

**AITENG ATER, NEW GENUS, NEW SPECIES, AN AMPHIBIOUS
AND INSECTIVOROUS SEA SLUG THAT IS DIFFICULT TO CLASSIFY
[MOLLUSCA: GASTROPODA: OPISTHOBRANCHIA: SACOGLOSSA(?):
AITENGIDAE, NEW FAMILY]**

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ABSTRACT. – *Aiteng*, new genus, shows characteristics of both Cephalaspidea and Acochlidea (pre-pharyngeal nerve ring) and Sacoglossa (pharynx, radula uniseriate, one tooth functional). As no family could be identified, the Aitengidae, new family, has been erected. It is placed in the Sacoglossa with which it has most characters in common. The type species is *Aiteng ater*, new species, a small, inconspicuous, grey to blackish opisthobranchs without shell, rhinophores, gills or other protuberances. The large eyes are lateral in uncoloured fields. The notum has wide free borders along the sides and posterior part. The head is extending, but can largely be retracted under the notum. The pharynx is large and the radular ribbon has tens of uniserial teeth in both ascending and descending limbs with one functional tooth in front of the pharynx. The teeth are triangular with a wide base, a strong central cusp and small denticles along sides. The salivary ducts are vesicular, the salivary glands consist of several tens of separate follicles. The main branch of the digestive gland runs from the small stomach posteriorly via the upper part of body branching off laterally and covering a large area with pale vessels that have small grey follicles in the upper part of the body except over the renopericardium. Dorsal vessels run just under the skin between the renopericardium and the border of the notum. Tens of hermaphrodite follicles are in the posterior part of the body. The penis is slender, unarmed. The prostate around the internal vas deferens above the pharynx. The female opening is in the right side close to the anus. *Aiteng ater*, new species, occurs on the solid mud bottom of dense mangrove forests in the Pak Phanang Bay, Gulf of Thailand. The specimens live amphibiously in and around small pools high in the intertidal zone, only covered by the sea during spring high tides. The slugs reach a length of 8-12 mm and feed on insect larvae and pupae.

KEY WORDS. – Gastropoda, Opisthobranchia, Sacoglossa, Aitengidae new family, *Aiteng* new genus, Mangrove, Thailand.

INTRODUCTION

Blackish slugs with a wide body and a length of about 10 mm were discovered on the mud and in small pools in a mangrove forest in the Pak Phanang Bay (Gulf of Thailand). When noting that they had a notum with a wide free border, the slugs were believed to be young specimens of the family Onchidiidae. That idea was rejected when the expanded head showed no stalked eyes, but internal eyes like those of the sacoglossan *Limapontia* spp. After leaving the mosquito saturated mangrove forest for taking a better view in the lab, it appeared that the species could not be allocated to any family known to the authors. Therefore, the slugs were studied in more detail. As no description of a family, genus, or species was found of which the characteristics fit with our slugs, the family, genus, and species are described as new in this paper.

MATERIALS AND METHODS

Details about locality, dates, and numbers are given in *Materials examined* in the chapter Taxonomy. Specimens were picked up with a small spoon from the mud. At the same time a part of the mud surface was taken up to a depth 20 mm and stored in a plastic box. Substrate and the slugs were transported to the lab. A number of individuals were narcotised with MgCl₂ and stored in a formaldehyde seawater solution. Some were set aside and after a few days transferred into 70% ethanol, and others were used for dissection in a Petri dish with a black wax layer on the bottom. Dissections were done by hand with the help of fine needles under a 4-64x stereo microscope. Notes, drawings, and photos were made of details at different stages of dissection. Live specimens were kept for six months in their closed box of 200 x 300 mm with the substrate on which

they were collected, but regularly provided with food. The mud surface remained irregular. In this way only a part of the substrate was submerged like it was in the field. The slugs were frequently observed, on some days also at night. Some feeding tests were conducted.

TAXONOMY

Aitengidae, new family

None of the known families of the Cephalaspidea, Sacoglossa and other opisthobranch orders fit with the characters of *Aiteng*, new genus, described below. Therefore, we create the monogeneric *Aitengidae*, new family, with the same characters as the genus.

Aiteng, new genus

Diagnosis. – Non-shelled opisthobranchs, body dorso-ventrally flattened, notum with wide free border under which head can be retracted. Cerata, gills, rhinophores, and tentacles lacking. Ganglionic nerve ring pre-pharyngeal. Pharynx large, radula uniseriate, both ascending and descending limbs with several tens of teeth, one functional tooth. Single major branch of digestive gland from simple stomach to posterior part, widely branching off laterally. Male aperture under right eye. Female opening on right body wall beside anus.

Type species. – *Aiteng ater*, new species, described in this paper from Pak Phanang Bay, Gulf of Thailand. Gender: masculine.

Etymology. – The name is derived from Ai Theng, which is the name of one of the popular puppets in shadow plays (wayang) in the southern part of Thailand. It is a jolly, smooth, black, male, who plays in the night. Statues and drawings of various famous puppets were seen along the roads in the area during our visits. The smooth Ai Theng with his large lateral eyes did remind us of the just discovered slug (Fig. 1A).

DISCUSSION AITENGIDAE AND AITENG

The new family has been placed in the Sacoglossa, with a question mark, based on several characters (see the discussion of the species below).

Aiteng ater, new species (Figs. 1–2)

Materials examined. – Seven individuals with lengths varying from 6 to 10 mm were found by the authors in the Pak Phanang Bay, in the mangrove forest west of the sand spit between bay and Gulf of Thailand (at 8°29'18"N, 100°10'55"E) on 29 Sep.2007.

Dozens of individuals of similar size were found at the same site on 3 Oct.2007. Two individuals in the same size range and two juveniles of 2.0 mm and 2.1 mm were found at the same site on 13 Apr.2008, and about 50 specimens varying in length between 4 and 12 mm on 4 Oct.2008. The description is based on 17 specimens, eight of which were dissected. The holotype and three paratypes are deposited in the Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research, National University of Singapore, and three paratypes in the Zoological Museum, University of Amsterdam (ZMA).

Live colouration. – Dorsum grey to black, area around eyes not pigmented (Figs. 1B,C, 2A,C). Upper foot border, lateral body sides, and underside notum rim grey. Foot sole grey or not pigmented.

External morphology. – Broad, smooth slugs, length 2.5 to 3 times width in creeping specimens (Fig. 1B,C). Body covered by notum with wide free border overhanging foot, but without tentacles, rhinophores, gills, cerata, tubercles or other protuberances (Figs. 1B,C,D, 2A,B,C). Head with velum and sideward directed eyes under low crests (Figs. 1D, 2C). Head can be retracted under frontal notum border. Foot sole over whole length divided by deep groove, often kept partly or wholly closed (Fig. 2B). Frontal foot corners not extended, rounded, anterior border smoothly curved, posterior tip rounded, usually not passing notum border, but notum can contract making foot border visible all around. Frontal borders of velum and foot rarely show slight notch. No clear renopericardial bulb. Renopore not located. Male aperture under right eye, female aperture opens besides anus in ventral side of notum rim against anterior right lateral body wall (Fig. 2C).

Internal characteristics. – Nervous system with four pre-pharyngeal ganglia. Eyes well developed, diameter 125–135 µm, length 180–220 µm, lens spherical (Fig. 1K). Eyes nearly sitting on cerebro pleural ganglion (Fig. 1E). Pharynx yellowish (length 900–1330 µm, height 780–875 µm in 8–11 mm long specimens) voluminous ascus slightly diverging left. Radula uniseriate, one functional tooth; 30–34 teeth in straight ascending limb, 29–33 teeth in curved descending limb, some small, broken teeth in ascus (Fig. 2F). Teeth triangular (height 70–84 µm) with strong median cusp and 6–10 small denticles along lateral border (Figs. 1M, 2H). Teeth in descending limb smaller, by clearly worn cusps. Two large, joined oral glands along ventral side of pharynx. Salivary duct ampullar, curved, laterally entering pharynx (Fig. 2D). Salivary glands consisting of tens of loose, irregularly shaped follicles. (Fig. 1I). Oesophagus short, dark-coloured, from posterior dorsal side of pharynx to simple stomach. Intestine dark pigmented, from anterior right side of stomach to anus. Major branch of digestive gland posteriorly from stomach, sending off side branches that branch several times forming fine network up into free border of notum; branches pale (Figs. 1F, 2D). Small, dark speckled, digestive follicles on dorsal side of branches (Fig. 1G), covering whole notum under skin, absent above pericardium. Renopericardium mid-frontal under dorsal skin of notum. Transparent dorsal vessels run under skin from near notum border to renopericardium (Figs. 1G, 2E).

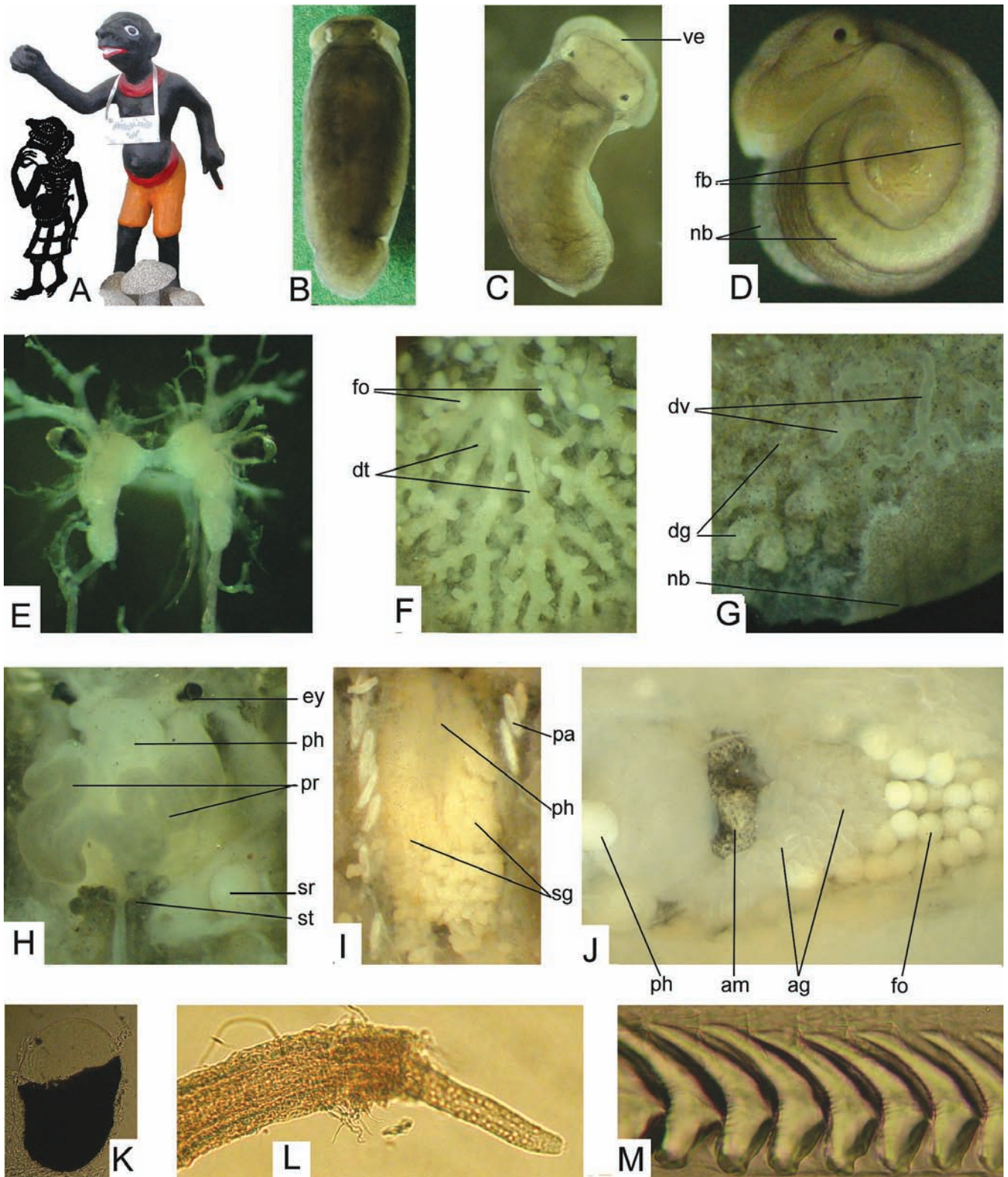


Fig. 1. *Aiteng ater*, new species: A, photo of a wayang (shadow puppet) and of a statue of Ai Theng at a shop near Pak Phanang; B, creeping adult specimen length 9.0 mm in lab; C, creeping young slug length 2.0 mm; D, young slug curled up length 2.1 mm; E, nerve ring, width of photo 170 μ m; F, digestive tubes in ventral view in posterior part of body, width of photo 2600 μ m; G, posterior lateral side of notum in dorsal view with skin largely removed showing digestive follicles and dorsal vessels; H, prostate dorsal view, width photo 270 μ m; I, parasites around salivary follicles, ventral view; J, ventral view of albumen gland, ampulla, and follicles; K, eye; L, penis; M, lateral view of radular teeth.
 Legend: ag – albumen gland; am – ampulla; dg – digestive follicles; dt – digestive tubes; dv – dorsal vessels; ey – eye; fb – foot border; fo – follicles of ovotestis; nb – notum border; pa – parasite; ph – pharynx; pr – prostate; sg – salivary follicles; sr – seminal receptacle; st – stomach; ve – velum.

Hermaphrodite follicles yellowish, numerous, length 120-190 μm (Fig. 1J). Connecting ductules gradually unite into hermaphroditic duct continuing through black spotted ampulla (Fig. 1J). Postampullary hermaphroditic duct short; splits into short oviduct and vas deferens. Albumen duct from compound albumen gland (Figs. 1J, 2G) connects to short oviduct. Fertilisation region, capsule gland and mucus gland very close, distal parts separate; large oviduct could not precisely be traced in these glands. Oviduct and vaginal duct partly united, connected with compact seminal receptacle shortly before female aperture. Vas deferens runs parallel with oviduct to right body wall and then anteriorly; prostate surrounds part of vas deferens curving along and over pharynx (Figs 1H, 2G), continuing as thin vas deferens to penis sack. Penis thin, unarmed, on right side of head (Fig. 1L).

Endoparasites. – White, cigar-shaped bodies of different sizes were found under the skin and loose on other organs in some specimens during dissecting (Fig. 1I). We

supposed these were parasites, but they were not identified or studied.

Habitat and behaviour. – All specimens were found in a dense mangrove forest high in the intertidal zone, not covered by the sea during neap high tides. The slugs were usually along the water level of crab burrows, foot prints, and small pools in rather stiff mud with fallen twigs and leaves. The salinity of the water varied between 18 and 37 S during our visits. The leaf cover of the mangrove trees *Avicennia marina* (Forsk.) Vierh., *Bruguiera cylindrica* (L.) Blume, and *Rhizophora apiculata* Blume, with an undergrowth of *Acanthus ilicifolius* L. and *Acrostichum aureum* L. shaded the substrate from direct sunlight. Specimens kept in the lab usually rested along the water's edge, often partly in the mud, with a preference for small depressions in the mud, which is similar to the field. When they were exposed to strong light, they moved until shade was found. Night observations showed that they were actively moving in the dark, but all movements were slow. Heart beats per 30 s

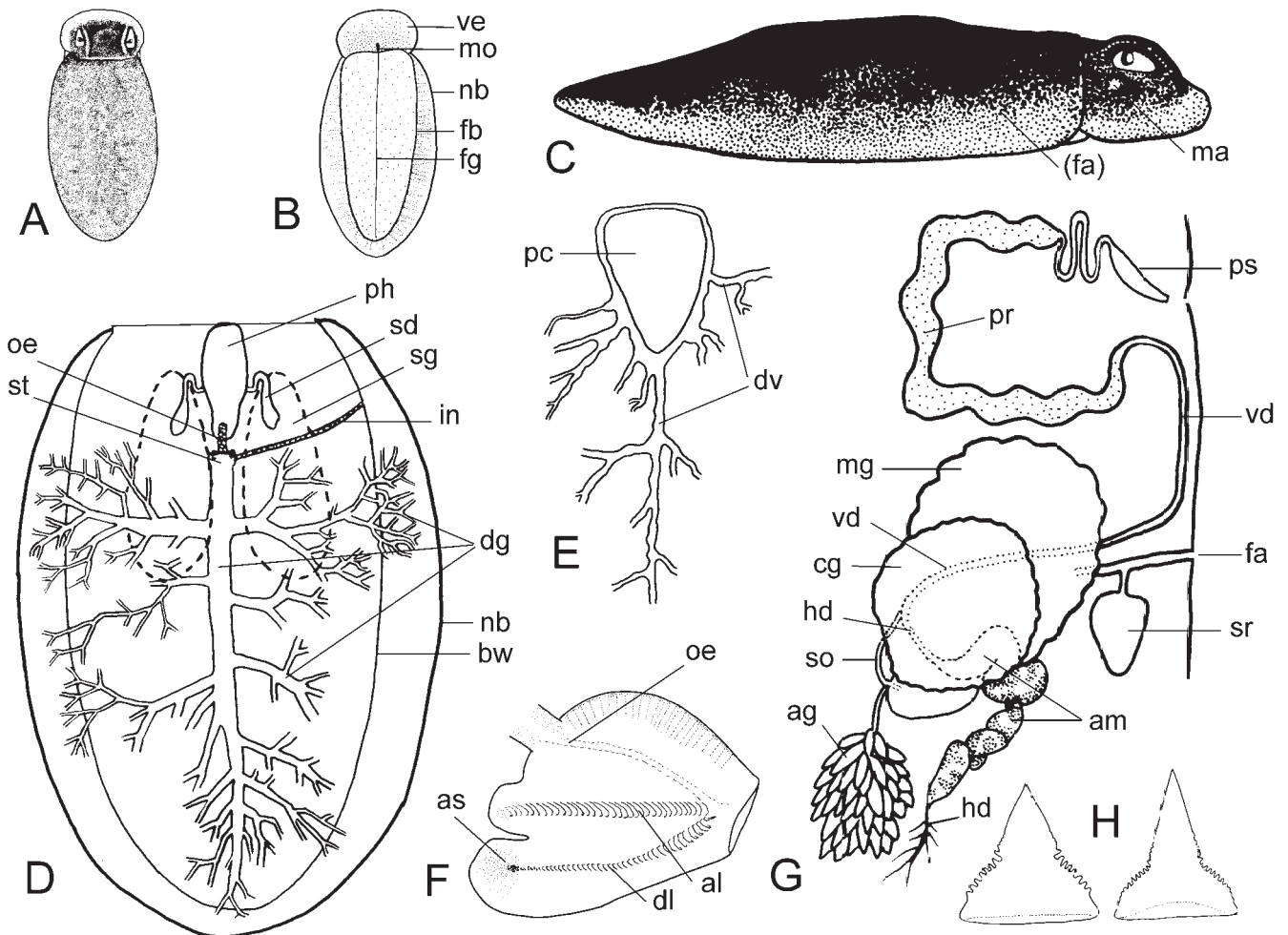


Fig. 2. *Aiteng ater*, new species: **A**, dorsal view of slug, length 9 mm, in rest; **B**, ventral view of slug in rest against glass; **C**, lateral view of creeping slug, length 11 mm; **D**, diagram of digestive system in dorsal view; **E**, dorsal vessels; **F**, pharynx, length 900 μm ; **G**, diagram of the genital complex in dorsal view; **H**, radular teeth of two specimens.

Legend: **ag** – albumen gland; **al** – ascending limb of radula; **am** – ampulla; **as** – ascus; **bw** – body wall; **cg** – capsule gland; **dg** – digestive gland; **dl** – descending limb of radula; **dv** – dorsal vessels; (**fa**) – position of female aperture hidden under free notum border; **fa** – female aperture; **fb** – foot border; **fg** – foot groove; **hd** – hermaphrodite duct; **in** – intestine; **ma** – male aperture; **mg** – mucus gland; **mo** – mouth; **nb** – notum border; **oe** – oesophagus; **pc** – renopericardium; **ph** – pharynx; **pr** – prostate; **ps** – penis sack; **sd** – salivary duct; **sg** – area of salivary follicles; **so** – short oviduct; **sr** – seminal receptacle; **st** – stomach; **vd** – vas deferens; **ve** – velum.

in three moving specimens were 30, 32, and 35 at 32°C. Feeding tests showed that small green algae collected from the site were neglected. However, pupae of insects of the orders Coleoptera and Lepidoptera found in the mud were opened and emptied by the slugs kept in the laboratory. Further trials showed that also imagines of mosquitos and ant larvae were eaten. Copulations and eggs were not seen in the field or laboratory. A few small slugs (length about 2 mm) were discovered in the substrate samples taken to the lab in April 2008. This suggests that reproduction may occur in the beginning of the year shortly after the rainy season.

Etymology. – The specific name is according the colour that looks black on the mud of its habitat.

DISCUSSION

Aiteng ater, new species, is a small, inconspicuous, grey to blackish opisthobranchs with a wide free notum border along its sides and posterior part, but without shell, rhinophores, gills or other protuberances. The absence of protuberances may be related to its specialism of living amphibiously high in the intertidal zone among mangroves. It also seems extremely specialised by feeding on insects. Striking internal features are the large pharynx with numerous uniseriate teeth in an ascending and a descending radular limb, the large oral and salivary glands, and the large area occupied by tubes of the digestive gland. These features are likely related to the difficulty of ingesting and digesting lipids and proteins of its insect foods.

The external characters give no direct clues to indicate a family or higher order; the species appears unique. The internal characters are somewhat confusing. The prepharyngeal ganglionic ring is characteristic for some families of Cephalaspidea (Schmekel, 1985; Mikkelsen, 1996) and Acochlidea (Ev. Marcus, 1982, Jörger et al., 2008); in other opisthobranch orders the ring is postpharyngeal (Schmekel, 1985; Jensen, 1996a). Acochlidea are very small interstitial slugs with a short foot and a large visceral hump, and the cephalaspid genera show besides a pre- or postpharyngeal nerve ring, a shell, sperm-groove, Hancock's organ, ciliated strips on the mantle margin, three gizzard plates, rachidian plus lateral teeth. Although some lack one or more of these characters (Mikkelsen, 1996), none of these is found in *Aiteng ater*, new species. The presence of a well developed pharynx with a uniserial radula on an ascending and a descending limb, a posteroventral ascus in which the worn teeth are stored instead of becoming lost during feeding are specific characteristics of the Sacoglossa (Bergh, 1878; Schmekel, 1985). Characteristic for sacoglossans are also the dorsal, symmetrically arranged branches of the digestive gland, the reproductive system with numerous small hermaphrodite follicles and a closed vas deferens (Sander-Esser, 1984; Gascoigne, 1985; Mikkelsen, 1996). The dorsal vessels under the skin of the notum that are connected with the renopericardium show similarity with the dorsal vessels in sacoglossan genera such as *Aplysiopsis*, *Bosellia*, *Cyerce*, *Elysia* and some others (Jensen, 1996a).

The number of radular teeth in *Aiteng ater*, new species, is much higher than in most sacoglossans. Only species of the shelled genus *Cylindrobulla* may have also 80 or more teeth (Jensen, 1989). The affinities of *Cylindrobulla* to other groups have long been disputed (Jensen, 1989, 1996b; Mikkelsen, 1998: table 1). Jensen (1996a) found that it belonged to a separate order in between Sacoglossa and Cephalaspidea for which she proposed the name Cylindrobullacea. Among the arguments indicated why *Cylindrobulla* would not belong to the Sacoglossa are: not associated with algae, which are the food for most sacoglossans; the possession of an atypical radula; atypical shape of the teeth; the lack of preradular teeth; doubt if the ascus was a real ascus. Mikkelsen (1996, 1998), on the other hand, found that *Cylindrobulla* belongs to the Sacoglossa by using similar cladistical analyses. In *Aiteng ater*, new species, the high number of teeth in the pharynx may be related to a high wear of the active tooth during feeding. Likely, making a hole is more difficult in an exoskeleton of an insect than in the membrane of an algal cell. The used teeth are clearly more worn than the teeth of algae eating sacoglossans. It may be that for rasping open an exoskeleton successively new teeth have to be used. Therefore, it seems likely that *Aiteng ater* needs to have a larger number of teeth available for feeding than slugs feeding on foods with a softer covering. In a series of pharynxes studied, one showed a decline in teeth size towards the ascus (Fig. 2F) and the others had teeth of similar size in their ascending and descending limbs, except shorter median cusps by wear in the descending limb. There was always only a small amount of broken teeth in the ascus. As there is no means of exit in the ascus of *Aiteng ater*, these observations may suggest that used teeth become resorbed in the ascus. This would also explain the absence of preradular teeth in adult specimens. A notum with a free margin such as in *Aiteng ater*, new species, is not found in other sacoglossans, but the lateral extension along the dorsal sides in *Costasiella coronata* Swennen, 2007 and, although less pronounced, the wider notum of the bare-backed *Limapontia depressa* Alder & Hancock, 1862 show some similarity and the extensions in these species are also filled with branches of the digestive gland.

Nearly all characteristics of *Aiteng ater*, new species, point to placing it in the Sacoglossa, but there are problems. The prepharyngeal nerve ring suggests a connection of the species with the Cephalaspidea (Schmekel, 1985; Jensen, 1996a; Mikkelsen, 1996). Abnormal is also the food of the species, nearly all known shelled and non-shelled sacoglossans feed on algae, a few are specialized on animal food (gastropod eggs), but up to now none on insects (Jensen, 1997). The place of the Aitengidae, new family, within the Sacoglossa or in a new order may be determined after further study.

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