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Ecological Studies of Food-Borne Trematode Infections in Cheongdo County, Kyongbuk Province, Korea*

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Abstract : In order to determine the epidemiological patterns of fish-borne trematodes in the vicinity of the river Cheongdo, Kyongbuk Province, Korea where the snails, *Parafossarulus manchourichus and Semisulcospira libertina,* are abundant, the infection rates for the cercarial and encysted larvae of digenetic trematodes in the snail and fish hosts, and prevalence of Clonorchiasis and Metagonimiasis among the residents were studied during the period of 1998 and 2002. Among the *Parafossarulus* snails examined, four species of larval trematodes were found; *Loxogenes liberum* was found to most frequently liberate cercaria with 1.81 per cent, followed by *Cyathocotyle orientalis* with 0.88 per cent, by *Exorchis oviformis* with 0.34 per cent and the least frequently by *Clonorchis sinensis* with 0.19 per cent. Among 2,179 *Semisulcospira* snails, seven species of larval trematodes and 3 kinds of undetermined cercariae were found in 85 snails, which comprises 3.9 per cent overall infection rate. Of these, the most frequently emerged cercaria was *Cyathocotyle orientalis* with 1.37 per cent, followed by *Cercaria nipponensis* with 0.55 per cent, *Cercaria incerta* with 0.5 per cent, and *Metagonimus* species with 0.41 per cent. In nineteen species of fish, *Clonorchis sinensis, Cyathocotyle orientalis, Echnochasmus* species *Exorchis oviformis, Metacercaria hasegawai, Metagonimus species, Metorchis orientalis, Centrocestus armatus, Clinostomum complanatum* and some kinds of undetermined larvae were found. Of these, the encysted larvae of *Cyathocotyle orientalis* was found most fequently in 18 species of fresh-water fish, followed by *Metacercaria hasegawai* in 17 species, *Clonorchis sinensis* and *Exorchis oviformis* in 12 species, and *Clinostomum complanatum* in 8 species of fish. In general, the infection rates of digenetic larval trematodes varied greatly from fish to fish. As for the intensity of *Clonorchis sinensis, Sarcocheilichthys wakiyae* was the most heavily infected species with on average number of 42.8 cysts per gram of flesh,

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followed by *Gnathopogon atromaculatus* with 42.7 and *Pungtungia herzi* with 17.6 cysts. In the case of *Metagonimus* infections, the intensity was relatively low and the average number of cysts varied from 0.01 in *Zacco temmincki* to 3.9 in *Microphysogobio yaluensis*. The intensity of the other digenetic trematodes showed variations depending on the fishes. The infection rates of *Clonorchis sinensis* among the residents in the vicinity of the river Cheongdo were relatively high, being overall 4.3 per cent with a prevalence of 6.3 per cent in males and 2.5 per cent in females. The difference in the rates of infection between males and females was found to be statistically significant (t >2). As for the age-specificity, the rate was 0.9 per cent in the 10-19 year age group and 5.7 per cent in the 30-39 year age group. The rate increased as age increased, reaching a maximum of 13.6 per cent in the 40-49 year age group, followed by a decrease. Regarding the intensity of *Clonorchis* infections, approximately 80 per cent of the residents with clonorchiasis had less than 1,000 eggs per gram of feces. In summary, this study showed that endemic foci of *Clonorchis sinensis* exist in the vicinity of the river Cheongdo and Clonorchiasis and metagonimiasis among the residents are still highly prevalent.

Key Words : *Centrocestus armatus, Clinostomum complanatum, Clonorchis sinensis, Cyathocotyle orientalis,* Digenetic larval trematode, *Echnochasmus species, Exorchis oviformis,* Metacercarial burden, *Metacercaria hasegawai, Metagonimus species, Metorchis orientalis, Parafossarulus manchouricus, Semisulcospira libertina*

Introduction

It is well known that food-borne trematode infections are prevalent and are primarily carried out by ingestion of raw or inadequately processed foods, particularly fish, shellfish, and aquatic plants, that harbour the trematode metacercariae in the notoriously endemic areas of Korea, Japan, China and other countries.

Kobayashi[1] found *Clonorchis* metacercariae in the flesh of several kinds of fresh-water fish, including *Pseudorasbora parva* and *Sarcocheilichthys morii,* and reported that human clonorchiasis was distributed mainly in the southern parts of Korea, especially in the vicinity of major rivers and their tributaries.

Many studies have been carried out to estimate the prevalence of clonorchiasis and other food-borne trematode infections among the residents of Kyongbuk Province, Korea, and determine the susceptibility of numerous fish species to larval trematodes infection, and it was of a surprise to find that the rates of clonorchiasis and other foodborne trematode infections in man and fish hosts in Kyongbuk Province are

less prevalent than expected and continue to decline during the past several decades.

The Cheongdo river running through Cheongdo county is situated in the southern part of Kyongbuk Province, and has twelve small rivulets flowing into its main stream. There are many unusual exotic eateries which serve raw fresh -water fish and brackish-water fish to local residents and visitors.

Earlier, Kwak[2] studied the clonorchiasis in the vicinity of the Cheongdo river, and found the endemic foci of *C. sinensis* in the vicinity of the stream Cheongdo, based on the infective cases among the residents and also demon- stration of the *Clonorchis* cercaria and metacercaria in the fresh-water snails and fish hosts of the liver fluke. However, no epidemiological studies on the food-borne trematode have so far been undertaken in the county.

The present study was undertaken to investigate the epidemiology as well as the control of foodborne trematode infections, to illuminate the latest patterns of larval trematode infections in the snail and fish hosts in Cheongdo stream, Kyongbuk Province, in comparison with the previously reported data in the same stream, and to evaluate the present status of the prevalence rate of clonorchiasis and other foodborne trematode infections among the residents.

Materials and Methods

1. Geographical conditions of surveyed areas

The Cheongdo county is situated in the southern part of Kyongbuk Province at 35.33'50"-35.50'37" north latitude, covering an area of 725.7 square kilometers. It is bordered on the south by Mt. Hwahak and Mt. Cheolma along the border of Miryang county, Kyongnam Province, and on the east by Mt. Kaji and Mt. Unmoon along the border of Kyungju city and Mt. Biesol, Mt. Samseong and Mt. Yongkok, arranged in a circle that makes the county appear to be a small hollow. The Cheongdo river, about 38.7 kilometers in length, has its origin in the east range of Mt. Bieseol, and it's main stream runs through the Cheongdo county and then joins with the Dongchang stream running from Mt. Unmoon.

Finally, it runs through the Miryang county and joins the Miryang river. There are six rivulets such as Pungkak, Osan, Bukok, KumHeok, Taegok and Dalo in the vicinity of the Cheongdo stream and five rivulets such as Chizon, Shinwon, Dongkok, Kwanwha and Unmoon in the Dongchang stream. In the present study, four localities in the stream were selected as the study areas, because of abundance of fresh-water snails and fishes there. The localities are from 200 to 300 meters above the sea level and the soil is mainly composed of sand, rock, and mud. Most of the time, there is relatively permanent slow-flowing water in the stream and it harbours fresh-water snail and many fishes.

2. Snail intermediate host survey

The snail habitat selected in this study was stream-bed of the Cheongdo river located near the Seowon village, Cheongdo county (Fig. 1) where the fresh-water fishes, such as *P. parva, P. herzi, P. rhombea, P. esocinus, A. intermedia,* and *G. atromaculatus,* were found to be infected with the metacercaria of *C. sinensis*[2].

The snail habitat was about 300 meters above the sea level and the soil was mainly composed of sand, mud, and rock. The water in the stream was relatively permanent slow-flowing and usually contained abundant organic materials and sewage. Many types of marsh plants and grasses covered the entire area.

There were many kinds of fresh-water fish, *Parafossarulus* and *Semisulco- spira* snails in the water. The snails were collected once or twice monthly in the habitat during the period from June, 1997 to October, 2002. Snails were collected by hand and put into dry plastic buckets with marsh plants and grasses, and forwarded to the parasitology laboratory.

Snails were first measured and then placed individually in petri-dishes containing about 50 mL of tap water, and the cercarial emergence was observed for one week. In order to evaluate the relationship between the infection rate and the size of the hosts, the *Parafossarulus* snails were divided into three size groups: small (7.0-8.9 ㎜), medium (9.0-10.9 ㎜) and large (11.0-12.9 ㎜) shell length.

The *Semisulcospira* snails were also divided into five size groups: 10.0-14.9 ㎜, 15.0-19.9 ㎜, 20.0-24.9 ㎜, 25.0-29.9 ㎜, and 30.0 ㎜ or more groups. Uninfected snails (not shedding cercariae) were crushed to confirm the absence of any larval stage.

In order to determine the specific

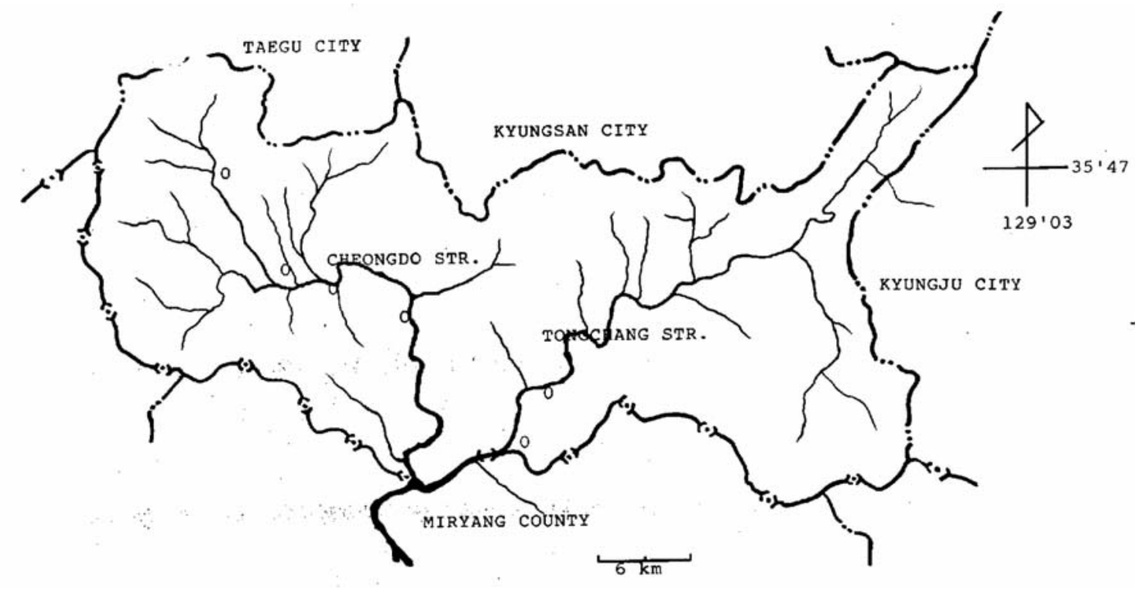

Fig. 1. Map showing the areas(○) surveyed in Cheongdo county and of fishes in Kyongbuk Province, Korea.

nomenclature of cercariae, the morphological features of cercariae freed from the snails were first studied in the living specimens. Some of the cercariae shed from the snails were stained with Semichon's acetocarmin and observed results were supplemented to those made on living specimens.

In order to determine the arrangement and the total number of flame cells in a cercaria, the living specimens stored in a refrigerator were put on a slide glass and a cover glass slipped on. All the edges of the cover glass were then sealed with paraffin-vaseline mixture, and observations were made under an oil immersion lens. Usually, flame cells and tubules could be seen under considerable cover glass pressure, however, the excretory system of *Clonorchis* cercaria was very difficult to trace, because of the existence of pigmented masses in the entire body and the fine structure of canals.

The cercaria obtained were also studied morphologically to determine the species by following "A monograph on cercariae in Japan and adjacent territories" by Ito[3].

3. Survey of intermediate fish host

In order to determine the infection rate and the intensity of the larval trematodes in different fresh-water fishes collected in the four localities in the Cheongdo county, studies were carried out during the period of 5 years since May, 1997. Fresh-water fishes were mostly caught by either netting or fishing with rod and line. The nineteen kinds of fresh-water fishes, the deep body bitterling (*Achanthorhodeus asmussi*), the slender bitterling (*Acheilognathus intermedia*), the oily bitterling (*Acheilognathus limbata*), flat bitterling (*Paracheilognathus rhombea*), the striped bitterling (*Acheilognathus yamatsytae*), the crussian carp (*Carassius carassius*), the long nose barbel (*Hemibarbus longirostris*), Microphysogobio *yaluensis,* the top mouth minnow (*Pseudorasbora parva*), blck striped gudgeon (*Pungtungia herzi*), the oily shinner (*Sarcocheilichthys wakiya*e), *Saurogobio dabryi,* the Korean gudgeon (*Squalidus chankaensis tsuchigae*), the short barbel gudgeon (*Gnathopogon atromaculatus*), the pale chub (*Zacco platypus*), the dark chub (*Zacco temmincki*), the spined loach (*Cobitis sinensis*), The Korean brook perch (*Coreoperca herzi*), and the Korean dark sleeper (*Mogurnda obscura*), were collected in the present study. The fishes were transported to the laboratory after removal of their intestinal contents to prevent autodigestion. The specific nomenclature of the fish was determined by the keys described by Chung[4].

One gram of flesh, 100 scales, all fins and tail of the fish were separated from a fish using a knife, and each material was then compressed between two large slides (50 × 90 ㎜) and was examined for encysted larvae under a binocular microscopy.

In order to isolate the metacercariae and to estimate the average number of cysts per gram of flesh, the digestion technique was employed. Thus, 1 gram of flesh was mixed with artificial gastric juice (0.2 mL of diluted hydrochloric acid plus 0.3 gram of pepsin/100 mL distilled water), and the mixure was then incubated at 37-38℃ for 30-40 minutes.

Subsequently, the mixture was stirred with a glass rod and allowed to stand for 10 minute to gather the isolated cysts in the center of the beaker. *Clonorchis* cysts and other larval trematodes in the sediment were counted under a dissecting microscope (× 100).

4. Survey of food-borne trematode infections in residents

In order to evaluate the prevalence of the food-borne trematodes infections among the residents in Cheongdo county, stool was examined. Thus, stool specimens were collected from Iseo elementary school children, Iseo middle school boys and girls, and the residents in Iseo Myun, Cheongdo county. They all resided near the snail habitats in the river.

The stool specimens were collected in cartons and then brought to the laboratory within 2 days of collection. They were first examined by the formalin -ether sedimentation technique[5]. If the food-borne trematode eggs were detected, the Stoll's egg-count technique[6] was applied to estimate worm burdens.

Results

Table 1 shows the relationship between infection rates of larval trematodes and the length of *Parafossarulus* snails. Among the 2,040 snails of various sizes examined, one or more species of larval trematodes were found in 66 snails, which comprises an overall infection rate of 3.23%. Four species of larval trematodes, *C. orientalis, C. sinensis, E. oviformis,* and *L. liberum,* were found.

Of these, *L. liberum* was found to be the most frequently liberated cercaria, the rate being 1.81%, followed by *C. orientalis* with the infection rate of 0.88% and *E. oviformis* with 0.34%. The least frequently liberated was *C. sinensis* with 0.19%. However, the percentage of infection varied with the shell length of snail.

The infection rate increase as the length of the snail increased, having the infection rates of 2.80%, 3.09%, and 3.75% in the small, medium, and large size groups, respectively.

In Table 2, the infection rates of larval trematodes from *Semisulcospira* snails, and the relationship between the liberation rates of cercariae and the shell length of snails are tabulated. In 2,179 *Semisulcospira* snails examined, seven species of larval trematodes and 3 kinds of undetermined cercariae were found in 85 snails, which comprises an overall infection rate of 3.9%.

Of these, the most frequently emerged cercaria was *C. orientalis* with 1.37%, followed by *C. nipponensis* with 0.55%, *C. incerta* with 0.5% and *Metagonimus* spp. with 0.41%. In the three kinds of undetermined cercariae, the infection rates varied from 0.09% to 0.22%. It should be noted that no *P. westermani* cercaria was found. In the snails with 10 -14 ㎜ shell length, the liberation rate of cercariae was found to be 0.63% and 3.72% in the snails with 15-19 ㎜ shell length. The rates subsequently increased

Table 1. Relationships between infection rates of larval trematodes and length of *Parafossarulus* snails (1998-2002)

Size group (㎜)	No. examined	*C.orientalis* No.*	%	*C.sinensis* No.	%	*E.oviformis* No.	%	*L.liberum* No.	%	Total No.	%
Small (5.0- 7.9)	157	0	0	0	0	0	0	3	2.80	3	2.80
Medium (8.0-10.9)	1,453	15	1.03	2	0.13	4	0.27	24	1.65	45	3.09
Large (11.0-13.9)	480	3	0.62	2	0.41	3	0.62	10	2.08	18	3.75
Total	2,040	18	0.88	4	0.19	7	0.34	37	1.81	66	3.23

* No. means the number of snails infected.

Remark: *C. sinensis: Clonorchis sinensis, C. orientalis: Cyathocotyle orientalis, E. oviformis: Exorchis oviformis, L. liberum: Loxogenes liberum.*

and reached to a maximum of the 10.61% in the snails of 25-29 ㎜ shell length, and then declined to 4.54% in the snails with more than 30 ㎜ shell length.

Relationship between the infection rates and intensity of *C. sinensis* meta -cercariae and the species of fish caught in the Cheongdo river are listed in Table 3. Of the 19 kinds of fish examined, *S. wakiyae* and *S. dabryi* were the most frequently infected with an infection rate of 100.0 per cent, followed by *G. atromaculatus* with 95.7 per cent, *P. herzi* with 86.9 per cent and *A.asmussi* with 66.7 per cent. The least frequently infected fishes were *A. intermedia* and *A. limbata,* with rates of 26.4 per cent and 21.3 per cent, respectively. No *Clonorchis* metacercaria was found in the flesh, scales, fins and tail of the remaining 7 species of fishes collected in this survey. The metacercarial density of *C. sinensis,* however, when expressed in an average number of encysted larvae per gram of flesh, was low as a whole. *S. wakiyae* was the most heavily infected with an average number of cysts being 42.8. *G. atromaculatus* was the next with an average number of 42.7 cysts. *P. herzi* and *P. parva* were moderately infected with an average number of 9.2 to 17.6 cysts. *A. intermedia, A. limbata* and *A. yamatsutae* were less heavily infected with an average of 0.9, 0.8, and 0.2 cysts, respectively.

In Table 4, our results on the infection rates and intensity of *Clonorchis* metacercariae in the flesh of fresh-water fishes are compared with those reported earlier by Kwak[2]. Of the fishes examined in 1994, the metacercariae of *C. sinensis* were found in six species. *P. parva* was the most highly infected with infection rate of 80.0 per cent, followed by *A. intermedia* with 71.1 per cent, and P. esocinus with 66.7 per cent. Of these, the infection rates in the species such as *G.*

Table 2. Incidence of infection of larval trematodes in *Semisulcospira libertina* (1998-2002)

Larva trematodes	Size of *Semisulcospira* snail (mm)											
	10-14 (941)*		15-19 (645)		20-24 (458)		25-29 (113)		30-34 (22)		Total (2,179)	
	No.†	%	No.	%	No.	%	No.	%	No.	%	No.	%
N. magnivatus	0		1	0.15	4	0.87	1	0.88	0		6	0.27
C. orientalis	5	0.53	13	2.01	8	1.74	3	2.65	1	4.54	30	1.37
Metagonimus sp.	0		3	0.46	5	1.09	1	0.88	0		9	0.41
C. armatus	1	0.10	2	0.31	2	0.43	0		0		5	0.22
C. yoshidae	0		0		3	0.65	0		0		3	0.13
C. nipponensis	0		2	0.31	10	2.18	0		0		12	0.55
C. incerta	0		3	0.46	6	1.31	2	1.76	0		11	0.50
P. westermani	0		0		0		0		0		0	
Cercaria A	0		0		2	0.43	3	2.65	0		5	0.22
Cercaria B	0		0		1	0.21	1	0.88	0		2	0.09
Cercaria C	0		0		1	0.21	1	0.88	0		2	0.09
Total	6(0.63)‡		24(3.72)		42(9.17)		12(10.61)		1(4.54)		85(3.90)	

* Nnumber in the parentheses means number of snails examined. † No. means the number of snails infected. ‡ Number in the Parentheses represents percent liberated.

Remark: *C. armatus: Centrocestus armatus, C. incerta: Cercaria incerta, C. nipponensis: Cercaria nipponensis, C. yoshidae : Cercaria yoshidae, C. orientalis: Cyathocotyle orientalis, E. oviformis : Exorchis oviformis, L. liberum: Loxogenes liberum, Metagonimus spp.:Metagonimus species, N. magnivatus: Notocotylus magnivatus, P. westermani: Paragonimus westermani.*

atromaculatus, P. rhombea, P. parva, and *P. herzi* increased in the period from 1994 to 2002, however, the rate in one species, *A. intermedia,* decreased. The average metacercarial density per gram of flesh of *C. sinensis* appeared to be higher in two species, *G. atromaculatus* and *P. herzi,* in 2002 than in 1994, but was lower in *A. intermedia, P. rhombea* and *P. parva.*

Table 5 lists the relationship between the infection rates and intensity of *Metagonimus* metacercariae and the species of fish collected in the vicinity of the river Cheongdo in Cheongdo county. Of the 19 species of fish examined, *Metagonimus* metacercariae in the flesh were found in 4 kinds of fish. Of them, the most frequently infected fish was *M. yaluensis* with 41.7 per cent, followed by *C. carassius* with 2.4 per cent, and *A. limbata* with 1.7 per cent. The less frequently infected was *Z. temmincki* with 0.3 per cent. Although the infection rates of metacercariae in scales were much

Table 3. Infection rates and intensities of *Clonorchis sinensis* metacercariae in fresh-water fishes collected from River Cheongdo, Kyongbuk, Korea (2002)

Species	No. of fish examined	Flesh		Fin & tail		Scales		Mean of cyst/g of flesh
		No.	%	No.	%	No.	%	
A. asmussi	3	2	66.7	0	0	0	0	1.3
A. intermedia	121	32	26.4	2	1.7	0	0	0.9
A. limbata	75	16	21.3	0	0	0	0	0.8
A. yamatsutae	10	2	40.0	0	0	0	0	0.2
C. carassius	42	0	0	0	0	0	0	0.2
G. atromaculatus	115	110	95.7	13	11.3	1	0.9	42.7
H. longirostris	3	0	0	0	0	0	0	0
M. yaluensis	24	13	54.2	6	25.0	1	4.2	3.2
P. rhombea	239	101	42.2	0	0	0	0	1.3
P. parva	22	10	45.5	1	4.5	0	0	9.2
P. herzi	137	119	86.9	33	24.1	10	7.3	17.6
S. wakiyae	5	5	100.0	0	0	0	0	42.8
S. dabryi	2	2	100.0	0	0	0	0	1.3
S. c. tsuchigae	21	13	61.9	12	57.1	0	0	2.4
Z. platypus	94	0	0	0	0	0	0	0
Z. temmincki	336	0	0	0	0	0	0	0
C. sinensis	20	0	0	0	0	0	0	0
C. herzi	12	0	0	0	0	0	0	0
M. obscura	9	0	0	0	0	0	0	0

higher than those of flesh in these cases, some were found in *C. carassius, Z. platypus* and *Z. temmincki,* but none in *A. limbata*. The infection rates of encysted larvae in the fins and tail were much higher in *C. carassius* with 28.6 per cent than in *Z. platypus* with 1.1 per cent. The metacercarial intensity in the fish was low, and the average number of the cysts per gram of flesh varied from 0.01 to 3.9.

Table 6 shows relationship existing between the infection rates of encysted larvae of digenetic trematodes other than *C. sinensis* and *Metagonimus* species and the species of fresh-water fish collected from the river Cheongdo. *C. orientalis* was found in 18 species of fish, followed by *M. hasegawai* in 17 speices, *E. oviformis* in 12 species, and *C. armatus* was the least common, found in only 2 species of fish. Of the 10 species of fish with *C. orientalis, S.dabryi* was the most highly infected with the positive rate of 100.0 per cent, followed by *S.c. tsuchigae* with 95.2 per cent, *C. herzi* with 95.0 per cent, and *A. yamatsutae* with 90.0 per cent. The less frequently infected fish were *Z. platypus* and *M. obscura* with 17.0 per cent and 11.1 per cent, respectively.

In the case of *M. hasegawai,* 17 species

Table 4. Comparison of iinfection rates and intensities of *Clonorchis sinensis* metacercariae in fresh-water fishes caught from River Cheongdo (1994 and 2002)

Species	No. of fish examined		Percent infected		Mean of cyst/g of flesh	
	Kwak (1994)	Author (2002)	Kwak (1994)	Author (2002)	Kwak (1994)	Author (2002)
A. asmussi	0	3	0	66.7	0	1.3
A. intermedia	83	121	71.1	26.4	11.0	0.9
A. limbata	0	75	0	21.3	0	0.8
A. yamatsutae	0	10	0	40.0	0	0.2
C. carassius	10	42	0	0	0	0
G. atromaculatus	9	115	44.4	95.7	30.9	42.7
H. longirostris	1	3	0	0	0	0
M. yaluensis	0	24	0	54.2	0	3.2
P. rhombea	20	239	30.0	42.2	8.8	1.3
P. parva	10	22	80.0	45.5	41.0	9.2
P. herzi	6	137	16.7	86.9	3.0	17.6
S. wakiyae	0	5	0	100.0	0	42.8
S. dabryi	0	2	0	100.0	0	1.3
S. c. tsuchigae	0	21	0	61.9	0	2.4
Z. platypus	64	94	0	0	0	0
Z. temmincki	82	336	0	0	0	0
C. sinensis	0	20	0	0	0	0
C. herzi	6	12	0	0	0	0
M. obscura	19	9	0	0	0	0
M. oxycephalus	3	0	0	0	0	0
P. esocinus	3	0	66.7	0	4.0	0
P. asotus	2	0	0	0	0	0

of fishes harbored the cyst with the infection rates varying from 2.1 per cent to 87.0 per cent. Of these, *G. atromaculatus* was the most highly infected with rate of 87.0 per cent, followed by *C. sinensis* with 85.0 per cent, while *Z. platypus* and *Z. temmincki* were slightly infected. The encysted larvae of *E. oviformis* were recovered from 12 species of fish and also found in the flesh, ranging in the frequency from 1.5 per cent to 100.0 per cent. Similarly, the larvae of *Echinochasmus* species and *C. complanatum* were found in 8 species of fish, followed by *M. orientalis* in 4 species of fish.

The presence of encysted larvae of digenetic trematodes other than *C. sinensis* and *Metagonimus* species on the scales of fresh-water fishes are listed in Table 7. Five kinds of encysted larvae and some undetermined larvae were found in the scales of fish. Of these, *E. oviformis* was found in 9 species of fish. The infection rate of the cyst on the scales ranged from 4.3 to 100.0 per cent.

The cyst of both *Echinochasmus* species and *M. orientalis* was found in 4 species of fish, followed by *M. hasegawai* in 3

Table 5. Infection rates and intensity of *Metagonimus* species in fresh-water fishes caught from River Cheongdo, Kyongbuk, Korea (2002)

Species	No. of fish examined	Flesh		Fin & tail		Scales		Mean of cyst/g of flesh
		No.	%	No.	%	No.	%	
A. asmussi	3	0	0	0	0	0	0	0
A. intermedia	121	2	1.7	0	0	0	0	0.1
A. limbata	75	0	0	0	0	0	0	0
A. yamatsutae	10	0	0	0	0	0	0	0
C. carassius	42	1	2.4	12	28.6	31	73.8	0.05
G. atromaculatus	115	0	0	2	1.7	0	0	0
H. longirostris	3	0	0	0	0	0	0	0
M. yaluensis	24	10	41.7	2	8.3	2	8.3	3.9
P. rhombea	239	0	0	0	0	0	0	0
P. parva	22	0	0	1	4.5	0	0	0
P. herzi	137	0	0	0	0	0	0	0
S. wakiyae	5	0	0	0	0	0	0	0
S. dabryi	2	0	0	0	0	0	0	0
S. c. tsuchigae	21	0	0	0	0	0	0	0
Z. platypus	94	0	0	1	1.1	26	27.7	0
Z. temmincki	336	1	0.3	7	2.1	120	35.7	0.01
C. sinensis	20	0	0	0	0	0	0	0
C. herzi	12	0	0	0	0	0	0	0
M. obscura	9	0	0	0	0	0	0	0

species of fish, and *C. orientalis* in 2 species of fish. However, the metacercarial rate varied and was generally low.

Table 8 presents the infection rates of encysted larvae of digenetic trematodes other than *C. sinensis* and *Metagonimus* species on the fins and tail of fresh-water fish. Five larval trematodes, *C. orientalis, Echinochasmus* species, *E. oviformis, M. hasegawai,* and *M. orientalis* were found. Of these *E. oviformis* was found in 15 species of fish, followed by *M. hasegawai. M. orientalis* was found in 4 species of fish.

The infection intensity of the encysted larvae of digenetic trematodes other than *C. sinensis* and *Metagonimus* species in the flesh of fresh-water fishes is shown in Table 9. The metacercarial density in fishes, however, when expressed in average number of encysted larae per gram of flesh, was low as a whole. In the case of *C. orientalis,* 18 species of fish harbored the cyst with intensity varying from 0.1 to 129.7. Of these, the most heavily infected fish was *P. parva,* being found to have 129.7 cysts, followed by *C. sinensis* with 31.4 cysts, *A. yamatsutae* with 13.8 cysts, and *P. herzi* with 13.6 cysts, whereas *A. asmussi, Z. platypus,* and *M. obscura* were very lightly infected. Of the 17 species of fish with *M.*

Table 6. Infection rates of encysted larvae of digenetic trematodes other than *Clonorchis sinensis* and *Metagonimus* species in flesh of fresh-water fishes caught in River Cheongdo (2002)

Species	No. of fish examined	C.o		E.s		E.o		M.h		M.o		C.a		C.c		Und.s	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
A. asmussi	3	1	33.3	0	0	3	100.0	2	66.7	0	0	0	0	0	0	0	0
A. intermedia	121	103	85.1	21	17.4	111	91.7	48	39.7	0	0	0	0	12	9.9	11	9.1
A. limbata	75	58	77.3	11	14.7	73	97.3	36	48.0	0	0	0	0	6	8.0	1	1.3
A. yamatsutae	10	9	90.0	0	0	6	60.0	3	30.0	0	0	0	0	0	0	4	40.0
C. carassius	42	16	38.1	0	0	0	0	10	23.8	0	0	0	0	0	0	7	16.7
G. atromaculatus	115	52	45.2	13	11.3	2	1.7	100	87.0	0	0	0	0	6	6.1	0	0
H. longirostris	3	1	33.3	0	0	0	0	0	0	0	0	0	0	0	0	3	100.0
M. yaluensis	24	16	66.7	16	66.7	8	33.3	12	50.0	1	4.2	0	0	1	4.2	0	0
P. rhombea	239	152	63.7	26	10.9	167	69.9	76	31.8	1	0.4	0	0	7	2.9	20	2.9
P. parva	22	18	81.8	11	50.0	14	63.6	5	22.7	17	77.3	0	0	1	4.5	4	18.2
P. herzi	137	112	81.8	8	5.8	2	1.5	40	29.2	5	3.6	0	0	4	2.9	2	1.5
S. wakiyae	5	4	80.0	1	20.0	0	0	3	60.0	0	0	0	0	0	0	0	0
S. dabryi	2	2	100.0	0	0	0	0	1	50.0	0	0	0	0	0	0	0	0
S. c. tsuchigae	21	20	95.2	0	0	4	19.0	5	23.8	0	0	0	0	1	4.8	18	85.7
Z. platypus	94	16	17.0	0	0	5	5.3	2	2.1	0	0	90	95.7	0	0	26	27.7
Z. temmincki	336	157	46.7	0	0	19	5.7	18	5.4	0	0	294	87.5	0	0	111	33.0
C. sinensis	20	19	95.0	0	0	0	0	17	85.0	0	0	0	0	0	0	0	0
C. herzi	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8.3
M. obscura	9	1	11.1	0	0	0	0	7	77.8	0	0	0	0	0	0	0	0

Remark: *C.o: Cyathocotyle orientalis, E.s: Echinochasmus species, E.o: Exorchis oviformis, M.h: Metacercaria hasegawai, M.o: Metorchis orientatis, C.a: Centrocestus armatus, C.c: Clinostomum complanatum, Und.s: Undetermined species.*

hasegawai, *G. atromaculatus* was the most heavily infected with larvae and the average number of larvae was 11.1. *C. sinensis* was the next with an average of 10.3. *A. intermedia, A. limbata,* and *M. obscura* were moderately infected with average number varying from 2.1 to 2.5 cysts.

However, *Z. temmincki* and *Z. platypus* were less heavily infected by the larvae with an average of 0.1 and 0.04 cysts, respectively. In the case of *E. oviformis,* the intensity of the cysts in the flesh was lower than that of *C. orientalis.* Of these, *A. limbata* was the most heavily infected with an average of 23.3 cysts, followed by *A. intermedia* with 17.0 cysts and *P. rhombea* with 6.0 cysts. On the other hand, *G. atromaculatus, S.c. tsuchigae, Z. platypus*, and *Z. temmincki* were very lightly infected. Similar pattern was observed in the cases of *Echinochasmus* species and *C. complanatum.*

The infection rate of *C. sinensis* among

Table 7. Infection rates of encysted larvae of digenetic trematodes other than *Clonorchis sinensis* and *Metagonimus* species in scales of fresh-water fishes caught in River Cheongdo (2002)

Species	No. of fish examined	C.o		E.s		E.o		M.h		M.o		Und.s	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
A. asmussi	3	0	0	0	0	3	100.0	0	0	0	0	1	33.3
A. intermedia	121	0	0	0	0	35	28.9	0	0	0	0	7	5.8
A. limbata	75	0	0	2	2.7	52	69.3	0	0	0	0	21	28.2
A. yamatsutae	10	0	0	0	0	1	10.0	0	0	0	0	0	0
C. carassius	42	0	0	1	2.4	0	0	2	4.8	1	2.4	1	2.4
G. atromaculatus	115	0	0	2	1.7	0	0	2	1.7	1	1.7	3	2.6
H. longirostris	3	0	0	0	0	0	0	0	0	0	0	0	0
M. yaluensis	24	2	8.3	0	0	1	4.2	0	0	1	4.2	5	20.8
P. rhombea	239	0	0	0	0	47	19.7	0	0	0	0	3	1.3
P. parva	22	0	0	0	0	5	22.7	0	0	1	4.5	0	0
P. herzi	137	0	0	0	0	0	0	7	5.1	0	0	0	0
S. wakiyae	5	0	0	0	0	0	0	0	0	0	0	2	40.0
S. dabryi	2	0	0	0	0	0	0	0	0	0	0	0	0
S. c. tsuchigae	21	0	0	0	0	0	0	0	0	0	0	0	0
Z. platypus	94	0	0	0	0	4	4.3	0	0	0	0	14	14.9
Z. temmincki	336	1	0	1	0.3	65	19.3	0	0	0	0	4	1.2
C. sinensis	20	0	0	0	0	0	0	0	0	0	0	0	0
C. herzi	12	0	0	0	0	0	0	0	0	0	0	0	0
M. obscura	9	0	0	0	0	0	0	0	0	0	0	0	0

Remark: *C.o: Cyathocotyle orientalis, E.s: Echinochasmus species, E.o: Exorchis oviformis, M.h: Metacercaria hasegawai, M.o: Metorchis orientatis, C.a: Centrocestus armatus, C.c: Clinostomum complanatum, Und.s: Undetermined species.*

the residents according to their sex and age is listed in Table 10. The infection rate of *C. sinensis* in 922 residents in the vicinity of the river Cheongdo was 4.3 per cent. In general, the rates for all the age groups were high; 0 per cent in the 0-9 years group, 0.9 per cent in the 10-19 years group and 0 per cent in the 20-29 years group. The rate increased to 5.7 per cent in the 30-39 years group and reached a maximum of 13.6 per cent in the 40-19 years group, thereafter remaining around 5.0 per cent. As for the sex-specificity, the rate was higher among males than females ($t > 2$).

The intensity of infection in 40 residents by sex is summarized in Table 11. The intensity of infection, expressed by eggs per gram of stool, was divided into three groups: light infection, EPG 1 -999; moderate infection, EPG 1,000 -9,999; and heavy infection, EPG over 10,000. Thirty-three cases or 82.5 per cent of the residents with clonorchiasis

Table 8. Infection rates of encysted larvae of digenetic trematodes other than *Clonorchis sinensis* and *Metagonimus* species in fins and tail of fresh-water fishes caught in River Cheongdo (2002)

Species	No. of fish examined	C.o		E.s		E.o		M.h		M.o		Und.s	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
A. asmussi	3	0	0	0	0	3	100.0	1	33.3	0	0	1	33.3
A. intermedia	121	2	1.7	0	0	86	71.1	0	0	0	0	33	27.3
A. limbata	75	32	42.7	8	10.7	75	100.0	0	0	0	0	10	13.3
A. yamatsutae	10	0	0	0	0	7	70.0	0	0	0	0	0	0
C. carassius	42	1	2.4	3	7.1	1	2.4	31	73.8	0	0	0	0
G. atromaculatus	115	1	0.9	3	2.6	1	0.9	48	41.7	2	1.7	5	4.3
H. longirostris	3	0	0	0	0	3	100.0	1	33.3	0	0	0	0
M. yaluensis	24	1	4.2	2	8.3	5	20.8	1	4.2	1	4.2	7	29.2
P. rhombea	239	0	0	5	2.1	231	96.7	6	2.5	0	0	13	5.4
P. parva	22	3	13.6	2	9.1	9	40.9	5	22.7	2	9.1	12	54.5
P. herzi	137	18	13.1	1	0.7	0	0	16	11.7	0	0	2	1.5
S. wakiyae	5	0	0	0	0	0	0	0	0	0	0	0	0
S. dabryi	2	0	0	0	0	1	50.0	0	0	0	0	0	0
S. c. tsuchigae	21	1	4.8	0	0	5	23.8	3	14.3	0	0	0	0
Z. platypus	94	0	0	0	0	30	31.9	0	0	0	0	34	36.3
Z. temmincki	336	1	0.3	4	1.2	147	43.8	1	0.3	0	0	27	8.0
C. sinensis	20	0	0	0	0	1	5.0	12	60.0	1	5.0	2	10.0
C. herzi	12	0	0	0	0	0	0	0	0	0	0	0	0
M. obscura	9	0	0	0	0	0	0	0	0	0	0	0	0

Remark: *C.o: Cyathocotyle orientalis, E.s: Echinochasmus species, E.o: Exorchis oviformis, M.h: Metacercaria hasegawai, M.o: Metorchis orientatis, C.a: Centrocestus armatus, C.c: Clinostomum complanatum, Und.s: Undetermined species.*

had less than 1,000 eggs. Only 7 cases or 17.5 per cent showed moderate infection. No difference in the intensity of infection between males and females was found.

Table 12 lists the prevalence of the metagonimiasis among the residents in the vicinity of the river Cheongdo. The overall infection rate for the metagoni - miasis among 922 residents was found to be 1.7 per cent, and the infection was significantly higher in males than in females; 2.7 per cent in males and 0.8 per cent in females. As for the age-specificity, the rate varied from 0 to 7.4 per cent, with a maximum infection in the 50-59 years of age group in male and in the 60 -69 years group in female.

Discussion

The results described herein indicate

Table 9. Infection intensity of encysted larvae of digenetic trematodes other than *Clonorchis sinensis* and *Metagonimus* species in flesh of fresh-water fishes caught in River Cheongdo (2002)

Species	No. of fish examined	Average number of cyst/g of flesh (es)							
		C.o	E.s	E.o	M.h	M.o	C.a	C.c	Und.s
A. asmussi	3	0.3	0	8.3	1.3	0	0	0	0
A. intermedia	121	11.0	0.4	17.0	2.5	0	0	0.2	1.1
A. limbata	75	6.6	0.3	23.3	2.3	0	0	0.1	0.03
A. yamatsutae	10	13.8	0	3.1	1.3	0	0	0	2.9
C. carassius	42	1.4	0	0	0.3	0	0	0	0.3
G. atromaculatus	115	2.8	0.4	0.2	11.1	0	0	0.1	0.1
H. longirostris	3	0.3	0	0	0	0	0	0	6.0
M. yaluensis	24	6.3	7.1	2.1	1.5	0.05	0	0.1	0
P. rhombea	239	2.6	0.2	6.0	0.7	0.01	0	0.04	0.6
P. parva	22	129.7	1.7	4.6	1.2	25.6	0	0.05	1.2
P. herzi	137	13.6	0.1	0.03	0.7	0.1	0	0.05	0.2
S. wakiyae	5	3.0	0.2	0	0.6	0	0	0	0
S. dabryi	2	2.0	0	0	1.3	0	0	0	0
S. c. tsuchigae	21	6.2	0	0.3	0.3	0	0	0.05	23.2
Z. platypus	94	0.3	0	0.1	0.04	0	14.9	0	1.3
Z. temmincki	336	3.2	0	0.1	0.1	0.01	10.4	0	2.1
C. sinensis	20	31.4	0	0	10.3	0	0	0	0
C. herzi	12	0	0	0	0	0	0	0	0.1
M. obscura	9	0.1	0	0	2.1	0	0	0	0

Remark: *C.o: Cyathocotyle orientalis, E.s: Echinochasmus species, E.o: Exorchis oviformis, M.h: Metacercaria hasegawai, M.o: Metorchis orientatis, C.a: Centrocestus armatus, C.c: Clinostomum complanatum,Und.s: Undetermined species.*

that fish-borne trematode infections, clonorchiasis and metagonimiasis, are still two of the most important parasitic diseases in the vicinity of the river Cheongdo, Kyongbuk Province, Korea.

Although the reduction in the prevalence of *C. sinensis* infections among the residents and in the number of *Clonorchis* metacercariae per fishes as well as a diminutive areas of the fish intermediate hosts in this Province has been realized for the past several decades, the causes leading to the reduction in *Clonorchis* infection have not yet been fully explained. In an earlier report, Joo and Hong[7] found *C. sinensis* in 13.2 per cent of males examined, whereas only 8.5 per cent of females were found to be infected. In their study, total number of subjects examined was 902 and the overall infection rate was 11.0 per cent. They performed only stool examination.

Table 10. Infection rate of *Clonorchis sinensis* among residents in vicinity of River cheongdo by sex and age groups (1998-2002)

Age group (year)	Male		Female		Total	
	No. examined	Positive rate (%)	No. examined	Positive rate (%)	No. examined	Positive rate (%)
0 - 9	38	0	23	0	61	0
10 - 19	236	1.3	229	0.4	465	0.9
20 - 29	3	0	3	0	6	0
30 - 39	26	7.7	61	4.9	87	5.7
40 - 49	59	22.0	51	3.9	110	13.6
50 - 59	30	13.3	24	8.3	54	11.1
60 - 69	34	5.9	44	4.5	78	5.1
70 -	20	20.0	41	4.9	61	9.8
Total	446	6.3	476	2.5	922	4.3

Table 11. Intensity of *Clonorchis sinensis* infection by Stoll's egg-count technique among residents in vicinity of River cheongdo (1998-2002)

Range of EPG (intensity)	Male		Female		Total	
	No. infected	Proportion (%)	No. infected	Proportion (%)	No. infected	Proportion (%)
1 - 999	21	75.0	12	100.0	33	82.5
1,000 - 9,999	7	25.0	0	0	7	17.5
10,000 -	0	0	0	0	0	0
Total	28	100	12	100	40	100

Therefore, if they carried out stool examinations and also intradermal tests, the rates would probably have been higher. In another survey by Joo *et al.*[8], egg positive rate was found to be as high as 7.7 per cent and the positive rate by intradermal test with *Clonorchis* antigen was 27.6 per cent. Stool examination of residents in Taegu and Kyongbuk Province in the fifth national parasitic survey in 1992 revealed 0.2 per cent and 2.7 per cent of egg positive rates, respectively. In the present study, we observed that *Clonorchis* egg positive rate by stool examination was as high as 4.3 per cent and *Metagonimus* egg positive rate was 1.7 per cent. Our results together with those of other earlier surveys suggest that the clonorchiasis is slowly changing its endemicity in the ecologically preserved areas. In the ecologically labile areas, people are apt to get infected by going to the endemic foci for such as fishing.

As shown by Chung *et al.*[9], the population density of snails in the habitat and the infection of the snail with the

Table 12. Prevalence rate of metagonimiasis among residents in vicinity of River cheongdo by sex and age groups (1998-2002)

Age group (year)	Male		Female		Total	
	No. examined	Positive rate (%)	No. examined	Positive rate (%)	No. examined	Positive rate (%)
0 - 9	38	0	23	0	61	0
10 - 19	236	0	229	0	465	0
20 - 29	3	0	3	0	6	0
30 - 39	26	3.8	61	0	87	1.1
40 - 49	59	5.1	51	2.0	110	3.6
50 - 59	30	13.3	24	0	54	7.4
60 - 69	34	5.9	44	4.5	78	5.1
70 -	20	10.0	41	2.4	61	4.9
Total	446	2.7	476	0.8	922	1.7

cercariae of digenetic trematodes have gradually been reduced in Kyongbuk Province, along with habitat reduction. Based on their observation of snail habitats, they also pointed out that water pollution due to massive drainage from homes and industrial waste products from newly established factories, together with land development and intense pesticide spraying for agriculture, would play an important role for the reduction of snail habitats. Furthermore, Joo and Hong[7] concluded that a large scale usage of pesticides and destruction of natural environment, particularly rivers, are the principal cause of reduction of *Clonorchis* infection among the residents in Kyongbuk Province. In addition to the vector snail reduction, change of people's attitude toward eating raw and undercooked fishes has also contributed to the changing endemicity. However, as shown in this study, the speed of decline is slow. Popular use of praziquantel for treatment of clonorchiasis and other trematode infections is certainly an another contributor to lowering endemicity.

Number of fish species distributed in an area, number of infected fish species with digenetic larval trematodes, and their infection rate and burden are parameters reflecting the degree of ecological damage and the potentiality of *C. sinensis* and other trematodes transmission to final hosts including human. Choi[10] in a comprehensive survey on *C. sinensis* in the rivers in the Province, found that 10 out of 21 fresh -water fish species were infected with *Clonorchis* metacercariae, and that *P. parva* was the most frequently infected fish with the infection rate of 93.2 per cent, followed by *P. esocinus, S. sinensis, H. labeo,* and *P. herzi* with 90.4 per cent, 87.8 per cent, 87.2 per cent, and 60.8 per cent, respectively. Lee *et al.*[11], in a comparative study on the infection rate of *Clonorchis* metacercariae in fresh-water

fishes collected in the vicinity of the rivers, small ponds and swamps in the Province, collected 25 fresh-water fish species and found that 12 fish species were infected with *Clonorchis* cysts. They further observed that the infection rate and intensity with Clonorchis cyst varied markedly from fish to fish.

In the present study, 19 species of fresh-water fish were identified. Of them, 12 species were found infected with *C. sinensis* metacercariae. When compared with previously reported data in Kyongbuk, our results are similar to those reported by Hwang and Choi[12] in the river Kumho, Joo[13] in the River Hyungsan , and Lee *et al.*[11] in the River Naktong and its tributaries, but the intensity of infections with *Clonorchis* cyst in the fish hosts varied markedly from fish to fish. The main factors for the varying infection intensities in different fishes are ecology of fishes such as habitats and migration as well as changing ecology of the river. And, as indicated by Lee and Joo[14] and also shown in the present study, the intensity of infection with *Clonorchis* cyst in the fish hosts is decreasing recently. These findings suggest that the scarcity of fish and the low incidence of *C. sinensis* in the fish hosts caught in the rivers, streams and ponds of Kyongbuk Province may be due to artificial pesticidal effects on the water, which would be inhibitory to the survival of larval trematodes.

In the fish host survey of *Metagonimus* species in this Province, a relatively high incidence of *Metagonimus* cysts have been reported by some investigators; on brackish-water fishes in the vicinity of the river Taechong by Joo *et al.*[15] and on fresh-water fishes in the river Hyungsan by Kim and Joo[16], in the river Taewha by Joo[17] and Yoo *et al.*[18], in the river Kumho by Hwang and Choi[12], and in the river Taega by Lee and Joo[14]. From the above mentioned studies, it was obvious that *Metagonimus* cysts are widely distributed in both fresh -water fish as well as brackish-water fishes in this Province and that the infection rate in the brackish-water fishes is far higher than that in the fresh-water fishes. In the present study, the encysted larvae of *Metagonimus* species were found mostly on the scales, fins and tail with more than 50 percent incidence, whereas a few number in the muscles and subcutaneous tissues. From the above considerations, it is concluded that the cysts were mostly found on the scales, fins, and tail in the fresh-water fishes such as *C. carassius* and *Z. temmincki,* whereas it was vice versa in the brackish -water fish, therefore, the cysts were mostly found in muscles and subcutaneous tissues. Although main reasons for variant infection rates and intensities in different fish hosts can not be fully explained, it could most likely be due to the ecology of fishes, such as habitats and migration as well as topical and seasonal conditions. Also, other factors such as water temperature, snail habitats and final hosts with metagonimiasis are to be taken into account.

Yamaguti[19] first found *C. complanatum*

metacercaria, belonging to the family Clinostomidae, in the muscle near gill, near base of pectoral fin, around buccal cavity and subcutaneous muscle of *C. carassius, P. esocinus, A. lanceolata, M. anguillicaudatus* and *P. parva.* In Korea, Chung *et al.*[20] presented a detailed report on *C. complanatum* from fish hosts in the vicinity of the river Ssanggye and some ponds such as, Kaumji and Kaechonji, located in Uiseong county, Kyongbuk Province. They also reported that the infection rate ranged from 1.6 per cent in *Z. temmincki* to 88.9 per cent in *A. rhombea* and *M. yaluensis,* and that the intensity of infection was highest in *C. auratus* with 13.0/fish infected and the abundance was the highest in *A. rhombea* with 7.8/fish examined. In the present study, 8 fish species harbored the metacercariae of *C. complanatum,* their rates ranging from 2.9 to 9.9 per cent. *P. rhombea* and *P. herzi* were less frequently infected with the cysts of less than 3.0 per cent.

In the studies of fish hosts with larval trematodes other than *C. sinensis* and *Metagonimus* species, Hwang and Choi[12] collected 13 fresh-water fish species in the vicinity of the river Kumho and found that they were infected with 10 kinds of larval trematodes including 3 unidentified larvae A, B and C. Of them, the encysted larva of *E. oviformis* was found most frequently in all species of fresh-water, followed by *M. hasegawai* in 12 species. *C. orientalis* in 8 species, *Echinochasmus* species in 6 species, and *M. orientalis* in 4 species of fish. They also reported that the rate and intensity of infection with the larval trematodes varied markedly from fish to fish. Kim and Joo[16] reported relatively lower rates of infection with the encysted larvae of digenetic trematodes in 10 species of fresh-water fish and 1 kind of brackish-water fish collected in the river Hyungsan. Of them, 8 species of fish were infected with *Metagonimus* species and all the fishes were heavily infected with the encysted larvae of *E. oviformis.* Similar results have also been obtained by Joo *et al.*[15] in the river Taechong, by Lee *et al.*[21] in the Ossep, by Joo and Jheon[22] in the river Wyangpi, Yoo *et al.*[18] in the river Taewha, and Lee and Joo[14] in the river Taega. These results strongly indicate the rate of infection with digenetic trematodes in fresh-water fishes is still high and the metacercarial burden in the fish varies greatly by different fish, and that *Clonorchis* and *Metagonimus* infections are caused by consuming raw fresh-water fishes collected from the river Cheongdo, Kyongbuk Province.

In the present study, the infection rate of *C. sinensis* among the residents was found to be relatively high. However, this can not necessarily reflect true infection rate among the residents in Cheongdo county, because mere one time fecal examination can not be sufficient enough to determine the true infection rate of the *Clonorchis* infection and also the infection patterns of liver fluke varies from village to village and from stream to stream. Nevertheless, the results obtained in this study are quite comparable with earlier

reports which are based on a singular examination of feces and similar laboratory procedure. Choi and Joo[23] found that only 7 of 1,200 residents examined in Taegu city were positive for *Clonorchis* eggs, and attributed such a decrease partly to decrease in the number of the intermediate hosts due to improvement of water pollution and partly to the effect of public health education on clonorchiasis and other parasitic diseases. However, no data are available on the question of how the persistent education on public health would result in decreased rate of clonorchiasis. Hyun and Joo[24] suggest that the decreased prevalence of the liver flukes among the residents with a good knowledge of sanitation in the Province resulted from marked improvement of the socioeconomic status and less possibilities to eat raw and uncooked fish.

The results on the sex-specific rates of *C. sinensis* and *M. yokogawai* infection with significantly higher with prevalence in males than in females at all age groups are in good agreement with those of previous studies[2,7,8,24], and suggest that this is probably due to the fact that males have more opportunities of eating raw and/or uncooked fresh-water fishes away from home, as was observed in the case of other fluke infections. This hypothesis is further strengthened by the fact that Korean people have traditional habits of eating raw fresh-water fishes, simply soaked in vinegar or red-pepper mash, as an appetizer, when drinking rice-wine and/or distilled spirits at social meetings. Since males frequently participate in such meetings, they have more occasions to eat raw and/or uncooked fishes.

In this survey, the prevalence rates of C. sinensis and *M. yokogawai* in the younger age groups were prominently lower than those of the older age groups. This seems to be due to several factors, such as persistent education on public health, reduction of the infection sources by treatment, and cultural, dietary and economic changes.

The intensity of infection, expressed by eggs per gram of feces, varied greatly depending on the infected cases. In this study, approximately 82.5 per cent of the 40 cases had less than 1,000 eggs per gram of feces, indicating that most cases of clonorchiasis were lightly infected. Such a low intensity can not adequately be explained, however, the improvement of the socioeconomic status, the effectiveness of public health education and anticlonorchis campaigns during the past several decades can be regarded as important factors for decreasing the infections. The results of our present study are in good agreement with the findings of Lee[25], Hyun and Joo[24], and Kwak[2], that a relatively low intensity of *Clonorchis* infections was observed at several areas in Kyongbuk Province, Korea. This is quite likely due to the fact that the small-sized fishes with *Clonorchis* cysts are mostly neglected for raw consumption by the residents, and are eaten as preserved foods after being boiled in the soybean sauce. Indeed, most patients with clonorchiasis state that they have eaten

C. carassius, C. carpio, and *C. carpio nudus* in a state of raw, cutting them in slices and mixing with vinegar or soybean paste, thus resulting in mild infection as seen in the present study.

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