# STUDIES ON THE MORPHOLOGY OF CERCARIAE OBTAINED FROM FRESHWATER SNAILS AT ERAWAN WATERFALL, ERAWAN NATIONAL PARK, THAILAND

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Abstract. The morphology of cercariae of freshwater snails from Erawan Waterfall, Erawan National Park, Kanchanaburi Province was studied between December 2002 and August 2003. The snail samples were collected by handpicking using a counts per unit of time sampling method. The cercariae, larva stage of a trematode, were investigated using the shedding method where they were categorized into three groups and six species. The first group, Pleurolophocercous cercariae, consists of *Haplorchis pumilio* ($C_1$) and *Stictodora tridactyla* ($C_3$). The second group, Furcocercous cercariae, consisted of *Mesostephanus appendicalatus* ($C_2$), *Transversotrema laruei* ($C_6$) and *Cardicola alseae*($C_4$). The third group, Xiphidio cercariae, has only one species which is *Loxogenoides bicolor* ($C_5$). Out of 1163 snails, only 62 were found to be infected by cercariae, equivalent to a 5.33% infection rate. The infections grouped by species of the cercariae are as follows: $C_1$ 22 (1.9%), $C_3$ 29 (2.5%), $C_2$ 1 (0.1%), $C_6$ 1 (0.1%), $C_4$ 6 (0.5%) and $C_5$ 3 (0.3%). The freshwater snail samples consist of four species. From a total of 1,163 samples, there are 687 *Melanoides jugicostis*, 91 *Tarebia granifera*, 296 *Thiara scabra* and 89 *Melanoides tuberculata*. Infections were found in 45 (6.5%), 6 (6.6%), 1 (0.3%) and 10 (11.2%), respectively.

## INTRODUCTION

Erawan Waterfall, located in Erawan National Park, Kanchanaburi Province, is not only a beautiful tourist destination but also the source Kwai Yai River, an important river for the residents and communities living on the western part of Thailand. A study of parasitic infections of freshwater snails in this water source directly benefits the local residents and the country as a whole. Most freshwater snails can become intermediate hosts for trematode cercariae which can grow and may be transmitted to people and animals. Since trematode cercariae found in snails have shapes similar to adult trematodes (Malek, 1922a,b), it is therefore possible to categorize trematodes using their morphological characteristics (Ito, 1980), excretory system (Komiya, 1961), and other internal organs.

According to morphological characteristics and excretory systems, trematode cercariae can be classified into 7 groups: Furcocercous cercariae, Pleurolophocercous cercariae, Monostome cercariae, Gymnocephalous cercariae, Echinostome cercariae, Xiphidio cercariae and Amphistome cercariae (Komiya, 1961; Schell, 1962; Malek and Cheng, 1974; Ito, 1980). This classification will be used in our study to distinguish cercariae.

The main objective of the study was to evaluate the parasitic infections of freshwater snails in the study areas, which give a rough idea of the infection rates in humans and ani-

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mals surrounding the areas.

## MATERIALS AND METHODS

The study started from site surveys and GPS measurements of survey spots (Garmin PLUS III, Taiwan), followed by sample collections by handpicking using a counts per unit of time sampling method (Olivier and Schneiderman, 1956). Three collectors handpicked snail samples every 20 minutes. The samples were collected three times, once each season, during the study (December 2002, April 2003, August 2003).

The snail samples were classified by conchology using Brandt's taxonomic key and were examined for parasitic infections with trematode cercariae using shedding and crushing methods. The morphological characteristics of cercariae were studied by employing conventional scanning electron microscopes. The cercariae were measured, sketched, and photographed.

## RESULTS

The areas around Erawan Waterfall consist of several streams and water pools that have water all year round. Limestone mountains are the main topographical characteristics of the areas covered with large and medium sized trees that allow sunlight to pass through to the streams below. Two of the survey points are popular swimming spots for tourists. Their coordinates are N 14º 22′ 11″, E 99º 08′ 42″ and N 14º 22′ 14″, E 99º 08′ 44″.

According to conchological characteristics, the freshwater snails found in this study can be classified into four groups, in the Family Thiaridae. The four groups are *Melanoides jugicostis*, *Tarebia granifera*, *Thiara scabra* and *Melanoides tuberculata* (Fig 1). The 1,163 snails were devided into each of these groups: 687 (59.1%), 91 (7.8%), 296 (25.4%) and 89 (7.6%), respectively.

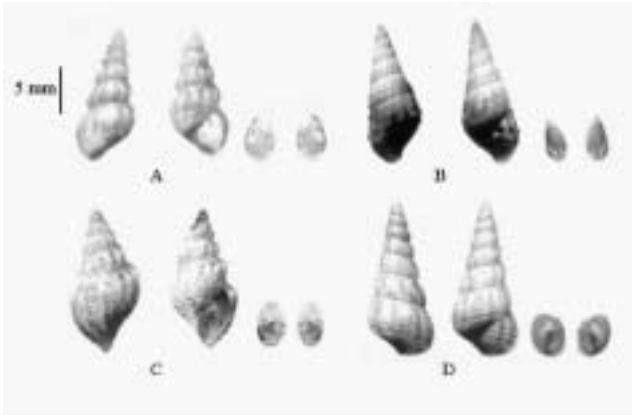


Fig 1–Shell morphology and operculum of snails collected from Erawan Waterfall, Erawan National Park; A: *Melanoides jugicostis*; B: *Tarebia granifera* ; C: *Thiara scabra*; and D: *Melanoides tuberculata.*

Table 1
Snail samples and infection rates in freshwater snails collected three times (three seasons) from Erawan Waterfall. (December 2002, April 2003, August 2003).

| Type of snail | *Melanoides jugicostis* | *Tarebia granifera* | *Thiara scabra* | *Melanoides tuberculata* | Total |
|---|---|---|---|---|---|
| Snail samples | 687 | 91 | 296 | 89 | 1,163 |
| Snail samples infected | 45 | 6 | 1 | 6 | 62 |
| Infection rate (%) | 6.5 | 6.6 | 0.3 | 11.2 | 5.3 |
| Type of cercariae (No. of infected snails) | C1(22), C2(1), C3(22), | C4(6) | C5(1) | C3(7),C5(2), C6(1) | C1(22),C2(1), C3(29),C4(6), C5(3),C6(1) |

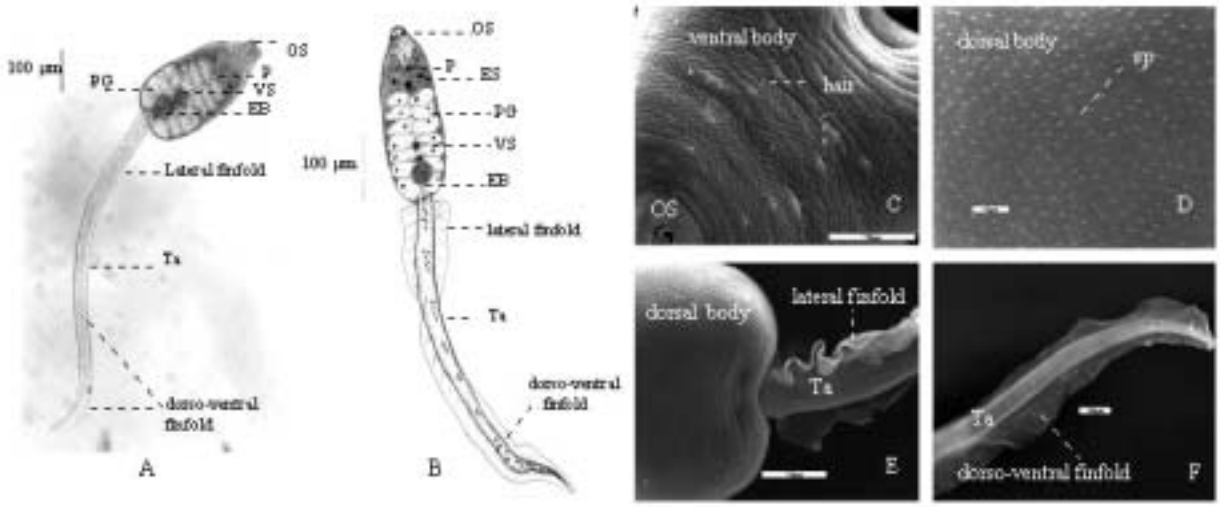


Fig 2–Images of *Haplorchis pumilio* ($C_1$) cercaria; A: light micrograph; B: drawing structure ; C-F: SEM micrographs (OS: oral sucker, ES: eye spot, P: pharynx, PG: penetration gland, VS: ventral sucker, EB: excretory bladder, Ta: tail, sp: spine).

The overall parasitic infection rate was 5.3% (1,163:62) (Table 1). The parasitic infection rate reached a peak in August 2003 where infection rates at survey locations 1 and 2 are 3.4% and 14.1%, respectively. The parasites were classified into three groups (Pleurocercus, Fucocercus, and Xiphidio cercariae) and subdivided into six types ($C_1$, $C_2$, $C_3$, $C_4$, $C_5$ and $C_6$) according to physical characteristics and internal organs as follows.

*Haplorchis pumilio* Looss, 1899 (Yamaguti, 1975) ($C_1$, Fig 2)

This parasite was found in 22 *Melanoides jugicostis*, which is equivalent to an infection rate of 1.9% of the total number of samples. The cercaria body is oval in shape with yellowish brown pigment (Fig 2A-B), covered entirely with fine reverse spines and sensory hairs on the side of the body (Fig 2C-D). A pigmented eye spot and pharynx were present. Seven pairs of penetration glands were arranged in two longitudinal series with ventral sucker and genital primodia in between. Their ducts were in two bundles and opened through the dorsal wall of the oral sucker in two oblique symmetrical rows (four in the front and four in the back). The ventral sucker and genital primodia were prevesicular. The excretory bladder had a round shape and was composed of fine pigment. Cytogenous glands were distributed posteriorly and partly laterally. A long tail was attached to the dorsal end of body, with lateral finfolds nearby and a dorso-ventral finfold for greater distal portion (Fig 2E-F). No flame cells are found in the tail stem.

Average size (in micrometers, calculated from 20 cercariae)

Body: 85-128 (av. 108) x 175-300 (av. 223); oral sucker: 30-45 (av. 37) x 30-45 (av. 37); eye spots: 5x10; pharynx :10-18 (av. 13); ventral sucker: 12-25 (av. 16) x 12-25 (av. 16); excretory bladder: 30-42.5 (av. 35) x 30-42.5 (av. 35); genital primordial:7.5-15 (av. 11.6); penetration gland :12.5-20 (av. 16) x 30-42.5 (av. 34); tail: 8-48 (av. 26) x 450-537 (av. 480); lateral finfolds: 13-25 (av. 22) x 150.

Movement behavior

Floating position. The cercaria floated on the surface or in the water. The body sinks lower than the tail. It moves by rolling up and spring-

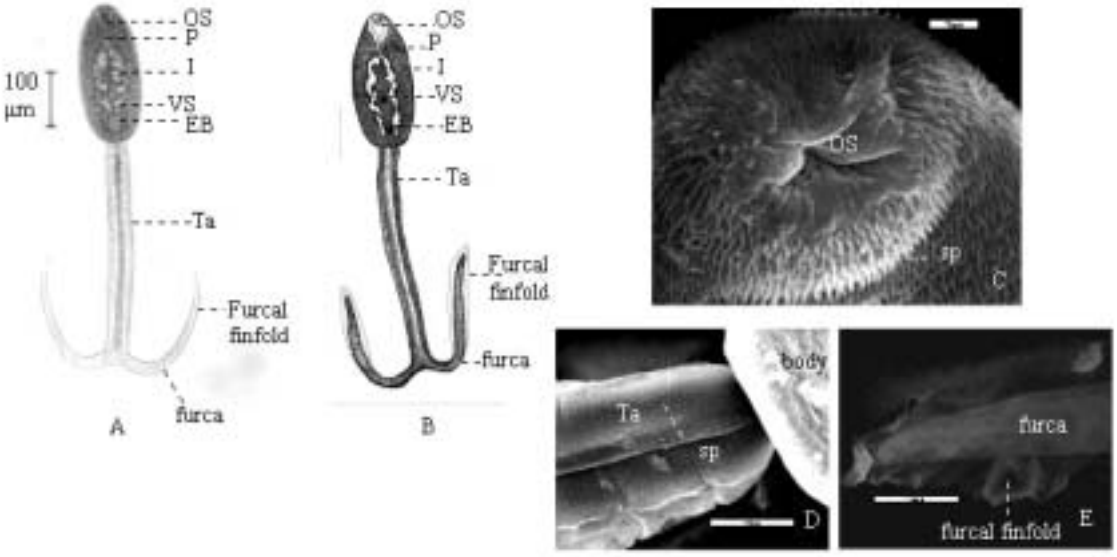


Fig 3–Images of *Mesostephanus appendicalatus* ($C_2$) cercaria; A: light micrograph; B: drawing structure. C-E: SEM micrographs (OS: oral sucker, P: pharynx, VS: ventral sucker, I: intestine, EB: excretory bladder, Ta: tail, sp: spine).

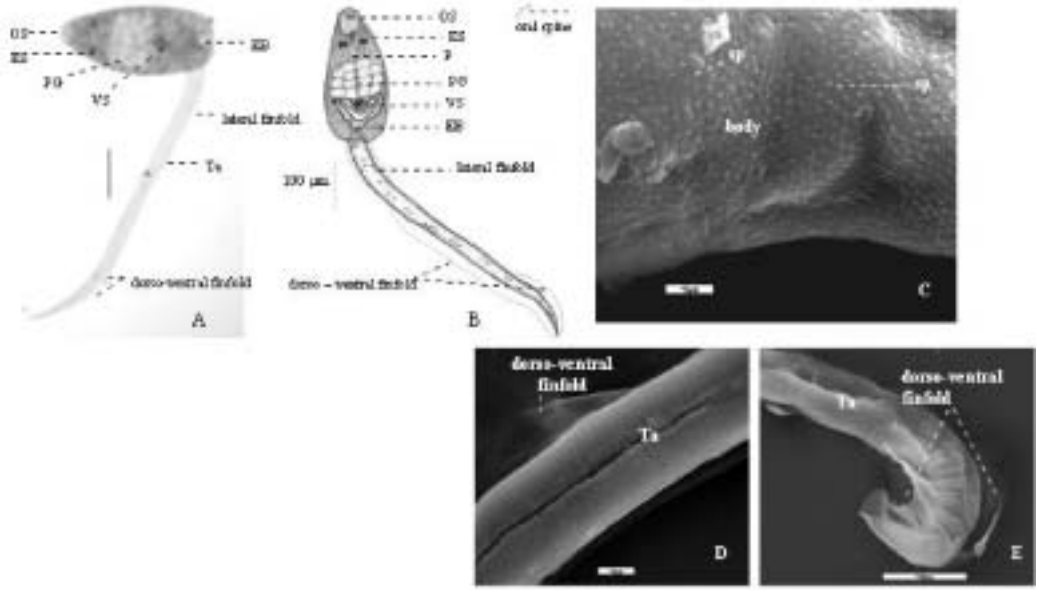


Fig 4–Images of *Stictodora tridactyla* ($C_3$) cercaria; A: light micrograph; B: drawing structure. C-E: SEM micrographs (OS: oral sucker, ES: eye spot, P: pharynx, PG: penetration gland, VS: ventral sucker, EB: excretory bladder, Ta: tail, sp: spine).

ing back the body to move forward in a screwing motion for 2 seconds and then rests for about 16 seconds. At this stage, the body is on top of the tail; it slowly rotates its body to the bottom letting the tail raise up into the floating position.

*Mesostephanus appendiculatus* Ciurea, 1916 (Yamaguti, 1975) ($C_2$, Fig 3)

This parasite was found in only one *Melanoides jugicostis,* which is equivalent to an infection rate of 0.1% of the total number of snail samples. The cercaria body has an

oval shape (Fig 3A-B). The body is also spinose, with many spines on the surface and the oral sucker (Fig 3C). Coarse granules and cytogenous glands are scattered inside the body. The pharynx is small and round. The prepharynx and esophagous are almost as long as the pharynx. A large intestine, composed of two cecae, is terminated near a small excretory bladder. A ventral sucker vestigial was found to be in small groups of early stage cells with 12 cells on the outer ring and 4 cells on the inner ring. The tail was forked and longer than the body and the tail surface was covered with many spines (Fig 3D). The tail stem was longer than the furcae; each furca with a dorsal and ventral finfold continuous from one another over the tip (Fig 3E). The tail tubule opens at the tip of each tail furca in which no flame cell was found.

Average size (in micrometers, calculated from 20 cercariae)

Body: 108-150 (av. 133) x 183-292 (av. 244); oral sucker: 20-67 (av. 38 ) x 25-55 (av. 43); pharynx: 10-18 (av. 16); ventral sucker: 13-30 (av. 20) x 13-30 (av. 26); excretory bladder: 13-30 (av. 21) x 13-30 (av. 21); tail stem: 33-83 (av. 56) x 266-475 (av. 389); tail furcal: 10-34 (av. 25) x 192-334 (av. 281).

Movement behavior

Floating position. The cercaria floated on the surface or in the water. The body sinks lower than the spreading fork tail. It moves by rolling up and springing back the body to swiftly move forward in a semi-circular motion. It then rests by floating with its head on top of the tail and slowly rotates its body to the bottom while lifting up its spreading fork tail. It floats for about 2-6 seconds.

*Stictodora tridactyla* Martin *et* Kuntz, 1955 (Yamaguti, 1975) ($C_3$, Fig 4)

This parasite was found in 22 *Melanoides jugicostis* and 7 *Melanoides tuberculata* which is equivalent to an infection rate of 2.9% of the total number of snail samples. The cercaria body was oval in shape and colored yellowish brown (Fig 4A-B). The body was spinose, with two types of spines: acicular spines and thorn-like spines (Fig 4C). The mouth opening had 3 transverse rows of 4-6, 12-14 and 22-24 spines each. An eye spot was present. Seven pairs of penetration glands extended between the pharynx and excretory bladder in four longitudinal rows (3:4:4:3). Their ducts, in two bundles, opened through the dorsal wall of an oral sucker. The excretory bladder was V-shaped, and had a large, thick wall. The tail was longer than the body and attached to the posterior part of the body. The tail with basal lateral finfolds and dorsal finfolds began a short distance anterior to the posterior end of the lateral finfolds and continued around the tail tip into the ventral finfold which terminated very close to the posterior end of the lateral finfolds (Fig 4D-E).

Aaverage size (in micrometers, calculated from 20 cercariae)

Body: 75-155 (av. 109) x 250-313 (av. 272); oral sucker: 38-50 (av. 40) x 35-50 (av. 40); eye spots: 5-13 (av. 9) x 10-18 (av. 13); pharynx : 10-20 (av. 17) x 15-20 (av. 17); ventral sucker: 10-25 (av. 19) x 10-25 (av. 19); excretory bladder: 40-115 (av. 54) x 50-100 (av. 75); penetration gland: 25-30 (av.27) x 25-30 (av. 27); tail: 30-55 (av. 38) x 475-600 (av. 533); lateral finfolds: 8-15 (av. 13) x 100.

Movement behavior

Floating position. The cercaria floated on the surface or in the water. The body sinks lower than the tail. It moved by turning its body left and right quickly, darting forward in a semi-circular motion for about 7 seconds, and resting for about 27 seconds. At this stage, the body floated on top of the tail; it slowly rotated its body, sinking to the bottom letting the tail float up into the floating position.

*Cardicola alseae* Meade et Pratt, 1965 (Yamaguti, 1975) ($C_4$, Fig 5)

This parasite was found in 6 *Tarebia*

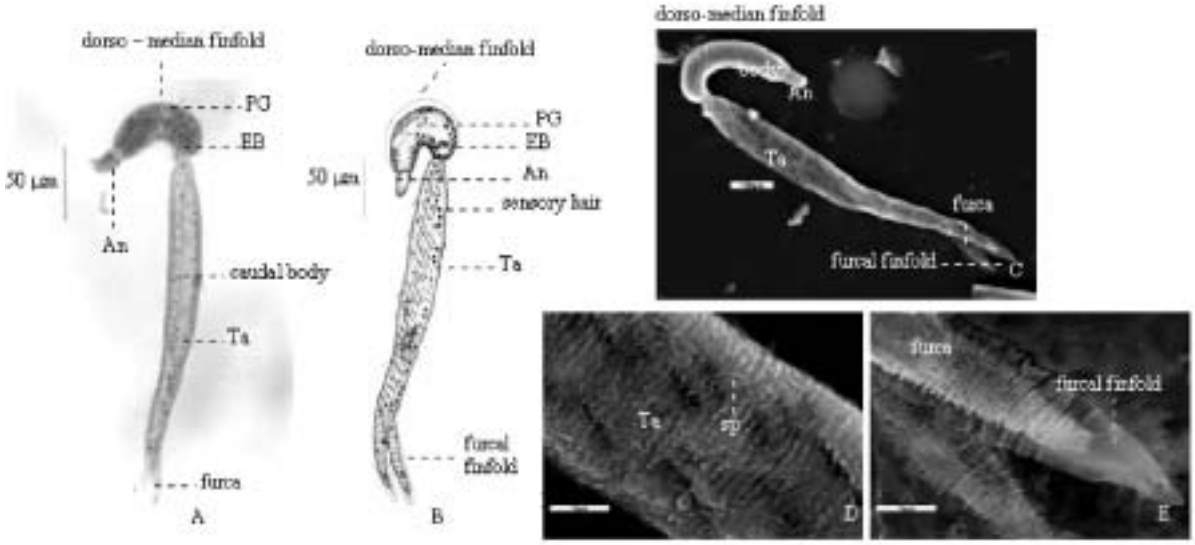


Fig 5–Images of *Cardicola alseae* ($C_4$) cercaria; A : light micrograph; B : drawing structure. C-E : SEM micrographs (An : anterior organ, PG : penetration gland, EB : excretory bladder, Ta : tail, sp : spine).

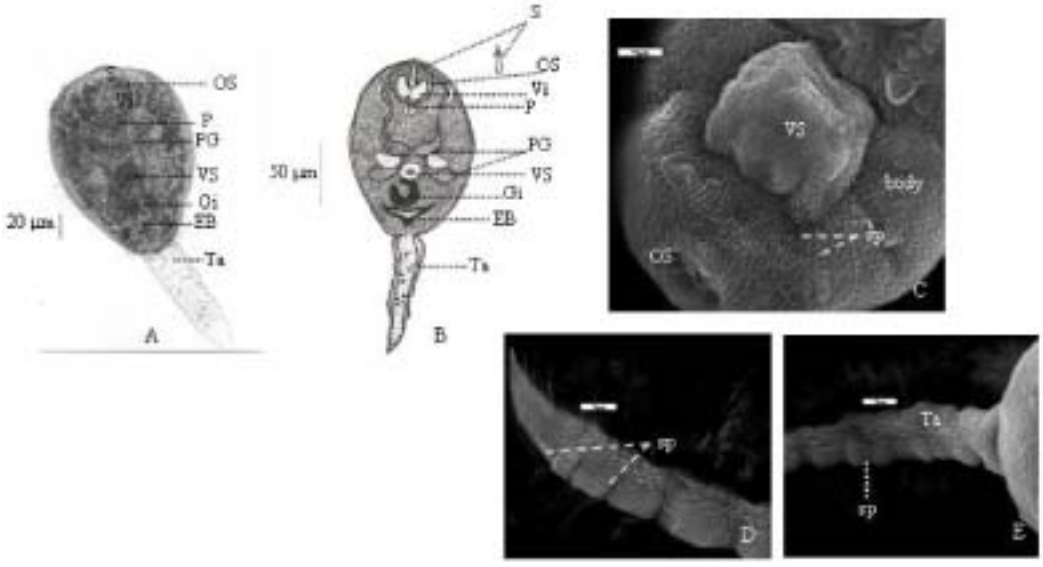


Fig 6–Images of *Loxogenoides bicolor* ($C_5$) cercaria; A : light micrograph; B : drawing structure. C-E : SEM micrographs (OS : oral sucker, Vi : virgulate gland, S : stylet, P : pharynx, PG : penetration gland, VS : ventral sucker, Gi : genital primordia, EB : excretory bladder, Ta : tail, sp : spine).

*granifera,* which is equivalent to an infection rate of 0.5% of the total number of snail samples. The cercaria body had a shape of a small cylinder (Fig 5A-C). The body was covered with minute spines and dotted by brownish granules. The apical papilla had 6 rows of dark spines. A delicate, narrow dorsal fin extended along the body length from the posterior bend to the permanent anterior constriction. A small, thin-walled excretory bladder was present. The tail was forked; the tail stem was longer than the furcase. The tail tubule extended from the bladder through the tail stem branches and opened at the arrowhead-

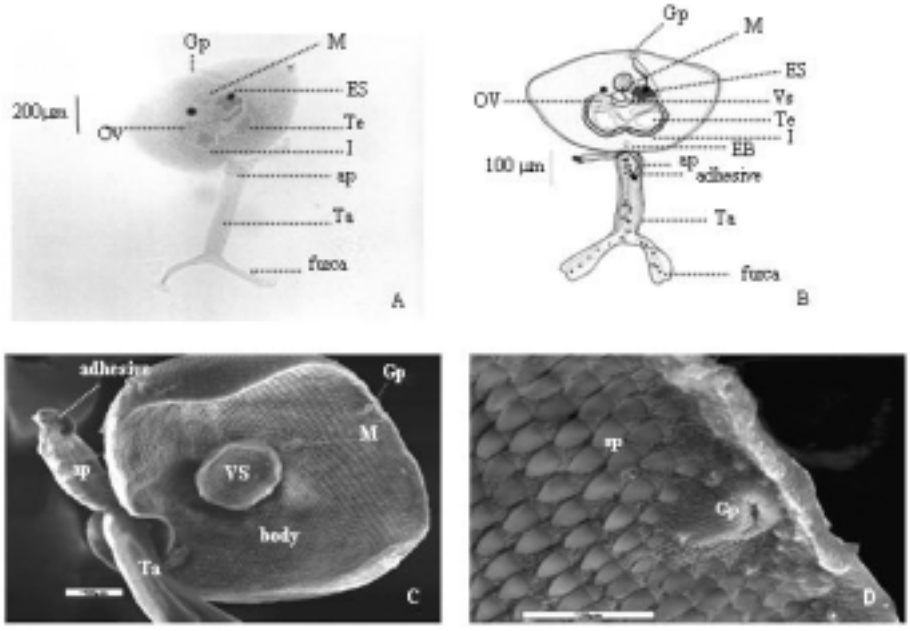


Fig 7–Images of *Transversotrema laruei* ($C_6$) cercaria; A: light micrograph; B: drawing structure. C-D: SEM micrographs (Gp: genital pore, M: mouth ventral, VS: ventral sucker, EB: excretory bladder, Te: testis, Ov: ovary, I: intestine, ap: appendages, Ta: tail, sp: spine).

shaped tip of the furca. No flame cells were found in the tail. The tail surface was covered with many minute spines and sensory hairs (Fig 5D). Finfolds were present on the surface of the furcae (Fig 5E).

Average size (in micrometers, calculated from 20 cercariae)

Body: 15-35 (av. 26) x 75-100 (av. 91); anterior organ: 13-16 (av. 14) x 16-21 (av. 19); excretory bladder: 2-10 (av. 4) x 10-38 (av. 17); tail stem: 13-28 (av. 24) x 166-200 (av. 180); tail furcal: 5-12 (av. 9) x 25-55 (av. 48); dorso-median finfold: 5-13 mm (av. 7).

Movement behavior

Floating position. The cercaria floated on the surface of the water with its body and tail slightly curled up. By curling its body to its tail, it moved forward for about 5 seconds and rested for about 1-2 seconds. It then rested by floating body on top of the tail and slowly rotated its body to the bottom while lifting up its spreading fork tail.

*Loxogenoides bicolor* Kaw, 1945 (Yamaguti, 1975) ($C_5$, Fig 6)

This parasite was found in 2 *Melanoides tuberculata* and 1 *Thiara scabra* which is equivalent to an infection rate of 0.3% of the total number of snail samples. The cercaria body was spinose and had an oval shape. Its entire body was dotted with granules. The ventral sucker was smaller than the oral sucker. A virgula organ was located in the region of the oral sucker. A stylet was present (Fig 6A-C). Three pairs of penetration glands exist: two anterior pairs with fine granules and a posterior pair with coarser granules staining darker with neutral red. All ducts opened near the tip of the stylet. There was a C-shaped genital primordial (Fig 6B) and a U-shaped excretory bladder. Attached to the posterior part of the body, the tail was shorter than the body. The tail was also spinose, with slightly longer spines at the tip (Fig 6D-E). Three to five groups of pigments were present in the tail. No flame cells were found.

Average size (in micrometers, calculated from 20 cercariae)

Body: 57-85 (av. 72) x 92-120 (av. 102); stylet: 4-5 (av. 4.5) x 16-20 (av. 18); virgulate gland: 8 x 8-15 (av. 12); oral sucker: 22-30 (av. 25) x 20-30 (av. 24); pharynx: 3-6 (av. 5) x 3-10 (av. 8.5); ventral sucker: 10-18 (av. 13) x 11-20 (av. 13); excretory bladder: 5-10 (av. 6.5) x 12-35 (av. 18); tail: 13-24 (av. 20) x 44-12 (av. 72).

Movement behavior

Floating position. The cercaria floated on the surface or in the water. The body sinks lower than the tail. It moved by folding its tail back to the body and turning its body to roll from left to right quickly, darting forward for about 90 seconds, and resting for about 5 seconds. At this stage, the body overturns and sinks lower than the tail.

*Transversotrema laruei* Velasgues, 1958 (Yamaguti, 1975) ($C_6$, Fig7)

This parasite was found in 1 *Melanoides tuberculuta,* which is equivalent to an infection rate of 0.1% of the total number of snail samples. The cercaria had a flat dish-shaped body, a wide, short body, colored yellowish brown (Fig 7A-B). The body surface was covered with scale-like spines and dotted with course granules. Eye spots are large and just posterior to the pharynx. The mouth was ventral. An oral sucker was absent. The esophagus was narrow, comparatively long, and bifurcated. Testes were symmetrical and just inside the ceca. The genital pore was median, on the anterior aspect of the body (Fig 7D). The ovary was anterolateral to the left testis. A large ventral sucker was present and covered with spines (Fig 7C). The tail was longer than the body and attached to the posterior part of the body. The tail furca was spatulate, thin, and notched at the distal end. The tail excretory tube was open outside at the indentation furca. There were four pairs of flame cells in the tail. At the base of the tail were a pair of bilaterally symmetrical appendages each with an adhesive pad at the distal end (Fig 7C).

Average size (in micrometers, calculated from 20 cercariae)

Body: 338-750 (av. 508) x 200-480 (av. 301); genital pore: 10-18 (av. 14); pharynx: 10-63 (av. 46) x 30-55 (av. 49); esopahagus: 25-50 (av. 36); eye spot: 15-20 (av. 17) x 15-20 (av. 17); excretory bladder: 8-25 (av. 10); ventral sucker: 80-100 (av. 94) x 80-100 (av. 96); testis: 45-93 (av. 59); ovary: 20-75 (av. 33); appendage: 15-70 (av. 39) x 113-280 (av. 154); tail stem: 35-190 (av. 81) x 225-600 (av. 351); tail furcal: 20-100 (av. 50) x 125-300 (av. 184).

Movement behavior

Floating position. The cercaria floated on the surface or in the water. The body sinks lower than the tail. It moved by turning its body left and right quickly, going forward in a screwing motion for about 5 seconds, and resting for about 1-2 seconds. At this stage, the body folded back to the tail and sinks lower than the tail or it sometimes rolls from left to right at the bottom.

When comparing the infection rates of all six types of cercariae, *Haplorchis pumilio* ($C_1$) and *Stictodora tridactyla* ($C_3$) cercariae had the highest rates. They were found in 22 and 29 snails, respectively. In addition, snails could be infected by cercariae of more than one type.

## DISCUSSION

It was found that the snails from stations 1 and 2 captured during different seasons had similar shell size and characteristics. This result suggests the snails were in the homologous life stage (adult stage).

The classification of snails is made by shell characteristics (*ie*, shell shape, number of whorls, structure of operculum, color, etc). All of the snails are classified into the family Thiaridae which includes *Melanoides*

*jugicostis, Tarebia granifera, Thiara scabra,* and *Melanoides tuberculata*. The number of snail samples found in the four snails above were 687 (59.1%), 296 (25.4%), 91 (7.8%) and 89 (7.6%), respectively. In Thailand, the snail family Thiaridae, as reported by Brandt (1974), is found in lakes, ponds, marshes, canals, streams, rivers and sources of river, such as waterfalls. The snail genus *Melanoides jugicostis* has never been reported in Kanchanaburi (Brandt, 1974). However, they were found in large numbers in this study.

At the first sampling site, 17 of 661 snails were infected (2.6%) and 45 of 502 (9.0%)snails were infected at the second sampling site. The infection rates reached their peak in August 2003, which was in the rainy season. The high infection rates were probably because the rain had washed animals feces into the water allowing the parasites to spread easily and quickly.

Pleuroplocercus cercariae are found in the Superfamily Opisthochiodea (Faust, 1929). The cercaria body is oval in shape. The penetration gland is well-developed while the ventral sucker is vestigial or absent. The tail is provided with dorso-ventral and sometimes lateral finfolds; pigmented eye spots are present (Schell, 1962; Malex and Cheng, 1974). The cercaria can be classified into two groups according to morphological characteristics.

Cercaria type 1 ($C_1$) was found in freshwater snails *Melanoides jugicostis*. The cercaria are oval in shape and covered with yellowish brown pigments. Granules are scattered throughout the body. Many minute spines are present on the body surface. An incompletely developed ventral sucker is smaller than the oral sucker. There are seven pairs of penetration gland cells. Pigmented eye spots are present. A globular excretory bladder is at the posterior end of the body. The tail is longer than the body with lateral finfolds on the anterior part of tail, and a dorso-ventral finfold on the posterior part of tail. This form is subdivided into Parapleurolophocercous cercariae (Schell, 1970). The cercariae develop in rediae in operculate snails and they have been reported in the family Heterophyidae (Odhner, 1914) whose adult flukes are found in intestine of mammals and sometimes humans. These cercariae resemble *Haplorchis pumilio* (Looss, 1896) which develop in radiae in *Melania reiniana* var. *hidachiensis* and *Melanoides tuberculata chinensis*, and encyst in pectoral fins and the base of the tail fin of fishes *Carassius* and *Cyprinus* (Yamaguti, 1975).

Cercaria type 3 ($C_3$) is found in *Melanoides jugicostis* and *Melanoides tuberculata*. The cercaria is oval in shape, spinose, and colored with yellowish brown pigments; granules are scattered throughout the body; penetration gland cells are aligned in four logitudinal rows (3:4:4:3); pigmented eye spots are present; the ventral sucker is smaller than the oral one; there is an excretory bladder oval, V-shaped with a thick wall; the tail is longer than the body; lateral finfolds are on the anterior part of the tail and the dorso-ventral finfold on the posterior part of tail. This form is subdivided into Parapleurolophocercous cercariae (Schell, 1970). The cercariae develop in rediae in operculate snails and they have been reported in the family Heterophyidae Odhner, 1914, whose adult flukes are found in intestine of mammals and sometimes humans. This type of cercaria resembles *Stictodora tridactyla* Martin et Kunts, 1955, the cercariae that will become adult flukes in vertebrates; these cercariae develop in radiae in *Pirenella conica,* and encyst in visceral organs and connective tissue in the head of the fish *Aphaninus faciatus* (Yamag uti, 1975).

Furcocercous cercariae (fork-tailed cercariae) are subdivided into two groups: Longifucate pharyngeate cercariae and Lophocercus-a pharyngeate cercariae.

Longifucate pharyngeate cercariae has been reported in the Superfamily Strigeoidea. The cercariae are usually longifurcate, the tail

stem is at least half as the long as the furcae, the body is oval in shape, the oral sucker, pharynx and intestine are well developed, the ventral sucker is vestigial; and there is a small excretory bladder and body without a dorso-median finfold (Schell, 1962; Malek and Cheng, 1974). In this study cercaria type 2 ($C_2$) and cercaria type 6 ($C_6$) were classified into this group.

Cercaria type 2 ($C_2$) was found in *Melanoides jugicostis.* The cercariae are oval in shape, have a forked tail longer than the body, a pharynx is present, the intestine is well developed and the ventral sucker is vestigial. Each furca has a dorso-ventral finfold, characteristic of the Vivax cercaria (Schell, 1970), and they develop in the filiform sporocyst in the snail. This type of cercariae resembles *Mesostephanus appendiculatus* (Ciurea, 1916) Lutz, 1935, whose sporocyst develops in *Cerithidea californica* (Yamaguti, 1975).

Cercaria type 6 ($C_6$) was found in *Melanoides tuberculata.* The cercaria have a body which is flat and dish-shaped, wide and short, covered with scale-like spines and yellowish brown in color. A pharynx is present, the intestine is well developed, the tail is forked, the tail stem is longer than the furcae, with bilaterally symmetrical appendages, each with an adhesive pad at the distal end at the base of the tail and the tail furca is spatulate. These cercariae resemble *Transversotrema laruei* Velasgues, 1958, the adult flukes of which are found in fishes. There is a report that their rediae develop in *Thiara riguettii* and metacercaria are found under the scales, in the opercula cavity or gills, especially in the muscle of *Lates calxarifer* and *Mollienesia latipinna* (Yamaguti, 1975).

Lophocercous-apharyngeate cercariae has been reported in the Superfamily Schistostomatoidea. The cercariae are brevifurcate, the tail stem is longer than the furcae, with an oval body. The oral sucker replaced by an extensible penetration gland. There may or may not be pigmented eye spots, there is a dorso-median finfold on the body and a small excretory bladder (Schell, 1962; Malek and Cheng, 1974). Cercaria type 4 ($C_4$) belongs to this group.

Cercaria type 4 ($C_4$) was found in *Terebia granifera.* The cercaria body is cylindrical in shape, is small in size, the anterior organ is protrusible, the pharynx is absent, there are dorso-median finfolds on the body and the penetration glands are all one kind. These cercariae are similar to *Cardicolinae alseae* Meade et Pratt, 1965, whose sporocysts develop in snails of the genus *Oxytrema silicula* (Yamaguti, 1975) and adult flukes in fishes (Schell, 1970).

Xiphidiocercariae are produced by species in the Superfamily Plagiorchioidea. The cercaria is body oval in shape, an oral and ventral sucker are present, the oral sucker is equiped with a stylet, there may or may not be a virgula organ, the excretory bladder is small and thin-walled and the penetration gland is developed (Schell, 1962; Malek and Cheng, 1974). Cercaria type 5 ($C_5$) falls into in this group.

Cercaria type 5 ($C_5$) is found in *Melanoides tuberculata* and *Thiara scabra.* The cercaria body is oval in shape, white in color, and small in size. A stylet is present in the oral sucker and it has a virgula organ, characteristic of Virgulate cercariae (Schell, 1970). The genitalia are primodial C-shaped, there is a U-shaped excretory bladder at the posterior end of body, the tail is spinose and shorter than body and many granules can be seen within the whole length of the tail. The cercariae develop in filiform sporocyts and adult flukes belong to family Lecithodeneriidae Odhner, 1910. These cercariae bear a resemblance to *Loxogenoides bicolor* Kaw, 1945, whose sporocysts are found in *Gonibasis depygis,* and adult flukes in amphibians (Yamaguti, 1975).

In this study, the snail family Thiaridae were intermediate hosts of the cercariae of six types. *Cardicola alseae* Meade et Pratt, 1965

($C_4$) was found in snails of the genus *Tarebia granifera. Haplorchis pumilio* Loos, 1896 ($C_1$) and *Mesostephanus appendicalatus* Ciurca, 1916 ($C_2$) were found in snails of the genus *Melanoides jugicostis*. *Transversotrema laruei* Velasgues, 1958 ($C_6$) was found in *Melanoides tuberculata*. *Stictodora tridactyla* Martin et Kunts, 1955 ($C_3$) and *Loxogenoides bicolor* Kaw, 1945 ($C_5$) were found in snails of more than one genus. The results suggest that the cercariae *Cardicola alseae* Meade et Pratt, 1965 ($C_4$) are more specific to intermediate hosts (*Tarebia granifera*) than the other cercariae, while *Melanoides tuberculata* can be intermediate hosts for several species of cercariae. The highest infection rate was found in *Melanoides jugicostis*; 8 snail samples from station one were infected (2.4%) and 37 out of 351 snail samples from station two were infected (10.5%) (Table 1).

In Thailand, there are very few reports of cercariae. In this study the cercariae were compared to cercariae found in morphology reports from other countries, but only to some extent since the relationship between cercariae and intermediat hosts varies from country to country. The data of cercariae infection rates in this study are somewhat limited due to the fact that the snail samples were collected only three times over a one-year period, *ie* during each of the three seasons. To further improve the results and accuracy of the study, one should collect snail samples periodically to monitor infections in snails each month. The authors believe this study will be invaluable to the understanding of biodiversity and public health.

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