

Studies on the Morphology of Larval and Adult Lung Fluke in the Philippines, with a Proposition of New Name, *Paragonimus Philippinensis* n. sp.

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Introduction

In the Philippines the existence of human paragonimiasis had already been known by Musgrave (1907) who reported 17 cases among Filipinos. Since then many reporters such as Garrison (1908), Willets (1913), Cabreza (1927), Tubangui (1939), Africa *et al.* (1940), Pesigan *et al.* (1947) made the case reports on human paragonimiasis in the Philippines. Despite of such many reports, however, no mention was made on the specific name of *Paragonimus* until Yogore *et al.* (1957) studied on the morphology of larval form of the lung fluke. After observing the morphology of redia, cercaria and metacercaria obtained from Sorsogon Province, Yogore and his co-workers concluded that there was no evidence to show that the species of lung fluke in the Philippines is not *P. westermani*. Thus until now, the Philippine lung fluke has been known as *P. westermani*.

Recently, in the course of cercarial studies on Leyte Island, one species of paragonimid cercaria from Jaro Municipality was observed by Ito (1977), one of the present authors,

who noted it tentatively as *Cercaria leyteensis* no. 19. He considered this cercaria will probably belong to some new species or at least to some new subspecies of *Paragonimus*, because of the difference in the size. This consideration seemed to be further supported by the feeding experiments to rats with the metacercariae by Yokogawa *et al.* (1977). According to them, the Philippine lung fluke can easily develop to maturity in rat, while *P. westermani* can hardly develop in rat. Moreover some immuno-serological differences between the Philippine lung fluke and *P. westermani* in Japan have also been revealed by Yokogawa *et al.* (1978).

Therefore some systematic morphological observations on all stages of the Philippine lung fluke were made by the present study. As a result, some distinct differences were observed between the Philippine lung fluke and *P. westermani* in Japan. In this paper the morphology of larval and adult fluke of the Philippine lung fluke was described, with a proposition of a new name, *Paragonimus philippinensis* n. sp.

Materials and Methods

1. First intermediate snail host:

The first intermediate snail host of the Philippine lung fluke was initially discovered by Tubangui (1946) who noted it as *Melania* spp. Later on Tubangui *et al.* (1950) identi-

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fied the snail with *Brotia asperata*. This identification was again changed as *Brotia asperata* form *dactylus* by Yogore *et al.* (1957) according to the advice of Dr. Abbott.

In 1976, many thiarid snails were collected from Jaro Municipality in Leyte Province. These snails were all seemed to be identical with *Brotia asperata* form *dactylus*, as reported by Yogore *et al.* (1957), but there still remained some doubt whether it is only one single species or not. Some snail specimens were sent to Dr. Tadashige Habe, a conchologist in the National Science Museum in Tokyo, for asking his identification. His response was as follows: "The specimens contained two closely related species. Furthermore the generic name, *Brotia* Adams, 1866, have now been splitted into many generic names. Consequently the name, *Brotia asperata* form *dactylus* should be corrected as *Antemelania asperata* (Lamarck), and *Antemelania dactylus* (Lea)" (Plate 1).

Among 143 snails collected from Jaro Municipality on March, 1976, three snails were positive for the cercaria of lung fluke, while no cercaria could be found from about 500 snails in Sorsogon Province on December, 1977. Thus, the present observation was based on the cercariae from Jaro Municipality only.

Snails collected from Jaro Province on March, 1976, were brought into the laboratory of the Schistosomiasis Control and Research Project in Palo for examining the cercaria. Cercariae were obtained by crushing the snails, and immersed in 0.4% NaCl solution for preserving several hours. Living materials were used for microscopical observation, whereas the measurements were taken on 20 specimens fixed in 10% hot formalin. The drawings were scaled to such measurements, and were illustrated semidiagrammatically, not by camera lucida.

2. Second intermediate crab host :

As to the second intermediate crab host of the Philippine lung fluke, the first report was also made by Tubangui (1946), who noted it as *Potamon* sp., which was soon renamed as *Parathelphusa* (*Barythelphusa*)

mistio by Tubangui (1947). This name was again corrected by Yogore *et al.* (1957) as *Parathelphusa* (*Barythelphusa*) *grapsoides complex* according to the identification of Dr. Chase. In this report the specific name of Yogore *et al.* (1957) was adopted without any correction (Plate 1).

Crab collections were made on November, 1976 in Jaro Municipality, Leyte Province, and on December, 1977 in Casiguran Municipality, Sorsogon Province, both of which are well-known endemic areas of paragonimiasis in the Philippines. Almost all crabs collected were found to harbour many cysts of *Paragonimus* in the heart, gill, muscle, etc. A detailed report on the epidemiological aspect of the incidence in the crab will be published in the near future by some of us.

Almost all crabs collected from Sorsogon and Jaro Provinces were examined in the laboratory in Japan. Cysts isolated from the crab were preserved in 0.8% NaCl solution. Measurements of each 20 specimens from two provinces were carried on in a suspended condition in the fluid, without any pressure of cover slip. To let the metacercariae excyst, cysts were kept at 38-40C for a few hours. Then almost all metacercariae crept out from the cyst and crawled about in the container. These living metacercariae were employed for observation and measurement under the microscope.

For observing the adult flukes, cysts were fed to dogs and rats experimentally. 110 days after feeding dogs, and 70 to 170 days after feeding rats, the flukes were obtained from the lungs of these mammals. These flukes were fixed with 70% alcohol under pressure, stained with alum-carmin, and mounted with canada-balsam. Observations and measurements were made by such specimens.

Results

1. Morphology of redia and cercaria :

Snail host : *Antemelania asperata*, *Antemelania dactylus*

Date, locality and infection rate :

Mar. 1, 1976, Jaro (Malobago),

1 out of 54, or 1.9 %

Mar. 15, 1976, Jaro (Malobago),

2 out of 89, or 2.2 %

Measurements :

body	179 (150-190) × 85 (77-95) μm
oral sucker	44 (40-48) × 42 (30-50) μm
stylet.....	31 (29-33) × 7 (6-8) μm
prepharynx	8 (6-10) × 8 (6-10) μm
pharynx	10 (9-11) × 10 (9-11) μm
acetabulum	31 (25-35) × 40 (35-45) μm
tail.....	20 (15-24) × 15 (13-18) μm

Specific description : (Fig. 1)

The daughter redia is elliptical in shape, and 0.4-0.7 × 0.2-0.3 mm in size. The pharynx is about 50 μm in diameter. This is followed by an intestine extending to the middle of the body. The intestine contains brownish food particles. Many sensory hairs are observed around the mouth opening of the redia. In one redia less than 10 cercariae in various stages of development and some

germ balls are contained.

The cercaria is a typical microcercous type. The body is ellipsoidal in shape, widest at the level of the prepharynx, and narrowest at the level of the acetabulum. A wide median groove is observed on the ventral side of the posterior half of the body. The body is covered with a somewhat thick cuticle provided with many spines directed backward. On the anterior surface of the body, especially around the mouth opening, there are observed many sensory hairs. The oral sucker is well developed. Within it, a strong, non-shouldered stylet is embedded. Several radial muscles coming from the anterior body wall and attaching to the base of the stylet, make the stylet move incessantly. The prepharynx and pharynx follow the oral sucker, but no cecum was recognized except only a short esophagus. The nervous commissure is butterfly-shaped, and situated transversely across the prepharynx. A well

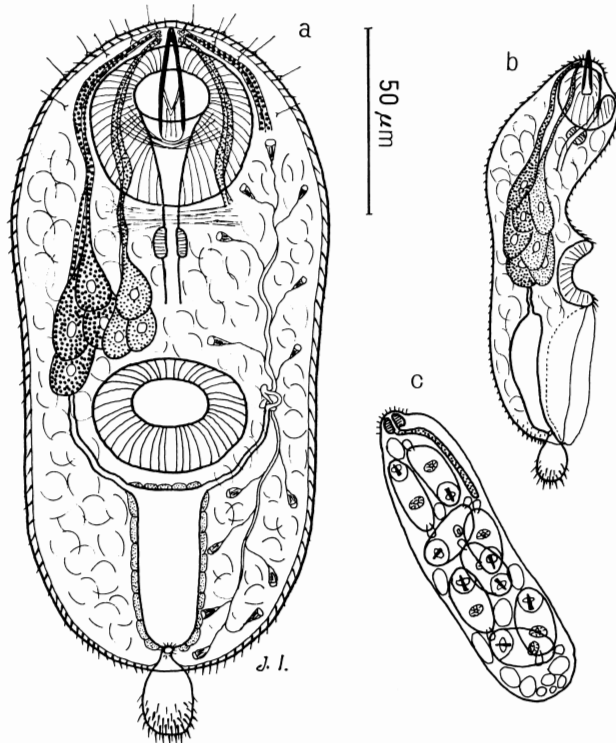


Fig. 1 Cercaria and redia of *Paragonimus philippinensis* n. sp.
a. cercaria, b. lateral view of cercaria, c. redia

developed acetabulum, slightly smaller than the oral sucker, is located posteriorly to the middle of the body. Seven pairs of penetrating gland cells are observed between the pharynx and the acetabulum. The inner three pairs contain fine granules, and the outer four pairs contain coarse granules. Their ducts are grouped in four bundles, and open at both sides of the apical end of the stylet.

A large cylindrical I-shaped excretory vesicle occupies the posterior part of the body. It reaches to the acetabulum, and is lined with a layer of epithelial cells. From its antero-lateral corner a main collecting tube arises forward, makes some convolution at the side of the acetabulum, then divides into anterior and posterior tubules to receive the flame cells. Only 14 pairs of flame cells could be detected, but it is very possible that some of them might be overlooked.

A conical-shaped short tail is inserted into the posterior end of the body. The posterior half of the tail is provided with many spines giving the appearance of shagginess.

2. Morphology of cyst and excysted metacercaria :

Crab host : *Parathelphusa (Barythelphusa) grapsoides complex*

Date and locality :

November, 1976, Jaro Municipality in Leyte Province

December, 1977, Casiguran Municipality in Sorsogon Province

Measurements :

cyst	324 (317-336) × 316 (307-336) μm
*cyst	295 (270-320) × 287 (260-320) μm
outer cyst wall	14 (10- 16) μm in thickness
inner cyst wall	7 (6- 8) μm in thickness
excysted metacercaria	537 (432-624) × 227 (192-269) μm
oral sucker ...	74 (67- 82) × 79 (72- 86) μm
acetabulum ...	87 (79- 96) × 93 (84-101) μm
rudimentary stylet	15 (12- 19) × 3.7 (2.9-4.3) μm
pharynx	35 (29- 41) × 35 (31- 38) μm

(* from Leyte, the others are from Sorsogon)

Specific description : (Fig. 2 and Pl. 1)

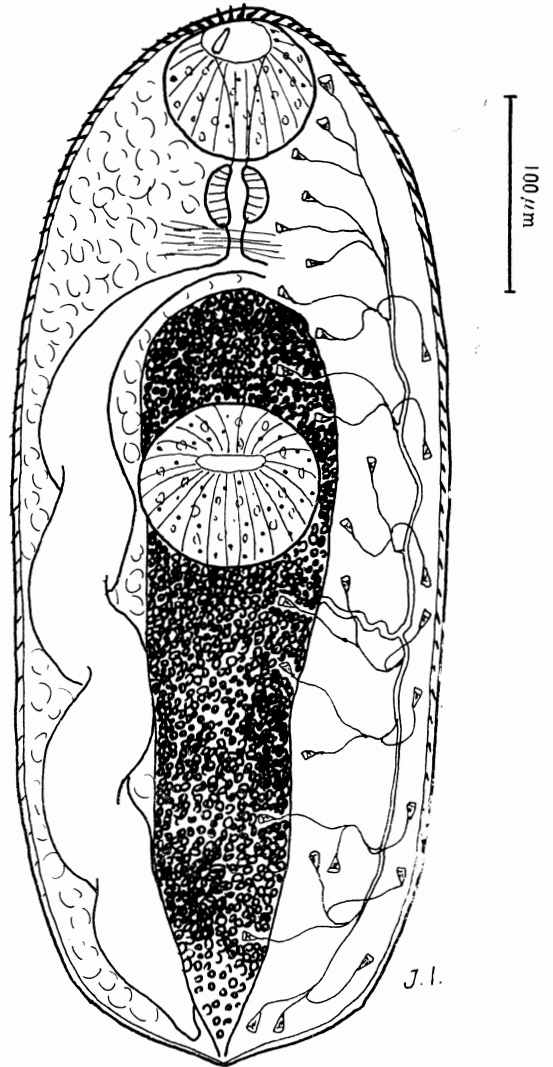


Fig. 2 Excysted metacercaria of *Paragonimus philippinensis* n. sp.

The cyst removed from the crab has no outer membrane, and is spherical or slightly ellipsoidal in shape. The cyst wall is composed of two layers. The outer wall is smooth, transparent and thick, whereas the inner one is striped, hyaline and thin. Table 2 gives the measurements of the cyst of Philippine *Paragonimus* in comparison with the same stage of *Paragonimus* in other countries. It is noticeable that the size of cyst of Sorsogon-strain given by Tubangui (1946), Yogore *et al.* (1957) and the present authors

agrees with each other, whereas that of Leyte-strain given by the present authors is much smaller than the Sorsogon-strain.

The excysted metacercaria is cylindrical or elongated ellipsoidal in shape, and crawls around actively by means of two suckers. The body surface is covered with many spines, being more dense anteriorly. A well developed oral sucker occupies the anterior part of the body. Usually a rudimentary stylet is recognized on the dorsal side of the oral sucker. An acetabulum is slightly larger than the oral sucker, and situates at a little anterior to the middle of the body. A pharynx follows the oral sucker directly, and is followed by a short esophagus which divides into two long ceca reaching to near the end of the body. These ceca are colorless because of no content, occupy the both lateral parts of the body, and twist three times as shown in Fig. 2. A nervous commissure is recognized across the esophagus transversely.

The most median part of the body is occupied by a large cylindrical excretory vesicle reaching to the level of cecal bifurcation. The vesicle is densely compacted with brown-

ish granules which can be easily discharged from the terminal pore by a pressure. From both lateral sides of the middle part of the vesicle, one pair of excretory tubes arises and soon divides into an anterior and a posterior collecting tubes each. Thirty pairs of flame cells are observed in ten groups, so that the flame cell formula is constructed as $2[(3+3+3+3+3)+(3+3+3+3+3)]=60$. In the Table 3, a comparison of the measurements of excysted metacercaria was made including that of Sorsogon-strain. Unfortunately no data could be obtained from the metacercaria of Leyte-strain.

3. Morphology of adult fluke :

Experimental mammalian host : dog and rat.

Measurements :

Nine worms of 110 days after feeding the dog ;

body7.7(6.3-10.2) × 4.4(3.7-5.8)mm

oral sucker...409(325- 557) × 479(374-792) μm

acetabulum...598(504- 696) × 665(586-768) μm

Five worms of 70 days after feeding the rat ;

body5.1(4.3-6.0) × 2.8(1.9-3.8)mm

oral sucker...350(310-380) × 460(400-530) μm

acetabulum...440(410-520) × 520(480-550) μm

Table 1 A comparison of the size of cercariae of *Paragonimus* spp. (μm)

Species	Body		Oral sucker		Acetabulum		Stylet		Tail		Authors
	l.	w.	l.	w.	l.	w.	l.	l.	l.	l.	
<i>P. philippinensis</i> n. sp.	199-240	69-93	45-58	41-58	31-38	34-38	21-29	14-24			Yogore <i>et al.</i> , (1957)*
"	150-190	77-95	40-48	30-50	25-35	35-45	29-33	15-24			Ito(1977), and present authors**
<i>P. westermanni</i>	180-269	70-130	42-63	42-63	24-36	30-38	36	15-30			Yamaguti(1943)
"	235-314	94-116	58-67	49-64	24-37	43-57	30-37	21-37			Komiya and Ito(1950)
<i>P. kellicotti</i>	171-244	56-89	40-44	40-44	29-33	29-33	33-38	13-18			Ameel(1934)
<i>P. ohirai</i>	160-360	74-135	40-66	38-63	30-49	36-50	21-32	19-31			Yoshida and Miyamoto(1959)
"	170-329	105-150	27-56	36-73	22-40	32-46	18-31	10-28			Yokogawa <i>et al.</i> (1960)
"	192-298	92-130	50-62	45-57	21-32	33-41	27-32	16-25			Ito <i>et al.</i> (1969)
<i>P. iloktsuenensis</i>	265	102	55	55	37	37	27	23			Chen(1940)
"	165-320	80-150	45-66	41-66	24-52	36-55	20-30	14-23			Yoshida(1959)
"	170-328	56-87	32-40	36-40	20-28	22-32	22-32	10-24			Chiu(1965)
<i>P. miyazakii</i>	131-181	70-82	33-38	35-40	28-34	30-35	27-32	16-20			Kawashima and Miyazaki(1964)
"	151-259	68-97	43-62	35-48	33-40	30-37	24-30	14-18			Hatsushika(1967)
<i>P. sadoensis</i>	194-296	86-129	47-57	42-53	20-33	32-38	29-33	17-25			Ito <i>et al.</i> (1969)

(* is Sorsogon-strain, ** is Leyte-strain)

Specific description: (Fig. 3 and Pl. 2)

In flattened toto mounts, the body is oval in shape, abruptly rounded anteriorly, and slightly more tapering posteriorly. The body surface is covered with many cuticular spines

which vary in shape from slender and sharp-pointed to scale-like. They are usually placed singly and arranged in diagonal rows, although occasionally in groups of two or three. The oral sucker is located at the anterior end of the body, and is slightly inclined ventrad

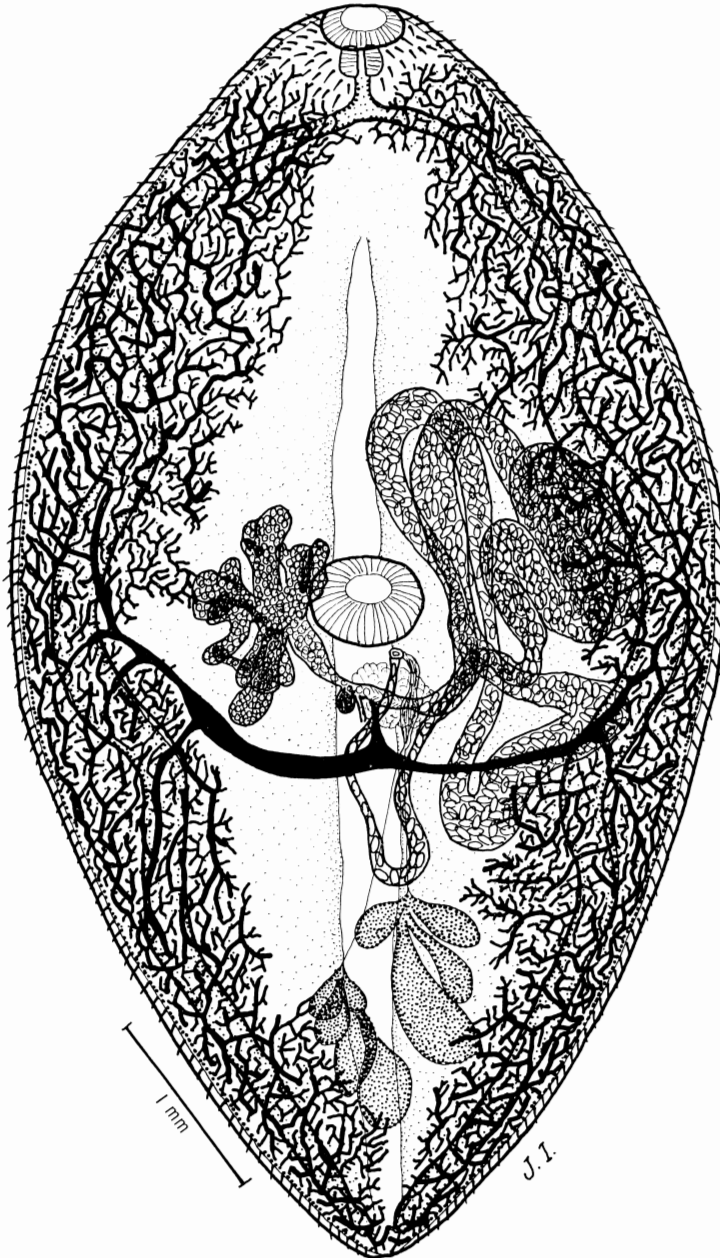


Fig. 3 Adult fluke of *Paragonimus philippinensis* n. sp.

making the mouth subterminal. The acetabulum, slightly larger than the oral sucker, is situated a little in front of the middle of the body. The pharynx is in contact with the oral sucker obliterating the prepharynx. The esophagus is very short and is followed by the intestinal ceca which have three large loops and numerous smaller ones formed by dorsal, ventral and lateral bending. These loops divide the worm roughly into three regions, the middle one of which include the acetabulum, ovary and uterus, and the posterior one the testes. The intestinal ceca reach almost to the posterior tip of the body.

The excretory vesicle is a long tube, flattened laterally, and extends from the pore at the posterior end of the body forward almost to the bifurcation of the intestinal ceca. The ovary is at one side just back or side of the acetabulum. It is sometimes on the right side, others on the left side. The shape of the ovary varies from typically six-lobed to less than six-lobed one. Usually it consists of a small central mass and several lobes, some of which being shortly subdivided again. The oviduct arises from the postero-inner side of the ovary, enters into the Mehlis' gland to become the ootype. Just before the oviduct enters to the gland, it gives off the Laurer's canal which is provided with a seminal receptacle. The uterus is on the other side of the ovary and extends laterally further toward the edge of the fluke than the ovary. The length of the uterus and the diameter of its convolutions depend on the age of the fluke. In older specimens it comes to fill the region dorsad of the acetabulum and extends on the side opposite the ovary almost to the lateral margin of the worm. Well developed vitelline glands are widely distributed on the lateral side of the body. These are consisted of clusters of glandular cells with brownish granular contents. The right and left transverse vitelline ducts pass along the dorsal side of the body to join the short common duct, and opens at the ootype.

The testes develop on each side of the body back of the ovary and uterus. It con-

sists of an ovoidal central mass and four to six irregular shaped lobes, although sometimes the central mass is lacking. The vasa efferentia arise from the anterior part of each testis, pass forward to the posterior margin of the Mehlis' gland, and connect through the vas deferens to the seminal vesicle. The seminal vesicle is a small spindle shaped, and varies in size with the amount of spermatozoa it contains. Its anterior end is followed by the pars prostatica and the ejaculatory duct, which opens into the genital atrium on the ventral surface, just back of the acetabulum and slightly toward the uterus side. There is no cirrus sac.

Eggs were observed in the uterus of the flukes obtained from rats fed with cysts of Leyte-strain only. They are yellowish brown in color, and are 80.2 (70-95) μm in length and 49.8 (40-60) μm in width. They are operculated with the operculum more or less strongly set off from the rest of the shell, and are frequently asymmetrical.

Discussion

1. Morphology of redia and cercaria :

The morphology of redia and cercaria of the Philippine lung fluke was initially studied by Yogore *et al.* (1957). They obtained the materials from Casiguran Municipality in Sorsogon, whereas the present description was based on the materials from Jaro Municipality in Leyte. For this reason a fundamental question might be existed between these two reports whether these materials are the same species or not. According to our present data with regard to the Philippine lung fluke, it could not be considered that there was so clear-cut differences between Sorsogon-strain and Leyte-strain, even though some differences on the size of cercaria, as well as cyst and excysted metacercaria, could be found between two strains. This question, however, will be remained in the future study.

As far as the description of the redia is concerned, no fundamental difference could be found between the report of Yogore *et*

Table 2 A comparison of the size of cysts of *Paragonimus* spp. (μm)

Species	length	width	Authors
<i>P. philippinensis</i> n. sp.	320	300	Tubangui (1946)*
"	296-337	296-326	Yogore <i>et al.</i> (1957)*
"	317-336	307-336	present authors*
"	270-320	260-320	present authors**
<i>P. westermani</i>	340-450	320-440	Yamaguti (1943)
"	380-420	380-420	Komiya <i>et al.</i> (1964)
<i>P. kellicotti</i>	381-457	381-447	Ameel (1934)
<i>P. ohirai</i>	272-321	191-264	Yokogawa <i>et al.</i> (1960)
"	283-340	217-283	Tada <i>et al.</i> (1969)
<i>P. iloktsuenensis</i>	214-302	200-230	Chen (1940)
<i>P. miyazakii</i>	404-450	404-460	Miyazaki <i>et al.</i> (1963)
"	360-470	380-550	Hatsushika (1967)
"	411-510	403-510	Ito <i>et al.</i> (1975)
<i>P. sadoensis</i>	274 \pm 28	240 \pm 22	Kawashima (1965)
"	267 \pm 25	241 \pm 21	Miyazaki <i>et al.</i> (1968)

* marks are from Sorsogon, ** mark is from Leyte

Table 3 A comparison of the size of excysted metacercariae of *Paragonimus* spp. (μm)

Species	Body		Oral sucker		Acetabulum		Pharynx		Stylet	Authors
	l.	w.	l.	w.	l.	w.	l.	w.	l.	
<i>P. philippinensis</i> n. sp.	444-651	252-296	69-79	68-82	—	—	—	—	7-21 (living)	Yogore <i>et al.</i> (1957)*
"	444-584	229-266	48-62	59-72	69-86	79-100	27-38	21-34	7-14 (fixed)	
"	432-624	192-269	67-82	72-86	79-96	84-101	29-41	31-38	12-19	present authors*
<i>P. westermani</i>	800-1100	270-380	65-80	90-100	115-140	117-147	36-50	45-60	21-28	Yamaguti (1943)
"	710-830	260-370	62-76	88-98	96-120	120-130	—	—	—	Komiya <i>et al.</i> (1964)
<i>P. kellicotti</i>	524-866	209-297	62-84	67-84	67-133	111-127	33-38	36-38	9-22	Ameel (1934)
<i>P. ohirai</i>	336-468	123-204	45-59	42-53	53-73	50-67	—	—	8-11	Miyazaki (1939)
"	297-527	169-266	62-72	36-66	62-80	59-75	23-36	19-26	7-12	Yokogawa <i>et al.</i> (1960)
<i>P. iloktsuenensis</i>	417	194	53	53	59	59	28	25	10	Chen (1940)
<i>P. miyazakii</i>	680-1000	380-460	86-93	89-98	120-150	140-160	—	—	—	Komiya <i>et al.</i> (1964)
"	810-1190	310-470	76-95	81-105	96-167	87-149	42-61	30-46	—	Kamo <i>et al.</i> (1961)

* Sorsogon-strain

al. and that of the present authors. Yogore *et al.*, however, put an emphasis upon the length of intestine as a differential character among the species of *Paragonimus*. After referring the fact that the intestine is shorter than the half length of the redia in *P. kellicotti* and *P. iloktsuenensis*, and the fact that it is longer than the half length of the redia

in *P. westermani*, they considered that no difference could be found between their materials and the redia of *P. westermani*. But according to our opinion, the length of the intestine is usually depend on the developmental stages of redia, and has a less meaning for diagnostic character. Even if there is no difference on the morphology of redia,

it will be very hard to conclude that the Philippine lung fluke can be identified with *P. westermani*.

As to the morphology of the cercaria, there is also no fundamental difference except the measurements and the number of flame cells between two reports. The difference of measurements is mainly remarked on the body size, which is $220 \times 78 \mu\text{m}$ in the report of Yogore *et al.*, and is $179 \times 85 \mu\text{m}$ in the present one. The former data were obtained from the cercaria of Sorsogon-strain, anesthetized by sodium pentobarbital, whereas the latter was based on the cercaria of Leyte-strain fixed with 10% hot formalin. So it is difficult to decide at present whether this difference is depend on the locality, or on the measurement method. But except the body size mentioned above, no remarkable difference was seen on the other parts such as suckers, stylet, tail, etc. between both reports. With regard to the flame cell, Yogore *et al.* (1957) described and illustrated 30 pairs of flame cells in the cercaria, whereas it was only 14 pairs by our observation. It should be noted here that the number of flame cell in the metacercaria of Sorsogon-strain was also 30 pairs as described in the previous chapter of this study. So the report of Yogore *et al.* is considered to be correct on the number of flame cell in the cercarial stage. It is inexcusable that our observation might be insufficient because of the meagre materials. In the future study, this will be confirmed.

In Table 1, a comparison of measurements of paragonimid cercariae was shown. Because of the general resemblance between the Philippine lung fluke and *P. westermani*, the discussion was focussed on four reports of Yamaguti (1943), Komiya and Ito (1950), Yogore *et al.* (1957) and the present one. Even though there is some difficulties to compare the data because of the difference of measuring method by each authors, it seems to be clear that the cercaria of the Philippine lung fluke is smaller than that of *P. westermani*. This is more clear on the sizes of the body, the stylet and the tail.

Concerning to these differences, Yogore *et al.* did not pay any attention, but merely stated that differences in the morphology of the cercaria apparently cannot be used for separating species of *Paragonimus*. This opinion of Yogore *et al.*, however, is not acceptable for us, since there are several cases of separating species in the same genus by cercarial measurements, such as *Heterophyes*, *Echinostoma*, *Trichobilharzia*, or even in *Paragonimus*. Consequently, from the fact of difference in the cercarial measurements, the Philippine lung fluke seems not to be identified with *P. westermani*. This opinion will be further confirmed by the subsequent discussion on the cyst and the metacercaria in the next chapter.

2. Morphology of cyst and excysted metacercaria :

A clear-cut diagnostic character for separating the Philippine lung fluke from *P. westermani* is the difference on the sizes of cyst and excysted metacercaria. Though there exists some differences on the size between the cyst of Sorsogon-strain and Leyte-strain, it will be more important character that both of which are distinctly smaller than that of *P. westermani*. As shown in Table 2, there is no corresponding size of the cyst with that of the Philippine lung fluke; namely, *P. westermani*, *P. kellicotti* and *P. miyazakii* are the larger group, and *P. ohirai*, *P. iloktsuenensis* and *P. sadoensis* are the smaller group than the Philippine lung fluke. These characters are also the same in the case of the metacercaria as shown in Table 3 which gives a comparison of the measurements of metacercariae. By these facts, it may be rather reasonable to treat the Philippine lung fluke as an independent species. Consequently it is considered that there is no difficulty to propose a new name for the Philippine lung fluke, separating from *P. westermani*.

As far as the description is concerned, the report of Tubangui (1946) and Yogore *et al.* (1957) on the cyst, as well as the report of Yogore *et al.* (1957) on the metacercaria,

agree entirely with the present report. However, the opinion of Yogore *et al.* directed toward to think that the Philippine lung fluke is *P. westermani*. In the Table 3 of Yogore *et al.*, they missed to quote the measurements of cyst of *P. westermani* given by Yamaguti (1943) who described its size as $340-450 \times 320-440 \mu\text{m}$. In addition, in their discussion on the cyst, only the differences between the Philippine lung fluke and the other species were emphasized, but no mention was made on the comparison with *P. westermani*. They remarked only as follows, "...the encysted metacercariae from this country are most similar to those of *P. ringeri* in Korea, Formosa and Northern China. The latter, however, apparently attain a larger maximum size."

The recent taxonomy, in general, is depend on not only the morphology but also the biology such as host-parasite relationships. For this reason, Yogore *et al.* added some data from their experimental infections. They fed domestic cats with cysts of the Philippine lung flukes, and obtained the results which seem to lead their opinion toward the identification with *P. westermani*. According to our experiments on dogs, almost the same result with *P. westermani* was obtained. On the contrary, however, a remarkable different result was observed on the experiments on rats. As already stated in the introduction of this report, the Philippine lung fluke can easily develop to maturity in the rat, while *P. westermani* can hardly develop in the rat (Yokogawa *et al.*, 1977). This result will support our opinion of separating the Philippine lung fluke from *P. westermani*.

As to the difference of the cyst size between Sorsogon-strain and Leyte-strain, the question will be remained to the further study in the future.

3. Morphology of adult fluke :

As described in the former, the body size of nine worms from dogs fed with cysts of Sorsogon- and Leyte-strain is $7.7(6.3-10.2)$ mm long and $4.4(3.7-5.8)$ mm wide, whereas

that of five worms from rats fed with cysts of Leyte-strain shows $5.1(4.3-6.0)$ mm long and $2.8(1.9-3.8)$ mm wide. It has already been known that the size of the adult fluke in the trematode is generally depend on the difference of the final host. Usually the fluke in the more suitable host develops larger than that in the less suitable host. From such view-point, the present data would be concluded that the dog is more suitable host than the rat for the Philippine lung fluke, and the difference of size between the flukes from dogs and rats has no meaning for the specific diagnosis. A comparison of the size of adults between Sorsogon-strain and Leyte-strain was also made on the dog experiment, but no difference could be found at present.

The measurements of the adult size of *P. westermani* given by several senior workers are as follows; $7-9 \times 4-6$ mm by Kerbert (1878), 9.6×5.0 mm by Katsurada (1900), 10.8×5.8 mm by Kubo (1912), $7.5-13$ mm long by Braun (1925), $7.5-16 \times 4.6$ mm by Sprehn (1978), and so on. Comparing the present data with these mentioned above, the present one seems to be slightly smaller than these one, but is considered that these are all within the range of the body size of *P. westermani*. In the other word, no significant difference could be found on the size of the adult between the Philippine lung-fluke and *P. westermani*.

As to the body structures, such as the shape of whole body, cuticular spines, shape and size of the ovary and the testes, no fundamental difference could be recognized, although only a slight difference seems to be existed between the Philippine lung fluke and *P. westermani*. The shape of ovary and testes has some tendency to be more irregular and weakly developed appearance than *P. westermani*. The typical six-lobed ovary was seen in only a few specimens, and the majority worms has less than six lobes in the ovary as shown in Plate 2. The vitelline glands of *P. westermani* are usually widely distributed on both the ventral and dorsal surface of the body, and sometimes continuous on the dorsal surface, whereas in the

Philippine lung fluke, these are rather limited to the lateral side of the body, and are omitted at the anterior part of the body, around the oral sucker. Consequently the general appearance of the Philippine lung fluke seems to be rather weakly developed than *P. westermani*, though these differences would be still insufficient for separating the Philippine lung fluke from *P. westermani* by the adult morphology only. Some more detailed study would be expected to find a critical feature on the adult morphology between the Philippine lung fluke and *P. westermani*.

Addendum

Most recently, a new name, *Paragonimus filipinus* was proposed by Miyazaki (1978) for some type of the lung fluke from Leyte Province. His material was only one adult fluke obtained from an experimental dog, with some living encysted metacercariae. The diagnostic character of the new species, according to Miyazaki, is the different shape of the ovary and the far thinner cyst-wall of the metacercariae. He described and figured the shape of the ovary as having bigger central mass and shorter lobes than the other species. He further noted, "...the new species is coexisting in Leyte area with *P. westermani* and *P. siamensis*".

By our present study, however, the Philippine lung fluke as a causative agent of human paragonimiasis in the Philippines, was renamed as *P. philippinensis*, instead of *P. westermani*, because of the morphological and biological differences. So the combination of the two reports might bring such an interpretation as, "in the Philippines, at least in Leyte Province, there are three species of *Paragonimus*, namely, *P. philippinensis* Ito *et al.*, 1978, *P. filipinus* Miyazaki, 1978 and *P. siamensis* Miyazaki *et Wykoff*, 1965". Further studies will give some conclusions for this problem.

Miyazaki, I. (1978): *Paragonimus filipinus*, sp. n. found in Leyte, the Republic of the Philippines (Trematoda: Troglotrematidae). Med. Bull. Fukuoka Univ., 5, 5-10.

Summary

To date in the Philippines, the local lung fluke has been identified as *Paragonimus westermani*, according to the report of Yogore

et al. (1957). Since then no discussion on the scientific name of the Philippine lung fluke was made until now.

Recently some questions were offered by Ito (1977) and Yokogawa *et al.* (1977, 1978), whether the Philippine lung fluke is *P. westermani* or not. Therefore the systematic morphological observations on all stages of the Philippine lung fluke were made by the present study. The results and conclusions were as follows:

1. On the general feature of the mother redia, no difference was found between the Philippine lung fluke and *P. westermani* as pointed out by Yogore *et al.* So Yogore *et al.* considered the Philippine lung fluke can be identified with *P. westermani*. According to our opinion, however, even if there exists no difference on the morphology of the redia, it may be very hard to identify the Philippine lung fluke with *P. westermani* by merely that fact.

2. The cercaria of the Philippine lung fluke was considerably smaller than that of *P. westermani*. This difference was more clear on the sizes of the body, the stylet and the tail. These differences would be rather important for separating the Philippine lung fluke from *P. westermani*, though Yogore *et al.* did not pay any attention on this difference.

3. The cyst and the metacercaria of the Philippine lung fluke was distinctly smaller than that of *P. westermani*, as shown in Table 2 and 3. This difference is considered as a clear-cut diagnostic character for separating the Philippine lung fluke from *P. westermani*. Concerning to this point, Yogore *et al.* emphasized only the difference between the Philippine lung fluke and the other species of *Paragonimus*, but no mention was made on the comparison with *P. westermani*.

4. As to the morphology of the adult fluke, the Philippine lung fluke seems to be slightly smaller, and rather weakly developed than *P. westermani*, though no fundamental difference could be found between them at present.

5. As a conclusion, according to the facts mentioned above, it is considered that it may be rather reasonable to treat the Philippine lung fluke as an independent species. Consequently, a new name, *Paragonimus philippinensis* n. sp. is proposed for the Philippine lung fluke, separating from *Paragonimus westermani*. This proposition would be further supported by the result of the infection experiments which will be reported successively by the present authors.

6. Concerning with the scientific name of the first intermediate snail host of the Philippine lung fluke, it had been reported as *Brotia asperata* form *dactylus* by Yogore et al. (1957) according to the identification of Dr. Abbott. In the course of the present study this was again corrected by Dr. Habe, a conchologist in the National Science Museum in Tokyo. According to him, the name of *Brotia asperata* form *dactylus* should be separated into two species and corrected as *Antemelania asperata* (Lamarck) and *Antemelania dactylus* (Lea).

7. Lastly in the course of this study, some considerable differences were revealed on the sizes of the cercaria and the cyst between Sorsogon-strain and Leyte-strain, namely those of Sorsogon-strain are larger than those of Leyte-strain. This fact suggests some question whether *Paragonimus philippinensis* might be separated into two subspecies or not. This question, however, will be remained to the further study in the future.

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フィリピン産肺吸虫の形態学的研究
 新種 *Paragonimus philippinensis* n. sp. の提案

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フィリピンの肺吸虫は永い間ウエステルマン肺吸虫と
 同定されていたが、伊藤 (1977) のセルカリアの形態に
 関する報告、横川ら (1977, 1978) のラッテにおける発
 育実験の報告などにより上述の同定に疑問が生じた。

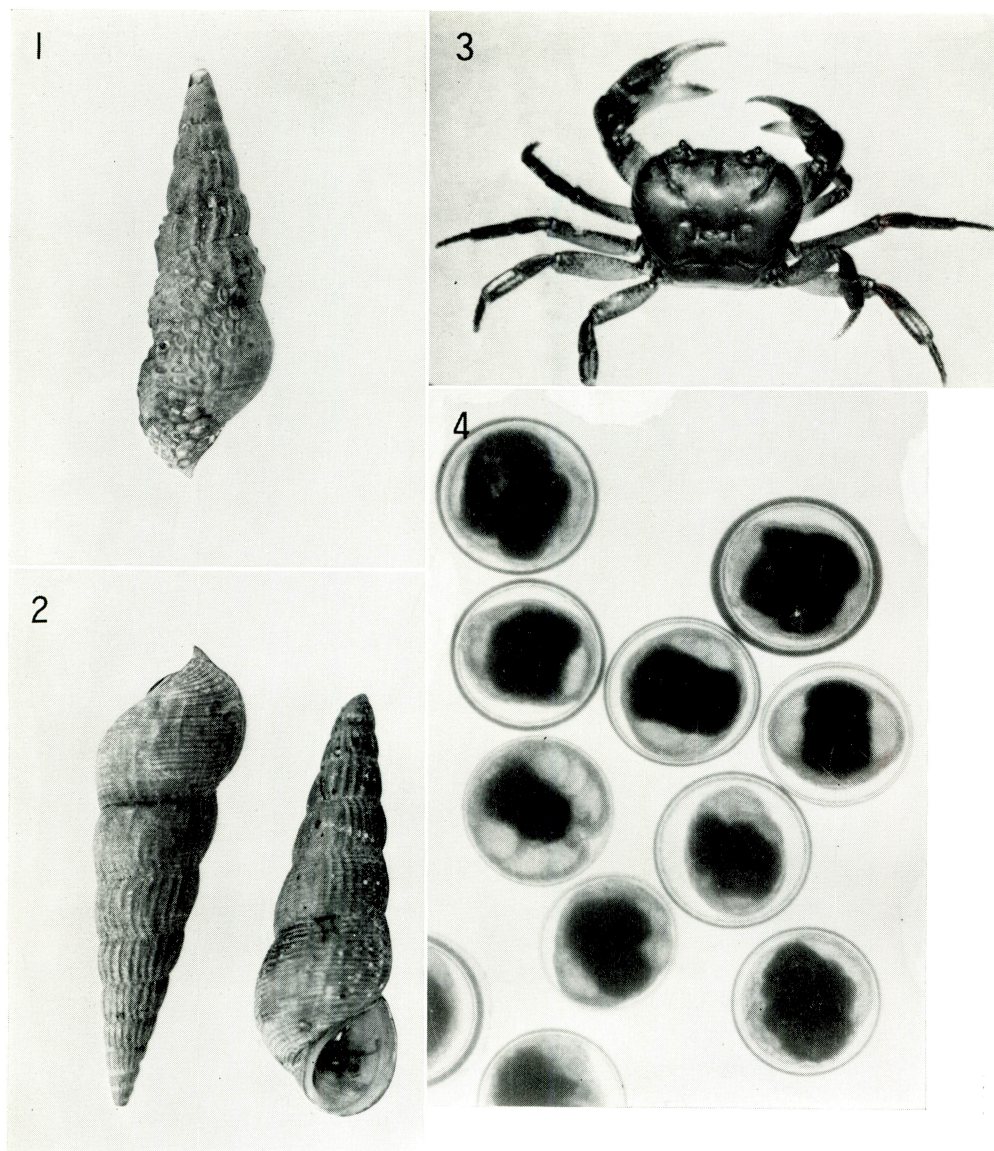
そこで筆者らはレヂア、セルカリア、メタセルカリア
 および母虫の形態を観察した結果、明らかにウエステル
 マン肺吸虫とは異なる所見をえた。すなわち、レヂアの
 形態ではほとんどその差を見いだせなかつたが、セルカ
 リア、シスト、メタセルカリアではいずれもフィリピン
 産肺吸虫は小形で、殊にシストの大きさではその差がい
 ちじるしかつた。また母虫もフィリピン産のものがやや
 小形であつた。

以上の結果により、また後報の予定である 発 育 実 験

の結果をも参照して、フィリピン産の肺吸虫に対し、
Paragonimus philippinensis n. sp. と命名することが
 妥当であると考えて提案した。

フィリピンの肺吸虫の二大流行地であるソルソゴンと
 レイテのそれぞれを比較すると、一般にレイテ産の方が
 ソルソゴン産よりも更に小形であり、亜種とすべきかど
 うかは将来の研究にまちなたい。

今回の研究の途上、第一中間宿主である貝の再同定
 を波部博士に依頼した結果、従来の *Brotia asperata*
 form *dactylus* は二つの種類に分けられ、それぞれ
Antemelania asperata および *Antemelania dactylus*
 とされた。



Explanation of Plates

Plate 1 Intermediate hosts and cysts of *Paragonimus philippinensis* n. sp.

1. *Antemelania asperata* (Lamarck).
2. *Antemelania dactylus* (Lea).
3. *Parathelphusa* (*Barythelphusa*) *grapsoides* complex.
4. Cysts from the crab.

Plate 2 Showing the variation of reproductive system of *Paragonimus philippinensis* n. sp.

- 1-5. Flukes of 116 days after feeding the dog with cysts of Sorsogon-strain.
- 6-9. Flukes of 130 days or 110 days after feeding the dog with cysts of Leyte-strain.

