New and little-known Pliocardiinae (Bivalvia, Vesicomyidae) from the continental slope off Mauritania

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Hoffman, L., Cosel, R. von & Freiwald, A., 2019. New and little-known Pliocardiinae (Bivalvia, Vesicomyidae) from the continental slope off Mauritania. – Basteria 83 (4-6): 151-157. Leiden.
Published 9 November 2019

This study reports four vesicomyid species of the bathyal zone collected in sediment samples off the Mauritanian continental slope. One species is described as new: *Isorropodon arguinensis* spec. nov. Three bathyal species *Waisiuconcha haeckeli*, *Isorropodon curtum*, *Callogonia mauritanica* are already known from Mauritania and all four are most likely endemic to the continental slope of Mauritania.

Key words: NE Atlantic, NW Africa, Mollusca, taxonomy, new species.

INTRODUCTION

For over a decade, biological and geoscience research at the Marine Research Department of the Senckenberg am Meer Institute (SaM) has focused on the biodiversity of benthic fauna of the bathyal zone off the West African coast. In this work, we review the chemosynthetic bivalves belonging to the subfamily Pliocardiinae (Vesicomyidae) found on two expeditions (MSM16-3 (Westphal et al., 2010) and POS346 (Westphal, 2007)) conducted on the continental slope of Mauritania.

Pliocardiinae Woodring, 1925 inhabit mud with low oxygen / high organic content in 150–5200 m. Their species diversity is modest with a high degree of endemism occuring in species of certain genera (ie. *Waisiuconcha* Beets, 1942, *Isorropodon* Sturany, 1896 and *Callogonia* Dall, 1889).

The first four West African species of Pliocardiinae were described by Thiele & Jaeckel (1931); see Table 1. Recent discoveries have increased our knowledge of the Pliocardiinae and added to Thiele and Jaeckel's pioneer contributions. Von Cosel & Salas (2001) introduced five new pliocardiinids from West Africa belonging to three known genera: *Isorropodon*, *Callogonia* and *Waisiuconcha*. Von Cosel & Olu (2009) introduced the genera *Wareniconcha* and *Elanaconcha* and added three more species. Krylova & Sahling (2010) revised the Vesicomyidae, introducing the division of Vesicomyidae into the subfamily Vesicomyinae Dall & Simpson, 1901 for the genus *Vesicomya* without chemoautotrophic bacteria and the subfamily Pliocardiinae Woodring, 1925 for genera with chemoautotrophic bacteria. Oliver et al. (2011) introduced a new species in *Isorropodon* and provided a wide overview of the chemosymbiontic bivalves from the Bay of Cadiz. Rodrigues et al. (2012) reported chemoauthotrophic bacteria in *Isorropodon*: *I. bigoti* von Cosel & Salas, 2001, *I. megadesmus* Oliver, Rodrigues & Cunha, 2011 and *I. perplexum* Sturany, 1896. Oliver & Drewery (2014) added *Isorropodon mackayi* Oliver & Drewery, 2014 and *I. nyeggaensis* Krylova, 2011 to this chemosynthetic group and discussed their endemic occurrence in cold seeps. Table 1 provides a list of known vesicomyids from West Africa.

We provide additional information concerning the four poorly-known species of Pliocardiinae that are endemic to the continental slope off Mauritania: *Waisiuconcha haeckeli*, *Callogonia mauritanica*, *Isorropodon curtum* and *Isorropodon arguinensis* spec. nov.

ABBREVIATIONS

H = Height; LV = Left valve; RV = Right valve; SaM = Senckenberg am Meer, Wilhelmshaven, Germany; SMF = Senckenberg Naturmuseum, Frankfurt am Main, Germany; T = Tumidity (thickness of paired valves); W = Width.

Species	Known distribution	References
Vesicomya atlantica (E.A. Smith, 1885)	NE Atlantic, Rockall Trough to Cape Verde basin, 1900-3360 m	von Cosel & Salas (2001)
Vesicomya adamsi (E.A. Smith, 1885)	Sierra Leone to Namibia, 4400-5300 m	von Cosel & Salas (2001)
Waisiuconcha haeckeli von Cosel & Salas, 2001	off Mauritania, 505-1310 m	von Cosel & Salas (2001), this study
Isorropodon arguinensis spec. nov.	off Mauritania, 516 m	this study
Isorropodon atalantae von Cosel & Olu, 2009	off Congo Republic, 3159-3113m	von Cosel & Olu (2009)
Isorropodon bigoti von Cosel & Salas, 2001	off Congo Republic 150-250 m and possibly off Mauritania 900-1200 m	von Cosel & Salas (2001)
Isorropodon curtum von Cosel & Salas, 2001	off Mauritania 370-1310 m	von Cosel & Salas (2001), this study
Isorropodon megadesmus Oliver, Rodrigues & Cunha, 2011	off NW Morocco, 1321-1322 m	Oliver et al. (2011)
Isorropodon striatum (Jaeckel & Thiele, 1931)	off Cameroon to Angola, 2492-4017 m	Thiele & Jaeckel, 1931 von Cosel & Salas (2001), von Cosel & Olu (2009)
Callogonia cyrili von Cosel & Salas, 2001	off Morocco, 1805 m	von Cosel & Salas (2001)
Callogonia mauritanica von Cosel & Salas, 2001	off Mauritania, 516-1100 m	von Cosel & Salas (2001), this study
Archivesica chuni (Jaeckel & Thiele, 1931)	off Ghana to Congo Republic, 2492-3159 m	Thiele & Jaeckel, 1931 von Cosel & Salas (2001)
Calyptogena valdiviae (Jaeckel & Thiele, 1931)	off Western Sahara to Gabon 670-2500 m	Thiele & Jaeckel, 1931 von Cosel & Olu (2009)
Wareniconcha guineensis (Thiele, 1931)	off Cameroon to Angola, 2492-4017 m	Thiele & Jaeckel, 1931 von Cosel & Olu (2009)
Elenaconcha guiness von Cosel & Olu, 2009	off Gabon to Mauritania, 439-1200 m	von Cosel & Olu (2009)
Christinaconcha regab (von Cosel & Olu, 2009)	Bay of Biscay to off Angola 2820-4125 m	von Cosel & Olu (2009)
Abyssogena southwardae Krylova, Sahling & Janssen, 2011	North Atlantic (including off the Canary Islands) and Pacific, 2985-6400 m	Krylova et al. (2011)

Table 1. Vesicomyidae from West Africa.

SYSTEMATIC PART

Class Bivalvia Linnaeus, 1758
Subclass Heterodonta Neumayr, 1884
Order Venerida Gray, 1854
Superfamily Glossoidea Gray, 1847
Family Vesicomyidae Dall & Simpson, 1901
Subfamily Pliocardiinae Woodring, 1925

Genus *Isorropodon* Sturany, 1896

Isorropodon curtum von Cosel & Salas, 2001
(Figs 1-3)

Isorropodon curtum von Cosel & Salas, 2001: 349-351, figs 59-62, 86-87.

Material examined. — Mauritania: Tanôudêrt Canyon: MSM16-3/14800, 20.2458°N - 17.6698°W, 560 m, 3-XI-2010, grab, two valves; MSM16-3/14801, 20.2460°N - 17.6696°W, 568 m, 3-XI-2010, grab, three valves. Banda Mound Complex: MSM16-3/14898, 17.6699°N - 16.6736°W, 505 m, 14-XI-2010, grab, one valve. Arguin South 3 Canyon: POS346/11509, 19.7082°N - 17.1500°W, 370 m, 1-I-2007, box core, two valves. Deep Mound Chain: MSM16-3/14852, 19.8107°N - 17.4705°W, 1310 m, 7-XI-2010, box core, ten valves; MSM16-3/14853, 19.8081°N - 17.4716°W, 1252 m, 7-XI-2010, box core, 31 valves; MSM16-3/14855, 19.8311°N - 17.4641°W, 1100 m, 7-XI-2010, box core, nine valves; MSM16-3/14856, 19.7721°N - 17.3681°W, 1118 m, 7-XI-2010, box core, one paired specimen, 19 valves; MSM16-3/14857, 19.7066°N - 17.3179°W, 1090 m, 7-XI-2010, box core, two valves.

Distribution. — The species was found in a latitude range of 17.6 to 20.2°N at 370–1310 m. Most shells were found in 1090-1310 m; shells from 370-568 m were juveniles. Von Cosel & Salas (2001) indicated only two shells as type material from an unprecise type locality ("off Mauritania in 900-1200 m").

Remarks. — The sediment in all locations was dominated by bathyal silty mud. All our shells were juveniles to subadult; our largest valve had a width of 6.3 mm. Von Cosel & Salas (2001) reported a maximum size of 11.3 mm.

Isorropodon arguinensis spec. nov.
(Figs 4-10)

Description of the holotype consisting of an empty shell (SMF351046). — Shell oval, thin and fragile. Prodissoconch with single growth stage, circular convex disk with smooth background, diameter 0.20 mm. Clear transition to dissoconch with raised margin and change in surface sculpture.

External valves smooth without major growth stages or radial features. Numerous fine growth stages as irregular commarginal sharp lines; sculpture rougher near ventral margin. Prosogyrous umbos well before the midline. Prodissoconch partly concealed by raised dorsal margin. Anterior margin well rounded, nearly a semi-circle. Ventral margin widely rounded; flattened and slightly concave posteriorly. Concave inflexion only in the adult phase. Posterior margin elongated and truncated dorsally. Posterio-dorsal margin slightly convex. Lunule well-rounded with raised line at margin. Ligament external, thin, elongated on posterio-dorsal margin reaching across nymph margins, translucent brown, length 3.8 mm. Escutcheon very narrow and long, largely hidden by nymph and ligament. Periostracum thin, light yellowish olive-green, translucent, eroded in the central and umbonal areas.

Hinge of right valve with two strong cardinal teeth and one rudimentary tooth: tooth no. 1 aligned with dorsal margin well in front of umbo; curved tooth no. 3 dorsally aligned below umbo (the two legs of the tooth are numbered 3a and 3b) and one rudimentary tooth no. 5 well behind the umbo, immediately following no. 3b. Hinge of left valve has one strong cardinal tooth, no. 2, forming a V-shape pointing downwards below the umbo (with the two legs numbered 2a and 2b) and a weak marginal tooth, no. 4. No lateral teeth developed. Posterio-dorsal margin with thin elongated and sharp nymph that ends with a smooth curve. Anterio-dorsal margin raised and sharp.

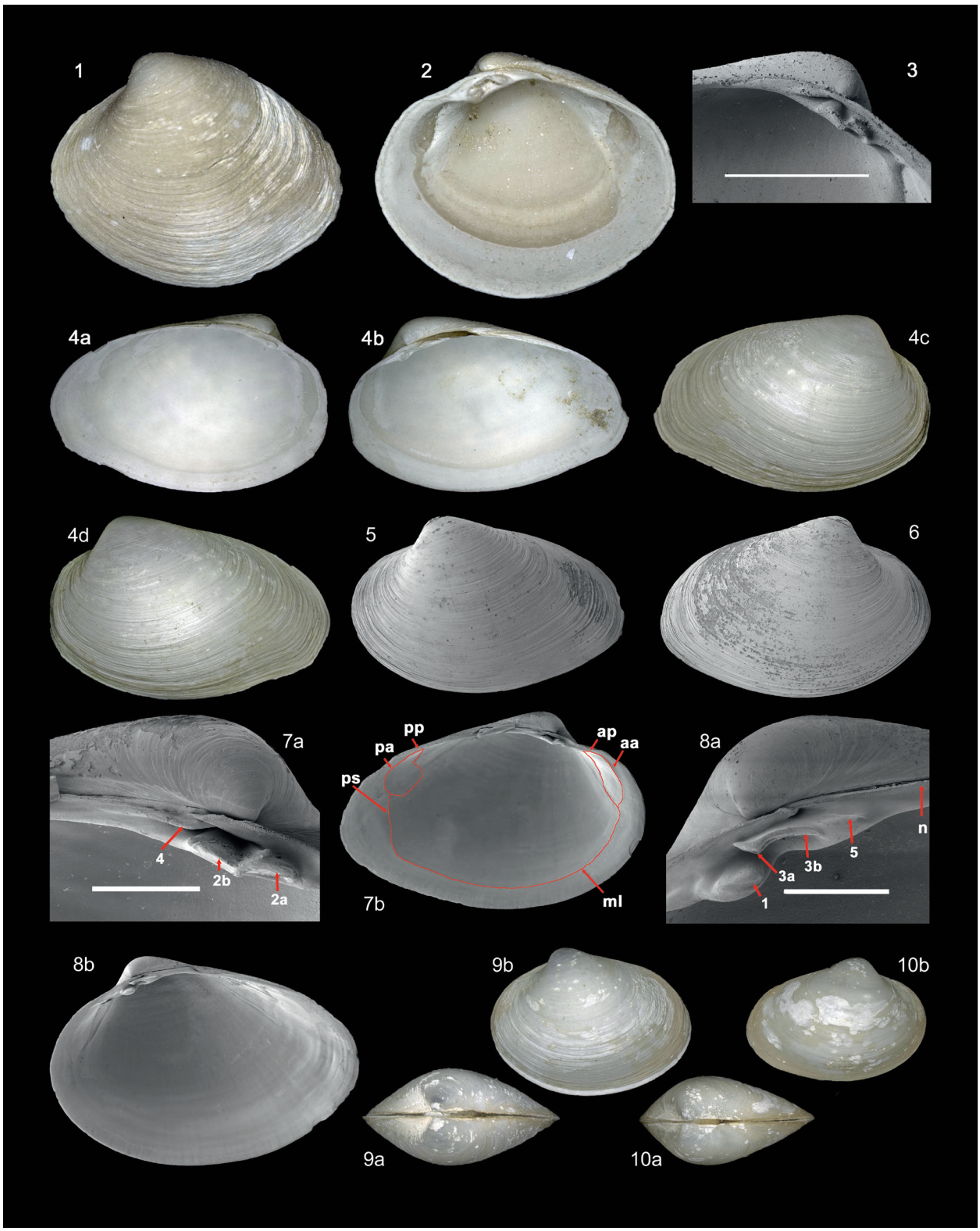
Inside surface smooth; only sculpture at muscle scars and inconspicuous pallial line. Ventral, anterior and posterior margins smooth, sharp and flattened. Anterior adductor muscle scar obliquely positioned under the dorsal margin. Inconspicuous retractor muscle scar at dorsal end of adductor muscle. Posterior adductor muscle scar with clear outline and corrugated centre; raised margin of scar on dorsal side. Small pedal retractor muscle scar on dorsal side of adductor muscle scar. Raised rib between dorsal margin of muscle scar and umbo. External margin pallial line clear; internal margin of pallial line visible posteriorly but inconspicuous towards the mid line. Weak pallial sinus.

External and internal shell opaque white. Height 9.6 mm; width 15.0 mm (W/H = 1.56); tumidity 8.8 mm.

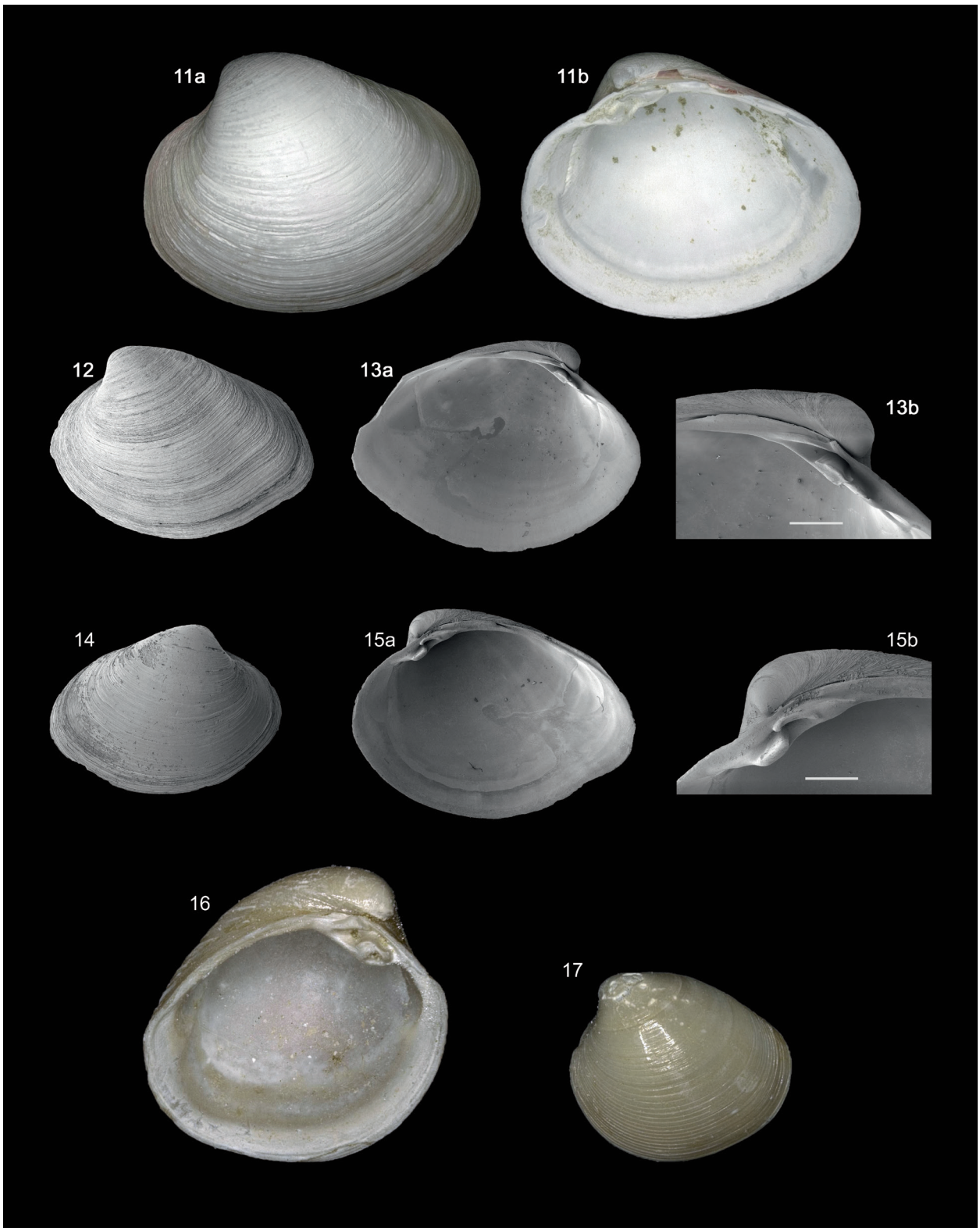
Variability. — Width up to 15 mm. Some paratypes show more truncation posteriorly, others have a more pointed outline. Truncated specimens and juveniles have a lower W/H ratio (1.46-1.47) than adults (1.47-1.56). The slightly concave posterior-dorsal margin is only developed in large (adult) specimens.

Type locality. — Mauritania: Arguin South 1 Canyon: MSM16-3/14848, 19.5479°N - 17.2617°W, 516 m, 6-XI-2010, box core in silty mud with low oxygen / high organic matter content.

Type material. — The holotype (SMF351046, Fig. 4) and



Figs 1-10. *Isorropodon* species. **Figs 1-3.** *Isorropodon curtum*, MSM16-3/14855. **1.** LV H 4.2 mm, W 6.3 mm. **2.** RV H 4.4 mm, W 6.3 mm; **3.** LV hinge, scale bar 1 mm. **Figs 4-10.** *Isorropodon arguinensis* spec. nov., MSM16-3/14848. **4.** Holotype H 9.6 mm, W 15.0 mm, T 8.83 mm, prodissoconch 0.19 mm. a, d. LV. b, c. RV. **5-10.** Paratypes. **5.** LV, H 7.1 mm, W 11.0 mm. **6.** RV, H 8.1 mm, W 12.1 mm. **7.** LV, H 8.8 mm, W 3.7 mm, cardinal teeth 2a–b, 4, scale bar 1 mm, anterior adductor (aa) muscle, anterior pedal retractor (ap) muscle, posterior adductor (pa) muscle, posterior pedal retractor (pp) muscle, pallial line (ml), pallial sinus (ps). **8.** RV, H 9.3 mm, W 13.7 mm, cardinal teeth 1, 3a–b, 5, nymph (n), scale bar 1 mm. **9.** W 8.7 mm, T 4.3 mm. **10.** W 7.5 mm, T 3.9 mm.



Figs 11-17. *Isorropodon*, *Callogonia* and *Waisiuconcha*. **Fig. 11.** *Isorropodon perplexum*, Amsterdam Mud Volcano, eastern Mediterranean, H 7.3 mm, W 9.3 mm, T 5.9 mm, prodissoconch 0.23 mm. **Figs 12-15.** *Callogonia mauritanica*, MSM16-3/14848. **12.** LV, H 7.8 mm, W 10.6 mm. **13.** LV, H 8.9 mm, W 12.1 mm, scale bar 1 mm. **14.** RV, H 6.8 mm, W 9.3 mm. **15.** RV, H 8.8 mm, W 11.9 mm, scale bar 1 mm. **Figs 16-17.** *Waisiuconcha haeckeli*, MSM16-3/14855. **16.** LV, H 3.9 mm, W 4.1 mm. **17.** LV, H 2.5 mm, W 2.9 mm.

paratypes from the type locality: two shells (SMF351047, Figs 9-10), 220 valves (SMF351048, including Figs 5-8), and two shells and 30 valves (SaMID79571). Only empty shells have been found.

Distribution. — The species is only known from the type locality.

Etymology. — *Isorropodon arguinensis* spec. nov. is named after the type locality, the Arguin Bank off northern Mauritania.

Remarks. — Placement of the species in *Isorropodon* Sturany, 1896 is based on its medium size, thin, elongated and globose valves, dorsally-aligned cardinal teeth, and slight development of the pallial sinus. *Vesicomya* Dall, 1886 is smaller, with near circular valves without pallial sinus. *Waisiuconcha* Beets, 1942 has strong valves, a deeply set pallial line without sinus and is smaller. *Callogonia* Dall, 1889 is less globose and has a well-developed pallial sinus.

Isorropodon arguinensis spec. nov. is characterized morphologically by its thin globose, elongated and truncated valves, and its hinge features. The type species *Isorropodon perplexum* Sturany, 1896 from the eastern Mediterranean is less elongated; it has a low W/H ratio (1.25-1.31), see Fig. 11. *Pliocardia atalantae* (von Cosel & Olu, 2009) from the Bight of Guinea is much larger, oblong with a lower W/H ratio (1.37-1.40). *Isorropodon bigoti* von Cosel & Salas, 2001 from the Bight of Guinea is less pointed posteriorly and its umbo is placed more centrally (W/H 1.26-1.47). *Isorropodon curtum* von Cosel & Salas, 2001 from Mauritania is less globose, less elongated (W/H 1.43-1.50) and it has stronger valves. *Isorropodon striatum* (Jaeckel & Thiele, 1931) from SW Africa is truncated posteriorly and a comparable W/H ratio (1.26-1.55). *Isorropodon megadesmus* Oliver, Rodrigues & Cunha, 2011 from the Gulf of Cadiz is more oblong and has a lower W/H ratio (1.30-1.47). Juveniles of the new species resemble specimens of *Isorropodon megadesmus*, *I. perplexum* (see Fig. 11) or *I. striatum*.

Rodrigues et al. (2012) and Oliver & Drewery (2014) discussed chemoautotrophic bacteria in species of *Isorropodon*. Likely the species from Mauritania also share this characteristic.

Soft parts of *I. arguinensis* are not available and further morphological and molecular descriptions depend upon the availability of live-collected specimens in the future.

Dating of the remains of *Desmophyllum pertusum* (Linnaeus, 1758) collected from the surface of sediment samples in canyons off Banc d'Arguin gave ages of less than 1000 years (Wienberg et al. 2018). We therefore, assume that our species is recent despite the fact that only empty shells have been found. A further argument is that all complete shells have the periostracum and an intact ligament.

Isorropodon arguinensis spec. nov. was found in the same type of muddy sediment, in the same region and in the depth range of *Isorropodon curtum* albeit that the sampling locations were different. We are uncertain whether they share a similar ecological environment.

Genus *Callogonia* Dall, 1889

Callogonia mauritanica von Cosel & Salas, 2001

(Figs 12-15)

Callogonia mauritanica von Cosel & Salas, 2001: 355-356, figs 72-73, 94-95.

Material examined. — Mauritania: Arguin South 1 Canyon: MSM16-3/14848, 19.5479°N - 17.2617°W, 516 m, 6-XI-2010, box core, one live-collected specimen (SaMID1353), 26 valves. Deep Mound Chain: MSM16-3/14855, 19.8311°N - 17.4641°W, 1100 m, 7-XI-2010, box core, two valves. The sediment in both localities consisted of silty mud with a high organic content in a low-oxygen environment.

Distribution. — The bathymetric distribution was between 516-1100 m with a single live occurrence at 516 m. The latitudinal range was 19.5-19.9°N. Von Cosel & Salas (2001) indicated only the holotype as type material from an unprecise type locality ("off Mauritania in 900-1200 m").

Remarks. — The species is easily distinguished by the well-developed pallial sinus (Figs 13a, 15a) and the faintly concave posterior-ventral margins (Figs 12, 13a, 14, 15a). It is also the largest species in our set of four vesicomyids.

Genus *Waisiuconcha* Beets, 1942

Waisiuconcha haeckeli von Cosel & Salas, 2001

(Figs 16-17)

Waisiuconcha haeckeli von Cosel & Salas, 2001: 341-343, figs 2-3, 23-32, 78-79, 104.

Material examined. — Mauritania: Banda Mound Complex: MSM16-3/14898, 17.6699°N - 16.6736°W, 505 m, 14-XI-2010, box core, one juvenile valve. Deep Mound Chain: MSM16-3/14852, 19.8107°N - 17.4705°W, 1310 m, 7-XI-2010, box core, 14 valves; MSM16-3/14853, 19.8081°N - 17.4716°W, 1252 m, 7-XI-2010, box core, four shells, 140 valves; MSM16-3/14855, 19.8311°N - 17.4641°W, 1100 m, 7-XI-2010, box core, 11 valves; MSM16-3/14856, 19.7721°N - 17.3681°W, 1118 m, 7-XI-2010, box core, five valves. The sediment in all localities consisted of silty mud with a high organic content in a low-oxygen environment.

Distribution. — Depth range was confirmed at 505-1310 m, latitude range 17.6-19.9°N. Von Cosel & Salas (2001) indicated the species from depth range 606-1200 m, latitude range 18.4-19.3°N.

Remarks. — The species is easily distinguished by the thick valves, the glossy olive periostracum and the absence of the pallial sinus (Figs 16-17). The maximum size of 4.0 mm indicated by von Cosel & Salas (2001) is in accordance with our observations (4.1 mm).

CONCLUDING REMARKS

All four taxa in Pliocardiinae discussed in this study are solely known from bathyal (370-1310 m) silty mud in a low-oxygen and high-organic matter environment off Mauritania. We assume all species to be endemic to this region. Oliver & Drewery (2014) provided an overview of endemism in *Isorropodon* and their endemic association to cold seeps. The endemic occurrence of Pliocardiinae and *Isorropodon* in particular can be expected in the bathyal sea bottom in the hydrocarbon province off Mauritania.

Three species (*Waisiuconcha haeckeli*, *Isorropodon curtum*, *Callogonia mauritanica*) were described by von Cosel & Salas (2001) and their location data were confirmed or further detailed. The fourth species (*Isorropodon arguinensis* spec. nov.) is new to science.

Taxonomic assessment of these endemic species in the Mauritanian fauna was precluded by lack of quality samples with soft parts. Additional morphological and molecular studies need to be performed once fresh, live-collected material becomes available.

ACKNOWLEDGEMENTS

We thank the crews and scientific staffs of the r/v Maria S. Merian and the r/v Poseidon for their dedication in acquiring the sediment samples that enabled this work. Both expeditions were funded by the Deutsche Forschungsgemeinschaft. We acknowledge Nicol Mahnken for her technical assistance in sample retention and sem sample preparation. We acknowledge the editors, Graham Oliver and anonymous reviewers for improving the manuscript.

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