida (1917), Kobayashi (1918a and 1918b), Ando (1918), Kobayashi (1922), Yokogawa and Wakeshima (1934), Yamaguti (1943), Komiya and Ito (1950), Shimizu (1958), Hamajima and Ishii (1963), and Han and Chun (1963).

Cercaria A

The cercaria (Schematic representation 8), belonging to cystophorous cercariae, resembles *Cercaria yoshidae*, but it has narrower tail (380~510 \times 6 μ m) and smaller bulbous (50~60 \times 45~60 μ m) and lacks the body. The excretory projection of this cercaria (100 \times 20 μ m) is also smaller than that of *Cercaria yoshidae*.

Similar cercariae were introduced by Kobayashi (1922) and Shimizu (1958).

Cercaria B

The cercaria, belonging to Kobayashi's (1922) gymnocephalus cercariae, is an ellipsoidal larva 320~400 \times 180~200 μ m (Schematic representation 9). The body surface is covered with the cuticle but has no spines. The oral sucker (60 \times 70 μ m) is somewhat smaller than the ventral sucker (65 \times 75 μ m).

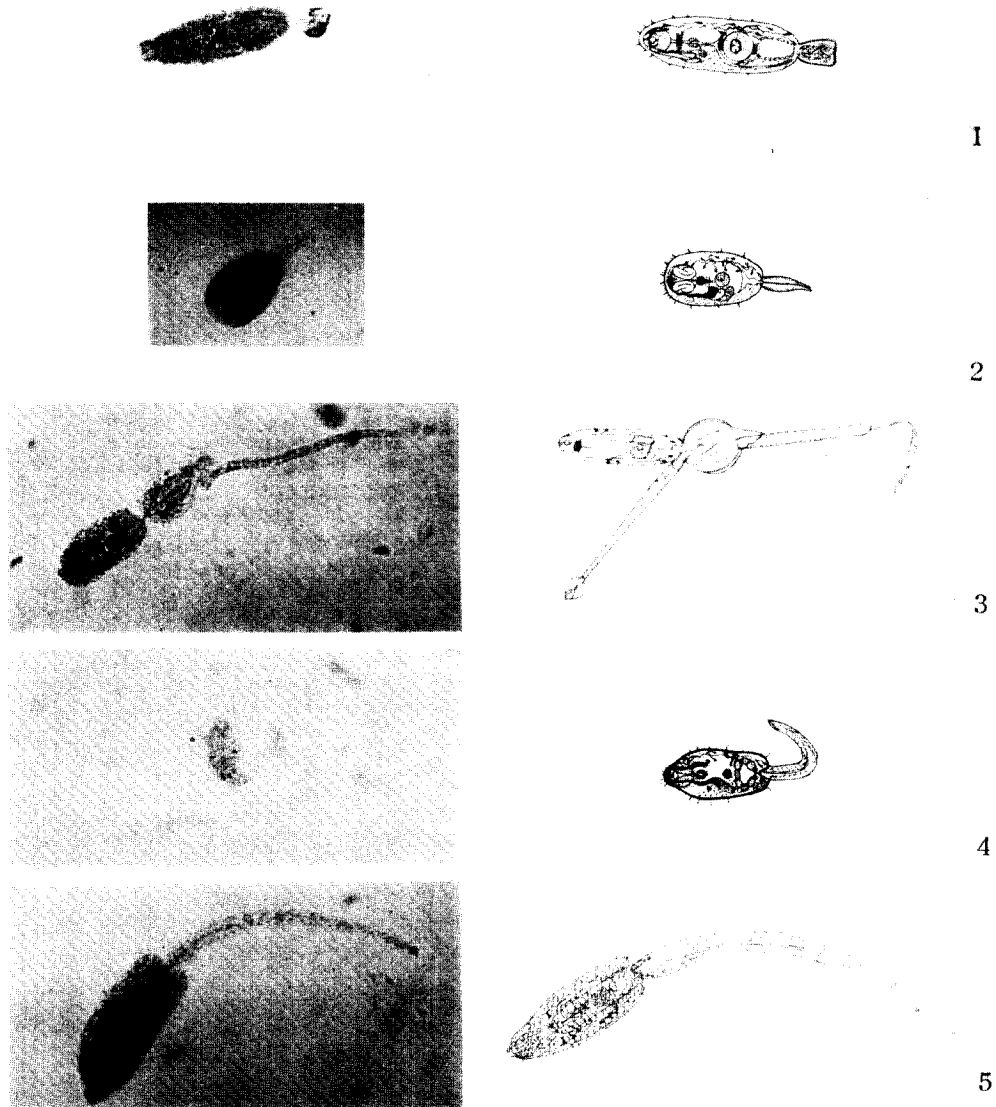
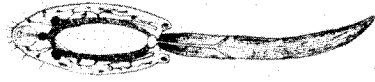
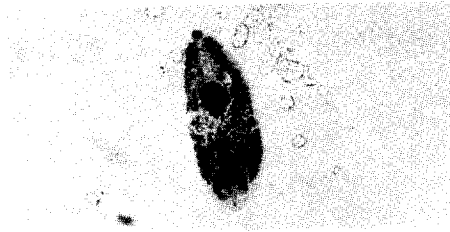


Plate 1. Microphotographs and the schematic figures of cercariae found from *Semisulcospira* snails (1mm = 20 μ m).

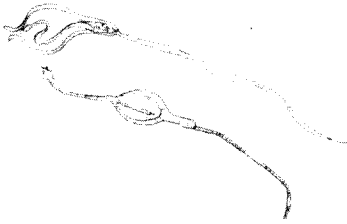
1. *Cercaria incerta*
2. *Cercaria nipponensis*
3. *Cercaria yoshidae*
4. *Centrocestus armatus*
5. *Metagonimus* species



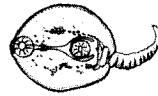
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7



A



B



C



D

Plate 2. Microphotographs and the schematic figures of cercariae found from *Semisulcospira* snails (1mm = 20 μ m).

6. *Notocotylus magnioyatus* 7. *Paragonimus westermani* 8. Cercaria A 9. Cercaria B
10. Cercaria C 11. Cercaria D

The intestinal ceca comprises an oval pharynx, a long esophagus and a pair of ceca extended to the nearby the posterior border of the acetabulum. From the excretory bladder, the excretory canal runs upwards to the anterior border of the pharynx. In the canal there are about 20 coarse refractile granules. The tail is small (27~30×14~17μm).

Similar cercariae were reported by Kobayashi (1922), and Shimizu (1958).

Cercaria C

The ellipsoid cercaria is also belonging to Kobayashi's (1922) gymnocephalus cercariae (Schematic representation 10). The body, containing amorphous refractile granules measures 120~220×140~150μm. The oral sucker (40×45μm) is situated in the anterior end of the body. The acetabulum(38×45μm) is not fully developed and located in the posterior middle of the body. The tail is flat, 120~150×20~30μm, and its end is attenuated.

Similar cercariae were presented by Kobayashi (1922), and Shimizu (1958).

Cercaria D

The cercaria, belonging to non-tailed cercariae, is oval or ellipsoid, 210~250×67~70μm (Schematic representation 11). The oral sucker (30×45μm) is distinct and situated in the anterior end of the body. However, the acetabulum (30×40μm) in the middle of the body, and the oval excretory bladder (68×35μm) in the posterior third of the body are not fully developed.

Similar cercariae were reported by Kobayashi (1922), Shimizu (1956), and Han and Chun (1963).

RESULTS

Table 1 presents variations of the proportion of infested to non-infested snails collected from 1965 to 1980 in Judong stream, an endemic area of *P. westermanni* in Kyungpook Province, Korea.

A total of 19,227 snails was examined for the presence of larval flukes, cercariae. The infestation rate of snails with the cercariae was found to be 4.7 per cent.

Table 1. Five-year-interval observations on proportions of *Semisulcospira* snails infested with larval flukes to non-infested snails collected in Judong stream, Kyungpook Province, Korea (1965~1980)

Year projected	No. of snails examined	No. of snails infested with cercariae	Per cent positive
1965	9,145	498	5.4
1970	5,367	214	4.0
1975	3,185	132	4.1
1980	1,530	53	3.5
Total	19,227	897	4.7

In general, the infestation rate of snails with the cercariae decreased progressively. The rate in 1965 was 5.4 per cent, but in 1970 dropped to 4.0 per cent and remained at approximately the same rate, 4.1 per cent in 1975. It then decreased to the lower rate, 3.5 per cent in 1980.

Table 2 lists the incidence of larval trematodes among the snails collected in Judong stream.

Seven species of cercariae, *Cercaria incerta* (Kobayashi, 1922) Faust, 1924, *Cercaria nipponensis* (Ando, 1915) Faust, 1924, *Cercaria yoshidae* (Osafune, 1898) Cort et Nichols, 1920, *Centrocestus armatus* (Tanabe, 1922) Yamaguti, 1933. *Metagonimus* species, *Notocotylus magniovatus* Yamaguti, 1934, and *Paragonimus westermanni* (Kerbert, 1878), and five kinds of undetermined cercariae were found.

Of these, the most frequently emerged cercaria was *Metagonimus* species 1.48 per cent, 285 out of 19,227, followed by *N. magniovatus* 0.87 per cent, *Cercaria nipponensis* 0.61 per cent, *Cercaria incerta* 0.10 per cent. The least frequently emerged was *P. westermanni* 0.04 per cent. In the four kinds of undetermined cercariae, the liberation rates varied from 0.04 to 0.15 per cent.

The liberation rates for *Cercaria incerta* in 1965 was found to be 0.36 per cent, whereas the rate in 1980 had dropped to 0.19 per cent.

Table 2. Incidences of larval flukes from *Semisulcospira* snails in Judong stream, an endemic area of *P. westermani* in Kyungpook Province, Korea (1965~1980)

Larval fluke	1965(9, 145)*		1970(5, 367)		1975(3, 185)		1980(1, 530)		Total(19, 227)	
	No. pos.	Per cent	No. pos.	Per cent	No. pos.	Per cent	No. pos.	Per cent	No. pos.	Per cent
<i>Cercaria incerta</i>	33	0.36	18	0.34	5	0.16	3	0.19	59	0.31
<i>Cercaria nipponensis</i>	74	0.81	33	0.61	7	0.22	4	0.26	118	0.61
<i>Cercaria yoshidae</i>	11	0.12	4	0.07	3	0.09	2	0.13	20	0.10
<i>Centrocestus armatus</i>	5	0.05	3	0.06	2	0.06	0	0	10	0.05
<i>Metagonimus</i> species	163	1.78	75	1.40	36	1.13	11	0.72	285	1.48
<i>Notocotylus magniovatus</i>	63	0.69	43	0.80	47	1.48	15	0.98	168	0.87
<i>Paragonimus westermani</i>	6	0.06	1	0.02	0	0	0	0	7	0.04
Cercaria A	13	0.14	5	0.09	4	0.13	2	0.13	24	0.15
Cercaria B	7	0.07	3	0.06	3	0.09	2	0.13	15	0.08
Cercaria C	4	0.04	2	0.04	1	0.03	1	0.07	8	0.04
Cercaria D	7	0.07	3	0.06	3	0.09	0	0	13	0.07
Unknown cercaria	112	1.22	24	0.45	21	0.66	13	0.85	170	0.88

* Parenthesis means the number of snails examined.

Table 3. Seasonal variation of cercariae from *Semisulcospira* snails collected in Judong stream, Kyungpook Province, Korea(1980)

Cercaria	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
<i>Cercaria incerta</i>	5	0	2	0	16	9	3	0	7	16	0	0	59
<i>Cercaria nipponensis</i>	0	3	4	10	25	35	9	16	9	2	3	2	118
<i>Cercaria yoshidae</i>	1	2	4	2	1	1	2	4	0	0	0	3	20
<i>Centrocestus armatus</i>	2	0	0	0	3	0	1	2	2	0	0	0	10
<i>Metagonimus</i> species	13	8	9	18	69	29	21	33	27	16	5	37	285
<i>Notocotylus magniovatus</i>	0	0	0	0	11	23	39	21	47	0	0	27	168
<i>Paragonimus westermani</i>	0	0	0	0	4	1	2	0	0	0	0	0	7
Cercaria A	0	0	0	2	5	3	3	0	11	0	0	0	24
Cercaria B	0	0	0	2	4	1	5	0	0	3	0	0	15
Cercaria C	0	0	0	0	1	5	0	0	2	0	0	0	8
Cercaria D	0	0	0	2	3	7	0	1	0	0	0	0	13
Unknown cercaria	3	7	8	24	23	36	14	8	5	13	21	8	170
Total No.	24	20	27	60	165	150	99	85	110	50	29	77	897
Positive%	0.12	0.10	0.14	0.31	0.86	0.78	0.51	0.44	0.57	0.26	0.16	0.40	4.67

Similar liberation rates were obtained in the four species of larvae, *Cercaria nipponensis*, *C. armatus*, *Metagonimus* species, and *P. westermani*. By contrast, the rate in the cercaria of *N. magniovatus* had increased, but the rate in *Cercaria yoshidae* was constant in the period from 1965 to 1980.

Table 3 summarizes the monthly incidence of cercariae from the snails in Judong stream. The snails were collected all the year round. The liberation rate for cercariae in January was 0.12 per cent, and the rates remained at the same values, 0.10 per cent in February and 0.14 per cent in March. It increased to 0.31

Table 4. Relationships between liberation rates for cercariae and length of snails in 7 species of cercariae in 19,227 snails examined

Cercaria	Length of snails(mm)						Total
	10~14	15~19	20~24	25~29	30~34	35~39	
<i>Cercaria incerta</i>	12(0.06)*	21(0.11)	5(0.03)	16(0.08)	2(0.01)	3(0.02)	59(0.31)
<i>Cercaria nipponensis</i>	28(0.15)	55(0.29)	15(0.08)	13(0.07)	5(0.03)	2(0.01)	118(0.61)
<i>Cercaria yoshidae</i>	2(0.01)	9(0.05)	4(0.02)	2(0.01)	2(0.01)	1(0.01)	20(0.10)
<i>Centrocestus armatus</i>	1(0.01)	5(0.03)	2(0.01)	1(0.01)	1(0.01)	0(0)	10(0.05)
<i>Metagonimus</i> species	116(0.60)	72(0.37)	29(0.15)	51(0.27)	2(0.01)	15(0.08)	285(1.48)
<i>Notocotylus magniovatus</i>	43(0.22)	55(0.29)	37(0.19)	13(0.07)	16(0.08)	4(0.02)	168(0.87)
<i>Paragonimus westermani</i>	0(0)	4(0.02)	2(0.01)	1(0.01)	0(0)	0(0)	7(0.04)
Total	202(1.05)	221(1.15)	94(0.49)	97(0.50)	28(0.15)	25(0.13)	667(3.47)

* Parenthesis means percentage.

per cent in April, and reached the peak, 0.86 per cent in May. It then decreased from June to November, and increased again in December.

The relationship between the liberation rates for cercariae and the length of snails in seven species of cercariae are summarized in Table 4.

In general there was no correlation of the liberation rate of cercaria to the length of snail host. The liberation rate for cercariae in the snails between 10~14mm shell length was 1.05 per cent, 202 out of 19,227. The rate for cercariae was the highest, 1.15 per cent in the snails between 15~19mm shell length. It continued at fairly low rates in the snails from 20~24mm and 25~29mm shell length, then dropped in the snails more than 30mm shell length.

The liberation rate for the cercaria of *P. westermani* was quite low. The average rate was 0.04 per cent, with the ranges from 0.02 to 0.01 per cent.

DISCUSSION

Little data can be found relative to the ecology of *Semisulcospira* snails and the infestation of the snails with the cercariae of digenetic trematodes in Korea.

Hirose (1913) reported for the first time that

a kind of snail, similar to *Oncomelania* species, collected from the river Napook in the vicinity of Nanam city harbored a cercaria thought to be the cercaria of *Clonorchis sinensis*.

At the same time, Muda (1913) found the cercaria of *Metagonimus* species from the freshwater snail, *Semisulcospira* species caught at a river of Haeju city, Whang-hae Province.

Kobayashi (1917) found the twelve kinds of larval trematodes from *Semisulcospira* snails collected in the several areas of Korea. Subsequently, he (1918) added the eight kinds of cercariae found in Kyung-gi and Chun-nam Province.

In 1922, Kobayashi described in detail the sixty kinds of cercariae belonging to thirteen groups demonstrated from the snails, which were collected in Japan and Korea.

Recently an attempt was made by Han and Chun (1963) to discover the cercariae of digenetic trematodes, and they found six species of cercariae, *Cercaria acanthatrium*, *Cercaria longicerca*, *Cercaria yoshidae*, *Metagonimus* species, and *P. westermani*, and four kinds of undetermined cercariae from *Semisulcospira* snails which were collected in Kim-hae plain in Kyungnam Province, Korea.

However, the recent status of the infestation

of snails with the cercariae of digenetic trematodes in the endemic areas of Kyungpook Province is unknown.

In Kyungpook Province, Judong has been known as one of the endemic areas of *P. westermani* since 1974. Numerous surveys on the second intermediate host of the fluke have been done by many workers (Ichinomiya, 1924; Park, 1962; Kim et al., 1974; Sohn and Choi, 1977; Lee and Choi, 1979; Choi and Hwang, 1980; and Choi, Joo and Kim, 1981). As a result, the distribution and population density of snails and crayfish, and the infestation of snails and crayfish with the larval trematodes was established.

The present survey reports seven species of known cercariae, *Cercaria incerta*, *Cercaria nipponensis*, *Cercaria yoshidae*, *Centrocestus armatus*, *Metagonimus* species, *Notocotylus magniovatus* and *P. westermani*, and four kinds of undetermined cercariae.

These results agree with the data reported by Han and Chun (1963), except for *N. magniovatus* and *Cercaria nipponensis*. In survey of Kim-hae plain by Han and Chun (1963), no *N. magniovatus* and *Cercaria nipponensis* were found.

The life cycle of *Cercaria incerta*, *Cercaria nipponensis*, *Cercaria yoshidae* and *N. magniovatus* is undetermined, but the cycle of *Centrocestus armatus*, *Metagonimus* species and *P. westermani* is established. In *Centrocestus armatus*, the first intermediate hosts are fresh-water fish and the second intermediate hosts are known as the birds and mammals. In *Metagonimus* species and *P. westermani*, the first intermediate hosts are species of *Semisulcospira* snails, and the second intermediate hosts are suitable fish in *Metagonimus* species and crayfish in *P. westermani*.

In Chilgok county, Choi and Hwang (1980) conducted a survey of the density of snail and

crayfish intermediate hosts of *P. westermani* in the streams. They found a few snails and crayfish in the streams and a low infection rate for the fluke in the residents, a prevalence of 4.0 per cent by the intradermal test.

Similar results were obtained in the intermediate host survey of *P. westermani* conducted by Kim and Choi (1977) in the northern Chilgok county, and by Choi, Joo, and Kim (1981) in Wiseong county, Kyungpook Province.

In the present study, the population density of *Semisulcospira* snails in Judong stream is very low and has decreased over the fifteen years from 1965 to 1980. The data presented in Table 1 and 2 show a marked decrease in the density of the snails and the infestation of snails with the cercariae of trematodes in the stream.

As previously indicated by Choi and Hwang (1980) and Choi, Joo, and Kim (1981), now *Semisulcospira* snails are rare intermediate host, and demonstration of *P. westermani* cercaria from the snails has become apparently difficult in recent years.

They indicated that large amounts of pesticide have been widely used on the farms and inside the houses. The residual pesticides in the farms would have drained into the streams and affect the ecology of snails and crayfish in the streams.

The lethal effect of various pesticides on the survival of snails and larval trematodes of *Clonorchis sinensis* was reported by Kim (1965), and *P. westermani* by Kim (1969).

Other factors might be sought as contributing to the changing pattern. The destruction of natural environment by constructing dams and ponds in the upper streams and a long drought all year round in recent years would affect the ecology of snails and the survival of larval trematodes.

SUMMARY

In an attempt to determine the incidence of the cercarial larvae of trematodes, *Semisulcospira* snails collected in Judong stream, an endemic area of *Paragonimus westermani*, in Kyungpook Province, Korea, were examined from 1965 to 1980.

The infestation rate for cercariae in the snails was 5.4 per cent, but in 1970 dropped to 4.0 per cent and remained at the same level, 4.2 per cent, in 1975. It then decreased to 3.5 per cent in 1980.

Seven species of cercariae, *Cercaria incerta* (Kobayashi, 1922) Faust, 1924, *Cercaria nipponensis* (Ando, 1915) Faust, 1924, *Cercaria yoshidae* (Osafune, 1898) Cort et Nichols, 1920, *Centrocestus armatus* (Tanabe, 1922) Yamaguti, 1934, *Metagonimus* species, *Notocotylus magniovatus* Yamaguti, 1934, and *Paragonimus westermani* (Kerbert, 1878), and five kinds of undetermined cercariae were found.

Of these, the most frequently emerged cercaria was *Metagonimus* species, followed by *Notocotylus magniovatus*. The least frequently emerged was *Paragonimus westermani*, with the rate of 0.04 per cent.

The liberation rates in the five kinds of undetermined species varied from 0.04 to 0.15 per cent.

In the monthly liberation rates for cercariae, the highest rate was encountered in May, and decreased in the period from June to November. It then somewhat increased again in December. There was no correlation in the liberation rate for cercariae and length of snails.

The results of this study indicate that the infestation of *Semisulcospira* snails with the cercariae of trematodes has decreased over the fifteen year period from 1965 to 1980.

LITERATURE CITED

- Ando, R. (1915) On the new endemic area of lung fluke in Gifu Prefecture, and study on its intermediate host and metacercaria. *Nippon Byori Gakkai Zasshi*, 5:125-128 (in Japanese).
- Cort, W.W., and Nichols, E.B. (1920) A new cystophorous cercaria from California. *J. Parasit.*, 7:8-15.
- Faust, E.C. (1924) Notes on larval flukes from II. Studies on some larval flukes from the central and south coast Province of China. *Am. J. Hyg.*, 4:241-301.
- Hara, C. (1916) On second intermediate host of *Paragonimus westermani* crayfish, in Korea. *J. Chosen Med. Assoc.*, 16:197-199 (in Japanese).
- Hamajima, F., and Ishii, Y. (1963) Studies on the host-parasite relationship of *Paragonimus westermani* (Kerbert, 1878). *Kyushu J. Med. Sci.*, 14:189-194.
- Han, J.S., and Chun, S.K. (1963) On the cercaria parasitic to *Semisulcospira libertina* in Kim-hae plain. *Bulletin Fisheries Coll. Pusan Nat. Univ.*, 5:39-44 (in Korean, English summary).
- Hirose, H. (1913) On the cercariae parasitized in fresh-water snails in the vicinity of Nanam, Korea. *J. Chosen Med. Assoc.*, 4:105-106 (in Japanese).
- Inemoto, K. (1916) Paragonimiasis in Korea, with special reference to histo-pathologic findings of paragonimiasis. *J. Chosen Med. Assoc.*, 16:245-261 (in Japanese).
- Ito, J. (1952) Redescription of *Cercaria yoshidae* Cort et Nichols, 1920, a cystophorous cercaria in the snail *Semisulcospira* spp. in Japan. *Jap. J. Med. Sci. and Biol.*, 5:447-454.
- Ito, J. (1953) Redescription of *Cercaria incerta* Faust, 1924, a cotylomicrocercous cercaria in snail host *Semisulcospira* spp. in Japan (Trematoda). *Jap. J. Med. Sci. and Biol.*, 6:289-297.
- Ito, J., and Watanabe, K. (1958) On the cercaria of *Centrocestus armatus* (Tanabe, 1922) Yamaguti, 1933, especially on its mucoid gland (Heterophyidae, Trematoda). *Jap. J. Med. Sci. and Biol.*, 11:21-29.

- Ito, J. (1959) A contribution to the morphology of Cercaria of *Notocotylus magnicvatus* Yamaguti, 1934 (Notocotylidae, Trematoda). *Jap. J. Med. Sci. and Biol.*, 12:133-137.
- Ito, J., Mochizuki, H., and Noguchi, M. (1959) Studies on the cercaria parasitic in *Semisulcospira libertina* in Shizuoka Prefecture. *Jap. J. Parasit.*, 8:913-922 (in Japanese, English summary).
- Kobayashi, H. (1918a) First intermediate host of *Paragonimus westermani*. *J. Chosen Med. Assoc.*, 21:1-18 (in Japanese).
- Kobayashi, H. (1918b) Study of cercariae in Korea, first report. *J. Chosen Med. Assoc.*, 21:19-80 (in Japanese).
- Kobayashi, H. (1919) First intermediate host of *P. westermani*. Second report. *Dobutsugaku Zasshi*, 27:49-60 (in Japanese).
- Kobayashi, H. (1921a) The reason why paragonimiasis is persisting as an endemic disease. *J. Chosen Med. Assoc.*, 36:44-51 (in Japanese).
- Kobayashi, H. (1921b) Studies on the lung fluke in Korea. III. Development in the first intermediate host and prophylactic measures against lung fluke. *Mit. Med. Hochsch. zu Keijo*, 4:5-16.
- Kobayashi, H. (1922) A review of Japanese cercariae. *Dobutsugaku Zasshi*, 34:252-270 (in Japanese).
- Kobayashi, H. (1926) Definitive and intermediate hosts of lung fluke in Korea. *Jap. Med. World*, 16:7-9 (in Japanese).
- Kobayashi, H. (1927) Study of lung fluke, Supplement. *Chosen Hakbutsugaku Zasshi*, 18:1-5 (in Japanese).
- Komiya, Y., and Ito, J. (1950) Contribution to the morphology of *Paragonimus westermani*. *Jap. J. Med. Sci. and Biol.*, 3:309-314.
- Kim, J.M. (1965) Studies on the molluscacidal and cercariacidal effects of various pesticides in liver fluke. *Korean J. Parasit.*, 3:86-106 (in Korean, English summary).
- Kim, H.J. (1969) Study on the effects of several pesticides on the life cycle of *Paragonimus westermani*. *Yonsei J. Med. Sci.*, 2:106-121 (in Korean, English summary).
- Kim, Y.M., Choy, C.H., and Choi, D.W. (1974) Epidemiological surveys of *Paragonimus westermani* in Kyungpook Province, Korea. *Kyungpook Univ. Med. J.*, 15:165-174.
- Lee, Y.C., and Chyu, I. (1957) Infestation pattern of metacercariae of *Clonorchis sinensis* and *Paragonimus westermani* from fresh-water fish and crabs collected in the river Mankyung. *J. Korean Med. Assoc.*, 2:293 (Abstract).
- Miyayama, M. (1938) On the *Semisulcospira* snails in Korea. *J. Chosen Med. Assoc.*, 28:1752 (Abstract, in Japanese).
- Miyazaki, I. (1961) Paragonimiasis, with special reference to its taxonomy, life-cycle, and distribution. *Thoracic Diseases*, 5:953-962 (in Japanese).
- Miyairi, K. (1917) Second intermediate hosts of lung fluke known by nowadays. *Jikken Iho*, 2:22 (in Japanese).
- Moriyashu, R. (1916) Paragonimiasis. *J. Chosen Med. Assoc.*, 16:201-244 (in Japanese).
- Muda, N. (1913) An addition to the findings of *Metagonimus yokogawai*. *Okayama Med. J.*, 287:15-32 (in Japanese).
- Muto, M. (1917) Contribution to the knowledge of *Metagonimus yokogawai*. *Okayama Med. J.*, 287:15-22 (in Japanese).
- Ohoki, Y. (1916) A study of *Paragonimus westermani* in Pyonsan area (Peninsula), Puan county, Chonpook Province, Korea. *J. Chosen Med. Assoc.*, 16:174-194 (in Japanese).
- Park, S.D., and Choi, D.W. (1974) Distribution of metacercariae in second intermediate host of lung fluke, *Paragonimus westermani*. *Kyungpook Univ. Med. J.*, 15:117-127.
- Shimizu, M. (1958) Studies on the cercaria parasitic in *Semisulcospira libertina* in Tokushima Prefecture. *Shikoku Acta Medica*, 13:626-646 (in Japanese, English summary).
- Seo, B.S., and Koo, B.Y. (1971) Studies on the lung fluke, *Paragonimus iloktsuenensis* Chen, 1940. 1. On the occurrence of *P. iloktsuenensis* in natural final host at the Naktong and Sumjin River delta in Korea. *Seoul J. Med.*, 12:31-43.
- Takahashi, S. (1929) A contribution to the life history of *Stamnosoma armatum* Tanabe. *Okayama Med. J.*, 41:127-138 (in Japanese).
- Ueno, N., Ishii, K., and Abe, H. (1930) On the

- cercariae parasitic in fresh-water snails in Kumamoto. *Kumamoto Med. J.*, 6:965-976 (in Japanese).
- Yokogawa, S., and Wakeshima, T. (1934) On the cercariae of *Melania libertina* from an endemic area of lung fluke in Shinchiku Province, Formosa. *Tokyo Iji Shinshi*, 2873:861-868 (in Japanese)
- Yokogawa, M., Araki, K., Koyama, H., Seo, B.S., Lee, S.H., and Cho, S.Y. (1971) On the lung fluke, *Paragonimus iloktsuenensis* Chen, 1940 in Korea. *Jap. J. Parasit.*, 20:215-221.
- Yamaguti, S. (1938) Zur Entwicklungsgeschichte von *Notocotylus attenuatus* (Rud, 1809) and *N. magniovatus* Yamaguti, 1934. *Zt. Parasitenk.*, 10: 288-292.
- Yamaguti, S. (1943) On the morphology of larval forms of *Paragonimus westermani*, with special reference to their excretory system. *Jap. J. Zool.*, 10:461-469.
- Yoshida, S. (1917) On the cercariae of *Melania libertina*. *Jap. J. Zool.*, 29:103-119 (in Japanese).

—국문초록—

慶尙北道の 다슬기에 寄生하는 吸蟲類 有尾幼蟲

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慶尙北道內 肺吸蟲 浸潤地인 蛇洞 溪谷에서 다슬기를 採集하여 吸蟲類 有尾幼蟲의 寄生狀을 1965년부터 1980년까지 調査하였다.

다슬기에서의 有尾幼蟲의 寄生率은 1965年 5.4%이었으나 1970년에는 4.0%로 떨어졌고 1975년에는 4.1%로 同率에 머물렀으며 1980년에는 3.5%로 떨어졌다.

7種의 有尾幼蟲 중 *Cercaria incerta*, *Cercaria nipponensis*, *Cercaria yoshidae*, *Centrocestus armatus*, *Metagonimus* species, *Notocotylus magniovatus* 및 *Paragonimus westermani*와 5種의 所屬未定 有尾幼蟲을 찾아 볼 수 있었다.

이 가운데서 *Metagonimus* species 有尾幼蟲이 가장 많이 游出되었고, 다음은 *Notocotylus magniovatus* 有尾幼蟲이었으며 肺吸蟲 有尾幼蟲은 가장 적게 游出되었다.

5種의 所屬未定 有尾幼蟲의 游出率은 0.04~0.15%로 起伏이 있었다.

月別 有尾幼蟲의 游出率에 있어서는 5월에 最高値를 나타내었으며 6月에서 11月 사이에는 낮았고 12月에 再次 높았다. 有尾幼蟲의 游出率과 다슬기의 크기와의 사이에는 아무런 相關은 認定할 수 없었다.

이번 調査 結果 다슬기에서의 吸蟲類 有尾幼蟲의 寄生率은 1965년부터 1980년까지의 15年間에 甚히 減少되었음을 나타내었다.