

## Studies on the Lungfluke *Paragonimus iloktsuenensis* Chen, 1940

### I. On the Occurrence of *P. iloktsuenensis* in the Natural Final Hosts at the Nakdong and Sumjin River Deltas in Korea

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#### Introduction

H. T. Chen (1934, 1935) found a lungfluke in house rats (*Rattus rattus*, *Rattus norvegicus*) which were caught in the vicinity of Ilo-  
ktsuen village of Canton, South China. Later, it was described in detail and named by him as a new species of *Paragonimus iloktsuenensis* (1940). Meanwhile I. Miyazaki (1939) found a different metacercaria from *Paragonimus westermani* in the crab hosts, *Sesarma intermedium* and *Sesarma dehaani* collected at the Kuma delta, Kumamoto, Japan and obtained the adult worms from the animal hosts experimentally fed with these metacercariae. After his extensive study on the morphological characteristics in the larval and adult worms, he described the several points to be able to differentiate them from *P. westermani* and named it *Paragonimus ohirai* as a new species.

In 1944, Miyazaki recorded the first occurrence of *P. iloktsuenensis* in Japan after the correction of his former identification of metacercariae which were found in the crab host, *Sesarma dehaani* at the mouth of the Shin-yodo River, Osaka Prefecture and proved

once by him to be identical with *P. ohirai*. In 1955, a species of *Paragonimus* from weasels in Kyushu, Japan was regarded by him as *P. kellicotti*, a lungfluke originally recorded by Ward (1908) in North America. However, later he corrected the occurrence of this fluke because it was determined as a new species by other workers.

Recently two more species of *Paragonimus*, such as *P. miyazakii* and *P. sadoensis*, were also described by various Japanese investigators (Kamo, H., Nishida, H., Hatsushika, R. and T. Tomimura, 1961; Miyazaki, I., Kawashima, K., Hamajima, F., and M. Otsuru, 1968). Although some controversial points are still remained on their definite identification, at least, a total of five species of *Paragonimus* has been reported in Japan.

On the other hand, in Korea, after his careful examination of a large number of the lungflukes collected from naturally and/or experimentally infected man and other various animals such as tiger, panther, fox, wolf and wild cats, H. Kobayashi (1917, 1918) mentioned that the differentiations among these specimens of the *Paragonimus* are due to individual variations and confirmed only one distinct species, *Paragonimus westermani*. Nagahana

(1935) reported *P. westermani* from a lion which was brought up for four years in zoological garden at Seoul, Korea. Up to date, in our country the only species of *P. westermani* has been recognized.

In 1970, Yokogawa et al. found a metacercaria identical with *P. iloktsuenensis* in the crab host, *Sesarma dehaani* collected at the Nakdong River delta, Pusan, Korea, and recorded the first case of this lungfluke in our country.

The purpose of this survey carried out from August, 1970 to February, 1971 is to prove the natural infection in the final hosts and the additional informations on the incidence of metacercariae at some other areas in Sumjin River delta, are also to be provided.

### Materials and Methods

**Areas surveyed:** Two areas "A" and "B" were selected for the survey as they are shown in Fig. 1 & 2; these areas are located

in the south-eastern part of the Korean Peninsula. The area "A" (=Hadan) occupies the western suburb of the city of Pusan, bounded by the estuaries of the Nakdong River. At this area, the initial survey has been conducted by Yokogawa et al. (1970) and proved the infection of *P. iloktsuenensis* in the crab hosts. The Area "B" (=Hadong) is located in the western corner of South Kyongsang Do (=Province), bounded by the estuaries of the Sumjin River, separating two provinces; the South Kyongsang and the South Cholla Do.

**Collection of Adult worms:** Rat traps were set up at sunset at the various places in the above two areas and collected early morning of the next day. All trapped animals were autopsied in the laboratory. The lungs, pleura and thoracic cavity were searched for the worms. Particularly the lungs were removed and examined separately with the aid of a dissecting microscope during and after teasing the tissues with small forceps and needles.

The isolated worms were collected in normal saline solution and then fixed in FAA (formalin, acetic acid and alcohol) fixative under the pressure between two slides tied with rubber band. After several hours in fixative the worms were transferred to vial with 70% alcohol. Later, these specimens were stained at laboratory in Semichon's acetocarmine. The observation of the cuticular structure was made on the specimens torn out from the body surface of the

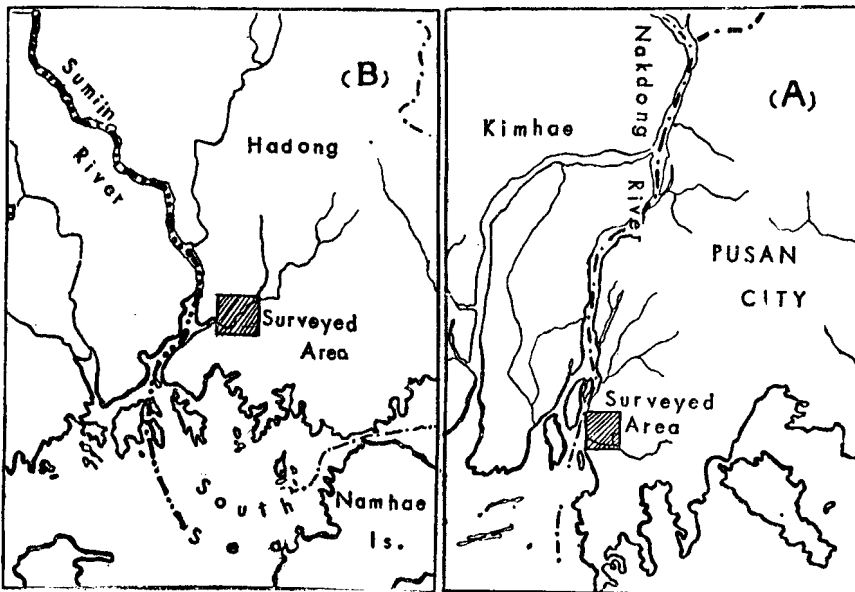


Fig. 1 & 2: Map showing the collection localities (Surveyed areas are shaded)

worm by razor blade.

**Collection of Metacercariae:** The brackish water crabs, mostly *Sesarma dehaani* were collected from the above mentioned two areas. To detect the metacercariae the crab liver was removed and compressed between two large slides and examined under a dissecting microscope. The metacercariae were carefully isolated from the tissues in the condition of encystment. Some of the metacercariae were fed to albino rats for obtaining adult worms which were used for the comparison with the worms collected from the natural hosts.

**Measurements:** All measurements of the adult worm structures were made on the stained specimens. The eggs collected from worm capsules and uterine tubules were used for their measurements. The metacercariae were measured in the living condition under the slight pressure of the coverglass.

### Results

**The larval infection in crab hosts:** The metacercariae of *P. iloktsuenensis* were exclusively found in *Sesarma dehaani*, except a case infected of *Helice tridens tridens* in the Area "B". Thirteen crabs including one *Helice tridens tridens* out of 167 crabs examined at the above two areas were found to be infected (7.9%). From these hosts, a total of 16 metacercariae were collected. The infection rate in the Area "B", Hadong was higher than in the Area "A", Hadan.

The metacercaria was oval in shape and the size measured in 0.204 by 0.166 mm (Fig. 8 in the Plate). *Sesarma dehaani* is considered to be the most important vector in transmission of this fluke and *Helice tridens tridens* should be recorded one of the intermediate hosts in these areas. It is worthy to mention that only this type of metacercariae were found at

the above surveyed areas.

**The adult worm infection in the rat host:** Three species of rats were trapped such as *Rattus norvegicus*, *Rattus rattus*, and *Apodemus agrarius* at the above two areas. As shown in Table 1, out of 52 rodent hosts examined five rats (9.6%), *Rattus norvegicus* were found to be infected with this fluke. From these infected hosts, all of seven worms were recovered in worm capsules of the lungs, none was found neither in the thorax nor in pleura. There was usually a single worm per worm capsule (Plate Fig. 9).

Table 1. Natural infection in rodent hosts.

Area	Species of rodents	No. of examined	No. of infected	No. of worms recovered
Hadan (Area "A")	<i>Rattus norvegicus</i>	18	3	5
	<i>Rattus rattus</i>	1	—	—
	<i>Apodemus agrarius</i>	4	—	—
Hadong (Area "B")	<i>Rattus norvegicus</i>	22	2	2
	<i>Rattus rattus</i>	7	—	—
	Total	52	5	7

\* Total No. of *R. norvegicus* examined: 40  
No. of *R. norvegicus* infected: 5 (12.5%)

**Description of the worms obtained:** The living worms were easily taken out by pressing the incised worm capsule with fingers. The living specimen is actively motile with constant contraction and expansion of the body in the lukewarm saline solution. The oral sucker tends to be protrusive. There is no definite shape in the living condition, however in the fixed specimen, both anterior and posterior ends of the worm are somewhat tapering. Thus the body shape in the fixed specimen is spindle shaped (Fig. 3 and Plate Fig. 7).

The size ranges from 8.31~11.31 mm in

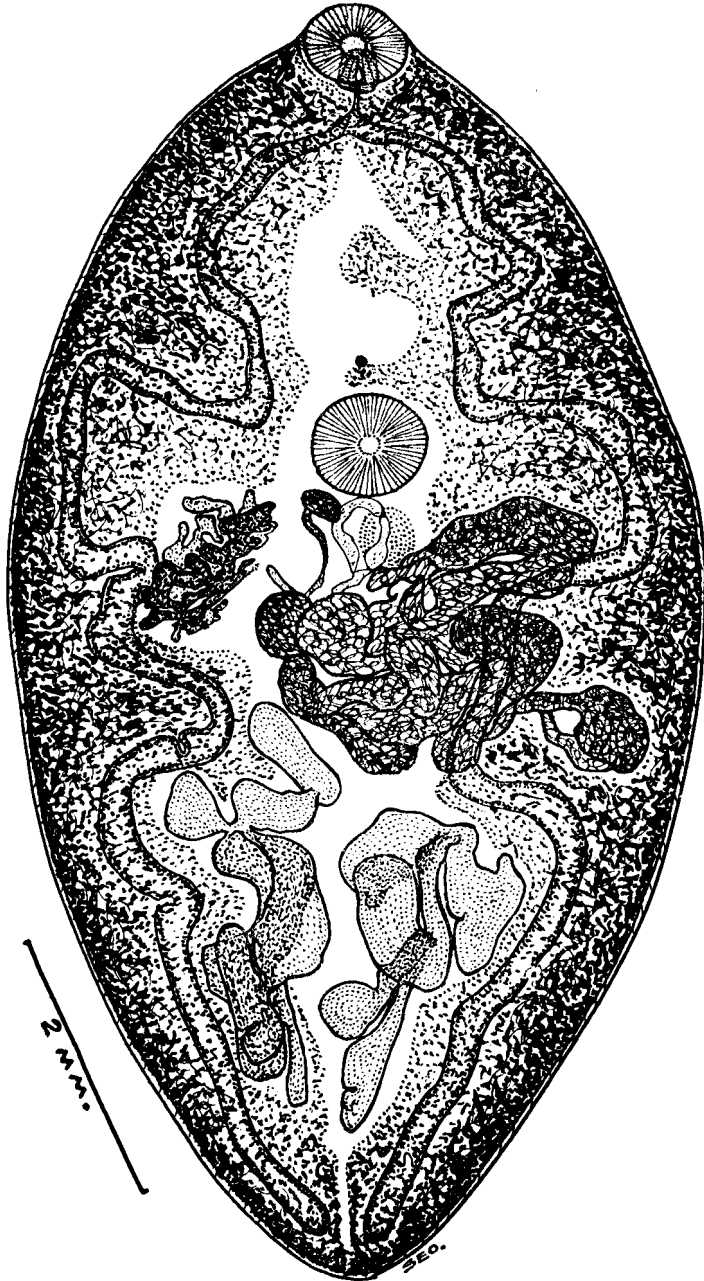


Fig. 3: Ventral view of the adult worm obtained

**Table 2.** Measurements of the adult worms obtained (in mm).

Specimen No.	BL & BW	BL/BW	OS & (VS)	BL/AV*	Pharynx and (Oesophag.)	Testes				Ovary		T/O #	BL/TL
						TL & TW		TL×TW		OL & OW	OL × OW		
						Rt.	Lt.	Rt.	Lt.				
I	9.10	1.86	0.62×0.62	3.26	0.26×0.26	2.49	3.10	3.45	4.03	1.29	1.00	3.74	3.26
	4.89		(0.75×0.74)		(0.26)	1.39	1.30			0.78			
II	8.31	2.39	0.44×0.52	3.16	0.31×0.26	2.24	1.94	1.83	1.70	1.02	0.83	2.12	3.98
	3.47		(0.69×0.52)		(0.26)	0.82	0.88			0.82			
III	8.42	2.42	0.57×0.35	2.54	0.26×0.24	1.94	1.63	1.98	2.97	1.02	0.62	4.0	4.71
	3.47		(0.64×0.78)		(0.39)	1.02	1.82			0.61			
IV	11.31	1.90	0.57×0.72	2.69	0.44×0.41					1.37	1.87		
	5.94		(0.93×0.82)		(0.41)			1.37					
V	11.26	2.12	0.62×0.67	2.52	0.41×0.36	1.94	2.04	1.58	2.83	1.26	1.37	1.61	5.66
	5.31		(1.01×0.98)		(0.31)	0.82	1.39			1.08			
VI	8.68	2.06	0.59×0.41	2.36	0.31×0.27	2.04		2.16		1.29	1.31	1.65	4.25
	4.21		(0.72×0.54)		(0.27)	1.06			1.02				
Average	9.51	2.13	0.57×0.52	2.76	0.33×0.30	2.13	2.18	2.20	2.88	1.21	1.17	2.62	4.37
	4.55		(0.79×0.73)		(0.32)	1.02	1.06			0.95			

Abbreviations used in this table: BL; Body length of the adult worm BW; Body width of the adult worm  
 OS; Oral sucker VS; Ventral sucker  
 TL; Length of testis TW; Width of testis  
 OL; Length of ovary OW; Width of ovary

\* AV; The distance between anterior end of the body and middle of the acetabulum

# T/O; Ratio of the average size of testes (avg. TL×TW) to the size of ovary(OL×OW).

length by 3.47~5.94 mm in width. The ratio of the body length to the body width is 2.13:1 (Table 2). The integument is covered with pointed or blunt or serrated cuticular spines in simple rows, in their arrangement grouped with a broad base. In a group of cuticular spines on the lateral side to ventral suckers, two to five spines are common in number(Plate Fig. 6).

The oral sucker is in size, 0.57×0.52 mm on an average, followed by a small pharynx (0.33×0.30 mm) and a short esophagus (0.32 mm). The ventral sucker, 0.79 mm by 0.73 mm in size on an average, is larger than the oral sucker and situated in midline, much anterior to the equatorial plane of the body. The average ratio of the body length to

the distance between the anterior end of the body and the middle of the acetabulum is 2.76 : 1 (Table 2).

The intestinal ceca extend in a zigzag manner to the posterior part of the body with two large loops formed at the anterior portions of the ventral sucker and two testes. There is a long convoluted excretory bladder extending in the midline from the caudal portion to the level of pharynx.

The irregularly lobed two testes are situated slight obliquely to each other in the middle of the acetabulum and the caudal portion of the body. The lobes of the testis are finger-shaped and four to six in number. The sizes are shown in Table 2(Fig. 4 & Plate Fig. 1).

The branched ovary is coral shaped. The

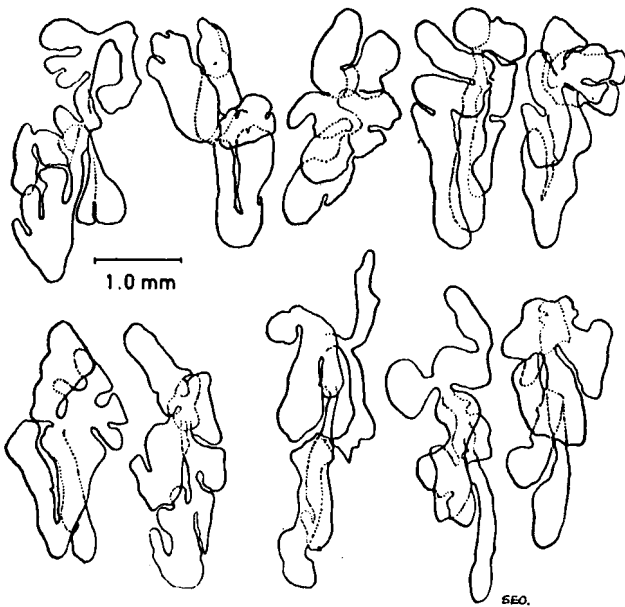


Fig. 4: The testes from the various specimens drawn with the aid of Camera lucida.

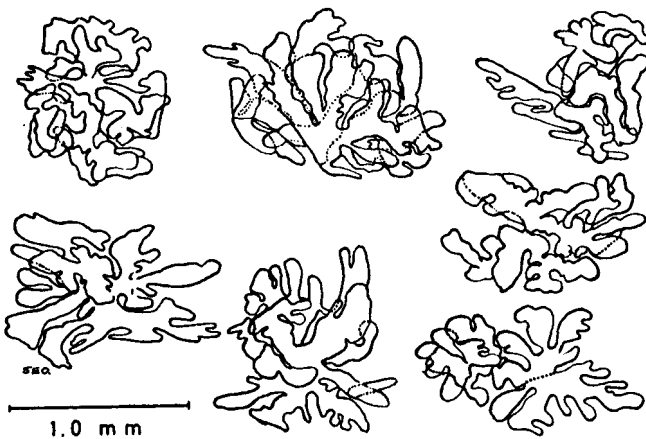


Fig. 5: The ovaries from various specimens drawn with the aid of Camera lucida.

main stems of the branches are usually four in number, from which several secondary branches originate (Fig. 5 & Plate Fig. 2, 3). The average ratio of the body length to the

testis length is 4.37 : 1.

**The characteristics of the eggs:** The hundred eggs obtained from uterine tubules and worm capsules were measured to observe the various criteria as for the species differentiation. The eggs are usually symmetrical in shape (84%). Its size ranges 57.4~100.1 $\mu$  in length by 38.0~61.1 $\mu$  in width;  $79.5 \pm 4.9\mu \times 48.5 \pm 2.9\mu$  on average (Table 3; Plate Fig. 4, 5 and Fig. 6).

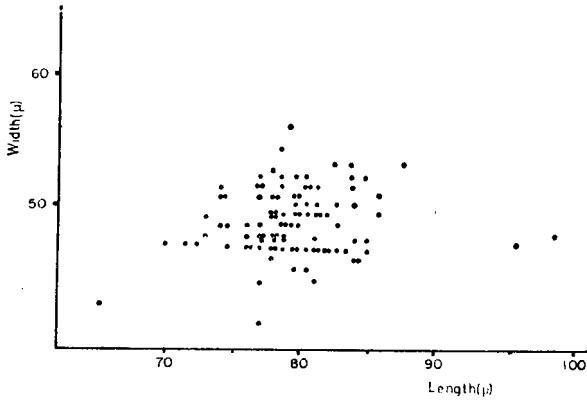
The spindle shape of eggs is the commonest (67.0%), the oval and ostrich egg shape is 26.0%, the reversed oval shape 1.0%, the elliptical shape 6.0 (Fig. 7).

The portion of the maximum width of the eggs are observed on the operculated half of the eggs (3.0%), on the middle (77.0%) and on the aboperculated half (20.0%) (Fig. 7). The rimmed extension of the egg shell on the base of operculum is observed (87.0%). The opercular width and height are  $22.0 \pm 1.6\mu$  and  $4.5 \pm 0.8\mu$  respectively. The average ratio of the egg length to width and the average ratio of the egg width to the opercular width are also calculated and their frequency distributions were shown in Fig. 8 (Table 3).

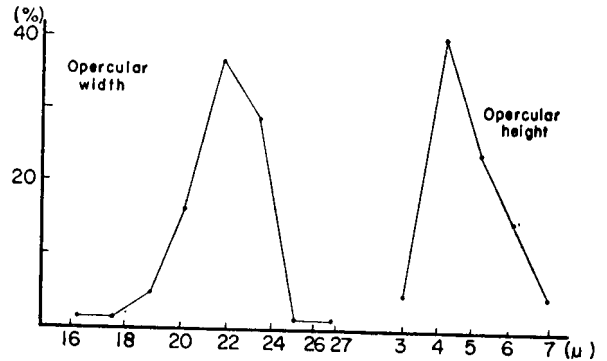
There is often a short spine shaped extension of the egg shell on the abopercular portion. The slight abopercular thickening of the egg shell is observed. The thickness of the egg shell is  $1.9 \pm 0.5\mu$  (Table 3, Fig. 9).

**Table 3.** Results of the measurements of the ova (in  $\mu$ ).

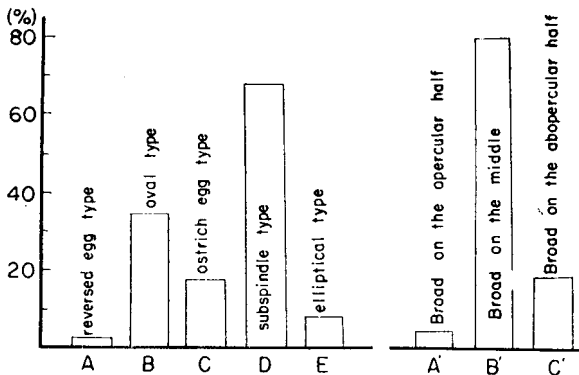
	Length (L)	Width (W)	L/W	W/L $\times$ 100	Opercular Width (OW)	Operc. Height	Thickness	W/OW
Mean	79.5	48.5	1.6	61.3	22.0	4.5	1.9	2.2
Standard deviation	4.9	2.9			1.6	0.8	0.5	
Median	79.7	48.7			22.6	4.7	2.2	
Mode	79.5	47.7			22.8	4.3	2.2	



**Fig. 6:** Correlation diagram showing length and width of the 100 eggs measured.

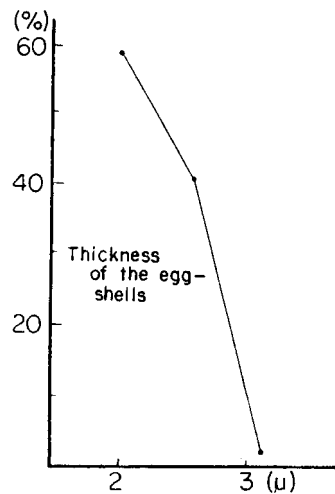


**Fig. 8:** Frequency distribution of the opercular width and height of the eggs.



**Fig. 7:** Histogram showing frequency distribution of the types of egg shapes and the maximum width of the eggs.

- A: Reversed egg type: Eggs with a round opercular apex, tapered abopercular portion and their maximum width on the opercular half.
- B: Oval type: Eggs with a round operc. apex and round aboperc. portion, max. width on the aboperc. half.
- C: Ostrich type: Round operc. apex and aboperc. portion, max. width on the middle, closely to the type of oval form.
- D: Subspindle type: Tapered operc. apex and aboperc. portion, max. width on the middle.
- E: Elliptical type: Round operc. apex and aboperc. portion, max. width on the middle.



**Fig. 9:** Frequency distribution of the thickness of the egg shells.

### Discussion

As previously mentioned, *Paragonimus westermani* has long been considered as only one distinct species in Asia. However, since Miy-

azaki (1939) has reported *Paragonimus ohirai* which is clearly different from the conventional species of the lungfluke of *P. westermanni*, the shape and arrangement of the cuticular spines, the morphological features and the comparative size of ovary and testes, the structural difference of the metacercaria and the characteristics of the eggs has been recognized as valid new criteria for the species identification of *Paragonimus* in the adult and larval forms. This great progress in the field of *Paragonimus* taxonomy resulted in the discoveries of many new species within several decades.

On the basis of the above mentioned criteria, at least four species, such as *P. westermanni*, *P. ohirai*, *P. iloktsuenensis* and *P. miyazaki* have been claimed to easily differentiate them each other by many Japanese workers.

Chen (1940) emphasized on the significance of the cuticular features in the specific diagnosis. On the other hand, according to Miyazaki (1943, 1949), the structure of the ovary and the metacercarial wall has a great validity as a criterion for the species identification. Tomimura et al. (1959) stated that the ratio of the testis to the ovary in the adult worm is an important criterion for the differentiation between *Paragonimus ohirai* and *P. iloktsuenensis*. Isshiki (1960, 1961 & 1962) claimed that it was possible to identify the above four species each other on the basis of the characteristic feature of the eggs.

The possible occurrence of the other type of *Paragonimus* in Korea has long been suggested by various workers. Chyu et al. (1969) made an extensive survey of the house rats (*Rattus norvegicus*) and the brackish water crabs (*Sesarma dehaani*) at the Kum River delta, Kunsan, Korea and failed to find neither larval nor adult worms for the above

hosts.

In Taiwan, the occurrence of the lungfluke, *P. iloktsuenensis* from the rat hosts, *Rattus norvegicus* and *Rattus coxinga* has already been reported by Chiu (1962 a) and Miyazaki and Chiu (1962 a & b).

In Korea, Yokogawa et al. (1971) first confirmed the occurrence of *P. iloktsuenensis* in the brackish water crabs collected at Pusan. In this survey, authors have conducted the detailed morphological examination of the worms from naturally infected rats and also fed to albino rats with these metacercaria and the comparison of the worms experimentally obtained with those collected from the natural host, was made. Conclusively, it is almost clear from the above observations that the present specimens collected from the house rats at the above mentioned two areas, are all identical with the species of *P. iloktsuenensis*. However, authors attempt to analyze the characteristics of these specimens on the basis of the new criterion for the specific diagnosis postulated by Miyazaki, Chen, Tomimura and Isshiki.

Ward and Hirsch (1915), Vevers (1923) and Chen (1940) mentioned that the cuticular spines in the specific diagnosis are reliable to divide the species of *Paragonimus*. However, Kobayashi (1917, 1918) described the impossibility to identify the species using the shape and arrangement of cuticular spines. And then, the structure of the internal organs of the worms has been recognized of less important for the specific diagnosis by the most of the above mentioned investigators. However, Chen (1940) said that the some species of *Paragonimus* can be divided into several groups by the characteristic features of the ovary.

After his careful comparison with a number



of this lungfluke, Miyazaki (1965) summarized the morphological comparisons of the adult worms and divided them into four groups such as *westermanni*; *kellicotti*, *miyazakii*; *compactus*; and *ohirai*, *iloktsuenensis* group on the basis of the combined structural characteristics of cuticles and ovary. According to him, *P. ohirai* and *P. iloktsuenensis* are hardly differentiated even by the above described characteristic of the adult worms. However, there are distinct differentiations between these two species in the structure of the metacercariae, the structures such as lacking of inner cyst wall, smaller size and narrower excretory bladder make possible to differentiate *P. iloktsuenensis* from *P. ohirai*.

Now, all of the present specimens show the typical shape and arrangement of grouped cuticular scales and the so-called coral-like feature of ovary which belongs to the type of *iloktsuenensis*. In addition the average ratio of the size of the testis to the ovary is 2.62 : 1 and the average ratio of the body length to the distance between the anterior end of the body and the middle of the acetabulum is 2.76 : 1. The subspindle type of eggs is the commonest in shape and the maximum width of the eggs is measured on the middle of the egg in 77 percent. All of these statistical results of the measurements of the ova closely coincide with those of *P. iloktsuenensis*, described by Isshiki (1962 a & b) and Tomimura (1959).

The validity of these criterion for the specific diagnosis of the genus *Paragonimus* should be carefully reconsidered by the further detailed study. However, from the above mentioned viewpoints on the identification of the present specimens, it is certainly confirmed that this is the first record on the existence of *Paragonimus iloktsuenensis* in the natural hosts, *Rattus norvegicus* trapped at the Nakdong and

Sumjin River deltas in Korea.

### Summary

During the period of August, 1970 to February, 1971, 52 rodent hosts (*Rattus norvegicus*, *Rattus rattus* and *Apodemus agrarius*) collected from the two areas at the estuaries of the Nakdong and the Sumjin Rivers, South Kyongsang Do, Korea were examined to prove the presence of *P. iloktsuenensis* of which metacercariae have already been found in the crab hosts (*Sesarma dehaani*) at the one of the above two areas.

The results of this survey are as follows:

Five rats, *Rattus norvegicus* (12.5%) were found to be infected with the adult worms was obtained. These worms are enclosed singly in the worm capsules in the right lobe of the lung.

The detailed study on the morphology of the adult worms collected was made for the specific diagnosis and the comparative observation with the worms obtained from albino rats experimentally infected with the metacercariae of *P. iloktsuenensis*, were also conducted for the definite identification.

The following structural characteristics are recognized; the cuticular spines are mostly grouped in single rows, indicating those of *ohirai-iloktsuenensis* type by Miyazaki(1965). The feature of ovary branched into a coral appearance closely coincides with the Chen's original description of *P. iloktsuenensis*. The average ratio of the size of the testis to the ovary is 2.62:1. The average ratio of body length to the distance between the anterior end and the middle of the acetabulum is 2.76:1. The shape of eggs is subspindle (67%). The maximum width of eggs is noticed on the middle of the egg (77%).

These observations are closely resembled to

those described on the known specimens of *P. iloktsuenensis* by Isshiki (1962) and Tomimura (1959).

From the above observations, it is certainly assumed that the present specimen is identical with *Paragonimus iloktsuenensis* Chen, 1940. Therefore, this is the first account of the occurrence of *P. iloktsuenensis* in the natural final host, *Rattus norvegicus* in Korea.

—國文抄錄—

怡樂村肺吸虫 (*Paragonimus iloktsuenensis* Chen, 1940)에 관한 研究

— 洛東江 및 蟾津江 河口에 있어 怡樂村肺吸虫의 自然感染 終宿主內 發生狀況 —

서울大學校醫科大學 寄生蟲學教室 및 風土病研究所

徐 丙 高 및 具 本 龍

우리나라의 肺吸虫은 *Paragonimus westermani* 가 唯一한 種類로만 알려져 있었으나 1970年 8月 横川等이 釜山市 下端 洛東江 河口에서 捕獲한 半鹹水産 介 *Sesarma dehaani* 에서 怡樂村肺吸虫 (*Paragonimus iloktsuenensis*)의 被囊幼虫을 처음으로 發見하고 本虫의 우리나라 分布를 確認한바 있다.

그後 著者들은 繼續하여 1971年 2月까지 사이에 第2 中間宿主內에서의 本虫의 分布 發見狀況을 調査하였던 바 下端 以外에 蟾津江 河口 慶南 河東 地域에서도 同一한 本虫의 被囊幼虫을 發見하고 本虫 우리나라 分布 地域으로 蟾津江 河口를 添加하였다.

한편 兩地域에서 捕獲한 鼠類宿主內에서의 肺吸虫을 採取하고 怡樂村肺吸虫으로 同定하였으며 이들 成虫 自然寄生樣相을 究明하여 다음과 같은 結果를 얻었다.

1) 捕獲된 鼠類 52마리中 5마리에서 成虫 自然寄生例를 發見하였다. 感染鼠類는 *Rattus norvegicus* 一種으로 感染率은 12%였고 總 7마리의 成虫을 採取하였다.

2) 虫體는 거의 全部 完全成熟한 것이었으며 肺內 虫囊에 한마리씩 發見되었고 胸腔, 肋膜 등 其他 部位에서 는 發見할수 없었다.

3) 虫體種別 同定을 爲하여 成虫의 形態를 詳細히 檢討하였고 同時에 被囊幼虫으로 實驗感染한 白鼠에서 一定時日後 採取한 虫體와 比較 檢討하였다.

虫體를 덮고 있는 皮棘 (cuticular spines)은 大部分 이 群生이고 所謂 *Ohirai-ilktsuenensis* 型이었다. 卵巢의 分岐樣相은 多分岐 珊瑚狀으로 Chen 氏의 原記載와 一致한다. 本虫과 가장 恰似한 *P. ohirai* 와 鑑別하기 爲하여 成虫體 및 卵子の 計測值와 그 形態를 觀察하였다. 即 卵巢面積에 대한 左右辜丸 平均面積의 平均比는 2.62:1이고 虫體前端에서 腹吸盤 中央까지의 距離에 對한 虫體長의 平均比는 2.76:1이었다. 虫囊 및 子宮內 虫卵 100個를 觀察한바 그 形態는 亞紡錘型이 67%로 大多數를 차지하고 있었으며 虫卵 最大幅이 虫卵中央部位에 位置하는 것이 77%였다.

以上 觀察結果를 一色 (1961), 富村 (1959)等이 *P. ohirai* 와 *P. iloktsuenensis* 를 成虫 및 虫卵으로 鑑別할 수 있는 것으로 報告한 結果와 比較할때 大體로 後者の 數值와 一致하였다.

4) 終宿主가 捕獲된 兩地域에서 모두 本虫 被囊幼虫 以外에 發見된바 없었으며 實驗感染 白鼠에서 採取한 成虫과 自然感染에서 얻은 虫體와 모든點에서 一致하였다.

5) 以上 成繼으로 미루어 볼때 本調査에서 採取한 虫體를 *P. iloktsuenensis* Chen, 1940으로 同定할 수 있었다. 따라서 本研究은 우리나라에 있어 本虫의 鼠類 自然感染 最初의 報告라 생각한다.

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### Explanations of Plate

**Fig. 1.** Photographes showing two testes of the adultworm.

**Fig. 2 and Fig. 3.** Photographs showing ovary, uterine tubules, ventral sucker, vitelline follicles and intestinal cecum.

**Fig. 4 and Fig. 5.** Ova of *P. iloktsuenensis*

**Fig. 6.** Cuticular spines on the ventral side near the ventral sucker

**Fig. 7.** Adult worm collected from the naturally infected rat host.  
(stained with Semichon's acetocarmin)

**Fig. 8.** Metacercaria attached to the liver of the brackish water crab, *Sesarma dehaani*.

**Fig. 9.** Photograph showing the worm capsule in the rat lung.

Plate



Fig. 3



Fig. 2



Fig. 1



Fig. 6



Fig. 5



Fig. 4



Fig. 9



Fig. 8



Fig. 7