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Biology and description of *Antisabia juliae* sp. nov., new Hipponicid gastropod commensal on *Turbo* spp. in Laing Island (Papua New Guinea)*

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SUMMARY: The gastropod family Hipponicidae comprises widely distributed but poorly known sedentary species. On the beach-rock of the coral reefs of Laing Island (Papua New Guinea) live rich populations of several gastropod *Turbo* species of which many specimens have attached to their shell a hipponicid gastropod attributed to a new species, *Antisabia juliae*. This new species, described in this paper, appears to have adapted its mode of life on live turbinids in several ways resulting in morphological changes (thin basal plate loosely adherent to the supporting shell, functional eyes, very long snout, functional radula, small osphradium) and ethological changes (foraging behaviour: it appears to feed on the epiphytic community growing on the host, in the vicinity of the "host" shell). Except for these characteristics, the mode of life appears quite similar to that of other hipponicid species with few big females surrounded by several much smaller males. Development occurs within the egg mass inside the female shell and a few young snails escape at the crawling stage.

Key words: Mollusca, Gastropoda, ecology, Hipponicidae, Papua New Guinea, Indopacific.

RESUMEN: BIOLOGÍA Y DESCRIPCIÓN DE *ANTISABIA JULIAE* SP. NOV., UN NUEVO GASTERÓPODO HIPONÍCIDO COMENSAL DE *TURBO* SPP. EN LA ISLA LAING (PAPÚA NUEVA GUINEA). La familia Hiponícidos comprende especies sedentarias ampliamente distribuidas pero poco conocidas. En las costas rocosas de los arrecifes coralinos de la isla Laing (Papúa Nueva Guinea) viven abundantes poblaciones de varias especies de *Turbo*, muchos de cuyos ejemplares portan un gasterópodo hiponícido atribuido a una nueva especie, *Antisabia juliae*, que se describe en este artículo. Esta especie parece haberse adaptado de varias maneras a vivir sobre los turbínidos vivos, lo que ha conducido a cambios morfológicos (placa basal delgada y ligeramente adherente a la concha de sostén, ojos funcionales, hocico muy largo, rádula funcional, osfradio pequeño) y etológicos (comportamiento alimentario: parece que se alimenta de la comunidad epifítica que crece sobre el patrón, en la inmediatez de la concha del "patrón"). Excepto por estas características, el modo de vida parece muy semejante al de otras especies de hiponícidos, con unas pocas hembras grandes rodeadas de varios machos mucho menores. El desarrollo tiene lugar en el interior de la masa de huevos, dentro de la concha de la hembra, y unos pocos caracoles juveniles escapan en el estadio de reptación.

Palabras clave: Moluscos, Gasterópodos, ecología, Hiponícidos, Papua-Nueva Guinea, Indopacífico.

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INTRODUCTION

Hipponicidae are a group of widely distributed but poorly known sedentary gastropods. Except for a few older papers (i.e., Quoy and Gaimard, 1835) there is only a small number of articles dealing with the detailed morphology and life habits of representatives of this family (for a review, see Knudsen, 1991, 1993). Due to the lack of knowledge about their anatomy, a considerable uncertainty prevails regarding the delimitation of the Indopacific genera and species (Knudsen, 1993), particularly in Papua New Guinea.

Laing Island (4° 10' 30" S, 144° 52' 47" E) lies in the western part of the Bismarck Sea, in the middle of Hansa Bay (Madang Province, northern coast of Papua New Guinea). This small island is almost completely surrounded by live coral formations and has an eroded coral plateau (beach rock), 75 meters wide, on three sides: east, north and south. On this plateau live rich populations of *Turbo setosus* Gmelin, 1791, *T. crassus* Wood, 1829, *T. brunneus* (Röding, 1798) and *T. sparverius* Gmelin, 1791, of which many specimens wear a hipponicid gastropod attributed to the genus *Antisabia* that we consider as a new species. This hipponicid was almost found only on the shells of these four species.

MATERIAL AND METHODS

During three missions on Laing Island in October-November 1990, 1992 and May-June 1995, we were able to collect samples for SEM observations and to describe the gross morphology, the spatial and specific distribution of this new *Antisabia* species (approx. 300 specimens were observed, most of which were returned live to the collecting site according to the wishes of the Papua New Guinea authorities).

The material was sampled at low tide on the beach rock. Supporting shells of *Turbo* spp. were sized and identified on site and the number, position on the host and sizes of the hipponicid shells recorded with a caliper square to the nearest 0.1 mm. Results were computed and interpreted through Systat® statistical software package.

Some samples were either ethanol preserved for dissection and radula extraction or glutaraldehyde fixed for scanning electron microscopy (SEM). Later, the samples for SEM were washed in 0.2 μm filtered seawater and postfixed in 0.5 % OsO_4 in distilled water at 4°C for 1 hour, washed in distilled water, dehydrated through graded ethanol series and dried by sublimation at 10°C under low pressure after inclusion in Peldri® fluorocarbon resin. The material was glued onto Al stubs with Tempfix® conductive resin, Au-Pd sputtered (15 nm) (cold diode Balzers sputtering device) and examined with a Jeol JSM-840/A scanning microscope.

DESCRIPTION

***Antisabia juliae* sp. nov.**
Class Gastropoda
Superfamily Hipponicacea Troschel, 1861
Family Hipponicidae Troschel, 1861

Material examined: Over 300 specimens were observed of which most were returned live to the beach. Approximately 50 specimens were preserved for dissection and SEM examination.

Holotype: A female specimen, collected in May 1995 cemented to a shell of *Turbo setosus* Gmelin, 1791 on the beach rock at Laing Island (Papua New Guinea); 4 mm length and 3 mm width; glutaradehyde/OsO_4 fixed and ethanol preserved. Deposited in the collections of the Royal Institute of Natural Sciences of Belgium in Brussels (IRSNB) under n° I.G. 28.371A

Holotype diagnosis: The shell is solid, patelliform in general shape, with a pyriform aperture. In lateral view, the anterior edge is convex and the apex is located quite closer to the posterior margin. Sculpture is constituted of 6 thick axial undulations becoming deeper close to the aperture, crossing irregular growth marks. The shell is whitish pink under a thin amber periostracum, partly covered by calcareous algae and other epiphytes. The interior is glossy white. The protoconch (not well conserved) is rissoid in shape (Fig. 3B), with 2.5 whorls, smooth (except superficial granulations due to the shell fabric) and disposed at right angle of the teleoconch. Its sizes are as follow: 400 μm in length, 270 μm in diameter, nucleus 120 μm in diameter. The basal plate is partly conserved: it is a thin white calcareous layer on the ventral side of the metapodium, smaller in diameter than the aperture of the shell.

When observed alive, the head showed a relatively big muscular and very extensible snout (several mm out of the shell; Figs. 1D, 4), the distal ends

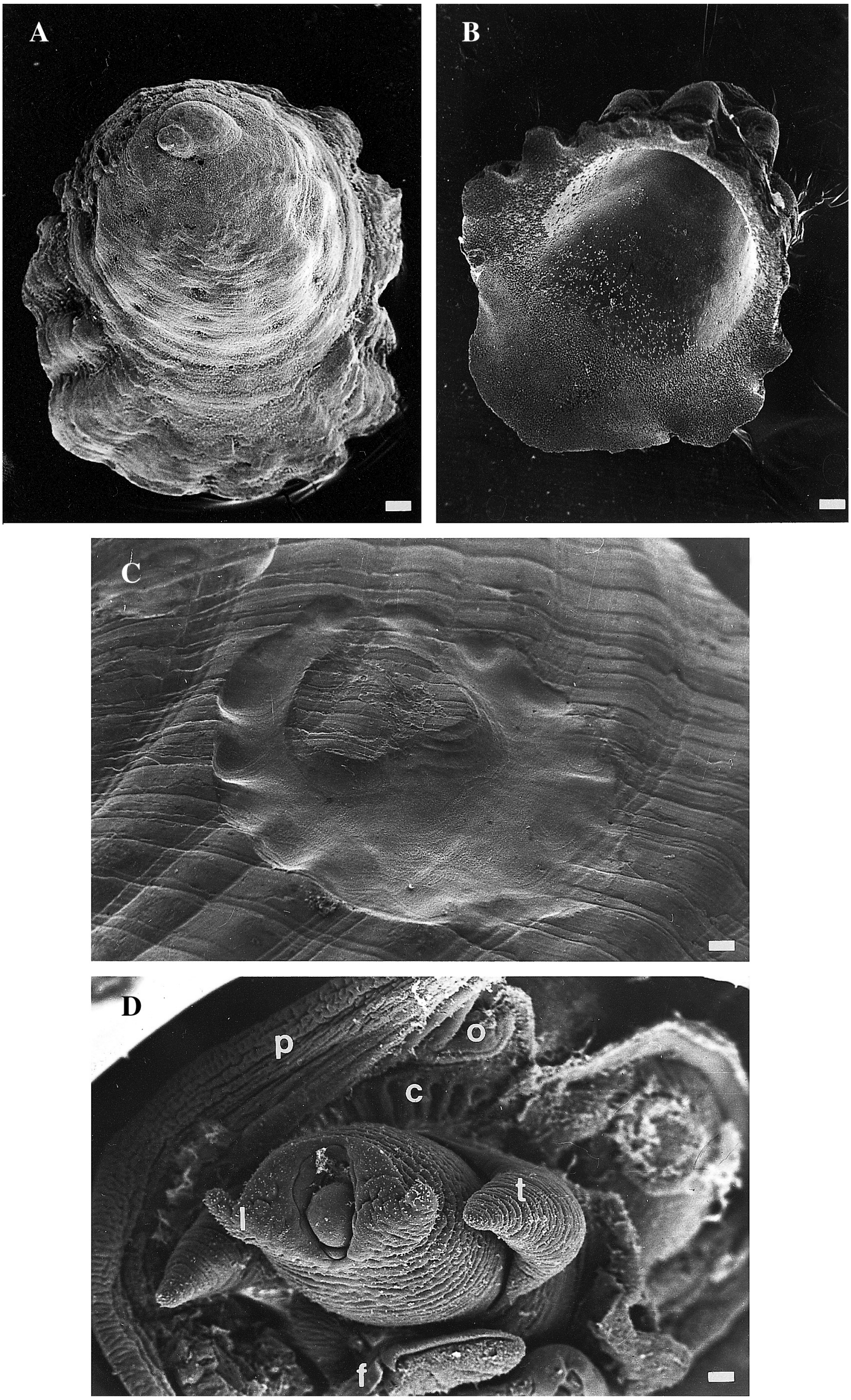

FIG. 1 – *Antisabia juliae* sp. nov.; **A**, shell, dorsal view of a female specimen (paratype; scale bar, 250 μm); **B**, shell, internal view of a female specimen (paratype; scale bar, 250 μm); **C**, fingerprint on the surface of a *Turbo* shell (scale bar, 250 μm); **D**, anterior cephalic region (scale bar, 100 μm) c, ctenidium (gill); f, anterior part of the propodium; l, lateral lobe of the snout; o, osphradium; p, mantle edge; t, tentacles.

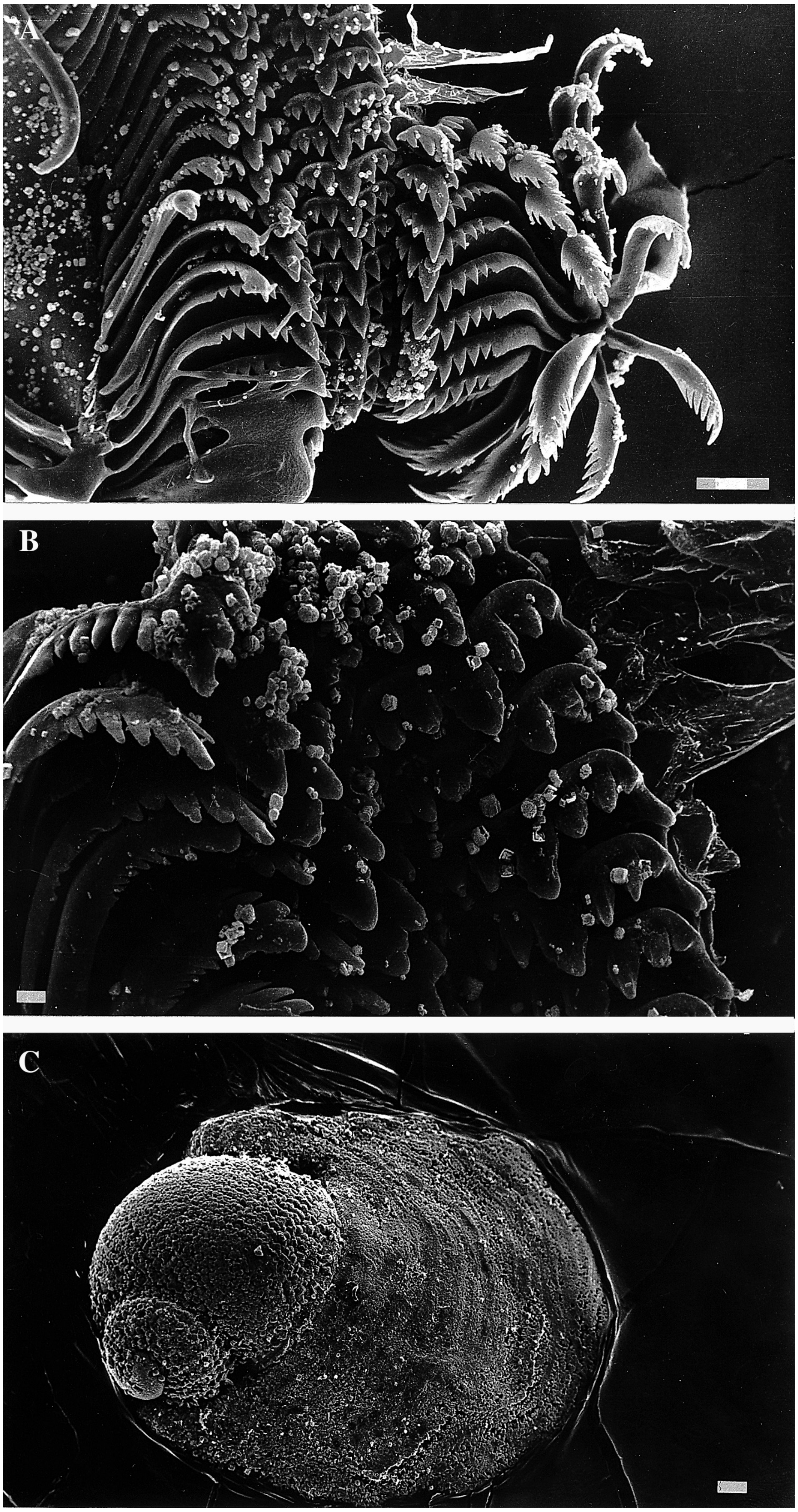

FIG. 2 – *Antisabia juliae* sp. nov. **A**, General view of the radula of a male specimen (scale bar, 50 μm). **B**, Detail of the anterior part (6 first rows) of the radula of a female specimen (scale bar, 10 μm). **C**, General view of a young snail recently hatched from the egg capsule. (scale bar, 10 μm).

of which bear a pair of blunt lateral mobile lobes (l, Figs. 1D, 4). Tentacles are conical, long and thin when extended, of the same length or slightly longer than the snout (t, Figs. 1D, 4), with small brown ventrolateral eyes at the base. The general colour is whitish with regular dark brown to black marks on the distal part of the tentacles (one third of their length) and on the edges and lateral parts of the snout except the distal lobes (Fig. 4).

Allotype: A male specimen, collected in May 1995 cemented to the same shell of *Turbo setosus* Gmelin, 1791 as the holotype, same locality; 2 mm length and 1.5 mm width; ethanol preserved (IRSNB collections N° I.G. 28.371B).

Allotype diagnosis: The shell (teleoconch) is very thin, low patelliform in general shape, with an irregular oval aperture. In lateral view, the anterior edge is convex and the apex is located at the level of the posterior margin. The shell is almost smooth, with 3 very weak axial undulations. The colour is whitish pink under a very thin inconspicuous periostracum. The interior is glossy white with heavy pink very small blotches close to the aperture of the shell.

The protoconch is rissoid in shape, with 2 whorls, smooth and disposed at right angle of the teleoconch. Its sizes are as follow: 350 μm in length, 250 μm in diameter, nucleus 120 μm in diameter. The basal plate is well preserved: reniform in shape, very thin, composed of juxtaposed spherulithic granules and only slightly adherent to the host shell. The colour pattern is similar to that of the holotype. The penis is prominent, reaching half the length of the snout, with a blunt shape, disposed on the right side of the head.

Paratypes: 3 isolated shells, 6 females and 9 males collected in November 1992 and May 1995, same locality, deposited in the IRSNB collections under N° I.G. 28.371C. 4 females and 2 males collected in May 1995 deposited in the collections of the Zoology Museum of Liège University (MZULg) under n° RE13900, RE13901, RE13902, RE13903, RE13904 and RE13905. 9 females and 13 males collected in October 1990, November 1992 and May 1995 in the collection of authors.

Etymology: One of the authors, MP, dedicates this species to his little child Julie, whose birth coincided with the beginning of this work and the first specimens found.

Other morphological features and variations within the population

The teleoconch is variable in shape and thickness: generally solid, patelliform to conical, it is more or less elevated according to the size and the localization of the specimen on the "carrier" mollusk shell (Figs. 1A, B): specimens located on the external part of the peristomium are generally larger than specimens on the columellar region of the host shell (shallower ovoid patelliform shells). The same observations were made on males and females. The biggest female specimens observed reach 14 mm in diameter, the biggest males less than 4 mm. Sculpture is present in more than 85% of specimens: it is constituted of 2 to 12 axial undulations becoming deeper closest to the aperture. The colour is generally very pale and uniform, whitish pink to pale brown in rare specimens under a thin smooth periostracum. The interior is glossy white with occasional heavy pink to chocolate brown very small blotches and a thin horse-shoe muscular scar. Concerning the microarchitecture, the shell is composed of three superimposed layers of crossed-lamellar fabric with the general axis of first order blocks of adjacent layers disposed at right angle from each other and second order lamellae displaying a characteristic angle of 40° to 50°.

The protoconch (when conserved) is naticoid (Fig. 3a) to rissoid (Fig. 3b) in shape, always with 2.5 whorls, always smooth (except superficial granulations due to the shell fabric, Fig. 2C) and disposed at right angle of the teleoconch (Figs. 2C, 3). In the population sampled, the size of the protoconch varies as follows: 350-420 μm in length (rarely up to 600 μm), 250-300 μm (rarely up to 400 μm) in diameter, nucleus 120-150 μm in diameter. The microstructure of the protoconch is aggregative spherulithic (Fig. 2C).

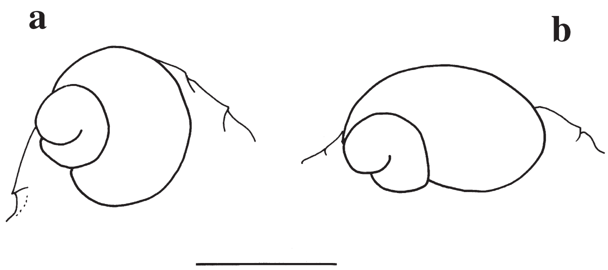

FIG. 3 – Camera lucida drawings of the two kinds of protoconch shapes of *Antisabia juliae* sp. nov. Scale bar, 300 μm. **A**, naticoid shape; **B**, rissoid shape (female illustrated in fig. 1A).

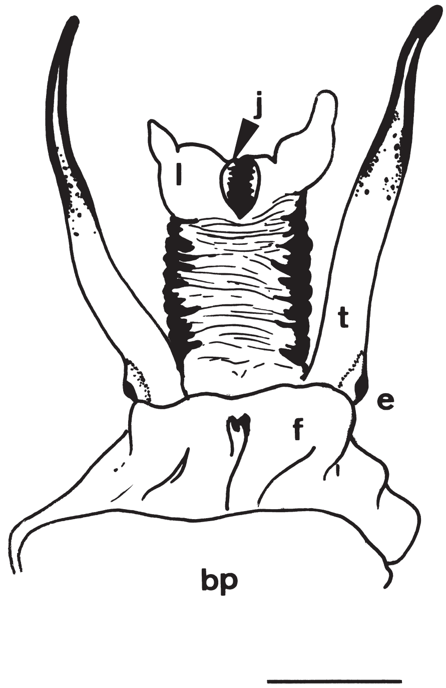

FIG. 4 – Camera lucida drawing of a ventral view of the head of a live female adult specimen of *Antisabia juliae* sp. nov. (paratype). Note the dark markings on the snout and tentacles. Scale bar, 1000 μm. bp, basal plate; e, eye; f, anterior part of the propodium; j, jaws; l, lateral lobe of the snout; t, tentacles.

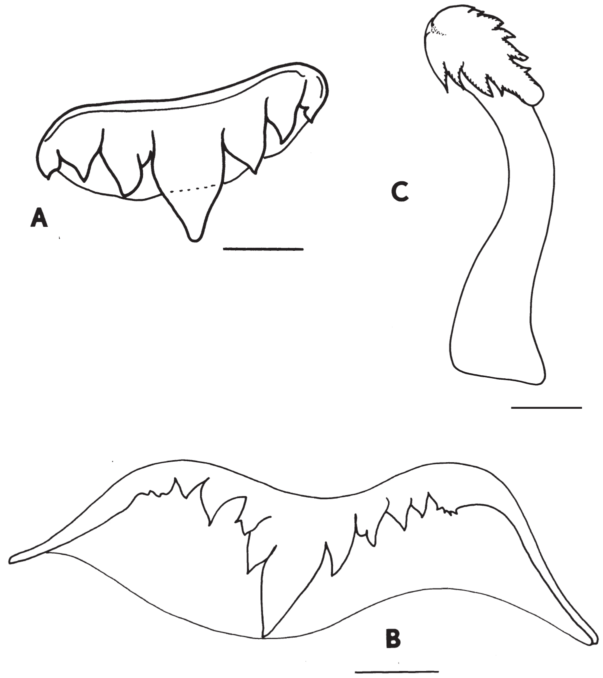

FIG. 5 – Radular teeth of *Antisabia juliae* sp. nov. **A**, rachidian tooth (Scale bar, 5 μm). **B**, lateral tooth (Scale bar, 20 μm). **C**, second marginal tooth (Scale bar, 20 μm).

In females, the basal plate (secreted by the ventral surface of the foot), termed "ventral valve" by Yonge (1953, 1960), is 100 to 250 μm thick and very loosely cemented to the shell of the host *Turbo* (Fig. 1C). It is smaller in diameter than the aperture of the *Antisabia juliae* sp. nov. shell so that its free edges plough a relatively wide and moderately deep ridge in the support (Fig. 1C). In males, the basal plate is very thin (30 to 50 μm thick), and only slightly adherent to the host shell.

The taenioglossate radula is very small (25-40 rows in females, 10-25 in males with no sexual differences in teeth morphology), close to the distal end of the extended snout (Fig. 2A). The rachidian tooth (Fig. 5A) is about 25 μm wide with 7 cusps, the central one being more developed. The lateral tooth (Fig. 5B) has a large median cusp with 5-6 minor cusps on each side (width of the tooth: 160 - 180 μm). The curved marginal teeth (Fig. 5C) are long and thin, with 9-13 distal cusps. The first three to six rows of the radula are worn away: cusps are broken or blunt (Fig. 2B).

The digestive tract was not examined in close details (Fig. 6). There are two small jaws (j, Figs. 4, 6) disposed dorsolaterally. The gut (g, Fig. 6) is

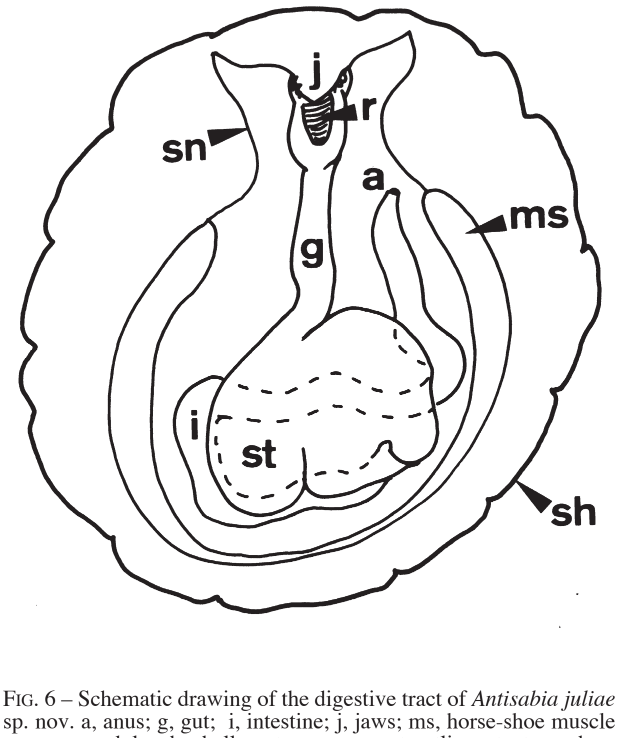

FIG. 6 – Schematic drawing of the digestive tract of *Antisabia juliae* sp. nov. a, anus; g, gut; i, intestine; j, jaws; ms, horse-shoe muscle scar; r, radula; sh, shell contour; sn, snout outline; st, stomach.

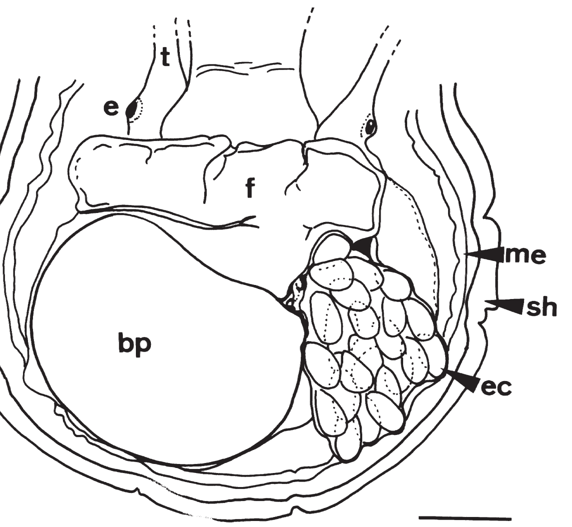

FIG. 7 – Camera lucida drawing of ventral view of a female *Antisabia juliae* sp. nov. with eggs capsule attached to the basal plate (paratype; scale bar, 1000 μm); bp, basal plate; e, eye; ec, eggs capsule; f, anterior part of the propodium; me, mantle edge; sh, shell contour; t, tentacles.

nearly straight. The stomach (st, Fig. 6) is quite wide and pouched, disposed at the middle to right side of the posterior body. The digestive gland is greenish brown, mainly disposed dorsally, to the left part of the stomach. The intestine is quite long and occupies a large part of the pallial cavity embedded in the digestive gland, containing numerous brownish-gray to green oval fecal pellets.

The mantle edge is thickened without apparent differenciations (p, Fig. 1D). The pallial cavity is quite deep. The osphradium appears as an oval ridge close to the mantle edge (o, Fig. 1D). The ctenidium is quite long, transversally disposed, with an L shape (approx. 50 short filaments; c, Fig. 1D).

In females, egg capsules are attached at the postero-lateral left side of the foot, at the edge of the basal plate (Fig. 7). Egg capsules (3-24 eggs, 500 μm in diameter) are thin walled pyriform bodies with a short stalk. Young snails escape at the crawling stage (Fig. 2C). Reproduction (many females wearing egg capsules) was observed at the beginning of the rainy season (October to November) and, to a lesser extent, at the end of it (May). Hatching (2 to 10 young snails per capsule) was observed in November and December.

Comparison with other related species in the Indopacific region

Antisabia juliae sp. nov. is quite easy to distinguish from other Indopacific species of Hipponicidae except from coexisting *Antisabia conica* (Schumacher, 1817) which has quite similar morphology and life habits: *A. juliae* has a smaller size, a much thinner basal plate, weaker sculpture on the shell and a narrower "preference" regarding the supporting shell, almost only live turbinids. Egg capsules of *A. conica* contain several hundred very small yellowish eggs, compared to the 3-24 big whitish eggs in the capsule of *A. juliae*. Both species appear evolutively very close.

Other hipponicid species are generally fixed on rocks, in crevices or on coral heads. *Antisabia foliacea* (Quoy et Gaimard, 1835) is relatively flat, with many growth lamellae piled up at the surface of the shell, each lamella is finely sculptured by radial threads. *Pilosabia subrufa* (Lamarck, 1819), *Pilosabia trigona* (Gmelin, 1791) and *Hipponix pilosa* (Deshayes, 1831) are readily distinguished by their shaggy or squamose periostracum. *Hipponix antiquatus* (Linné, 1767) has a bigger, heavy shell with axial sculpture composed of very prominent rugose ribs crossed by microscopic incised lines.

Choice of supporting shell and localization

All specimens of *Antisabia juliae* sp. nov. of Laing Island are found on 4 species of Turbinid gastropods, 3 of which form abundant populations on the beach rock : *Turbo setosus* Gmelin, 1791, *T. crassus* Wood, 1829, *T. brunneus* (Röding, 1798). *T. sparverius* Gmelin, 1791 is less common. No other shell was found to harbour any hipponicid species until 1995 when we found rare specimens on *Trochus maculatus* Linnaeus, 1758 (one sample), *Tectus pyramis* (Born, 1778) (3 specimens on the same sample) and *Notohaliotis* sp. (one sample).

Bigger shells wear a significantly higher number of commensal individuals than smaller ones (N=60). There is a direct significant correlation of the number of *A. juliae* with the size of the host shell (Table

TABLE 1. – Matrix of Spearman correlation coefficients (r_s) between number of *Antisabia juliae* sp. nov. shells and the size and species of the *Turbo* host shell (number of observations = 60)

	Size	Number males	Number females	Species
Number males	0.808*	1.000	–	–
Number females	0.814*	0.938*	1.000	–
Species	0.223°	0.074°	0.031°	1.000

* Highly significant ($\alpha < 0.01$)
° Not significant

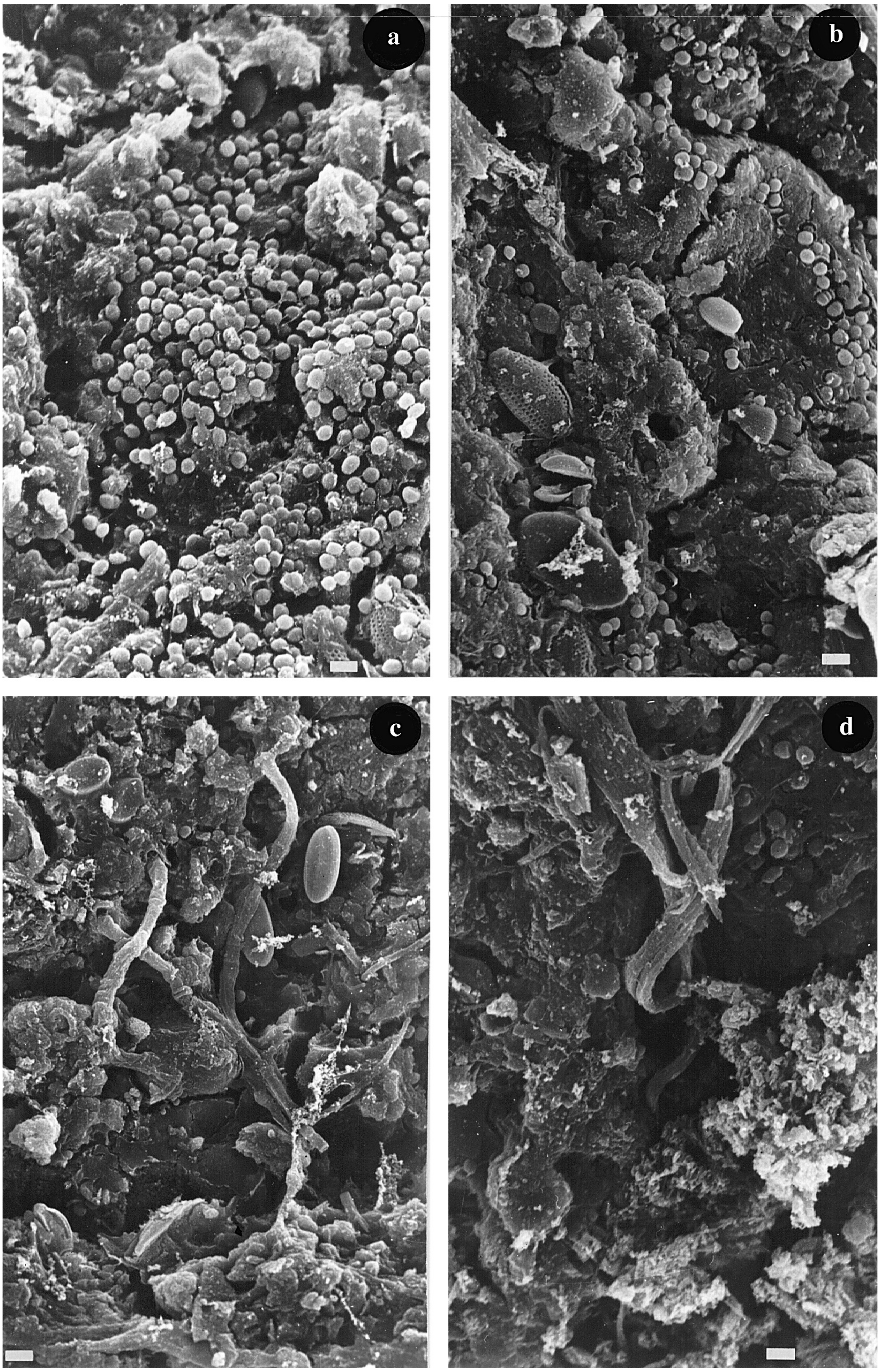

FIG. 8 – **a**, Detail of the epiphytic community scraped off the shell of *Turbo setosus* (mainly cyanobacteria). Scale bar, 10 μm. **b**, Composition of a fecal pellet collected inside the intestine of a female *Antisabia juliae nov. sp.* living on the *Turbo* shell illustrated at A: pennate (benthic) diatoms and cyanobacteria similar to that observed on the shell. Scale bar, 10 μm. **c**, Detail of the epiphytic community scraped off the shell of *Turbo brunneus* (mainly pennate diatoms and filamentous algae). Scale bar, 10 μm. **d**, Composition of the stomach content of a female *Antisabia juliae* sp. nov. living on the *Turbo* shell illustrated at C: pennate (benthic) diatoms, filamentous algae and cyanobacteria similar to that observed on the shell. Scale bar, 10 μm.

1): *A. juliae* is rare on shells smaller than 20 mm in length, whereas shells bigger than 60 to 80 mm frequently harbour one or two females (rarely >3) of relatively large size (6-14 mm diameter) surrounded by 2 to 6 smaller males (up to 21, 1-3 mm diameter). The number of males is also strongly correlated to the number of females ($r_s = 0.94$, $\alpha < 0.01$).

At the same size, there is no significant difference in the number of specimens of *A. juliae* on the 3 more abundant species of *Turbo* (N=57). There is also no significant correlation between the size of *A. juliae* and the size of the host shell.

As already observed by Laws (1971) for *Antisabia conica*, most specimens of *A. juliae* are found on the ventral columellar region of the shell, close to the upper part of the peristomium (87 % of the specimens sampled, N = 250) either on the last whorl or at the base of the last spiral whorl, 10 % are found at the external upper part of the peristomium and 3 % close to the external anterior part of the shell. Several specimens are generally found close together with females surrounded by smaller males.

Distribution around Laing Island

Antisabia juliae sp. nov. is quite abundant on Laing Island, where about 50% of specimens of *Turbo* (all species together) harbour one or more specimens. But its distribution on the beach rock is not homogeneous: it is much more abundant at the northern part of the island where more than 80% of the turbinids wear one or more hipponicid snails. Along the western side, its occurrence remains fairly high (45% to 60% of turbinid shells) whereas this species is less represented at the southern sites (5% to 20% of turbinid shells). There is no important *Turbo* population on the eastern (lagoonal) side. On the beach rock, this distribution is mainly explained by the mean sizes of *Turbo* spp.: large specimens (60 to 90 mm high) mainly occur directly on the beach rock and underneath big dead corals at the northern and western sides of the island whereas smaller specimens shelter in crevices of boulders and under smaller rocks at the southern part of the island.

Foraging

Morphological features (long snout, relative small size of the gill filaments, structure of the radula, worn teeth at the anterior edge; Figs. 1D, 2A, 2B) together with observations of live specimens attest that *Antisabia juliae* sp. nov. does not behave as a filtering snail like *Hipponix antiquatus* (= *H. cranioides*) observed by Yonge (1953). No evidence of host fecal pellet eating was ever encountered as observed in *Hipponix australis* (Risbec, 1935). Living specimens are frequently seen with the shell not closely affixed to the substrate, the snout and tentacles extruded well away through the space so produced and browsing on the host shell. Moreover, the area around *A. juliae* shells is generally relatively "clean" compared to other similar part of the host shell. When compared to the epiphytic community (Figs. 8A, C) found on the host shell, the composition of stomach content and of fecal pellets (Figs. 8B, D) shows striking similarities: benthic pennate diatoms, rhodophyta, chlorophyta and cyanobacteria constitutes the bulk of the pellets with a very similar composition when compared to the epiphytic community living on the same host shell. No sand grains were observed as in *Hipponix australis* analysed by Knudsen (1991).

Any contact stimulus around the snout or tentacles immediately triggers the protrusion of the radula so that this species appears even able to grasp meiofaunal organisms: a partially digested harpacticoid copepod was even found in two cases. It seems that *A. juliae* feeds upon the epiphytic community, microorganisms and perhaps meiofauna in the area that can be reached by the snout.

As the basal plate secreted by the foot is only very loosely cemented to the host shell, we tried to verify the real sedentary nature of this species even if no specimen was ever observed moving or even loose on the host shell. Several attempts (approximately 30 specimens) to let a carefully removed snail fix itself again on the same or another shell (with or without the basal plate) never succeeded : all *A. juliae* died within 6 to 96 hours except some small males remaining unattached for more than 6 days. It appears thus probable that this species, like other in the family Hipponicidae, has real sedentary habits.

DISCUSSION

The hipponicid *Antisabia juliae* sp. nov. was first tentatively attributed to the species *Antisabia conica* (Schumacher) but it appears to present several distinct features that let us consider it a new species. *A. juliae* sp. nov. appears to have adapted to its mode of life on live turbinids in several ways resulting in morphological, ethological and functional changes.

Its preferential location on the basal fasciolar area of the host shell implies it should be progressively recovered by the growing *Turbo* shell. Nevertheless, a displacement reaction of *A. juliae* towards "safer" areas is not likely to occur even if the basal plate secreted by the foot is very thin and only very loosely cemented to the host shell (compared to the attachment of other Hipponicid species living on dead shells or on the beach rock, like *Sabia foliacea* for example). This can explain the preferential "choice" of large (adult) supporting shells (with much slower growth) that so limits the risk of being quickly recovered.

Life on large active intertidal snails also changes the foraging behaviour of this species with correlated morphological changes: it appears to feed on the epiphytic community growing on the host shell, in the vicinity of the sedentary hipponicid; larger supporting shells are likely to wear a more diversified and quick growing epibiontic biocenose with a relatively high turnover. Associated with this kind of food collecting habit, this species has developed specific morphological features: long extensible snout with short mobile lateral appendages, functional grasping radula, presence of eyes, etc.

Except for these characteristics, the mode of life appears quite similar to that of other Hipponicids with a few large females surrounded by several much smaller males. Development occurs within the egg mass inside the female shell and a few young snails escape at the crawling stage. Indirect observations of the shell structure suggests a quick growth that should also be considered as an adaptation to this mode of life.

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