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TWO NEW GASTROPODS, *ELYSIA BANGTAWAENSIS* AND *E. SIAMENSIS* FROM SOUTHERN THAILAND (OPISTHOBRANCHIA, SACOGLOSSA, ELYSIIDAE)

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Key words: Mollusca, Sacoglossa, Elysiidae, *Elysia*, Thailand.

ABSTRACT

Two new *Elysia* species were found in brackish mangrove habitats in the southern part of the Gulf of Thailand in the area around Pattani. *Elysia bangtawaensis*, a large species with grooved rhinophores, was discovered living on bare mud in mangrove forests. This species looks like a fallen leaf and shows sophisticated phototrophic behaviour enabling it to survive without feeding while producing many eggs over a long period. *Elysia siamensis*, a small species, was found on filamentous green algae in a brackish channel. The latter species has long, thin, cylindrical rhinophores, and is further characterized by a screw-like penis, and a long thin process on the tip of its metapodium.

INTRODUCTION

Only two species of the Sacoglossan family Elysiidae were found during a survey for molluscs in the southern part of the Gulf of Thailand near Pattani. Both belong to the genus *Elysia* (see Jensen (1992) for characteristics of the family and its generic division). Most *Elysia* species live on algae in rather accessible marine habitats such as tidal pools on rocky shores, seagrass meadows, or sublittoral algal beds. However, the Thai species were living in a muddy, brackish environment: one on bare soft mud on the floor of mangrove forests, the other on green algae in channels within a soft mud mangrove area. Neither species could be identified with already described forms and are therefore described as new.

DESCRIPTIVE PART

Elysia bangtawaensis nov. spec. (Fig. 1, A-O)

MATERIAL

On 30 March 1997, about 30 specimens were found within a mangrove (mainly *Rhizophora* spp.) forest at 06°

51'28"N, 101° 09'31"E, near the village of Bang Tawa, about 11 km west of Pattani. The living slugs had a length of 35-51 mm.

On 6 April 1997, two specimens were found in a mangrove forest in the inner part of Pattani Bay at 06°53'50"N, 101°20'50"E, near Dato village, about 12 km northeast of Pattani. The living slugs had a length of 28-37 mm.

On 22 July 1997, eleven specimens were found in a ditch at 06°52'17"N, 101°18'48"E, near Di village, about 6 km east of Pattani. The slugs had a length of 32-45 mm.

The species is named in honour of the people of Bang Tawa village, where the first specimens were discovered in the mangrove forest. [The villagers have protected their forest against the shrimp culture companies that are converting large parts of the natural productive and complex coastal ecosystems into 'bio-industrial deserts'.]

The description is based on the specimens collected near Bang Tawa. One specimen has been selected as holotype and is deposited in the Zoologisch Museum Amsterdam (ZMA Moll. 3.98.001), together with four paratypes (ZMA Moll. 3.98.002). The specimens from the other localities are similar to those from Bang Tawa.

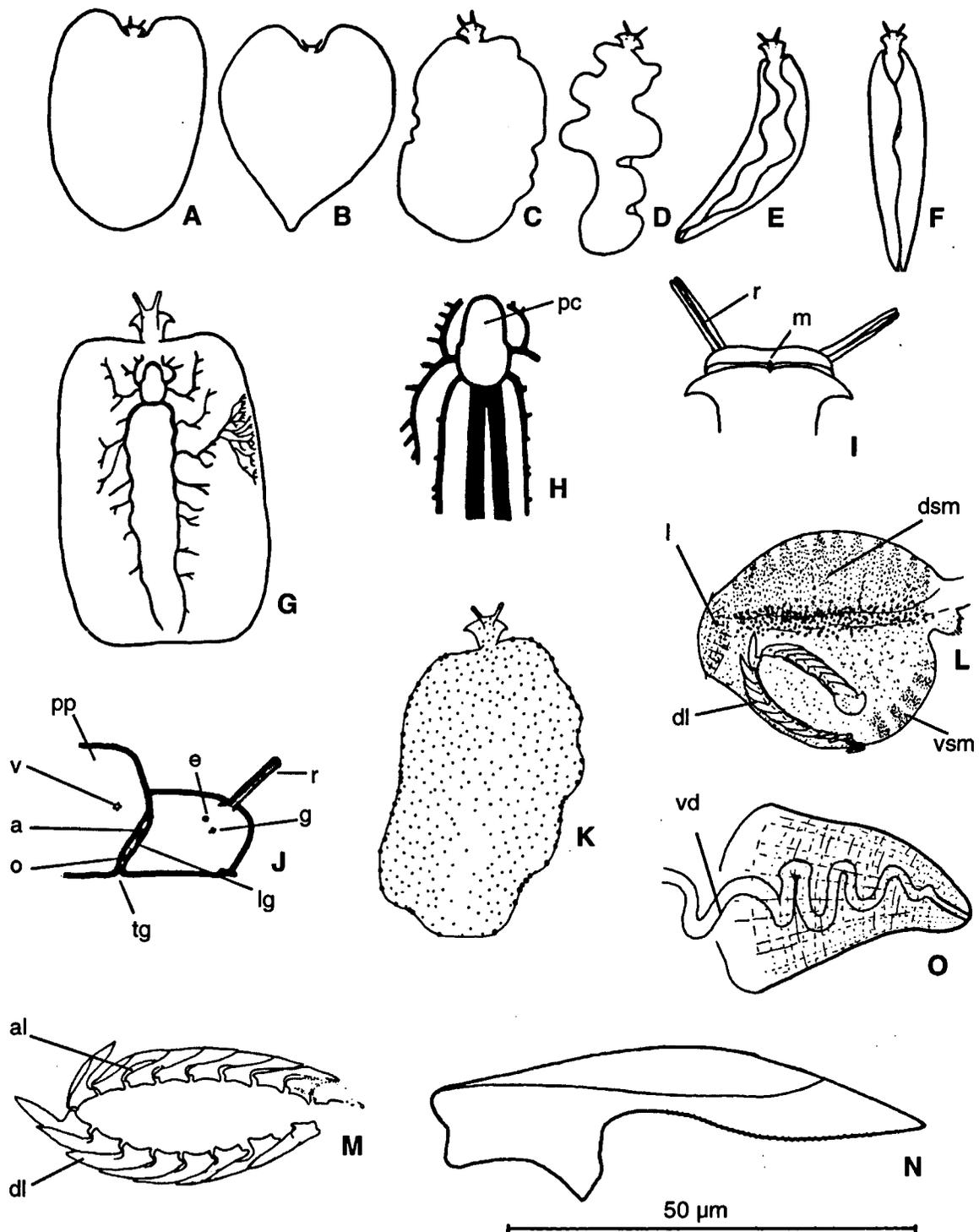


Fig. 1 A-O. *Elysia bangtawaensis* nov. spec.

A-F. Dorsal views of living specimens in various stages of expansion or contraction. G. Pericardial bulb and main stems of dorsal vessels in expanded slug. H. Pericardial bulb and main stems of dorsal vessels in creeping slug. I. Ventral view of anterior part of living slug. J. Lateral view of right side of anterior part of body. K. Dorsal view showing the reddish-orange glands on the parapodial margins (large dots) and the distribution of the large opaque white glandular spots. L. Pharynx. M. Lateral view of complete radula. N. Lateral view of radular tooth (scale line is 50 μ m). O. Penis.

a - anus; al - ascending limb; dl - descending limb; dsm - dorsal septate muscle; e - eye; g - gonopore; l - pharyngeal lip; lg - lateral groove; m - mouth; o - oviduct; pc - pericardium; pp - parapodium; r - rhinophore; tg - transverse groove; v - vagina; vd - vas deferens; vsm - ventral septate muscle.

External appearance

Living specimens of *E. bangtawaensis* have a length of up to 51 mm. Their shape is extremely variable, varying from flat and very thin to a large sized, 'normal' *Elysia*. The shape depends strongly not only on whether the slug is still or creeping, disturbed or undisturbed, but also on the amount of available light.

The head is small and narrow. The rhinophores are short and thin, longitudinally grooved on the frontal side over their whole length. Their length is only slightly greater than the width of the foot behind the eyes. The eyes are far apart laterally behind the rhinophores, in small inconspicuous areas lacking colour.

The anterior border of the parapodia is in front of the pericardial hump; their posterior border unite with the metapodium. The parapodia can expand enormously, particularly sideways. This makes the slug look like a leaf, an impression that is reinforced by the extensively branched vessels on the dorsal side. The parapodia can also be kept curled up, or contracted in parts or over the whole, which gives the slug a totally different appearance (Fig. 1 A-F).

The pericardium is elongate, about twice as long as wide. Most specimens have three pairs of dorsal vessels which branch up densely to the parapodial border. The prominent pair is connected with the posterior wall of the pericardium. They extend to near the posterior border of the parapodia. On the latero-posterior sides of the pericardium are two, in some specimens three, less prominent vessels. The most anterior ones branch to the anterior and latero-anterior parts of the parapodia. Some anastomosis may be present in the branches in the frontal part of the parapodia and along the border. No branches occur above the foot area. The vessels are usually swollen, but can be found flat and less conspicuous. The vessels of the major pair are parallel and close together, or they separate with a wide bend, depending in the degree of contraction of the parapodia (Fig. 1 G, H).

The foot sole is divided into two parts by a transverse groove somewhat behind the anterior point of attachment of the parapodia. The groove is shallow and can easily be overlooked in both living and preserved specimens. The anterior border of the foot is curved and notched. The antero-lateral corners are pointed (Fig. 1 I). The second part of the foot is weakly developed with no clear demarcation between foot and parapodia.

There is a lateral groove on the right side of the body (Fig. 1 J). It starts near the frontal point of attachment of the right parapodium and slants across to the transverse groove in the foot sole. The anus is in the upper part of the lateral groove. The opening of the oviduct is in the lower part of the groove. The vagina is in the body wall under the right parapodium. The male gonopore is a little in front of and below the right eye, nearly touching the spotless eye-field (Fig. 1 J).

The colour of living *Elysia bangtawaensis* appears uniformly dark green with a series of 12-40 prominent, reddish-orange spots along the outer margins of the parapodia.

Less prominent opaque white spots and still smaller, white and reddish-orange specks of varying size are visible on the dorsal and ventral sides of the body, including parapodia, foot, pericardium and rhinophores. The reddish-orange spots are glands that protrude from the epidermis; they contain an orange hydrophobic fluid. The white spots also protrude from the epidermis. Their content looks more granular. The large white spots and the white and orange specks are well dispersed and do not show a specific pattern or local concentrations (Fig. 1 K). There is no epidermal pigmentation other than the red and white glands. The green colour is located in a net of very fine, branched 'threads' in which no main stems are visible. The intensity of the green varies depending on the degree of contraction and locally on the degree to which the reproductive organs shine through.

Internal features

The pharynx is remarkably small. It is about the size of the central ganglia, a dark band of pigment on its sides making it distinguishable. The dorsal septate muscles reach to the pigment band (Fig. 1 L). The ventral septate muscles are visible, but the ascus muscle is vestigial. The limbs of the radula are short. There are 7-9 teeth in the ascending limb and similar numbers in the descending part (Fig. 1 M). The ascus is not prominent and contains only a few teeth. In a few dissected specimens the teeth in the ascus seemed to lie in a short channel below the pharynx; in one specimen the ascus seemed to be a continuation of the descending limb in which the teeth were in disorder. The teeth are small, blade-shaped and have about 32 very fine denticles (Fig. 1 N). The teeth in animals of 35-48 mm length are all of about the same size, about 67 μm total length.

The small muscular penis is conical and has no armature (Fig. 1 O). The numerous small spherical gonads are within the parapodia, in a single layer when the parapodia are fully expanded, in multiple layers when contracted. The outer ones are male follicles; those nearer to the centre are female. The thin ductules are arranged ventrally, but the whole system is so tightly embedded in parenchymatic tissue, consisting mainly of sticky green fibres, that the structure of the reproductive system could not be clearly discerned.

Reproduction

The egg strings are long and thin, up to 320 mm long and about 0.5 mm wide. At the end of the laying period, the egg strings are considerably shorter. Most strings do not have a definite shape. They may appear as tight, unattached balls, or as wide loops. Some strings show only a tendency to spiral whilst others are very spiral-shaped. The possibility of fixing the string onto a solid object during laying seems to be an important factor in its shape. The eggs in the strings are not arranged in any obvious pattern. They are close together, about 6-10 eggs per cross-section. There is no extra-capsular yolk in the string as described in some other *Elysia* species (Boucher, 1983;

Jensen, 1986). Fresh eggs are yellowish, older ones whitish. The transparent gelatinous string is uncoloured. The size of fresh egg capsules is $127 \pm 6 \mu\text{m}$ by $106 \pm 4 \mu\text{m}$. A few capsules contain two or three fresh eggs. These capsules are slightly larger, but have less free space inside. The veliger larvae hatch within a week at temperatures varying between 20 and 27°C. The shells of newly hatched larvae measure about 112 by 87 μm .

Habitat and Behaviour

In the mangrove forests near the villages of Bang Tawa, Di and Dato, the slugs were found lying expanded on a soft mud bottom in small, shallow pools during low tide.

Salinity on the site near Bang Tawa varied between 20‰ to 35‰, and near Di between 7‰ to 15‰, but salinity was measured only a few times. The salinity may fluctuate more widely over the year. In addition, the site near Dato is also brackish, with fluctuating salinity (Swennen, 1996). In aquarium tests, the slugs showed normal behaviour and survived for several days in salinities as high as 37‰ and low as 4‰. At 2‰, test slugs died after little more than one day.

No macro algae were present in the surroundings when the slugs were found. However, in October it was discovered that a small green alga *Derbesia* cf. *marina* was growing in the same area in the stiff mud between mangrove roots above mean high tide level. The alga is probably not submerged during normal and most high spring tides during the summer months. In winter, mean sea-level in the area is about 30 cm higher and the algae will be submerged for some time during most of the higher high tides. An aquarium experiment showed that the slugs suck the cytoplasm out of *Derbesia*.

A number of slugs were kept in containers with seawater without algae and taken to The Netherlands. Among these captive slugs, the first copulations were observed on 7 April. During copulation a pair of slugs formed a tight knot in which it was difficult to see whether it contained one or two slugs. Egg-laying started on 8 April. The slugs then produced egg strings regularly. The last egg strings were produced on 26 June. In the meantime, the slugs slowly shrank until they measured 20 mm in length. Thereafter they lost their green colour, shrank further and most of them died, one by one. On 25 October, one appeared to be still alive, but it had shrunk to a length of 10 mm. It was given a bunch of *Derbesia* cf. *marina*, started feeding and regained its green colour. Three weeks later it had grown to 21 mm in length.

In captivity, the slugs show a marked phototaxis. Around sunrise they lie immobile with the parapodia widely expanded. They contract their parapodia when the light becomes stronger, and contract them further and close them over the back in still stronger light; meanwhile they begin to creep. They then concentrate in a spot where the light intensity is lower. In glass containers without any cover, the slugs creep close together trying to push under each other. If there is a leaf or piece of dark plastic, they

seek cover underneath. In a glass container with soft mud on the bottom, they hide wholly or partly under the surface layer of the mud. When the light intensity becomes lower, and also in the afternoon when the sun goes down, they disperse, return to the open and expand their parapodia. The same behaviour can be induced with lamp light. Contracting the parapodia and curling them up also occurs when the slug is suddenly touched or disturbed in any way.

DISCUSSION

There are only a few large (>25 mm) *Elysia* species known from tropical waters. All differ from *E. bangtawaensis* in several characteristics. *E. leucolegnote* Jensen, 1986, described from Hong Kong, has in common with *E. bangtawaensis* that it also resembles a green leaf by holding its parapodia open, and is also a true mangrove species. However, it differs in having only two veins entering the pericardium, a white line along the parapodial margins, a triangular white patch on the dorsal surface of the head up to the dorsal surface of the rhinophores, narrow radular teeth with recurved tips, and an egg string that contains a band of extra-capsular yolk material.

The other large species, *E. bennettiae* Thompson, 1973, *E. grandifolia* Kelaart, 1858, *E. marginata* (Pease, 1871), *E. ornata* (Swainson, 1840), *E. ornata* (Pease, 1860), *E. rufescens* (Pease, 1860) and *E. yaeyamana* (Baba, 1936) have brightly coloured edges and submarginal bands along the parapodial borders, larger radular teeth, and are reported from non-mangrove habitats. Some of these names are synonyms, but there is much confusion about the nomenclature of these species (Marcus & Marcus, 1963; Thompson, 1973; Carlson & Hoff, 1978; Jensen, 1986; Jensen & Wells, 1990).

Elysia siamensis nov.spec. (Fig. 2, A-H)

MATERIAL

On 6 April 1997, nine specimens were found on a mixture of filamentous green algae along the shallow bank in the Yaring River estuary (06°53'27"N, 101°22'E). The living slugs varied in length between 9 and 12 mm. The animals were taken to the laboratory and after a short inspection preserved in formalin as there was insufficient time to observe them alive. They were found together with some juvenile specimens of the nudibranch *Gymnodoris pattani* Swennen, 1996. The type locality of both species is exactly the same. The new species is named after Siam, the former name of Thailand.

The description is based on the specimens collected on the Yaring River. One specimen has been selected as holotype and is deposited in the Zoologisch Museum Amsterdam (ZMA Moll. 3.98.003), together with six paratypes (ZMA Moll. 3.98.004).

External appearance

Living specimens have a length up to 12 mm. The head

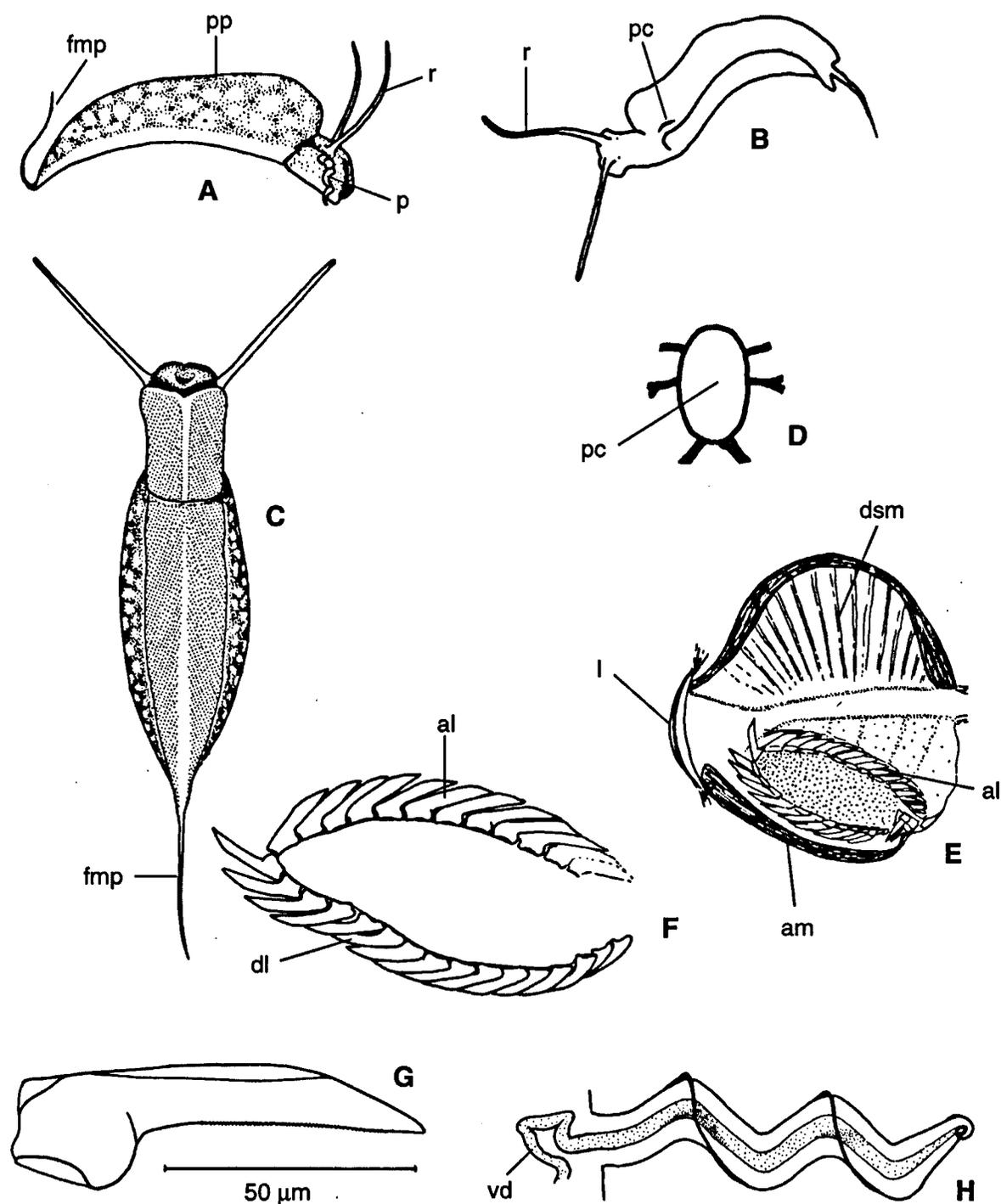


Fig. 2. A-H. *Elysia siamensis* nov. spec.

A. Lateral view of living specimen with everted penis during anaesthesia in magnesium chloride. B. Outline of living specimen with posterior edge of parapodia extended. C. Ventral view of living specimen. D. Pericardial bulb and main stems of dorsal vessels. E. Pharynx.

F. Lateral view of complete radula. G. Lateral view of radular tooth (scale line is 50 μm). H. Penis.

al - ascending limb; am - ascus muscle; dl - descending limb; dsm - dorsal septate muscle; fmp - filament of metapodium; l - pharyngeal lip; p - penis; pc - pericardium; pp - parapodium; r - rhinophore; vd - vas deferens.

has a shallow longitudinal groove from in front of the rhinophores to the anterior border. The cylindrical rhinophores are long and thin. The eyes are positioned behind the rhinophores in small fields lacking pigment.

The parapodia are thick and smooth. Pencil sketches show the parapodia slowly becoming shorter towards the metapodium (Fig. 2 A). One drawing was made of a specimen in which the posterior borders of the parapodia were extended (Fig. 2 B). This was not observed in the preserved specimens. It is not clear whether this was an aberrant individual or an extreme contraction in the posterior part of the parapodia. The foot is clearly demarcated from the body over its whole length, and divided into two parts by a transverse groove. The anterior border is notched; the anterior corners are blunt. The metapodium has a long, thin filament (Fig. 2 A-C). The pericardium is elongate, two to three times as long as it is wide. Three pairs of dorsal vessels are connected to the wall of the pericardium: two along the sides in the anterior half and one on the posterior wall (Fig. 2 D).

The main colour is greenish, mottled with darker and lighter blotches. A darker pigmented triangle, in which the longitudinal groove is situated, is medio-frontal on the head. A darker pigmented band runs on both sides from the base of the tentacles to the attachment of the parapodium and latero-anterior border of the pericardium. The rhinophores, the fields around the eyes and the thin appendage on the metapodium are not pigmented. The foot sole is rather dark, and a lighter coloured longitudinal band runs in the centre over its length. In preserved specimens, the outside of the parapodia show variable lighter blotches and small yellowish and brownish dots.

The male gonopore is a little in front of and below the right eye. The oviduct is in the lower part of the groove in the right side of the body. A separate vagina could not be located.

Internal features

The pharynx (Fig. 2 E) is larger than in the preceding species notwithstanding the smaller size of the slug. The pharyngeal lip is more developed, the dorsal septate muscles are larger, the ascus muscle is well developed, and the radula occupies a larger part of the pharynx. The pigment band is much less pronounced than in *E. bangtawensis*.

There are about 12 teeth in the ascending, 14-16 in the descending limb, and a few loose teeth in the ascus (Fig. 2 F). The teeth are rather straight blades with finely serrated cutting edges (Fig. 2 G). They have a length of about 77-83 μm , the oldest ones being smaller.

In all the preserved specimens the penis is spirally everted. The penis is not armed, and shows three spirals (Fig. 2 A, H). In preserved animals of a total length of 6-7 mm the penis length is 1-1.3 mm.

DISCUSSION

Several small *Elysia* species have been described. How-

ever, the West Australian *Elysia filicauda* (Jensen & Wells, 1990) is the only other known species with a thin tail appendage. It is about the same size as *E. siamensis*, but differs in several aspects. It has rather solid rhinophores, and only one pair of dorsal vessels connected with the pericardium. It has two pairs of dark spots on the parapodial margins, and the rhinophores have dark tips. There are numerous white dots and dark stripes on the rhinophores, head, and dorsal surface of the thin tail appendage. It has a conical penis. It has only 3-4 teeth in the ascending limb and 5-8 in the descending limb of the radula. The radular teeth have a different shape. *E. filicauda* feeds on *Acetabularia* and does not eat filamentous algae. From all these differences it is clear that *E. siamensis* is not conspecific with *E. filicauda*.

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