

## Newly found endemic foci of *Paragonimus westermani* in Ulchin county, Kyungpook Province, Korea\*

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### Introduction

Human paragonimiasis is found to be endemic in the neighborhood of mountain streams of Korea where crayfish and crabs are abundant and is still recognized as a major clinical and public health problem.

The initial report on the existence of autochthonous cases of paragonimiasis in Korea was made by Ichinomiya(1924) for the first time by detecting the *Paragonimus* eggs among the residents in Kyungpook Province. He also commented that the residents are generally fond of crabs, often uncooked or immersed in soybean sauce, and take the liquor of crushed crayfish for the treatment of measles.

Afterwards, Park and Song(1961) reported the several endemic foci of *P. westermani* in such localities as Chilgok, Dalseong, Cheongsong and Yeongyang counties of the Province, Kim et al.(1974) in an epidemiological survey of *P. westermani* reported finding the lung fluke with a 4.3 percent positive rate among the residents in the Province.

Quite recently, some published reports on parasitic diseases indicate that infective cases with lung fluke and the crayfish with *Paragonimus* metacercariae are distributed in some areas of Ulchin county, Kyungpook Province(Joo et al., 1985; Hong et al., 1986; Shin and Joo, 1990).

This study was therefore carried out to find the endemic foci of *P. westermani* in Ulchin county. This report deals with the infection rates for cercarial

and metacercarial larvae of *P. westermani* in the snail and crayfish hosts, and the prevalence of the lung fluke among the residents in the newly found endemic foci in Ulchin county.

### Materials and Methods

**Surveyed area:** Ulchin county is situated in northwestern part of Kyungpook Province, at 36.1–37.8 degree north latitude, having an area of 988 square kilometers, and has a population of about 83,900; almost equally distributed between mountainous and coastal areas. The localities surveyed are from 100 to 400 meters in altitude and the bed of the streams is mainly composed of pebbles and rock with sand(Fig. 1). The water in the streams is relatively permanent and slow-flowing and there are many *Semisulcospira* snails and crayfish in the water. The details of the geographical conditions were presented by Shin and Joo(1990).

**The snail intermediate host:** During 6 years from July 1985, the collections of snails were made once or twice yearly in the eight locations in the vicinity of the three streams. The population density of the snail was measured by the approximate number per square meters of stream bed. The snails were collected by hand and put into dry plastic buckets with aquatic plants and grasses and forwarded to the laboratory. They were examined for the presence of *Paragonimus* cercariae using both immersing and crushing techniques.

**The crayfish intermediate host survey:** The

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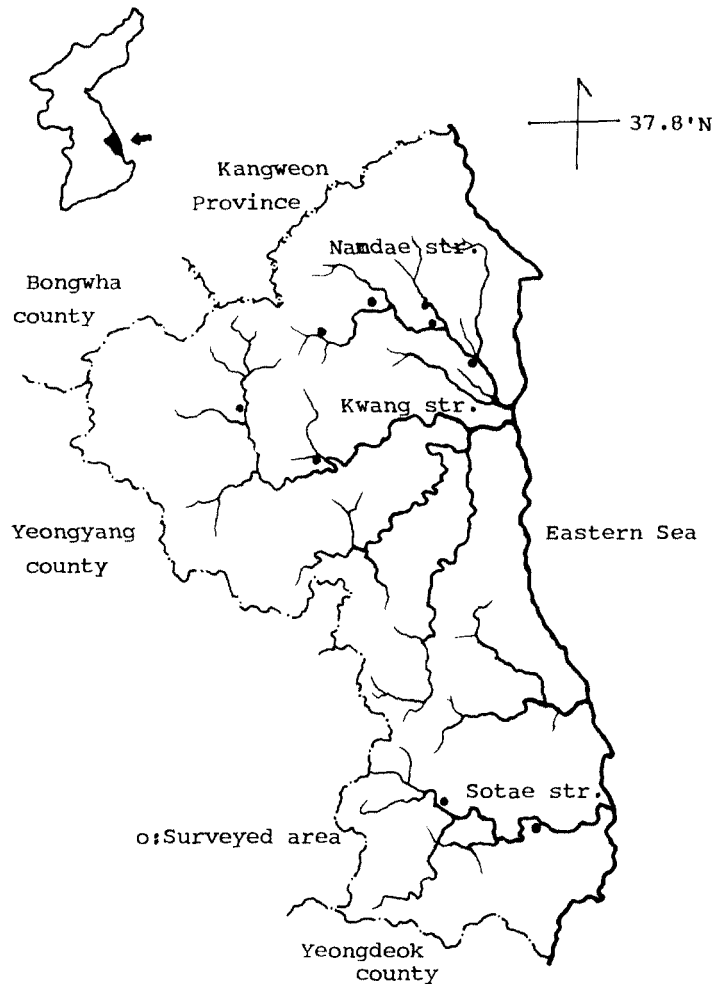


Fig. 1. Surveyed areas in Ulchin county in Kyungpook Province.

crayfish during the day are hidden under stones in shallow, slow-flowing fresh-water mountain streams. Therefore, the collections of fresh-water crayfish were made at night with the aid of a lamp or a torch when they are out of their hiding places in search for food. They may also be caught by clear cut their hiding places in the water, and simply catching them with bare hands. The population density of the crayfish was measured by the number of crayfish collected per man-hour.

The crayfish collected were forwarded to the laboratory and after removing the carapace, were dissected into the cephalothorax, the liver, the gills,

the heart, and the leg muscles. They were separately compressed between two large slides (50×90mm) and examined for the presence of the encysted larvae of *P. westermani* under a binocular dissecting microscope. The cysts that were seen were dissected out from the crayfish tissues and organs, and transferred into petridishes containing normal physiological saline solution. The number of cysts in each crayfish tissues and organs were noted.

**Prevalence of *P. westermani* in residents:** Individuals were evaluated by specific parasitological and immunological tests. Stool and sputum samples were examined by standard MGL technique and

NaOH clarification technique.

Intradermal tests were carried out *Paragonimus* antigen of 0.02ml into the volar surface of the forearm. The wheals obtained were measured immediately after the injections, and another measure was taken from 15 to 30 minutes later. Wheals which had increased an average of 4mm or more were considered as positive reactions, 3mm or less were negative, while 3.5mm were recorded as doubtful.

Blood samples were drawn from positive reactors. Serum samples were stored at -20°C used as needed. The samples were examined by micro-ELISA procedures described by McLaren et al. (1975) and Cho et al.(1981).

### Results

Table 1 lists the snail population density and the

infection rate for *Paragonimus cercaria* from *S. libertina* collected in the eight habitats in the vicinity of three streams in Ulchin county.

The distribution ranges and the population density of the snails in the habitats varied considerably. The range of the habitats was from 200 to 700 meters, and the approximate number of snails collected ranged from 5 to 20, with an average 12 per square meter of stream beds. A total of 9,698 snails examined, only one or 0.01 percent were found to be infected with *Paragonimus cercaria*.

The population density of the crayfish in the habitats in the vicinity of three streams in Ulchin county, altogether with environmental conditions are presented in Table 2. The population density in the Ducheon habitat in the neighbourhood of Namdae stream was somewhat higher than that in the others, and the number of crayfish collected ranged from

Table 1. Snail population density and infection rate for *Paragonimus cercariae* from *Semisulcospira libertina* caught in habitats of Ulchin county, Kyungpook Province, Korea

Location of snail host		Approximate range of snail habitats(m)	Approximate No. of snail**	No. of snail examined	Percent infected
Village	Myun* & town				
Samdang	Buk myun	200	10	2,015	0
Hadang	Buk myun	700	20	529	0
Ducheon	Buk myun	450	20	5,052	0.02
Chunglim	Ulchin town	300	10	151	0
Samkeon	Seo myun	400	15	1,502	0
Sokwang	Seo myun	500	10	246	0
Chokum	Oncheon myun	300	5	147	0
Deokin	Oncheon myun	200	5	56	0
Total				9,698	0.01

\* Myun means administration unit in a Province.

\*\* Per m<sup>2</sup> of stream bed.

Table 2. Population density of crayfish in eight locations in Ulchin county, together with environmental conditions

Environmental conditions			Population density (No. of crayfish/man-hour)		
Stream	Location	Bottom structure	Minimum	Maximum	Mean
Namdae	Samdang	Rock and pebble	1	4	2
	Hadang	Rock and pebble	1	3	2
	Ducheon	Rock and pebble	1	12	10
	Chunglim	Pebble and sand	0	0	0
Kwang	Samkeon	Rock and pebble	0	4	2
	Sokwang	Rock and pebble	1	5	2
Sotae	Chokum	Pebble and rock	0	2	1
	Deokin	Pebble and rock	0	1	1
Total			0	12	2

Table 3. Infection rate and numerical distribution of *Paragonimus* metacercariae in the body parts of crayfish

Locality	No. tested	No. infected	Mean of cyst per crayfish (range)	Body part of crayfish			
				Cephalothorax	Gills	Liver	Others*
Namdae stream							
Samdang	216	14 (6.5)	1.2 (1-2)	13 (76.5)**	4 (23.5)	0	0
Hadang	76	7 (9.2)	1.1 (1-2)	6 (75.0)	2 (25.0)	0	0
Ducheon	506	102 (20.2)	2.0 (1-4)	136 (65.4)	65 (31.3)	6 (2.9)	0
Subtotal	798	123 (15.4)	1.9 (1-4)	155 (66.8)	71 (30.6)	6 (2.6)	0
Kwang stream							
Samkeon	53	1 (1.9)	1.0 (1)	0	1 (100.0)	0	0
Sokwang	323	33 (10.2)	1.5 (1-3)	25 (50.0)	24 (48.0)	1 (2.0)	0
Subtotal	376	34 (9.0)	1.5 (1-3)	25 (49.0)	25 (49.0)	1 (2.0)	0
Sotae stream							
Chokum	37	1 (2.7)	1.0 (1)	1 (100.0)	0	0	0
Deokin	10	0	0	0	0	0	0
Subtotal	47	1 (2.1)	1.0 (1)	1 (100.0)	0	0	0
Total	1,221	158 (12.9)	1.8 (1-4)	181 (63.7)	96 (33.8)	7 (2.5)	0

\* Others include the heart and leg muscles.

\*\* Number in parentheses mean the percentage.

1 to 12, with an average of 10 per man-hour.

Table 3 shows the infection rate and numerical distribution of *Paragonimus* metacercariae in the body parts of crayfish. A total of 1,221 crayfish were examined and metacercariae was recovered from 158, an overall infection rate of 12.9 per cent. In distribution of the infected crayfish in the surveyed areas, *C. similis* with *Paragonimus* metacercariae were collected from six of the seven localities in the vicinity of three streams. In the vicinity of Namdae stream, a high infection rate was observed at Ducheon habitat, being found in 20.0 per cent, and maximum number of metacercariae per crayfish was 4. The average number of cysts per positive crayfish was 2.0 in the Ducheon habitat, 1.2 in the Samdang and 1.1 in the Hadang, respectively.

In Kwang basin, a high infection rate was observed at Sokwang, being found in 10.2 per cent and the average number of cyst per crayfish was 1.5. Along the Sotae stream a low infection rate was observed at Chokum, where only one metacercariae was detected among *C. similis*, while, metacercariae were not found at the Deokin habitat.

In numerical distribution on encysted larvae of lung fluke in body parts showed wide variations according to the surveyed localities. A total of 284 larvae was recovered from 158 crayfish, of which 181 or 63.7 percent were obtained from the cephalothorax, 96 or 33.8 percent from the gills and 7 or 2.5 percent from the liver, respectively.

In Table 4, the prevalence rates of *P. westermani* among the residents are tabulated by the eight vi

Table 4. Prevalence of *Paragonimus westermani* with intradermal test among residents in Ulchin county, Kyungpook Province, Korea

Endemic foci surveyed	Male		Female		Total	
	No. tested	Percent positive	No. tested	Percent positive	No. tested	Percent positive
Samdang-dong	63	31.8	45	35.6	108	33.3
Hadang-dong	66	31.8	54	20.4	120	26.7
Ducheon-dong	77	48.1	62	21.0	139	36.0
Chunglim-dong	40	35.0	34	29.4	74	32.4
Sokwang-dong	31	16.1	2	0	33	15.2
Samkeon-dong	15	26.7	30	6.7	45	13.3
Chokum-dong	12	8.3	11	27.2	23	17.4
Deokin-dong	20	15.0	14	14.3	34	14.7
Total	324	32.4	252	22.6	576	28.1

Table 5. Summary of positive intradermal test with *Paragonimus* antigen by sex and age groups among residents in Ulchin county, Kyungpook Province, Korea

Age group (Y)	Male		Female		Total	
	No. tested	Percent positive	No. tested	Percent positive	No. tested	Percent positive
0-9	70	20.0	55	18.2	125	19.2
10-19	79	24.1	56	25.0	135	24.4
20-29	30	30.0	25	28.0	55	29.1
30-39	34	50.0	17	23.5	51	41.2
40-49	49	38.8	42	35.7	91	37.4
50-59	37	54.1	36	16.7	73	35.6
60-	25	28.0	31	12.9	56	19.6
Total	324	32.4	252	22.6	576	28.1

llages and by number examined and the positive percent of the intradermal reactions. One hundred sixty-two persons were found to be positive reactors with *Paragonimus* antigen out of 576 examined, this amounting to 28.1 percent of the residents. In general, the positive rates in the villages of Namdae basin were relatively high, 33.3 percent to the Samdang, 26.7 percent in the Hadang, 36.0 percent in the Ducheon and 32.4 percent in the Chunglim, respectively, while, rates among the residents in the vicinity of Kwang and Sotae streams were lower, and the prevalences varied from 13.3 to 17.4 percent.

The positive intradermal test with *Paragonimus* antigen by sex and age groups among the residents in Ulchin county are summarized in Table 5. The sex-specific rates of infections was significantly higher in males than in females: 32.4 percent in males and 22.6 percent in females, respectively ( $t > 2$ ). In

the age-specific rates, the prevalences of males were always higher than that of females in all age groups but in the 10-19 age group.

The results of positivity of parasitological and serological tests are presented in Table 6. Of the 576 residents, 162 were found positive intradermal test, all of whom had a history of eating raw fresh-water crayfish. The positivity of *Paragonimus* eggs by examinations of both sputum and stool was 39 or 20.1 percent of the sputa examined, and 10 or 2.7 percent in stools, respectively. A total of 42 individuals were examined by micro-ELISA for their specific IgG antibody, 17 cases or 40.5 percent were to be positive.

## Discussion

Paragonimiasis is one of the most common

Table 6. Distribution of positivity of parasitological and serological tests for *P. westermani* in surveyed residents analyzed by age groups

Age group (Y)	Intradermal test		Sputum test		Stool test		Micro-ELISA	
	No. tested	No. positive	No. tested	No. positive	No. tested	No. positive	No. tested	No. positive
0-9	125	24	34	10	85	3	2	1
10-19	135	33	53	11	93	4	33	14
20-29	55	16	20	1	20	0	0	0
30-39	51	21	26	5	28	1	1	0
40-49	91	26	26	3	61	0	0	0
50-59	73	31	28	8	57	2	3	1
60-	56	11	7	1	30	0	3	1
Total	575	162	194	39	374	10	42	10

Table 7. The reported prevalence of *Paragonimus westermani* in Kyungpook Province, Korea

Source	Locality (county)	No. tested	Percent positive	Group tested & methods
Ichinomiya (1924)	Chilgok	1,016	4.0	General population & sputum examination
	Wiseong	3,453	5.2	
	Cheongsong	3,658	4.0	
	Andong	2,037	2.3	
	Yeongju	1,188	23.4	
	Subtotal	11,350	6.1	
Walton & Chyu (1959)	Yeongcheon	325	4.6	Public officials & intradermal test
	Andong	452	3.5	
	Pohang	345	4.9	
	Subtotal	1,122	4.3	
Park & Song (1962)	Cheongsong	300	44.5	School children & intradermal, sputum tests
	Dalseong	1,008	8.9	
	Taegu	560	5.0	
	Yeongcheon	410	3.9	
	Subtotal	2,278	11.7	
Kim et al. (1974)	Yeongcheon	5,332	1.3	General population & intradermal test
	Wiseong	1,258	1.7	
	Cheongsong	1,295	17.0	
	Sangju	1,762	1.5	
	Dalseong	1,425	11.7	
	Yeongyang	1,724	7.5	
	Andong	1,627	2.3	
	Taegu	1,883	1.4	
Subtotal	16,106	4.3		
Kim & Choi (1977)	Chilgok	814	6.4	General population & intradermal test
Shon & Choi (1977)	Chilgok	222	23.4	General population & intradermal test
Choi & Hwang (1980)	Wiseong	569	4.0	General population & intradermal test
Choi et al. (1981)	Wiseong	1,175	3.6	School children & intradermal test
Authors	Ulchin	576	28.1	General population & intradermal, sputum, stool tests and micro-ELISA

snail-transmitted diseases in the neighborhood of mountain streams of some counties, Korea where snails and crayfish were abundant and represents a public health problem today. By performing the county-wide surveys of the lung fluke infections in forty-three villages, Ulchin county during the 6 years from July, 1985, eight endemic foci of *P. westermani* were found. The findings in this survey are based on skin reactions by intradermal tests with *Paragonimus* antigen, on the discovery of *Paragonimus* eggs by sputum and stool examinations, and also micro-ELISA technique on the residents.

In practice, this is not indicative of the true prevalence among the residents in endemic areas, because the intradermal test is highly sensitive, one time fecal and sputum examinations are not sufficient to determine the true infection rate, and also ELISA technique is very difficult to determine the criteria, optical density as a differential point of positive reaction for presently ill paragonimiasis. However, the results are quite comparable with earlier reports based on skin reactions by intradermal tests and on one time examination of sputum by means of similar laboratory procedures. As shown in Table 7, it is noted that the present results show relatively high prevalence compared with earlier reports available. This difference might have been due, in part, to social and economic factors, such as inadequate public health and improved transportation and easy availability of crayfish through more frequent communication between adjacent areas. The prevalence of *P. westermani* among the residents in the present survey was found to be 28.1 per cent and there was a significant difference in the rate of infection between males and females, the former was 32.4 percent and the latter 22.6 percent. These findings are in agreement with those of previous investigators (Kim et al., 1974; Choi and Hwang, 1980; Joo et al., 1985) and suggest that this is probably related to some differences in the opportunities of eating raw or uncooked freshwater crayfish away from home. In fact, Korean males have more opportunities to go mountain climbing than females and are fond of collecting

crayfish in the mountain streams, where they eat raw or uncooked crayfish with rice-wine and/or distilled spirits.

In approximately 24 percent of the positive intradermal cases, *Paragonimus* eggs could be demonstrated by a single sputum examination. Some practical difficulties in sampling were experienced as many residents, who showed a positive intradermal tests for paragonimiasis, do not produce sputum but only saliva.

In the previous report by Choi et al. (1982) 12 species of cercariae were found from *S. libertina* in Kyungpook Province by crushing and natural emerging methods. The total number examined in their study was 19,227 snails and the overall infection rate for *Paragonimus* cercaria was 0.04 percent. In present study, the population density on *S. libertina* in three streams surveyed in Ulchin county was relatively abundant and the infection rate for *Paragonimus* cercariae was 0.01 percent. Our figures are in agreement with the data obtained by Park et al. (1984) in Andong county, and by Joo et al. (1985) in Ulchin county, but the degree of infection with *Paragonimus* cercaria is lower than reported by Choi et al. (1982).

In the previous studies of crayfish hosts of *P. westermani* in Kyungpook Province, Korea, Park and Choi (1974) reported that the metacercaria of *P. westermani* was found from crayfish collected 4 out of 65 mountain streams, and almost all of the metacercaria were found on the cephalothorax, the gills, the liver, and the heart of the crayfish examined. Choi et al. (1983) in a study of comparative infection of *P. westermani* metacercariae from crayfish in endemic areas reported that the infection rate of the crayfish with metacercariae of the lung fluke decreased drastically over the eight years period from 1974 to 1982. However, no decrease in the infection rate for *Paragonimus* metacercariae from the crayfish in Ulchin county was observed in this study.

According to the local officials, rural and urban people often visit these Ulchin Pulyunggyegok (Science place No. 6) and Ulchin Seongnyugul cave (Natural Monument No. 155) on weekends or

holidays, and the majority of the residents in the villages along the sides of the mountain streams enjoy the collection of the crayfish and also consuming raw or uncooked crayfish with rice-wine or distilled spirits, which is done primarily by males. They are not concerned about infection of *P. westermani*, but believe that crayfish collected in these waters are completely free of larval trematodes because the water is clear and running over pebbles and rocky bottoms. These conditions increased the incidence of eating infected crayfish therefore increase the incidence of more serious infections with *P. westermani*. With the demonstration of *Paragonimus* metacercaria in the crayfish host and the higher prevalence of the lung fluke among the residents of Ulchin county makes it very apparent that eight villages of Ulchin county are the endemic foci.

### Summary

Endemic foci of *P. westermani* were found in Ulchin county, Kyungpook province, Korea. The population density of the snails per square meter of the habitats ranges from 5 to 20, with an average of 12. Of the eight habitats, Ducheon habitat had snails infected with *Paragonimus* cercaria, and the infection rate was very low, the average being 0.01 percent.

Of the crayfish examined, 12.9 percent harbored the encysted larvae of *P. westermani*. The number of *Paragonimus* cysts per infected crayfish ranged from 1.0 to 2.1, with an average of 1.8.

The overall percentage of *P. westermani* infections among the residents was found to be 28.1 percent and significant difference was observed in the sex-specific rate of the individuals infeted.

In the age specific rate of infections, the rate varied from 20.0 to 54.1 percent in males and 12.9 to 35.7 percent in females, with a maximum infection rate in males in the 50-59 age group and in females in the 40-49 age group.

This study indicate that endemic foci of *P. westermani* exist in the vicinity of mountain streams in Ulchin county and the infection rate of the lung

fluke among the residents is relatively high.

**Key Words:** Fresh-water crayfish, Metacercaria, *Paragonimus westermani*, Prevalence, Ulchin county

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= 국문초록 =

## 경북 울진군에 있어서 폐흡충의 새 침윤지

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경북 울진군 주민들에서의 폐흡충 감염상을 알아보기 위해 1985년 3월부터 1990년 10월까지 역학적 조사를 하던중 새로운 침윤지를 발견하였다.

발견된 침윤지는 울진군 북면 3개처, 울진읍 1개처, 서면 2개처, 온전면 1개처 등 8개 지역이었다.

이지역 주민들에서의 폐흡충 피내반응 검사에 의한 양성율은 13.3%~36.0%였으며, 성별감염율에 있어서는 남성은 32.4%, 여성은 22.6%로 양자간에 유의적 차는 인정할 수 있었다.

8개 지역의 하천에는 폐흡충의 제1 및 제2중간숙주가 서식하고 있었으며, 이곳 주민들에서의 폐흡충 감염율이 높다는 점을 유의하여 폐흡충 침윤지임을 알았다.