THE ROUTE OF MIGRATION OF *PARAGONIMUS SIAMENSIS* MIYAZAKI & WYKOFF, 1965 IN THE WHITE RAT

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INTRODUCTION

The route of migration of six species of paragonimid flukes has been studied. In *Paragonimus westermani* by Yokogawa *et al.* (1962) and *P. heterotremus* by Wittayawudthikul (1985), worms penetrated the small intestine and entered the abdominal cavity, went into the abdominal wall, then returned to the abdominal cavity and invaded liver, diaphragm before reaching the lung. The pattern of migration was similar in *P. ohirai* as observed by Okura (1963), *P. skrjabini* by Hu *et al.*, (1982) and *P. kellicotti* by Stromberg and Dubey (1978), except that the passage to the abdominal wall was omitted. *P. miyazakii* seemed to be an intermediate between the two groups as in one infection, one-third of the worms went through the abdominal wall but the other two-thirds did not (Yokogawa *et al.*, 1964). Ahmad *et al.*, (1977) studied the route of migration of *P. siamensis* in bandicoot, but did note xamine hosts earlier than 12 days after infection. This study examines the route of migration of *P. siamensis* particulary during the first two weeks using the white rat as the experimental animal.

MATERIALS AND METHODS

Thirty white rats of both sexes, 2-3 months old, were each given orally 50 metacercariae of *P. siamensis* from naturally infected ricefield crabs, *Parathelphusa dugasti.* Two rats were autopsied at various selected times from 1 hour to 9 weeks. The whole body muscle of rat was searched for the worms including abdominal cavity, pleural cavity and internal organs and without the aid of Evans' blue small lesions in the tissues could be easily recognized with naked eyes. The worms were dissected under dissecting microscope, compressed then fixed in AFA, stained in Mayer's haemalum, dehydrated in ethanol, cleared in methyl benzoate and mounted in Canada balsam.

RESULTS

Table 1 shows the numbers and sites of worms recovered in white rats infected with metacercariae of *P. siamensis* and autopsied at various selected times. At one hour after infection, most of the metacercariae were in the stomach and still encysted; one excysted metacercaria was found inside the first part of small intestine and one worm was found in the abdominal cavity. Six hours after infection, most of the worms were found in the abdominal cavity; only one worm of one rat was found in the stomach wall. There were lesions in the stomach wall, and the first 3 centimetres of the small intestine. At 12 hours most worms were found in the abdominal cavity and wall, and a few were in the pleural cavity and stomach wall. At 24 hours and 2 days after infection no worms were found in the abdominal cavity or stomach wall; most were in the abdominal wall and small numbers in liver, diaphragm and thoracic muscle. At 5 and 7 days, some worms were still in the abdominal wall and a few were in the abdominal cavity. From 2 to 5 weeks some worms were still in the abdominal wall and cavity but most were recovered from the pleural cavity, some had reached the

Table 1

Locations and numbers of worms recovered in white rats at various times after receiving orally 50 metacercariae of *Paragonimus siamensis*, (Two rats were autopsied at each period of time).

Time after infection	number of worm recovered					
	Abdominal cavity	Abdominal wall	Pleural cavity	Lungs	Other organs*	Total(%)
1 hr	1	-	-	-	15	16 (32)
6 hr	10	-	-	-	1	11 (22)
12 hr	6	5	-	-	1	12 (24)
24 hr	-	6	-	-	4	10 (20)
2 dy	-	7	-	-	4	11 (22)
5 dy	2	11	-	-	-	13 (26)
7 dy	1	11	-	-	-	12 (24)
2 wk	2	9	-	5	2	18 (36)
3 wk	-	1	12	-	-	13 (26)
5 wk	1	-	26	1	-	28 (56)
7 wk	-	-	9	6	-	15 (30)
9 wk	-	-	12	8	-	20 (40)

* Other organs include stomach, intestine, liver, diaphragm, thoracic muscle, and foreleg.

lungs, small numbers were in the diaphragm, thoracic muscle and one worm was found in the muscle of foreleg. From 6 to 9 weeks, worms were recovered from pleural cavity and lung only; most were in the pleural cavity.

These data reveal that after ingestion, metacercariae excyst in the stomach and the first part of small intestine, penetrate through the stomach wall and small intestinal wall into the abdominal cavity, then invade the abdominal wall and other near-by areas. Later the worms appear in abdominal cavity again, before entering the pleural cavity and then the lung where they become adults in the cysts.

Body and suckers of excysted metacercariae, 1-8, and 20-week-old *P. siamensis* recovered from infected white rats were measured and their development was recorded. Measurements were of compressed worms and so were larger than they should be, and the worms were so thick that the internal organs can not be seen clearly unless they were flattened.

At one week after infection, the worms were double the size of the excysted metacercariae (Fig. 1), and rudimentary testes and ovary could be recognized. The worms gradually increased in size as they grew older; they reached three and four times as large as the excysted metacercariae in two and three weeks respectively. By four weeks, the worms grew double the size of three-week-old worms; testes, ovary and other reproductive organs were well developed but the vitellaria could not be seen. At five weeks, the worms were slightly bigger than four-week-old worms and rudimentary vitellaria were visible. The vitellaria became more prominent by 6 weeks but no eggs were seen. The first observation of eggs was in two worms of a total of thirty worms recovered from worm cysts at 7 weeks.

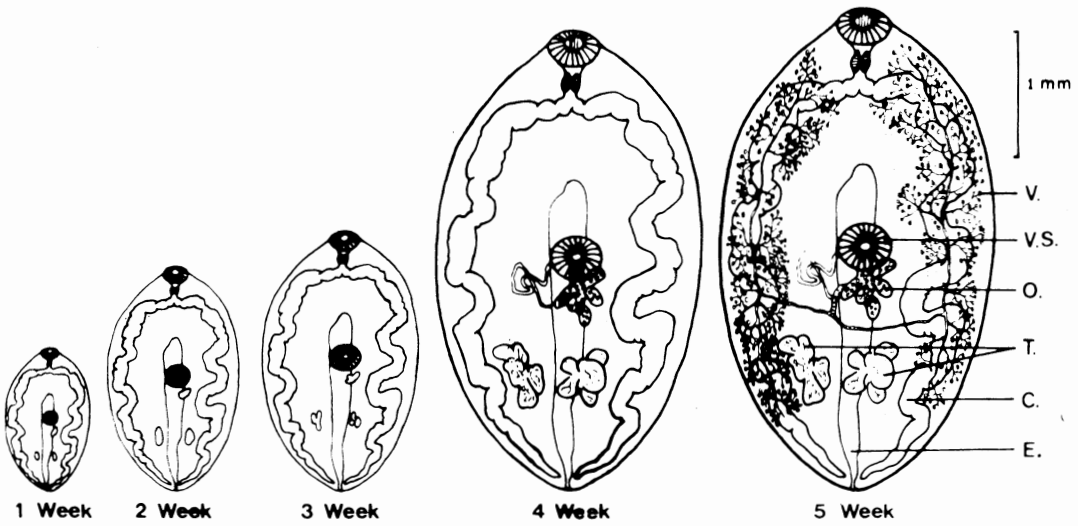

Fig. 1—Drawing of *Paragonimus siamensis* to show the development of the worms 1 to 5 week-old, recovered from white rats. C = caeca, E = excretory bladder, O = ovary, T = testes, V = vitellaria, V.S. = ventral sucker.

On average, the measurement of excysted metacercaria was 0.6 × 0.4 mm., and the worm at one week was 1.1 × 0.6 mm., 2 weeks 1.9 × 0.9 mm., 3 weeks 2.1 × 1.1 mm., 4 weeks 3.8 × 1.7 mm., 5 weeks 3.9 × 2.3 mm., 6 weeks 4.3 × 2.3 mm., 8 weeks 4.4 × 2.3 mm., and old adults at 20 weeks was 5.4 × 3.6 mm. Matured adult at 7 weeks measured 4.4 × 2.3 mm.

It seemed that the worm's body sizes gradually increased until they were sexually mature. During development, the ratio of body length : body width was more or less 2 : 1, and the ventral sucker was slightly larger than the oral sucker, but once sexually mature the body width increased and the ratio of body length : body width became 1.5 : 1, and the oral sucker became slightly larger than the ventral sucker. Throughout development the width of the two suckers was always greater than the length.

The number of worms per cyst ranged from one to five, but usually they lived in pairs.

DISCUSSION

The present study showed that in white rat *P. siamensis* also migrated into abdominal muscle, diaphragm, thoracic muscle, liver and muscle of foreleg in addition to the abdominal cavity, pleural cavity and lung which were reported earlier by Ahmad *et al.*, (1977) who used bandicoot as the host. This pattern of migration agrees with that of *P. westermani* reported by Yokogawa *et al.* (1962) and *P. heterotremus* by Wittayawudthikul (1985 pers, comm.) but differs in site of excystment of the metacercariae. *P. siamensis* excyst in the stomach and the first three centimetres of the small intestine, whereas the other two species excyst in the middle of the small intestine. *P. kellicotti*, *P. miyazakii*, and *P. ohirai* also excyst in the middle of the small intestine (Stromberg and Dubey, 1978; Yokogawa *et al.*, 1964; Okura, 1963). This might be due to the fact that the metacercariae of *P. siamensis* have a thin cyst wall and excyst readily *in vitro* after exposure to strong light.

Yokogawa *et al.*, (1962) demonstrated that *P. westermani* could not develop to the adult in rat, and the route of migration in cat differed from the route in rat. They also suggested that the route of migration of

P. westermani in suitable host was characterized by migration to the muscle of the abdominal wall. It seems that the route of migration of paragonimid worms is determined by the species of parasite and also by the species of host.

P. siamensis recovered from white rats in this study were smaller than worms from bandicoots (Ahmad *et al.*, 1977) and from cats (Miyazaki and Wykoff, 1965). It could be concluded that the size of worms was limited by the size of the hosts, or that the white rat is not a good host for *P. siamensis* even though worms reach sexual maturity.

SUMMARY

After they were ingested, the metacercariae of *Paragonimus siamensis* excysted in the stomach, penetrated through the stomach wall and the first 3 centimetres of small intestinal wall into the abdominal cavity, then penetrated into abdominal muscle. The worms stayed in abdominal muscle for about one week, then appeared again in the abdominal cavity before entering the pleural cavity and lungs; they also appeared in thoracic muscle, diaphragm, liver, and muscle of foreleg.

The worm's size increased steadily until worm reaches sexual maturity then body size increased slowly. Genital primordia could be recognized at one week, of the reproductive system vitellaria were the last to appear at week 5, and eggs were first seen in the 7-week-old worms.

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