

## **Three New Species of Aglajid Cephalaspidean Mollusks from the Tropical Indo-Pacific of the Verde Island Passage**

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Three new species of aglajid opisthobranchs are described from the Verde Island Passage of the Philippines. *Philinopsis buntot* sp. nov. is found from two localities in Batangas, Luzon. It is immediately recognizable and distinct from all other aglajids by its medial projection that extends from the posterior end of the posterior shield. Its penis has a lobate prostate and a bilobed penial papilla with a basal collar. The collar and the lobes of the papilla bear small spines around their margins. *Philinopsis aliciae* sp. nov., known only a single specimen from the Philippines, is similar to *P. buntot*, but lacks the distinctive tail or any posterior medial appendage. It has a simple penis, which lacks any trace of penial spines. *Chelidonura alexisi* sp. nov. is characterized by its black body, often with minute opaque white spots. It has a simple penis with two cuticularized conical papillae, one situated near the middle and the other near the apex. This species is known from four specimens and a photo of a fifth specimen, also observed in the Philippines, on the southern side of the Verde Island Passage.

KEYWORDS: Aglajidae, Indo-Pacific, new species, biodiversity

The Aglajidae is a diverse clade of Cephalaspidean heterobranch gastropods with more than 60 species (Camacho-García et al. 2014). The greatest diversity of species is found in the Indo-Pacific tropics with a concentration of species within the Coral Triangle, encompassing most of the Philippines, Indonesia and Papua New Guinea, where nearly half of the members of the family are found (Gosliner et al., 2008). Recently, six new species of aglajids were described (Gosliner 2011). The systematic relationships of the family have been reviewed by Rudman (1972a, 1972b, 1972c, 1974, 1978), Gosliner (1980), and Baba (1985) and the first molecular phylogeny of the group was published by Camacho-García et al. (2014). This preliminary phylogeny provides the systematic framework for a revision of the family, but no major realignment of taxonomic boundaries was proposed, pending the sampling of additional genes and taxa to produce a more robust phylogeny.

Since Gosliner's (2011) description of six new agalajids, several additional species have come to light, largely through the 2011 Hearst Philippine Biodiversity Expedition launched jointly by the California Academy of Sciences, the University of the Philippines, the National Museum of the Philippines and the Bureau of Fisheries and Aquatic Resources. Holotypes are deposited in the National Museum Philippines (PNM) and paratypes are deposited in the invertebrate zoology collections of the California Academy of Sciences (CASIZ).

### METHODS

Over the last few years, new specimens of aglajids were collected from Batangas Province, Luzon Island, Philippines. Specimens were preserved in either 10% formalin for proper preserva-

tion of anatomical structures, or preserved entirely in 95% ethanol for later molecular study. Prior to preservation of any specimen in formalin, a tissue sample was taken from the animal and preserved in 95% ethanol for later molecular study.

Upon return to the California Academy of Sciences, dissections were completed, and drawings of anatomical structures were accomplished using a Nikon SMZ-U binocular microscope with drawing tube. Specimens of copulatory organs were mounted on stubs and air-dried. Structures were then coated with gold/palladium using a Denton Desk II vacuum sputter coater. Scanning electron micrographs were produced by a LEO 1450 VP scanning electron microscope. Specimens and dissected structures were deposited at the Philippine National Museum (PNM) or the California Academy of Sciences in the Invertebrate Zoology Department collection (CASIZ).

The methodology for molecular study of two of these species was described in Camacho García et al. (2014). Phylogenetic analyses for these species are included in that paper.

## SPECIES DESCRIPTIONS

### Family Aglajidae Pilsbry, 1895

#### Genus *Philinopsis* Pease, 1860

Type species: *Philinopsis speciosa* Pease, 1860, by monotypy

#### ***Philinopsis buntot* Gosliner, sp. nov.**

Figures 1C–E, 2A, 3, 4.

**MATERIAL EXAMINED.**— HOLOTYPE: PNM 41060, 5 m depth, subsampled for molecular study, Anilao Harbor, Mabini, Batangas Province, Luzon, Philippines, 13.75994°S, 120.83036°E, 30 April 2011, E. Jessup. PARATYPE: CASIZ, 185780, one specimen, 5 m depth, Anilao Harbor, Mabini, Batangas Province, Luzon, Philippines, 13.75994°S, 120.83036°E, 24 May 2011, T. M. Gosliner. CASIZ 185942, one specimen, dissected, 7 m depth, Cemetery Beach, Tingloy, Batangas Province, Luzon, Philippines, 13.68433°S, 120.82993°E, 19 May 2011, T. M. Gosliner. CASIZ 185777, two specimens, 7 m depth, Cemetery Beach, Tingloy, Batangas Province, Luzon, Philippines, 13.68433°S, 120.82993°E, 19 May 2011, T. M. Gosliner.

**GEOGRAPHICAL DISTRIBUTION.**— Thus far, known only from southern Luzon Island, Philippines.

**ETYMOLOGY.**— The name “buntot” is the Tagalog word for tail, referring to the distinctive posterior appendage of this species.

**NATURAL HISTORY.**— This species is found crawling on clean sand where it is nocturnally active. It has not been observed diurnally and may remain buried in the sand during the day.

**DESCRIPTION.**— *External morphology:* The living animals are 7 to 12 mm in length and 3–6 mm wide. The general body color of the living animal (Figs. 1C–E) is translucent white with varying amounts of reticulated brown pigment on the dorsal surface. In specimens with sparse brown pigment patches of opaque white may also be present. The brown pigment frequently surrounds small yellow spots on the dorsal surface. Larger yellow spots are evident along the margins of the cephalic and posterior shields and on the margins of the parapodia.

Living animals are elongate, and relatively slender. The anterior end of the cephalic shield is blunt and quadrangular. The cephalic shield is roughly rectangular and terminates posteriorly with a rounded edge. No upturned papilla was observed on the end of the cephalic shield. The posterior shield is slightly rounded anteriorly and terminates in a medial elongate, digitiform posterior projection that is well-elevated from the base of the shield. This appendage is rounded at the apex

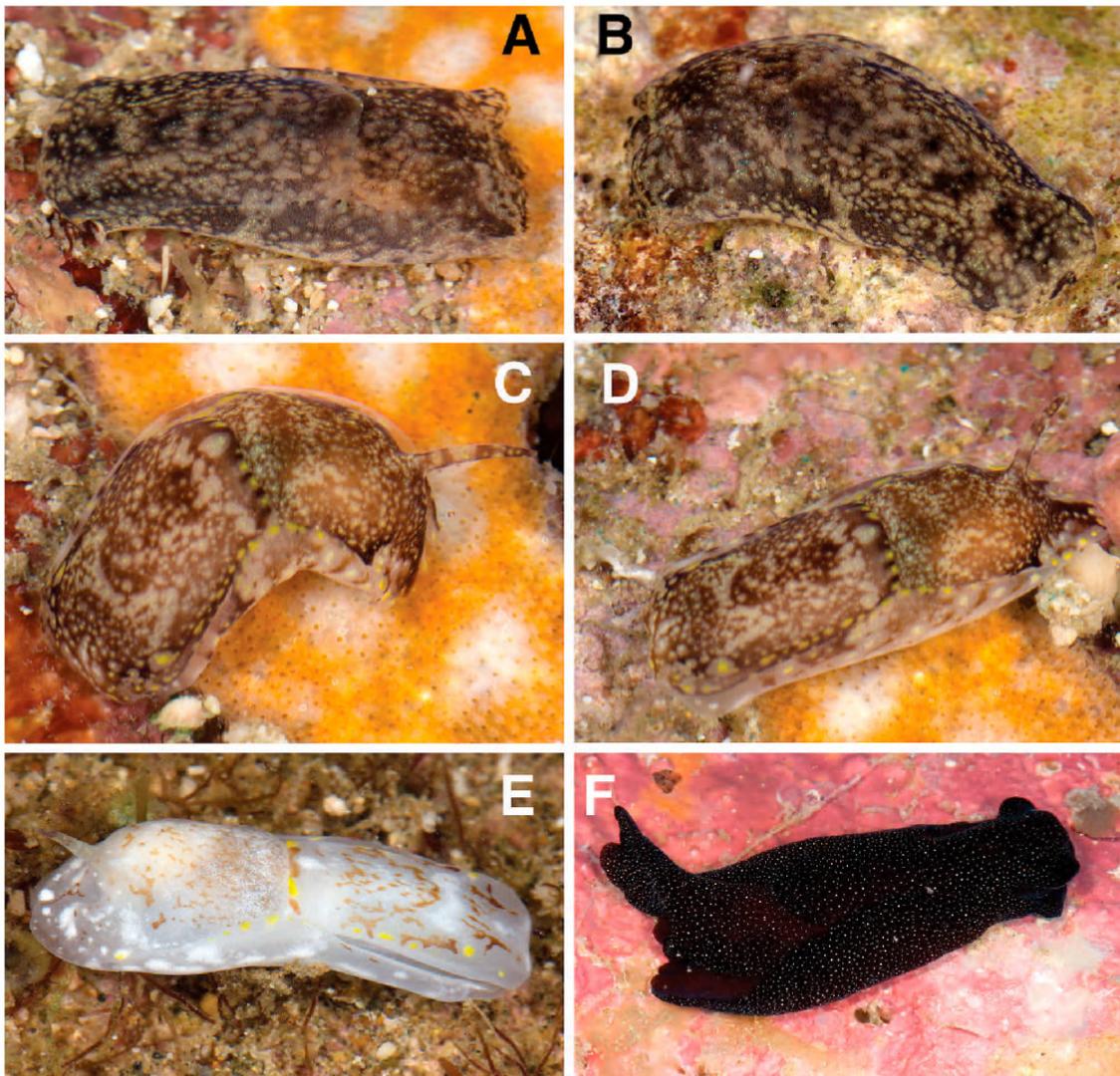


FIGURE 1. Living animals A–B. *Philinopsis aliciae* sp. nov., holotype, PNM 41061, Mabini, Philippines. C. *Philinopsis buntot* sp. nov., holotype, PNM 41060, Mabini, Philippines, ventral view showing markings on foot. D. *Philinopsis buntot*-paratype, CASIZ 185942, Tingloy, Philippines. E. *Chelidomura alexisi* sp. nov., holotype, PNM 41062, Mabini, Philippines.

and is often held upright in actively crawling individuals. The posterior end of the posterior shield is much lower than the area with the projection and two relatively flat lateral posterior lobes are short and simply rounded. The parapodia are relatively short, leaving most of the cephalic and posterior shields visible. The gill is simply plicate consisting of 12 primary folds and is situated ventrally on the right posterior end of the animal.

*Shell* (Fig. 2A): The shell is relatively thickly calcified and consists of a narrow band that occupies the posterior extreme of the animal. There is a membranous periostracum that is slightly more extensive anteriorly than the calcified portion. The area at the base of the shell near the protoconch is more thickly calcified than the rest of the shell.

*Digestive system*: The buccal mass is large, highly muscularized and slightly elongate posteriorly and occupies the body cavity for the entire length of the cephalic shield. The buccal bulb entirely lacks any vestige of a radula. There is a large ventral oral gland and a smaller dorsal oral gland. At the posterior end of the buccal mass, near the junction with the crop, is a pair of elongate salivary glands. The crop is large and saccate, wider than the buccal bulb. The crop narrows pos-

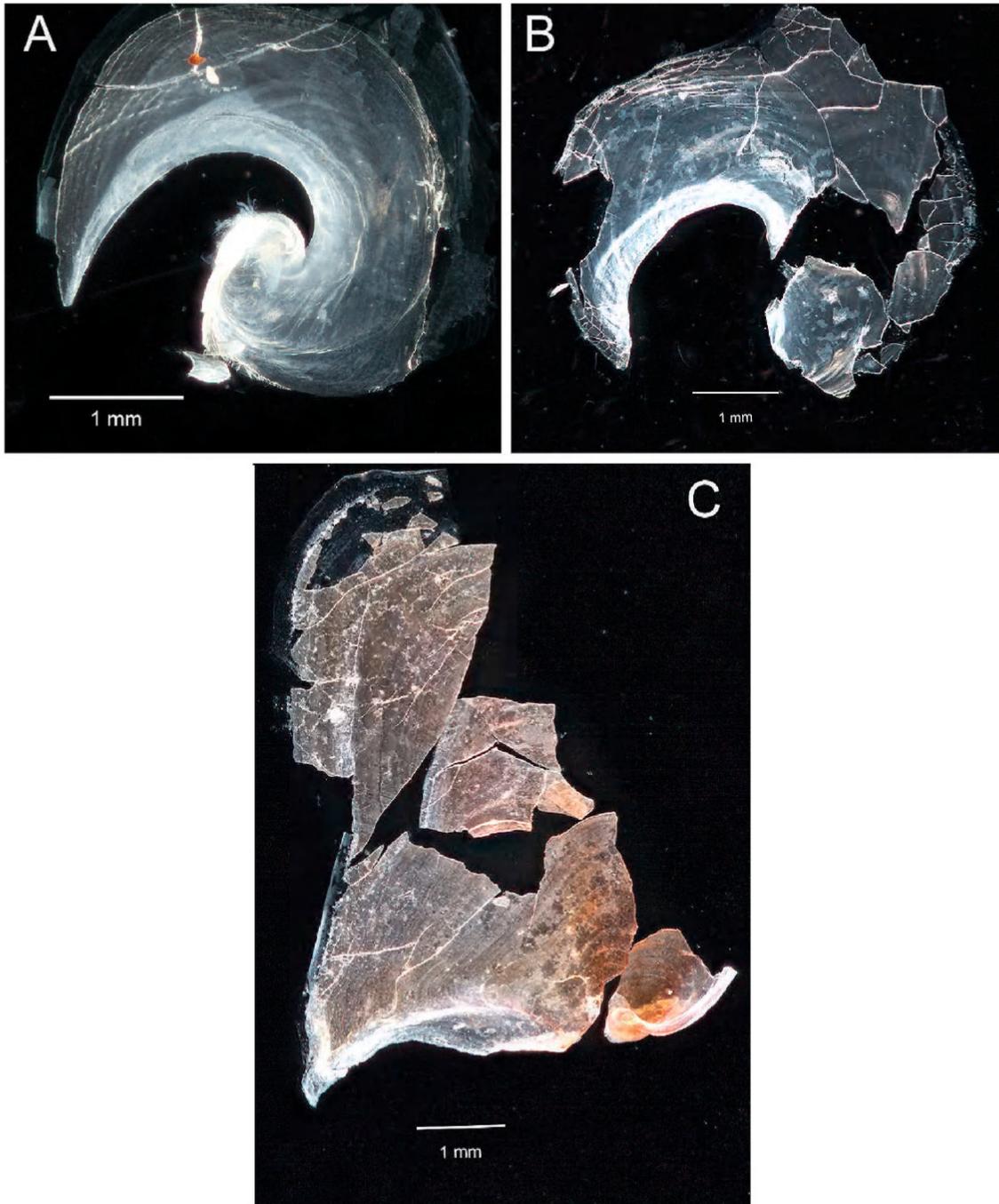


FIGURE 2. Shells. A. *Philinopsis buntot* sp. nov., paratype, CASIZ 185942, Tingloy, Philippines. B. *Philinopsis aliciae* sp. nov., holotype, PNM 41061, Mabini, Philippines. C. *Chelidonura alexisi* sp. nov., holotype, PNM 41062, Mabini, Philippines.

teriorly and enters the digestive gland. The intestine emerges from the right side of the digestive gland and terminates near the posterior end of the body near the base of the gill.

*Central Nervous System* (Fig. 3A): The circumesophageal nerve ring consists of paired cerebral, pedal and pleural ganglia and a single supraintestinal ganglion on the right side. The cerebral and pedal commissures are both elongate with well-separated respective ganglia. Immediately adjacent and posterior to the right pleural ganglion is the supraintestinal ganglion. From its posterior end is the right branch of the visceral loop and the osphradial nerve. The two lateral branches

of the visceral loop join posteriorly at the posterior ganglia. The left visceral loop enters the subintestinal ganglion, whereas the right lateral nerve enters the visceral ganglion. The visceral ganglion is larger than the subintestinal ganglion. From the visceral ganglion is the genital nerve, which has a distinct genital ganglion. The buccal ganglia can be seen near the middle of the ventral surface of the buccal mass and are somewhat separated from each other.

**Reproductive System** (Figs. 3B–C, 4): The arrangement of reproductive organs is essentially monaulic (as discussed by Gosliner 1994) but with a single branch of the hermaphroditic duct to the albumen and membrane glands (Fig. 3C). From the large ovotestis, which is intermingled with the digestive gland, emerges the convoluted ampulla. The ampulla narrows into the hermaphroditic duct, which curves around the receptaculum seminis and enters the short, coiled albumen and membrane glands by means of a single duct. The larger mucous gland is bilobed with a massive primary lobe and smaller secondary one. The outer margins of both lobes bear a rounded margin with numerous tooth-shaped lobes. The hermaphroditic duct then joins the duct of the receptaculum seminis and continues to the genital atrium, where it joins the duct of the bursa copulatrix. The bursa is large and spherical. Its duct is narrow where it joins the bursa and widens until its widest portion at the genital atrium. The genital atrium is large and muscular. The atrium also has a lobate vestibular gland situated on its ventral surface. From the genital atrium the open, ciliated sperm groove leads to the cephalic penis. The penis (Figs. 3B, 4) consists of a penial sac and a thick, curved, irregularly-shaped prostate gland that is joined to the penial sac by a narrow duct. Within the penial sac is an elongate penial papilla (Figs. 3B, 4A). The papilla has a bilobed apex with an expanded outer collar. The collar (Figs. 4A–C) is ornamented with undivided and bifid penial spines as are the inner (Fig. 4D) and outer (Fig. 4E) lobes of the penial papilla.

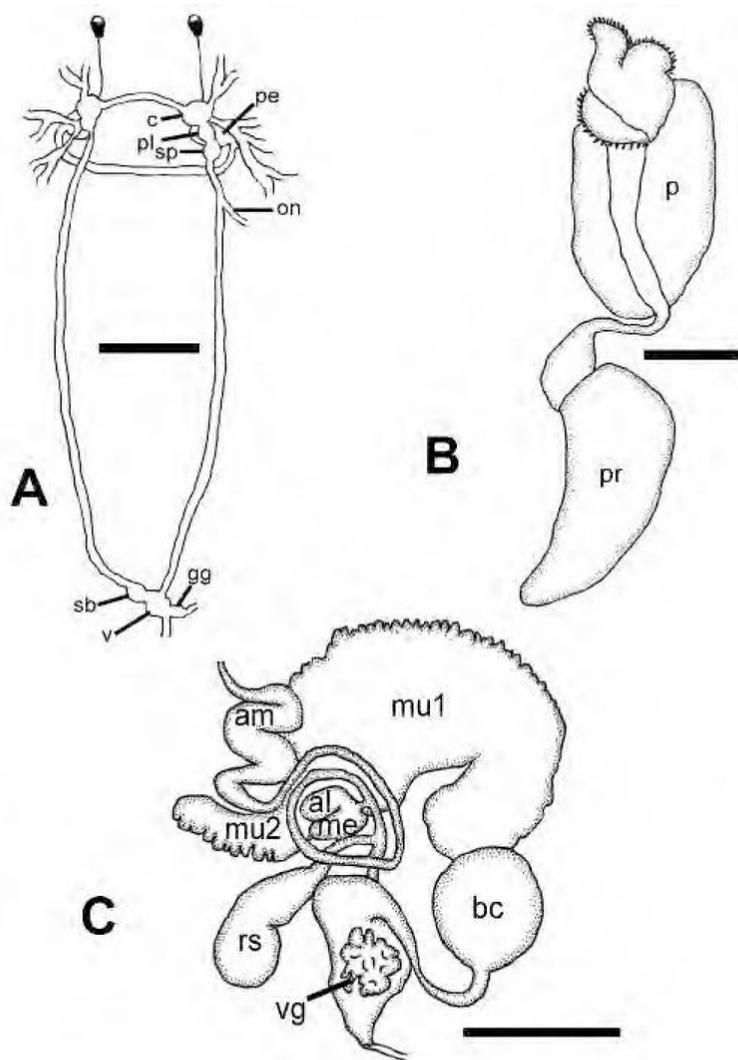


FIGURE 3. Internal anatomy, *Philinopsis buntot*. sp. nov., paratype, CASIZ 185942, Tingloy, Philippines. A. Central nervous system c-cerebral ganglion, gg-genital ganglion, on-osphradial nerve, pe-pedal ganglion, pl-pleural ganglion, sp-supraintestinal ganglion, su-subintestinal ganglion, v-visceral ganglion, scale = 1 mm. B. Penis, p-penial papilla, pr-prostate, scale = 0.75 mm. C. Posterior reproductive organs, al-albumen gland, am-ampulla, bc-bursa copulatrix, me-membrane gland, mu1-mucous gland large, mu2-mucous gland small, rs-receptaculum seminis,vg-vestibular gland, scale = 1 mm.

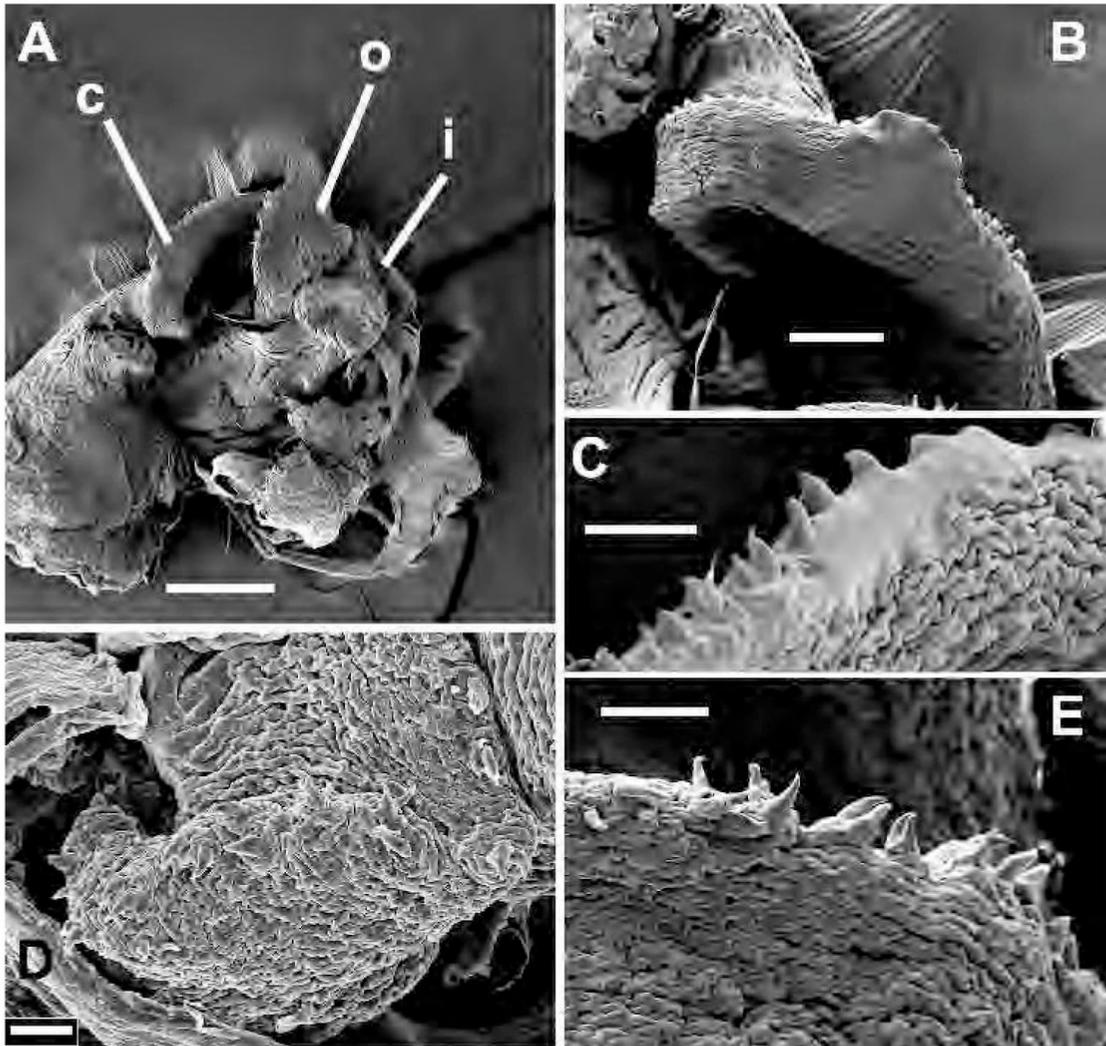


FIGURE 4. *Philinopsis buntot*, sp. nov., paratype, CASIZ 185942, Tingloy, Philippines, scanning electron micrographs of penis. A. Entire penial papilla, c-collar. i-inner lobe, o-outer lobe, scale = 150  $\mu$ m. B. Collar, scale = 80  $\mu$ m. C. Collar showing detail of spines, scale = 20  $\mu$ m. D. Inner lobe, scale = 20  $\mu$ m. E. Outer lobe, 20  $\mu$ m.

**REMARKS.**— The presence of a quadrangular anterior end of the body, a posterior lobe of the cephalic shield, a large muscular bulb, the single branch of the hermaphroditic duct to the albumen and membrane glands, a bilobed mucous gland are all characteristics of species of *Philinopsis* (Rudman, 1972a). *Philinopsis buntot* lacks the elevated posterior extension of the cephalic shield but has all the other characteristics of *Philinopsis*. The anatomy of *P. buntot* differs significantly from other described members of the genus. The most obvious morphological attribute that distinguishes *P. buntot* is the presence of the elongate posteromedial appendage on the posterior shield. The penis is also similar to that described for *P. falciphallus* Gosliner, 2011 and *P. coronata* Gosliner, 2011. These two species also have a oblong prostate that is connected to the penial sac by means of a thin duct. In all three species, the penial papilla is armed with spines, whereas no other species of *Philinopsis* are known to have an armed penis. In *P. falciphallus*, the base of the penis has a series of spines and a large chitinous sickle-shaped spine near the apex, whereas *P. coronata* has a ring of spines around the apex of the penial papilla and a ring of larger spines at the base of the penial papilla with a second ring of larger spines above the penial papilla. The arrangement of spines along the margins of the two penial papilla lobes and spines along a basal collar in *P. buntot* is unique to this species.

In his review of *Philinopsis*, Rudman (1972a) indicated there were two distinct groups of species. Members of the first group are characterized by having a large quadrangular head, a bulbous buccal mass and a specialized penis with a basal elongate penial papilla and a short prostate (Marcus and Marcus 1967: fig. 12) or a simple penis in *P. depicta* (Renier, 1807) (Gosliner 1980). Members of the second group of species have a rounded head with an elevated bulbous region (that resembles the front end of a Boeing 747) with prominent eyes visible at the base of the bulb, an elongate, tubular buccal bulb and a simple penis.

In the molecular study by Camacho-García et al. (2014) (Fig. 7), these two groups are largely upheld, but two additional groups of taxa being included in the same clade as the taxa with a tubular buccal bulb. *Philinopsis orientalis* (Baba, 1949) and *P. petra* (Marcus and Marcus, 1976) are sister to the clade of species with the tubular buccal mass. *Philinopsis coronata* Gosliner, 2011, together with *P. buntot* (as *P. sp.* CASIZ 185779), is sister to the remainder of the members of this clade. *Philinopsis falciphallus*, which has very similar morphology to *P. buntot* and *P. coronata*, surprisingly nests with *Aglaja regiscorona* Bertsch, 1972, and several species of *Chelidonura*. This relationship requires additional study as the COI mitochondrial gene was not able to be amplified for *P. falciphallus*. The morphological distinctions of *P. buntot*, *P. coronata* and *P. falciphallus* are discussed above, but the molecular data suggesting a sister species relationship between *P. buntot* and *P. coronata* is consistent with their morphological similarity.

***Philinopsis aliciae* Gosliner, sp. nov.**

Figures 1A–B, 2B, 5.

**MATERIAL EXAMINED.**—HOLOTYPE: PNM 41061, dissected, 5 m depth, subsampled for molecular study, Anilao Harbor, Mabini, Batangas Province, Luzon, Philippines, 13.75994°S, 120.83036°E, 30 April 2011, A. Hermosillo.

**GEOGRAPHICAL DISTRIBUTION.**—Known only from the southern Luzon Island, Philippines (present study).

**ETYMOLOGY.**—The name “aliciae” honors my good friend and colleague, Alicia Hermosillo, who collected this specimen. Ali’s keen eye and infectious enthusiasm brighten up any field trip and produce a wealth of remarkable new observations and species.

**NATURAL HISTORY.**—This species is found in the same habitat and at the same locality as the preceding species on a sandy bottom in 5 m depth. Little else is known about its biology.

**DESCRIPTION.**—*External morphology:* The living specimen was 11 mm in length and 4 mm wide. The general body color of the living animal (Figs. 1A–B) is mottled dark chocolate brown. Between the brown regions are clear areas of transparent white, which contain minute flecks of light green. The living animal is elongate and wide. The anterior end of the cephalic shield is uniformly round but blunt and quadrangular. The cephalic shield is roughly rectangular and terminates posteriorly with a medial, rounded knob. The posterior shield is slightly rounded anteriorly and terminates in a rounded lobe without any extension. The two lateral posterior lobes of the posterior shield are short and simply rounded. They are about equal in length. The parapodia are very short, leaving most of the cephalic and posterior shields visible. The gill is simply plicate consisting of 13 primary folds and is situated on the right posterior side of the animal.

*Shell* (Figs. 2B, 5A): The shell is relatively thickly calcified and consists of a thicker band that occupies the posterior extreme of the animal. There is a thin membranous periostracum that is slightly more extensive anteriorly than the calcified portion. The area at the base of the shell near the protoconch is more thickly calcified than the rest of the shell and a posterior lobe is present on the left side of the shell. The shell was fractured into several pieces prior to dissection.

*Digestive system:* The buccal mass is large, highly muscularized and slightly elongate posteri-

orly. It occupies the entire length of the cephalic shield. The buccal bulb lacks any vestige of a radula. There is a large ventral oral gland and the small dorsal oral glands were indistinct. At the posterior end of the buccal mass, near the junction with the crop, is a pair of elongate salivary glands. The crop is large and saccate, as wide as the buccal bulb. The crop narrows posteriorly and enters the digestive gland. The intestine emerges from the right side of the digestive gland and terminates near the posterior end of the body near the base of the gill.

**Central Nervous System** (Fig. 5B): The circumesophageal nerve ring consists of paired cerebral, pedal and pleural ganglia and a single supraintestinal ganglion on the right side. The cerebral and pedal commissures are both elongate with well-separated respective ganglia. Immediately adjacent and posterior to the right pleural ganglion is the supraintestinal ganglion. From its posterior end is the right branch of the visceral loop and the osphradial nerve. The two lateral branches of the visceral loop join posteriorly at the posterior ganglia. The left visceral loop enters the subintestinal ganglion, whereas the right lateral nerve enters the visceral ganglion. The visceral ganglion is larger than the subintestinal ganglion. From the visceral ganglion is the genital nerve, which lacks a distinct genital ganglion. The buccal ganglia can be seen near the middle of the ventral surface of the buccal mas and are somewhat separated from each other.

**Reproductive System** (Figs. 5C–D): The posterior reproductive organs are not well preserved. The arrangement of reproductive organs is monaulic (Fig. 5D) with a single branch to the albumen and membrane glands. From the large ovotestis, which is intermingled with the digestive gland, emerges the convoluted ampulla. The ampulla narrows into the hermaphroditic duct, curves around female glands and has a single branch to the short, coiled albumen and membrane glands. A distinct receptaculum seminis could not be distinguished. The larger mucous gland is bilobed with a massive primary lobe and smaller secondary one. The hermaphroditic duct continues to the geni-

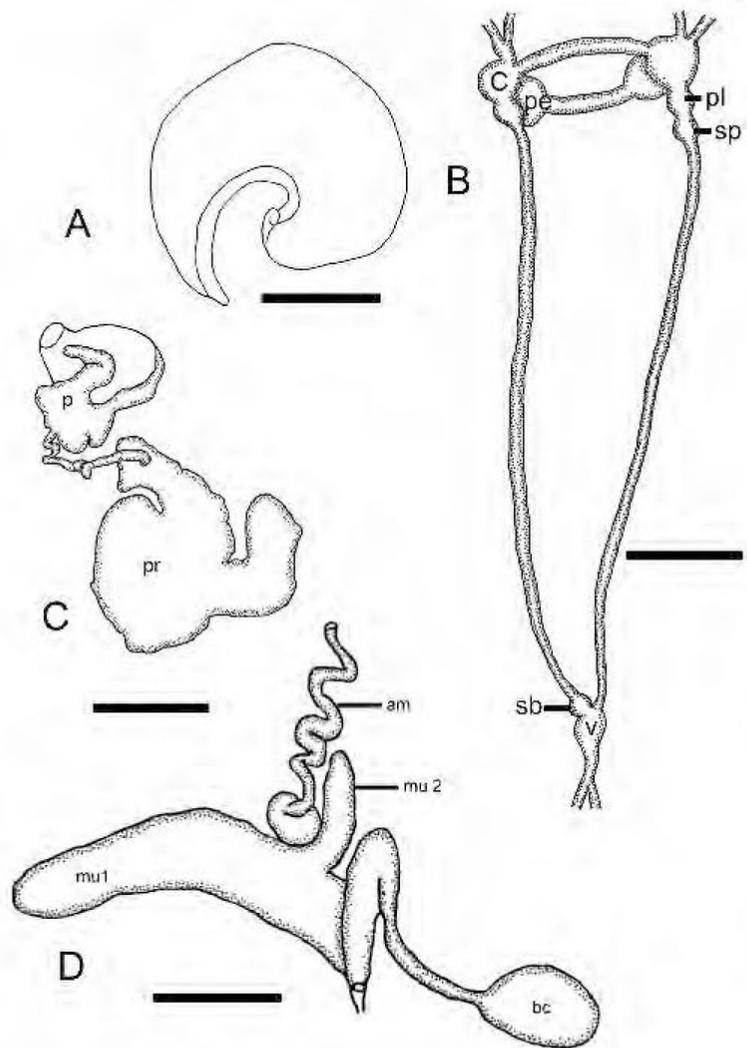


FIGURE 5. *Philinopsis aliciae* sp. nov., holotype, PNM 41061, Mabini, Philippines. A. Shell, scale = 1.5 mm. B. Central nervous system c—cerebral ganglion, pe—pedal ganglion, pl—pleural ganglion, sp—supraintestinal ganglion, su—subintestinal ganglion, v—visceral ganglion, scale = 1 mm. C. Penis, p—penial papilla, pr—prostate, scale = 0.75 mm. D. Posterior reproductive organs, am—ampulla, bc—bursa copulatrix, mu1—mucous gland large, mu2—mucous gland small, scale = 1 mm.

tal atrium where it joins the duct of the bursa copulatrix. The bursa is large and spherical. Its duct is narrow where it joins the bursa and widens until its widest portion at the muscularized genital atrium. From the genital atrium, the open, ciliated sperm groove leads to the cephalic penis. The penis (Fig. 5C) consists of a penial sac and a lobate prostate gland that is joined to the penial sac by a narrow duct. Within the penial sac is a large, curved penial papilla, which appears to be devoid of spines.

**REMARKS.**—*Philinopsis aliciae* is very similar in its external coloration to some specimens of *P. buntot*, described above. Most significantly, it lacks the distinct “tail-like” posterior appendage of the posterior shield, which characterizes *P. buntot*. Internally, there are also significant differences, as well. The central nervous system of *P. buntot* contains a distinct genital ganglion (Fig. 3A) at the posterior end of the central nervous system, which is absent in *P. aliciae*. The general shape of the penis is similar in the two species, with a well-developed prostate separated from the penis by a thin duct. In *P. buntot*, the prostate is oblong in shape, whereas in *P. aliciae* it is more irregular in shape. The penis of *P. buntot* has a series of undivided and bifurcate spines on the penial collar and two lobes of the penial papilla. In *P. aliciae*, the penis contains a single simple lobe, lacks a penial collar and lacks any armature on the penial papilla. Both *P. buntot* and *P. aliciae* are sympatric and were collected from the same dive site on the same dive. The two species avoided each other when placed in the same container. When multiple specimens of *P. buntot* were observed together they aggregated and were observed mating with each other. Both species have marked genetic differences and *P. aliciae* does not cluster with other species of *Philinopsis* (unpublished data), likely owing to the lack of amplification of the 16S and H3 genes for this species. This species is tentatively described as a species of *Philinopsis*, based on anatomical characters, but verification of its systematic position must await additional molecular study.

### **Genus *Chelidonura* A. Adams, 1850**

Type species: *Bulla hirundinina* Quoy and Gaimard, 1832, by monotypy

#### ***Chelidonura alexisi* Gosliner, sp. nov.**

Figures 1E, 2C, 6.

**MATERIAL EXAMINED.**—HOLOTYPE: PNM 41062, dissected, sub-sample removed for molecular study, 20 m depth, crawling on sandy slope, Mainit Bubbles, Mabini, Batangas, Philippines, 13.68651°S 120.89533°E, 18 May 2009, Alexis Principe. PARATYPES: CASIZ 204580, 3 specimens, not dissected, 17 m depth, crawling on sandy slope, Shipyard, Puerto Galera Bay, Mindoro Oriental, Philippines, 13.516026°S 120.965622°E, 27 March 2015, T. Gosliner and Kelly Markello.

**GEOGRAPHIC RANGE.**—Known only from southern Luzon Island, Philippines (present study) and Puerto Galera (northern Mindoro Island) (Carole Harris, pers. comm., unpublished data).

**ETYMOLOGY.**—The name *alexisi* is named for dive guide and photographer Alexis Principe who found the only specimen of this species. Alexis has made many new discoveries and has a great passion for the unique biodiversity of the Philippines.

**NATURAL HISTORY.**—This species was found crawling on the surface of silty sand in the open in 20 m of water.

**DESCRIPTION.**—*External morphology:* The living animal is 30 mm in length. The general body color of the living animal (Fig. 1E) is uniformly black with numerous minute punctations of opaque white. This pigment pattern is found on the cephalic and posterior shields and parapodia, but opaque white spots are absent from the foot. One specimen observed in Puerto Galera (unpublished data) lacked opaque white spots. The living animals are elongate, and narrow. The anterior end of the cephalic shield is quadrilobate. Fine sensory appendages are evident along the anterior margin

of the head and in the preserved specimen individual nerve cells appear to be found at the base of each bristle-like appendage. The cephalic shield is elongate making up almost two-thirds of the body length. It is triangular, broadest anteriorly and terminates posteriorly with a short rounded lobe. The posterior shield is well rounded anteriorly and terminates in a long bilobed appendage on the left side and a short, broad posterior lobe on the right. The parapodia are relatively wide, largely covering most of the cephalic shield at its widest part. The gill is plicate with 8 primary folds.

*Shell* (Figs. 2C, 6A): The shell is relatively thinly calcified and has a shiny brownish tinge. It occupies most of the posterior shield. The shell is thin and brittle and fragmented into four pieces when it was removed from the holotype. There is a broad anteriorly-directed wing and an elongate extension that is deeply embedded in the posterior shield right to the end of the left posterior lobe. The protoconch is visible at the base of the shell.

*Digestive system*: The buccal mass is small, highly muscularized, occupying the anterior one-fourth of the cephalic shield. The buccal bulb entirely lacks any vestige of a radula. There is a small dorsal oral gland and a large ventral one. At the posterior end of the buccal mass, near the junction with the crop, is a pair of elongate salivary glands. The crop is small and saccate, about the same width as the buccal bulb. The crop narrows posteriorly and enters the digestive gland. The intestine emerges from the right side of the digestive gland and terminates near the posterior end of the body near the base of the gill.

*Central Nervous System* (Fig. 6B): The circumesophageal nerve ring consists of paired cerebral, pedal, pleural ganglia and a single suprainestinal ganglion on the right side. The cerebral and pedal commissures are both short with poorly separated ganglia. Immediately adjacent and posterior to the right pleural ganglion is the suprainestinal ganglion. From its posterior end is the right branch of the visceral loop and the osphradial nerve. The two lateral branches of the visceral loop join posteriorly at the posterior ganglia. The left visceral loop enters the subintestinal ganglion, whereas the right lateral nerve enters the visceral ganglion posterior to its junction with the subintestinal ganglion. The visceral ganglion is larger than the subintestinal ganglion. From the visceral ganglion is the genital nerve, which lacks a distinct genital ganglion.

*Reproductive System* (Figs. 6C–D): The arrangement of reproductive organs is a modified monaulic arrangement (Fig. 6C). From the large ovotestis, which is intermingled with the digestive gland, emerges the convoluted ampulla. The ampulla narrows into the hermaphroditic duct, which curves along the inner face of the receptaculum seminis and enters short, coiled albumen and membrane glands. It appears to have only a single entrance to these glands. The larger mucous gland is curved with a massive single lobe. The hermaphroditic duct then joins the duct of the long receptaculum seminis and continues to the genital atrium where it joins the thick, muscular genital atrium. The bursa copulatrix is large and spherical. Its duct is wide and short and widens slightly at the genital atrium. From the genital atrium the open, ciliated sperm groove leads to the cephalic penis. The penis (Fig. 6D) consists of a penial sac and an elongate, curved prostate gland that is joined to the penial sac by a short, narrow duct. Within the penial sac is a large penial papilla that is ribbed, lobed and blunt. At the base of the papilla are about 5–7 small glandular structures that have a small chitinous hook extending outward from the glandular base (Fig. 6D). The primary lobe of the penial papilla has a conical protuberance near the middle of its length. A second protuberance is found near the apex of the papilla.

**REMARKS.**— This species is similar in external color pattern to *Chelidonura inornata* Baba, 1955 and some color variants of *C. sandrana* Rudman, 1973 (Gosliner et al. 2008). In *C. inornata* the body is black with small opaque white spots, but white spots are absent from the cephalic shield and posterior shield whereas in *C. alexisi* the spots are present on the entire body except for the inside of the parapodia. Additionally, specimens of *C. inornata* have a broad anterior opaque white

band with smaller orange lines or spots in front of the white band near the margins anterior end of the head shield. The posterior end of the cephalic shield usually has a thin opaque white margin. The head of *C. inornata* has three distinct lobes, whereas *C. alexisi* has four lobes. In both species, the left lobe of the posterior shield is longer than right one and in *C. inornata* they may be markedly unequal or subequal. The internal anatomy of *C. inornata* remains largely undescribed (Rudman 1970). Rudman illustrated the penis as having a short prostate with a simple penial papilla. A specimen of *C. inornata* examined here (CASIZ 179987), has a simple penis devoid of any cuticular hooks or conical warts. *Chelidonura inornata* is generally found on hard substrate often associated with living coral colonies, whereas *C. alexisi* inhabits sandy areas.

*Chelidonura sandrana* also has some similarities to *C. alexisi*. As mentioned above, some color variants have a black body with opaque white spots. In *C. sandrana*, the right lobe of the posterior shield is very truncated and simple rounded, whereas in *C. alexisi* it is longer and lobate or acutely pointed. The penis of *C. sandrana* has a simple short prostate and a conical penial papilla that lacks any armature or warty protrusions (Rudman, 1973). In *C. alexisi*, the penis has distinct chitinous hooks and two warty protrusions. *Chelidonura alexisi* is about twice the size of the largest specimens of *C. sandrana*.

In the molecular phylogenetic analysis of the aglajids (Camacho-García et al. 2014), *C. alexisi* (as *C. sp.* CASIZ 181278) is sister to a clade composed of *C. mandroroa* and *C. inornata* (Fig. 7). Both *C. inornata* and *C. mandroroa* have a tribloate head whereas it is quadrilobate in *C. alexisi*. The penis of *C. mandroroa* has a single apical cuticular spine whereas *C. alexisi* has two cuticular warts and several basal chitinous spines and *C. inornata* has an entirely unarmed penis (Rudman 1970; present study). This clade of three species is sister to a clade containing the *C. sandrana* species complex and *C. pallida* Risbec, 1951.

*Chelidonura alexisi* can be clearly distinguished from all other aglajids by its quadrolobate anterior margin of the head and its unique color pattern of a black body with or without small opaque white spots. The shape of the anterior portion of the body is most similar to *C. inornata*,

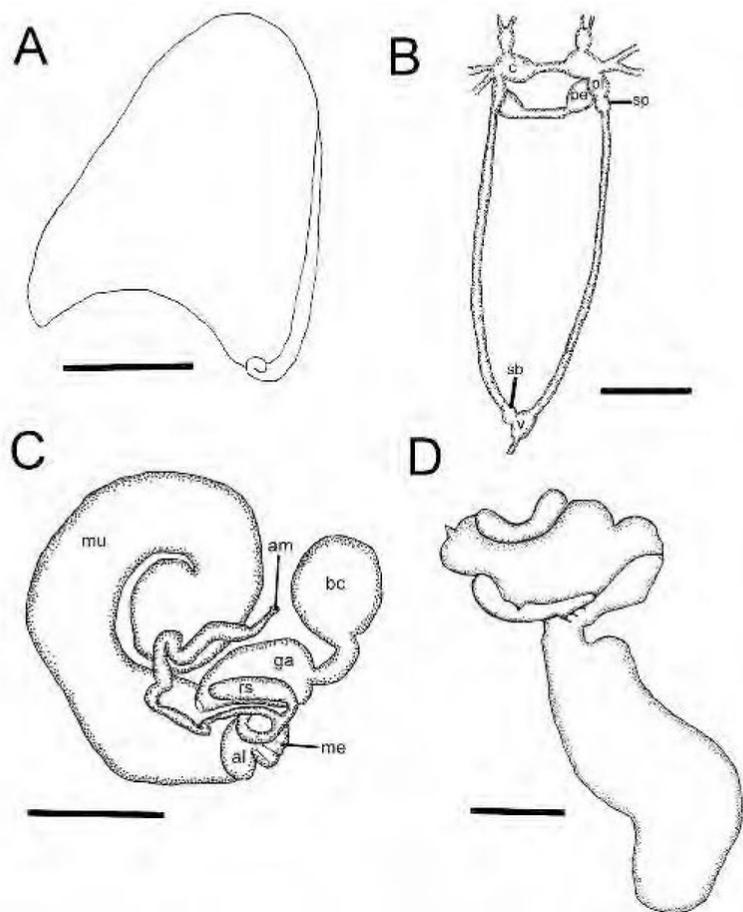


FIGURE 6. *Cheilidonura alexisi* sp. nov., holotype, PNM 41062, Mabini, Philippines. A. Shell, scale = 1 mm. B. Central nervous system c–cerebral ganglion, pe–pedal ganglion, pl–pleural ganglion, sp–supraintestinal ganglion, su–subintestinal ganglion, v–visceral ganglion, scale = 1 mm. C. Posterior reproductive organs, al–albumen gland, am–ampulla, bc–bursa copulatrix, genital atrium, me–membrane gland, mu–mucous gland large, rs–receptaculum seminis, scale = 0.75 mm. D. Penis, scale = 0.5 mm.

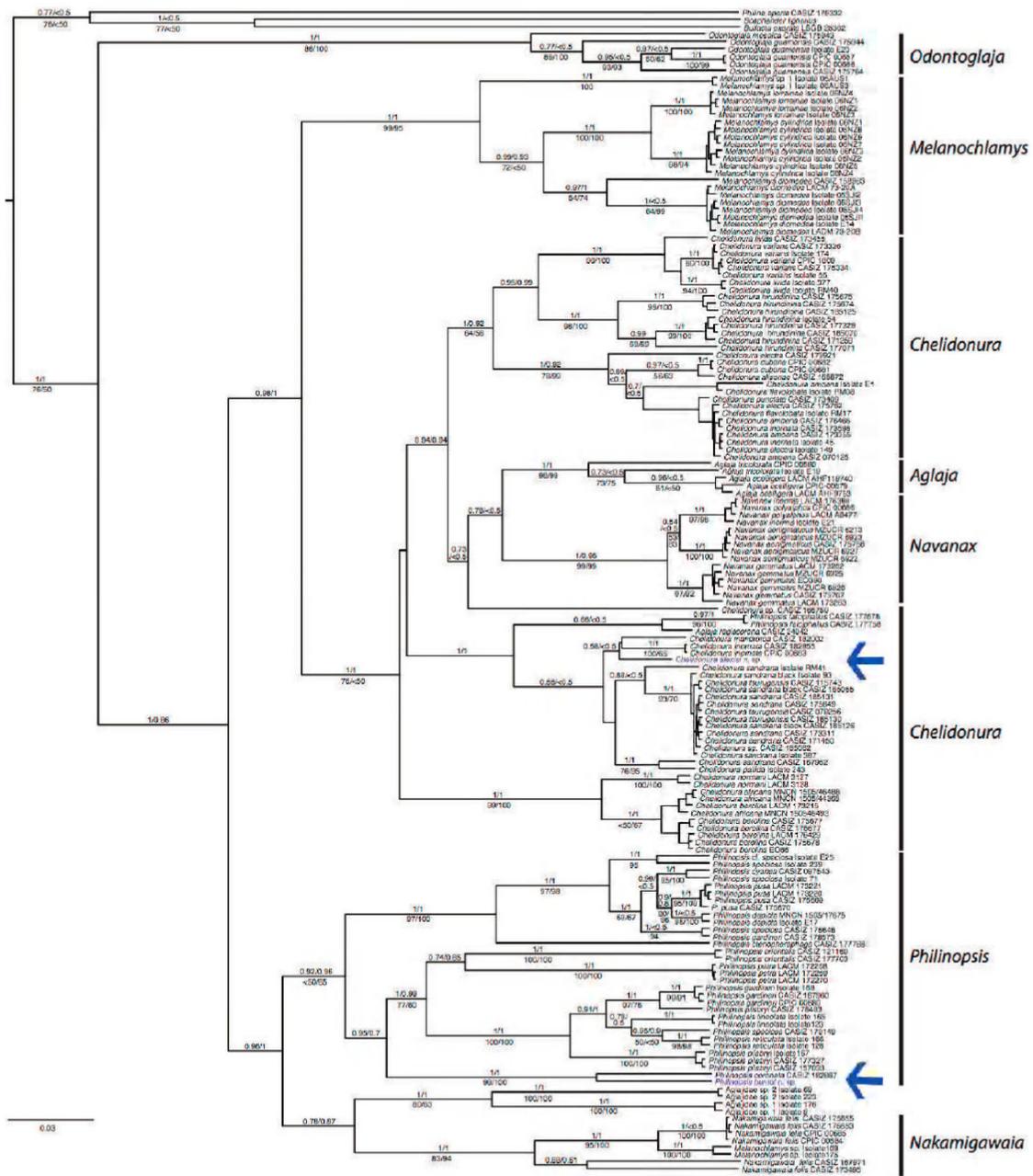


FIGURE 7. Bayesian maximum credibility tree showing all taxa included for the analysis of the combined H3, 16S, and COI sequence alignments (after Camacho et al. 2014). Posterior probabilities are indicated above each branch (for the analysis without COI third positions on the left, and for the analysis with COI third positions on the right) and bootstrap values are indicated below each branch. Branch lengths are also shown here indicating the proportion of substitutions. Species names are color-coded according to their range, blue for Indo-Pacific, red for Atlantic and green for Eastern Pacific. The phylogenetic positions of *Philinopsis buntot* sp. nov. and *Chelidonura alexisi* sp. nov. are indicated by arrows on the tree.

*C. mandroroa* and *C. sandrana*, but all of these species have differences in external and internal morphology, as well as genetic differences.

### DISCUSSION

The Verde Island Passage (VIP) separating southern Luzon Island from northern Mindoro Island in the northern Philippines, has been shown to represent the center of the center of marine biodiversity (Carpenter and Springer 2005; Gosliner et al. 2008) for both shore fishes and opistho-

branches. Gosliner (2011) described six new aglajid species, three of which were found in the VIP: *Philinopsis ctenophorophaga*, *P. falciphallus* and *P. coronata*. With the descriptions of three new species of aglajids in this paper: *P. buntot*, *P. aliciae* and *Chelidonura alexisi*, all recorded only from the VIP, this area has the richest known diversity for this family, with 25 species being found in these waters. Camacho-García et al. (2014) demonstrated that other cryptic species complexes of aglajids are found in the Indo-Pacific region and the total diversity of aglajids might be even greater.

Aglajid cephalaspideans are predators on a wide variety of other opisthobranchs, ctenophores, flatworms and annelid worms (Gosliner et al. 2008). Many of them appear to be highly specialized predators and this trophic diversification might have driven the diversification of aglajids in the Coral Triangle and in the VIP, more specifically. Little is known about the natural history and prey specificity of the species described in the present paper and far more detailed observations of the natural history of aglajids are required to better understand the causal factors that have contributed to their diversification in the VIP. The two closely related species, *C. alexisi* and *C. inornata* that are found sympatrically in the VIP are found in different habitats. *Chelidonura alexisi* is known only from sandy and silty habitats, whereas *C. inornata* is associated with living corals. *Philinopsis buntot* and *P. coronata* are sister species and there appears to be some habitat differences as to where they are found. *Philinopsis buntot*, inhabits clean shallow water sand flats whereas *P. coronata* is found on silty slopes in deeper water.

Ortea et al. (2014) described a new genus, *Migaya* Ortea, Caballer, Moro and Espinosa, 2014, for *Aglaja felis* Marcus and Marcus, 1970, based on the phylogeny presented by Camacho-García et al., 2014. *Aglaja felis* was considered as a member of the genus *Nakamigawaia* Kuroda and Habe in Habe, 1961, by Camacho-García et al. (2014). Ortea et al. noted that the type species of *Nakamigawaia*, *N. spiralis* Kuroda and Habe in Habe, 1961, was not included in Camacho-García et al.'s analysis and that *N. spiralis* has a distinct planispiral shell and lacks sensory bristles around the head (Baba 1985). Ortea et al. also removed *Spinoaglaja* Ortea, Moro and Espinosa, 2007, from synonymy with *Philinopsis* Pease, 1860, based on the phylogeny of Camacho-García et al. and the fact that members of one subclade have a distinctive shell morphology. Ortea et al. (2014:94) stated that "if the shell is really a valid character to separate genera within the family Aglajidae, each genus should have a typical kind of shell." Despite the obvious circularity of this statement, the authors continue to state *Melanochlamys* Cheeseman, 1881 and *Philinopsis* do not have distinctive shell morphology. The same is true for *Navanax* Pilsbry, 1895 where species can have either a simple calcified shell or a calcified portion with an expanded conchiolin wing (Gosliner 1980). Interestingly, *Chelidonura* A. Adams, 1850 has a consistent shell morphology, with minor variation, but has been shown not to be monophyletic Camacho-García et al. (2014). whereas shell morphology may ultimately prove to be an informative systematic character in the higher classification of aglajid cephalaspideans, neither a comprehensive phylogeny nor a complete review of shell morphology has been undertaken for members of the family. Thus, it is premature and imprudent to make additional systematic changes in the classification of aglajids, based exclusively on differences in shell morphology and other minor morphological differences that require verification. whereas the paper by Ortea et al. raises some intriguing suggestions about character evolution, it raises more questions than answers in providing an understating of how morphological attributes are distributed across the aglajid phylogeny. Future studies require greater taxon sampling to establish systematic partitioning of aglajid cephalaspideans as suggested by Gonzales and Gosliner (2014), where some taxa previously assigned to Philinidae appear to cluster with members of the Aglajidae.

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## LITERATURE CITED

- BABA, K. 1985. Anatomical review of a cephalaspidean mollusk, *Nakamigawaia spiralis* Kurdoa & Habe in Habe 1961, (Aglajidae), from Japan. *Special Publication of the Mukaishima Marine Biological Station*, 1985:1–5.
- CAMACHO-GARCÍA, Y. E., E. ORNELAS-GATDULA, T. M. GOSLINER, AND Á. VALDÉS. 2014. Phylogeny of the family Aglajidae (Pilsbry, 1895) (Opisthobranchia: Cephalaspidea) inferred from mtDNA and nDNA. *Molecular Phylogenetics and Evolution* 71:113–126.
- CARPENTER, K., AND V. G. SPRINGER. 2005. The center of the center of marine shore fish biodiversity: the Philippine Islands. *Environmental Biology of Fishes* 72:467–480.
- GONZALES, C., AND T. GOSLINER. 2014. Six new species of *Philine* (Opisthobranchia: Philinidae) from the tropical Indo-Pacific. The Coral Triangle: the 2011 Hearst Biodiversity Expedition. Special Publication of the California Academy of Sciences: 351–383.
- GOSLINER, T. M. 1980. Systematics and phylogeny of the Aglajidae (Opisthobranchia: Mollusca). *Zoological Journal of the Linnean Society* 68:325–360.
- GOSLINER, T. 1994. Gastropoda: Opisthobranchia. Pages 235–355 in F. Harrison and A. Kohn, eds., *Microscopic Anatomy of Invertebrates*. V. 5. Mollusca, ch. 5. John Wiley & Sons, New York, New York, USA.
- GOSLINER, T. 2011. Six new species of aglajid opisthobranch mollusks from the tropical Indo-Pacific. *Zootaxa* 2751:1–24.

- GOSLINER, T. M., D. BEHRENS, AND Á. VALDÉS. (2008) *Indo-Pacific Nudibranchs and Sea Slugs: a Field Guide to the World's Most Diverse Fauna*. Sea Challengers, Gig Harbor, Washington, and California Academy of Sciences, San Francisco, California, USA. 426 pp.
- MARCUS, EV., AND ER. MARCUS. 1967. American opisthobranch mollusks Part I, Tropical American opisthobranchs. *Studies in Tropical Oceanography, Miami* 6:1-137.
- ORTEA, J., M. CABALLER, L. MORO AND J. EPINOSA. 2014. What the shell tells in Aglajidae: A new genus for *Aglajafelis* (Opisthobranchia: Cephalaspidea). *Revista de la Academia Canaria de Ciencias* 26: 83-119.
- RUDMAN, W. B. 1970. *Chelidonura inornata* Baba and *C. electra* sp. nov. from the Solomon Islands (Opisthobranchia, Aglajidae). *Journal of the Malacological Society of Australia* 2:7-12.
- RUDMAN, W. B. 1972a. On *Melanochlamys* Cheeseman, 1881, a genus of the Aglajidae (Opisthobranchia: Gastropoda). *Pacific Science* 26:50-62.
- RUDMAN, W. B. 1972b. A comparative study of the genus *Philinopsis* Pease, 1860. (Aglajidae, Opisthobranchia). *Pacific Science* 26:381-399.
- RUDMAN, W. B. 1972c. Structure and functioning on the gut of the Bullomorpha (Opisthobranchia). Part 4. Aglajidae. *Journal of Natural History* 6:547-560.
- RUDMAN, W. B. 1973. On some species of *Chelidonura* (Opisthobranchia: Aglajidae) from Zanzibar and Fiji. *Zoological Journal of the Linnean Society* 52:201-215.
- RUDMAN, W. B. 1974. A comparison of *Chelidonura*, *Navanax* and *Aglaja* with other genera of the Aglajidae (Opisthobranchia, Gastropoda). *Zoological Journal of the Linnean Society* 54:185-212.
- RUDMAN, W. B. 1978. A new species and genus of the Aglajidae and the evolution of the philinacean opisthobranch molluscs. *Zoological Journal of the Linnean Society* 62:89-107.



Gosliner, Terrence M. 2015. "Three New Species of Aglajid Cephalaspidean Mollusks from the Tropical Indo-Pacific of the Verde Island Passage." *Proceedings of the California Academy of Sciences, 4th series* 62(6), 191–205.

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