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Epidemiological studies of *Clonorchis sinensis* in the upper stream areas of Naktong river*

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INTRODUCTION

Clonorchiasis is one of the main endemic parasitic diseases in Korea, and is still recognized as a major public health problem in many areas. The initial report on *C. sinensis* in Korea was made by Matsumoto(1915) who conducted a survey on intestinal helminths by stool examination among Koreans in Taegu Charity hospital located in Kyungpook Province. Kobayashi(1924) reported nine species of fresh-water fish belonging to the family Cyprinidae as the second intermediate host of *C. sinensis*. An endemic focus of the liver fluke in the vicinity of Yeongcheon, Kyungpook Province was reported by Nishimura (1943) who described the presence of metacercariae characteristic of *C. sinensis* in fresh-water fish in the same area where the snails harboring the cercariae were found.

In the past fifty years, epidemiological studies of *C. sinensis* have been made by many investigators in an attempt to determine the prevalence in the residents of Korea.

Walton and Chyu(1959) in a nationwide survey on the prevalence of clonorchiasis in Korea reported 2,066 positive reactors of 9.771 residents for intradermal reaction. The positives were found in all Provinces, the highest percentage occurring in Kyungpook Provionce with 36.0 percent and the lowest, in Cheju Province with 2.0 per cent. They also estimated that in south Korea alone some 4.5 million residents were infected by *C. sinensis*, posing a public health problem of considerable magnitude.

After the begining of the New community project in the third "Five-year economic development plan" in 1972, the Korean government made plans to control helminthic infections, and performed the mass treatment of egg positive cases although *A. lumbricoides*, *T. trichiura* and hookworm were the principal subjects.

At the same time, environmental measure, especially night soil disposal were taken into consideration although its enforcement was not sufficient.

As a result, these operations resulted in a gradual decrease in the prevalence of soil-transmitted parasitic diseases. However, the data of the previous surveys revealed that *C. sinensis* infections still remained highly prevalent, especially in the vicinity of the rivers and their tributaries in Korea.

Quite recently, the relatively high prevalence of *C. sinensis* in the residents and in fresh-water fish hosts in the vicinity of the river Ahnseong(Joo and Hong, 1991) and in the river Banbyun Basin (Chung et al., 1991) suggested that clonorchiasis is still widespread in Kyungpook Province.

In recent years there are newly established factories and many apartments in the vicinity of the river Naktong and its tributaries, and massive drainage of waste products into the river together with intense spray of pesticides on nearby farms may have caused the destruction of the natural environment of the river.

* The results of this study were presented at the 34th annual meeting of the Korean Society for Parasitology(1992).

The purpose of this study is to observe the present status of larval trematode infections in the snail and fish hosts, and infection patterns of *C. sinensis* among the residents in the upper stream areas of the Naktong river, Kyungpook Province.

Geographical conditions of surveyed area

The river Naktong, about 511.8 kilometers in length, has its origin in the south range of the Mt. Teaback. The main stream of the river runs to Kyungpook Province, where the river joins with the stream Banbyun in Andong county, the stream Wie in Wiseong county, the stream Naeseong in Yeongpung county, the stream Buk in Sangju county, the stream Kam in Seonsan county, the stream Hoe in Kolyung county, and the river Kumho in Dalseong county. It then runs through the Kyungnam Province and joins again with the river Hwang, the river Nam, and the river Mirlyang. Finally it runs into the southern Sea of Korea(Fig.1).

The 27 villages and the single primary school in the vicinity of the upper stream areas of the river were selected as the study areas because the fresh-water fish in the water are abundant. The localities are from 83 to 223 meters above sea level and the soil is mainly composed of sand and pebbles with mud.

The water level in the river is relatively permanent slow-flowing except 5-10 days after a heavy rain and usually contains abundant organic material and sewage. Many types of marsh plants and grass cover the entire area. There are many kinds of fresh-water fish in the water.

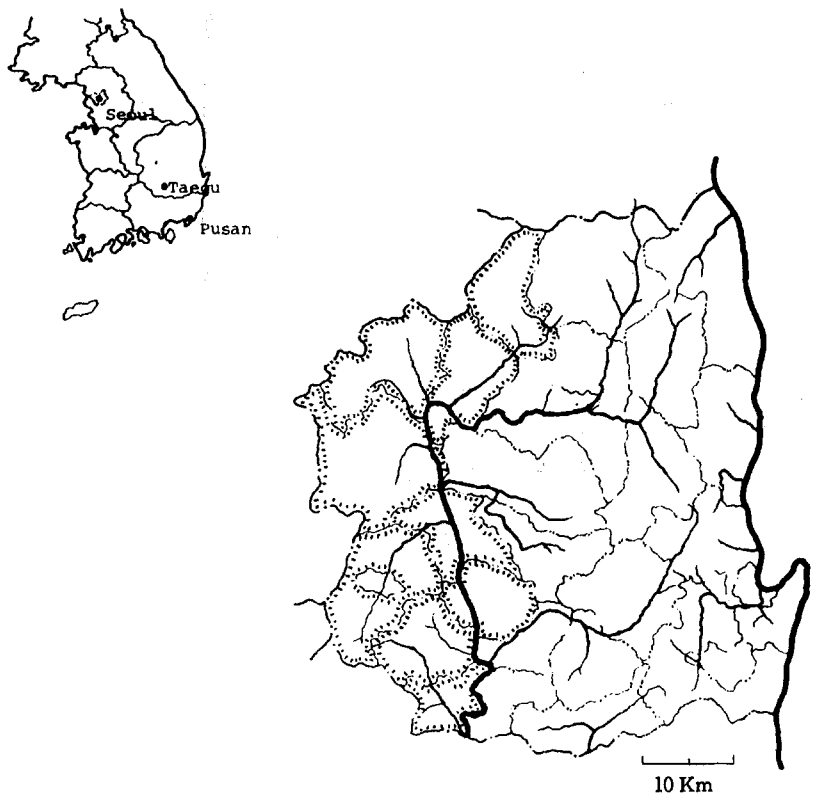

Fig. 1. Map of Kyungpook Province, Korea. Black bold lines show the counties and rivers surveyed.

Materials and Methods

1. Survey of *C. sinensis* infection in residents :

During the period from June, 1991 to September, 1992, the fecal examination was made in order to discover *Clonorchis* eggs among the residents, aged from 6 to 69 years, living in 9 counties of the upper stream of the Naktong river, Kyungpook Province, Korea.

A total of 1,555 specimens were collected from 786 male and 769 female residents living in 2,018 households, but not all family members complied.

Those in the 10-19 year age group were much less inclined to cooperate. The proportion of residents tested out of total number varied from 11.2 per cent to 32.7 per cent, with an average of 21.2 per cent(Table. 1).

The specimens, collected in cartons, were brought to the Department of Parasitology laboratory and examined by the MGL technique, and then the Stoll's egg count technique was applied.

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 are 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 results at any time "t". The "r" is the force of infection, which is defined by Muench 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 the unit quantity which is subject to change.

2. The features of transmitting *C. sinensis* infection :

In order to evaluate the features of transmitting *C. sinensis* infections in the upper stream areas of the Naktong river, 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 :

$$y = X - Z \qquad (1)$$

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 :

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

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

From equation (1), by differentiation,

$$dy/dt=dx/dt-dz/dt \qquad (4)$$

$$=(1-x)-b(x-z)[\text{from Eqs.(2)\&(3)}]$$

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

This is another simple linear equation, whose general solution is

$$y=\frac{a}{b-a.}e^{-at}+Ce^{-bt}$$

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

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

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

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

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

$$y=ate^{-at} \qquad (7)$$

3. The levels of intensity of *C. sinensis* infection :

In order to determine the levels of intensity of *C. sinensis* infection, the EPG of clonorchiasis

Table 1. Total number of residents and number tested in nine different counties in the upper stream of Naktong river(1992)

Surveyed area		Draining	No. of	No.	Percent
County	Village	river	residents	tested	tested
Chilgok	Kwanho 2nd	Naktong	320	65	20.3
	Namyul	river	863	43	5.0
	Neseock 2nd		223	49	22.0
	Subtotal		1,406	157	11.2
Kolyung	Sachon	Hoe	246	38	15.4
	Podong	stream	319	72	22.6
	Yeondong		288	50	17.4
	Shanglim*		178	177	99.4
	Subtotal		1,031	337	32.7
Kumlyung	Daeyang lst	Kam	170	46	27.1
	Daeyang 2nd	stream	168	61	36.3
	Pukseong		129	47	36.4
	Subtotal		467	154	33.0
Munkyung	Seochung	Kum	343	44	12.8
	Daesang lst	stream	579	48	8.3
	Maewha		329	61	18.7
	Subtotal		1,248	153	12.3
Sangju	Shinchon lst	Buk	199	53	26.6
	Pyonggi lst	stream	211	56	26.5
	Lungam lst		165	45	27.3
	Subtotal		575	154	26.8
Seongju	Suseong lst	Taega	326	50	15.3
	Suseong 2nd	stream	65	37	57.0
	Shinjung		330	72	21.8
	Subtotal		721	159	22.1
Seonsan	Changlim	Naktong	82	38	46.8
	Kumho lst	river	415	52	12.5
	Songkok 2nd		205	62	30.2
	Subtotal		702	152	21.7
Yeocheon	woolae lst	Naeseong	199	45	22.6
	Woolae 2nd	stream	156	40	25.6
	Oshin		273	54	19.8
	Subtotal		628	139	22.1
Yeongpung	Kumkwang 2nd	Naeseong	222	83	37.4
	Kumkwang 3nd	stream	183	32	21.3
	Yongheol lst		150	35	28.3
	Subtotal		555	150	27.0
	Total		7,333	1,555	21.2

* Primary school children.

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 the probit of cumulative frequency 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 cumulative percentage out of the total number of positive cases. The intensity of *C. sinensis* infection was represented as the fifty per cent level of EPG in a population($Cs.D_{50}$). Fifty per cent level of EPG in this population($Cs.D_{50}$) was obtained by solving the equation : $\log X=(5-a)/b$

4. Therapeutic effects of praziquantel(Embay 8440) against *C. sinensis* infection :

In order to determine the efficacy of praziquantel, a total of 302 cases of *C. sinensis* infection were treated with the dosage of 25mg/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* egg in the feces, which was confirmed by at least three further examinations by MGL technique.

5. Blood biochemistry tests :

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

6. The fish host survey :

Fresh-water fish were caught by netting and fishing at the 9 localities in the upper stream of the Naktong river. 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, after removal of their intestinal contents, and each material was compressed between two large slides(50 ×90mm) and examined for the metacercariae of *C. sinensis* 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(0.2ml of diluted hydrochloric acid and 0.3g of pepsin per 100ml of distilled water), and the mixture were incubated under the temperature 37－38℃ for 30－40 minutes.

7. The snail intermediate host survey :

In order to determine the density of the snail population and the infection rates for *Clonorchis* cercariae in the snails collected in 7 localities in the upper stream of the Naktong river, studies were conducted during the period of 2 years from May, 1991 to September, 1992.

Collections of *Parafossarulus* snails were made from late in June to early in September. The density of the snail population was measured by the approximate number of snails per square meter in the river bed. The snails were collected by hand and put into damp plastic buckets with marsh grass and forwarded to the Department of Parasitology laboratory.

In order to determine the infection of *Clonorchis* cercariae, ten snails were put into petridishes containing about 40 ml of tap water for 48 hours and observations made on the liberation of cercariae. All the snails in a dish revealing the cercariae were crushed to determine the total percentage of infection.

Results

The prevalence of *C. sinensis* among the residents of nine counties in the upper stream areas of the Naktong river are shown in Table 2. The same data is presented graphically in Fig. 2.

Table 2. Prevalence of *Clonorchis sinensis* among residents by County(1992)

County	Male		Female		Total	
	No. examined	Percent infected	No. examined	Percent infected	No. examined	Percent infected
Chilgok	73	42.5	84	21.4	157	31.2
Kolyung	172	33.1	165	20.6	337	27.0
Kumlung	90	16.7	64	3.1	154	11.0
Munkyung	82	26.8	71	5.6	153	17.0
Sangju	81	6.2	73	4.1	154	5.2
Seongju	87	17.2	72	11.1	159	14.5
Seonsan	69	36.2	83	1.2	152	17.1
Yeocheon	71	46.5	68	1.4	139	25.2
Yeongpung	61	32.8	89	7.9	159	18.0
Total	786	28.4	769	10.3	1,555	19.4

Table 3. Prevalence of *Clonorchis sinensis* among residents by sex and age group(1992)

Age group (Year)	Male		Female		Total	
	No. examined	Percent infected	No. examined	Percent infected	No. examined	Percent infected
0– 9	93	2.0	88	2.3	187	2.1
10–19	19	5.3	13	7.7	32	6.3
20–29	49	18.4	50	2.0	99	10.1
30–39	121	35.5	98	13.3	219	25.6
40–49	145	37.9	124	8.9	269	24.5
50–59	199	34.2	219	15.1	418	24.2
60–	154	29.2	177	10.2	331	19.0
Total	786	28.4	769	10.3	1,555	19.4

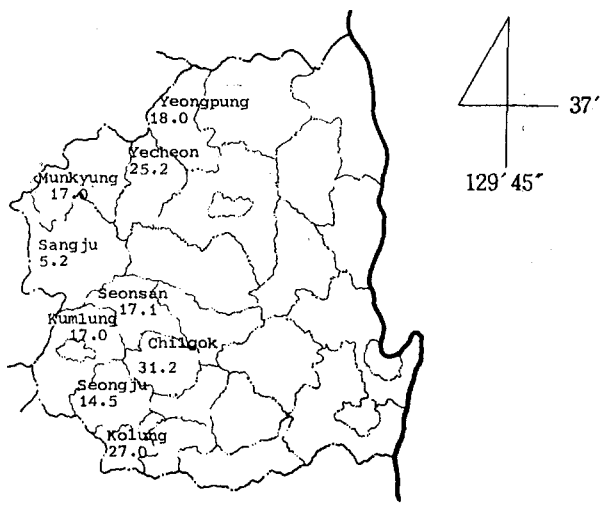

Fig. 2. Study areas in Kyungpook Province, Korea.

Table 4. Fraction of *Clonorchis sinensis* positives by sex, for the arrangement of catalytic curve, special type, $y=k(1-e^{-rt})$(1992)

Age		Male			Female		
(Y)	t	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
$\sum A$			8.89			5.99	
$\sum tA$			443.35			305.85	
$\bar{t}$			49.87			51.06	
$\sum' A$			11.11			7.48	
$\bar{t}'$			62.32			63.82	
r'			0.017			0.01	
$\sum' k=1A$			52.50			37.50	
k			0.21			0.19	
r			0.021			0.013	

Remark : 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 $\sum A$($\sum A$: area under histogram). So must the sums of products of items in *y* columns by those in *t* columns(t : value of center point of each age band) to get$\sum tA$. The quantity $\underline{k}$ is the ratio of observed $\sum A$ to the value expected(if $\underline{k}$ were 1) for the value of r' determined from $\bar{t}$ (r : estemated rate).

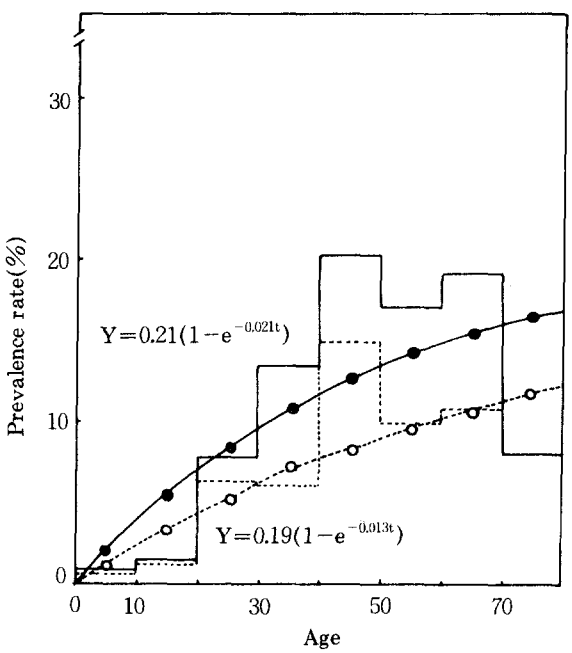

Fig. 3. Simple catalytic curves and histograms showing fraction of *Clonorchis* positive cases in upper stream areas of Naktong river(1992) by age from 0 to 70 years.

Table 5. Application of the two-stage catalytic model to the age prevalence of clonorchiasis among residents in the upper stream areas of river Naktong(1992)

Age group (Year)	t	y	A	tA	e^{-bt}	e^{-at}	$\frac{a(e^{-at}-e^{-bt})}{b-a}$
0 – 9	5	0.0855	0.855	4.275	0.9185	0.9093	0.0874
10 – 19	15	0.2500	2.500	37.500	0.7749	0.7520	0.2175
20 – 29	25	0.1919	1.919	47.975	0.6537	0.6218	0.3030
30 – 39	35	0.3515	3.515	123.025	0.5515	0.5142	0.3543
40 – 49	45	0.4460	4.460	200.700	0.4653	0.4252	0.3809
50 – 59	55	0.4497	4.497	247.335	0.3925	0.3516	0.3885
60 – 69	65	0.2900	2.900	185.500	0.3312	0.2908	0.3838

$\sum tA = 849.31$ $\sum A = 20.646$ $\bar{t} = 41.136$ $\sum' A = 29.494$ $\bar{t}' = 58.766$

$a' = 0.013$ $a = 0.019$ $b' = 0.012$ $b = 0.017$ $\frac{a}{b-a} = 9.5$

Two-stage catalytic curve: $y = 9.5(e^{-0.017t} - e^{-0.019t})$

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).

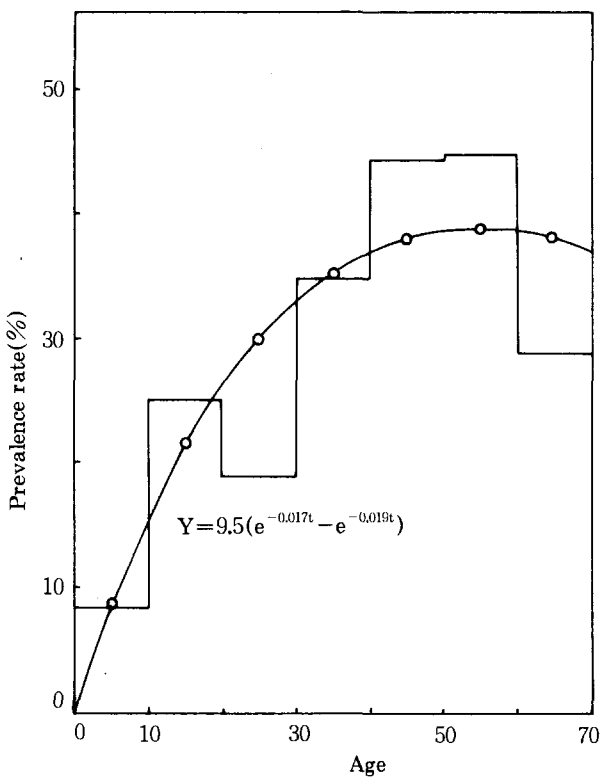

Fig. 4. Two-stage catalytic curve and histogram showing fraction of *Clonorchis* positive cases by age in upper stream areas of river Naktong.

Table 6. Comparison of data of two-stage catalytic model to age prevalence of clonorchiasis among residents in Kyungpook Province in 1964, 1976 and 1992, revealed by intradermal test and stool examination

Age	t	Shin(1964)		Choi et al.(1976)		Authors(1992)	
		y	$\frac{a\ (e^{-bt}-e^{-at})}{b-a}$	y	$\frac{a\ (e^{-bt}-e^{-at})}{b-a}$	y	$\frac{a\ (e^{-bt}-e^{-at})}{b-a}$
0－ 4	2.5	0.0359	0.0563	0.0046	0.0291	0.0855	0.0874
5－ 9	7.5	0.1189	0.1532	0.0688	0.0834		
10－14	12.5	0.1814	0.2347	0.1098	0.1326	0.2500	0.2175
15－19	17.5	0.2729	0.3023	0.1529	0.1764		
20－29	25	0.3475	0.3825	0.2712	0.2337	0.1919	0.3030
30－39	35	0.4631	0.4555	0.3713	0.2961	0.3515	0.3543
40－49	45	0.5026	0.4966	0.4537	0.3447	0.4460	0.3809
50－59	55	0.4879	0.4810	0.4676	0.3816	0.4497	0.3885
60－	65	0.4522	0.4518	0.3306	0.4083	0.2900	0.3838
$\sum tA$		1079.10		894.74		849.31	
$\sum A$		25.63		820.52		20.646	
$\bar{t}$		42.10		43.59		41.137	
$\sum' A$		36.61		29.32		29.494	
$\bar{t}'$		60.13		62.27		58.766	
a'		0.016		0.009		0.013	
a		0.023		0.012		0.019	
b'		0.007		0.006		0.012	
b		0.010		0.008		0.017	
$\frac{a}{a-b}$		1.769		3.000		9.5	

Remark : Each age group 5 and 10 years wide. The sums of item in the y columns(y : fraction having positives, by age) must therefore be multiplied by 5 and 10 to get$\sum A$($\sum A$: 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$\sum tA$.

Of 1,555 residents, 19.4 per cent were found to be infective cases. Infection rates were consistently higher for males than for females through all different counties. The prevalence of *C. sinensis* varied widely from one county of the Province to another. In practice, rates in the Chilgok, Kolyung and Yeocheon counties were relatively high, while, rates in the Kumlung and Sangju counties were very low.

Table 3 summarizes the prevalence of *C. sinensis* among the residents by sex and age groups. The sex-specific rate of infection was significantly higher in males than in females ; 28.4 per cent in males and 10.3 per cent in females, respectively($t>2$). In the age-specific rates, the prevalences of groups under 20 years of age varied from 2.0 to 5.3 per cent in males while from 2.3 to 7.7 per cent in females, suggesting no difference between both sexes. But the prevalences of males were always higher than those of females in all groups over 20 years; 18.4 per cent of males and 2.0 per cent of females in the 20－29 year age group, 35.8 per cent and 13.3 per cent in the 30－39 year group, 37.9 per cent and 8.9 per cent in the 40－49 year group, 34.2 per cent and 15.1 per cent in the 50－59 year group, and 29.2 per cent and 10.2 per cent in the over 60 year group, respectively.

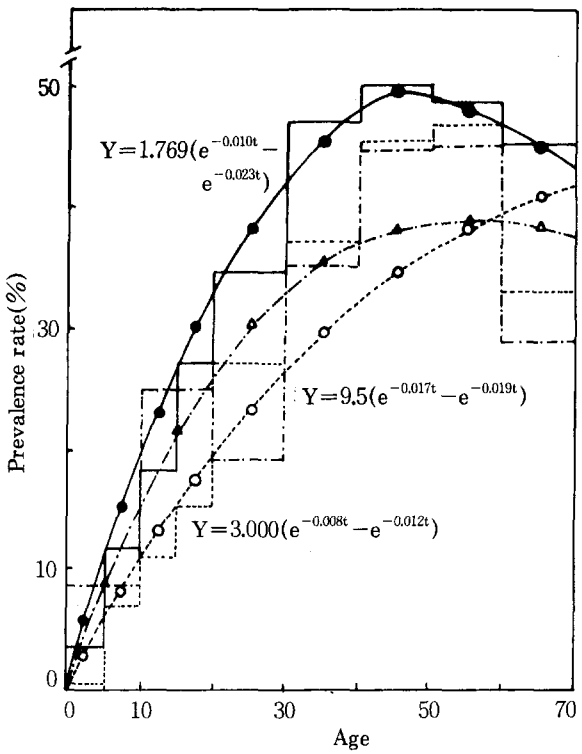

Fig. 5. Two-stage catalytic curves and histograms showing fraction of *Clonorchis* positives in Kyungpook Province in 1964, 1976 and 1992, revealed by intradermal test and stool examination.

Table 7. Intensity of *Clonorchis sinensis* by Stoll's egg-count technique among residents in the upper stream areas of Naktong river(1992)

Range of EPG	Male		Female		Total	
	No. infected	%	No. infected	%	No. infected	%
0– 500	136	61.0	53	67.1	189	62.6
501– 1,000	35	15.7	11	13.9	46	15.2
1,001– 2,000	19	8.5	10	12.7	28	9.3
2,001– 3,000	3	1.3	2	2.5	5	1.7
3,001– 4,000	4	1.8	2	2.5	6	2.0
4,001– 5,000	4	1.8	0	0	4	1.3
5,001– 6,000	2	0.9	1	1.3	3	1.0
6,001– 7,000	5	2.2	0	0	5	1.7
7,001– 8,000	1	0.4	0	0	1	0.3
8,001– 9,000	2	0.9	0	0	2	0.7
9,001–10,000	1	0.4	0	0	1	0.3
10,001–20,000	7	3.1	0	0	7	2.3
20,001–30,000	2	0.9	0	0	2	0.7
30,001–	2	0.9	0	0	2	0.7
Total No. infected	223		79		302	

* EPG : Eggs per gram of feces.

Table 8. Frequency distribution and cumulative percentage of *Clonorchis* positive cases in the upper stream areas of river Naktong(1992)

X(EPG)	Male		Female		Total	
	Freq*	Cum.%**	Freq.	Cum.%	Freq	Cum.%
− 100	60	26.91	22	27.84	82	27.15
− 200	34	42.15	13	44.29	47	42.71
− 300	16	49.32	6	51.88	22	49.32
− 400	19	57.84	5	58.20	24	57.84
− 500	7	60.98	7	67.59	14	62.58
− 600	7	64.12	2	69.59	9	65.56
− 700	9	68.16	3	73.38	12	69.53
− 800	7	71.30	3	77.17	10	72.84
− 900	6	73.99	1	78.43	7	75.15
− 1,000	6	76.68	2	80.96	8	77.80
− 2,000	19	85.20	10	93.61	29	87.40
− 3,000	3	86.55	2	96.14	5	89.06
− 4,000	4	88.34	2	98.67	6	91.05
− 5,000	4	90.13	0	98.67	4	92.37
− 6,000	2	91.03	1	99.93	3	93.36
− 7,000	5	93.27			5	95.02
− 8,000	1	93.72			1	95.35
− 9,000	2	94.62			2	96.01
−10,000	1	95.07			1	96.34
−20,000	7	98.21			7	98.21
−30,000	2	99.11			2	99.31
−40,000	1	99.56			1	99.64
−50,000	1	100.01			1	99.97
No. of examined	785		769		1,555	
No. of positive	223		79		302	
Prercent positive	28.4		10.3		19.4	
Constant "a"	2.25		0.94		2.06	
Constant "b"	1.11		1.66		1.20	
C_s. D_{50}	2.86		2.70		2.76	

* Freq. : Frequency.
** Cum.% : Cumulative percentage.

The application of the special type of a simple catalytic curve for the prevalence rates of *C. sisnensis* by sex and age group is shown in Table 4 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 $y=0.610(1-e^{-0.015t})$ and female's was $y=0.105(1-e^{-0.020t})$. 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 prevalance of clonorchiasis is shown in Table 5 and illustrated in Fig. 4.

The infection rate of *C. sinensis* was found to be as high as 33.69 per cent, the value of constant "a" was found to be 0.019. In other words, the force of infection was 19 per annum per 1,000 susceptible persons. However, the value of constant

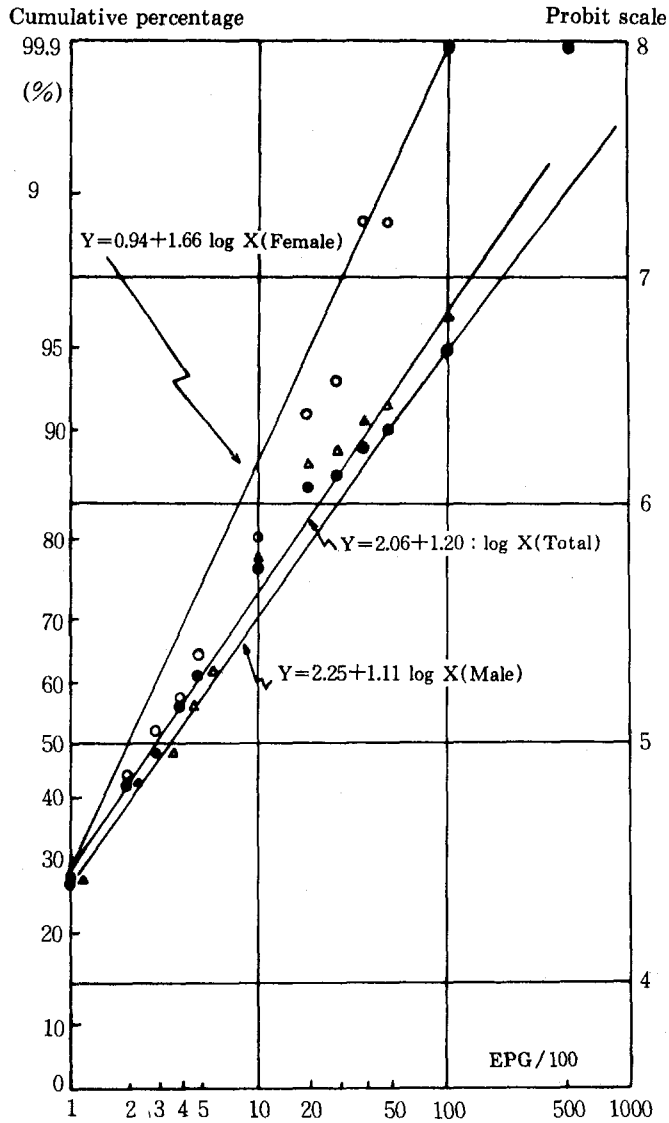

Fig. 6. Regression lines of cumulative percentage of *C. sinensis* egg positive cases against EPG density in log-probit scale in upper stream areas of river Naktong.

"b" was found to be 0.017 representing that the rate of disappearance from the positive to negative during the observed period was per annum 17 per 1.000 *Clonorchis* positive cases. Therefore,

$$y=9.5(e^{-0.017t}-e^{-0.019t})$$

The data of the two-stage catalytic model to the age prevalence of *C. sinensis* among residents in Kyungpook Province in 1964 and 1976 are compared with the data in 1992 and listed in Table 6 and illustrated in Fig. 5.

In 1964, the two-stage catalytic curve was $y=1.769(e^{-0.010t}-e^{-0.023t})$, the value of constant "a" was found to be 0.023, that being the rate of infection of *C. sinensis*. 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 observed period was only

10 annum per 1,000 clonorchiasis patients.

In 1976, the overall prevalence rate for clonorchiasis was reduced from 27.7 per cent in 1964 to 19.6 per cent in 1976. The two-stage catalytic model fitted well with the infection rates by age in *Clonorchis* positive cases, and the calculation lead to the equation: $y=3.0(e^{-0.008t}-e^{-0.009t})$.

The data in 1992 fitted with the two-stage catalytic curve: $y=9.5(e^{-0.017t}-e^{-0.019t})$. The results indicate that the force of *Clonorchis* infection was much lower in 1992 than those in 1964 and 1976.

Table 7 lists the intensity of infections by sex in 302 residents with clonorchiasis. The intensity of infection, expressed in egg per gram of feces was divided into 500 egg intervals in the first and second classes, and followed by 1,000 and 10,000 egg intervals for the purposes.

The number of egg per gram of feces was less than 500 in 136 males or 61.0 per cent and 63 females or 67.1 per cent, 501-1,000 in 35 cases or 15.7 per cent and 11 cases or 13.9 per cent, 1,001-10,000 in 41 or 18.4 per cent and 15 or 19.0 per cent, and more than 10,001 in 11 males or 4.9 per cent. The largest number was recorded to be 46,000 in a 41-year old male in Yeocheon county.

The frequency distribution and cumulative percentage of *Clonorchis* positive cases against EPG density in the log-probit scale in the upper stream areas of the river Naktong are shown in Table 8 and illustrated by Fig.6. Among a total of 302 residents examined, the regression curve was $y=2.06+1,20 \log X$. The intensity of *C. sinensis* infection, expressed as the fifty per cent level of EPG in a resident(C.s. D_{50}), was 2.76 (about EPG : 300). In the intensity of *Clonorchis* infection by sex, the male's regression equation was $y=2.25+1.11 \log X$ and the female's was $y=0.94+1.66 \log X$, respectively. The values of C.s. D_{50} for the males was 2.86 and that for the females, 2.70.

The numerical distribution of intensity of *Clonorchis* infections among the residents by sex and age groups are shown in Table 9.

171 cases or 76.7 per cent of 223 males and 64 cases or 81.0 per cent of 79 females were found to be lightly infected, 41 cases or 18.4 per cent in males and 15 or 19.0 per cent in females were moderately infected, and 11 cases or 4.9 percent in males aged between the age of 30 to 39 were heavily infected.

Table 10 lists the numerical distribution of intensity of *C. sinensis* infections according to administrative districts. The mean EPG of 302 cases was 1,614 ; 1,936 for males and 690.0 for females. The *Clonorchis* positive cases in Chilgok county revealed the highest mean EPG count for males, but relatively lower mean EPG count in females. Those in Kolyung and Sangju counties, revealing relatively high mean EPG counts for males, showed low EPG counts in females.

The mean EPG counts in both sexes were the lowest in the residents in Yeongpung county. The *Clonorchis* positive cases in Munkyung county showed intermediary EPG counts in both sexes.

The distribution of results on the blood biochemical tests according to the intensity of *Clonorchis* infections are shown in Table 11. The level of AST(Aspartate transaminase : normal range of value with 5-40 units) was normal in 92.3 per cent of the light infection group, 89.3 per cent of the moderate infection group, and 90.9 per cent of the heavily infection group.

The normal ALT(Alanine transaminase : normal value with 5-40 units) was observed in 93.2 per cent, 94.6 per cent and 100.0 per cent of the light, moderate and heavy infection groups, respectively.

The clonorchiasis patients with a slightly elevated ALP(Alkaline phosphatase) value of 201-450 units showed 19.1 per cent, 30.4 per cent and 54.5 per cent in the light, moderate and heavy infection groups, respectively.

The normal TTT(Thymol turbidity test) value of 0-5.0 units was observed in 95.7 per cent, 89.3 per cent and 90.9 per cent of the light, moderate and heavily infection groups, respectively.

The cases showing 5.1-10.0 units of TTT were 3.4 per cent in the light infection group, 10.7

Table 9. Nemerical distribution in intensity of *Clonorchis* infections among residents by sex and age groups(1992)

Age group	Male			Female			Total			Mean
(Year)	L*	M**	H***	L	M	H	L	M	H	EPG
0– 9	2	0	0	2	0	0	4	0	0	500
10–19	0	1	0	0	1	0	0	2	0	4,800
20–29	7	12	0	0	1	0	7	3	0	1,010
30–39	32	10	1	10	3	0	42	13	1	1,332
40–49	43	7	5	7	4	0	50	11	5	3,206
50–59	55	10	3	29	4	0	86	12	3	1,033
60–	32	11	2	16	2	0	48	13	2	1,173
Total	171 (76.7)	41 (18.4)	11 (4.9)	64 (81.0)	15 (19.0)****	0	235 (77.8)	56 (18.5)	11 (3.6)	1,614
Total No. infected	223			79			302			

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

per cent in the moderately infection group and 9.1 per cent in heavily infection group.

In Table 12, the therapeutic effects of praziquantel against *C. sinensis* are summarized. A total of 302 patients harboring *C. sinensis* were treated with praziquantel dosage of 25mg/kg three times a day. 230 cases of the light infection group was cured completely 28 days after treatment. 39 or 83.0 per cent out of the 47 moderately infected patients and 7 or 77.8 per cent of the 9 heavily infected patients were cured completely 28 days after treatment.

Among the non-cured patients, 14 lightly infected cases, 8 moderately cases, 2 heavily cases and 2 very heavily infected cases showed egg reduction rates between 92.59 and 99.97 per cent.

Table 13 lists the infection rates and intensities of *Clonorchis* metacercariae according to the fish species. Of the seven species of fish with *C. sinensis*, the most highly infected fish was *Pseudorasbora parva* with 39.1 per cent, followed by *Paracheilognathus rhombea* with 20.0 per cent, and *Gnathopogon atromaculatus* with 17.0 per cent. The less frequently infected fish were *Hemibarbus longirostris*, *Saurogobio dabryi*, and *Pseudogobio esocinus*, ranging from 2.6 per cent to 9.1 per cent. No *Clonorchis* metacercaria was found in the flesh, scales, fins and tail of the remaining 13 species of fish collected in this study. The metacercarial intensity of *C. sinensis* in fish, however, expressed in the average number of cysts per gram of flesh, was low as a whole. Of these, *P. parva* was the most heavily infected and the average number of cyst being 55.9, *G. atromaculatus* was next with an average of 8.9 cysts. *P. rhombea*, *P. esocinus*, and *P. herzi* were moderately infected with an average varing from 2.0 to 3.6 cysts. *H. longiostris* and *S. dabryi* were less heavily infected average of 1.0 cysts, respectively.

The population density of the snails and the infection rates of *Clonorchis* cercaria in the snails collected at 5 habitats in the upper stream areas of the river Naktong in Kyungpook Province are summarized in Table 14. Generally, the liberation rates for *Clonorchis* cercaria in the snails were very low. A total of 4,472 snails were examined for the cercaria, of which 4 or 0.09 per cent were infected with *C. sinensis*. The infection rates in

the snails varied from habitat. At Suseong habitat, 0.13 per cent were found to be infected with *Clonorchis* cercaria, while at Podong and Shinjung habitats, 0.08 per cent and 0.07 per cent, respectively were found to be infected. No infection of the snails was found in Sachon and Daeyang habitats.

DISCUSSION

Clonorchiasis has long been known as one of the most important endemic diseases in Kyungpook

Table 10. Nemerical distribution in intensity of *Clonorchis* infections among residents by administrative district of Kyungpook Province(1992)

County	Sex	No. Positive	Intensity of *Clonorchis* infection			
			Light infection	Moderate infection	Heavy infection	Mean EPG
Chilgok	M	31	18	9	4	4,639
	F	18	15	3	0	600
	Subtotal	49	33	12	4	3,155
Kolyung	M	57	40	15	2	3,714
	F	34	25	9	0	772
	Subtotal	91	65	24	2	1,166
Kumlyung	M	15	9	6	0	1,867
	F	2	1	1	0	1,050
	Subtotal	17	10	7	0	1,771
Munkyung	M	22	19	2	1	968
	F	4	4	0	0	550
	Subtotal	26	23	2	1	904
Sangju	M	5	3	1	1	3,720
	F	3	3	0	0	400
	Subtotal	8	6	1	1	2,475
Seongju	M	15	11	3	1	740
	F	8	7	1	0	963
	Subtotal	23	8	4	1	818
Seonsan	M	25	21	3	1	1,444
	F	1	1	0	0	300
	Subtotal	26	22	3	1	1,400
Yeocheon	M	33	29	2	2	2,582
	F	2	2	0	0	200
	Subtotal	35	31	2	2	2,446
Yeongpung	M	20	20	0	0	355
	F	7	6	1	0	530
	Subtotal	27	26	1	0	400
Total	M	223	171	41	11	1,936
	F	79	64	15	0	690
	Total	302	235	56	11	1,614

Table 11. Mean values and distribution rates of blood biochemistry tests according to the intensity of *Clonorchis* infections(1992)

Test of blood biochemistry	Range of values	Intensity of *Clonorchis* infection		
		Light	Moderate	Heavy
AST(unit)	5−40*	217(92.3)	50(89.3)	10(90.9)
	41−100	16(6.8)	6(10.7)	1(9.1)
	101−	2(0.9)	0	0
	Mean±SD	25.5±13.5	26.5±12.4	27.0±6.5
ALT(unit)	5−40*	219(93.2)	53(94.6)	11(100.0)
	41−100	15(6.4)	3(5.4)	0
	101−	1(0.4)	0	0
	Mean±SD	21.7±15.2	21.9±13.1	18.4±6.5
ALP(unit)	0−200*	190(80.9)	39(69.6)	5(45.5)
	201−450	45(19.1)	17(30.4)	6(54.5)
	451−	0	0	0
	Mean±SD	154.6±43.6	174.0±61.2	136.8±35.7
TTT(unit)	0−5.0*	225(95.7)	50(89.3)	10(90.9)
	5.1−10.0	8(3.4)	6(10.7)	1(9.1)
	10.1−	2(0.9)	0	0
	Mean±SD	2.6±1.8	2.4±1.5	2.5±1.0
Total No. tested		235	65	11

* Normal range of value.

Table 12. Summary of therapeutic effects of praziquantel* at 25mg/kg three times for single day in the treatment of clonorchiasis(1992)

Gorup	No. of case treated	No. of case cured	Egg reduction rate(%)	Cure rate (%)
Light	244	230	92.59	94.3
Moderate	47	39	98.93	83.0
Heavy	9	7	99.97	77.8
Very heavy	2	0	99.25	0

* Follow-up at 28 days after therapy

Remark : Light : EPG count less than 1,000.
Moderate : EPG count between 1,001 to 10,000.
Heavy : EPG count between 10,001 to 30,000.
Very heavy : EPG count over 30,001.

Province, Korea through the various investigations for the several decades ago(Matsumoto, 1915: Chung, 1926; Nishimura, 1943; Lee and Kim, 1958; Walton and Chyu, 1959; Lee et al., 1960). However, these surveys have been carried out in restricted small areas, not covering each area of the Province.

After the first "Five-year economic develop ment plan" in 1962, this Province-wide data on the prevalence of the infection in relation to administrative unit areas such as cities, counties, towns or myuns, and villages have been available.

Shin(1964) conducted a survey for *C. sinensis*

Table 13. Summary of infection rates and intensity for *Clonorchis* metacercariae from fresh-water fish in the upper stream of Naktong river(1992)

Species	No. of fish examined	Percent infected	No. of cyst/g of flesh(ea)	
			Range	Average
Family Cyprinidae				
Carassius carassius Linaeus	185	0	0	0
Coreoleucicus splendidus Mori	5	0	0	0
Cyprinus carpio Linnaeus	5	0	0	0
*Cyprinus carpio nudus**	13	0	0	0
Gnathopogon atromaculatus Nichols et Pope	94	17.0	1–16	8.9
Hemibarbus labeo (Pallas)	58	0	0	0
Hemibarbus longirostris(Regan)	28	3.6	1–1	1.0
Moroco oxycephalus(Bleeker)	36	0	0	0
Paracheilognathus rhombea(T et S**)	25	20.0	2–9	3.6
Pseudogobio esocinus(T et S)	11	9.1	2–2	2.0
Pseudorasbora parva(T et S)	23	39.1	3–91	55.9
Pungtungia herzi Herzenstein	56	7.1	1–5	2.3
Sarcocheilichthys sinensis Bleeker	13	0	0	0
Saurogobio dabryi Bleeker	38	2.6	1–1	1.0
Zacco platypus(T et S)	254	0	0	0
Zacco temmincki(T et S)	96	0	0	0
Family Bagridae				
Corebagrus brevicorpus Mori	17	0	0	0
Family Cichlidae				
Tilapia massambica Peters*	5	0	0	0
Family Siluridae				
Parasilurus asotus Linnaeus	4	0	0	0

* fish from breeding ponds.
** T et S: Temminck et Schlegel.

Table 14. Infection rates of *Parafossarulus* snails with *Clonorchis* cercaria in the upper stream areas of river Naktong(1992)

Steam	Habitat	No. examined	Percent infected
Hoecheon	Sachon	270	0
	Podong	1,229	0.08
Kamcheon	Daeyang	76	0
	Pukseong	0	0
Taegacheon	Suseong	1,562	0.13
	Shinjung	1,335	0.07
Naeseongcheon	Kumkwang	0	0
	Yougheol	0	0
Total		4,472	0.09

among the residents of all age groups from twelve Myuns, randomly selected from the six counties in Kyungpook Province, using cutaneous reactions with the *Clonorchis* antigen, and reported that 23.6−27.4 per cent of those living near the river areas of Yeongcheon and Andong counties, 23.6−29.1 per cent of those living in the rice paddy areas of Wiseong and Sangju counties, and 23.8−27.7 per cent of the residents livng in the mountainous areas of Cheongsong and Yeongyang counties were infected with *C. sinensis*.

Choi et al.(1976) carried out an epidemiological study of *C. sinensis* in the same counties of Kyungpook Province surveyed by Shin(1964), and reported that the overall prevalence rate for clonorchiasis reduced from 27.7 per cent to 19.6 per cent in a period of 10 years.

Seo et al.(1981) reported the prevalence rates among residents in some different areas of the Province; 14.1, 16.8 and 21.4 per cent in riverside areas of Chilgok, Kumi, and Andong counties, 0.4 and 2.4 per cent in coastal areas of Uljin and Yeongil counties, respectively.

In the present study, the prevalence rate for *C. sinensis* among the residents was found to be 19.4 per cent. The rates of infection varied according to counties, varying from 5.2 to 31.2 per cent. The prevalence rate according to county showed the higher in Chilgok county(31.2%), Kolyung county(27.0%), Yeocheon county(25.2%), Yeonpung county(18.0%), Seonsan county(17.1%), and Munkyung county(17.0%) in order. The other counties of Seongju, Sangju, and Kumlung showed the lower rates between 5.2 to 14.5 per cent.

Although there have been several efforts to estimate the infected cases of *C. sinensis* in the upper stream areas of the river Naktong, this cannot reveal the real figure of the cases because one time fecal examination are not sufficient to determine the true infection rate of clonorchiasis, and because the endemicity and infection pat terns of *C. sinensis* varies greatly stream by stream and village by village. The results obtained in this study are in general similar to those reported by Choi et al.(1976) showing relatively high prevalence of *C. sinensis* in Kyungpook Province, although the degree of infection is not so high as reported by Shin(1964), Joo and Choi (1974), and Rim et al.(1978).

The main factors contributing to the different infection rates according to the county are considered to be due, in part, to social and economic factors, such as inadequate public health and improved transportation and easy availability of fish through more frequent communication between adjacent areas.

There was a significant difference between the infection rates of males and females. The former was 28.4 per cent and the latter 10.3 per cent. These findings are in agreement with those of

previous studies(Choi et al., 1976; Joo, 1980 and 1984; Seo et al., 1981; Joo and Hong, 1991; Chung et al., 1991), and suggest that this is probably related to some differences in the opportunities of eating raw or uncooked freshwater fish away from home. As Joo and Hong (1991) indicated, 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 males frequently participate in such meetings, they have more chance of risk of infection than the females.

Although many other reports on the difference in the prevalence by sex have been available, the results obtained are not all in agreement. It may be due, in part, to a variety of male behaviors and customs according to the locality surveyed.

Irrespective of sex, age distribution of the prevalence was 2.1 per cent in 0-9 year age group, increased markedly to 25.6 per cent in 30-39 year group, followed by a somewhat constant level, of 24.5 and 24.2 per cent in those between the age of 40 to 59 years and ended in a slight decrease(19.0 per cent) in those over 60 year of age.

Likewise, the prevalence being higher among the older age group suggests that this is probably related to frequent chance of eating raw or uncooked fish hosts, as was observed in cases of the other fluke infections. Although the main reasons for *Clonorchis* infections among children are not clear, it is thought to come from the practice of giving raw fish to children by adults or elderly persons in their village areas. Some times, ignorant Korean mothers feed raw fish to their children believing it will help them to grow strong. Such consideration was also recongnized by Kim(1974), Rim(1986), and Joo and Hong (1991).

In the features of transmitting *C. sinensis* infection in the endemic areas of Korea, Song et al. (1979) conducted a mathematical approach to the mode of transmission of clonorchiasis for the residents of the Naktong and Han river basins, using the two-stage catalytic model which was proposed by Muench(1959). He reported for the first time that the equations of the two-stage catalytic curve for residents of Kimhae county in the Kyungnam Province and six counties of the Kyungpook Province were found to be $y=1.133(e^{-0.006t}-e^{-0.051t})$ and $y=1.769(e^{-0.010t}-e^{-0.023t})$, respectively. They also commented that the mode of transmission of clonorchiasis in Kimhae county represented a more rapid pattern of infection than that of Kyungpook Province. Similar results have been obtained by Rim(1986). In the present study, the special type of a simple catalytic curve for males was found to be $y=0.610(1-e^{-0.015t})$, and for females, $y=0.105(1-e^{-0.028t})$. These results indicate that the infection rate for males were usually higher than that for females in older age groups.

From the data presented in Table 6 and in Fig. 5, it was noted that the two-stage catalytic model fit well with the age prevalence for clonorchiasis in 1964, 1976, and 1992, and the calculation led to the equations : $y=1.769(e^{-0.010t}-e^{-0.023t})$, a=0.023, b=0.010 in 1964 and $y=3.000(e^{-0.008t}-e^{-0.012t})$, a=0.012, b=0.008 in 1976. As shown in Fig. 5, the force of infection was higher in 1964, 23 per 1,000 susceptibles, compared with 12 per 1,000 susceptibles in 1976. On the other hand, the loss of positivity was 10 per annum per 1,000 clonorchiasis cases in 1964, however, it was higher in 1976, where it was 17 per 1,000 *Clonorchis* positive cases.

In this study, the overall infection rate for *C. sinensis* was observed to be 33.69 per cent. The value of constant "a" was found to be 0.019 and that of "b", 0.017. Therefore, the force of *Clonorchis* infection was much lower than those in 1964 ; 19 per 1,000 susceptibles, while, the loss of positivity was 17 per annum per 1,000 *Clonorchis* positive cases.

It was clear that the age prevalence increased gradually from the first year of life up to 30 years of age, and then reached a maximum for the 40 to 59 year old groups. The theoretically

obtained two-stage catalytic curve fit so well with the observed data that a catalytic model was found useful in understanding the features of the transmission of *C. sinensis* infections.

In earlier studies on the intensity of *Clonorchis* infections, Kim(1974) reported that the higher intensity of the infection in the males than the females was statistically significant in the high endemic area, but not in the low endemic area. From his current pathobiology and chemotherapy of clonorchiasis, Rim(1986) attempted the mathematical approach in order to identify the intensity and endemicity of clonorchiasis, and he reported that the regression equations originated from Kimhae county were $y=2.75+1.46 \log X$, Cs $D_{50}=34.76$ in 1973 and $y=3.27+1.59 \log X$, Cs $D_{50}=12.25$ in 1983, respectively.

In the present study, the regression equation was $y=2.06+1.20 \log X$, Cs $D_{50}=2.76$. Of these, that for male, $y=2.25+1.11 \log X$, Cs $D_{50}=2.86$ and for female, $y=0.94+1.66 \log X$, Cs $D_{50}=2.70$, respectively.

Thus, these results indicate that approximately 77.80 per cent of the 302 clonorchiasis cases(76.68 per cent of 228 males and 80.96 per cent of 79 females) examined had less than 1,000 eggs per gram of feces, and that most cases of clonorchiasis were found to be lightly infected. It is difficult to comment on this infection pattern, but public health education and the remarkably improved socioeconomic status of the residents during the past 30 years should be emphasized in this connection.

In the studies on liver functions in clonorchiasis cases, Soh and Im(1970) conducted a study on the clinical symptoms, blood picture, and liver function of 424 out-patients with clonorchiasis at the Severance hospital, and reported that albumin decreased in 20.6 per cent of the patients while globulin increased in 42.6 per cent, and BUN decreased in 27.0 per cent. Alkaline phosphatase(ALP), AST, ALT increased in 48.5 per cent, 34.1 per cent, and 32.1 per cent, respectively. A study of Kim et al.(1982) observed that AST, ALT, ALP, total bilirubin, BUN, total protein, A/G ratio, total cholesterol, and TTT in *Clonorchis* positive cases, and reported that the mean values of AST, ALT bilirubin increased in accordance with *Clonorchis* intensity, while the total protein and A/G ratio showed a tendency to be decreased as the intensity increased.

In this study, a series of liver function tests examined showed normal value in most cases. Our results are similar to those reported by Choi et al.(1970), Soh and Im(1970), Hyun and Rim (1977), and Kim et al.(1982), although the laboratory findings are varied by the investigators.

It is noted that, although the liver is diffusely disturbed in clonorchiasis, the liver function tests are often within the normal value. Thus, the results should be carefully evaluated by combining various function tests.

The studies on the treatment and therapeutic effects of various drugs against patients with clonorchiasis have been made for many years. Praziquantel was recently found to be effective against various cestode and trematode infections in man and animals by many investigators. Rim (1983) observed a 6.7−100.0 per cent of cure rate in 283 *Clonorchis* infected patients for one or two days with different dosage of the praziquantel, and also reported that the dosage of 25mg/kg three times a single day marked the most highly therapeutic effect. A study of Lee(1984) reported that one single dose of 40mg/kg was recommended for large scale treatment of *C. sinensis* infecion with praziquantel under field conditions. In the present study, a single dose of 25mg/kg three times a day, showed an egg reduction rate of 92.6−99.3 per cent and a cure rate of 0−94.8 per cent with transient side effects of mild abdominal discomfort, dizziness, and headaches. Our results are similar to those reported by Soh and Im(1970), Rim et al.(1983), and Lee(1984). On the basis of the results of various workers and our figures, it is concluded that praziquantel has a remarkable therapeutic effect against *C. sinensis* infections and it is a safe drug for clonorchiasis

treatment.

In the studies of fish hosts of *C. sinensis* in Kyungpook Province, Lee(1968) found the high incidence of *Clonorchis* metacercaria in several fresh-water fish such as *P. parva*, *S. sinensis*, *P. esocinus* and *H. labeo* collected in the river Kumho. Choi(1976) examined twenty-one species of fish collected in the tributaries of the river Naktong, Kyungpook Province, and he reported that *P. parva* was the most heavily infected fish being found in 51.4 cysts per gram of flesh, followed by *P. herzi*, *G atromaculatus*, *P. esocinus*, *S. sinensis*, and *H. labeo* with the infection of 14.2, 15.4, 18.6, 19.5, and 10.3 cysts, respectively.

A study of Joo and Hong(1991) reported that 17 species of fish belonging to the families Cyprinidae, Bagridae, Channidae, Serranidae, and Siluridae were collected in the river Ahnseong, of which 10 species harboured the encysted larvae of *C. sinensis*. They also reported that *P. parva* was the most frequently infected fish being found in 85.4 per cent, followed by *P. herzi*, *P. esocinus*, *G. atromaculatus*, and *H. longirostris* with an infection rate of 77.3 per cent, 72.5 per cent, 64.8 per cent, and 56.1 per cent, in decreasing order. Similar results were reported by Hwang and Choi(1980) in the river Kumho, Kim and Choi(1981) in the natural and fish breeding ponds, Joo(1984) in the river Hyungsan, and Lee(1991) and Chung et al. (1991) in the tributaries of the river Naktong.

In the present study, 20 species of fresh-water fish were collected in the upper stream areas of the river Naktong, of which 7 species such as *G. atromaculatus*, *H. longirostris*, *P. rhombea*, *P. parva*, *P. herzi*, and *S. dabryi* harboured the encysted larvae of *C. sinensis*. Of these, *P. parva* and *G. atromaculatus* were heavily infected, and the infection rates ranged from 17.0 per cent to 39.1 per cent. *H. longirostris* and *S. dabryi* were less frequently infected with rates of 3.6 per cent and 2.6 per cent, respectively. In the intensity of infection, the average number of *C. sinensis* cysts per gram of flesh in the 7 fish species varied from 1.0 in *H. longirostris* and *S. dabryi* to 55.9 in *P. parva*. Our results are similar to those reported by Joo and Hong(1991), Chung et al.(1991), and Lee (1991), but *Clonorchis* larvae in the hosts showed a lower rate of infection.

The scarcity of the fish and lower incidence of *C. sinensis* in fish hosts in this study may be due to the ecological change of the river. The destructon of the natural environment such as regulating the construction of many septa across the river to store water for irrigation of the rice fields, a constant water level change and the great scale use of pesticides on the farms and fields in the vicinity would affect the natural environmental conditions of the fish hosts. As a matter of fact, there are many newly established factories and apartments in the vicinity of the river and the massive drainage of waste products into the river, together with the intense spraying of insecticides on the fields, may be causing the low infection rate for the larval trematodes in fish.

In the studies on snail hosts in Kyungpook Province, Nishimura(1943) reported that in the Yeongcheon area in the vicinity of the river Kumho, 43.7 per cent of 213 snails examined were infected with *Clonorchis* cercaria.

A similar high infection rate was reported by Lee and Kim(1958) in the Kumho area where 6.0 −8.0 per cent of the snails examined were found to be positive with the cercaria.

In previously reported data, the infection of snails with *Clonorchis* cercaria was so abundant that it was considered likely that similar other cercariae might have been included in the *C. sinensis* cercaria.

Choi et al.(1975) conducted a survey for *Clonorchis* cercariae among the snails collected from 10 well-distributed stations in the Province, and reported that the proportion of infected snails was 0.8 per thousand of all snails examined.

A study of Chung et al.(1980) found that 4 species of cercariae of digenetic trematodes were infected, in which the infection rate for *Clonorchis* cercaria was 0.12 per cent. A much lower infection rate was reported by Joo and Hong(1991) in

the river Ahnseong, where 0.05 per cent of the snails collected in three localities were infected with *C. sinensis*.

In this study, the infection rate for cercaria of *C. sinensis* among the snails collected in the upper stream areas of the river Naktong was found to be 0.09 per cent. The results obtained in the present survey are in agreement with the data obtained by Joo and Hong(1991) in the river Ahnseong, and Chung et al.(1980) in the river Kumho, but the degree of infection with the cercaria is lower than reported by Nishimura(1943), Lee and Kim(1958), Choi et al.(1975) and Chung et al.(1980) in the river Kumho, by Soh et al. (1975) in the river Mangyung, by Lee(1956), Chun(1963) and Kim(1974) in the vicinity of the river Naktong in Kyungnam Province, although Choi(1977) in the river Nam, Hwang(1978) in the river Hwang, and Joo(1980) in the river Taewha reported much lower figure.

As previously indicated by Chung et al.(1980) and Joo and Hong(1991), in recent yeares, *Parafossarulus* snails are rare intermediate host, and the infection rate of *Clonorchis* cercaria among the snails is very low. It was suggested that the massive drainage of home and industrial waste products into the rivers, together with the intense insecticide spraying of the rice fields and inside houses may have affected the ecology of snails in the rivers and the survival of larval trematodes.

Summary

This study was undertaken to determine the epidemiological patterns of the liver fluke, the prevalence of *Clonorchis sinensis* among the residents, and the infection rates for the metacercarial and cercarial larvae in the fish and snail hosts in the upper stream areas of the river Naktong, Kyungpook Province from June, 1991 to September, 1992.

The infection rate for *C. sinensis* among the residents was relatively high, being found to be 19.4 per cent with a prevalence of 28.4 per cent in males and 10.3 per cent 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* in the upper stream areas of the river Naktong, Kyunpook Province, 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 $y=0.610(1-e^{-0.015t})$ and females was $y=0.105(1-e^{-0.020t})$.

From these equations the force of infection of 15 and 20 effective infections giving positive stool examination per 1,000 residents annually was suggested. And the symptote is at about 61.0 and 11.0 per cent, the estimated value of the limit of possible positive cases in the residents. For the analysis of the age prevalence patterns of *Clonorchis* positive cases applied the two-stage catalytic model.

The equation is $y=9.5(e^{-0.017t}-e^{-0.019t})$. In other words, the force of infection was annually 19 per 1,000 susceptibles and the disappearance rate from positive to negative cases was annually 17 per 1,000 clonorchiasis cases in this population. 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 $y=2.06+1.20 \log X$.

Of the twenty species of fish examined, 7 species were infected with the encysted larvae of *C. sinensis*. Infection rates varied greatly by fish species and ranged from 2.6 per cent in *S. dabryi* to 39.1 per cent in *P. parva*. In the intensity of infection with *C. sinensis*, *P. parva* was the most heavily infected species, the average numer of cysts per gram of the fish flesh being 55.9, followed by *G. atromaculatus* with 8.9 cysts. *P. rhombea*, *P. herzi* and *P. esocinus* were moderately infected, with an average number varing from 2.0 to 3.6 cysts.

Five snail habitats were found were found in

the upper stream areas of the river Naktong.

Three areas had snails infected with *Clonorchis* cercaria, but the proportion of infected snails was very low, the average rates varing from 0.07 to 0.13 per cent.

It was found that endemic foci of *C. sinensis* exists in the upper stream areas of the river Naktong and the infection rates with *Clonorchis* larvae in fresh-water fish and snails varied greatly according to the species of fish and its habitats.

Key Words: *Clonorchis sinensis*, river Naktong, Prevalence, Catalytic model, Fresh-water fish, metacercaria

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＝國文抄錄＝

洛東江 上流地域에 있어서 肝吸蟲의 疫學的 調査

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慶北 洛東江 上流地域에 있어서 肝吸蟲의 浸潤狀을 決定하기 위해 1991年 6月 부터 1992年 9月까지 住民들에 있어서 肝吸蟲 感染狀, 第2中間宿主, 淡水魚에서의 肝吸蟲 被囊幼蟲 寄生狀 및 第1中間宿主, 쇠우렁에서의 有尾幼蟲의 寄生狀을 調査하였다.

住民들에 있어서 肝吸蟲 感染率은 19.4%로 比較的 높았으며, 性別感染率에 있어서는 男性은 28.4%, 女性은 10.3%로 男女間의 有意的 差를 認定할 수 있었다($t>2$).

洛東江 上流地域에 있어서 肝吸蟲 感染者에 대한 分析을 하기 위한 方法으로 Catalytic model의 特異型을 適用하였던 바, 觀測値로 부터 얻어진 理論曲線은 男性에서는 $y=0.610(1-e^{-0.015t})$, 女性은 $y=0.105(1-e^{-0.020t})$이었다. 肝吸蟲 感染者는 每年 住民 1,000名中에서 男子는 15名, 女子는 20名의 比率로 産出되며, 이 지역에서의 感染者 最高 出現可能限界는 男子 61%, 女子 11%이었을 것으로 推定된다.

年令別 感染率을 分析할 目的으로 Muench의 two-stage catalytic model를 適用하였던 바, $y=9.5(e^{-0.017t}-e^{-0.019t})$, 즉, 每年 肝吸蟲 感染者는 住民 1,000名에 對해 19名의 比率로 産出되며, 感染者 1,000名中 17名의 比率로 陰性으로 전환되어 消失되고 있음을 알 수 있었다.

肝吸蟲 感染者에 있어서 EPG의 Cumulative percentage와 Bliss의 probit table를 利用하여 回歸方程式을 計算하였던 바, $y=2.06+1.20\log X$이었다.

採集된 20種의 魚類中 7種의 魚類에서 肝吸蟲 被囊幼蟲을 檢出할 수 있었으며, 檢出率은 魚種別로 甚한 差異를 나타내었다. 이들 淡水魚에서의 肝吸蟲 被囊幼蟲 感染度에 있어서는 참붕어에서는 55.9個로 가장 많았고, 다음은 8.9個인 물개였으며, 납지리, 돌고기 및 모래모치에서는 2.0－3.6個로 中間値를 나타내었다.

5個地域의 쇠우렁 서식처를 發見할 수 있었으며, 이들 쇠우렁에서의 肝吸蟲 有尾幼蟲의 寄生率은 매우 낮아 平均 0.09%였다.

以上의 成績으로 미루어보아 洛東江 上流地域은 肝吸蟲의 流行地域으로 남아 있을 뿐만 아니라 淡水魚와 쇠우렁에서의 肝吸蟲 幼蟲의 感染率은 魚種別, 地域別로 甚한 差異가 있음을 알았다.