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Epidemiological studies of *Clonorchis sinensis* in the coastal areas of Kyungpook, Korea*

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- Abstract -

In order to determine the epidemiological patterns of the liver fluke, the infection rates for *Clonorchis* larvae in the snails and fish hosts, and the prevalence of *C. sinensis* among the residents in the coastal areas of Kyungpook Province were studied from April, 1992 to September, 1993.

Four snail habitats were found in the river Hyungsan and some streams. One area had snails infected with *Clonorchis* cercaria, but the proportion of infected snails was very low, the average rates varying from zero to 0.081 percent. Of the 19 species of fish, 3 species were infected with the encysted larvae of *C. sinensis*. Infection rates varied greatly by the fish species, and ranged from 6.7 percent in *P. herzi* to 88.9 percent in *G. artomaculatus*. In the intensity of infection with *C. sinensis*, *G. atromaculatus* was the most heavily infected species, the average number of cysts per gram of the fish flesh being 72.2, followed by *P. herzi* with 53.0 cysts.

The infection rate for *C. sinensis* among the residents was relatively high, being found to be 5.9 percent with a prevalence of 7.0 percent in males and 5.1 percent in females. The difference in the rate of infection between males and females is found to be statistically significant($t>2$).

For the quantitative analysis of epidemiology of *C. sinensis*, a special type of simple catalytic model was applied to the sex and age infection rates revealed by stool examination for *Clonorchis* eggs. The simple catalytic curve for males was $y=0.21(1-e^{-0.021t})$, and females was $y=0.19(1-e^{-0.013t})$.

From these equations the force of infection of 2.1 and 1.3 effective infections giving positive stool examination per 1,000 residents annually was suggested. And the asymptote is at about 21.0 percent of males and 19.0 percent of females, the estimated values of the limit of possible positive cases in the residents.

For the analysis of the age prevalence patterns of *Clonorchis* positives applied the two-stage catalytic model, and the equation is $y=0.511(e^{-0.0093t}-e^{-0.0275t})$. For the analysis of the intensity of infection, the frequency distribution by the *Clonorchis* egg counts was calculated as well as the cumulative percentage to the total number of positive cases, and the regression equation is $y=1.07+1.50 \log X$.

This study indicate that endemic foci of *C. sinensis* exist in the coastal areas of Kyungpook Province and the prevalence of the liver fluke among the residents is still high, and that the infection rates with *Clonorchis* larvae in the fresh-water fish and snails varied greatly by the species of fish and its habitats.

Keywords : *Clonorchis sinensis*, Metacercaria, Snail and fish intermediate hosts, Epidemiology, Kyungpook Province, Catalytic model, prevalence.

Introduction

Clonorchis sinensis is one of the popularly known human liver flukes, with high prevalence in Korea, Japan, China, Taiwan and Vietnam, infected by taking orally the mature *Clonorchis* metacercariae with fresh-water fish.

The initial description of this fluke in Korea was made by Matsumoto(1915) who carried out a survey on intestinal helminths among Koreans in Taegu Charity hospital. Kobayashi(1920) summarized survey findings on the infection with the larval trematodes in the snail and fish hosts and the infection rate of *C. sinensis* among the residents in Korea. Sekigutchi et al.(1937 a, b) in their studies of the intestinal helminths reviewed the high prevalence of *C. sinensis* among the residents in Kimhae area. Nishimura(1943) made a survey of intestinal parasites in Taegu and Yeongcheon areas, and reported that an endemic focus of *C. sinensis* exists in the vicinity of Yeongcheon.

He also described the presence of metacercariae characteristics of *C. sinensis* in fresh-water fish in the same area where the snails harbouring the cercariae were found. After the World War II, Hunter et al.(1949) conducted a survey by fecal concentration method throughout the South Koera, visiting mainly city areas at random, and found the endemicity of *C. sinensis* depend on the area.

In a nationwide survey of the prevalence of clonorchiasis and paragonimiasis, Walton and Chyu(1959) estimated, after an intradermal test with *Clonorchis* antigen that in South Korea some 4.5 million people were infected by *C. sinensis*, posing a public health problem of considerable magnitude.

Afterwards, many investigators have made studies on the prevalence of *C. sinensis*, among the residents(Shin, 1964; Choi et al., 1976; Seo et al., 1981; Joo and Hong, 1991; Hyun, 1992), and on the infection rates and intensity for *Clonorchis* metacercariae in different fish groups in the Province(Lee, 1968; Choi, 1976; Hwang and Choi; 1980; Joo et al., 1983; Chung et al., 1991; Lee et al., 1992).

Since the beginning of the New Village (Saemaul) Movement(1972), the Korean government made plans to control human parasitic diseases, and carried out the mass treatment of egg-positive cases. These operations resulted in a gradual decrease in the infection rates of helminthic diseases. However, the data of the previous surveys (Joo and Hong, 1991; Chung et al., 1991; Hyun and Joo, 1993) revealed that *C. sinensis*, still remained highly prevalent, especially in the vicinity of the rivers and their tributaries of the Province.

This study has been proceeded as a part of our investigation in the epidemiology and control of human clonorchiasis, since *C. sinensis* is still recognized as a major public health problem in Korea.

This report deals with the infection patterns of the snail and fish hosts with larval trematodes and the prevalence of *C. sinensis* among the residents in the coastal areas of Kyungpook Province.

Materials and Methods

1. Geographical conditions of surveyed areas:

Kyungpook Province is situated in the southeastern part of the Korean peninsula, having an area of 19,700 square kilometers, and is chiefly separated into the western hilly area, the central low land and the eastern hilly and/or coastal area. The coastal area of the Province is rather simple and close to the Taebaek mountain range, for geographical reasons it has never really been developed here to any great extent in comparison to the other coasts. Only at Yeongil Bay there is a sandy hill along the coast, thus established it as good fishing area as well as a good tourist spot.

The 14 villages and four primary schools in the vicinity of the river Hyungsan and some streams in the coastal areas of the Province were selected

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

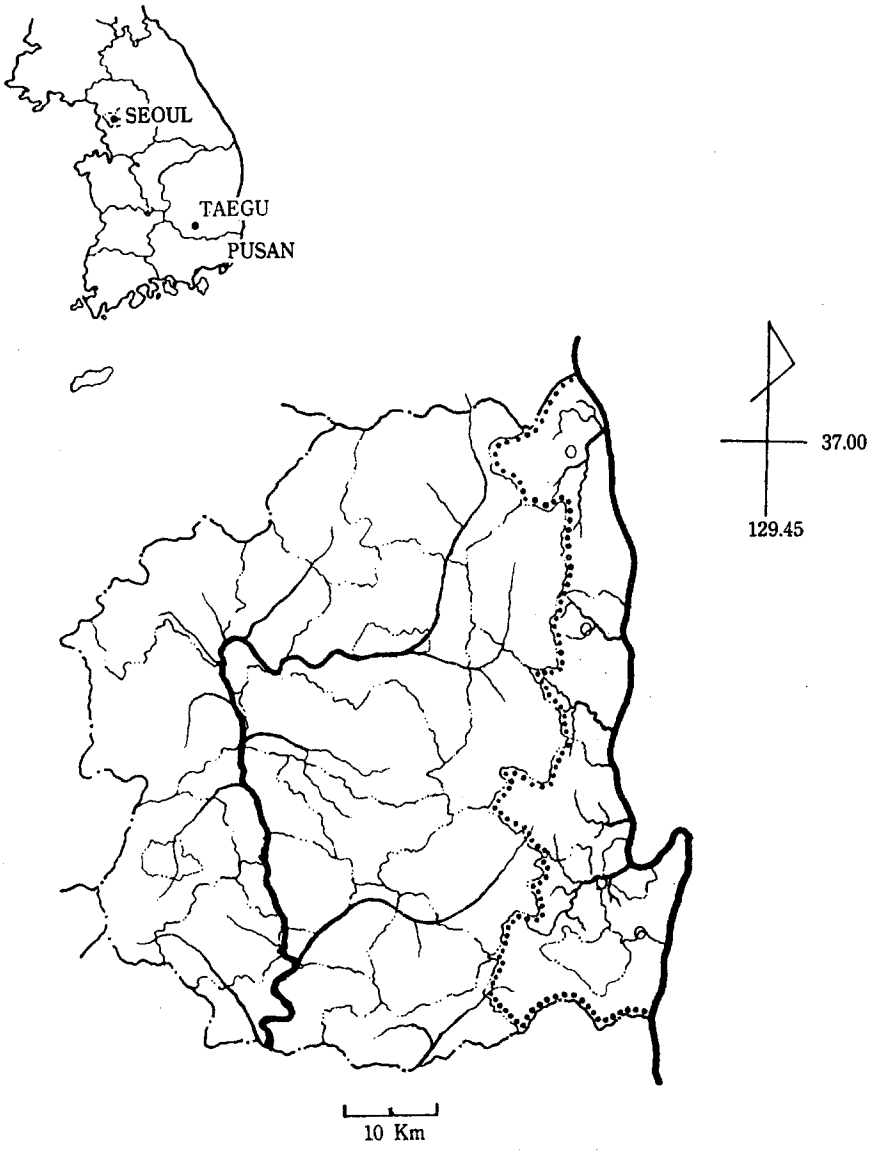

Fig 1. Map showing the surveyed counties(Black bold lines) and snail habitats(O) in Kyungpook Province.

as the study areas because of the presence of fresh-water fish in the water (Fig. 1).

More detailed geographical conditions of surveyed areas were presented by Lee et al.(1979), Joo et al.(1983), Joo(1984), and Joo et al.(1985).

2. The snail intermediate host survey:

From May to October in 1993, the collections of *P. manchouricus* snail were made once or twice monthly in two localities in the vicinity of the river Hyungsan, one locality in the Taechong, Ossep and Namdae streams, respectively. The density of the snail population was measured by the approximate number of snails per square meter in the river and stream bed. The snails were collected by hand and put into damp plastic buckets with marsh grasses and forwarded to the Parasitology laboratory. The snails were examined for the presence of *Clonorchis* cercariae using both immersing and crushing techniques. Ten snails were put into

Table 1. Total number of subjected residents and number tested in coastal areas of Kyungpook Province, Korea(1993)

Surveyed area	Sex	Total No. of residents	No. tested	Percent tested
Kyungju city	M	70,484	237	0.34
	F	71,411	262	0.37
	Subtotal	141,895	499	0.35
Kyungju county	M	62,997	336	0.54
	F	63,502	350	0.55
	Subtotal	125,599	686	0.55
Ulchin county	M	34,454	226	0.66
	F	35,385	242	0.68
	Subtotal	69,839	468	0.67
Yeongduk county	M	32,144	218	0.68
	F	33,935	288	0.85
	Subtotal	66,079	506	0.77
Yeongil county	M	82,734	162	0.20
	F	82,333	221	0.27
	Subtotal	165,067	383	0.23
Total	M	281,913	1,179	0.42
	F	286,566	1,363	0.48
	Total	568,479	2,542	0.45

petridishes containing about 40 ml of tap water of 48 hours and observations made on the liberation of cercariae.

All snails in a dish revealing the cercariae were crushed to determine the total percentage of infection. Most of the cercariae were studied in the living state. Some of the cercariae shed from the snails were stained with Semichon's acetocarmine or neutral red and observations made supplemented those made on living materials.

3. The fish host survey:

In order to determine the infection rates and intensity for *Clonorchis* metacercariae in the different fresh-water fish collected in six localities in the Hyungsan river, Taechong, Namdae and Ossep streams, studies were conducted during the period of 2 years from May, 1992. Fresh-water fish were caught by netting and fishing with rod and line.

The fish, after removal of their intestinal contents to prevent autodigestion, were forwarded to the laboratory. The specific name of the fish was determined by the keys described by Chung(1977). One gram of flesh, 100 scales, all fins and tail of the fish were separated from each fish using a knife, and each material was compressed between two large slide(50 × 90 mm) and examined for *Clonorchis* metacercariae under a binocular dissecting microscope.

In order to isolate the metacercariae and estimate the average number of cysts per gram of flesh, the digestion technique was applied: 1 gram of flesh was mixed with artificial gastric juice(0.2 ml of diluted hydrochloric acid and 0.3 gram of pepsin per 100ml of distilled water), and the mixture were incubated under the temperature 37~38 ℃ for 30~40 minutes.

4. Prevalence of *C. sinensis* in residents:

During the period from October, 1992 to October, 1993, the fecal examination was made in order to discover *Clonorchis* eggs among the residents, aged from 5 to 79 years. A total of 2,542 specimens were collected from 1,179 male and 1,363 female residents in Kyungju city, Yeongil county, Yeongduk county, Ulchin county and Kyungju county of Kyungpook Province. Those in the 20~29 year age group were much less inclined to cooperate. The proportion of residents tested out of

the total number varied from 0.23 per cent to 0.67 per cent, with an average of 0.45 per cent(Table 1). The specimens, collected in cartons, were brought to the laboratory and examined by the MGL technique, and then the Stoll's egg counts technique was applied.

5. The quantitative epidemiological analysis:

a) Age prevalence of *C. sinensis* : In order to estimate the quantitative analysis for age and sex distribution of prevalence, a special type of the simple catalytic curve, which was proposed by Muench(1959), was used. The simple catalytic curve is expected from the following equations:

$y=1-e^{-rt}$ or $y=k(1-e^{-rt})$

In a special type of the simple catalytic curve, "y" is the fraction of positive result at any time "t". The "r" is the force of infection, which is defined by Muench(1959) as a term of effective contacts per individual per unit of time, which means a sufficient number to produce infection in susceptibles. The "e" is the base of natural logarithm. The "k" is a fraction of unit quantity which is subject to change.

b) The features of transmitting *C. sinensis* infections: In order to estimate the feature of transmitting *C. sinensis* infections in the coastal areas of Kyungpook Province, two-stage catalytic model, which was proposed by Muench(1959), was used. Since both parameters, such as production and disappearance of positive cases, were considered to be constant over a period long enough to include the oldest age groups in this study, and the "y" denotes the remainder which, at any age, has been infected and still retains evidence of infection, the following equation can be derived:

$$y = X - Z \quad \cdots\cdots (1)$$

Where "X" denotes the fraction of the population at any age which has become infected, and "Z" represents the part which has lost all evidence of infection.

When constant "a" and "b" are rates at which "X" and "Z" are formed, respectively, the speeds at which two stage reactions: production of positivity "X" and loss of positivity "Z" proceed, are expressed by the following two equations;

$$dx/dt = a(1-x) \quad \text{or} \quad x=1-e^{-at} \quad \cdots\cdots (2)$$

$$\text{and} \quad dz/dt = b(x-z) \quad \text{or} \quad dz/dt = by \quad \cdots\cdots (3)$$

From equation (1), by differentiation,

$$dy/dt = dx/dt - dz/dt = a(1-x)-b(x-z)$$

[From Eqs. (2) & (3)]

$=ae^{-at}-by$ [From Eqs. (2) & (3)].

This is another simple linear equation, whose general solution is

$$y = \frac{a}{b-a} e^{-at} - Ce^{-bt} \quad \cdots\cdots (4)$$

if $y = 0$ when $t = 0$, it becomes

$$y = \frac{a}{b-a} (e^{-at} - e^{-bt}) \quad \cdots\cdots (5)$$

or, when "a" is larger than "b", it is

$$y = \frac{a}{a-b} (e^{-bt} - e^{-at}) \quad \cdots\cdots (6)$$

and if "a" = "b", it is

$$y = a+ate^{-at} \quad \cdots\cdots (7)$$

The maximum values of Eqs. (5) or (6) and (7) occur at

$$t = \frac{\ln a - \ln b}{a-b} \quad \text{or} \quad t = \frac{1}{a} \quad \cdots\cdots (8)$$

When In "a" or In "b" is the natural logarithm of "a" or "b" to the base "e", Muench provided the nomograms in his monograph.

c) The levels of intensity of *C. sinensis*

Table 2. Infection rates of Parafossarulus snails with *Clonorchis* cercariae in the coastal areas of Kyungpook Province(1993)

River of stream	Habitat	Approximate No. of Snail.m' of river bed(ea)	No. examined	Percent infected
Hyungsan river	Nawon	21	1,229	0.081
Taechong str.	Daebon	3	111	0
Ossep str.	Shinyang	10	119	0
Wyangpi str.	Susan	5	57	0

infections: In order to evaluate the levels of intensity of *C. sinensis* infections, the EPG of clonorchiasis patients was converted into a cumulative percentage and represented as a regression equation using Bliss' probit table. The regression line is represented by a simple equation of,

$$y = a + b \log X$$

where "y" is probit of cumulative fregueucy at "X" EPG and "a" and "b" are the constant, "a" corresponds to the percentage of cases with EPG count 1(zero in logarithm) and "b" is the regression line plotted against the horizontal axis.

The frequency distribution by EPG counts was calculated as well as the fifty per cent level of EPG in a population (Cs. D_{50}) was obtained by solving the equation:

$$\log X_{50} = (5 - a)/b$$

6. Blood biochemistry test:

Blood biochemistry for such as AST, ALT, ALP, and TTT were carried out in all patients with clonorchiasis before the medication.

7. Therapeutic effects of praziquantel (Embay 8440) against *C. sinensis* infections:

In order to determine the efficacy of praziquantel, a total of 151 cases of *C. sinensis* infections were treated with the dosage of 25 mg/kg three times for a single day. Fecal examination consisted of MGL technique and Stoll' s egg count method. The evaluation of efficacy was based upon the egg reduction rate or the absence of eggs in the feces. Complete cure was determined by the absence of *Clonorchis* eggs in the feces, which was confirmed by at least three further examinations by MGL technique.

Results

The distribution of the *Parafossarulus* snails in the river and/or stream in the coastal areas of Kyungpook Province is shown in Table 2 and in Fig. 1.

The solid square in Fig. 1 indicates the habitats found in the present survey.

Five snail habitats were found. The approximate number of snails collected in the habitats were from 57 to 1,229 with an average of 9.75 per square meter of stream-bed. Thus, the snail population measured in the all habitats was very low. The liberation rates for *Clonorchis* cercaria in the snails were very low.

A total of 1,506 snails were examined for the presence of the cercaria, of which only 1 or 0.066 per cent infected snails were found. At Nawon habitat 0.081 per cent were infected with *Clonorchis* cercaria, while, no infection of the snails was found in Daebon, Shinyang and Susan Habitats.

Tahle 3 summarizes the infection rates and intensities of *C. sinensis* metacercariae according to the different fish species. Of the fish caught, three kinds, *G. atromaculatus*, *P. parva*, and *P. herzi*, were infected with metacercaria of *C. sinensis* . The most highly infected fish was *G. atromaculatus* with 88.9 per cent, followed by *P.*

Table 3. Summary of infection rates and intensity of *Clonorchis* metacercariae from fresh-water fish and brackish-water fish caught in some rivers and streams of the coastal areas, Kyungpook Province(1993)

Species	No. of fish examined	Percent infected	No. of cysts/g of flesh(ea) Rang	·Average
Fimily cyprinidae				
Carassius carassius Linnaeus	71	-	-	-
Culter brevicauda Gunter	14	-	-	-
Gnathopogon atromaculatus Nichols et Pope	72	88.9	1-259	72.2
Moroco oxycephalus(Bleeker)	9	-	-	-
Paracheilognathus rhombea(T et S*)	'23	-	-	
Pseudogobio esocinus(T et S)	1	-	-	-
Pseudorasbora parva(T et S)	15	13.3	1-7	4.0
Pungtungia herzi Herzenstein	104	6.7	3-108	53.0
Zacco platypus(T et S)	142	-	-	-
Zacco temmincki(T et S)	188	-	-	-
Famaily Anabntidae				
Macropodus chinensis(Bloch)	6	-	-	-
Famaily Bagridae				
Coreobagrus brevicorpus Mori	14	-	-	-
Famaily Serranidae				
Coreoperca herzi Herzenstein	58	-	-	-
Famaily Siluridae				
Parasilurus asotus Linnaeus	16	-	-	-
Famaily Eleotridae				
Mogurnda obscura(T et S)	58	-	-	-
Famaily Mugilidae				
Mugil cephalus Linnaeus	7	-	-	-
Famaily Plecoglossidae				
Plecoglossus altivelis(T et S)	52	-	-	-
Famaily Gasterosteidae				
Gasterosteus aculeatus aculeatus(T et S)	52	-	-	-
Famaily Centrachidae				
Lepiomis macrochirus Rafinesque	8	-	-	-

* T et S : Temminck et Schlegel.

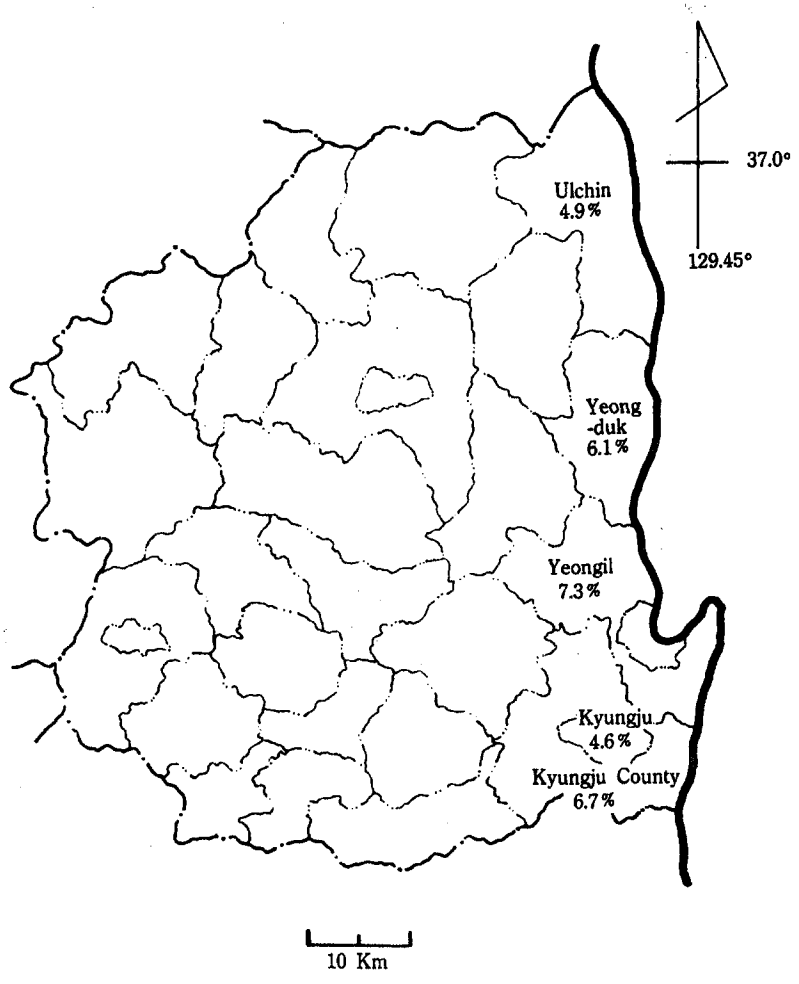

Fig 2. Surveyed county in Kyungpook Province, Korea.

Table 4. Prevalence of *Clonorchis sinensis* among residents by administrative district(1993)

Surveyed area	Male		Female		Total	
	No. examined	Percent infected	No. examined	Percent infected	No. examined	Percent infected
Kyungju city	237	7.6	262	1.9	499	4.6
Kyungju county	336	6.0	350	7.4	686	6.7
Ulchin county	226	7.5	242	2.5	468	4.9
Yeongduk county	218	8.3	228	4.5	506	6.
Yeongil county	162	5.6	221	8.6	383	7.3
Total	1,179	7.0	1,363	5.1	2,542	5.9

parva with 13.3 per cent. The less frequently infected fish was *P. herzi* with 6.7 per cent. No *Clonorchis* metacercaria was found in the flesh, scales, fins and tail of the remaining 16 species of fish collected.

Of the metacercarial intensity of *C. sinensis*

Table 5. Prevalence of *Clonorchis sinensis* in the coastal areas by sex and age group(1993)

Age group (Year)	Male		Female		Total	
	No. examined	Percent infected	No. examined	Percent infected	No. examined	Percent infected
0-9	347	0.9	344	0.6	691	0.7
10-19	361	1.4	408	1.2	769	1.3
20-29	51	7.8	63	6.3	114	7.0
30-39	73	13.7	97	6.2	170	9.4
40-49	93	20.4	120	15.0	213	17.4
50-59	122	17.2	141	9.9	263	13.3
60-69	83	19.3	129	10.9	212	14.2
70-	49	8.2	61	9.8	110	9.1
Total	1,179	7.0	1,363	5.1	2,542	5.9

Table 6. Fraction of *Clonorchis sinensis* positives by sex, for the arrangement of catalytic curve, special type, $y=k(1-e^{-rt})$ (1993)

Age group (Year)	t	Male			Female		
		y	e^{-rt}	$k(1-e^{-rt})$	y	e^{-rt}	$k(1-e^{-rt})$
0-9	5	0.009	0.9003	0.0209	0.006	0.9370	0.0119
10-19	15	0.014	0.7297	0.0567	0.012	0.8228	0.0336
20-29	25	0.078	0.5915	0.0857	0.063	0.7225	0.0527
30-39	35	0.137	0.4795	0.1093	0.062	0.6343	0.0694
40-49	45	0.204	0.3886	0.1283	0.150	0.5596	0.0836
50-59	55	0.172	0.3150	0.1438	0.099	0.4891	0.0970
60-69	65	0.193	0.2553	0.1563	0.109	0.4295	0.1083
70-	75	0.082	0.2069	0.1665	0.098	0.3770	0.1183
ΣA			8.89			5.99	
ΣtA			443.35			305.85	
$\bar{t}$			49.87			51.06	
$\Sigma' A$			11.11			7.48	
$\bar{t}'$			62.33			63.82	
r'			0.017			0.01	
$\Sigma k=1A$			52.50			37.50	
k			0.21			0.19	
r			0.021			0.013	

Remak:Each age group is 10 years wide. The sums of items in the y(y:fraction of sample in each age group giving positive results) columns must therefore be multiplied by 10 to get ΣA(ΣA:area under histogram). So must the sums of items in y columns by those in t columns (t: value of center point of each age band) to get ΣtA. The quantity k is the ratio of observed A to the value expected(if k were 1) for the vaule of r determined from t(r:estimated rate).

G. atromaculatus was the most heavily infected with the larvae and the average number of cysts was 72.2

P. herzi was next with an average of 53.0 cysts. *P. parva* was less heavily infected with the larvae, with an average of 4.0 cysts.

Table 4 lists the prevalence of *C. sinensis* among the residents in the coastal areas of Kyungpook Province. The same data is presented graphically in Fig. 2.

A total of 2, 542 residents, 5.9 per cent were found to be infective cases.

The infection rates of *C. sinensis* varied widely from one county to another.

In practice, Yeongil and Kyungju counties were relatively high, while, the rates in the Kyungju city

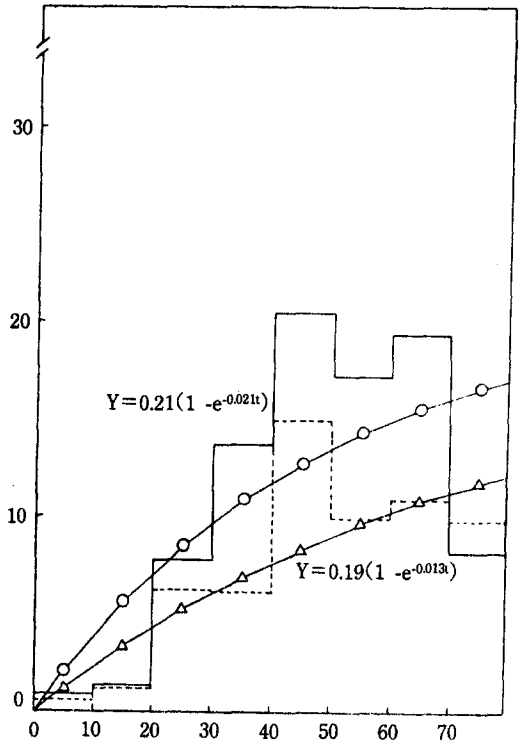

Fig 3. Simple catalytic curves and histograms showing fraction of *Clonorchis* positive cases in coastal areas of Kyungpook Province(1993) by age from 0 to 80 years.

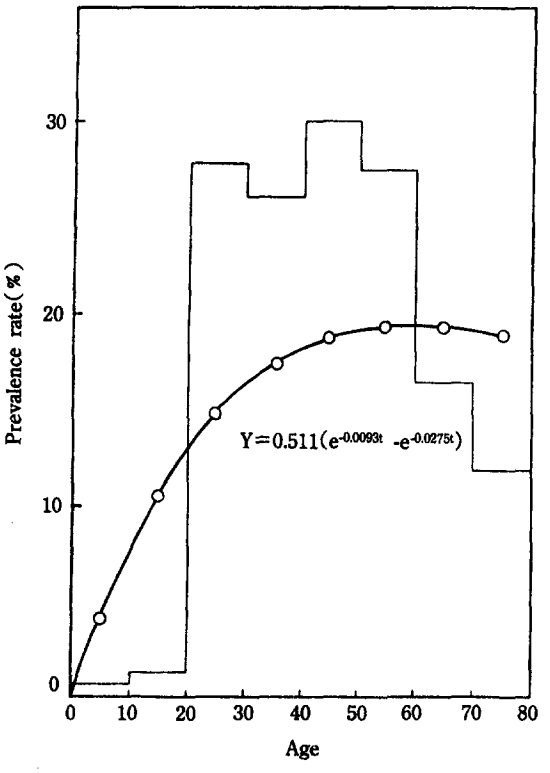

Fig 4. Two-stage catalytic curve and histogram showing fraction of *Clonorchis* positive cases by age in coastal areas.

and Ulchin county were very low.

The prevalence of *C. sinensis* among the residents by sex and age groups are summarized in Table 5. In the age specific rates was relatively high, 0.7 per cent in the 0-9 year age group and 1.3 per cent in the 10-19 year age group.

The rate increased step by step, 7.0 per cent in the 20-29 year age group, 9.4 per cent in the 30-39 year age group and reached a maximum, 17.4 per cent in 40-49 year age group, after which in remained around 10.0 per cent. The sexspecific rate of infections was higher in males than in females; the former was 7.0 per cent and the latter, 5.1 per cent.

The application of the special type of a simple catalytic curve for the prevalence rates of *C. sinensis* by sex and age groups is listed in Table 6 and illustrated in Fig. 3. The values of the constant estimated from the nomogram for the observed data, lead to the equation, male's simple catalytic curve was

$$y=0.21(1-e^{-0.021t})$$

and female's was

$$y=0.19(1-e^{-0.013t})$$

The difference was so great that the curve of the female group was much lower than that of the male group.

The application of the two-stage catalytic model to the age prevalence of clonorchiasis is presented in Table 7 and illustrated in Fig. 4. The prevalence rate of *C. sinensis* was found to be as high as 15. 1 per cent, the value of constant "a" was found to be 0.0093. In other words, the force of infection was

Table 7. Application of two-stage catalytic model to age prevalence of clonorchiasis in the coastal areas(1993)

Age group (Year)	t	y	A	tA	e^{-at}	e^{-bt}	$\frac{a}{b-a}(e^{-at}-e^{-bt})$
0-9	5	0.007	0.07	0.35	0.9545	0.8715	0.0424
10-19	15	0.013	0.13	1.95	0.8697	0.6619	0.1061
20-29	25	0.278	2.78	68.25	0.7925	0.5028	0.1480
30-39	35	0.260	2.60	91.00	0.7221	0.3819	0.1738
40-49	45	0.300	3.00	135.00	0.6580	0.2901	0.1879
50-59	55	0.274	2.74	150.70	0.5995	0.2203	0.1937
60-69	65	0.164	1.64	106.60	0.5463	0.1674	0.1936
70-	75	0.118	1.18	88.50	0.4978	0.1271	0.1894
ΣtA=642.35		ΣA=14.09		$\bar{t}$=45.58	Σ'A=17.61		$\bar{t}'$=56.98
a'=0.0075		a=0.0093		b'=0.002	b=0.0275		$\frac{a}{b-a}$=0.511

Remark t:Value of center point of each age band(years)
y:Fraction having positive histories, by age
A:y times width of age band(years)

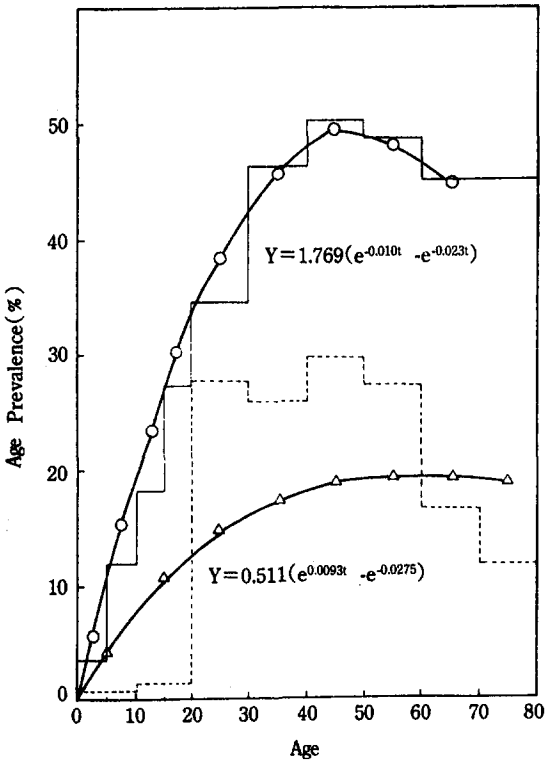

Fig 5. Two-stage catalytic curve and histogram showing fraction of *Clonorchis* positive in 1964 and 1993, revealed by intradermal test and stool examination.

9.3 per annum per 1,000 susceptibles. However, the value of constant "b" was found to be 0.0275 representing that the rate of disappearance from the positive to the negative during the observed period was per annum 27.5 per 1,000 clonorchiasis positive cases. Therefore,

$$y=0.511(e^{-0.0093t}-e^{-0.0275t})$$

and the maximum value of "y" occurred at

$$t=\frac{\ln b-\ln a}{b-a}=\frac{\log b-\log a}{b-a}\times 2.3026$$

=59.56 years

The date of the two-stage catalytic model to the age prevalence of *C. sinensis* among the residents in the Kyungpook province in 1964 are compared with the data in 1993, and listed in Table 8 and illustrated in Fig. 5. Of the river-side areas in 1964, the two-stage catalytic curve was

$$y=1.769\,(e^{-0.023t}-e^{-0.010t})$$

the value of constant "a" was found to be 0.023, that being the rate of *Clonorchis* infections. However, the value of constant "b" was observed to be 0.010, showing that the rate of disappearance from the positive to the negative during the period was 10 annum per 1,000 patients with

Table 8. Comparison of data of two-stage catalytic model to age prevalence of clonorchiasis among residents in Kyungpook province in 1964 and 1993, revealed by intradermal test.

Age group (Year)	t	Shin(1964) y	Shin(1964) $\frac{a}{a-b}(e^{-at}-e^{-bt})$	Authors(1993) y	Authors(1993) $\frac{a}{a-b}(e^{-at}-e^{-bt})$
0 - 4	2.5	0.0359	0.0563	0.007	0.0424
5 - 9	7.5	0.1189	0.1532		
10-14	12.5	0.1814	0.2347	0.013	0.1061
15-19	17.5	0.2729	0.3023		
20-29	25	0.3475	0.3825	0.278	0.1480
30-39	35	0.4631	0.4555	0.260	0.1738
40-49	45	0.5026	0.4966	0.300	0.1879
50-59	45	0.5026	0.4966	0.300	0.1879
60-69	65	0.4522	0.4518	0.164	0.1936
70-	75	—	—	0.118	0.1894
ΣtA		1079.10		642.35	
ΣA		25.63		14.09	
$\bar{t}$		42.10		45.58	
Σ'A		36.61		17.61	
$\bar{t}'$		60.13		56.98	
a′		0.016		0.0075	
a		0.023		0.0093	
b′		0.007		0.0022	
b		0.010		0.0275	
$\frac{a}{a-b}$		1.769		0.511	

Remark : Each age group 5 or 10 years wide. The sums of item in the y columns (y:fraction having positive, by age) must therefore be multiplied by 5 or 10 to get A(A:area under histogram). So must the sums of products of items in the y columns by those in t columns(t: value of center point of each age band) to get tA.

Table 9. Intensity of *Clonorchis sinensis* by Stoll' s egg-count technique(1933)

Range of EPG	Male No. infected	Male %	Female No. infected	Female %	Total No. infected	Total %
0 - 500	47	57.3	33	47.8	80	53.0
501-1,000	13	15.9	15	21.7	28	18.5
1,001-2,000	8	9.8	8	11.6	16	10.6
2,001-3,000	5	6.1	8	11.6	13	8.6
3,001-4,000	1	1.2	2	2.9	3	2.0
4,001-5,000	1	1.3	1	1.4	2	1.3
5,001-6,000	4	4.9	2	2.9	6	4.0
6,001-	3	3.7	0	0	3	2.0
Total	82		69		151	

clonorchiasis.

In the coastal areas in 1993, the overall prevalence rate for clonrchiasis was relatively lower than that of the river-side areas; the former was 15.1 per cent and the latter, 19.4 per cent.

The two-stage catalytic model fitted well with the infection rates by age groups in *Clonorchis* positive cases, and the calculation lead to the equation;

Table 10. Frequency distribution and cumulative percentage of *Clonorchis* positive cases(1993)

X(EPG)	Male		Female		Total	
	Freq.*	Cum. %*	Freq.	Cum. %	Freq.	Cum. %
-200	27	32.9	24	34.8	51	33.8
-400	20	57.3	9	47.8	29	53.0
-600	2	59.8	8	59.4	10	59.6
-800	8	69.5	5	66.7	13	68.2
-1,000	3	73.2	2	69.7	5	71.5
-2,000	8	82.9	8	81.2	16	82.1
-3,000	5	89.0	8	92.8	13	90.7
-4,000	1	90.2	2	95.7	3	92.7
-5,000	1	91.5	1	97.1	2	94.0
-6,000	4	96.3	2	100.0	6	98.0
-7,000	0	96.3			0	98.0
-8,000	0	96.3			0	98.0
-9,000	0	96.3			0	98.0
-10,000	0	96.3			0	98.0
-20,000	3	100.0			3	100.0
No. of examined	1,179		1,363		2,542	
No. of positive	82		69		151	
Percent positive	7.0		5.1		5.9	
Constant "a"	1.58		0.65		1.07	
Constant "b"	1.33		1.65		1.50	
Cs. D_{50}	2.57		2.63		2.62	

* Freq. : Frequency

** Cum. % : Cumulative percentage

Table 11. Numerical distribution of intensity of *Clonorchis* infections by administrative district(1993)

Surveyed area	Sex	No. Positive	Intensity of *Clonorchis* infection			Mean EPG
			Light	Moderate	Heavy	
Kyungju city	M	18	13	5	0	989
	F	5	3	2	0	1,680
	Subtotal	23	16	7	0	1,139
Kyungju county	M	20	16	3	1	1,450
	F	26	15	11	0	1,223
	Subtotal	46	31	14	1	1,322
Ulchin county	M	17	14	3	0	1,071
	F	6	6	0	0	467
	Subtotal	23	20	3	0	913
Yeongduk county	M	18	9	7	2	2,222
	F	13	10	3	0	677
	Subtotal	31	19	10	2	1,574
Yeongil county	M	9	6	3	0	578
	F	19	12	7	0	1,074
	Subtotal	28	18	10	0	914
Total	M	82	58	21	3	1,344
	F	69	46	23	0	1,046
	Total	151	104	44	3	1,208

$y=0.511(e^{-0.0083t}-e^{-0.0275t})$

Table 9 summarizes the intensity of *Clonorchis* infections in 51 residents by sex. The intensity of

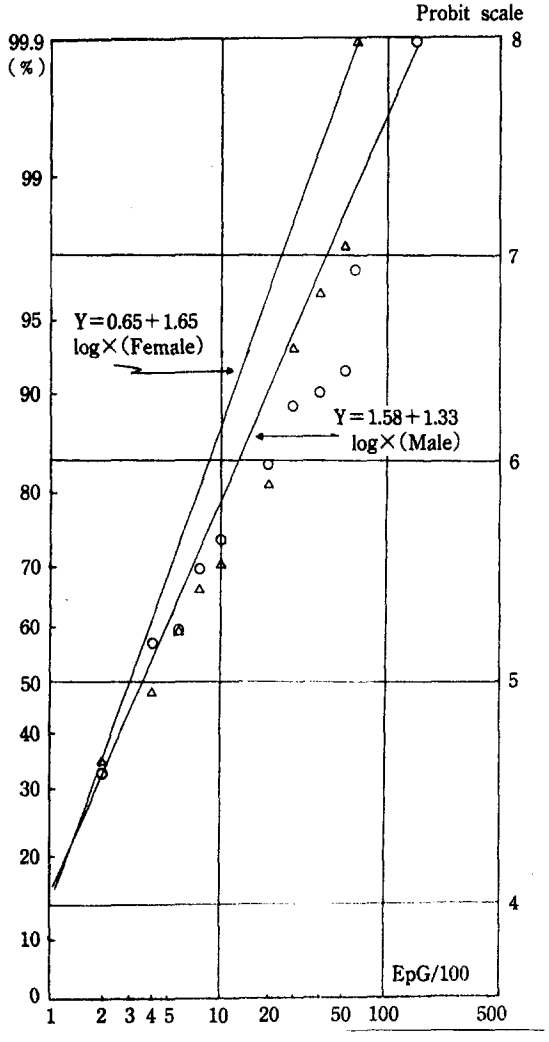

Fig 6. Regression lines of cumulative percentage of *C. sinensis* positives against EPG density in log probit scale in the coastal areas, Kyungpook Province, Korea.

infection, expressed in egg per gram of feces was divided into 500 egg intervals in the first and second classes, followed by 1,000 egg intervals for the purposes of convenience. The number of EPG of feces was less than 1,000 in 64 males or 73.2 per cent and 48 females or 69.5 per cent, 1,001-6,000 eggs in 19 males or 23.2 per cent and 21 females or 30.5 per cent, and more than 6,001 in 3 males or 3.7 per cent. The largest number was recorded to be 24,000 eggs in a 60-year old male in Yeongduk county.

The frequency distribution and cumulative percentage of *Clonorchis* positive cases against EPG density in the log-probit scale are shown in Table 10 and illustrated in Fig. 6. In a total of 151 positive cases examined, the regression curve was,

$$y=1.07+1.50 \log X$$

the intensity of *C. sinensis* infections, expressed as the fifty per cent level of EPG in a population (Cs. D_{50}), was 2.62(about EPG :262).

In the intensity of *Clonorchis* infection, the male's regression equation was,

$$y= 1.58+1.33 \log X$$

and the female's was

$$y=0.65+1.65 \log X,$$ respectively,

The values of Cs. D_{50} for the males was 2.57 and that for the females, 2.63. Table 11 shows the numerical distribution of intensity of *C. sinensis* infections according to the administrative district.

The meam EPG in 151 positive cases was 1,208 eggs; the males was 1,344 eggs and the females, 1,046 eggs.

The positive cases in Yeongduk county revealed the highest mean EPG in males, but relatively lower EPG for females. Those in Ulchin county, revealing relatively high mean EPG for males, showed low EPG in females. The *Clonorchis* positive cases in Kyungju county showed intermediary EPG in both sexes.

In Table 12, the numerical distribution of intensity of *C. sinensis* infections among the residents by sex and age groups are listed. Of the positive cases, 56 cases or 68.3 per cent in males and 46 or 66.7 per cent in females were found to be ligthly infected. 23 cases or 28.0 per cent in males and 23 or 33.3 per cent in females were moderately infected, and 3 cases or 3.7 per cent in males were heavily infected. The positive cases in the 10-19 year age group revealed the highest mean EPG counts, but relatively lower mean EPG count in

Table 12. Numerical distribution of intensity of *Clonorchis* infections by sex and age group(1993)

Age group (Year)	Male			Female			Total			Mean EPG
	L	M	H	L	M	H	L	M	H	
0~9	3	0	0	2	0	0	5	0	0	320
10~19	4	0	1	3	2	0	7	2	1	2,860
20~29	3	1	0	2	2	0	5	3	0	975
30~39	9	1	0	3	3	0	12	4	0	800
40~49	12	7	0	11	7	0	23	14	0	1,411
50~59	16	5	0	10	4	0	26	9	0	759
60~69	8	7	1	11	3	0	19	10	1	1,333
70~	1	2	1	4	2	0	5	4	1	2,260
Total	56	23	3	46	23	0	102	46	3	1,279
	(68.3)*	(28.0)	(3.7)	(66.7)	(33.3)	(0)	(67.5)	(30.5)	(2.0)	
Total No. infected		82			69			151		

Remark L: EPG count less than 1,000
M: EPG count between 1,001 to 10,000
H: EPG count over 10,001
* Number in parentheses means the percentage.

Table 13. Distribution rates of blood biochemistry tests according to intensity of *Clonorchis* infections(1993)

Test of blood biochemistry	Range of values	Intensity of *Clonorchis* infection		
		Light	Moderate	Heavy
AST(unit)	5~40	94(90.4)	42(95.5)	3(100.0)
	41~100	5(4.8)	1(2.3)	0
	101~	5(4.8)	1(2.3)	0
ALT(unit)	5~40	94(90.4)	43(97.7)	3(100.0)
	41~100	9(8.7)	0	0
	101~	1(1.0)	1(2.3)	0
ALP(unit)	0~200	63(60.6)	42(95.5)	2(66.6)
	201~450	41(39.4)	2(4.5)	1(33.3)
	451~	0	0	0
TTT(unit)	0~5.0	101(97.1)	43(97.7)	2(66.6)
	5.1~10.0	1(1.0)	0	0
	10.1~	3(1.9)	1(2.3)	1(33.3)
Tatal No. tested		104	44	3

the 0-9 year age group. Those in the 40-49 and 60-69 year age groups showed intermediary EPG count, respectively.

Table 14 summarizes the therapeutic effects of

Table 14 .Summary of therapeutic effects of praziquantel* at 25 mg/kg three times for single day in treatment of clonorchiasis(1993)

Group	No. of case treated	No. of case cured	Egg reduction rate	Cure rate
Light	104	100	92.71	96.2
Moderate	44	41	98.86	93.2
Heavy	3	0	96.92	0

* Follow-up at 28 days after therapy
Remark Light : EPG count less than 1,000.
Moderate : EPG count between 1,001to 10,000.
Heavy : EPG count over 10,001.

praziquantel against *C. sinensis* infections. Of 104 light infection group with praziquantel dosage of 25mg/kg three times in a single day, it showed 92.71 per cent egg reduction rate and 96.2 per cent cure rate .

41 cases or 93.2 per cent out of the 44 moderate infection group were cured completely 28 days after treatment. Of 3 heavily infected cases with the same dosage, the egg reduction rate was 96.92 per cent and no case was cured.

Discussion

Kyungpook Province has been known as one of the endemic areas of *C. sinensis* in Korea. The first report on the existence of autochthonous cases of *C. sinensis* in Korea was made by Matsumoto (1915). He carried out a survey on intestinal helminths by stool examinations among the in-and outpatients of Taegu Charity hosptial located in Kyungpook Province, and reported that the infection rate of the liver fluke was 18.6 per cent. Kobayashi(1924) first discovered the *Clonorchis* metacercariae from the flesh of several kinds of fresh-water fish including *P. parva* collected in seven areas of southern Korea, and demonstrated that fresh-water fish belonging to the Family Cyprinidae served 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.

Few works on the liver fluke in Korea was done before the end of the World War II, and some studies on the incidence of *C. sinensis* infections and its intermediate hosts were conducted by Japanese investigators in Korea(Furuyama, 1927; Sekigutchi, 1937a, b; Nishimura, 1943). The epidemiological studies of *C. sinensis* in Kyungpook province, Korea were instituted mostly in the vicinity of river Naktong(Shin, 1964; Kim et al., 1971; Joo and Choi, 1974; Choi et al., 1976; Rim et al., 1978; Seo et al., 1981; Joo, 1984; Hyun and Joo(1993), river Kumho(Hwang and Choi 1980). river Hyungsan(Joo, 1984), river Taega(Choi, 1978), and river Ahnseong(Joo and Hong, 1991), and in natural and fish breeding ponds(Kim and Choi, 1981).

As a result of previous studies, the prevalence rate of *C. sinensis* amang the residents were found to be high, ranging from 0.4 per cent to 54.8 per cent.

In addition, it has been demonstrated that approximately 30 piscine species belonging to the 3 Families, i. e., Cyprinidae and Clupeidae, play the important role in transmitting the liver fluke in the Province.

The coastal areas in this survey is isolated from the tributaries of the river Naktong and situated in the eastern part of Kyungpook Province. There are many peculiar houses that would sell raw-fish to local residents and visitors.

Furthermore, rural and urban residents visit these areas on weekends and/or holidays, and the majority of residents in the villages along the sides

of the river and/or streams enjoy fishing and also consuming the raw-fish with distilled spirits and/or rice wine.

The results in this study show that the prevalence of *C. sinensis* in 2, 542 residents was 5.9 per cent and *Parafossarulus* snail and many kinds of fresh water fish present in the river and/or some streams.

In the studies on snail intermediate host in Kyungpook Province, Nishimura(1943) conducted a snail survey for the cercariae of *C. sinensis* in the Yeongcheon area, and reported that 3 kinds of larval trematodes were found in the 212 snails collected, and rhe infection rate of *Clonorchis* cercariae was 43.7 per cent.

After the Korea War, Lee and Kim(1958) conducted a comprehensive survey for *C. sinensis* in the vicinity of the river Kumho, and reported that the infection rate for the cercaria of the fluke was relatively high, ranged from 6.0 per cent to 8.0 per cent.

Subsequently Choi et al.(1975) carried out a survey for *Clonorchis* cercariae in the snails collected from 10 well-distributed stations in the river Naktong and its tributaries of Kyungpook Province, and reported that *Parafossarulus* snail existed in the limit areas, and that infection rates of the snail with *Clonorchis* cercaria was very low ranging from 0.04 per cent to 0.11 per cent, Chung et al. (1980) in a study of seasonal variation of the snail populations and larval trematode infections in the river Kumho found that 4 kinds of cercariae were infected, in which the infection rate for *Clonorchis* cercaria was 0.12 per cent.

A much lower infection rates were reported by Joo and Hong(1991) in the river Ahnseong, Hyun and Joo(1993) in the upper stream areas of the river Naktong, and also in the present study. Those surveys made before 1960 mostly indicated infection rates of 6.0-43.7 per cent, in the period of about 20 years during the War, *Parafossarulus* snails in the river Naktong and its tributaries in the Province had a high rate of infection. On the contrary, in those surveys made after 1970, the infection rate was low.

In all of data reported before 1960, the snails with *Clonorchis* cercaria was so that it was considered likely that the snails might be infected as a result of occasional dumping of sewage and night soil in the rivers an and/or by pollution from local residents defecating near the rivers, After the beginning of the New community project in the third "Five-year economic development plan" in 1972, a majority of the low-lying marshy areas was converted into the rice fields, where the life of the snails was incessantly disturbed by cultivation of the soil, ploughing and weeding. As a result, the habitat of the snails became limited to the uncultivated river beds and marshes. The present study revealed that the population density of the snails in the habitats was very low, and demonstration of *Clonorchis* cercariae from the snails was apparently difficult. It was suggested that the massive drainage of home and industrial waste products into the rivers, together with the intense pesticides spraying of the rice-fields and inside houses may have affected the ecology of snails in the rivers and the survival of larval trematodes. In fact, newly established apartments and factories near the rivers and intense insecticides spary in the farms and rice-fields in the vicinity may result in the destruction of natural environmental conditions, especially in the rivers.

In earlier studies of the fish intermediate hosts in Kyungpook Province, a constantly high infection rate of *Clonorchis* metacercariae has been reported by many investigators, such as Nishimura(1943), Lee and Kim(1958), Kim(1961), Lee(1968) and Hwang and Choi(1980) in the river Kumho, Shin(1964), Choi(1976), Lee et al.(1992) and Hyun and Joo(1993) in the upper stream areas of the river Naktong.

The other main reports were in the river Taega by Choi(1978), in the river Ahnseong by Joo and Hong(1991), in the river Panbyon by Chung et al.(1991), and in the natural and fish-breeding ponds by Kim and Choi(1981). According to all of these surveys, it is obvious that in the river Naktong and its tributaries the metacercaria of *C. sinensis* are widely distributed in fresh-water

fish.

In the coastal areas of the Province there have been some reports from the Kyungju, Yeongduk, Ulchin and Ulju counties. In Kyungju county, Shin(1963) reported on *T. hakonensis* from the well-known river Hyungsan, which was followed by Joo(1984) has surveyed 10 species of fresh-water fish and 1 kind of brackishwater fish within a wider area. From his survey, it was found that *G. atromaculatus* was the most frequently infected fish, being found in 93. 5 per cent, followed by *P. parva*, *P. herzi*, and *P. rhombea* with the rate of 74.2 per cent, 17.6 per cent, and 2.6 per cent in decreasing order.

In Ulju county, especially in the river Taewha, three reports have been made up to date, namely by Joo(1980) on 9 species of fresh-water fish, by Yoo et al. (1984) on 10 species of the fresh-water fish and 2 kinds of the brackish-water fish with the results of 8.3-92.3 per cent, and lately by Joo (1988) who has investigated 16 species of fish again in more details and within a wider area.

According to his survey, 50.0 per cent of *P. parva* were infected with *Clonorchis* metacercariae, and other fishes, though the number of examined fishes were small, the infection rates as *C. brevicorpus*, *G. atromaculatus*, *G. majimae*, *P. rhombea*, *P. esocinus*, and *P. herzi*.

In Yeongduk county, there have been the Families of Cyprinidae, Anabantidae, Bagridae, Serranidae, Siluridae, Eleotridae, Gasterosteidae and Centrachidae, and 2 kinds of brackish-water fish belonging to the Families of Mugilidae and Plecoglossidae were collected in the some rivers and/or streams, of which 3 species such as, *G. atromaculatus*, *P. parva* and *P. herzi* harbored the encysted larvae of *C. sinensis*. The infection rates and intensities with *Clonorchis* metacercariae in the 3 species of fish varied markedly from fish to fish.

The average number of the cysts was from 4.0 in *P. parva* to 72.2 in *G. atromaculatus*. This results are similar to those reported by Lee et al. (1979) in the river Ossep, by Joo(1980 & 1988) and Yoo et al.(1984) in the river Taewha, and by Joo(1984) in the river Hyungsan, but *Clonorchis* larvae in the fish hosts showed a lower rate of infection. As previously indicated by Hwang and Choi(1980), Lee et al.(1992), Hyun and Joo(1993), and also in this study, the scarity of the fish and a lower infection rates of *C. sinensis* in fish hosts may be due to the collection techniques, geographical variations or general changes in the population distribution of various fish species, and the changing ecology of the rivers and/or streams.

As known in Table 3, No *C. sinensis* metacercaria was found in 16 species of fish. Kobayashi(1912) found *Clonorchis* metacercaria in *C. carassius* from Miyagi, Shiga and Okayama Prefecture, Japan, and reported it as the intermediate host of the liver fluke, Miki(1992) experimentally infected *Clonorchis* cercaria to *P. parva*, *C. carassius* and *C. carpio*, and reported that many *Clonorchis* metacercariae were found in *P. parva*, whereas, no metacercaria was found in *C. carassius* and *C. carpio*. Rhee et al.(1982) studied the clavate cells of epidermis in *C. carpio nubus* with reference to its defense activities to *C. sinensis*, and reported that a large number of clavate cells were found in the epidermis of *P. asotus*, *C. carpio* and *C. carassius* which were not suitable as fish hosts for the liver fluke, while clavate cells were not found in *P. parva*. Judging from the above results it is uncertain whether *C. carassius*, *C. carpio* and *P. asotus* served as fish hosts of *C. sinensis* and it must be studied further. *Z. platypus* was reported as the second intermediate host of *C. sinensis* by Nishimura (1943), who made a survey of the fish hosts in Yeongcheon, Korea. But according to the records of many other investigators they were never found in this fish. The blue gill, *Lepiomis macrochirus* Rafinesque, was the first recorded as the intermediate host of the intestinal fluke by Joo(1980) in the river Taewha, Korea.

Later Joo and Park(1982) examined a large number of *L. macrochirus* in the same river, and reported that 36.5 per cent among 52 blue gill was infected with *M. yokogawai*, while, no single case was found harboured the *Clonorchis* metacercariae.

Similar results have been obtained by Yoo et al.(1984), and also in this study.

Whether this fish can serve as a natural intermediate host of *C. sinensis* is to be studied further.

These results are quite conceivable that low incidence of *Clonorchis* larvae in snails and fish collected in the some rivers and/or streams may be due to the ecological change of the rivers and/or streams. The destruction of the natural environment such as causing the water level to drop, regulating the construction of may concrete septa across the river and/or stream to store water, and the construction of dams ponds in the upper stream areas for domestic and agricultural purposes, the great scale use of pesticides, and the massive drainage of home and industrial waste products into the river and/or stream would affect the natural environmental conditions.

The prevalence for *C. sinensis* among the residents, in present study was relatively high. The infection rate in 2,542 residents was 5.9 per cent.

Actually, although there have been several efforts to estimate the real figure of clonorchiasis in the coastal areas, this cannot reveal the real infected cases because one time fecal examination is not sufficient to determine the true infection rate of *C. sinensis*. However, the results are quite comparable with earlier reports based on one time examination of feces by means of similar laboratory procedure. Our results are similar to those reported by Joo and Baik(1986) showing relatively high prevalence of *C. sinensis* in Kyungpook Province, although the degree of infection is not so high as reported by Joo and Choi(1974), Rim et al.(1978), Joo and Hong(1991), and Hyun and Joo(1993), the prevalence rates among the residents varied according to surveyed county, varying from 4.6 per cent to 7.3 per cent. The rates showed the higher in Yeongil county with 7.3 per cent, in Kyungju county with 6.7 per cent and Yeongduk county with 6.1 per cent in order. The other areas of Ulchin and Kyungju city showed the lower rates between 4.6-4.9 per cent.

Although probable reasons for relatively high infection rates in these residents and different rates according to the surveyed areas are not known, it is considered to be due to social and economic factors, such as inadequate public health, improved transportation and easy availability of fish through more frequent communications between adjacent areas, and a variety of behaviors and customs according to the localities surveyed.

There was a significant difference between the infection rates of males and females. The former was 7.0 per cent and latter, 5.1 per cent. These findings are identical with those of earlier studies(Joo, 1980 & 1984; and Hyun and Joo, 1990), and suggest that this is probably related to some differences in the opportunities of eating raw or uncooked fresh-water fish away from home. This assumption is supported by the fact that Korean people have a custom of eating raw-fish soaked simply in vinegar or red-pepper mash, as an appetizer when drinking rice-wine and/or distilled spirits at social meetings. Since females infrequently participate in such meetings, they have much less exposure to the *Clonorchis* infections.

The infection patterns of age specific rate of the liver fluke were appreciably varied; *C. sinensis* were initially established in the 0-9 year age group with a average of 0.7 per cent. It subsequently increased and reached a maximum of 17.4 per cent in the 40-49 year age group and followed by a decrease.

The prevalence being higher among the older age group (between age of 20 to 40 years) would be explained by the successive new infection and long survival of the parasites in human bodies. Although main reasons for *Clonorchis* infections among children (0-9 year age group) are not clear, it is thought to come from the practice of giving raw fresh-water fish to children by adults and/or elderly persons in their village areas. Sometimes, ignorant mothers feed raw fish to their children believing it will help them to grow strong. Such consideration was also recognized by Kim(1974), Rim(1986), Joo and Hong(1991) and Hyun and Joo(1993).

In the eariler studies for the epidemiological changes of clonorchiasis among the residents in the endemic areas of Korea, Song et al.(1979) made an excellent approach to the mode of transmission of clonorchiasis for the residents of the river Naktong basin, using a two-stage catalytic model proposed by Muench(1959), and also estimated that the mode of transmission in Kimhae county, Kyungnam Province represented a more rapid patterns of infection than that of some endemic areas of Kyungpook Provinve. Similar results have been obtained by Rim(1986) and Hyun and Joo(1993).

In the study the simple catalytic curve(a spectial type) for males was $y=0.21(1-e^{-0.021t})$ and for females, $y=0.19(1-e^{-0.013t})$. The results indicated a force of infection of 21 males and 13 females effective infections giving stool examinations per 1,000 residents per year in this surveyed areas.

And the asymptote is at about 21.0 per cent of males and 19.0 per cent of females the estimated values of the limit of possible infections in this population.

From the presented in Table 8 and Fig. 5, it was noted that the two stage catalytic model fit well with the age prevalence for clonorchiasis in 1964 and 1993, and the calculation lead to the equations; $y=1.769(1-e^{-0.023t}-e^{-0.010t})$, a=0.023, b=0.010 in 1964 and $y=0.511(1-e^{-0.0093t}-e^{-0.0275t})$ in 1993.

Summarizing all of the previous data in Korea, the age prevalence of *C. sinensis* was found to follow a peculiar pattern, a phase of increase in the initial stage from the youngest age group towards certain age group, which is usually followed by a phase of roughly constant level in adult age groups and further by a phase of decline in the older age groups, and was illustrated by the formula of the two stage catalytic model. Therefore, the theoretically obtained two stage catalytic curve fit so will with the observed data that a catalytic model was found useful in understanding the features of the transmission of *C. sinensis* infections.

In the intensity of *Clonorchis* infections among the residents, Rim et al(1973) reported that the mean EPG (average number of eggs per gram) in feces in different age group was found to be higher among the older age groups. They also commented that such and increase in intensity was considered to be caused by an accumulation of adult worms through repeated infections. Kim(1974) in an ecological studies of *C. sinensis* reported that the higher intensity of the infection in the males than the females was statistically significant in the high endemic locality but not in the low endemic locality.

In the present study, approximately 71.5 per cent of the 151 residents with clonorchiasis had less than 1,000 eggs per gram of feces. Thus, these results indicate that most cases of clonorchiasis residents examined were found to be lightly infected.

Song et al.(1983) made the mathematical approach in order to identify the intensity and endemicity of clonorchiasis in Korea, and reported that the regression equations orginated from Kimhae county, on the lower stream of the Naktong river were y=3.44+1.20 log X, Cs. D_{50}=19.95., and from Buyeo county, in the area of the Kum river basin were y=3.893+1.65 log X, Cs. D_{50}=4.45, respectively.

Quited recently Hyun and Joo(1993) conducted an epidemiological studies of *C. sinensis* in the upper stream areas of the Naktong river, and reported that the regression equation was y=2.06+1.20 log X, Cs. D_{50}=2.76.

In this study, the regression equation for males was y=1.58+1.33 log X, Cs. D_{50}=2.57 and for females, y=0.65+1.65 log X, Cs. D_{50}=2.63 respectively.

The main reasons for predominance of residents with lower intensity of *Clonorchis* infection in this surveyed areas are difficult to explained, but the remarkable improvement of the socioeconomic status and public health education of the residents during the past 30 years should be emphasized in this conection.

In fact, of the fish collected in the some rivers and/or streams of the coastal areas, the encysted larvae of *C. sinensis* are found most frequently in

the small-sized fresh-water fish, i. e., *P. parva, G. atromaculatus* and *P. herzi*, etc.

These fish are apparently neglected by the residents for raw consumption, but are eaten only by residents near the river basin usually cooked. According to the residents with clonorchiasis, they eat *C. carpio nudus, C. carassius* and *C. carpio* in a state of raw, making them in a slice and mixed with vinegar and/or soybean paste. This assumption is supported by the fact that most cases of clonorchiasis in this study show the mild infections. It is supposed that some cases of moderate and heavy infections would occur if the infections originating from the eating of small-sized fish which usually harboured many metacercariae.

In the studies on the laboratory findings of *C. sinensis* infections, Germer et al.(1955) carried out a laboratory and clinical studies of clonorchiasis in Korea, and reported that no increase in serum bilirubin was noted in any of 35 patients with pure clonorchiasis, whereas this value was elevated in 12 cases or 30.8 per cent of 39 patients with clonorchiassis. Thymol turbidity was increased in 42.5 per cent of patients with clonorchiasis, but in 78.8 per cent of those who cirrhotic.

Cho et al.(1970) couducted a study on the liver function of 23 symptomless cases with clonorchiasis, and reported that the serum level of total protein, globulin, cholesterol, thymol turbidity were whithin normal values, whereas, albumin revealed the minimum value of normal limits. a study of Sho and Im(1970) reported that albumin decreased in 20.6 per cent of patients, while globulin increased in 42.6 per cent, and BUN decreased in 27.0 per cent.

Subsequently Kim et al.(1982) reported that the mean values of AST, ALT, and bilirubin increased in accordance with *Clonorchis* intensity, while the total protein and A/G ration showed a tendentcy to be decreased as the intensity increased. similar results have been obtained by Rim et al.(1973), Hyun and Rim(1977), and Hyun and Joo(1993), although the laboratory findings are varied by the investigators.

In this study, a seires of liver function test examined showed normal value in most cases. Summarizing all of the previously reported data and our own figures, it is noted that, although the liver is diffusedly disturbed in clonorchiasis, the liver funcion tests are often within the normal value.

Thus, the results should be carefully evaluated by combining various funcion tests.

As to the clinical therapeutic effects of praziquantel on human clonorchiasis, Rim(1983) reported that the dosage of 25 mg/kg three times for only one day, the egg reduction rate was 99.5 per cent and the cure rate was 85.7 per cent.

Similar results have been obtained by Seo et al.(1983), Rim et al.(1985), and Hyun and Joo(1993). A study of Lee(1984) reported that with the dose of 30 mg/kg twice a day, the cure rate was 94.9 per cent and egg reduction rate, 99.0 per cent.

A dosage of 30 mg/kg three times a day showed 91.4 per cent cure rate and 99.9 per cent egg reduction rate. He also concluded that one single dose of 40 mg/kg was recommended for large scale treatment of *C. sinensis* infections with praziquantel under field conditions.

In the present study, a single dose of 25 mg/kg three times a day showed egg reduction rates of 92.7-98.9 per cent and cure rates of 0-96.2 per cent with transient side effects of mild abdominal discomfort, vomiting and nausea, headache and dizziness, etc. In the basis of the previouly reported data and our own figures, it is concluded that praziquantel has an excellent effectiveness against *C. sinensis* infections and currently the most highly effective and safe drug for clonorchiasis treatment.

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