Recent Brachiopoda from the Mozambique-Madagascar area, western Indian Ocean

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ABSTRACT
Nineteen genera of Recent brachiopods, i.e. *Discradisca* Stenzel, 1964, *Novocrania* Lee & Brunton, 2001, *Basiliola* Dall, 1908, *Cryptopora* Jeffreys, 1869, *Gryphus* Megerle von Mühlfeldt, 1811, *Dallithyris* Muir-Wood, 1959, *Stenosarina* Cooper, 1977, *Xenobrochus* Cooper, 1981, *Terebratulina* d'Orbigny, 1847, *Chlidonophora* Dall, 1903, *Eucalathis* Fischer & Oehlert, 1890, *Macandrevia* King, 1859, *Frenulina* Dall, 1895, *Jolonica* Dall, 1920, *Argyrotheca* Dall, 1900, *Phaneropora* Zezina, 1981, *Nipponithyris* Yabe & Hatai, 1934, *Megerlia* King, 1850 and *Megerella* n. gen. have been identified in the material collected during three French cruises MAINBAZA, MIRIKY and ATIMO VATAE to the Mozambique-Madagascar area during the years 2009-2010. One genus and four species are described as new: the genus *Megerella* n. gen. with type species *M. hilleri* n. gen., n. sp. and the species *Eucalathis daphneae* n. sp., *Eucalathis malgachensis* n. sp. and *Macandrevia emigi* n. sp. *Eucalathis daphneae* n. sp. differs from congeneric species in having an incomplete loop. It is ornamented by single, broad, rounded costae. *Eucalathis malgachensis* n. sp. is characterized by a fascicostate surface with strong ribs triangular in cross-section. *Macandrevia emigi* n. sp. differs from other species of the genus by its triangular outline and much smaller size. *Megerella hilleri* n. gen., n. sp. is a small kraussinid with a bifurcate loop with distal extensions uniting to form a complete ring. The genus *Macandrevia* and the species *Frenulina sanguinolenta* (Gmelin, 1971) are recorded for the first time from the Indian Ocean. While minor regional differences occur within the three study regions of Madagascar, a comparison of the overall Madagascar brachiopod biota with those of other parts of the Indian Ocean shows a strong similarity to faunas from southern Africa, with 12 out of 25 species common to both areas.

KEY WORDS
Brachiopoda,
biodiversity,
biogeography,
Madagascar,
Mozambique Channel,
MAINBAZA,
MIRIKY,
ATIMO VATAE,
Indian Ocean,
new species,
new genus.

RÉSUMÉ
Les brachiopodes actuels de la région Mozambique-Madagascar, Océan Indien de l'Ouest.
Dix-neuf genres de brachiopodes actuels : *Discradisca* Stenzel, 1964 ; *Novocrania* Lee & Brunton, 2001 ; *Basiliola* Dall, 1908 ; *Cryptopora* Jeffreys, 1869 ; *Gryphus* Megerle von Mühlfeldt, 1811 ; *Dallithyris* Muir-Wood, 1959 ; *Stenosarina* Cooper, 1977 ; *Xenobrochus* Cooper, 1981 ; *Terebratulina* d'Orbigny, 1847 ; *Chlidonophora* Dall, 1903 ; *Eucalathis* Fischer & Oehlert, 1890 ; *Macandrevia* King, 1859 ; *Frenulina* Dall, 1895 ; *Jolonica* Dall, 1920 ; *Argyrotheca* Dall, 1900 ; *Phaneropora* Zezina, 1981 ; *Nipponithyris* Yabe & Hatai, 1934, *Megerlia* King, 1850 et *Megerella* n. gen. ont été identifiés dans le matériel récolté dans la région Mozambique-Madagascar pendant les expéditions françaises MAINBAZA, MIRIKY et ATIMO VATAE en 2009 et 2010. Un genre et quatre espèces sont décrits comme nouveaux : le genre *Megerella* n. gen. avec l'espèce type *M. hilleri* n. gen., n. sp. et les espèces *Eucalathis daphneae* n. sp., *Eucalathis malgachensis* n. sp. et *Macandrevia emigi* n. sp. *Eucalathis daphneae* n. sp. diffère des espèces congénériques par son brachidium incomplètement fermé. Elle est ornée par des côtes individuelles, larges et arrondies. La surface externe de *Eucalathis malgachensis* n. sp. se caractérise par des côtes fortes avec une section transversale triangulaire. *Macandrevia emigi* n. sp. diffère des espèces congénériques par son contour triangulaire et sa taille plus petite. *Megerella hilleri* n. gen., n. sp. est un petit kraussinidé avec un brachidium bifurqué dont les extensions distales s'unissent pour former un anneau continu. Le genre *Macandrevia* et l'espèce *Frenulina sanguinolenta* (Gmelin, 1791) sont signalés pour la première fois dans l'Océan Indien. Malgré des différences mineures au sein des trois secteurs considérés, une comparaison de l'ensemble des brachiopodes de Madagascar avec ceux d'autres régions de l'Océan Indien montre une forte similarité avec les faunes du sud de l'Afrique, avec 12 des 25 espèces communes aux deux régions.

MOTS CLÉS
Brachiopoda,
biodiversité,
biogéographie,
Madagascar,
canal du Mozambique,
MAINBAZA,
MIRIKY,
ATIMO VATAE,
Océan Indien,
espèces nouvelles,
genre nouveau.

INTRODUCTION AND CONTEXT

The brachiopods described in this report were collected by thr *rotundata* ee expeditions to the Mozambique-Madagascar region in the western Indian Ocean during the years 2009-2010 under the leadership of Philippe Bouchet of the Muséum national d'Histoire naturelle, Paris (MNHN). It formed part of the programme *Our Planet Reviewed*, a joint initiative of an academic institution (MNHN) and an NGO – Pro-Natura International (PNI) in partnership with Institut d'Halieutique et des Sciences marines, University of Toliara (IH-SM) and the Madagascar Bureau of Wildlife Conservation Society (WCS) – to document, sample and describe the neglected components of biodiversity in key ecosystems of the World, of which the Mozambique-Madagascar area is one. These expeditions, funded by the Total Foundation, Prince Albert II de Monaco Foundation and the Stavros Niarchos Foundation, are affiliated with the *Census of Continental Margins* (CoMarges) component of the *Census of Marine Life* initiative. The marine expeditions are networking with the *Census of Marine Life* and the *Barcode of Life* initiatives, while the *World Union for Nature* (IUCN) has declared its support for the project (see www.laplaneterevisitee.org).

The expeditions

In April of 2009 the deep-sea survey conducted by the MAINBAZA expedition, using the research vessel (RV) *Vizconde de Eza* and operated by the MNHN and Instituto Español de Oceanografia (IOE), sampled the benthic marine fauna of 46 stations from a depth range of 100-1400 m in the Central Mozambique Channel, of which 24 stations (52.2%) yielded brachiopods.

In June-July of 2009 the MIRIKY expedition (with RV *Miriky*) collected benthic samples from 120 stations from a depth range of 100-1000 m in the northern part of the Mozambique Channel off north-western Madagascar, of which 18 (15%) yielded brachiopods.

In April-June of 2010 the ATIMO VATAE expedition (using the trawler RV *Nosy Bé II*) sampled the marine benthos of 424 stations down to 500 m depth off the little-known South coast of Madagascar, of which 36 stations (8.5%) yielded brachiopods. Details of the ATIMO VATAE expedition to the "deep South" of Madagascar are described in: www.coml.org/news/south-madagascar-expedition

Details of localities for all three expeditions are listed in the Appendix and shown on a regional map (Fig. 1). Brachiopods were never prolific – in total, they were found in only 78 stations out of 590 sampled (13.2%), a proportion similar to that found by Cooper (1973b) from the *Vema* expeditions.

All collections are stored in the MNHN but the brachiopods were temporarily assigned by Ph. Bouchet to us. The results of these studies form the basis for this report. The specimens were kept under the catalogue numbers MNHN IB-2013-28 to MNHN IB-2013-100, and MNHN IB-2013-506 to MNHN IB-2013-515.

Previous studies on recent brachiopods from the Indian Ocean

A small number of brachiopods were dredged from the Indian Ocean by the *Challenger* expedition in 1873-1876 but mainly from high latitudes around Marion and Kerguelen Islands (Davidson 1880, 1886-1888). Muir-Wood (1959) gave a comprehensive list of all stations from which brachiopods were dredged and all previous expeditions that had collected and

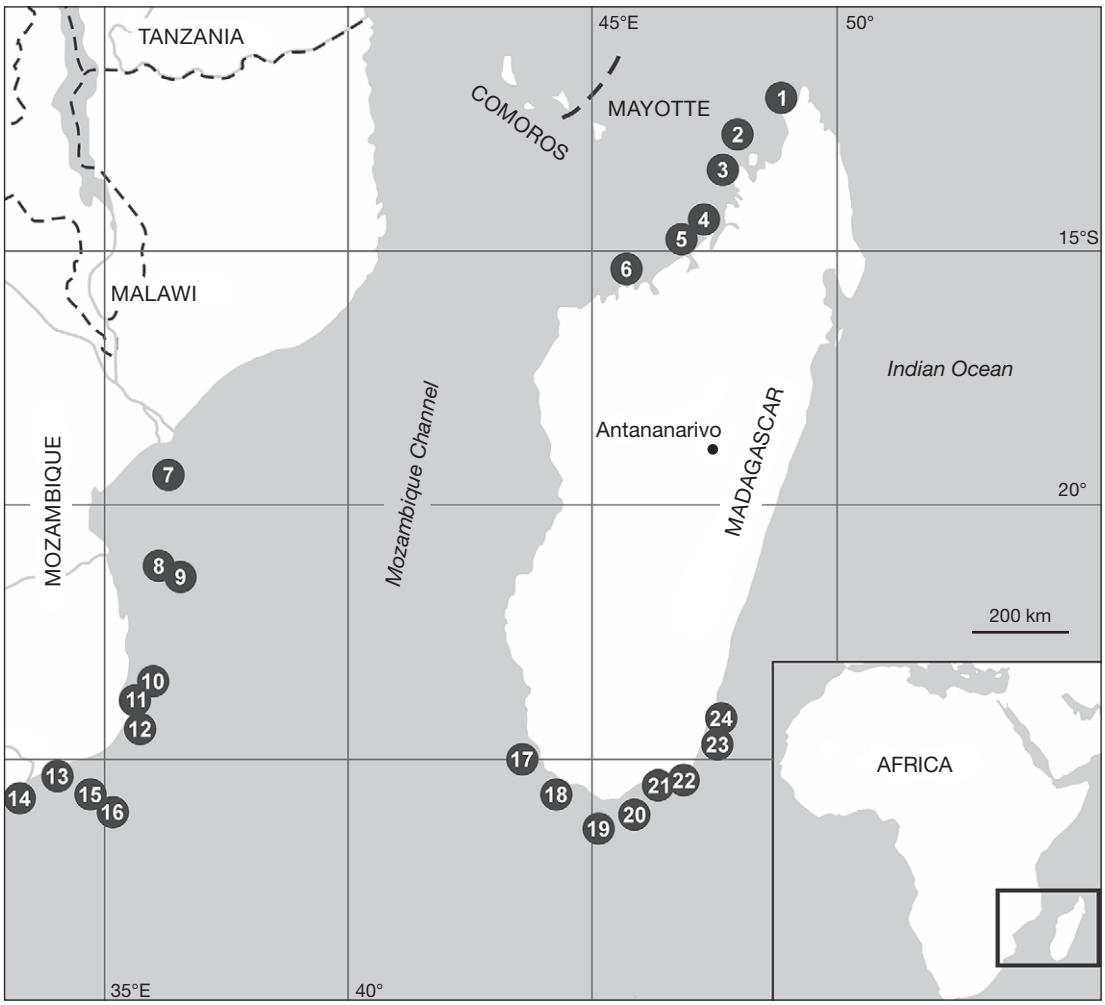

FIG. 1. — Location map of the brachiopod-bearing stations of the MAINBAZA, MIRIKY and ATIMO VATAE expeditions: **1**, DW 3196; **2**, DW 3112, DW 3116, DW 3228; **3**, DW 3230, DW 3232, DW 3234; **4**, DW 3239, CP 3240, CP 3289, CP 3293, CP 3294; **5**, CP 3247; **6**, CP 3252-3253, CP 3261, CP 3278; **7**, CC 3152-3154; **8**, CP 3146; **9**, CP 3145, CC 3157-3158; **10**, CP 3139-3144, **11**, CC 3159; **12**, CC 3166; **13**, CP 3130, CP 3132-3133, CP 3136, CP 3138, CC 3175; **14**, CP 3130; **15**, CC 3170-3171; **16**, DW 3167; **17**, CP 3589, CP 3592; **18**, DW 3581, CP 3585, CP 3587, CP 3595, DW 3599; **19**, CP 3613-3615; **20**, DW 3552-3553, DW 3555, DW 3557; **21**, DW 3564; **22**, TA01, TP03, TB01, TS09, TP18, DW 3573; **23**, DW 3515, DW 3518-3519, CP 3520; **24**, DW 3522-3524, CP 3527, DW 3528-3529, DW 3530-3534. Details of location: see Appendix.

identified brachiopods from the Indian Ocean and adjacent seas. In addition, she described three new species obtained from the John Murray Expedition of 1933-1934. Cooper (1973a) described nine new brachiopod species from cruises 7 and 8 of the RV *Anton Bruun* in the Mozambique Channel, while in 1977, 14 species of brachiopods were collected by the BENTHEDI cruise to the Mozambique Channel and later identified by Zezina (1987), including one new species.

In addition, both Foster (1974) and Cooper (1981a) described brachiopods from high latitudes above 40°S in the southern Indian Ocean, the latter from specimens taken from cruises MD03 (1974) and MD08 (1976) of the M.S. *Marion Dufresne.* Specimens from cruise MD24 of the *Marion Dufresne* in 1980 to the south-western part of the Indian Ocean are as yet undescribed and await study. Finally, Hiller (1986) described 17 species, including three new species, from the East coast of South Africa, some of which range northwards along the East African coast.

SYSTEMATIC

Phylum BRACHIOPODA Duméril, 1805
Subphylum LINGULIFORMEA Williams, Carlson, Brunton, Holmer & Popov, 1996
Class LINGULATA Gorjansky & Popov, 1985
Order LINGULIDA Waagen, 1885
Superfamily DISCINOIDEA Gray, 1840
Family DISCINIDAE Gray, 1840

Genus *Discradisca* Stenzel, 1964

TYPE SPECIES. — *Orbicula antillarum* d'Orbigny, 1845, by original designation of Stenzel (1964: 627).

TABLE 1. — Measurements (in mm) of *Novocrania* sp.

Station No.	Length	Width
DW 3167	8.2	10.1
DW 3167	7.9	9.7
DW 3167	7.7	9.1
DW 3167	6.5	8.1
DW 3167	6.3	6.9

TABLE 2. — Measurements (in mm) of *Basiliola arnaudi* Cooper, 1981.

Station No.	Length	Width	Thickness
DW 3212	14.3	14.2	10.1
DW 3216	16.3	15.0	11.8
DW 3552	15.5	13.8	–

Discradisca sp.
(Fig. 2A)

MATERIAL EXAMINED. — **South Madagascar**. ATIMO VATAE, stn TP03, 1 specimen.

DEPTH RANGE. — 17-21 m.

MEASUREMENTS. — Length 2.8 mm, 3.4 mm width.

REMARKS
The very limited material, represented by one specimen attached to the substrate, prevents identification to species level. The shell is thin, small, and subcircular in outline, with the apex situated subposteriorly. The external surface of the adult shell is covered with numerous, very indistinct ribs. A similar discinid with indistinct radial ornamentation was reported by d'Hondt (1987) from the Réunion Island region.

Subphylum CRANIIFORMEA
Popov, Bassett, Holmer & Laurie, 1993
Class CRANIATA
Williams, Carlson, Brunton, Holmer & Popov, 1996
Order CRANIIDA Waagen, 1885
Superfamily CRANIOIDEA Menke, 1828
Family CRANIIDAE Menke, 1828

Genus *Novocrania* Lee & Brunton, 2001

TYPE SPECIES. — *Patella anomala* Müller, 1776, by original designation of Lee & Brunton (1986: 150).

Novocrania roseoradiata (Jackson, 1952)
(Fig. 2B, C)

Crania roseoradiata Jackson, 1952: 7-9, pl. 1, figs 1-4.

MATERIAL EXAMINED. — **South Madagascar**. ATIMO VATAE, stn TS09, 1 dorsal valve.

DEPTH RANGE. — 5-6 m.

MEASUREMENTS. — Length 8.6 mm, width 9.5 mm.

REMARKS
The investigated specimen collected off southern Madagascar corresponds well with the species *Crania roseoradiata* described by Jackson (1952) from South Africa. The shell is small, circular, with a low, subcentral apex. The muscle scars are well marked (Fig. 2C). The posterior adductor muscle scars are large, rounded, and widely separated, while the anterior muscle scars are elevated and kidney-shaped. In the anterior half of the shell impressions of branching mantle canals are observed.

In the character of the muscle scars this species shows similarity with *Novocrania anomala* (Müller, 1776) from the Mediterranean and northern Atlantic (Logan & Long 2001). Emig (2014) regards *N. anomala* and *N. turbinata* (Poli, 1796) as synonyms, based mainly on molecular analyses (see Cohen *et al.* 2014). Jackson (1952: 9) advocated a revision of the two forms, which Emig (2014) has now done.

Novocrania sp.
(Fig. 2D-H; Table 1)

?*Crania* species – Cooper 1981a: 11-12, figs 2-4.

MATERIAL EXAMINED. — **Mozambique Channel**. MAINBAZA, stn DW 3167, 5 dorsal valves.
North-West Madagascar. MIRIKY, stn DW 3199, 5 dorsal valves of young individuals.

DEPTH RANGE. — 228-652 m.

MEASUREMENTS. — See Table 1.

DESCRIPTION
Shell small, subcircular, wider than long, conical in profile, with nearly straight posterior margin. Shell surface ornamented by concentric growth lines; on better preserved specimens single pustules are observed. Apex situated posterocentrally to subposteriorly. Dorsal valve interior with circular posterior adductor muscle scars. Anterior adductor muscle scars very small, ovate, positioned close to one another (Fig. 2G). Below the scars low, subtriangular shallow depressions are visible on the inner surface. Marginal rim distinct, slightly concave (Fig. 2H).

REMARKS
The specimens collected in the Mozambique Channel and northern Madagascar resemble the specimen from Walters Bank, South of Madagascar described by Cooper (1981a) as *Crania* sp., suggesting conspecificity of those brachiopods. They are, however, two to three times larger than Cooper's specimen. As a ventral valve is missing we are unable to propose a new species.

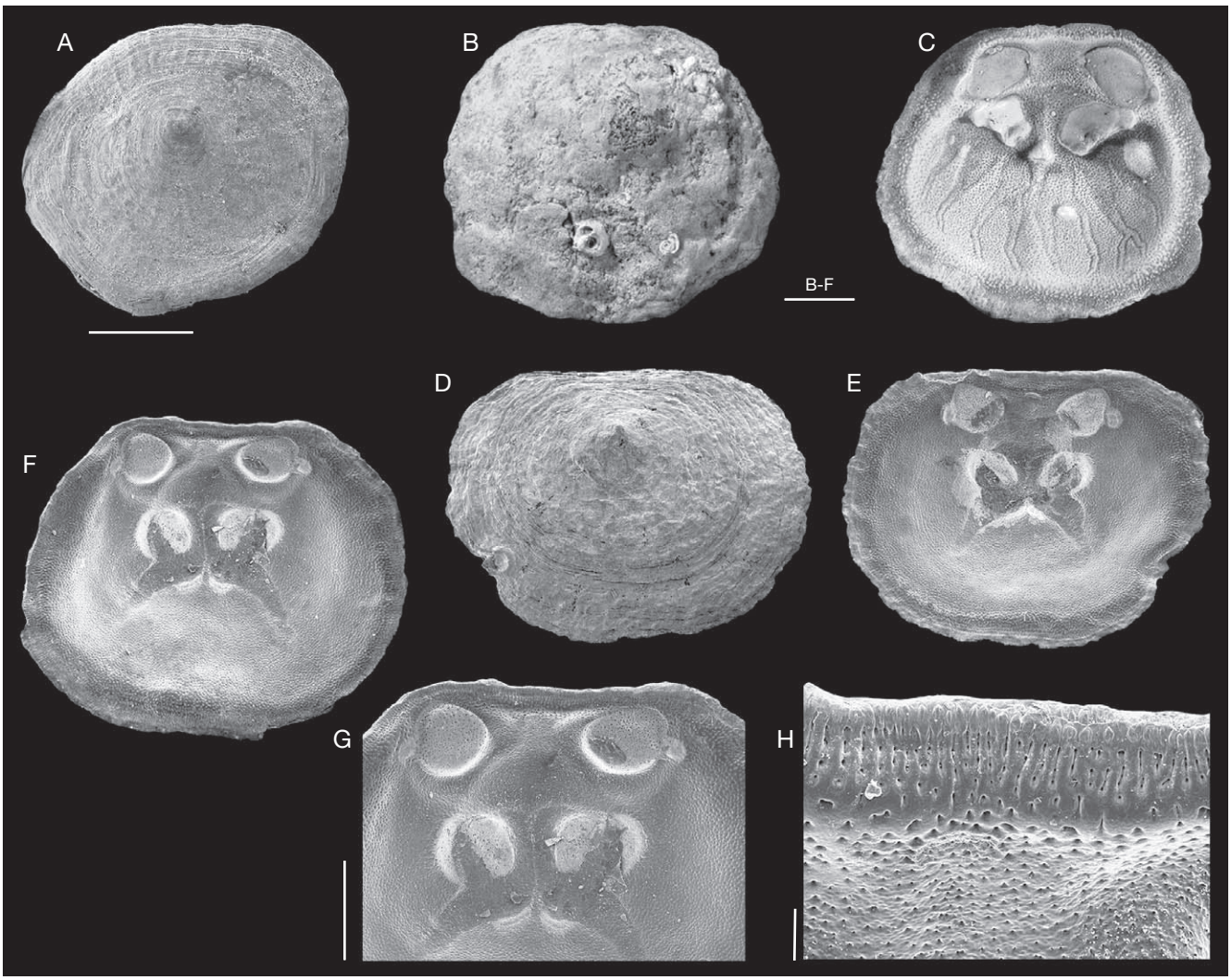

Fig. 2. — **A**, *Discradisca* sp., South Madagascar, Bay of Galions, ATIMO VATAE, stn TP03, 17-21 m, dorsal view of complete specimen (IB-2013-28). **B**, **C**, *Novocrania roseoradiata* (Jackson, 1952), outer and inner views of dorsal valve (IB-2013-29), South Madagascar, S. Bay of Lokaro, ATIMO VATAE, stn TS09, 5-6 m. **D**-**H**, *Novocrania* sp., Mozambique Channel, Almirante Leite Bank, MAINBAZA, stn CC 3167, 228-230 m, dorsal valves (IB-2013-30-31); **D**, **E**, outer and inner views; **F**-**H**, inner view, and enlargement of posterior part to show muscle scars (**G**) and margin (**H**). **A**, **D**-**H**, SEM. Scale bars: A, 1 mm; B-G, 2 mm; H, 200 µm.

Subphylum RHYNCHONELLIFORMEA Williams, Carlson, Brunton, Holmer & Popov, 1996
Class RHYNCHONELLATA Williams, Carlson, Brunton, Holmer & Popov, 1996
Order RHYNCHONELLIDA Kuhn, 1949
Superfamily Pugnacoidea Rzhonsnitskaya, 1956
Family Basiliolidae Cooper, 1959

Genus *Basiliola* Dall, 1908

Type species. — *Hemithyris beecheri* Dall, 1895, by original designation of Dall (1908: 442).

Basiliola arnaudi Cooper, 1981
(Fig. 3; Table 2)

Basiliola arnaudi Cooper, 1981a: 16, pl. 3, figs 1-14. — Zezina 1985: 115; 1987: 555; 1994: 44; 2010: 1179.

Material examined. — **North-West Madagascar**. MIRIKY, stn DW 3212, 1 bivalved specimen. — Stn DW 3216, 1 bivalved specimen.
South Madagascar. ATIMO VATAE, stn DW 3552, 1 ventral valve. — Stn DW 3555, 3 ventral valves, 1 dorsal valve.

Depth range. — 296-369 m.

Measurements. — See Table 2.

Remarks
This species was first described by Cooper (1981a) from Samper Bank, South-East of Madagascar, for "small nearly round *Basiliola*" which Cooper carefully distinguished from previously-described forms of the genus, all from the Pacific Ocean (Logan 2007; Bitner 2008, 2009). The distinctive corrugated teeth and sockets, subfalciform crura, general shape, overall dimensions and depth range of our specimens are in accord with Cooper's types of *B. arnaudi* from Samper Bank.

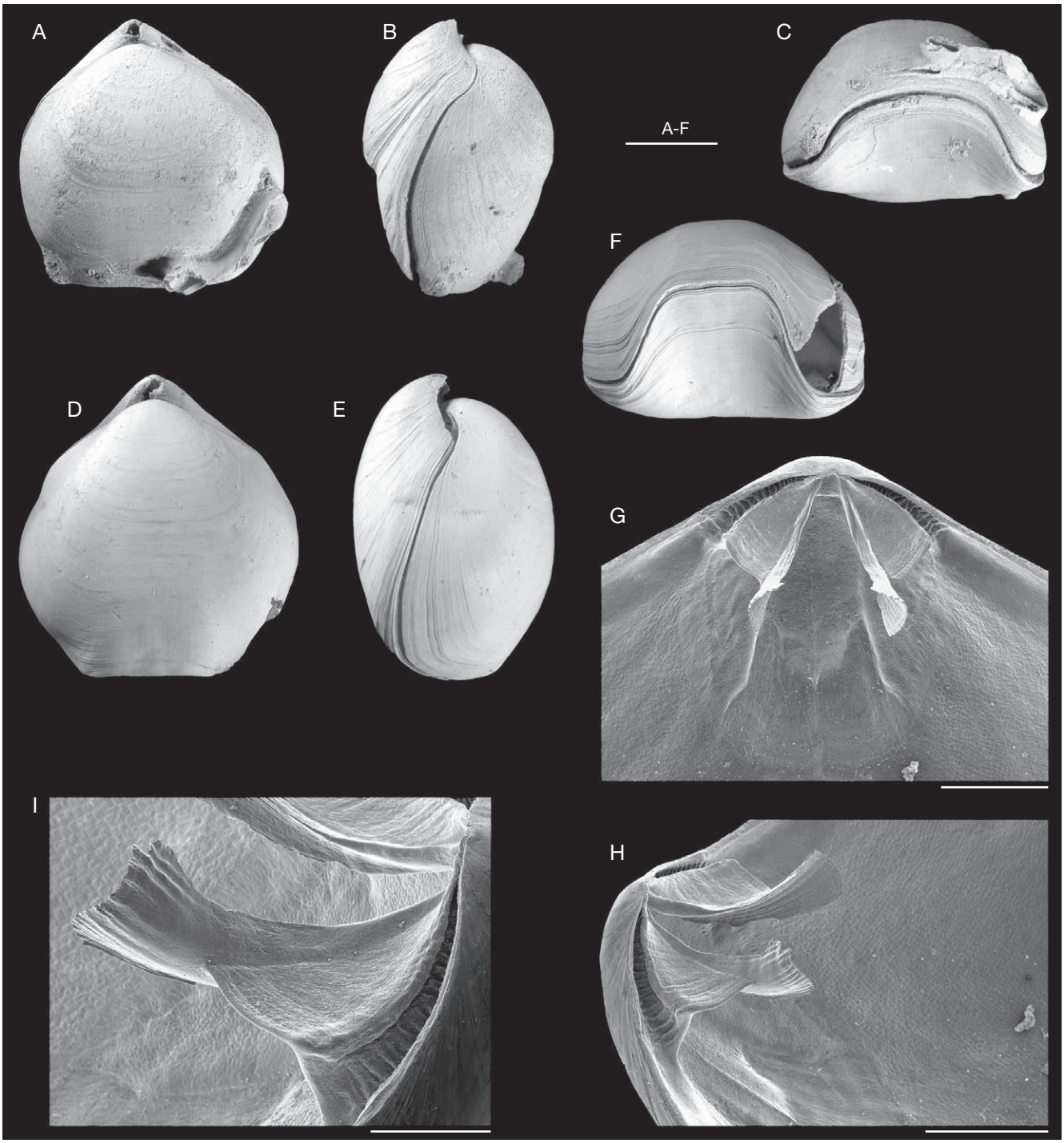

Fig. 3. — *Basiliola arnaudi* Cooper, 1981, North-West Madagascar, between Nosy Be and Leven Bank, MIRIKY: **A**-**C**, dorsal, lateral and anterior views of complete specimen (IB-2013-32), stn DW 3212, 367-369 m; **D**-**I**, complete specimen (IB-2013-33), stn DW 3216, 296-350 m; **D**-**F**, dorsal, lateral and anterior views; **G**-**I**, SEM micrographs of posterior part of dorsal valve interior. Scale bars: A-F, 5 mm; G, H, 2 mm; I, 1 mm.

Superfamily Dimerelloidea Buckman, 1918
Family Cryptoporidae Muir-Wood, 1955

Genus *Cryptopora* Jeffreys, 1869

Type species. — *Cryptopora gnomon* Jeffreys, 1869, by monotypy of Jeffreys (1869: 136).

Cryptopora boettgeri Helmcke, 1940
(Fig. 4; Table 3)

Cryptopora boettgeri Helmcke, 1940: 286-290, figs 29-33, 35-36. — Muir-Wood 1959: 292. — Cooper 1973a: 6; 1973b: 11. — Zezina 1985: 113; 2010: 1179.

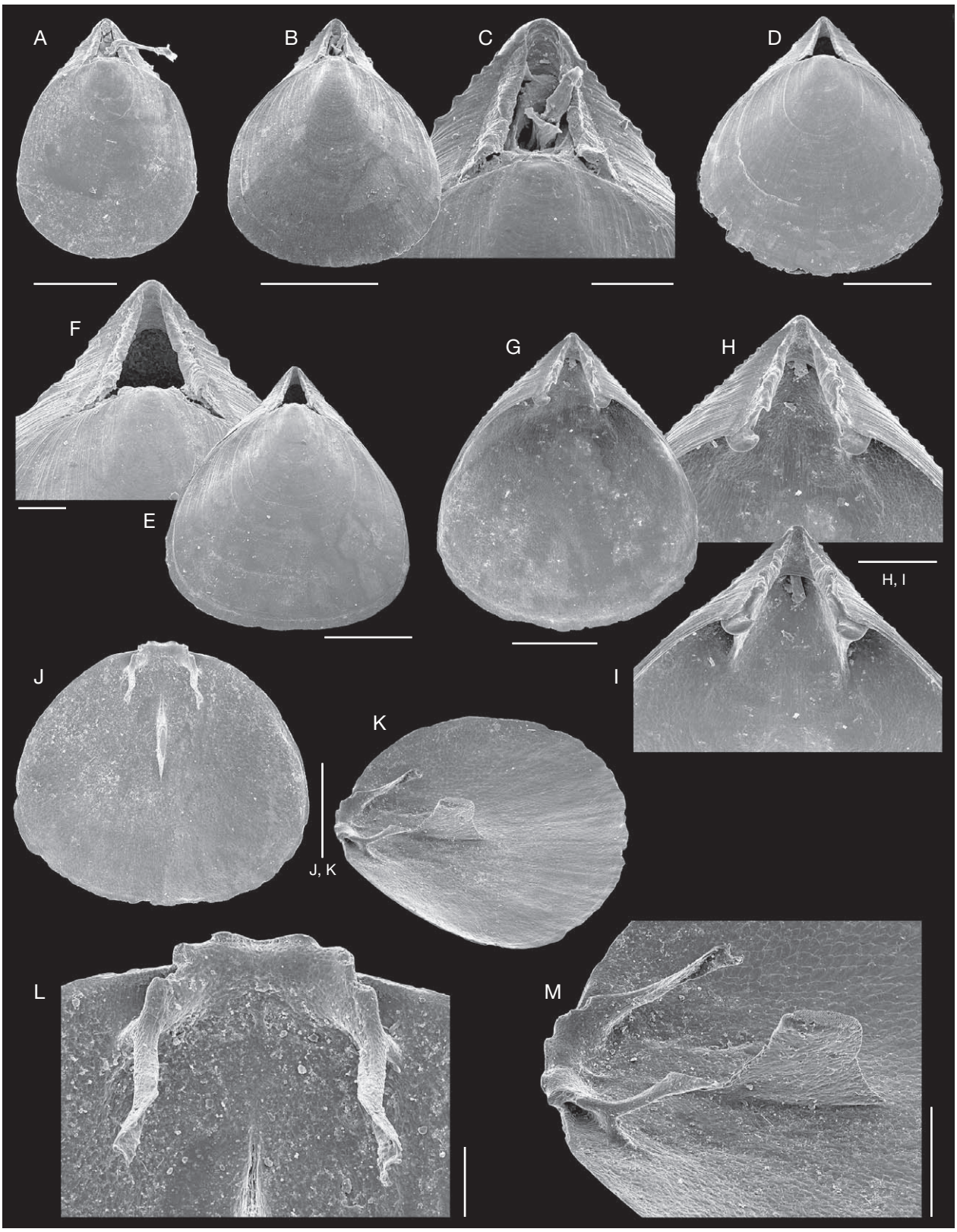

Fig. 4. — *Cryptopora boettgeri* Helmcke, 1940: **A**, dorsal view of complete immature specimen (MNHN IB-2013-34), South Madagascar, South Point Barrow, ATIMO VATAE, stn CP 3585, 549-576 m; **B**, **C**, dorsal view of complete specimen (MNHN IB-2013-35) and enlargement of the umbonal part (**C**), South Madagascar, South-West Point Barrow, ATIMO VATAE, stn CP 3592, 450-455 m; **D**, dorsal view of complete specimen (MNHN IB-2013-36), Mozambique Channel, Zambeze transect, MAINBAZA, stn CC 3152, 443-445 m; **E**, **F**, dorsal view of complete specimen (MNHN IB-2013-37) and enlargement of posterior part (**F**), stn CP 3592; **G**-**I**, inner view of ventral valve (**G**), and enlargement and tilted views (**H**, **I**) of umbonal part to show elevated deltidial plates, teeth and dental plates (MNHN IB-2013-38), stn CP 3592; **J**-**M**, dorsal valve (MNHN IB-2013-39), inner and oblique views (**J**, **K**), and enlargements (**L**, **M**) to show details of crura and septum, stn CP 3592. All SEMs. Scale bars: A, H, I, M, 500 µm; B, D, E, G, J, K, 1 mm; C, F, L, 200 µm.

TABLE 3. — Measurements (in mm) of *Cryptopora boettgeri* Helmcke, 1940.

Station No.	Length	Width	Thickness
CP 3585	3.4	2.8	0.9
CP 3585	3.2	2.8	0.9
CP 3585	2.5	2.1	0.7
CP 3585	2.2	1.9	0.6
CP 3585	1.6	1.4	0.4
CP 3585	1.4	1.1	0.3
CP 3592	2.8	2.7	0.8

TABLE 4. — Measurements (in mm) of *Cryptopora curiosa* Cooper, 1973.

Station No.	Length	Width	Thickness
CP 3132	3.6	2.7	1.5
CP 3132	3.2	2.5	1.1
CP 3132	2.4	1.9	0.8
CP 3132	2.3	1.7	0.8
CP 3133	3.5	3.1	1.2
DW 3581	2.8	2.4	0.9

MATERIAL EXAMINED. — **Mozambique Channel**. MAINBAZA, stn CP 3136, 1 bivalved specimen. — Stn CC 3152, 1 bivalved specimen. — Stn CC 3154, 1 bivalved specimen.
South Madagascar. ATIMO VATAE, stn DW 3552, 1 bivalved specimen. — Stn DW 3553, 1 bivalved specimen. — Stn CP 3585, 56 bivalved specimens. — Stn CP 3592, 70 bivalved specimens, 2 ventral valves, 2 dorsal valves. — Stn CP 3615 – 1 bivalved specimen.

DEPTH RANGE. — 264-636 m.

MEASUREMENTS. — See Table 3.

REMARKS
The genus *Cryptopora* is represented by three species in the Indian Ocean: *C. boettgeri* Helmcke, 1940, *C. curiosa* Cooper, 1973 and *C. maldivensis* Muir-Wood, 1959 (Logan 2007; Bitner 2008). *C. boettgeri* was originally described by Helmcke (1940) from the Agulhas Bank off the Cape of Good Hope, South Africa at 500-564 m depth and from near Dar-es-Salaam, Tanzania at 404 m. It was later recorded from the West coast of South Africa at 3045 m by Cooper (1973b) and from four stations to the West, South and East of South Africa by Hiller (1994). This species is one of the commonest found in the present study, with over 100 specimens from two localities in South Madagascar. Examination of the holotype of *C. boettgeri* (ZMB Bra 2019 in the Humboldt Museum, Berlin) indicates a close external similarity in size and shape to specimens from Madagascar, while internal features of the dorsal valve of the latter, such as the hatchet-shaped septum (Fig. 4M) and the large, flattened and serrated endings of the crura (Fig. 4L, M) are also in accord with Helmcke's species. It should be noted that *C. maldivensis*, the third Indian Ocean cryptoporid, has a similar-shaped septum and serrate crural terminations to *C. boettgeri* but has narrower and smoother deltidial plates.

Cryptopora curiosa Cooper, 1973
(Fig. 5; Table 4)

Cryptopora curiosa Cooper, 1973a: 6, pl. 1, figs 4-6; pl. 2, figs 1-25. — Zezina 1985: 113; 2010: 1179. — Logan *et al.* 2008: 301, fig. 2d-g.

Cryptopora ? cf. *boettgeri* – Muir-Wood 1959: 294, pl. 5, fig. 11.

MATERIAL EXAMINED. — **Mozambique Channel.** MAINBAZA, stn CP 3132, 10 bivalved specimens, 1 ventral valve and 1 dorsal valve. — Stn CP 3133, 1 bivalved specimen.
South Madagascar. ATIMO VATAE, stn DW 3581, 1 bivalved specimen.

DEPTH RANGE. — 101-229 m.

MEASUREMENTS. — See Table 4.

REMARKS
Cryptopora curiosa is readily distinguished from other species of *Cryptopora* by its elaborate wing-like (auriculate) growths on the deltidial plates (Fig. 5A, B). In the Indian Ocean this species has been identified by Cooper (1973a) from the Andaman Islands and the coasts of South Africa, Mozambique and Somalia, all at depths of less than 100 m. It is also relatively common in sediments in the Red Sea, ranging in depth from 56-1537 m although most of these specimens have been clearly transported seawards from their living sites (Logan *et al.* 2008). Although slightly less elongate, the specimens from Madagascar are similar in size and shape to those described and illustrated by Cooper (1973a) and are likewise found in shallow waters up to about 100 m depth, being, however, less common than its congener *C. boettgeri*. Curry (1983) has postulated that the auriculate flanges of the deltidial plates in *C. curiosa* might aid the long pedicle in providing posterior weighting to prevent the posterior margin of the shell from gradually sinking into the sediment.

Order TEREBRATULIDA Waagen, 1883
Suborder TEREBRATULIDINA Waagen, 1883
Superfamily TEREBRATULOIDEA Gray, 1840
Family TEREBRATULIDAE Gray, 1840
Subfamily GRYPHINAE Sahni, 1929

Genus *Gryphus* Megerle von Mühlfeldt, 1811

TYPE SPECIES. — *Anomia vitrea* Born, 1778, by monotypy of Megerle von Mühlfeldt (1811: 64).

Gryphus capensis Jackson, 1952
(Fig. 6F-J)

Gryphus capensis Jackson, 1952: 16-18, pl. 1, figs 10-13.

MATERIAL EXAMINED. — **North-West Madagascar**. MIRIKY, stn DW 3196, 1 bivalved open specimen, slightly broken ventral valve.

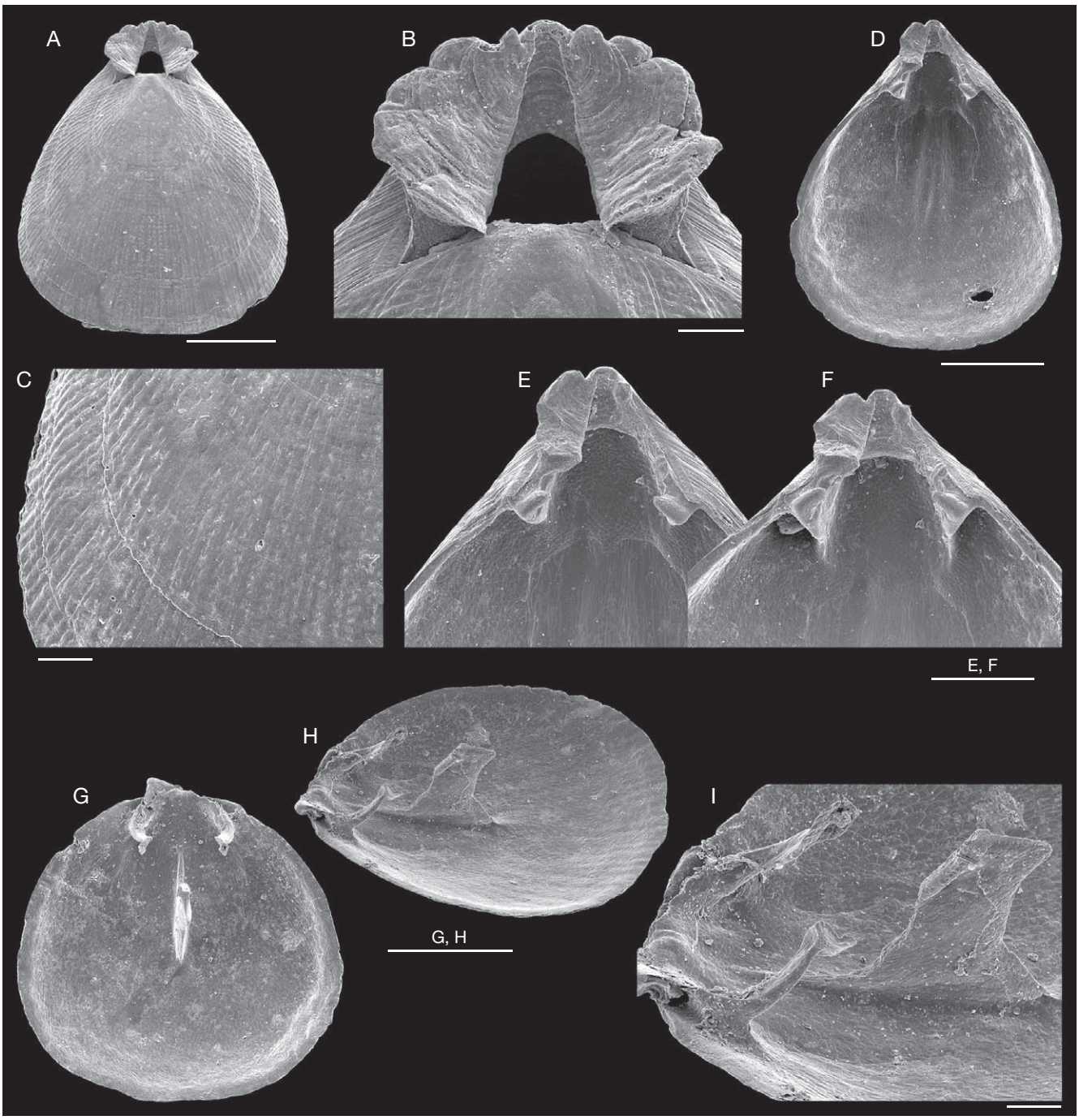

Fig. 5. — *Cryptopora curiosa* Cooper, 1973, Mozambique Channel, Maputo transect, MAINBAZA, stn CP 3132, 101-102 m: **A**-**C**, complete specimen (MNHN IB-2013-40), dorsal view (**A**), and enlargement of the umbonal part (**B**) to show details of auriculated deltidial plates and of the outer surface (**C**) to show radial ornamentation; **D**-**F**, inner view of ventral valve (**D**), and enlargement of posterior part (**E**) and tilted view (**F**) to show teeth and dental plates (MNHN IB-2013-41); **G**-**I**, inner and oblique views of dorsal valve (MNHN IB-2013-42) to show septum and crura. All SEMs. Scale bars: A, D, G, H, 1 mm; B, C, I, 200 µm; E, F, 500 µm.

Depth range. — 238-249 m.

Measurements. — Length of dorsal valve 11.0 mm, width 10.1 mm.

Remarks

There are five species of *Gryphus* recorded from modern seas, of which the best known is the type species *G. vitreus* (Born, 1778) from the Mediterranean Sea (Logan 1979). The only representative of this genus from the Indian Ocean is *G. capensis* which Jackson (1952) described from the South coast of South Africa. Hiller (1991, 1994) has also recorded it from the same general region. The sole specimen of *G. capensis* obtained in this study from North-West Madagascar differs slightly from the type species in that the transverse band of the loop has a more pronounced ventral arching at the centre (Fig. 6J). It is, however, consistent with the specimens described by Jackson (1952). The shell is small, elongate oval, ventribiconvex. The

TABLE 5. — Measurements (in mm) of *Dallithyris dubia* Cooper, 1981.

Station No.	Length	Width	Thickness
CP 3141	21.9	17.6	12.7
CP 3141	20.4	16.0	–
CP 3141	20.0	17.0	11.8
CP 3141	17.4	14.3	11.0
CP 3141	14.1	11.1	8.3

TABLE 6. — Measurements (in mm) of *Xenobrochus africanus* (Cooper, 1973).

Station No.	Length	Width	Thickness
CP 3143	7.2	5.3	3.5
DW 3564	5.5	4.3	2.7

foramen is large, oval with a short, excavate pedicle collar. The teeth are short but wide with very weak swollen bases. The cardinal process is small, whereas the triangular outer hinge plates are wide and concave, bordered by crural bases. The loop is short with parallel descending branches and a broad transverse band. The shell is composed of three layers with a relatively thin tertiary prismatic layer (Fig. 6H).

Subfamily DALLITHYRIDINAE Katz & Popov, 1974

Genus *Dallithyris* Muir-Wood, 1959

TYPE SPECIES. — *Dallithyris murrayi* Muir-Wood, 1959, by original designation of Muir-Wood (1959: 305).

Dallithyris dubia Cooper, 1981
(Fig. 7; Table 5)

Dallithyris? *dubia* Cooper, 1981a: 21, 22, pl. 4, figs 21-29. — Zezina 1985: 149; 2010: 1184.

MATERIAL EXAMINED. — **Mozambique Channel**. MAINBAZA, stn CP 3138, 7 bivalved specimens, 1 dorsal valve. — Stn CP 3141, 34 bivalved specimens, 2 ventral valves, 1 dorsal valve.

DEPTH RANGE. — 684-707 m.

MEASUREMENTS. — See Table 5.

DESCRIPTION

Shell of medium size (maximum length of 21.9 mm), thin, elongate oval to subtriangular in outline, ventribiconvex. Shell surface smooth with numerous, distinct growth lines. Beak suberect, foramen large, circular, permesothyrid. Symphytium small, slightly concave, partially visible. Anterior commissure rectimarginate to incipiently uniplicate.

Ventral valve interior (Fig. 7F) with small teeth and short, excavate pedicle collar. Dorsal valve interior with long inner socket ridges and triangular and distinct cardinal process (Fig. 7H, I). Outer hinge plates relatively narrow, concave. Loop short with a broad transverse band angularly folded (Fig. 7G-I).

REMARKS

The genus *Dallithyris*, with type species *D. murrayi*, was first established by Muir-Wood in 1959 from specimens obtained from the Maldive Islands and Saya de Malha Bank in the Indian Ocean. Later Cooper (1981a) questionably assigned four specimens from Samper Bank to *Dallithyris*, recognizing the uncertainty of the loop characteristics of the type species. We assign our specimens to *Dallithyris* notwithstanding, based on the similarity of the loop in Fig. 7H, I to that illustrated by Cooper in his plate 4, fig. 28. Apart from the type of loop, the beak character supports assignment of *D. dubia* to the genus *Dallithyris*. In *Stenosarina* Cooper, 1977 the beak is nearly straight, whereas in *Kanakythyris* Laurin, 1997 it is incurved with a very small foramen (Laurin 1997; Bitner 2009). *Dallithyris dubia* differs from its congeneric species in being much smaller (see Muir-Wood 1959; Cooper 1983; Bitner 2006b, 2007, 2008, 2014). *D. dubia* was found only in the Mozambique Channel in our study, where it is relatively common.

Genus *Stenosarina* Cooper, 1977

TYPE SPECIES. — *Stenosarina angustata* Cooper, 1977, by original designation of Cooper (1977: 95).

Stenosarina sp.

MATERIAL EXAMINED. — **South Madagascar**. ATIMO VATAE, stn DW 3555, 2 ventral valves with partly damaged anterior part.

DEPTH RANGE. — 455-458 m.

REMARKS

Of the eight present-day species of *Stenosarina* known (Logan 2007) only *S. crosnieri* (Cooper, 1983) has been recorded from the Indian Ocean, where it has been identified from 430-700 m depth off the north-western side of Madagascar (Cooper 1983). The two specimens recorded here from South Madagascar extend the geographical range of the genus but, while the material is poorly preserved, the smooth surface, small concave symphytium and nearly straight beak are characteristic of *Stenosarina* and suggest attribution to this genus.

Superfamily DYSCOLIOIDEA Fischer & Oehlert, 1890
Family DYSCOLIIDAE Fischer & Oehlert, 1890
Subfamily AENIGMATHYRIDINAE Cooper, 1983

Genus *Xenobrochus* Cooper, 1981

TYPE SPECIES. — *Gryphus africanus* Cooper, 1973, by original designation of Cooper (1981a: 19).

Xenobrochus africanus (Cooper, 1973)
(Fig. 6A-E; Table 6)

Gryphus africanus Cooper, 1973a: 8, pl. 4, figs 31-38.

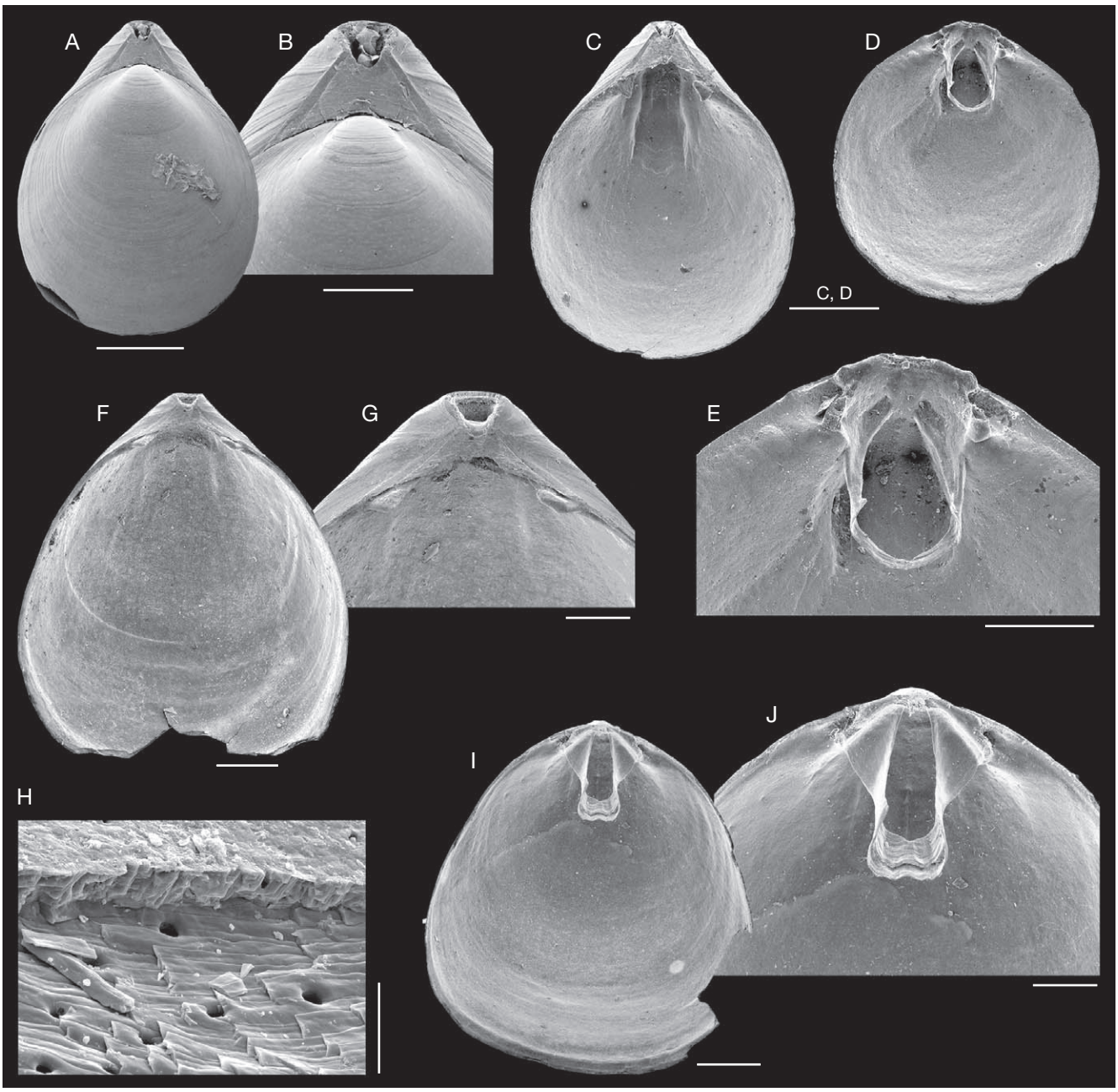

Fig. 6. — **A**-**E**, *Xenobrochus africanus* (Cooper, 1973), Mozambique Channel, Inhambane transect, MAINBAZA, stn CP 3143, 264-277 m (MNHN IB-2013-50): **A**, **B**, dorsal view of complete specimen and enlargement of the umbonal part to show details of the beak (**B**); **C**, inner view of ventral valve; **D**, **E**, inner view of dorsal valve (**C**), and enlargement of posterior part (**E**) to show details of brachial skeleton; **F**-**J**, *Gryphus capensis* Jackson, 1952, North-West Madagascar, West of Cap d'Ambre, MIRIKY, stn DW 3196, 238-249 m (MNHN IB-2013-43): **F**-**H**, inner view of ventral valve (**F**), enlargement of posterior part (**G**) to show teeth and symphytium, and broken transverse section, showing secondary fibres and prims of the tertiary layer (top), characteristic for the genus, **I**, **J**, inner view of dorsal valve, and enlargement of posterior part (**J**) to show details of cardinalia and loop. All SEMs. Scale bars: A, C, D, F, I, 2 mm; B, E, G, J, 1 mm; H, 50 µm.

Xenobrochus africanus – Cooper 1981a: 20, pl. 4, figs 30-35; 1983: pl. 2, figs 20-23. — Hiller 1986: 111-113, fig. 6. — Laurin 1997: 430, 431, figs 15, 16. — Bitner 2010: 647, fig. 3D-G. — Zezina 2010: 1185.

Material examined. — **Mozambique Channel.** MAINBAZA, stn CP 3143, 1 bivalved specimen.
South Madagascar. ATIMO VATAE, stn DW 3564, 1 bivalved specimen.

Depth range. — 264-456 m.

Measurements. — See Table 6.

Remarks

The genus *Xenobrochus* is represented by nine species and is restricted to the Indian Ocean and West Pacific (Logan 2007; Bitner 2008, 2011). *X. africanus* was originally described by Cooper (1973a) from Durban Bay, South Africa at 355 m depth under the name of *Gryphus africanus* but he later (Cooper 1981a) assigned it as type species to his new genus *Xenobrochus*. This species was rare in our study but characterized by a completely visible symphytium, and internally

TABLE 7. — Measurements (in mm) of *Terebratulina meridionalis* Jackson, 1952.

Station No.	Length	Width	Thickness
CC 3175	9.6	8.0	4.6
TP 18	6.7	5.4	3.0
DW 3530	8.6	6.7	4.0
DW 3530	7.1	6.6	3.1
DW 3532	5.3	4.1	2.1
DW 3533	7.8	6.9	3.8
DW 3534	8.2	7.2	4.2
DW 3534	6.6	5.3	3.0

TABLE 8. — Measurements (in mm) of *Chlidonophora chuni* Blochmann, 1900.

Station No.	Length	Width	Thickness
CP 3145	6.7	6.1	3.6
CP 3145	5.4	5.3	2.8
CP 3146	6.4	6.5	3.1
CC 3157	6.9	6.1	–
CC 3157	6.2	6.1	2.9
CC 3157	5.7	5.7	3.0
CC 3157	5.3	5.4	2.6

by very narrow outer hinge plates and a rounded, concave transverse band (Fig. 6D, E).

Superfamily CANCELLOTHYRIDOIDEA Thomson, 1926
Family CANCELLOTHYRIDIDAE Thomson, 1926
Subfamily CANCELLOTHYRIDINAE Thomson, 1926

Genus *Terebratulina* d'Orbigny, 1847

TYPE SPECIES. — *Anomia retusa* Linnaeus, 1758, by subsequent designation (Brunton *et al.* 1967: 176).

Terebratulina meridionalis Jackson, 1952
(Fig. 8; Table 7)

Terebratulina meridionalis Jackson, 1952: 13, pl., fig. 8. — Cooper 1973a: 10-11, pl. 3, figs 43-45. — Hiller 1991: 441; 1994: 778. — Zezina 2010: 1186.

Terebratulina caput-serpentis var. *septentrionalis* – Davidson 1880: 33-36, pl. 1, figs 6-9.

MATERIAL EXAMINED. — **Mozambique Channel.** MAINBAZA, stn CC 3175, 1 bivalved specimen.
South Madagascar. ATIMO VATAE, stn TB01, 3 bivalved specimens. — Stn TP18, 1 bivalved specimen. — Stn DW 3519, 8 bivalved specimens. — Stn DW 3530, 21 bivalved specimens. — Stn DW 3531, 1 dorsal valve. — Stn DW 3532, 15 bivalved specimens, 2 ventral valves, 2 dorsal valves. — Stn DW 3533, 1 bivalved specimen. — Stn DW 3534, 9 bivalved specimens, 1 dorsal valve. — Stn CP 3573, 1 bivalved specimen.

DEPTH RANGE. — 22-307 m.

MEASUREMENTS. — See Table 7.

REMARKS
Terebratulina is one of the most widely distributed and diverse brachiopod genera in Recent oceans. However, while 23 species are known globally (Logan 2007), only three species have been identified from the Indian Ocean, mostly from South Africa (Jackson 1952; Cooper 1973a; Hiller 1986, 1991, 1994). The investigated specimens correspond well with those described as *T. meridionalis* Jackson, 1952 from western South Africa. The shell is small, elongate oval in outline. The surface is covered with ribs which are strong in posterior and lateral parts but becoming weak or indistinct in the anterior half (Fig. 8D, I). The inner socket ridges are prominent with roughened surface acting as a cardinal process (Fig. 8F-H). The loop forms a broad ring.

Family CHLIDONOPHORIDAE Muir-Wood, 1959
Subfamily CHLIDONOPHORINAE Muir-Wood, 1959

Genus *Chlidonophora* Dall, 1903

TYPE SPECIES. — *Terebratulina incerta* Davidson, 1878, by original designation of Dall (1903: 1538).

Chlidonophora chuni Blochmann *in* Chun, 1900
(Fig. 9; Table 8)

Chlidonophora chuni Blochmann *in* Chun, 1900: 404, 405; Blochmann 1906: 695-696. — Helmcke 1940: 239, fig. 6. — Muir-Wood 1959: 296, pl. 4, figs 5-7. — Cooper 1973a: 13, pl. 8, figs 17-26. — Hiller 1986: 121-123, fig. 11A-H. — Zezina 1981b: 157; 1985: 133; 1987: 555, 556; 2010: 1187.

MATERIAL EXAMINED. — **Mozambique Channel**. MAINBAZA, stn CP 3145, 12 bivalved specimens, 1 dorsal valve. — Stn CP 3146, 1 bivalved specimen. — Stn CC 3157, 10 bivalved specimens, 1 ventral valve, 3 dorsal valves. — Stn CC 3158, 1 bivalved specimen.

DEPTH RANGE. — 1161-1421 m.

MEASUREMENTS. — See Table 8.

REMARKS
Only two Recent species are known of this genus. *Chlidonophora chuni* is restricted to the Indian Ocean while *C. incerta* is from the Atlantic Ocean and Caribbean (Logan 2007). Muir-Wood (1959: pl. 4, figs 6-7) figured the lophophore but not the loop of *C. chuni* from Minikoi, surmising it to be similar to that of *C. incerta*, which she also figured for comparison (her pl. 3, fig. 8). Cooper (1973a: 13), on the other hand, maintained that the loop of *C. chuni* "contrasts strongly" with that of *C. incerta*. He illustrated one of Blochmann's specimens of *C. chuni* (USNM 110436a) from off the Maldives to show the loop. However, the crural processes in that particular specimen are barely discernible (his pl. 8, fig. 26), whereas in the specimens from Madagascar

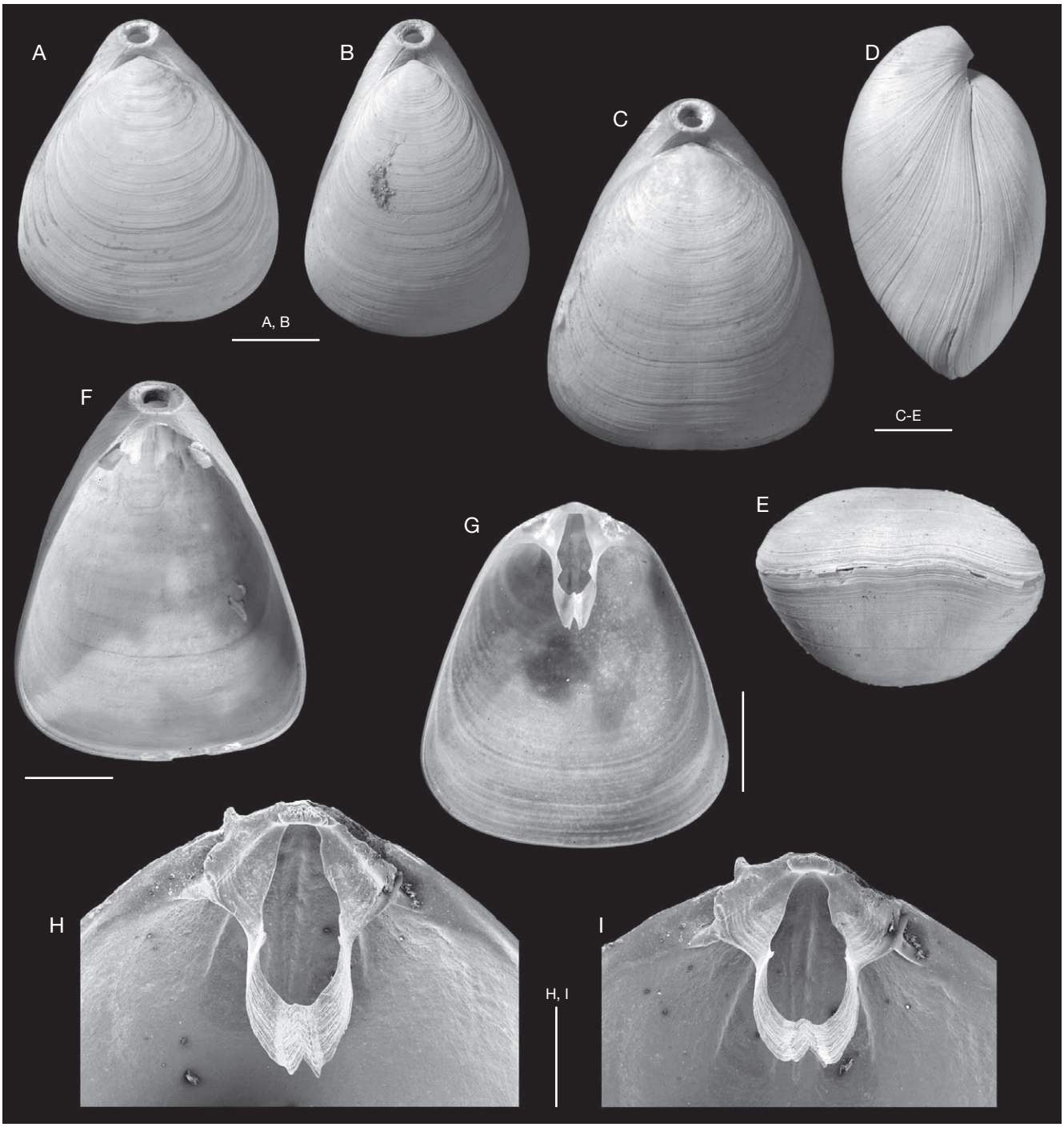

FIG. 7. — *Dallithyris dubia* Cooper, 1981, Mozambique Channel, Inhambane transect, MAINBAZA, stn CP 3141, 684-698 m: **A**, **B**, dorsal views of complete specimens (MNHN IB-2013-44-45); **C**-**E**, dorsal, lateral and anterior views of complete specimen (MNHN IB-2013-46); **F**, inner view of ventral valve (MNHN IB-2013-47); **G**, inner view of dorsal valve (MNHN IB-2013-48); **H**-**I**, SEM micrographs of posterior part of dorsal valve interior (**H**) and tilted view (**I**) to show details of cardinalia and brachial skeleton (MNHN IB-2013-49). Scale bars: A-G, 5 mm; H, I, 2 mm.

they can be prominent, pointed and strongly converging, although they do not unite (compare Fig. 9G-J and Fig. 9K, L). Hiller's description (1986) of the loop of *C. chuni* from eastern South Africa is much more in agreement with that seen from Madagascar, although his fig. 11F is similar to Cooper's. Relative measurements suggest that these differences are not a function of growth stages.

Subfamily EUCALATHINAE Muir-Wood, 1965

Genus *Eucalathis* Fischer & Oehlert, 1890

TYPE SPECIES. — *Terebratulina murrayi* Davidson, 1878, by original designation of Fischer & Oehlert (1890: 72).

TABLE 9. — Measurements (in mm) of *Eucalathis daphneae* n. sp.

Station No.	Length	Width	Thickness
DW 3196	5.9	6.0	–
DW 3196	4.2	4.1	2.6
DW 3234 (holotype)	5.3	5.2	2.7
DW 3234	5.2	4.9	3.5

TABLE 10. — Measurements (in mm) of *Eucalathis malgachensis* n. sp.

Station No.	Length	Width	Thickness
DW 3524	5.9	5.2	3.4
DW 3528	6.3	5.5	3.5
DW 3528	5.6	4.0	2.7
DW 3552	5.1	4.7	2.8
DW 3557	3.8	3.1	2.3
CP 3614 (holotype)	4.6	4.1	2.6

Eucalathis magna Cooper, 1981
(Fig. 10A-D)

Eucalathis magna Cooper, 1981a: 17, pl. 1, figs 1-6. — Zezina 2010: 1187.

MATERIAL EXAMINED. — **South Madagascar**. ATIMO VATAE, stn DW 3529, 1 bivalved specimen.

DEPTH RANGE. — 402-207 m.

MEASUREMENTS. — Length 13.4 mm, width 10.7 mm, thickness 4.8 mm.

REMARKS

Species of the genus *Eucalathis* are common in all the oceans of the world and range greatly in depth. Six species have been recorded from the Indian Ocean: *E. rotundata* Cooper, 1981; *costellata* Cooper, 1981; *fasciculata* Cooper, 1973; *magna* Cooper, 1981*; murrayi* (Davidson, 1878); and *rugosa* Cooper, 1973 (Logan 2007). *E. magna* is very rare in the investigated material, represented by only one specimen. It was originally described, also based on one specimen, from the West of Heard Island at a depth of 790 m by Cooper (1981a). The present finding extends its geographical range.

This species is characterized by a large size for the genus and almond-like outline. Both in outline and ornamentation *E. magna* strongly resembles *Terebratulina* species. Cooper (1981a: 17) indicated the absence of deltidial plates, however, although minute they are present, both in the specimen from off South of Madagascar and the holotype.

Eucalathis daphneae n. sp.
(Fig. 10E-O; Table 9)

TYPE MATERIAL. — **North-West Madagascar**. MIRIKY, stn DW 3234, holotype (MNHN IB-2013-61; Fig. 10F-J). — Same data, stn DW 3196, paratypes (MNHN IB-2013-62, 63; Fig. 10E, K-O).

TYPE LOCALITY. — Madagascar, MIRIKY, stn DW 3234, 13°27'S, 47°55'E, 187-247 m.

ETYMOLOGY. — Named in honour of Daphne E. Lee (University of Otago, Dunedin, New Zealand) in recognition of her contribution to the study of Cenozoic brachiopods.

DIAGNOSIS. — *Eucalathis* with single, broad, rounded costae nearly smooth in anterior half, and incomplete loop.

MATERIAL EXAMINED. — **North-West Madagascar**. MIRIKY, stn DW 3196, 8 bivalved specimens. — Stn DW 3234, 2 bivalved specimens, 1 ventral valve, 1 dorsal valve.

DEPTH RANGE. — 187-249 m

MEASUREMENTS. — See Table 9.

DESCRIPTION

Shell small (maximum observed length 5.9 mm), ventribiconvex, widely subtriangular in outline. Shell surface covered with 10-12 strong, single, rounded costae. Costae weakly beaded posteriorly, nearly smooth in anterior half except where crossed by elevated growth lines; intercostal spaces wide. Anterior commissure rectimarginate. Hinge line slightly curved. Beak low, suberect. Foramen large, subcircular, mesothyrid; deltidial plates small, triangular (Fig. 10E, G). Ventral valve interior with small teeth; pedicle collar wide. Dorsal valve interior with massive inner socket ridges extending beyond margin. Cardinal process distinct. Crura long, slender; crural processes short, can be slightly incurved. Loop short with an incomplete transverse band (Fig. 10I-O). Low, short median ridge visible on inner dorsal valve. Inner margin of both valves crenulated.

REMARKS

In size, outline and ornamentation the new species described here is most similar to *Eucalathis rotundata*. In the strong costation *E. daphneae* n. sp. also resembles *E. rugosa* Cooper, 1973, differing in size and outline, as well as in the character of costae. *E. rugosa* possesses beaded, strongly tuberculate ribs (Cooper 1973c; Laurin 1997; Bitner 2008, 2009, 2010); in *E. daphneae* ribs are nearly smooth. However, the species described by Cooper (1973c, 1981a) have a typical loop for the genus, whereas in all specimens collected in North-West Madagascar the loop has an incomplete transverse band.

Among Recent representatives of chlidonophorids only in the species *Melvicalathis macroctena* (Zezina, 1981) may the loop be incomplete (Zezina 1981b; Lee *et al.* 2008), however, it possesses broad, triangular in cross-section costae with smooth ridges without any tubercles, differing greatly from *E. daphneae*. In the fossil chlidonophorids an incomplete loop is observed only in the Eocene-Oligocene genus *Orthothyris* Cooper, 1955 (see Bitner & Müller 2015).

Eucalathis malgachensis n. sp.
(Fig. 11; Table 10)

TYPE MATERIAL. — **South Madagascar**. ATIMO VATAE, stn CP 3614, holotype (MNHN IB-2013-64; Fig. 11F-I). — Same locality, stn DW 3552, CP 3614, CP 3615, four paratypes (MNHN IB-2013-66-69: Fig. 11B-E, J-L).

TYPE LOCALITY. — South Madagascar, South Cap Sainte Marie, ATIMO VATAE, stn CP 3614, 26°14'S, 45°09'E, 250-300 m.

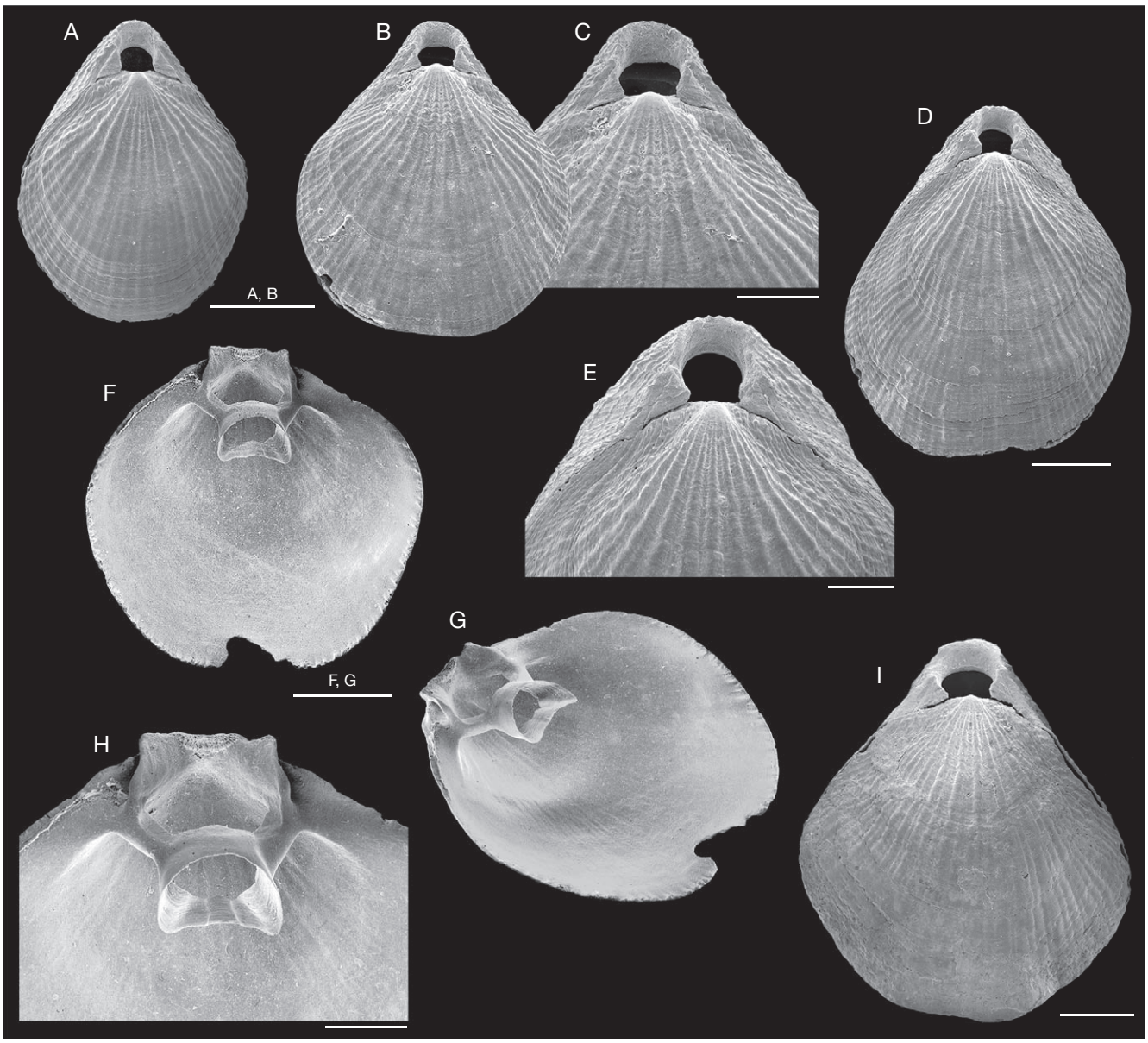

Fig. 8. — *Terebratulina meridionalis* Jackson, 1952; **A**-**E**, dorsal views of complete specimens, and enlargements (**C**, **E**) of umbonal part to show details of the beak (MNHN IB-2013-50-52), South Madagascar, north of Sainte Luce, ATIMO VATAE, stn DW 3530, 80-86 m; **F**-**H**, interior of dorsal valve (MNHN IB-2013-53), inner (**F**) and oblique (**G**) views, and enlargement (**H**) of posterior part to show details of loop and cardinalia, South Madagascar, north of Sainte Luce, ATIMO VATAE, stn DW 3532, 86-87 m; **I**, dorsal view of complete specimen (MNHN IB-2013-54), Mozambique Channel, Maputo transect, MAINBAZA, stn CC 3175, 155-165 m. All SEMs. Scale bars: A, B, D, F, G, I, 2 mm; C, E, H, 1 mm.

Etymology. — Referring to the Malgache, the French name of the ethnic group that forms nearly the entire population of Madagascar.

Diagnosis. — *Eucalathis* with fascicostate surface, primary ribs strong, triangular in cross-section, 7 to 9 in number, loop angular at the anterior.

Material examined. — **South Madagascar**. ATIMO VATAE, stn DW 3515, 1 bivalved specimen. — Stn DW 3522, 7 bivalved specimens. — Stn DW 3523, 13 bivalved specimens. — Stn DW 3524, 37 bivalved specimens. — Stn DW 3528, 6 bivalved specimens. — Stn DW 3534, 5 bivalved specimens. — Stn DW 3552, 54 bivalved specimens, 1 ventral valve, 2 dorsal valves. — Stn DW 3553, 76 bivalved specimens, 4 ventral valves, 4 dorsal valves. — Stn DW 3557, 14 bivalved specimens. — Stn DW 3564, 1 bivalved specimen. — Stn CP 3595, 2 bivalved specimens. — Stn DW 3599, 2 bivalved specimens. — Stn CP 3613, 11 bivalved specimens, 1 ventral valve, 1 dorsal valve. — Stn CP 3614, 4 bivalved specimens. — Stn CP 3615, 64 bivalved specimens, 3 ventral valves, 4 dorsal valves.

Depth range. — 122-910 m.

Measurements. — See Table 10.

Description

Shell small (maximum length 6.3 mm), strongly biconvex, triangular in outline with greatest width near anterior. Shell surface fascicostate with the dominance of strong, triangular in cross-section, primary ribs 7 to 9 in number; secondary ribs delicate, indistinct. Growth lines distinct. Anterior commissure

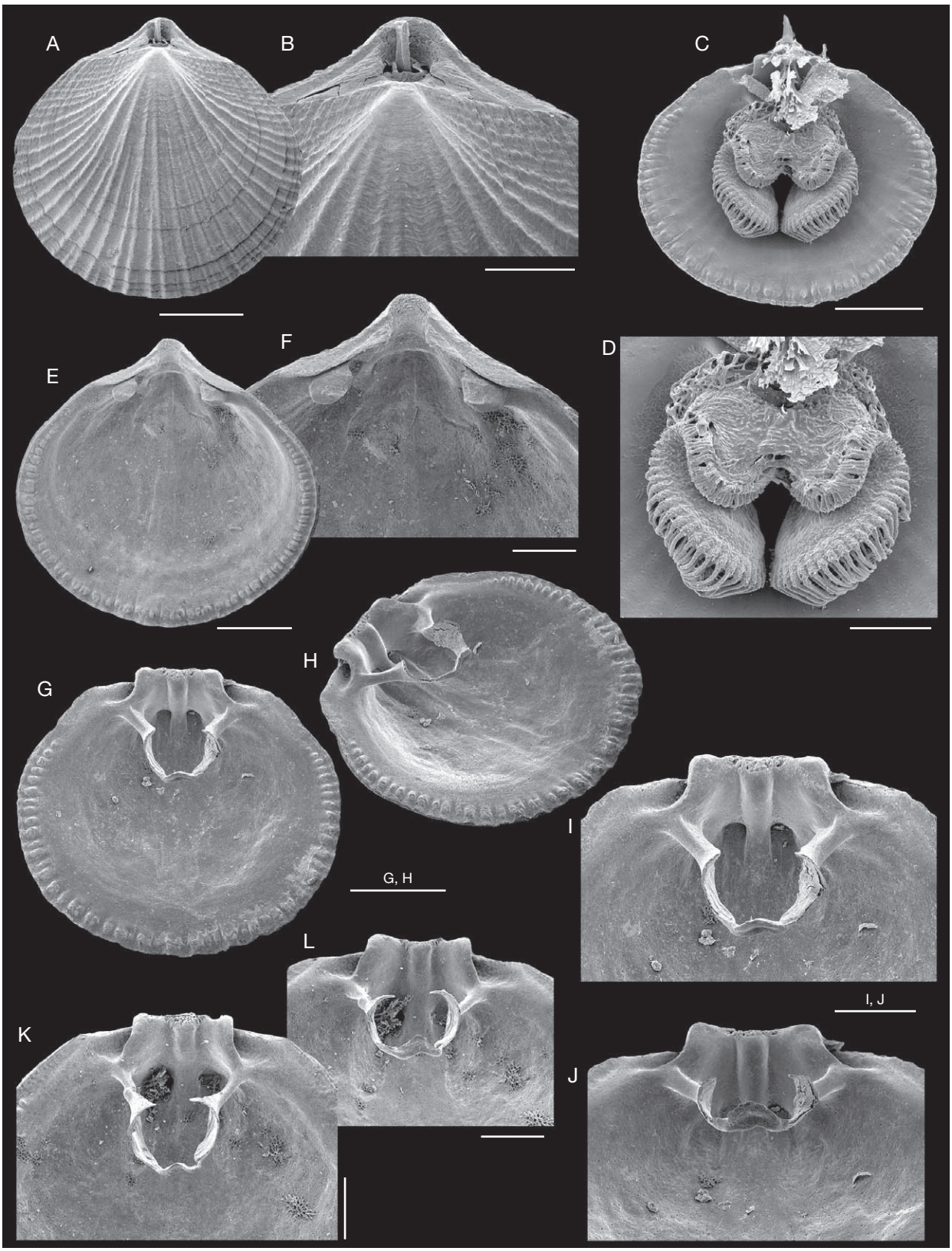

Fig. 9. — *Chlidonophora chuni* Blochmann, 1900, Mozambique Channel, Bazaruto transect, MAINBAZA: **A**, **B**, dorsal view of complete specimen (MNHN IB-2013-55), and enlargement of the umbonal part (**B**) to show details of the beak, stn CC 3158, 1220-1248 m; **C**, **D**, inner view of dorsal valve (MNHN IB-2013-56) with preserved subplectolophous lophophore, (**D**) enlargement of lophophore, stn CC 3157, 1410-1416 m; **E**, **F**, inner view of ventral valve (MNHN IB-2013-57) and enlargement of umbonal part (**F**), stn CC 3157; **G**-**J**, inner and oblique views of dorsal valve (MNHN IB-2013-58), enlargement (**I**) and tilted view (**J**) of posterior part to show cardinalia and loop, stn CC 3157; **K**, **L**, inner and tilted views of posterior part of dorsal valve (MNHN IB-2013-59), stn CC 3157. All SEMs. Scale bars: A, C, E, G, H, 2 mm; B, F, D, I-L, 1 mm.

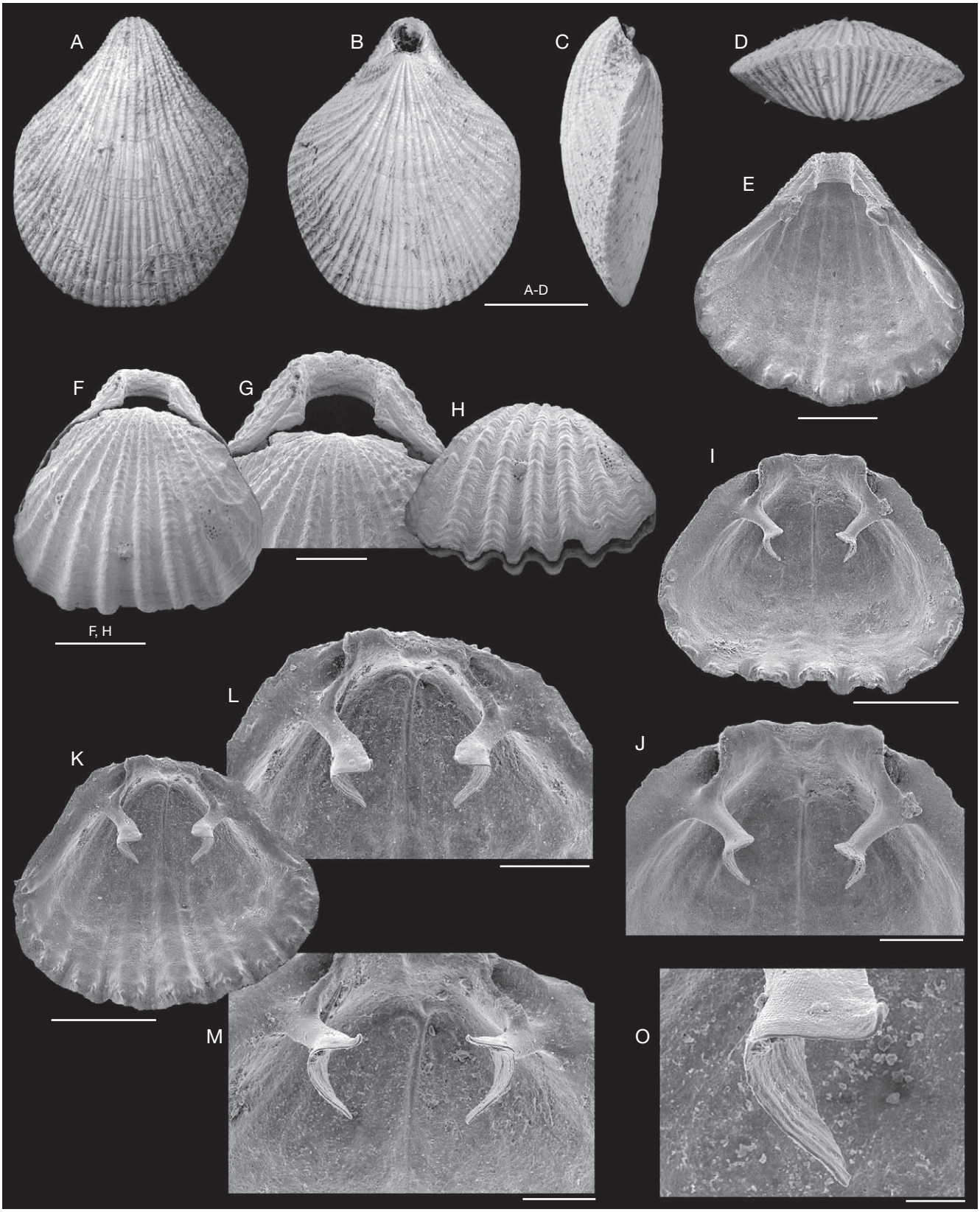

Fig. 10. — **A**-**D**, *Eucalathis magna* Cooper, 1981, ventral, dorsal, lateral and anterior views of complete specimen (MNHN IB-2013-60), South Madagascar, sector of Manantenina, stn DW 3529, 402-407 m; **E**-**O**, *Eucalathis daphneae* n. sp., North-West Madagascar, MIRIKY, SEM: **E**, inner view of ventral valve (MNHN IB-2013-62), paratype, West of Cap d'Ambre, stn DW 3196, 238-249 m; **F**-**J**, dorsal view of complete specimen, enlargement of umbonal part (**G**) and anterior view to show rounded ribs (**H**), and inner view of dorsal valve (**I**, **J**) of the same specimen to show cardinalia and loop, holotype (MNHN IB-2013-61), West of Nosy Be, stn DW 3234, 187-247 m; **K**-**O**, inner view of dorsal valve (MNHN IB-2013-63), enlargement (**L**) and tilted (**M**) views of posterior part, and a fragment of incomplete transverse band (**O**), paratype, stn DW 3196, 238-249 m. Scale bars: A-D, 5 mm; E, F, H, I, K, 2 mm; G, J, L,1 mm; M, 500 µm; O, 200 µm.

Table 11. — Measurements (in mm) of *Macandrevia emigi* n. sp.

Station No.	Length	Width	Thickness
CP 3139 (paratype)	12.3	11.5	6.2
CC 3170 (holotype)	12.6	12.0	6.3
CP 3589	7.3	6.4	3.4
CP 3589	7.6	6.0	3.2

Table 12. — Measurements (in mm) of *Frenulina sanguinolenta* (Gmelin, 1791).

Station No.	Length	Width	Thickness
DW 3230	5.7	5.1	2.8
TA01	7.2	6.5	4.1
TS09	5.5	4.7	2.4
DW 3519	7.7	6.9	4.4

rectimarginate to incipiently broadly unisulcate. Hinge margin short, straight to slightly curved. Beak suberect to erect with a large, subcircular, mesothyrid foramen; deltidial plates minute, triangular, disjunct. Ventral valve interior with a broad pedicle collar and small, hooked teeth (Fig. 11E). Dorsal valve interior with massive inner socket ridges extending beyond margin. Cardinal process prominent (Fig. 11K, L). Crura stout, crural processes short. Loop thin, angular at anterior, however, in some specimens it can be thickened (Fig. 11M).

Remarks

This species is the most common brachiopod in the studied material (more than 300 specimens), occurring only in South Madagascar. It differs from hitherto described species of *Eucalathis* in the strong costation of its broad, triangular in cross-section ribs. A similar triangular ribbed shell is observed in *Melvicalathis macroctena*, however, ribs in the latter species have smooth ridges without tubercles (Lee *et al.* 2008).

Superfamily Zeillerioidea Allan, 1940
Family Zeilleriidae Allan, 1940
Subfamily Macandreviinae Cooper, 1973

Genus *Macandrevia* King, 1859

Type species. — *Terebratula cranium* Müller, 1776, by original designation of King (1859: 261).

Macandrevia emigi n. sp.
(Fig. 12; Table 11)

Type material. — **Mozambique Channel**. MAINBAZA, stn CC 3170, holotype (MNHN IB-2013-71; Fig. 12J-Q). — Same data, stn CP 3139, three paratypes (MNHN IB-2013-72-74; Fig. 12D-I).

Type locality. — Mozambique Channel, Maputo transect, MAINBAZA, stn CC 3170, 25°58'S, 34°47'E, 949-952 m.

Etymology. — Named in honour of Christian C. Emig (BrachNet, Marseille, France), a prodigious worker in the field of inarticulated brachiopods.

Diagnosis. — Small *Macandrevia* with subtriangular outline and large, oval permesothyrid foramen. Loop and cardinalia typical of the genus.

Material examined. — **Mozambique Channel**. MAINBAZA, stn CP 3139, 1 bivalved specimen. — Stn CC 3170, 1 bivalved specimen. **South Madagascar**. ATIMO VATAE, stn CP 3589, 35 bivalved immature specimens.

Depth range. — 132-1195 m.

Measurements. — See Table 11.

Description

Shell of medium size (maximum observed length 12.6 mm), thin, translucent, elongate oval to rounded while young to subpentagonal in adult, ventribiconvex. Shell surface smooth with numerous growth lines. Lateral commissures straight, anterior commissure rectimarginate to incipiently sulcate. Hinge line short, slightly curved. Beak suberect to erect. Foramen large, oval, permesothyrid, deltidial plates rudimentary.

Ventral valve interior with small teeth supported by divergent dental plates united by a callus closely applied to the valve floor (Fig. 12H, N). Dorsal valve interior with small cardinal process and high inner socket ridges. Inner hinge plates attached directly to the valve floor. Low, short median septum present in early stages of ontogeny (Fig. 12D-F), in adults median septum absent (Fig. 12O, P). Loop long with narrow descending and ascending branches, transverse band moderately broad with short projections, and short spines anteriorly (Fig. 12Q).

Remarks

The superfamily Zeillerioidea comprises 10 extant species belonging to a single genus, *Macandrevia* (Logan 2007). Species of the genus have previously been recorded virtually from pole to pole and usually from cold deep waters (Cooper 1975) but not from the Indian Ocean or western and central Pacific. This description of a new species, based mainly on 35 specimens from South Madagascar, is thus the first record of the genus from the Indian Ocean. Most species of *Macandrevia* are eurybathic, with *M. tenera* extending down to 4600 m but the depth range of *M. emigi* n. sp. is much less. The new species is comparable in size to the northern Atlantic species, *M. novangliae* Cooper, 1977 and *M. tenera* (Jeffreys, 1876) (Cooper 1975, 1977, 1981b), other species are much larger. However, the species from the Madagascar region differs from all hitherto described species in its triangular outline.

Superfamily Laqueoidea Thomson, 1927
Family Frenulinidae Hatai, 1938
Subfamily Frenulininae Hatai, 1938

Genus *Frenulina* Dall, 1895

Type species. — *Anomia sanguinolenta* Gmelin, 1791, by original designation of Dall (1895: 724).

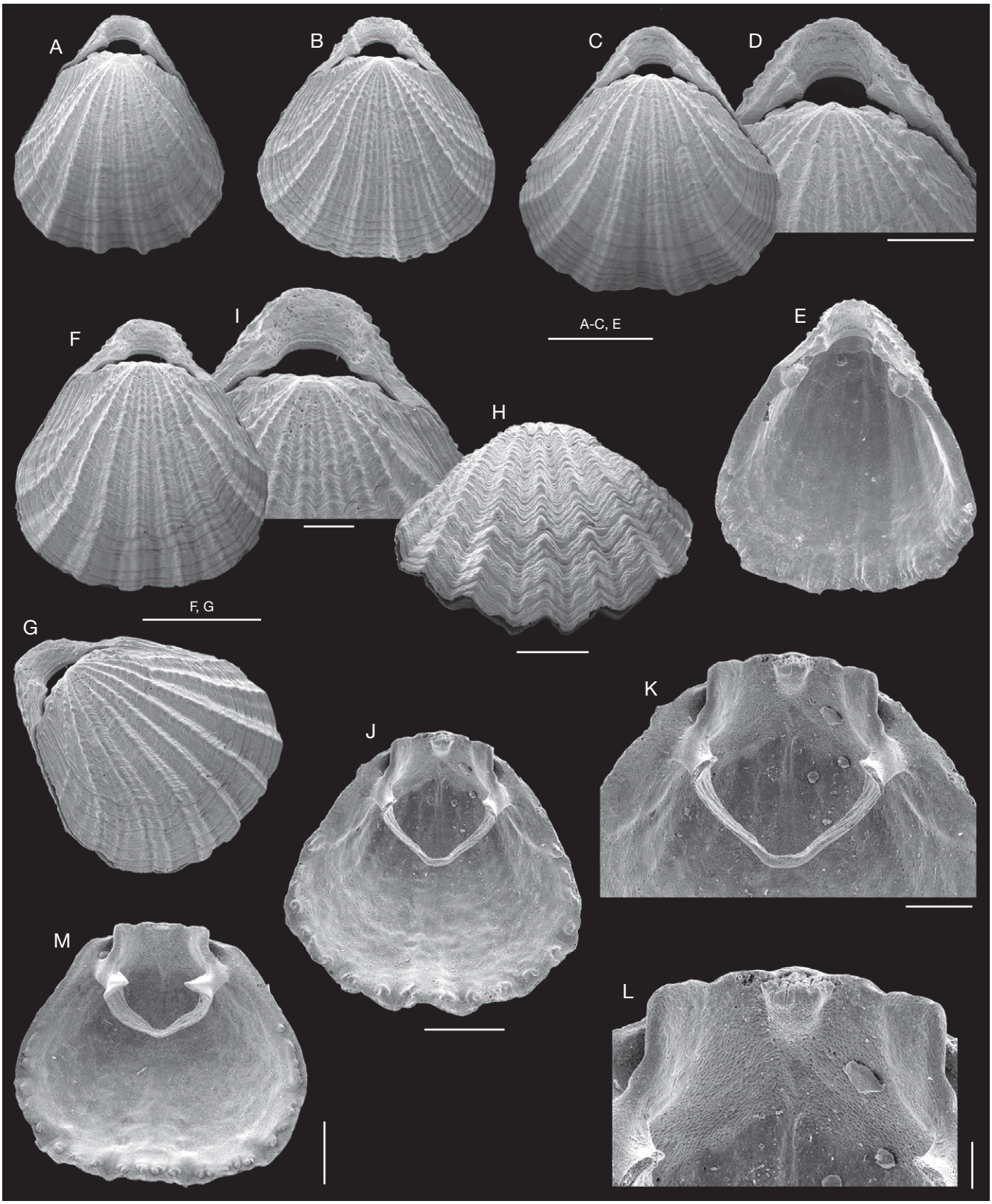

FIG. 11. — *Eucalathis malgachensis* n. sp., South Madagascar, ATIMO VATAE: **A**, dorsal view of complete specimen (MNHN IB-2013-65), paratype, South Cap Sainte Marie, stn CP 3614, 250-300 m; **B**-**D**, dorsal views of complete specimens and enlargement (**D**) of umbonal part (MNHN IB-2013-66-67), paratypes, South of Faux-Cap, stn DW3552, 264-280 m; **E**, inner view of ventral valve (MNHN IB-2013-68), paratype, stn DW 3552; **F**-**I**, dorsal, oblique and anterior views of complete specimen, and enlargement (**H**) of umbonal part, holotype (MNHN IB-2013-64), stn CP 3614; **J**-**L**, interior of dorsal valve, and enlargements (**K**, **L**) to show details of cardinalia and brachidium, paratype (MNHN IB-2013-69), South Cap Sainte Marie, CP 3615, 284-286 m; **M**, inner view of dorsal valve (MNHN IB-2013-70), visible thickened loop, stn DW 3552. All SEMs. Scale bars: A-C, E-G, 2 mm; D, H-J, M, 1 mm; K, 500 µm; L, 200 µm.

Frenulina sanguinolenta (Gmelin, 1791)
(Fig. 13A; Table 12)

Anomia sanguinolenta Gmelin, 1791: 3347.

Megerlia sanguinea – Davidson 1887: 108-111, pl. 20, figs 1-8.

Frenulina sanguinolenta – Dall 1920: 336-337. — Hatai 1940: 327-329, pl. 4, figs 42, 44-47, 49, 50, 52-54. — Cooper 1973a: 21-22, pl. 6, figs 1-3; pl. 8, figs 12-16. — Zezina 1985: 168. — Emig 1987: 169, pl. 2.V.1, figs b, c. — d'Hondt 1987: 38. — Saito 1996: 492, fig. 5. — Laurin 1997: 450-451, fig. 47H-J. — Bitner 2006a: 420-422, figs 2D-M, 3A-F; 2006b: 28; 2008: 439, Fig. 10C-G; 2009: 16, 7F-H; 2010: 649, fig. 3K-M; 2014: 250-253, fig. 8A-E.

Material examined. — **North-West Madagascar.** MIRIKY, stn DW 3230, 1 bivalved specimen.
South Madagascar. ATIMO VATAE, stn TA01, 1 bivalved specimen. — Stn TB01, 1 bivalved specimen. — Stn TS09, 2 bivalved specimens. — Stn DW 3519, 2 bivalved specimens. — Stn DW 3531, 3 bivalved specimens. — DW 3532, 1 bivalved specimen. — Stn DW 3534, 1 bivalved specimen.

Depth range. — 5-158 m.

Measurements. — See Table 12.

Remarks
Frenulina sanguinolenta is a common and widely distributed species in the Pacific region and has been recorded by many authors (see Bitner 2006a, b, 2008, 2009, 2010, 2014). Apart from a contentious occurrence of a single specimen from the eastern Mediterranean (Taddei Ruggiero 2000; Logan *et al.* 2004) the species appears to be otherwise restricted to the Pacific Ocean. Cooper (1973a) described *Frenulina cruenta* from the coast of Mozambique and Somalia in the western Indian Ocean and distinguished it from *F. sanguinolenta* by its greater size, more intense colour banding and conjunct deltidial plates, in contrast to the disjunct deltidial plates usually seen in *F. sanguinolenta*. Here we record *F. sanguinolenta* for the first time from the Indian Ocean and also note the presence of several specimens attached to corals from shallow reefs of Toleara, South-West Madagascar collected by Bernard Thomassin in 1975 and presented to A. Logan for study.

Genus *Jolonica* Dall, 1920

Type species. — *Campages* (*Jolonica*) *hedleyi* Dall, 1920, by original designation of Dall (1920: 366).

Jolonica suffusa (Cooper, 1973)
(Fig. 13B-E)

Compsoria suffusa Cooper, 1973a: 25, pl. 7, figs 26-44, pl. 8, figs 1-10. — Zezina 1985: 170.

Jolonica suffusa – MacKinnon & Hiller 2010: 194, text-figs 1E-J, 2E, F, 4A-D, 5A-B, 6A-D, 7A-F. — Zezina 2010: 1190.

Material examined. — **Mozambique Channel.** MAINBAZA, stn CP 3130, 1 bivalved open specimen.
North-West Madagascar. MIRIKY, stn CP 3261, 1 ventral valve.
South Madagascar. ATIMO VATAE, stn CP 3587, 1 bivalved, slightly damaged specimen.

Depth range. — 112-217 m.

Measurements. — Length 25.8 mm, width ?20.5 mm, thickness 15.9 mm.

Remarks
This species was originally described by Cooper (1973a) from off Mozambique as *Compsoria suffusa*. Re-study of the loop and cardinalia resulted in the placing of *Compsoria* in synonymy with *Jolonica* (MacKinnon & Lee 2006a; MacKinnon & Hiller 2010). This laqueoid genus is represented in modern oceans by four species, of which three (including the type species) have been previously recorded from the Indian Ocean (Logan 2007). The collection from Madagascar contains only three specimens but they are well enough preserved to be able to identify them with the type species *J. suffusa* which was comprehensively described and illustrated by Cooper (1973a). While the early adult loop in Fig. 13F is slightly shorter in relative length than that shown in Cooper (1973a: pl. 7, fig. 35), the two forms are otherwise closely similar. Its shell is elongate oval, smooth, pale pink in colour. In the ventral valve the deltidial plates are conjunct (Fig. 13C, D). The teeth are supported by well-developed dental plates (Fig. 13E). The cardinal process is prominent. The loop is long with descending branches attached to the short median septum by connecting bands.

Superfamily Megathyridoidea Dall, 1870
Family Megathyrididae Dall, 1870

Genus *Argyrotheca* Dall, 1900

Type species. — *Terebratula cuneata* Risso, 1826, by original designation of Dall (1900: 44).

Argyrotheca jacksoni Cooper, 1973
(Fig. 14K, L)

Argyrotheca jacksoni Cooper, 1973a: 17, pl. 3, figs 9-13. — Bitner *et al.* 2008: 282-284, fig. 3A-K. — Logan *et al.* 2008: 303. fig. 3G-O. — Zezina 2010: 1191. — Logan & Bitner 2013: 169-171, fig. 6A-M.

Argyrotheca australis – Zezina 1987: 558.

Argyrotheca sp. — Hiller 1994: 784, fig. 12.8-12.9.

Material examined. — **South Madagascar.** ATIMO VATAE, stn CP 3615, 1 bivalved specimen, 1 ventral valve.

Depth range. — 284-286 m.

Measurements. — Length 1.6 mm, width 1.9 mm, thickness 1.0 mm; length 1.8 mm, width 2.4 mm.

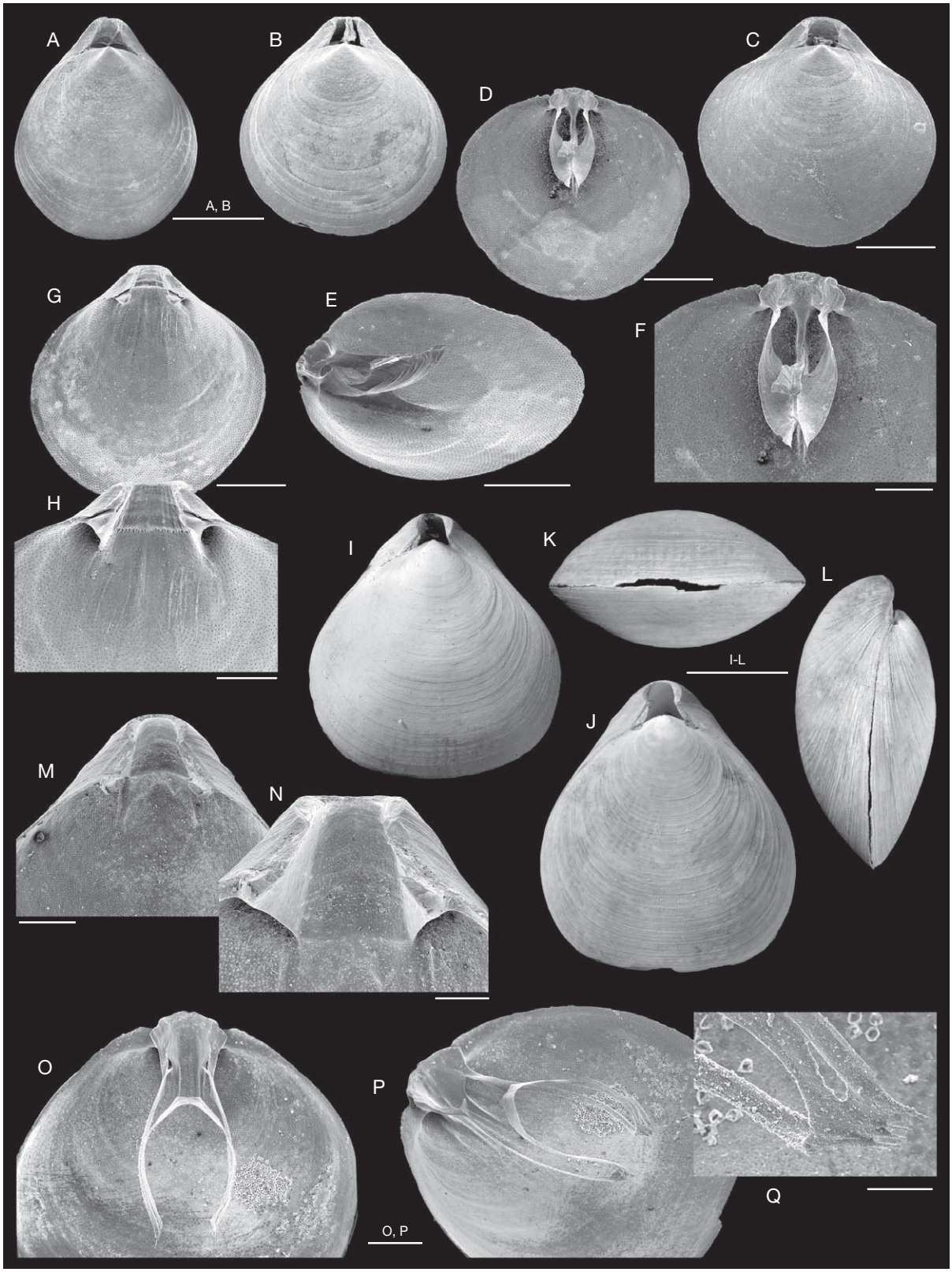

FIG. 12. — *Macandrevia emigi* n. sp.: **A**-**C**, dorsal views of complete specimens (MNHN IB-2013-75-76), South Madagascar, South-West Point Barrow, ATIMO VATAE, stn CP 3589, 132-153 m; **D**-**F**, inner view of dorsal valve of young individual (MNHN IB-2013-73), and oblique view (**E**) and enlargement of posterior part (**F**) to show details of a loop, paratype, stn CP 3589; **G**, **H**, inner view of ventral valve (MNHN IB-2013-74) and tilted view to show dental plates (**H**), paratype, stn CP 3589; **I**, dorsal view of complete specimen (MNHN IB-2013-72), paratype, Mozambique Channel, Inhambane transect, MAINBAZA, stn CP 3139, 1092-1195 m; **J**-**Q**, complete specimen (MNHN IB-2013-71), holotype, Mozambique Channel, Maputo transect, MAINBAZA, stn CC 3170, 949-952 m: **J**-**L**, dorsal, anterior and lateral views, **M**, **N**, posterior part of ventral valve interior and tilted view to show distinct dental plates, SEM **O**-**Q**, interior view of dorsal valve, oblique view, and enlargement of fringe of spines (**Q**), SEM. Scale bars: A-E, G, M, O, P, 2 mm; F, H, N, 1 mm; I-L, 5 mm; Q, 500 µm.

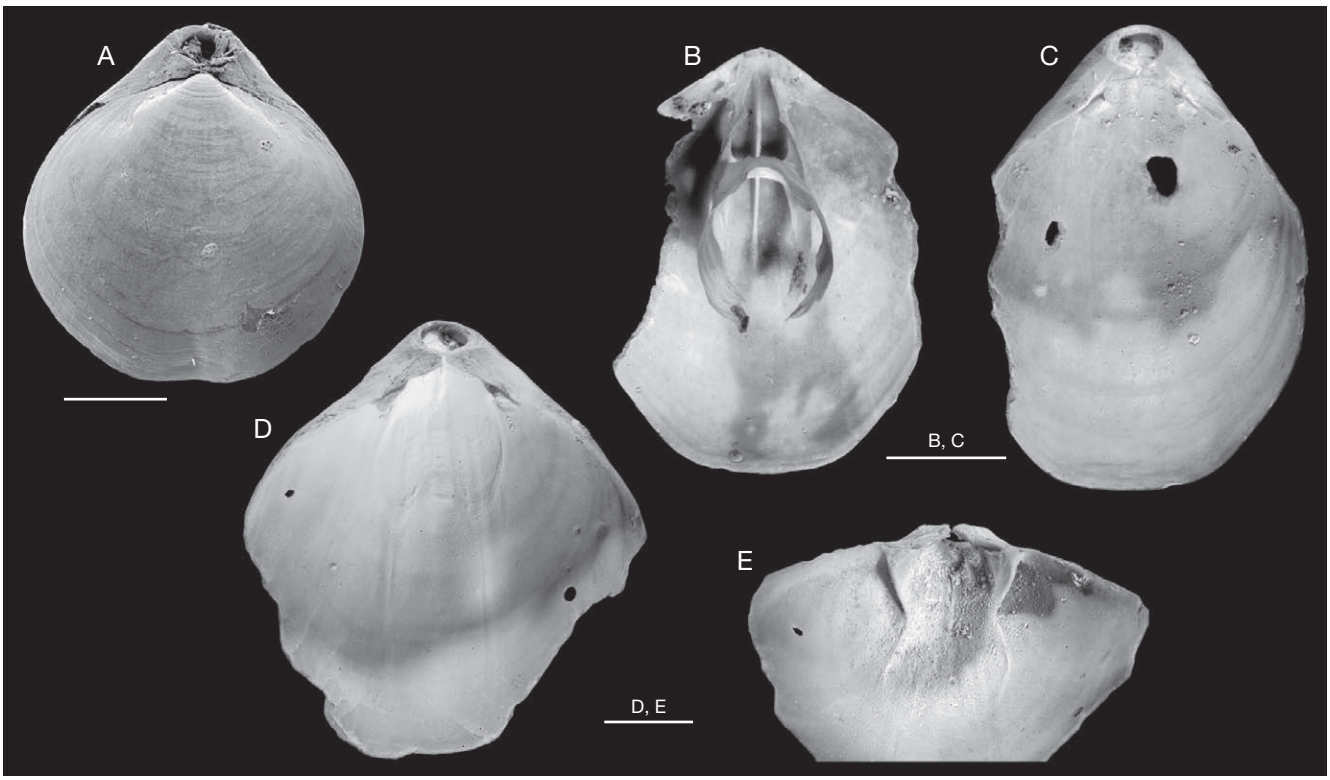

Fig. 13. — **A**, *Frenulina sanguinolenta* (Gmelin, 1791), dorsal view of complete specimen (MNHN IB-2013-77), South Madagascar, Bay of Galions, ATIMO VATAE, stn TA01, 7-14 m, SEM. **B**-**E**, *Jolonica suffusa* (Cooper, 1973): **B**, **C**, interior views of dorsal and ventral valves, showing brachidium, of open specimen (MNHN IB-2013-78), Mozambique Channel, Maputo transect, MAINBAZA, stn CP 3130, 112-127 m, **D**, **E**, inner view of ventral valve (MNHN IB-2013-79), and tilted view (**H**) to show dentral plates, North-West Madagascar, between Majumga and Cap Saint-André, MIRIKY, stn CP 3261, 197-217 m. Scale bars: A, 2 mm; B-E, 5 mm.

Remarks

This species is characterized by its thin shell, small size (length of ventral valve rarely exceeding 2 mm) and numerous, shallowly rounded ribs. The investigated specimens are consistent with specimens of this species recorded by Cooper (1973a), Logan *et al.* (2008) and Logan & Bitner (2013) from the Red Sea. The specimens of *A. jacksoni* described from the Persian Gulf (Bitner *et al.* 2008) differ slightly from those studied here and in the Red Sea in having more marked ribs. In outline and ornamentation the specimens from Madagascar are similar to *A. cuneata* (Risso, 1826) from the Mediterranean Sea, but lack the pink-red wash between the costae which is characteristic of that species.

The studied specimens differ strongly from another *Argyrotheca* species described from this region, *A. angulata* Zezina, 1987, in outline and ornamentation. *A. angulata* is very transversely elongate (see below) and its shell is nearly smooth, having only four fine radial lines (Zezina 1987).

Argyrotheca cf. ***angulata*** Zezina, 1987
(Fig. 14A-J)

cf. *Argyrotheca angulata* Zezina, 1987: 558, 559, fig. 2.

Material examined. — **North-West Madagascar.** MIRIKY, stn 3199, 2 bivalved specimens.

Depth range. — 527-652 m.

Measurements. — Length 2.9, width 3.8 mm, thickness 1.7 mm; length 2.5 mm, width 3.9 mm, thickness 1.6 mm.

Remarks

There are two specimens of *Argyrotheca* in the MIRIKY collection from locality DW 3199 that externally resemble *A. angulata* as described by Zezina (1987) from the Mozambique Channel. However, while both our specimens resemble the single specimen of Zezina's in being markedly wider than long and having similar ornament, they show a very distinctive internal feature of ventro-laterally directed expansions or "prongs" emanating from the dorsal median septum (Fig. 14B-E) that were not described in *A. angulata*. These prongs are comparable to those described as "extravagant internal thickenings" in *A. hewatti* from the Gulf of Mexico by Cooper (1977: 111). Similar but smaller-scale outgrowths are known for *A. cuneata* from the Mediterranean (see Álvarez *et al.* 2008a, b for list of authors and discussion of this feature). These outgrowths, which are formed of secondary fibres (Fig. 14E), do not seem to be muscle platforms and at present their function is unknown. Because of the small number of specimens at our disposal we are reluctant to describe our form as a new species at this stage.

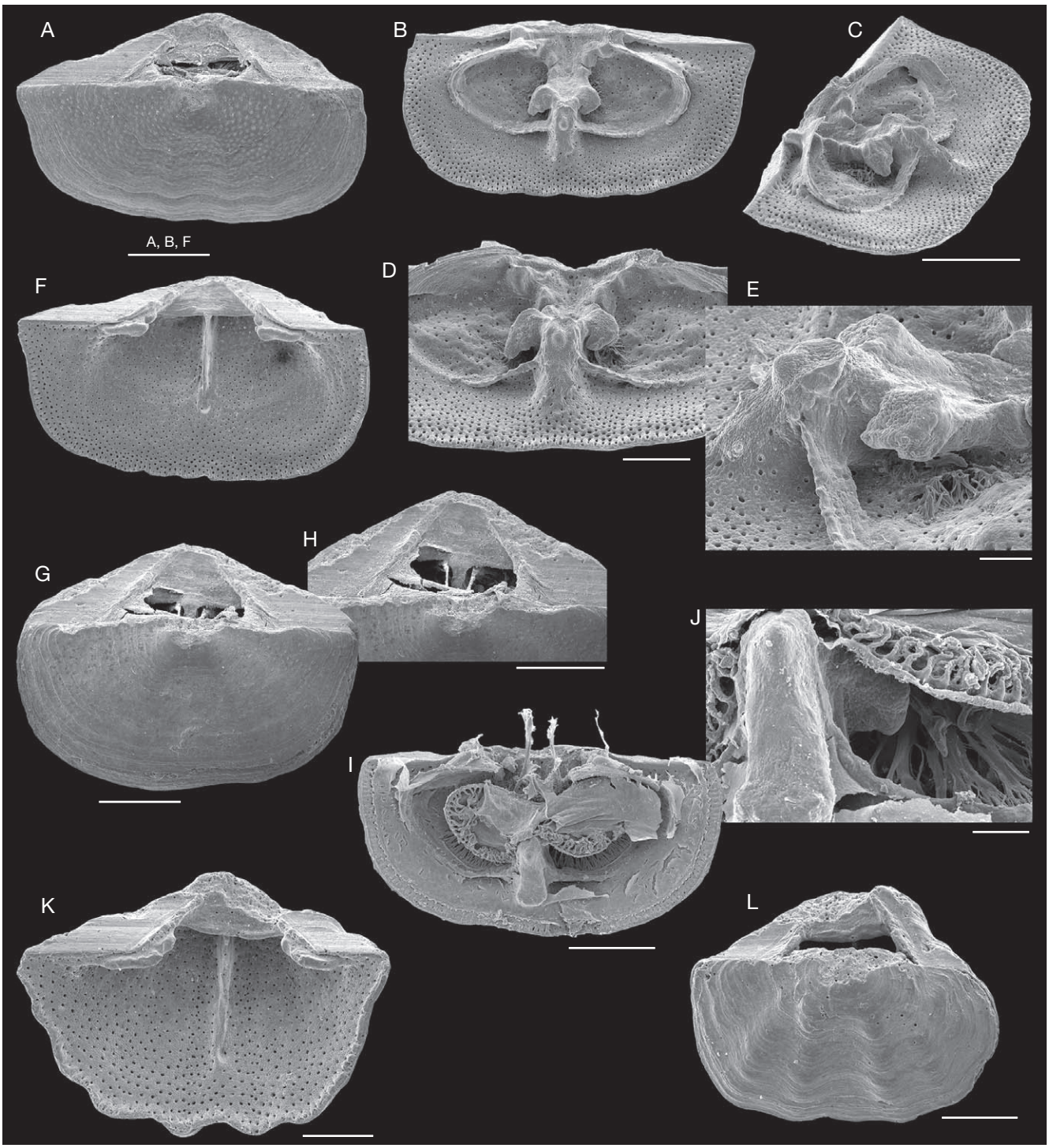

FIG. 14. — **A**-**J**, *Argyrotheca* cf. *angulata* Zezina, 1987, North-West Madagascar, West of Cap d'Ambre, MIRIKY, stn DW 3199, 527-652 m: **A**-**E**, complete specimen (MNHN IB-2013-80), dorsal view (**A**); **B**-**E**, inner, oblique, tilted anterior views of dorsal valve, and enlargement (**E**) of septum and lateral outgrowths; **F**, inner view of ventral valve; **G**-**J**, complete specimen (MNHN IB-2013-81), dorsal view (**G**) and enlargement of umbonal part to show details of the beak; **I**, **J**, inner view of dorsal valve and enlargement (**J**) of tilted anterior view to show the prong; **K**, **L**, *Argyrotheca jacksoni* Cooper, 1973, South Madagascar, South Cap Sainte Marie, ATIMO VATAE, stn CP 3615, 284-286 m: **K**, inner of view of ventral valve (MNHN IB-2013-82); **L**, dorsal view of complete specimen (MNHN IB-2013-83). All SEMs. Scale bars: A-C, F-I, 1 mm; D, K, L, 500 µm; E, J, 200 µm.

Superfamily PLATIDIOIDEA Thomson, 1927
Family PLATIDIIDAE Thomson, 1927
Subfamily PHANEROPORINAE Zezina, 1981

Genus *Phaneropora* Zezina, 1981

TYPE SPECIES. — *Phaneropora galatheae* Zezina, 1981, by original designation of Zezina (1981a: 18).

TABLE 13. — Measurements (in mm) of *Phaneropora galatheae* Zezina, 1981.

Station No.	Length	Width	Thickness
CC 3152	2.9	2.4	0.8
CC 3152	2.3	1.9	0.7
CP 3585	3.4	2.7	1.0
CP 3585	2.8	2.3	0.8
CP 3585	2.4	1.9	0.6
CP 3592	3.0	2.4	0.9
CP 3592	2.8	2.2	0.8
CP 3592	2.5	2.0	0.7

TABLE 14. — Measurements (in mm) of *Nipponithyris afra* Cooper, 1973.

Station No.	Length	Width	Thickness
CP 3139	12.1	11.3	6.0
CP 3140	14.3	13.2	7.3
CP 3140	13.1	12.7	7.1
CC 3166	7.3	7.4	3.3
CC 3166	5.7	5.8	2.3
CP 3235	10.2	9.4	4.7
CP 3252	14.8	12.7	6.2
CP 3252	14.7	13.5	6.5
CP3252	13.1	11.2	5.8

TABLE 15. — Measurements (in mm) of *Megerlia truncata* (Linnaeus, 1767).

Station No.	Length	Width	Thickness
DW 3232	13.1	15.7	6.4
DW 3232	12.5	16.6	6.2
CP 3247	13.9	16.4	7.1
DW 3289	15.4	18.5	8.1
DW 3294	9.6	12.2	2.3
DW 3528	10.8	12.9	5.0
DW 3528	7.4	8.9	3.1

Phaneropora galatheae Zezina, 1981
(Fig. 15; Table 13)

Phaneropora galatheae Zezina, 1981a: 18-19, pl. 4, figs 1-7; 1985: 205; 1987: 560. — Foster 1989: 298, fig. 14.29-14.30. — Laurin 1997: 449, 450, figs 36A-D, 37. — Bitner 2008: 444, fig. 15A-F.; 2009: 16, fig. 9A.

Leptothyrella cf. *ignota* – Hiller 1986: 137, 138, fig. 19A-D.

MATERIAL EXAMINED. — **Mozambique Channel**. MAINBAZA, stn CC 3152, 29 bivalved specimens. — Stn CC 3153, 4 bivalved specimens. — Stn CC 3154, 5 bivalved specimens.
South Madagascar. ATIMO VATAE, stn DW 3515, 1 bivalved specimen. — Stn CP 3585, 10 bivalved specimens. — Stn CP 3592, 22 bivalved specimens, 1 ventral valve, 1 dorsal valve. — Stn CP 3615, 5 bivalved specimens.

DEPTH RANGE. — 184-636 m.

MEASUREMENTS. — See Table 13.

REMARKS
The subfamily Phaneroporinae is represented by two genera, the monospecific genus *Phaneropora* Zezina, 1981 and *Leptothyrella* Muir-Wood, 1959 having three species, *L. ignota*, *L. incerta*, and *L. fijiensis*. Both genera are very similar externally but clearly differ internally. In *Phaneropora* there is a gap between the crura and septal pillar (Zezina 1981a, 1987; Bitner 2008) whereas *Leptothyrella* has continuous descending branches attached to the septum (Muir-Wood 1959; Logan 1983, 1998; Álvarez & Emig 2005; Bitner 2008). Thus, the presence or absence of descending branches constitute the main criterion for separating those genera (MacKinnon & Lee 2006b; see also discussion in Bitner 2008: 444).

Phaneropora galatheae has already been reported from the Madagascar region (Hiller 1986; Zezina 1987). It is a small species, weakly biconvex with a smooth surface. Its foramen is large, margined by two, narrow deltidial plates; beak ridges are distinctly tuberculate (Fig. 15F, H). The teeth are supported by short dental plates (Fig. 15I). The flattened area at the extremity of each crura is interpreted as the rudiment of a descending branch (Fig. 15L, M).

Superfamily TEREBRATELLOIDEA King, 1850
Family DALLINIDAE Beecher, 1893
Subfamily NIPPONITHYRIDINAE Hatai, 1938

Genus *Nipponithyris* Yabe & Hatai, 1934

TYPE SPECIES. — *Nipponithyris nipponensis* Yabe & Hatai, 1934, by original designation of Yabe & Hatai (1934: 588).

Nipponithyris afra Cooper, 1973
(Fig. 16; Table 14)

Nipponithyris afra Cooper, 1973a: 20-21, pl. 71, figs 1-21. — Zezina 1985: 161; 1994: 48; 2010: 1196. — Hiller 1994: 778. — Laurin 1997: 449, figs 35, 47A-G.

MATERIAL EXAMINED. — **Mozambique Channel.** MAINBAZA, stn CP 3139, 14 bivalved specimens. — Stn CP 3140, 32 bivalved specimens. — Stn 3141, 11 bivalved specimens. — Stn 3142, 2 bivalved specimens. — Stn CC 3166, 9 bivalved specimens. — Stn CC 3171, 5 bivalved specimens.
North-West Madagascar. MIRIKY, stn CP 3235, 42 bivalved specimens. — Stn CP 3252, 3 bivalved specimens. — Stn DW 3253, 1 bivalved specimen. — Stn CP 3278, 3 bivalved specimens.

DEPTH RANGE. — 243-1195 m.

MEASUREMENTS. — See Table 14.

REMARKS
Of the three species of *Nipponithyris* so far recorded from modern seas (Logan 2007; Bitner 2008) *N. afra* is the only one from the Indian Ocean, occurring off Mozambique at depths of 740-960 m (Cooper 1973a). This species is characterized by a smooth, sulcate shell, strongly thickened posteriorly. The specimens identified here, which extend the species' depth range, are generally larger in the mature stage than those described by Cooper (1973a) but are otherwise closely similar. Fig. 16K shows the complete loop in an early terebratelliform stage from MAINBAZA station 3139 and may be compared with one of Cooper's paratypes shown in his plate 7, fig. 19. In the studied material *Nipponithyris afra* is one of the commonest species (more than 120 specimens).

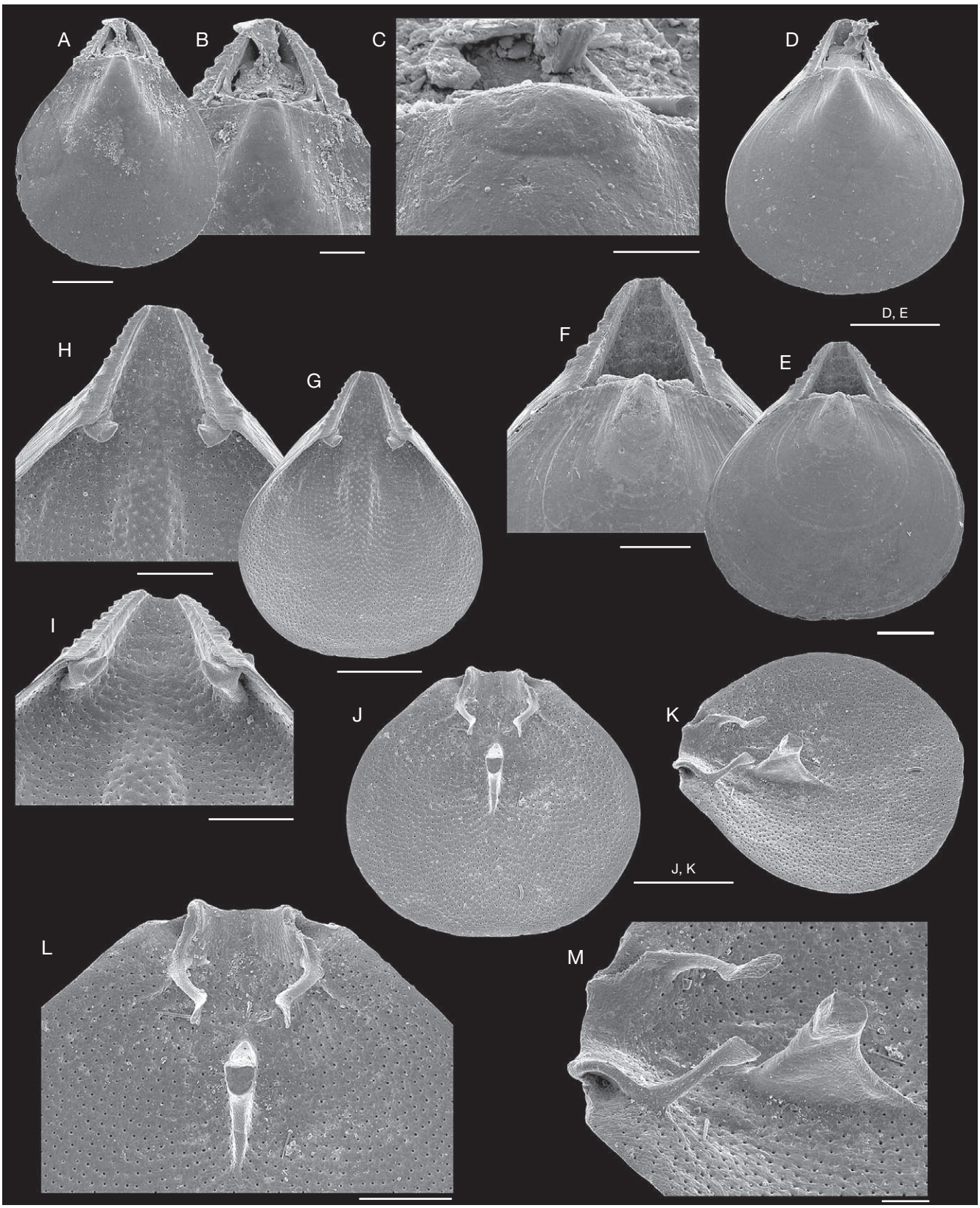

FIG. 15. — *Phaneropora galatheae* Zezina, 1981, South Madagascar, South-West Point Barrow, ATIMO VATAE, stn CP 3592, 450-455 m: **A**-**C**, dorsal view (**A**) of immature complete specimen (MNHN IB-2013-84), and enlargement of the umbonal part to show details of the beak (**B**) and the dorsal protegular node (**C**); **D**, dorsal view of complete specimen (MNHN IB-2013-85); **E**, **F**, dorsal view of complete specimen (**E**) and enlargement of the umbonal part (**F**) (MNHN IB-2013-86); **G**-**I**, inner view of ventral valve (MNHN IB-2013-87), and enlargement of posterior part (**H**), and tilted view to show dental plates (**I**); **J**-**M**, dorsal valve (MNHN IB-2013-88), inner and oblique views, and enlargement (**L**, **M**) to show details of brachidium and cardinalia. All SEMs. Scale bars: A, F, H, I, L, 500 µm; B, M, 200 µm; C, 50 µm; D, E, G, J, K, 1 mm.

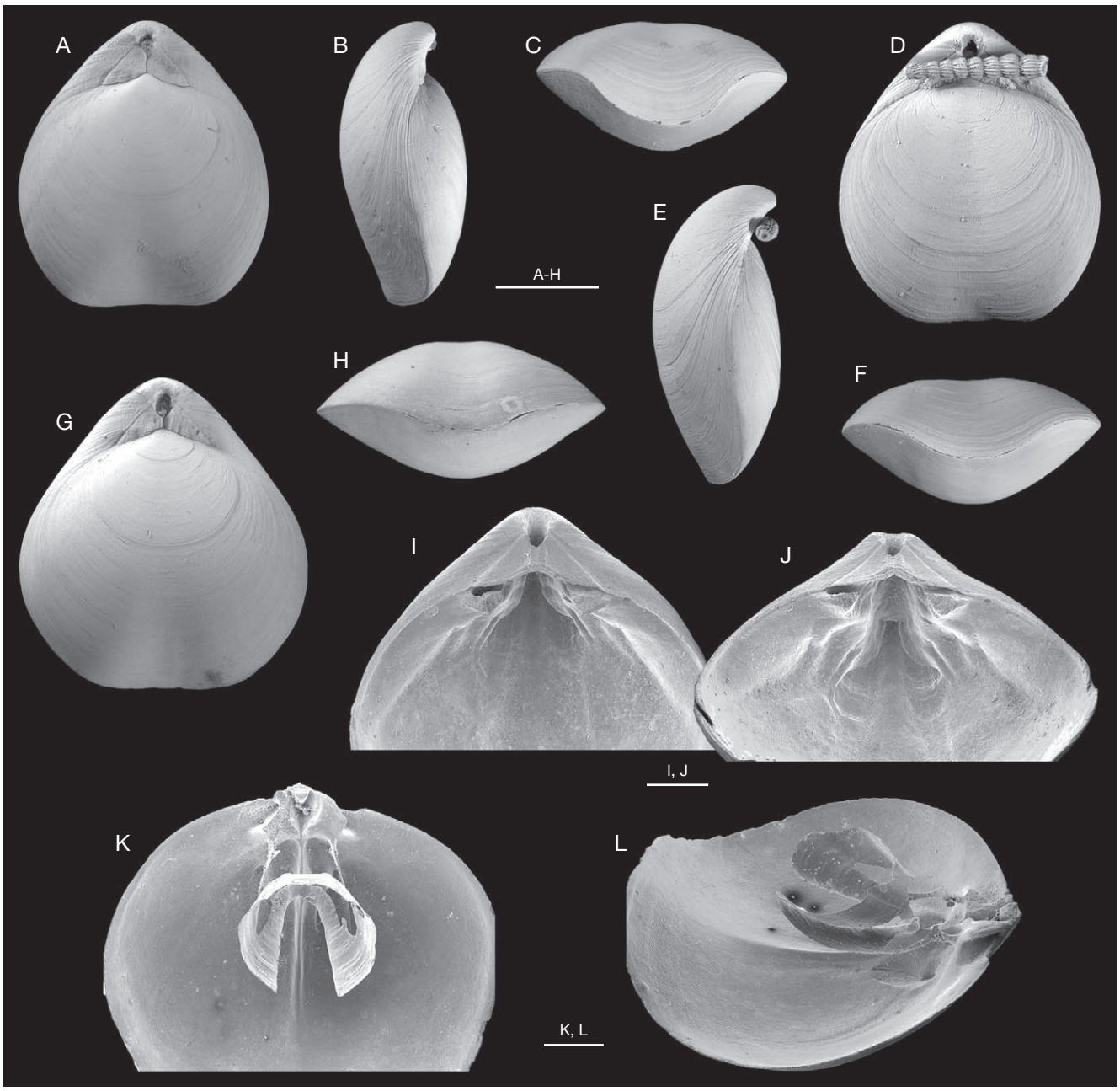

Fig. 16. — *Nipponithyris afra* Cooper, 1973: **A-H**, dorsal, lateral and anterior views of complete specimens (MNHN IB-2013-89-91), North-West Madagascar, off Majumga, MIRIKY, stn CP 3252, 850-900 m; **I**, **J**, inner views of ventral valve (MNHN IB-2013-92), and tilted (**J**) to show swollen bases and grooves to accommodate inner socket ridges, SEM, North-West Madagascar, between Majumga and Cap Saint-André, MIRIKY, stn CP 3278, 750-780 m; **K**, **L**, inner and oblique views of dorsal valve (MNHN IB-2013-93) to show brachial loop, SEM, Mozambique Channel, Inhambane transect, MAINBAZA, stn CP 3139, 1092-1195 m. Scale bars: A-H, 5 mm; I-L, 2 mm.

Superfamily Kraussinoidea Dall, 1870
Family Kraussinidae Dall, 1870
Subfamily Megerliinae
Hiller, MacKinnon & Nielsen, 2008

Genus *Megerlia* King, 1850

Type species. — *Anomia truncata* Linnaeus, 1767, by original designation of King (1850: 145).

Megerlia truncata (Linnaeus, 1767)
(Fig. 17G-K; Table 15)

Anomia truncata Linnaeus, 1767: 1152, 229.

Mühlfeldtia truncata – Fischer & Oehlert 1891: 80, pl. 7, figs 11a-u.

Megerlia truncata – Davidson 1887: 103, pl. 19, figs 11-20. — Brunton *et al.* 1967: 177, pl. 4, figs 14-25. — Logan 1979: 68, pl. 9, figs 1-23. — Cooper 1981b: 16, pl. 3, figs 5-11.

Megerlia gigantea – Cooper 1981a: 27-28, pl. 6, figs 1-26.

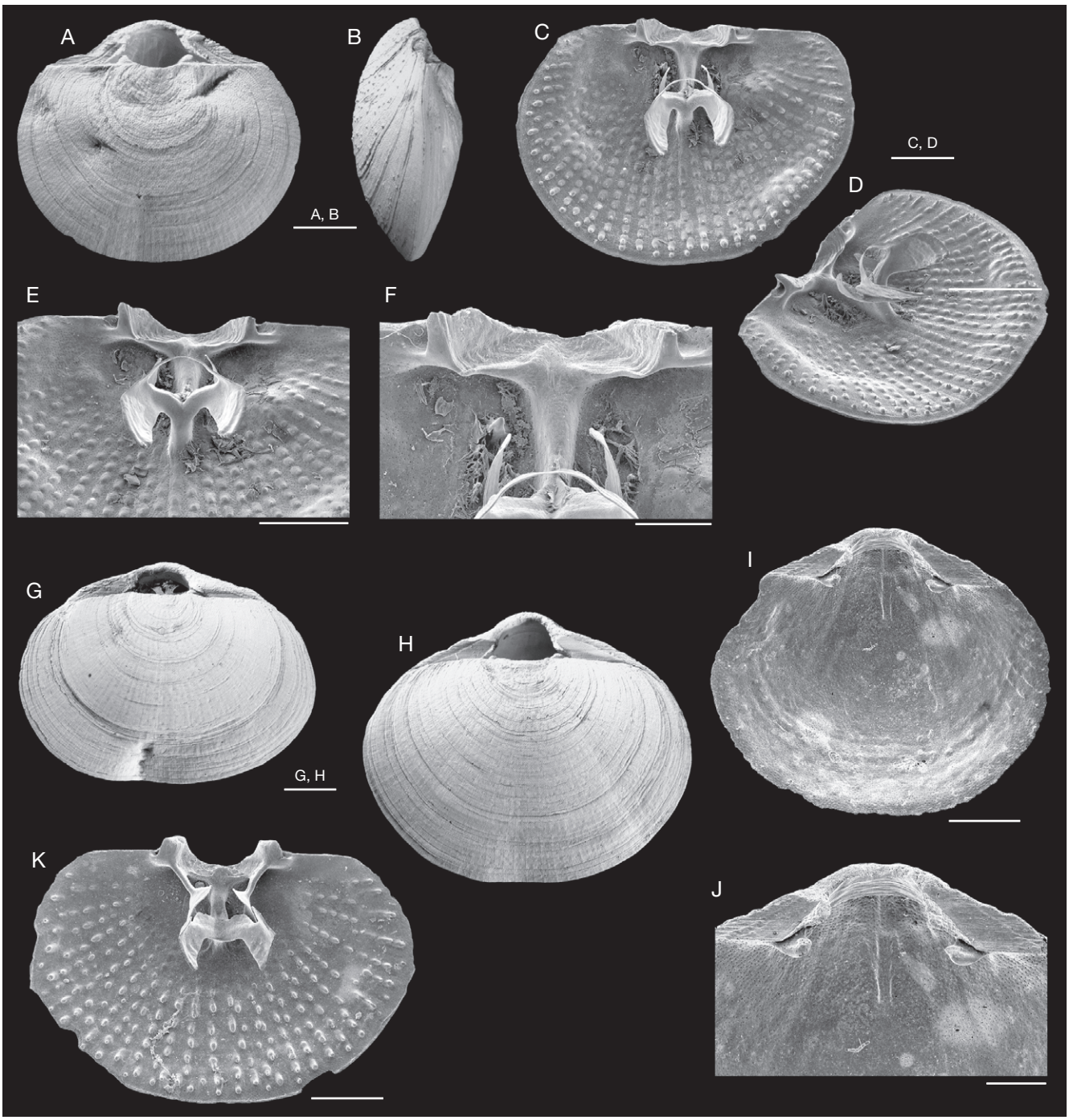

FIG. 17. — **A**-**F**, *Megerlia acrura* Hiller, 1986: **A**, **B**, ventral and lateral views of complete specimen (MNHN IB-2013-94), North-West Madagascar, off the Bay of Nazendry, MIRIKY, stn DW 3239, 230-288 m; **C**-**F**, interior of dorsal valve (MNHN IB-2013-95), oblique and tilted views, and enlargement (**F**) of posterior part to show details of cardinalia, Mozambique Channel, Inhambane transect, MAINBAZA, stn CC 3159, 148-152 m, SEM; **G**-**K**, *Megerlia truncata* (Linnaeus, 1767): **G**, **H**, dorsal views of complete specimens (MNHN IB-2013-96-97), North-West Madagascar, MIRIKY; **G**, West of Nosy Be, stn DW 3232, 210-310 m; **H**, in front of the Nazendry Bay, CP 3289, 332-379 m; **I**, **J**, Inner view of ventral valve (MNHN IB-2013-98), and enlargement of posterior to show teeth, area and pedicle collar, South Madagascar, South of Faux-Cap ATIMO VATAE, stn DW 3552, 264-280 m, SEM; **K**, inner view of dorsal valve (MNHN IB-2013-99), stn DW 3552, 264-280 m, SEM. Scale bars: A, B, G, H, 3 mm; C-E, I, K, 2 mm; F, J, 1 mm.

MATERIAL EXAMINED. — **North West Madagascar.** MIRIKY, stn DW 3228, 1 bivalved specimen. — Stn DW 3232, 2 bivalved specimen. — Stn DW 3239, 1 bivalved specimen. — Stn CP 3240, 1 bivalved specimen. — Stn CP 3247, 1 bivalved specimen. — Stn DW 3289, 1 bivalved specimen. — Stn CP 3293, 1 ventral valve. — Stn DW 3294, 3 bivalved specimens.

South Madagascar. ATIMO VATAE, stn DW 3515, 1 bivalved specimen. — Stn CP 3527, 1 bivalved specimen. — Stn DW 3528, 9 bivalved specimens. — Stn DW 3529, 4 bivalved specimens. — Stn DW 3552, 12 bivalved specimens, 3 ventral valves, 5 dorsal valves. — Stn DW 3553, 2 bivalved specimens, 1 ventral valve. — Stn CP 3613, 2 bivalved specimens. — Stn CP 3615, 1 bivalved specimen, 2 dorsal valves.

Table 16. — Measurements (in mm) of *Megerlia acrura* Hiller, 1986.

Station No.	Length	Width	Thickness
CP 3144	7.2	8.2	3.4
CC 3159	7.9	10.0	3.5
CC 3159	8.5	9.6	4.4
DW 3239	11.2	13.1	4.9
DW 3294	9.6	12.2	2.3

Table 17. — Measurements (in mm) of *Megerella hilleri* n. gen., n. sp.

Station No.	Length	Width	Thickness
DW 3515	2.8	2.8	1.4
DW 3519	1.7	1.9	0.8
DW 3519	1.3	1.4	0.5
DW 3519 (holotype)	3.4	3.7	1.5
DW 3522	4.4	5.2	1.9
DW 3522	1.9	2.0	0.9
DW 3530	2.9	2.7	1.4
DW 3530	1.8	1.9	0.8
DW 3532 (paratype)	2.6	2.8	1.2
DW 3564	3.2	3.7	1.3
CP 3573	4.2	4.2	2.0
CP 3614	3.2	3.3	1.2

Depth range. — 184-442 m.

Measurements. — See Table 15.

Remarks

Three of the four known species of *Megerlia* that occur globally are found in the Indian Ocean. *Megerlia truncata*, the type species is widely distributed throughout the oceans of the World (Cooper 1981b; Logan 2007) but is perhaps most common in the Mediterranean Sea (Logan 1979). Jackson (1921) also recorded this species from the Persian Gulf. The present study is the first published record of *M. truncata* from the southern Indian Ocean unless the variety *monstruosa* (Scacchi, 1838) is accepted as a synonym (see Logan 1979; Bitner 1990; Hiller 1994). Specimens from Madagascar are virtually indistinguishable from typical Mediterranean forms and usually inhabit the same moderate depths down to about 500 m. Cooper (1981b) notes the variability in the external shell of this species, while the progressive changes that take place during the ontogenetic development of the loop of the dorsal valve have been illustrated by Davidson (1887) and Logan (1979), among others. The closely-related *M. echinata* has been recorded from the coast of South Africa and in the Red Sea (Cooper 1973a; Logan *et al.* 2008), while another comparable *Megerlia* species from the Indian Ocean area is *M. acrura* Hiller, 1986 from the coast of South Africa (see below). *M. gigantea* (Deshayes, 1863), described by Cooper (1981a) from South of Madagascar, is here placed in the synonymy of *M. truncata* because, in our opinion, there are insufficient reasons to separate them and, in this respect, we therefore follow Davidson (1887) rather than Cooper (1981a).

Megerlia acrura Hiller, 1986
(Fig. 17A-F; Table 16)

Megerlia acrura Hiller, 1986: 132-134, fig. 17A-L.

Megerlina gigantea – Zezina 1987: 559-560.

Megerlia ? *gigantea* – Zezina 1994: 48-49.

Material examined. — **Mozambique Channel.** MAINBAZA, stn CP 3144, 3 bivalved specimens. — Stn CC 3159, 6 bivalved specimens.
North West Madagascar. MIRIKY, stn DW 3196, 1 bivalved specimen. — Stn DW 3239, 1 bivalved specimen.

Depth range. — 148-288 m.

Measurements. — See Table 16.

Remarks

Megerlia acrura was described by Hiller (1986) from 0-200 m depth from the coasts of South Africa and Mozambique in the Indian Ocean. Externally it is very similar to *M. truncata* but is smaller and lacks crura. Our specimens from the Mozambique Channel and North-West Madagascar are from a similar shallow depth range as Hiller's and show the same acrurate condition.

The specimens described by Zezina (1987, 1994) from the Western Indian Ocean as *M. gigantea* show no development of crura, thus they are considered to belong to *M. acrura*.

Subfamily Kraussininae Dall, 1870

Genus *Megerella* n. gen.

Type species. — *Megerella hilleri* n. gen., n. sp. by monotypy.

Etymology. — Referring to the affinity of this genus to the genera *Megerlina* and *Megerlia*.

Diagnosis. — Small, subquadrate kraussinid with widely spaced ribs and a bifurcate loop with distal extensions uniting to form a complete oval ring, weak dental plates present in adults.

Megerella hilleri n. sp.
(Figs 18, 19; Table 17)

Type material. — **South Madagascar**. ATIMO VATAE, stn DW 3519, holotype (MNHN IB-2013-508; Fig. 18G-I). — Same locality, stn DW 3519, DW 3532, DW 3534, 5 paratypes (MNHN IB-2013-509, 511, 513-515; Figs 18D-E; 19C-E, G-M).

Type locality. — South Madagascar, between Lokaro and Ste Luce, 24°52'S, 47°28'E, stn DW 3519, 80-83 m.

Etymology. — Named in honour of Norton Hiller (Melbourne, Australia) in recognition of his work on brachiopods from the Indian Ocean.

Diagnosis. — As for the genus.

Material examined. — **South Madagascar.** ATIMO VATAE, stn DW 3515, 1 bivalved specimen. — Stn DW 3518, 1 bivalved specimen. — Stn DW 3519, 19 bivalved specimens, 1 ventral

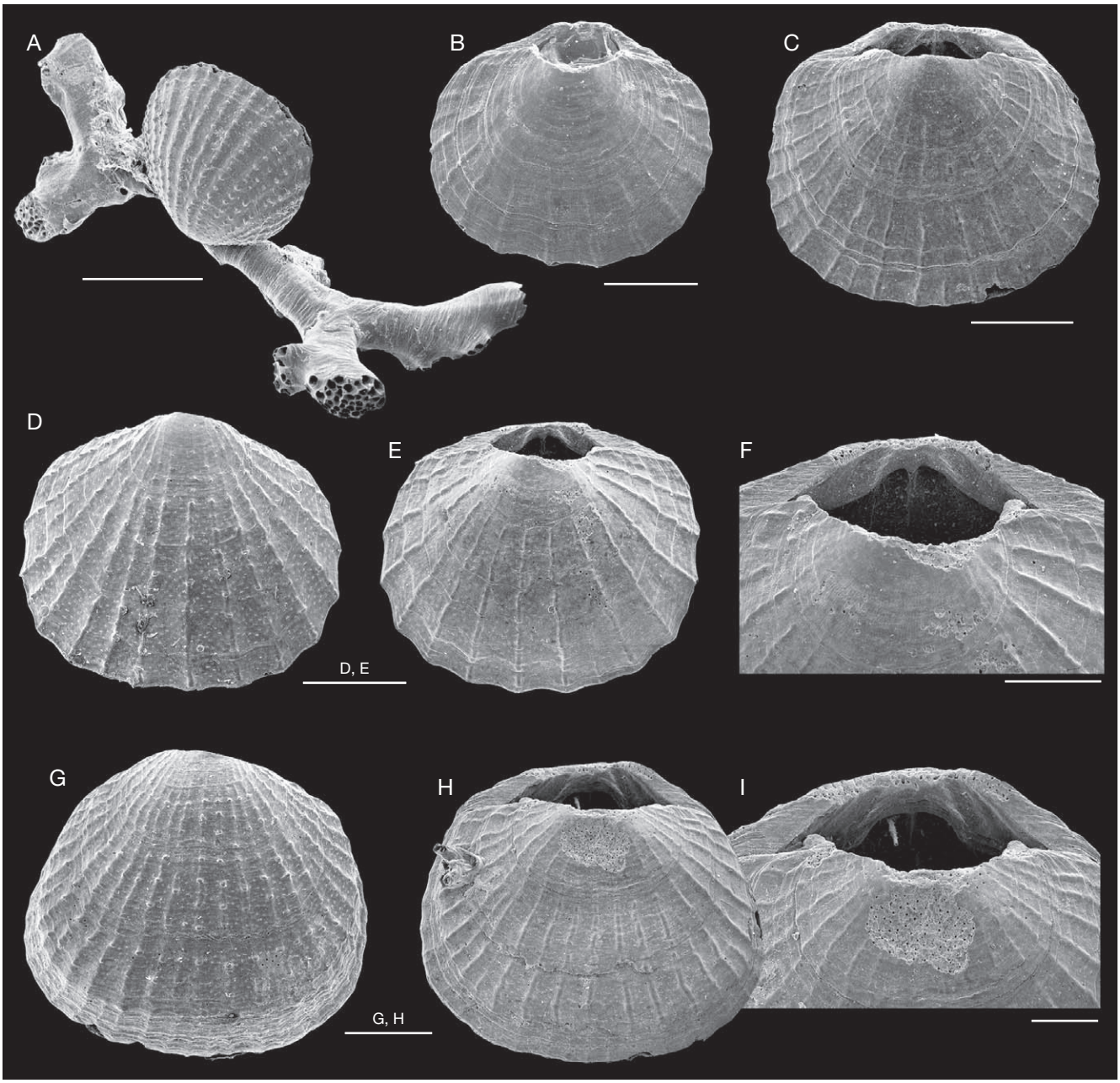

Fig. 18. — *Megerella hilleri* n. gen., n. sp. South Madagascar, ATIMO VATAE: **A**, complete specimen (MNHN IB-2013-100) in living position attached to bryozoan, between Lokaro and Ste Luce, stn DW 3519, 80-83 m; **B**, dorsal view of immature complete specimen (MNHN IB-2013-506), stn DW 3519, 80-83 m; **C**, dorsal view of complete specimen (MNHN IB-2013-507), sector of Sainte Luce, stn DW 3534, 296-307 m; **D**-**F**, ventral and dorsal views of complete specimen, and enlargement (**F**) of umbonal part to show details of beak and area, paratype (MNHN IB-2013-509), north of Sainte Luce, stn DW 3532, 86-87 m; **G**-**I**, ventral and dorsal views of complete specimen, and enlargement (**I**) of umbonal part, holotype (MNHN IB-2013-508), stn DW 3519, 80-83 m. All SEMs. Scale bars: A, 2 mm; B, F, I, 500 µm; C-E, G, H, 1 mm.

valve, 1 dorsal valve. — Stn CP 3520, 2 bivalved specimens. — Stn DW 3522, 2 bivalved specimens. — Stn DW 3530, 14 bivalved specimens. — Stn DW 3531, 3 bivalved specimens. — Stn DW 3532, 9 bivalved specimens. — Stn DW 3534, 6 bivalved specimens, 1 ventral valve, 1 dorsal valve. — Stn DW 3564, 1 bivalved specimen. — Stn CP 3573, 1 bivalved specimen. — Stn CP 3614, 1 bivalved specimen.

Depth range. — 54-456 m.

Measurements. — See Table 17.

Description

Shell small (maximum observed length 4.4 mm), subquadrate in outline, usually wider than long, maximum width at mid-line, biconvex with slightly more convex ventral valve. Shell surface costate with 15-25 radiating ribs, widely spaced and rounded in profile on dorsal valve and weakly beaded on ventral valve; ribs never bifurcate but rare intercalating ribs are observed. Lateral commissures straight, anterior commissure rectimarginate to incipiently sulcate in some larger

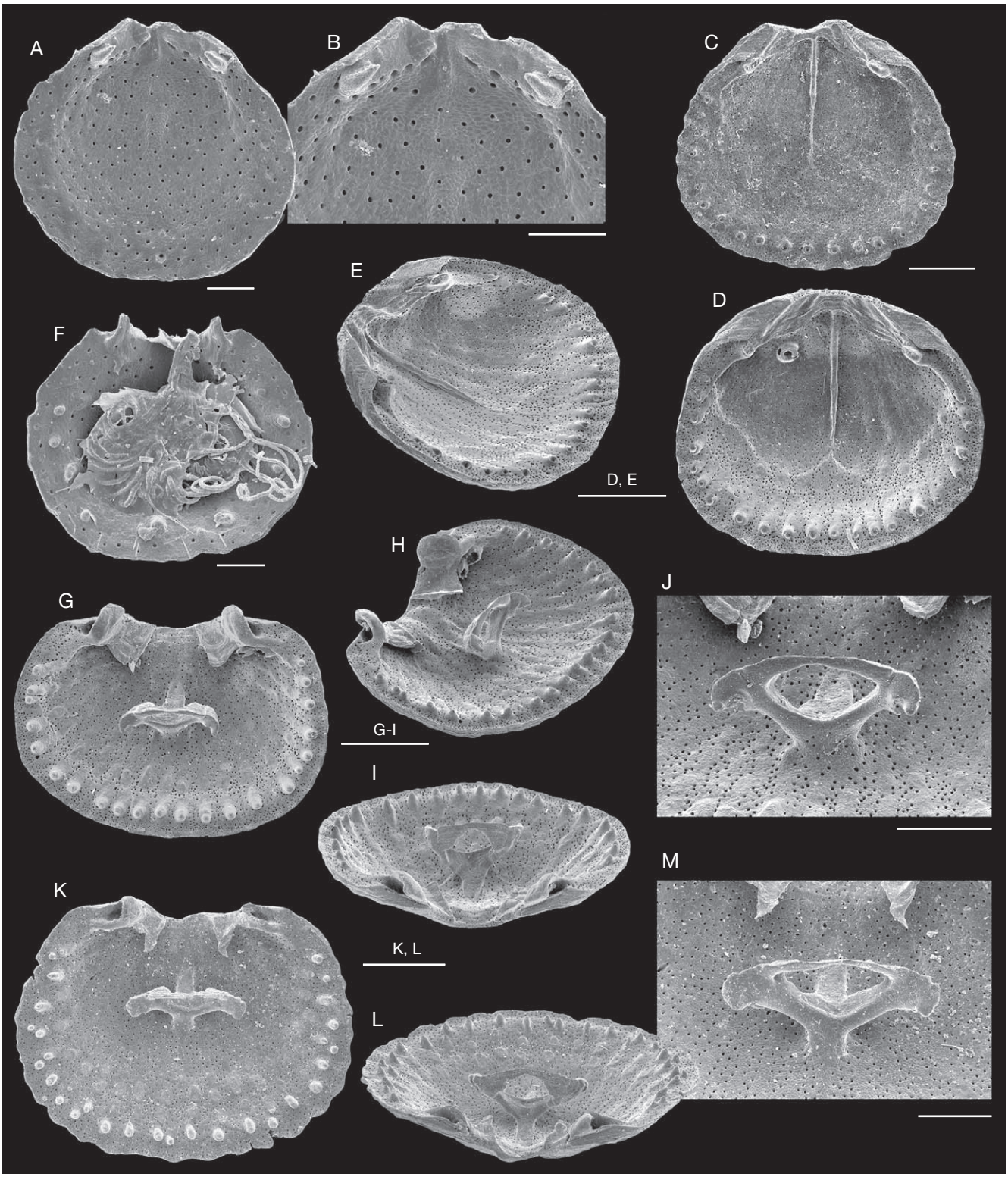

Fig. 19. — *Megerella hilleri* n. gen., n. sp., South Madagascar, ATIMO VATAE: **A**, **B**, young individual (MNHN IB-2013-510), inner view of ventral valve and enlargement of umbonal part to show details of teeth, between Lokaro and Ste Luce, stn DW 3519, 80-83 m; **C**, inner view of ventral valve paratype (MNHN IB-2013-511), stn. DW 3519, 80-83 m; **D**, **E**, inner and oblique views of ventral valve, and enlargement (**E**) of umbonal part to show details of pedicle collar and median septum, paratype (MNHN IB-2013-512), sector of Sainte Luce, stn DW 3534, 296-307 m; **F**, inner view of dorsal valve of young individual (MNHN IB-2013-513), stn DW 3519; **G**-**J**, dorsal valve, inner, oblique and posterior views, and enlargement of tilted anterior view, to show details of cardinalia and brachial skeleton, paratype (MNHN IB-2013-514), stn DW 3534; **K**-**M**, inner and posterior views of dorsal valve, and enlargement of anterior tilted view, paratype (MNHN IB-2013-515), stn DW 3519. All SEMs. Scale bars: A, B, F, 200 µm; C, D, G-I, K, L, 1 mm; E, J, M, 500 µm.

TABLE 18. — List of the brachiopod species identified in the material collected during three cruises/regions, and comparison with southern Africa (after Jackson 1952; Cooper 1973a, b; Hiller 1986, 1991, 1994).

Species	North-West Madagascar	Mozambique Channel	South Madagascar	Southern Africa West and central	Southern Africa East, including Mozambique
Discradisca sp.			×		
Novocrania roseoradiata (Jackson, 1952)			×	×	
Novocrania sp.	×	×			
Basiliola arnaudi Cooper, 1981	×		×		
Cryptopora boettgeri Helmcke, 1940		×	×	×	×
Cryptopora curiosa Cooper, 1973		×	×		×
Gryphus capensis Jackson, 1952	×			×	
Dallithyris dubia Cooper, 1981		×			
Stenosarina sp.			×		
Xenobrochus africanus (Cooper, 1973)		×	×		×
Terebratulina meridionalis Jackson, 1952		×	×	×	
Chlidonophora chuni Blochmann, 1900		×			×
Eucalathis magna Cooper, 1981			×		
Eucalathis daphneae n. sp.	×				
Eucalathis malgachensis n. sp.			×		
Macandrevia emigi n. sp.		×	×		
Frenulina sanguinolenta (Gmelin, 1791)	×		×		
Jolonica suffusa (Cooper, 1973)	×	×	×		
Argyrotheca jacksoni Cooper, 1973			×		×
Argyrotheca cf. *angulata* Zezina, 1987	×				
Phaneropora galatheae Zezina, 1981		×	×		×
Nipponithyris afra Cooper, 1973	×	×			×
Megerlia truncata (Linnaeus, 1767)	×		×		×
Megerlia acrura Hiller, 1986	×	×			×
Megerella hilleri n. gen., n. sp.			×		

specimens. Hinge line long, straight. Beak short, suberect, usually abraded due to very short pedicle (Fig. 18A). Beak ridges sharp. Cardinal area in ventral valve striated. Foramen large, deltidial plates narrow, disjunct.

Ventral valve interior with short but well-developed pedicle collar. Teeth small, hooked, supported in adults by weak dental plates (Fig. 19A-E). Median septum not present in early stages (Fig. 19A-B) but extending about ⅔ length of valve in adult forms (Fig. 19C-E). Margin of valve with single row of tubercles in adult form, each tubercle tip excavated. Dorsal valve interior with no cardinal process; divergent inner socket ridges excavate below, outer hinge plates broad, dental sockets relatively deep. Short rudimentary crura attached to inner sides of socket ridges (Fig. 19F-M). Centrally-placed septal pillar bearing bifurcate loop of brachial skeleton with distal extensions uniting to form a complete oval ring (Fig. 19G-M), lateral extremities of ring with slight claw-like development (Fig. 19J-M). Interiors of both valves endopunctate, but with size and disposition of punctae variable, radial ridges weakly developed, terminating in a single peripheral row of prominent tubercles, some with excavated tips (Fig. 19K), along inner margin of commissure (Fig. 19G-I, K, L). Lophophore plectolophous, mantle spiculate.

REMARKS

The ribbed ornamentation, large foramen, no development of crura and descending branches, and brachial skeleton in the form of an oval structure arising from the centre of the dorsal valve indicate the attribution of the studied specimens to the family Kraussinidae and subfamily Kraussininae (see Hiller *et al.* 2008). They differ, however, greatly from other members of this subfamily, *Kraussina* Davidson *in* Suess, 1859, *Megerlina* Eudes-Deslongchamps, 1884, and *Pumilus* Atkins, 1958, in which brachial lamellae are not united and form a V-shaped structure.

DISCUSSION

Twenty-five species of Recent brachiopods, belonging to 19 genera have been recognized in the studied material collected during three French cruises MAINBAZA, MIRIKY and ATIMO VATAE to the Mozambique-Madagascar area in 2009-2010 (see Table 18). One genus and four species have been described as new: *Eucalathis daphneae* n. sp., *E. malgachensis* n. sp., *Macandrevia emigi* n. sp., and *Megerella hilleri* n. gen, n. sp. The genus *Macandrevia* and the species *Frenulina sanguinolenta* are recorded for the first time from the Indian Ocean.

In a new biogeographical classification (Spalding *et al.* 2007) Southern Madagascar and Western and Northern Madagascar constitute two ecoregions, i. e. areas of relatively homogeneous species composition, distinct from adjacent areas. Our study also reveals that regional differences occur within the three study areas of Madagascar. The brachiopods collected in North-West Madagascar during the cruise MIRIKY are

represented by 10 species belonging to nine genera. Those collected in the Mozambique Channel during the cruise MAINBAZA are represented by 12 species belonging to 11 genera. The brachiopods collected in South Madagascar during the cruise ATIMO VATAE display the greatest diversity with 17 species belonging to 15 genera. Only one species, *Jolonica suffusa* has been identified in all three regions, whereas there are 12 species found only in one of those three regions. The North-West Madagascar region and Mozambique Channel have four species in common, also North-West Madagascar has four species in common with the South Madagascar region. A greater affinity is observed between the areas of Mozambique Channel and South Madagascar where seven species are in common.

It is worth mentioning that five of the species recognized in the studied collection have a very wide distribution. The species *Xenobrochus africanus*, *Frenulina sanguinolenta*, *Phaneropora galatheae*, and *Nipponithyris afra* are also known from the West Pacific (Laurin 1997; Bitner 2009, 2010), and *Megerlia truncata* was reported from the Persian Gulf (Jackson 1921) and is very common in the Mediterranean Sea and Eastern Atlantic (Logan 1979, 2007; Álvarez & Emig 2005).

Houart & Héros (2013, 2015) studied the distribution of muricid gastropods from ATIMO VATAE and MIRIKY collections and found a marked endemism in the AV material, with a significant number of new species from South Madagascar. While three of our four new species occur in the South, only two were found exclusively in this region. Clearly these numbers are not significant enough to postulate a similar high endemism in southern Madagascar brachiopods.

The composition of brachiopod fauna from this part of the Indian Ocean, apart from the Madagascar region, was briefly discussed by Cooper (1981a) who summarized earlier studies of brachiopods by Davidson (1880, 1887), Helmcke (1940), Jackson (1952), Muir-Wood (1959), Cooper (1973a) and Foster (1974), including brachiopods collected by the RV *Vema* from Agulhas Bank South Africa where three kraussinid species were identified (Cooper 1973b). More recently Hiller (1986, 1991, 1994) described South African brachiopods and discussed their regional affinities, pointing out that their geographical distribution is controlled by two oceanographic systems, the Agulhas Current on the East and the Benguela Upwelling System on the West. He noted that this fauna is dominated by kraussinids and this is the case in the collection from Madagascar. A comparison of the overall Madagascar brachiopod biota with those of other parts of the Indian Ocean shows the strongest similarity to those from southern Africa, with 12 out of 25 species occurring in both areas (Table 18).

The absence of thecideide brachiopods in the study collection from Madagascar that are known from the Red Sea (Logan & Bitner 2013), Europa Island in the Mozambique Channel (Zezina 1987; Baker & Logan 2011; Simon & Hoffmann 2013; Logan *et al.* 2015) and South of Madagascar (Cooper 1981a), may result from the fact that they are generally shallow-water forms usually associated with coral reefs, thus are absent in our deeper water offshore samples.

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APPENDIX

Station list.

	Location	Depth	Species
	Mozambique Channel, MAINBAZA expedition 2009		
Maputo transect			
CP 3130	25°53'S, 33°07'E	112-127 m	*Jolonica suffusa* (Cooper, 1973)
CP 3132	25°11'S, 35°02'E	101-102 m	*Cryptopora curiosa* Cooper, 1973
CP 3133	25°11'S, 35°10'E	200-201 m	*Cryptopora curiosa*
CP 3136	25°12'S, 35°17'E	503-505 m	*Cryptopora boettgeri* Helmcke, 1940
CP 3138	25°13'S, 35°21'E	700-707 m	*Dallithyris dubia* Cooper, 1981
Inhambane transect			
CP 3139	23°35'S, 36°06'E	1092-1195 m	*Nipponithyris afra* Cooper, 1973 *Macandrevia emigi* n. sp.
CP 3140	23°33'S, 36°02'E	886-898 m	*Nipponithyris afra*
CP 3141	23°33'S, 35°55'E	684-698 m	*Dallithyris dubia* *Nipponithyris afra*
CP 3142	23°31'S, 35°50'E	446-475 m	*Nipponithyris afra*
CP 3143	23°32'S, 35°46'E	264-277 m	*Xenobrochus africanus* (Cooper, 1973)
CP 3144	23°33'S, 35°41'E	171-180 m	*Megerlia acrura* Hiller, 1986
Bazaruto transect			
CP 3145	21°47'S, 36°24'E	1408-1421 m	*Chlidonophora chuni* Blochmann, 1900
CP 3146	21°38'S, 36°07'E	1161-1185 m	*Chlidonophora chuni*
Zambeze transect			
CC 3152	19°34'S, 36°45'E	443-445 m	*Cryptopora boettgeri* *Phaneropora galatheae* Zezina, 1981
CC 3153	19°35'S, 36°46'E	518-524 m	*Phaneropora galatheae*
CC 3154	19°36'S, 36°47'E	636 m	*Cryptopora boettgeri* *Phaneropora galatheae*
Bazaruto transect			
CC 3157	21°46'S, 36°25'E	1410-1416 m	*Chlidonophora chuni*
CC 3158	21°46'S, 36°12'E	1220-1248 m	*Chlidonophora chuni*
Inhambane transect			
CC 3159	23°55'S, 35°37'E	148-152 m	*Megerlia acrura*
CC 3166	24°22'S, 35°42'E	708-715 m	*Nipponithyris afra*
Almirante Leite Bank			
DW 3167	26°12'S, 35°02'E	228-230 m	*Novocrania* sp.
Maputo transect			
CC 3170	25°58'S, 34°47'E	949-952 m	*Macandrevia emigi* n. sp.
CC 3171	25°59'S, 34°42'E	771-776 m	*Nipponithyris afra*
CC 3175	25°34'S, 34°11'E	155-165 m	*Terebratulina meridionalis* Jackson, 1952
	North-West Madagascar, MIRIKY expedition 2009		
West of Cap d'Ambre			
DW 3196	12°08'S, 48°56'E	238-249 m	*Gryphus capensis* Jackson, 1952 *Eucalathis daphneae* n. sp. *Megerlia acrura*
DW 3199	12°06'S, 48°57'E	527-652 m	*Novocrania* sp. *Argyrotheca* cf. *angulata* Zezina, 1987
Between Nosy Be and Leven Bank			
DW 3212	12°34'S, 47°54'E	367-369 m	*Basiliola arnaudi* Cooper, 1981
DW 3216	12°34'S, 47°52'E	296-350 m	*Basiliola arnaudi*
DW 3228	12°55'S, 48°11'E	260-319 m	*Megerlia truncata* (Linnaeus, 1767)
West of Nosy Be			
DW 3230	13°25'S, 47°57'E	71-158 m	*Frenulina sanguinolenta* (Gmelin, 1791)
DW 3232	13°24'S, 47°58'E	210-310 m	*Megerlia truncata*
DW 3234	13°27'S, 47°55'E	187-247 m	*Eucalathis daphneae* n. sp.
Off the Bay of Nazendry			
DW 3239	14°30'S, 47°27'E	230-288 m	*Megerlia truncata* *Megerlia acrura*
CP 3240	14°30'S, 47°27'E	251-257 m	*Megerlia truncata*
Off the Bay of Mahajamba			
CP 3247	14°50'S, 47°00'E	349-442 m	*Megerlia truncata*

APPENDIX. – Continuation.

Station	Location	Depth	Species
Off Majumga			
CP 3252	15°22'S, 45°58'E	850-900 m	*Nipponithyris afra*
CP 3253	15°25'S, 45°55'E	243-950 m	*Nipponithyris afra*
Between Majumga and Cap Saint-André			
CP 3261	15°35'S, 45°43'E	197-217 m	*Jolonica suffusa*
CP 3278	15°24'S, 45°56'E	750-780 m	*Nipponithyris afra*
In front of Nazendry Bay			
CP 3289	14°29'S, 47°26'E	332-379 m	*Megerlia truncata*
CP 3293	14°30'S, 47°26'E	268-408 m	*Megerlia truncata*
CP 3294	14°29'S, 47°27'E	263-331 m	*Megerlia truncata*
South Madagascar, ATIMO VATAE expedition 2010			
Bay of Galions			
TA01	25°09'S, 46°45'E	7-14 m	*Frenulina sanguinolenta*
TP03	25°03'S, 46°59'E	17-21 m	*Discradisca* sp.
Evatra Point			
TB01	25°00'S, 47°06'E	22 m	*Terebratulina meridionalis* *Frenulina sanguinolenta*
S. Bay of Lokaro			
TS09	24°57'S, 47°06'E	5-6 m	*Novocrania roseoradiata* *Frenulina sanguinolenta*
Off Bay Fort-Dauphin			
TP18	25°02'S, 47° 03'E,	54-56 m	*Terebratulina meridionalis*
Between Lokaro and Ste Luce			
DW 3515	24°53'S, 47°28'E	184-203 m	*Eucalathis malgachensis* n. sp. *Mergelia truncata* *Megerella hilleri* n. gen., n. sp. *Phaneropora galatheae*
DW 3518	24°50'S, 47°28'E	99-101 m	*Megerella hilleri* n. gen., n. sp.
DW 3519	24°52'S, 47°28'E	80-83 m	*Terebratulina meridionalis* *Frenulina sanguinolenta* *Megerella hilleri* n. gen., n. sp.
CP 3520	24°51'S, 47°28'E	80-86 m	*Megerella hilleri* n. gen., n. sp.
Sector of Manantenina			
DW 3522	24°23'S, 47°32'E	154-168 m	*Eucalathis malgachensis* n. sp.
DW 3523	24°23'S, 47°31'E	200-220 m	*Eucalathis malgachensis* n. sp.
DW 3524	24°23'S, 47°32'E	307-319 m	*Eucalathis malgachensis* n. sp.
CP 3527	24°23'S, 47°32'E	305-313 m	*Megerlia truncata*
DW 3528	24°24'S, 47°33'E	424-438 m	*Eucalathis malgachensis* n. sp. *Megerlia truncata*
DW 3529	24°24'S, 47°33'E	402-407 m	*Eucalathis magna* Cooper, 1981 *Megerlia truncata*
North of Sainte Luce			
DW 3530	24°36'S, 47°32'E	80-86 m	*Terebratulina meridionalis* *Megerella hilleri* n. gen., n. sp.
DW 3531	24°38'S, 47°31'E	54-56 m	*Terebratulina meridionalis* *Frenulina sanguinolenta* Megerella *hilleri* n. gen., n. sp.
DW 3532	24°39'S, 47°32'E	86-87 m	*Terebratulina meridionalis* *Frenulina sanguinolenta* *Megerella hilleri* n. gen., n. sp.
Sector of Sainte Luce			
DW 3533	24°42'S, 47°32'E	187-209 m	*Terebratulina meridionalis*
DW 3534	24°43'S, 47°32'E	296-307 m	*Terebratulina meridionalis* *Eucalathis malgachensis* n. sp. *Frenulina sanguinolenta* *Megerella hilleri* n. gen., n. sp.
South of Faux-Cap			
DW 3552	26°07'S, 45°39'E	264-280 m	*Basiliola arnaudi* *Cryptopora boettgeri* *Eucalathis malgachensis* n. sp. *Megerlia truncata*

APPENDIX. – Continuation.

Station	Location	Depth	Species
DW 3553	26°08'S, 45°39'E	280-333 m	*Cryptopora boettgeri* *Eucalathis malgachensis* n. sp. *Megerlia truncata*
DW 3555	26°09'S, 45°40'E	455-458 m	*Basiliola arnaudi* *Stenosarina* sp.
DW 3557	26°08'S, 45°39'E	282-333 m	*Eucalathis malgachensis* n. sp.
East of Faux-Cap			
DW 3564	25°37'S, 46°20'E	433-456 m	*Xenobrochus africanus* *Eucalathis malgachensis* n. sp. *Megerella hilleri* n. gen., n. sp.
Sector of Fort-Dauphin			
DW 3573	25°13'S, 47°14'E	87-88 m	*Terebratulina meridionalis* *Megerella hilleri* n. gen., n. sp.
South Point Barrow			
DW 3581	25°30'S, 44°16'E	209-229 m	*Cryptopora curiosa*
CP 3585	25°32'S, 44°16'E	549-576 m	*Cryptopora boettgeri* *Phaneropora galatheae*
CP 3587	25°32'S, 44°18'E	151 m	*Jolonica suffusa*
South-West Point Barrow			
CP 3589	25°03'S, 44°00'E	132-153 m	*Macandrevia emigi* n. sp.
CP 3592	25°02'S, 43°58'E	450-455 m	*Cryptopora boettgeri* *Phaneropora galatheae*
South Point Barrow			
CP 3595	25°35'S, 44°15'E	821-910 m	*Eucalathis malgachensis* n. sp.
Sector of Lavanono			
DW 3599	25°45'S, 44°29'E	122-123 m	*Eucalathis malgachensis* n. sp.
South Cap Sainte Marie			
CP 3613	26°13'S, 45°08'E	225-282 m	*Eucalathis malgachensis* n. sp. *Megerlia truncata*
CP 3614	26°14'S, 45°09'E	250-300 m	*Eucalathis malgachensis* n. sp. *Megerella hilleri* n. gen., n. sp.
CP 3615	26°14'S, 45°09'E	284-286 m	*Cryptopora boettgeri* *Eucalathis malgachensis* n. sp. *Argyrotheca jacksoni* Cooper, 1973 *Phaneropora galatheae* *Megerlia truncata* *Megerella hilleri* n. gen., n. sp.