A new genus and thirteen new species of Scaphopoda (Mollusca) from the tropical Pacific Ocean

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Scarabino V. & Scarabino F. 2010. — A new genus and thirteen new species of Scaphopoda (Mollusca) from the tropical Pacific Ocean. *Zoosystema* 32 (3): 409-423.

ABSTRACT
A new genus and 13 new species of Scaphopoda (ten Dentaliida and three Gadilida) are described from the tropical Pacific Ocean in the Coral Sea, Solomon Islands, Vanuatu, Fiji, Wallis Island and Tonga. The new genus is named *Boissevainia* n. gen. and the new species are *Paradentalium choneides* n. sp., *P. danielleae* n. sp., *Fustiaria electra* n. sp., *F. diaphana* n. sp., *Gadilina lauensis* n. sp., *Episiphon joanae* n. sp., *E. wallisi* n. sp., *E. indefensum* n. sp., *E. kantori* n. sp., *E. lacteum* n. sp. (Dentaliida); *Bathoxiphus kathieae* n. sp., *Annulipusellum aenigmaticum* n. sp. and *Boissevainia mossiae* n. gen., n. sp. (Gadilida). The new taxa not only highlight the diversity of the class in the tropical Pacific Ocean, but also indicate the presence of morphologies not yet recorded for the region or described for the class.

KEY WORDS
Mollusca,
Scaphopoda,
marine biodiversity,
tropical Pacific Ocean,
new genus,
new species.

RESUMÉ
Un nouveau genre et treize nouvelles espèces de Scaphopoda (Mollusca) de l'océan Pacifique tropical.
Un nouveau genre et 13 nouvelles espèces de Scaphopoda (dix Dentaliida et trois Gadilida) sont décrits pour l'océan Pacifique tropical, Îles Salomon, Vanuatu, Fidji, Île Wallis et Tonga. Le nouveau genre est nommé *Boissevainia* n. gen. et les nouvelles espèces sont : *Paradentalium choneides* n. sp., *P. danielleae* n. sp., *Fustiaria electra* n. sp., *F. diaphana* n. sp., *Gadilina lauensis* n. sp., *Episiphon joanae* n. sp., *E. wallisi* n. sp., *E. indefensum* n. sp., *E. kantori* n. sp., *E. lacteum* n. sp., (Dentaliida) ; *Bathoxiphus kathieae* n. sp., *Annulipusellum aenigmaticum* n. sp. et *Boissevainia mossiae* n. gen., n. sp. (Gadilida). Non seulement les nouveaux taxons mettent en valeur la diversité de la classe dans l'océan Pacifique tropical, mais ils indiquent également la présence de morphologies non encore décrites pour cette région ou pour la classe.

MOTS CLÉS
Mollusca,
Scaphopoda,
biodiversité marine,
océan Pacifique tropical,
genre nouveau,
espèces nouvelles.

INTRODUCTION

Four modern taxonomic studies dealing with Scaphopoda of the Indo-Pacific region described 114 new species, highlighting the richness of the class in this area (Scarabino 1995, 2008; Scarabino & Caetano 2008; Lamprell & Healy 1998). Of these new species, 62 were described from the tropical Pacific (with New Caledonia, the best studied area, hosting a total 116 species), 13 from the Indian Ocean and 48 from Australia (most of them from the north-east and seaboards).

Curation of the Scaphopoda gathered during several expeditions undertaken by the MNHN and IRD in the tropical Pacific, revealed a remarkably high number of additional new species, some of which are described here. Taxa belonging to the families Gadilidae Stoliczka, 1868 and Siphonodentaliidae Tryon, 1884 are being studied separately due to the large number of new taxa, while the present study describes one new genus and 13 new species, 10 belonging to Dentaliida Da Costa, 1776 and three to Gadilida Starobogatov, 1974 (other than Gadilidae and Siphonodentaliidae).

MATERIAL AND METHODS

The material studied (765 specimens, 268 collected alive and 497 shells) originated from 43 stations sampled during eight oceanographic expeditions at depths of 118-1200 m. The expeditions are known as EBISCO (Coral Sea), SALOMON 1 and SALOMON 2 (Solomon Islands), MUSORSTOM 8 (Vanuatu), MUSORSTOM 10 (Fiji), MUSORSTOM 7 (Wallis Island), BORDAU 1 (Fiji) and BORDAU 2 (Tonga). Information on the expeditions is available in Bouchet *et al.* (2008). All this material, unless indicated otherwise for some paratypes, is deposited in the MNHN.

All measurements are expressed in mm. For shells with an oval cross-section, both maximum and minimum extents are given; point of maximal curvature (arc) and distance from the apex to the arc. The bathymetric range is the internal interval between the two extreme values, that is, the minimum range within which all specimens could have occurred. Regarding the radula, in scaphopods, given the current knowledge of radular anatomy, the lateral teeth are the most relevant features, and in their normal position, cover the rachidian tooth, which offers valuable taxonomic information (V. Scarabino pers. obs.). Therefore, we selected the 2 or 3 median rows containing teeth in better condition for study and spread them out at various angles to permit better observation of the rachidian. Descriptions are based on the holotypes. SEM images were processed in the Service commun de Microscopie électronique du MNHN.

ABBREVIATIONS

AMS	The Australian Museum, Sydney;
BMNH	The Natural History Museum, London;
IRD	Institut de Recherche pour le Développement, France;
MNHN	Muséum national d'Histoire naturelle, Paris;
ZMA	Zoological Museum, Amsterdam;
dd	shells;
L	maximum length;
lv	live collected;
W	maximum width;
w	minimum width.

SYSTEMATICS

Class SCAPHOPODA Bronn, 1862
Order DENTALIIDA Starobogatov, 1974
Family DENTALIIDAE Children, 1834
Genus *Paradentalium* Cotton & Godfrey, 1933

Paradentalium choneides n. sp.
(Fig. 1A-D)

TYPE MATERIAL. — **Fiji.** South of Viti Levu, MUSORSTOM 10, stn DW 1388, 18°19'S, 178°02'E, 313-446 m, 1 dd holotype (MNHN 22766). — Stn CP 1390, 18°19'S, 178°05'E, 234-361 m, 1 lv paratype (MNHN 22767).

TYPE LOCALITY. — Fiji, south of Viti Levu, 18°19'S, 178°02'E, 313-446 m (MUSORSTOM 10, stn DW 1388).

ETYMOLOGY. — From the Greek *chone*, *choneides* meaning "as a funnel", to highlight the apical callus shape.

MATERIAL EXAMINED. — Only type material known.

DISTRIBUTION. — Fiji. Live in 234-361 m.

TABLE 1. — Main differences among the holotypes of *P. danielleae* n. sp., *P. rudoi* Scarabino, 1995 and *P. kabati* Scarabino, 2008 (measures in mm).

Characters	*P. danielleae* n. sp.	*P. rudoi*	*P. kabati*
Arc (curvature)	2	2.8	5
Arc from apex	14.5	6.4	20
Anterior shell section	roughly circular	roughly circular	circular

DESCRIPTION

Shell 15.7 mm long, solid, slightly curved, white and polished. Outline irregularly defined by marked growth lines. Six high, smooth, round-edged ribs fading but not disappearing towards anterior aperture except for the dorsal rib that remains clear. Intercostal spaces smooth, straight to concave at apex area to slightly convex at anterior aperture, no secondary ribs. Ribs protruding slightly at apex where there is a funnel-type callus. Shell section hexagonal. Anterior aperture straight, thin-walled, roughly hexagonal in section.

Measurements of holotype: L 15.7, W 1.6, w 0.5, arc 0.5 at 9.2 from apex.

REMARKS

The main characters of *Paradentalium choneides* n. sp. are the protruding ribs at the apex and the funnel-type callus, newly observed for the genus. This apical characteristic is similar to that of the gadilid genus *Entalinopsis* Habe, 1957. *Paradentalium choneides* n. sp. resembles *P. intercalatum* (Gould, 1859) and *P. gradile* Chistikov, 1979 in overall outline, but *P. choneides* n. sp. is narrower, the intercostal spaces are smooth instead of longitudinally sculptured and have no secondary ribs, in contrast to the other species (see Chistikov 1979; Scarabino 1995). Another related species, *P. hexagonum* (Gould, 1859), is larger, and more curved and tapering (see Scarabino 1995: fig. 28g, h).

ETYMOLOGY. — Named after Danielle Plaçais, a volunteer at MNHN, in recognition for her careful sorting of many expedition samples.

MATERIAL EXAMINED. — Only type material known.

DISTRIBUTION. — Wallis Island. Live at 330 m.

DESCRIPTION

Shell 37.2 mm long, solid, polished, translucent white, slightly curved. Six smooth, slim primary ribs, the most evident on the dorsal axis, 2 in dorso-lateral positions and the other 3, less evident, ventrally positioned. Intercostal spaces smooth, straight on posterior third of shell to convex anteriorly. Secondary ribs appear close to apex and all vanish in varying degrees towards the oblique anterior aperture, dorsal sculpture remaining longer while the ventral sculpture vanishes completely. Apex simple, anterior shell section roughly circular with vestige of dorsal rib.

Measures of holotype: L 37.2, W 2.4-2.6, w 0.6, arc 2 at 14.5 from apex.

REMARKS

The characteristic distribution of the ribs of *P. danielleae* n. sp. approaches that of *P. rudoi* Scarabino 1995, from the western Indian Ocean and *P. kabati* Scarabino, 2008, from Vanuatu. The main differences (summarized in Table 1) include colour, arc, distance of arc from apex and anterior apertures.

Paradentalium danielleae n. sp.
(Fig. 1E, F)

TYPE MATERIAL. — **Wallis Island.** MUSORSTOM 7, stn DW 583, 13°11'S, 176°14'W, 330-365 m, 1 lv holotype (MNHN 22773); 2 lv, 1 dd paratypes (MNHN 22774).

TYPE LOCALITY. — Wallis Island, 13°11'S, 176°14'W, 330-365 m (MUSORSTOM 7, stn DW 583).

Family FUSTIARIIDAE Steiner, 1991
Genus *Fustiaria* Stoliczka, 1868

Fustiaria electra n. sp.
(Fig. 1H-K)

TYPE MATERIAL. — **Fiji.** BORDAU 1, stn DW 1469, Lau Ridge (Vatoa), 19°40'S, 178°10'W, 314-377 m, 1 lv holo-

type (MNHN 22775); 1 lv paratype (MNHN 22776). — Stn DW 1472, Lau Ridge (Vatoa), 19°40'S, 178°10'W, 262-266 m, 2 dd paratypes (MNHN 22777).

TYPE LOCALITY. — Fiji, Lau Rigde (Vatoa), 19°40'S, 178°10'W, 314-377 m (BORDAU 1, stn DW 1469).

ETYMOLOGY. — From the Latin *electrum* meaning "amber", highlighting the colour of the shell.

OTHER MATERIAL EXAMINED. — **Fiji.** BORDAU 1, stn DW 1469, Lau Ridge (Vatoa), 19°40'S, 178°10'W, 314-377 m, 3 dd. — Stn DW 1471, Lau Ridge (Vatoa), 19°40'S, 178°10'W, 280-296 m, 2 dd.
Tonga. BORDAU 2, stn DW 1532, seamount, 21°44'S, 175°20'W, 322-322 m, 1 dd. — Stn DW 1535, seamount, 21°43'S, 175°18'W, 268 m, 1 lv, 4 dd. — Stn DW 1587, Vava'u group, 18°37'S, 173°54'W, 309-400 m, 4 dd. — Stn DW 1634, seamount, 21°45'S, 175°20'W, 321-322 m, 1 dd.
Wallis Island. MUSORSTOM 7, stn DW 601, 13°19'S, 176°17'W, 350 m, 1 dd. — Stn DW 610, 13°21'S, 176°09'W, 286 m, 1 dd.

DISTRIBUTION. — Fiji, Wallis Island and Tonga. Live at 268 m, shells to 350 m.

DESCRIPTION
Shell 28.6 mm long, solid, polished, slowly tapering and gently curved. Entirely coloured dark-yellow to orange. Apex with short projection of internal wall, oblique on dorsal side, a notch on dorsal side and a long regular slit in the ventral side. Shell section circular.

Measurements of holotype: L 28.6, W 2.8, w 1.05, arc 2 at 11 from the apex

REMARKS
Fustiaria electra n. sp. most closely resembles *F. caesura* (Colman, 1958) (holotype AMS C62230, examined) from eastern Australia, the other completely coloured *Fustiaria* species described from the area, which is clearly more tapering than *F. electra* n. sp. (see Scarabino 1995: fig. 88g; Lamprell & Healy 1998). Also more tapering are the other three *Fustiaria* species that exhibit a long ventral slit in the tropical Pacific: *F. nipponica* (Yokoyama, 1922), the commonest species, which is translucent white and prefers shallow water; *F. mariae* Scarabino, 2008, which is coloured only on the apical sector; and *F. steineri* Scarabino, 2008, which is white and polished, characterized by the different wall thickness of the dorsal and ventral sides, and which tapers clearly more rapidly than the other species (see Scarabino 1995: fig. 88e; 2008).

Fustiaria diaphana n. sp.
(Fig. 1L-O)

TYPE MATERIAL. — **Coral Sea.** EBISCO, stn DW 2639, 20°47'S, 161°01'E, 289-294 m, 1 dd holotype (MNHN 22778); 2 dd paratypes (MNHN 22779).

TYPE LOCALITY. — Coral Sea, south of Lansdowne Bank, 20°47'S, 161°01'W, 289-294 m (EBISCO, stn DW 2639).

ETYMOLOGY. — The species epithet derives from the Greek, meaning translucent.

OTHER MATERIAL EXAMINED. — **Coral Sea**. EBISCO, stn DW 2639, 20°47'S, 161°01'E, 289-294 m, 14 dd.

DISTRIBUTION. — Coral Sea. Shells at 289-294 m.

DESCRIPTION
Shell 35.3 mm long, well curved, translucent, very gradually tapering, smooth, growth lines noticeable, thick-walled for ¾ from apex becoming thin-walled and fragile towards the anterior aperture, cross section slightly laterally compressed throughout. Apical and anterior apertures straight, apical callus thick, walls oblique to lumen, ventral side exhibits a vertical

FIG. 1. — **A**-**D**, *Paradentalium choneides* n. sp., holotype (15.7 mm), Fiji, 18°19'S, 178°02'E, 313-446 m (MUSORSTOM 10 stn DW 1388); **A**, apical section; **B**, apical area in lateral view showing protruction of ribs; **C**, lateral view of shell; **D**, dorsal view of shell; **E**, **F**, *Paradentalium danielleae* n. sp., holotype (37.2 mm), Wallis Island, 13°11'S, 176°14'W, 330-365 m (MUSORSTOM 7 stn DW 583); **E**, apical section; **F**, lateral view of shell; **G**, *Gadilina lauensis* n. sp., holotype (58.8 mm), Fiji, 16°28'S, 179°50'W, 1004-1012 m (BORDAU 1 stn CP 1400), lateral view of shell; **H**-**K**, *Fustiaria electra* n. sp., holotype (24.8 mm), Fiji, 19°40'S, 178°10'W, 314-377 m (BORDAU 1 stn DW 1469); **H**, lateral view of shell; **I**, apical area in dorsal view; **J**, apical area in lateral view; **K**, apical area in ventral view; **L**-**O**, *Fustiaria diaphana* n. sp., holotype (35.3 mm), Coral Sea, 20°47'S, 161°01'W, 289-294 m (EBISCO stn DW 2639); **L**, lateral view of shell; **M**, dorsal view of shell; **N**, dorso-frontal view of apex; **O**, frontal view of apex; **P**-**U**, *Gadilina lauesis* n. sp., radula; **P**, external view of rachidian tooth; **Q**, internal views of two rachidian teeth; **R**, external view of whole lateral tooth; **S**, detail of the head of lateral tooth; **T**, internal view of marginal tooth. Scale bars: 100 µm.


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series of V-shaped threads that continue for a short distance internally in the ventral axis of shell, visible because of the transparency of the shell. Lumen also laterally oval, internal wall extends outside, entire on dorsal side and fissured ventrally.

Measurements of holotype: L 35.5, W 1.6-1.51, apex 1.23-1.10, arc 3.6 at 17 from apex.

REMARKS

Fustiaria diaphana n. sp. is characterized primarily by its almost parallel sides, resembling some species of *Episiphon* but clearly differing in the apex and apical callus. As no radular information is available, the allocation of the new species in *Fustiaria* must be considered tentative but here suggested given the similarity of the apical structure with *Fustiaria langfordi* (Habe, 1963) and *F. vagina* Scarabino, 1995 (see Scarabino 1995: fig. 88h, i). Young specimens show the apex slightly oblique, the dorsal side longer and a shallow notch in the ventral axis, resembling *F. vagina* apical morphology.

Family GADILINIDAE Chistikov, 1975
Genus *Gadilina* Foresti, 1895

Gadilina lauensis n. sp.
(Fig. 1G, P-T)

TYPE MATERIAL. — **Fiji.** Lau Ridge, BORDAU 1, stn CP 1400, 16°28'S, 179°50'W, 1004-1012 m, 1 lv holotype (MNHN 22780); 3 dd paratypes (MNHN 22781).

TYPE LOCALITY. — Fiji, Lau Ridge, 16°28'S, 179°50'W, 1004-1012 m (BORDAU 1, stn CP 1400).

ETYMOLOGY. — From Lau Ridge, the type locality.

OTHER MATERIAL EXAMINED. — **Fiji.** Lau Ridge, BORDAU 1, stn CP 1400, 16°28'S, 179°50'W, 1004-1012 m, 3 dd.

DISTRIBUTION. — Fiji. Live at 1004-1012 m.

DESCRIPTION

Shell 58.8 mm long, slender, smooth, polished, translucent, rather strongly curved and thin-walled. Transverse section suboval throughout, slightly flattened on dorsal side and rounded ventrally. Anterior aperture straight, apex with a thick callus and lumen slightly oval.

Radula: rachidian tooth slightly curved in section, anterior margin irregular, internal face irregularly rough with a medial knob; lateral teeth wide, head roughly granulose, with three major primary cusps, the central quite pointed, and five small denticles on the internal face; marginal teeth sinusoidal, with a small cusp in the anterior angle connecting with laterals.

Measurements of holotype: L 58.8, W 3.42-3.2, w 0.65, arc 5 at 26 from apex.

REMARKS

The most similar species to *G. lauensis* n. sp. is *Gadilina pachypleura* (Boissevain, 1906) (syntypes ZMA 3.06.063, ZMA 3.06.064, examined) from Indonesia at 1788-1886 m depth (Boissevain 1906). The new species is more curved and tapering, and has a larger and straighter anterior aperture. *Gadilina insolita* (Smith, 1894), widely distributed in the Indo-Pacific region, has a highly variable shell outline, especially in the morphology of the apical region, from a wide apex and a very thick apical callus with a small lumen to a long tapering apical area without a clear callus (Smith 1894; Scarabino 1995: fig. 95a, b). In young specimens, the vestiges of longitudinal threads are clearly visible in the apical area. Also, the transverse section of the shell varies from roughly oval to triangular with the dorsal side straight in the apical area in extreme forms (V. Scarabino pers. obs.). *Gadilina lauensis* n. sp. is the third living species known in the genus. The radula of *G. insolita* (illustrated by Scarabino 1995: fig. 90) is quite similar and confirms that this character is appropriate for identification of the genus.

Subfamily EPISIPHONINAE Chistikov, 1975
Genus *Episiphon* Pilsbry & Sharp, 1897

Episiphon kantori n. sp.
(Fig. 2D-J)

TYPE MATERIAL. — **Solomon Islands.** SALOMON 2, stn CP 2189, 08°20'S, 160°02'E, 660-854 m, 1 lv holotype (MNHN 22782); 3 lv paratypes (MNHN 22783).

TYPE LOCALITY. — Solomon Islands, 8°20'S, 160°02'E, 660-854 m (SALOMON 2, stn CP 2189).

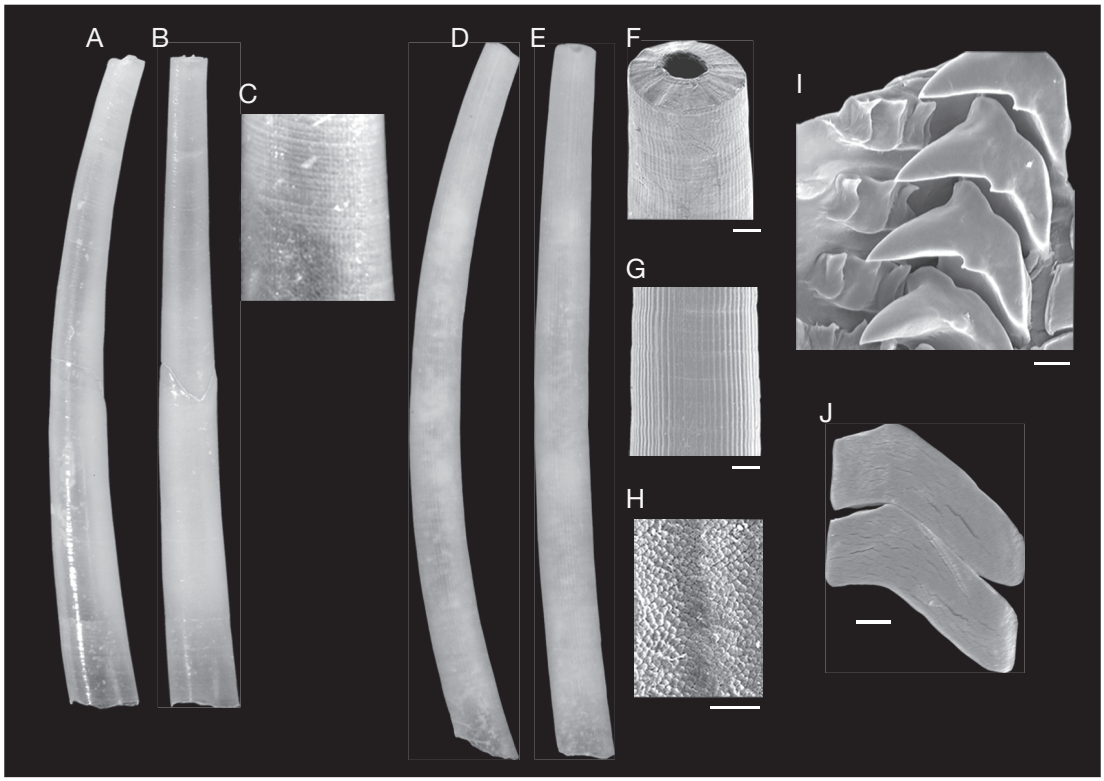


FIG. 2. — **A**-**C**, *Episiphon virginieae* Scarabino, 1995, holotype (9 mm), New Caledonia, Loyalty Islands, 20°42'S, 167°00'E, 282 m (MUSORSTOM 6, stn DW 399); **A**, lateral view of shell; **B**, dorsal view of shell; **C**, detail of sculpture; **D**, **E**, *Episiphon kantori* n. sp. holotype (8.05 mm), Solomon Islands, 8°20'S, 160°02'E, 660-854 m (SALOMON 2, stn CP 2189); **D**, lateral view of shell; **E**, dorsal view of shell; **F**-**H**, *Episiphon kantori* n. sp., shell details; **F**, dorso-frontal view of apical area; **G**, sculpture at the posterior third of shell; **H**, microsculpture at the same area; **I**, **J**, *Episiphon kantori* n. sp., radula; **I**, detail of rachidian and lateral teeth; **J**, internal view of two marginal teeth. Scale bars: 100 µm.

ETYMOLOGY. — Named after Yuri Kantor (Institute of Evolution, Russian Academy of Sciences, Moscow), in recognition for his advice on radulae processing and friendly interactions during his visits to MNHN.

OTHER MATERIAL EXAMINED. — **Solomon Islands.** SALOMON 1, stn CP 1857, 09°40'S, 160°49'E, 720-849 m, 16 lv, 28 dd.
SALOMON 2, stn CP 2176, 9°10'S, 158°59'E, 579-875 m, 1 lv, 5 dd. — Stn CP 2179, 08°49'S, 159°43'E, 765-773 m, 25 lv, 31 dd. — Stn CP 2180, 08°48'S, 159°41'E, 708-828 m, 3 lv, 5 dd. — Stn CP 2182, 08°47'S, 157°38'E, 762-1060 m, 8 lv, 48 dd. — Stn CP 2186, 08°17'S, 160°00'E, 487-541 m, 2 lv, 2 dd. — Stn CP 2189, 08°20'S, 160°02'E, 660-854 m, 41 lv, 38 dd. — Stn CP 2193, 08°24'S, 159°27'E, 362-432 m, 6 dd. — Stn CP 2205, 07°43'S, 158°29'E, 391-263 m, 1 dd. — Stn CP 2214, 07°42'S, 157°44'E, 550-682 m, 1 lv, 2 dd. — Stn CP 2217, 07°49'S, 157°41'E, 1045-1118 m, 3 dd. — Stn CP 2226, 06°39'S, 156°14'E, 490-520 m, 6 lv, 12 dd. —Stn CP 2241, 06°55'S, 156°21'E, 815-1000 m, 43 lv, 46 dd. — Stn CP 2248, 07°43'S, 156°25'E, 650-673 m, 15 lv, 3 dd. — Stn CP 2268, 07°49'S, 156°53'E, 632-640 m, 1 dd.

DISTRIBUTION. — Solomon Islands. Live at 487-815 m (richest range 650-815 m), shells at 362-1045 m.

DESCRIPTION

Shell 8.5 mm long, thread-like outline, regularly curved, slowly tapering, translucent grey. Longitudinally sculptured with 70 striae. Shell section circular. Apex simple with notable protruding callus, lumen small, circular, central. Anterior aperture straight. Microsurface barely granulose. Radula: rachidian tooth with three central projections on the internal

face and anterior border curved, smooth. Lateral teeth with pronounced head with an elevated posterior angle, a strong and pointed primary cusp and a secondary denticle at the external border. Marginal teeth noticeably angled with respect to the border adjacent to the laterals.

Measurements of holotype: L 8.5, W 0.66, w 0.52, arc 0.45 at 3.6 from apex.

REMARKS

Episiphon kantori n. sp. is most similar to *Episiphon wallisi* n. sp., described below. The present species is longer and less translucent, the apical callus protrudes and is more densely striated. *Episiphon wallisi* n. sp. has the apical callus flat, only 24 striae and the arc located at the centre of the shell, while in *E. joanae* n. sp. (below) it is closer to the posterior end.

Episiphon wallisi n. sp.
(Fig. 3A-D)

TYPE MATERIAL. — **Wallis Island.** MUSORSTOM 7, stn DW 604, 13°21'S, 176°08'W, 415-420 m, 1 lv holotype (MNHN 22784); 2 lv paratypes (MNHN 22785).

TYPE LOCALITY. — Wallis Island, 13°21'S, 176°08'W, 415-420 m (MUSORSTOM 7, stn DW 604).

ETYMOLOGY. — Named from the type locality.

OTHER MATERIAL EXAMINED. — **Wallis Island.** MUSORSTOM 7, stn DW 523, 13°12'S, 176°16'W, 455-515 m 2 lv, 5 dd. — Stn DW 601, 13°19'S, 176°17'W, 350 m, 14 lv, 18 dd. — Stn DW 604, 13°21'S, 176°08'W, 415-420 m, 5 lv, 22 dd.

DISTRIBUTION. — Wallis Island. Live at 350-415 m.

DESCRIPTION

Shell 6.4 mm long, regularly curved with arc located at the centre of shell, slowly tapering, translucent white. Longitudinally sculptured with 24 fine primary striae and secondary ones on the posterior third. Apex simple, slightly dorsoventrally depressed, callus flat, lumen circular, central. Anterior aperture oblique, thin-walled, slightly depressed dorsoventrally.

Measurements of holotype: L 6.4, W 0.57-0.54, w 0.4, arc 0.54 at 3.2 from apex.

REMARKS

See Remarks for *Episiphon joanae* n. sp. below.

Episiphon indefensum n. sp.
(Fig. 3E-G)

TYPE MATERIAL. — **Solomon Islands.** SALOMON 2, stn CP 2182, 08°47'S, 159°38'E, 762-1060 m, 1 dd holotype (MNHN 22786); 2 dd paratypes (MNHN 22787).

TYPE LOCALITY. — Solomon Islands, 08°47'S, 159°38'E, 762-1060 m (SALOMON 2, stn CP 2182).

ETYMOLOGY. — From the Latin *indefensus* (meaning undefended, unprotected) refering to the multiple fractures observed in all specimens studied.

OTHER MATERIAL EXAMINED. — **Solomon Islands.** SALOMON 2, stn CP 2182, 08°47'S, 159°38'E, 762-1060 m, 19 dd.

DISTRIBUTION. — Only known from the type locality. Shells at 762-1060 m.

DESCRIPTION

Shell 7.9 mm long, well curved with the arc located at posterior ⅓ of shell, slowly tapering, opaque cream. Longitudinally sculptured with 48 fine striae and secondary ones that appear at the posterior ¼ of the shell. Apex simple circular, callus thin, lumen central, circular, large. Anterior aperture straight, circular.

Measurements of holotype: L 7.9, W 0.63, w 0.32, arc 0.72 at 3.6 from apex.

REMARKS

Breakages and repairs of unknown origin are present in all specimens studied. Compared to *E. joanae* n. sp. and *E. wallisi* n. sp., the present new species has an intermediate number of striae, its arc is located posterior, the lumen is much larger due to its thin apical callus. *Episiphon truncatum* (Boissevain, 1906) (syntypes ZMA 3.06.065-067, examined) from Indonesia (281 m), has almost similar breakages as *E. indefensum* n. sp. in adult specimens, but is much larger, solid, brilliant, the sculpture consists of encircling wrinkles in the apical sector and the apical section is roughly subtriangular. The apical callus of *E. indefensum* n. sp. is clearly thin for the genus.

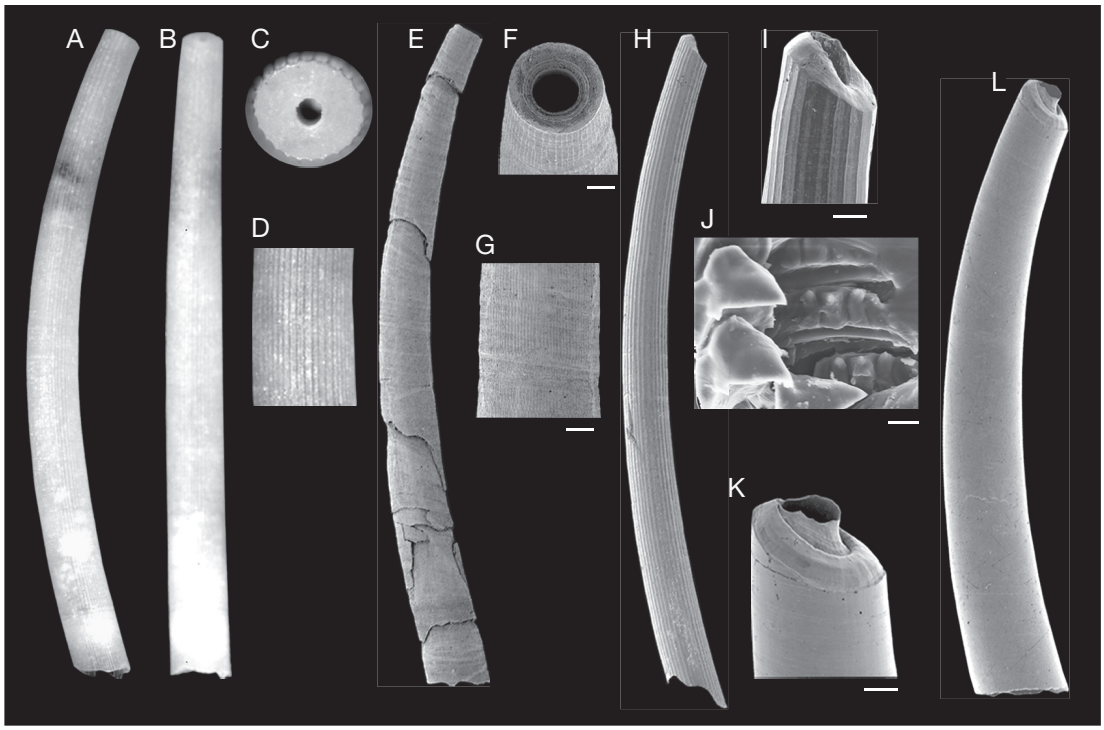


FIG. 3. — **A**-**D**, *Episiphon wallisi* n. sp. holotype (6.5 mm), Wallis Island, 13°21'S, 176°08'W, 415-420 m (MUSORSTOM 7 stn DW 604); **A**, lateral view of shell; **B**, dorsal view of shell; **C**, frontal view of apex; **D**, sculpture at the posterior third of shell; **E**-**G**, *Episiphon indefensum* n. sp. holotype (7.9 mm), Solomon Islands, 8°47'S, 157°38'E, 762-1060 m (SALOMON 2 stn CP 2182); **E**, lateral view of shell; **F**, dorso-frontal view of apical area; **G**, sculpture at the middle of shell; **H**, **I**, *Episiphon joanae* n. sp. holotype (7 mm), Fiji, Ride de Lau, 18°43'S, 178°23'W, 392-407 m (BORDAU 1 stn DW 1469); **H**, lateral view of shell; **I**, latero-dorsal view of apical area; **J**, *Episiphon joanae* n. sp., radula, rachidian and lateral teeth; **K**, **L**, *Episiphon lacteum* n. sp. holotype (16 mm), Waterwitch Bank, Wallis Island, 12°31'S, 176°40'W, 275-295 m (MUSORSTOM 7 stn DW 538); **K**, lateral-dorsal view of apical area; **L**, lateral view of shell. Scale bars: F, G, I, K, 100 µm; J, 10 µm.

Episiphon joanae n. sp.
(Fig. 3H-J)

TYPE MATERIAL. — **Fiji.** Lau Ridge, BORDAU 1, stn DW 1469, 19°40'S, 178°10'W, 392-407 m, 1 dd holotype (MNHN 22788); 2 dd paratypes (MNHN 22789).

TYPE LOCALITY. — Fiji, Lau Ridge, 19°40'S, 178°10'W, 392-407 m (BORDAU 1, stn DW 1469).

ETYMOLOGY. — Named after Joan Pickering (BMNH) for her assistance at the time of Scarabino's (1995) monograph on Scaphopoda.

OTHER MATERIAL EXAMINED. — **Tonga.** BORDAU 2, stn DW 1585, 18°33'S, 173°57'W, 578 m, 3 dd.
Wallis Island. MUSORSTOM 7, stn DW 604, 13°21'S, 176°08'W, 415-420 m, 2 dd.
Vanuatu. MUSORSTOM 8, stn DW 1065, 16°16'S, 167°21'E, 360-419 m, 1 lv, 3 dd. — Stn CP 1131-1132, 15°38'S, 167°03'-167°04'E, 140-182 m, 2 dd.
Solomon Islands. SALOMON 2, stn CP 2176, 09°09'S, 158°59'E, 579-875 m, 1 dd. — Stn CP 2184, 09°17'S, 160°00'E, 464-523 m, 2 dd. — Stn CP 2260, 08°04'S, 156°55'W, 399-427 m, 1 dd.

DISTRIBUTION. — Solomon Islands, Vanuatu, Fiji, Wallis Island, Tonga. Live at 360 m. Shells at 182-579 m.

DESCRIPTION

Shell 11 mm long, well curved, translucent, glossy, section slightly dorsoventrally depressed throughout, dorsal wall thicker than ventral wall. Arc located close to centre of shell. Sculptured by 24 slim ribs, no secondary ribs observed. Apex oblique, ventral side longer, with protruding callus, thicker in ventral

side and lumen circular with short projecting pipe, anterior aperture oblique.

Radula: rachidian tooth with three central projections on the internal face and anterior border curved, smooth. Lateral teeth with pronounced head with an elevated posterior angle, a strong and pointed primary cusp and a secondary denticle at the external border. Marginal teeth slightly angled.

Measurements of holotype: L 7, W 0.7, w 0.3, arc 0.25 at 3 from apex.

REMARKS

Episiphon joanae n.sp. has a similar apical outline to *E. lacteum* n. sp., here described, but is more curved, shiny and translucent and has a well-defined sculpture.

Episiphon lacteum n. sp.
(Fig. 3K, L)

TYPE MATERIAL. — **Wallis and Futuna.** MUSORSTOM 7, stn DW 538, Waterwitch Bank, 12°31'S, 176°40'W, 275-295 m, 1 dd holotype (MNHN 22790); 1 dd paratype (MNHN 22791). — Stn DW 569, Waterwitch Bank, 12°30'S, 176°51'W, 300-305 m, 1 dd paratype (MNHN 22792). — Stn DW 610, Wallis Island, 13°21'S, 176°09'W, 286 m, 1 dd paratype (MNHN 22793).

TYPE LOCALITY. — Waterwitch Bank, 12°31'S,176°40'W, 275-295 m (MUSORSTOM 7, stn DW 538).

ETYMOLOGY. — From the Latin *lacteus* meaning "milk-white".

OTHER MATERIAL EXAMINED. — **New Caledonia.** EBISCO, stn DW 2570, north of Bellona, 20°27'S, 158°45'E, 235-263 m, 1 dd.

DISTRIBUTION. — NE of Fiji and and Coral Sea. Shells in 263-300 m.

DESCRIPTION

Shell 16 mm long, well curved, arc located at posterior third, milk-white coloured, smooth, polished, slowly tapering. Apex oblique with protruding apical callus and an irregular short central plug. Section circular, anterior aperture straight.

Measurements of holotype: L 16, W 1.5, w 9.5, arc 0.64 at 5.2 from apex.

REMARKS

The main distinctive character of this species, which in this regard is similar to *Episiphon joanae* n. sp., described above, is the obliqueness of the apex and the degree of protuberance of the apical callus, distinguishing both species from all other species in the genus.

Order GADILIDA Starobogatov, 1974
Suborder ENTALIMORPHA Steiner, 1992
Family ENTALINIDAE Chistikov, 1979
Subfamily BATHOXIPHINAE Chistikov, 1983
Genus *Bathoxiphus* Pilsbry & Sharp, 1897

Bathoxiphus kathieae n. sp.
(Fig. 4A-E)

TYPE MATERIAL. — **Solomon Islands.** SALOMON 2, stn CP 2241, 06°55'S, 156°21'E, 815-1000 m, 1 lv holotype (MNHN 22794); 2 lv paratypes (MNHN 22795); 1 lv paratype (BMNH).

TYPE LOCALITY. — Solomon Islands, 06°55'S, 156°21'E, 815-1000 m (SALOMON 2, stn CP 2241).

ETYMOLOGY. — Named after Kathie Way (BMNH) for her kind reception and help during the study of the BMNH scaphopod collections.

OTHER MATERIAL EXAMINED. — **Solomon Islands**. SALOMON 1, stn CP 1857, 09°40'S, 160°49'E, 720-849 m, 11 dd.
SALOMON 2, stn CP 2176, 09°09'S 158°59'E, 579-875 m, 17 lv, 39 dd. — Stn CP 2182, 08°47'S, 157°38'E, 762-1060 m, 1 dd. — Stn CP 2241, 06°55'S, 156°21'E, 815-1000 m, 16 lv. — Stn CP 2253, 07°27'S, 156°15'E, 1200-1218 m, 2 dd. — Stn CP 2267, 07°48'S, 156°20'E, 590-600 m, 2 dd.

DISTRIBUTION. — Solomon Islands. Live at 815 m, shells at 590-1200 m.

DESCRIPTION

Shell 5.9 mm long, well curved, solid, translucent grey, shell section oval, notably compressed laterally. Longitudinally sculptured with 36 thin ribs beginning close to the smooth apical area, with secondary lines close to the apex and double in number. Dorsal and ventral shell walls at apical area thicker than lateral walls and reflected in the oblique apical callus. Radula: rachidian tooth high with anterior

margin simple, rounded, folded inward. Heads of lateral teeth smooth, with 2 sharp primary cusps and, between them, 5 subequal secondary pointed curved cusps; marginal teeth long, slightly curved, with a wide contact area with lateral.

Measurements of holotype: L 5.9, W 0.8-06, w 0.3-0.2, arc 0.7 at 3.1 from apex.

REMARKS

Bathoxiphus kathieae n. sp. has unique characters for the genus, notably its sculpture and polished surface. The preapical callus is present but the lumen is larger than in other species of *Bathoxiphus*. The most similar species is *B. inexpectatus* Scarabino, 1995, from New Caledonia, but this is longer (the holotype measures 11.9 mm) and has a smooth surface. A third species, *B. soyomaruae* Okutani, 1964, widely distributed through Indo-Pacific bathyal and abyssal depths (Scarabino 1995), is much longer, has some irregular longitudinal undulations, but not ribs, and is particularly compressed laterally. The radula of *Bathoxiphus* is very similar in the four species grouped under it and is therefore diagnostic. The radula of *B. ensiculus* (Jeffreys, 1877) from the Atlantic Ocean was illustrated by Chistikov (1983: pl. 1, fig. 1) and that of *B. soyomaruae* Okutani, 1964, from the West Pacific, by Scarabino (1995: fig. 121b).

Suborder GADILIMORPHA Steiner, 1992
Family PULSELLIDAE Boss, 1982
Genus *Annulipulsellum* Scarabino, 1986

Annulipulsellum aenigmaticum n. sp.
(Fig. 4F-H)

TYPE MATERIAL. — **Solomon Islands.** SALOMON 2, stn CP 2189, 08°20'S, 160°02'E, 660-854 m, 1 dd holotype (MNHN 22796); 3 dd paratypes (MNHN 22797).

TYPE LOCALITY. — Solomon Islands, 08°20'S, 160°02'E, 660-854 m (SALOMON 2, stn CP 2189).

ETYMOLOGY. — From the Latin *aenigmaticus* meaning "mysterious".

OTHER MATERIAL EXAMINED. — **Solomon Islands.** SALOMON 2, stn CP 2182, 08°47'S, 157°38'E, 762-1060 m, 2 dd.

DISTRIBUTION. — Solomon Islands. Shells in 762-854 m.

DESCRIPTION

Shell 5.7 mm long, solid, well curved. Surface entirely sculptured by transverse encircling wrinkles crossed by 60 longitudinal striae. Section circular, apex simple, preapical callus thick, lumen circular and central.

Measurements of holotype: L 5.7, W 0.7, w 0.3, arc 0.4 at 2.7 from apex.

REMARKS

The characteristic transversely wrinkled surface allies this species to *Annulipulsellum* Scarabino, 1986, a monotypic genus known from abyssal depths from the Atlantic Ocean, although the sectional outline of the wrinkles differs. However, the presence of longitudinal sculpture in the new species clearly distinguishes it from *A. euskadii* Scarabino, 1986, which only has the transverse sculpture, although the thick apical callus and lumen is also similar (see Scarabino 1986). Nevertheless, no other scaphopod reported in the literature or noted in the field by us, worldwide, has similar sculpture; we refer the present species to *Annulipulsellum*, pending the discovery of other related species that might permit modification of the generic diagnosis or creation of a new genus.

Family *incertae sedis*

REMARK

Since no radular data are available, and given the unique and previously unreported shape of the apex among the Scaphopoda, the new genus here proposed is only assigned at subordinal level based on shell morphology.

Genus *Boissevainia* n. gen.

TYPE SPECIES. — *Boissevainia mossiae* n. sp.

ETYMOLOGY. — Named after Maria Boissevain, in recognition of her historical work on the scaphopods of the *Siboga* Expedition to Indonesia.

DIAGNOSIS. — Shell medium in size, regularly curved, gradually tapering, and polished white. Sculptured by longitudinal striae at the apex that vanish towards the anterior aperture and notorious growth lines. Apical section slightly laterally compressed with undulate outline due to two wide, flat, round-edged, lateral lobes and thick dorsal and ventral triangular lobes. Preapical callus, thick near apex and reinforce dorsal and ventral lobes of the lumen walls, resulting in a canoe-shaped appearance. Lumen slightly laterally compressed.

Radula: unknown.

DISTRIBUTION. — Recent, tropical Pacific, bathyal.

REMARKS

The apical structures have not previously been reported in Scaphopoda and are the main characters diagnosing the genus.

Boissevainia mossiae n. sp.
(Fig. 4I-L)

TYPE MATERIAL. — **Fiji.** MUSORSTOM 10, stn CP 1341, Bligh Water, 16°53'S, 177°44'E, 500-614 m, 1 dd holotype (MNHN 22798); 3 dd paratypes (MNHN 22799).

TYPE LOCALITY. — Fiji, Bligh Water, 16°53'S, 177°44'E, 500-614 m (MUSORSTOM 10 stn CP 1341).

ETYMOLOGY. — Named after Mauricette Bourgeois (aka Mossi), a volunteer at MNHN, who has carefully sorted numerous molluscs samples.

OTHER MATERIAL EXAMINED. — **Fiji.** MUSORSTOM 10, stn CP 1316, Bligh Water, 17°15'S, 178°22'E, 478-491 m, 1 dd. — Stn CP 1341, Bligh Water, 16°53'S, 177°44'E, 500-614 m, 6 dd.
Vanuatu. MUSORSTOM 8, stn DW 1072, 15°40'S, 167°20'E, 622-625 m, 10 dd.
Solomon Islands. SALOMON 2, stn CP 2182, 08°47'S, 157°38'E, 762-1060 m, 3 dd.

DISTRIBUTION. — Solomon Islands, Vanuatu and Fiji. Shells at 491-762 m.

DESCRIPTION

Shell medium in size, regularly curved, gradually tapering, and polished white, anterior area of shell translucent. Outline irregular as a result of prominent growth lines. Sculptured by 32 thin longitudinal striae at the apex, vanishing towards the anterior aperture. Apical section slightly laterally compressed and with an undulate outline due to 2 wide, flat, round-edged, lateral lobes and thick dorsal and ventral triangular lobes. Preapical callus thick near apex and reinforcing the dorsal and ventral lobes of the lumen walls, resulting in a canoe-shaped appearance. Lumen slightly laterally compressed.

Radula: unknown.

Measurements of holotype: L 7.5, W 0.8-0.7, w 0.3, arc 0.6 at 3.4 from apex.

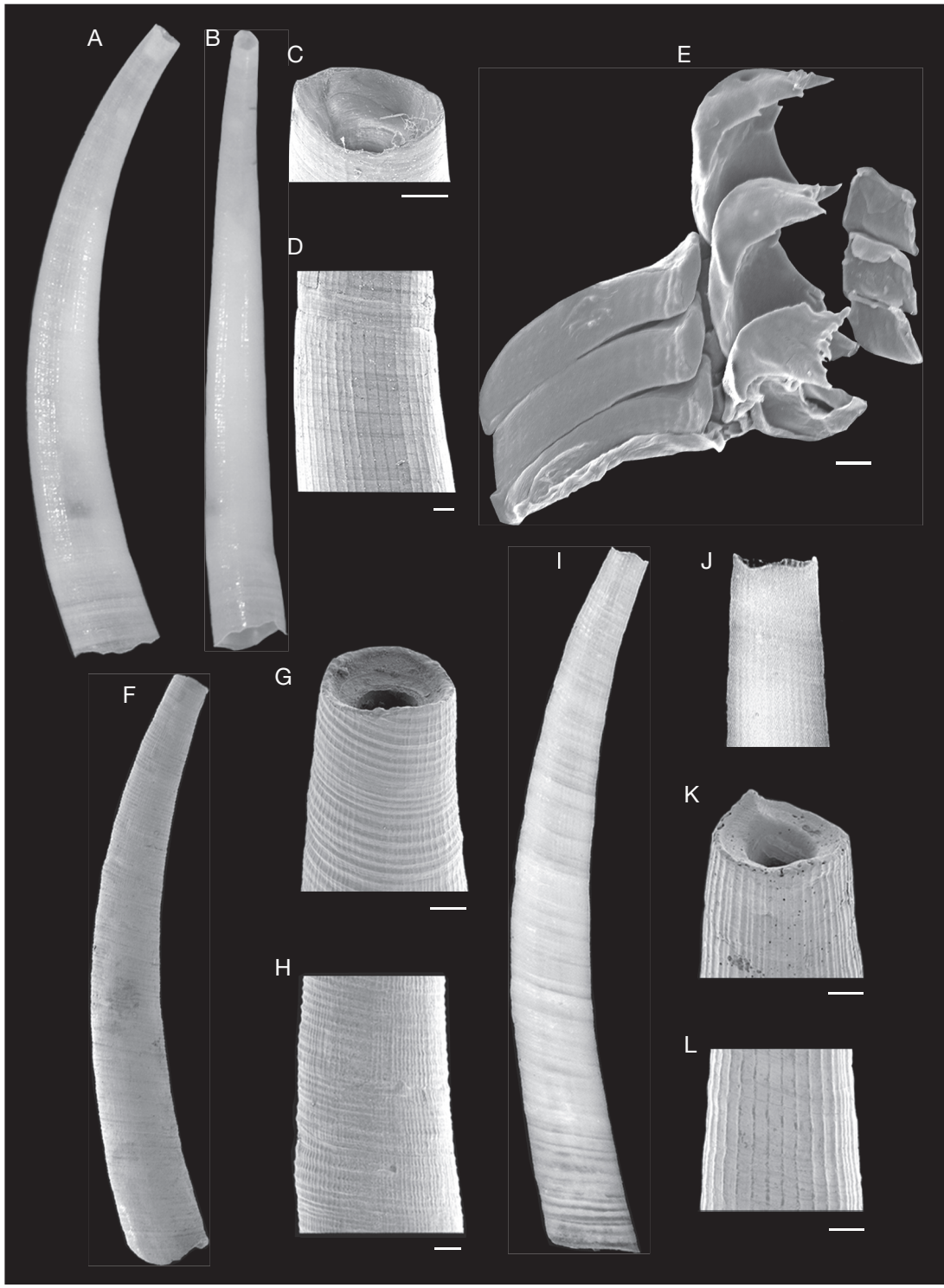
REMARKS

Boissevainia mossiae n. sp. bears a resemblance to *Pulsellum eborascence* (Watson, 1879) from Northern Australia, for which a lectotype 5 mm long was selected by Lamprell & Healy (1998: 1444) (BMNH 1887.2.9.69) and here examined. However, the latter is more tapering, with the arc situated anteriorly, the striae are finer and more numerous, and the apex is simple, resembling that of *Striopulsellum*.

GENERAL DISCUSSION

The diagnosis of *Episiphon* given by Scarabino (1995: 286) states "rarely longitudinal striae near the apex or throughout". The presence of longitudinal sculpture along the entire length of the shell was added to include *Episiphon virginieae* Scarabino, 1995 (Fig. 2A-C), considered as the first *Episiphon* reported as exhibiting such characteristics. Three of the four new *Episiphon* species here described have very well-defined longitudinal sculpture, thus validating the widespread presence

FIG. 4. — **A**, **B**, *Bathoxiphus kathieae* n. sp., holotype (5.9 mm), Solomon Islands, 6°55'S, 156°21'E, 815-1000 m (SALOMON 2 stn CP 2241); **A**, lateral view of shell; **B**, dorsal view of shell; **C**-**E**, *Bathoxiphus kathieae* n. sp.; **C**, latero-dorsal view of apex; **D**, **E**, radula, general view of marginal, lateral and rachidian teeth; **F**-**H**, *Annulipusellum aenigmaticum* n. sp. holotype (5.7 mm), Solomon Islands, 8°20'S, 160°02'E, 660-854 m (SALOMON 2 stn CP 2189); **F**, lateral view of shell; **G**, latero-dorsal view of apical area; **H**, sculpture at the posterior half of shell; **I**, **J**, *Boissevainia mossiae* n. gen., n. sp. holotype (7.5 mm), Fiji, 16°53'S, 177°44'E, 500-614 m (MUSORSTOM 10 stn CP 1341); **I**, lateral view of shell; **J**, lateral view of apical area; **K**, **L**, *Boissevainia mossiae* n. gen., n. sp., paratype, Vanuatu, 15°40'S, 167°20'E, 622-625 m (MUSORSTOM 8 stn DW 1072); **K**, lateral-dorsal view of apical area; **L**, sculpture at the posterior half of shell. Scale bars: C, D, G, H, K, L, 100 µm; E, 10 µm.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of this character in the genus. The four new species of *Episiphon*, together with *E. virginieae*, are the only members of the genus having longitudinal sculpture all along the shell and highlight its diversity. The rachidian teeth, with three central projections on the internal face, seem to be unique to the genus and should be considered diagnostic at the genus level. *Episiphon lacteum* n. sp. is provisionally placed in this genus pending radular studies.

Here a third species of a group until now refered to *Fustiaria* but lacking a key feature (i.e. apical slit) of this genus is described. Further comparative studies, including molecular characters, are needed to elucidate relationships among all the species assigned to *Fustiaria*.

Caetano *et al*. (2006), studying western Atlantic species, called attention to two sets of species grouped in the six-ribbed genus *Paradentalium*. One group has a hexagonal section at the apex with similar intercostal spaces and equally spaced primary ribs usually reaching the anterior aperture (as in *P. choneides* n. sp.). The second group exhibits an irregular distribution and prominence of the ribs at the apex, resulting in intercostal spaces with different sizes and a circular or subcircular anterior shell section in adult specimens (as in *P. rudoi*, *P. danielleae* n. sp. and *P. kabati*). The presence in the Indo Pacific region of both forms, calls for further studies to test the monophyly of each of the two groups.

The new species here described not only highlight the diversity of the class in the tropical Pacific Ocean, but also reveal the existence of unique morphologies not yet recorded for the region or for the Scaphopoda as a whole. *Paradentalium choneides* n. sp. has protruding ribs at the apex and the funnel type callus, not previously observed in the genus, and the new species of *Bathoxiphus* is the first of the genus in which longitudinal sculpture has been described. *Boissevainia mossiae* n. gen., n. sp., has a newly described apical morphology and *Annulipulsellum aenigmaticum* n. sp. is unique among the Gadilida in its combination of transverse, encircling wrinkles and longitudinal striae and may represent a different, previously unreported lineage.

Acknowledgements
The continuing support of P. Bouchet, V. Héros, P. Maestrati, J.-P. Rocroi (MNHN), Y. Kantor (Institute of Evolution, Russian Academy of Sciences, Moscow) and K. Way (BMNH) are gratefully acknowledged. Thanks are also due to Mauricette Bourgeois and Danielle Plaçais for their care on sorting from bottom samples many of the specimens here studied. Special mention is given to Robert H. Cowie (University of Hawaii) for his careful editing and help with the English. John Healy and Henk Dekker are also acknowledged for the useful suggestions made to the manuscript as is Julien Marmayou for editorial work. The support of our family, especially Cecilia, Inés and Margarita, was also crucial for completing this work.

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Submitted on 13 November 2008;
accepted on 11 January 2010.