

A new species of bathymodioline mussel (Mollusca, Bivalvia, Mytilidae) from Mauritania (West Africa), with comments on the genus *Bathymodiolus* Kenk & Wilson, 1985

Rudo von COSEL

Laboratoire de Biologie des Invertébrés marins et Malacologie,
Muséum national d'Histoire naturelle,
55 rue Buffon, F-75231 Paris cedex 05 (France)
cosel@mnhn.fr

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ABSTRACT

Bathymodiolus mauritanicus n. sp., taken by commercial trawler at about 1000 m off Banc d'Arguin, northern Mauritania, is described and placed in the context of the genus *Bathymodiolus* Kenk & Wilson, 1985. No cold seep or hydrocarbon seep has yet been discovered in this region, although the repeated appearance of other mollusc groups typical for this kind of biotope suggests their existence. The new species belongs to a rather uniform and well-defined group of four species of bathymodioline mussels, informally designated as the *Bathymodiolus childressi* group, which differs from typical *Bathymodiolus* in a number of shell and soft part characters, specifically a multibundle posterior retractor, almost terminal umbones and the attachment of the anterior retractor to the posterior part of the umbonal cavity. An attempt is also made to reevaluate most of the other species of *Bathymodiolus*, which results in four groups: 1) the *B. thermophilus* group (one species, eastern Pacific only: Galapagos, East Pacific Rise); 2) the *B. brevior* group (five species, Atlantic: Mid-Atlantic Ridge, West Pacific, Indian Ocean); 3) the *B. heckerae* group (two species, Atlantic); and 4) the *B. childressi* group (four species, Atlantic, West Pacific).

KEY WORDS

Mollusca,
Bivalvia,
Mytilidae,
Bathymodiolus,
West Africa,
deep-sea,
cold seeps,
provisional grouping,
new species.

RÉSUMÉ

Une nouvelle espèce de moule bathymodioline (*Mollusca, Bivalvia, Mytilidae*) de Mauritanie (Afrique occidentale) et remarques sur le genre *Bathymodiolus* Kenk & Wilson, 1985.

Bathymodiolus mauritanicus n. sp. est décrite et placée dans le contexte du genre *Bathymodiolus* Kenk & Wilson, 1985. L'espèce a été récoltée par un chalutier commercial au large du Banc d'Arguin, nord de la Mauritanie, à une profondeur d'environ 1 000 m. Aucun suintement froid ou d'hydrocarbure n'a été détecté dans cette région, mais la récolte régulière d'autres mollusques habitant ce type d'environnement dans le même endroit suggère l'existence de telles sources. L'espèce nouvelle appartient à un groupe uniforme et bien défini de moules bathymodiolines, dénommé groupe de *Bathymodiolus childressi*, et comprenant quatre espèces. Ce groupe se distingue des autres *Bathymodiolus* connus par plusieurs caractères de la coquille et des parties molles, principalement le rétracteur postérieur à nombreux faisceaux, la position à peu près terminale des umbos et le rétracteur antérieur fixé dans la partie postérieure de la cavité umbonale. Finalement, la plupart des autres espèces de *Bathymodiolus* peuvent être réunies dans quatre groupes assez homogènes : 1) le groupe de *B. thermophilus* (une espèce, Pacifique Est seulement : Galapagos, Dorsale Est-Pacifique) ; 2) le groupe de *B. brevior* (cinq espèces, Atlantique : Ride Médio-Atlantique, Pacifique Ouest, océan Indien) ; 3) le groupe de *B. heckerae* (deux espèces, Atlantique) ; et 4) le groupe de *B. childressi* (quatre espèces, Atlantique, Pacifique Ouest).

MOTS CLÉS

Mollusca,
Bivalvia,
Mytilidae,
Bathymodiolus,
Afrique occidentale,
mer profonde,
fluides froids,
groupement provisoire,
nouvelle espèce.

INTRODUCTION

Species of *Bathymodiolus* Kenk & Wilson, 1985 are a spectacular component of deep-sea hydrothermal vent and cold seep communities. Fourteen species have been described to date (Kenk & Wilson 1985; Hashimoto & Okutani 1994; Cosel *et al.* 1994, 1999; Gustafson *et al.* 1998; Cosel & Olu 1998; Hashimoto 2001), and other species are under study by various authors (for details and a list of all mussels, see Table 5). Most of the material has been collected by manned or remote-operated submersibles. On the 2001 Paris Shell Show and collectors' bourse, four specimens of an unknown large deep-water mussel, identified as "*Bathymodiolus puteoserpentis* Cosel, Métivier & Hashimoto, 1994", with locality "Nouakchott, Mauritania, 1000 m", were offered for sale. Two other specimens of the same

species, with the origin "off Mauritania", had already been shown to me by a private collector who had obtained them at Dakar from the collection of the late Marcel Pin. A further two specimens were donated subsequently by the Belgian shell dealer G. Poppe with more precise data of collection. The eight specimens, live-taken but unfortunately without soft parts, were put at my disposal. The purpose of the present paper is to describe the species and place it into the context of the genus *Bathymodiolus*.

ABBREVIATIONS

MNHN Muséum national d'Histoire naturelle, Paris;
NMNZ Museum of New Zealand Te Papa Tongarewa, Wellington;
NSMT National Science Museum, Tokyo;
USNM National Museum of Natural History, Smithsonian Institution, Washington, D. C.

ECOLOGICAL BACKGROUND

The Mauritanian deeper slope has been the target of several oceanographic expeditions (e.g., using the research vessels RV *Meteor*, RV *Tyro*, RV *Ernst Haeckel* and RV *N'Diago*), however, to my knowledge none of them has yielded *Bathymodiolus*-like mussels. The RV *N'Diago* of the Centre de Recherches océanographiques (CRO) of Nouadhibou worked only in shallower depths down to about 300 m. No expedition has yet been mounted specifically to seek cold seeps or reducing sediments in the area. However, the presence of such sites off Mauritania is suggested by the record of a very large undescribed species of *Acharax* Dall, 1908 (family Solemyidae H. & A. Adams, 1857, see also Métivier & Cosel 1993) taken by the Dutch RV *Tyro* during the "Mauritania II" expedition (1988, stn MAU 105, off Banc d'Arguin, 19°43'N, 17°44'W, 1600-1900 m, specimen in Leiden Museum). The bottom fauna at this station comprised mainly holothurians, ophiuroids, actinians and pycnogonids. Moreover, the RV *Ernst Haeckel* of the former German Democratic Republic took a small vesicomid species at 600-800 m in the same area (Cosel & Salas 2001).

The few deep-water molluscs originating from Mauritania, that have periodically appeared on the "shell market", are said to come from "commercial trawlers", which suggests that they were taken by the specially equipped shrimpboats (with one large shrimp trawl rigged up like a fish-trawl for deep-water work) coming mostly from Spain and working in the Mauritanian economic zone at 400 to 1200 m, catching deep-water shrimps such as *Aristeomorpha foliacea* (Risso, 1827), *Plesiopenaeus edwardsianus* (Johnson, 1867), *Aristeus antennatus* (Risso, 1846), *Acanthephyra* sp. and others. Among molluscs in the by-catch were three species of small Vesicomidae, which were taken between 800 and 1200 m and described by Cosel & Salas (2001). This is further evidence for the presence of reducing sediments or possibly cold seeps or hydrocarbon seeps in the area.

SYSTEMATICS

Family MYTILIDAE Rafinesque, 1815

Genus *Bathymodiolus* Kenk & Wilson, 1985

TYPE SPECIES. — *Bathymodiolus thermophilus* Kenk & Wilson, 1985, by original designation.

Bathymodiolus mauritanicus n. sp.

(Figs 1; 2; 4)

TYPE MATERIAL. — Holotype: off Banc d'Arguin, Mauritania, reportedly, 18°41'N, 16°45'W, 1200 m, I.1994, by the commercial trawler *Peixe de Mar*, 1 complete shell (MNHN); paratypes: same locality (2 MNHN, 1 USNM, 1 NSMT, 1 NMNZ).

TYPE LOCALITY. — Off Banc d'Arguin, Mauritania, 1200 m.

MATERIAL EXAMINED. — Off Mauritania, reportedly 400 m, 2 shells, live-collected, in coll. J. Pélorce ex coll. M. Pin.

DISTRIBUTION. — Mauritanian slope, said to be from 1000-1200 m (the "400 m" of one of the lots is probably erroneous).

DESCRIPTION

Shell large, up to 110 mm long, rather thick-walled and solid, moderately short, wedge-shaped-modioliform, little variable, modestly inflated, equivalve, length/height ratio 1.8-1.9. Beaks almost terminal to terminal or even slightly protruding anteriorly. Anterior margin narrowly rounded, ventral margin visibly concave in the middle part, occasionally with a well-marked crease at the end of the first fourth or fifth of the valve, which makes the anterior part appear bent ventrally. Posterior margin ventrally broadly rounded, postero-dorsal margin still markedly convex; postero-dorsal corner well rounded. Ligament plate more or less arched. Exterior with well developed, dense, irregular growth lines. Umbone broad and somewhat flattened.

Periostracum thick, dark chestnut brown, smooth, dull, with no periostracal hairs and no byssal endplates of other specimens. Umbonal region generally eroded in half-grown and larger specimens.

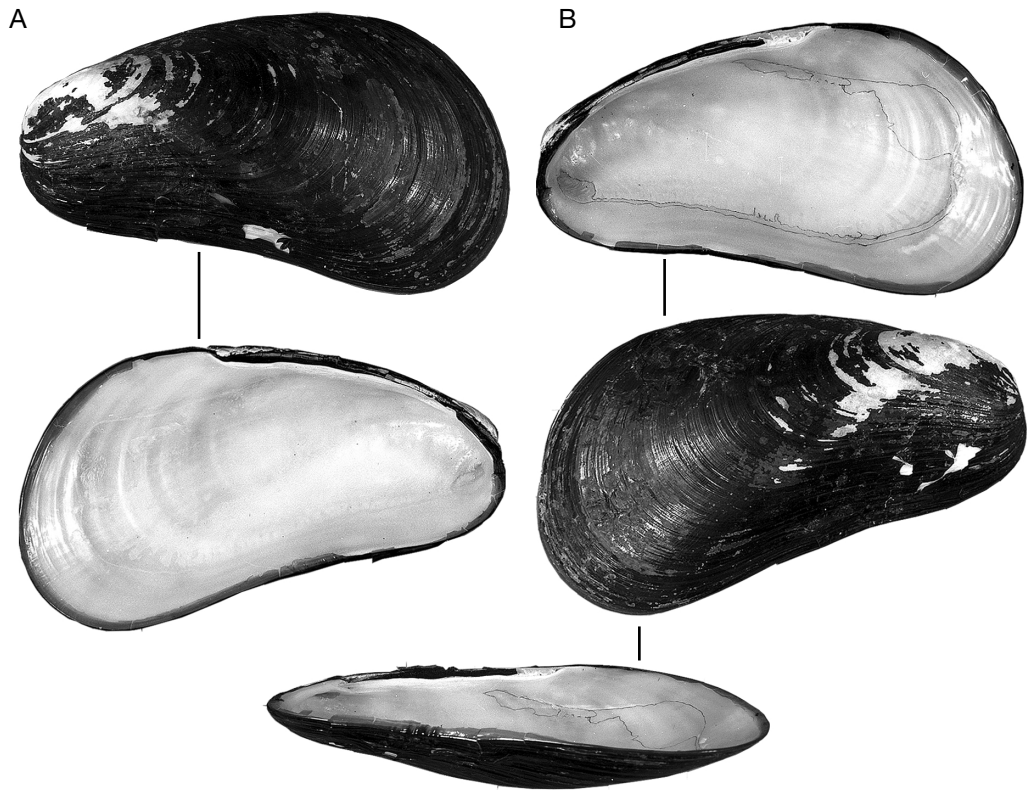


FIG. 1. — *Bathymodiolus mauritanicus* n. sp., holotype (MNHN), length 98.1 mm; **A**, exterior and interior of left valve; **B**, exterior, lateral and ventral views of interior of right valve.

Hinge toothless, anterior hinge margin strengthened to a buttress along the valve edge and protruding ventrally. Posteriorly, buttress not abruptly ending but gradually passing into the subligamental shell ridge. Ligament opisthodontic, strong, extending to more or less in front of the postero-dorsal corner (depending on the situation of the latter), ending abruptly without any taper. Subligamental shell ridge faint, visible along two thirds of ligament length and from both ventral and lateral perspectives. Anterior adductor scar small and oval, under or just behind the umbone. Posterior adductor scar large, rounded-oval, united with the long scar of the posterior pedal and byssus retractor muscle. Scar of the anterior bundle of the posterior retractor not at all or hardly separated from that of the posterior bundle, the anterior end situated under

the posterior third or fourth of the ligament. Anterior byssus retractor scar in the posterior part of the umbonal cavity, well behind the beaks, visible only when viewed from posterior and ventrally. Pallial line only weakly concave in the middle.

Shell without periostracum dull whitish, interior white and slightly nacreous.

Animal not known, but judging from the muscle scars, it is evident that it has an almost continuous multibundle posterior retractor.

See Table 1 for measurements.

Biotope not known. All known specimens (about 200) of *B. mauritanicus* n. sp. were taken in one single trawl haul (G. Poppe pers. comm.), which means the trawl went over an isolated, densely populated mussel bank, obviously located on a seeping site.

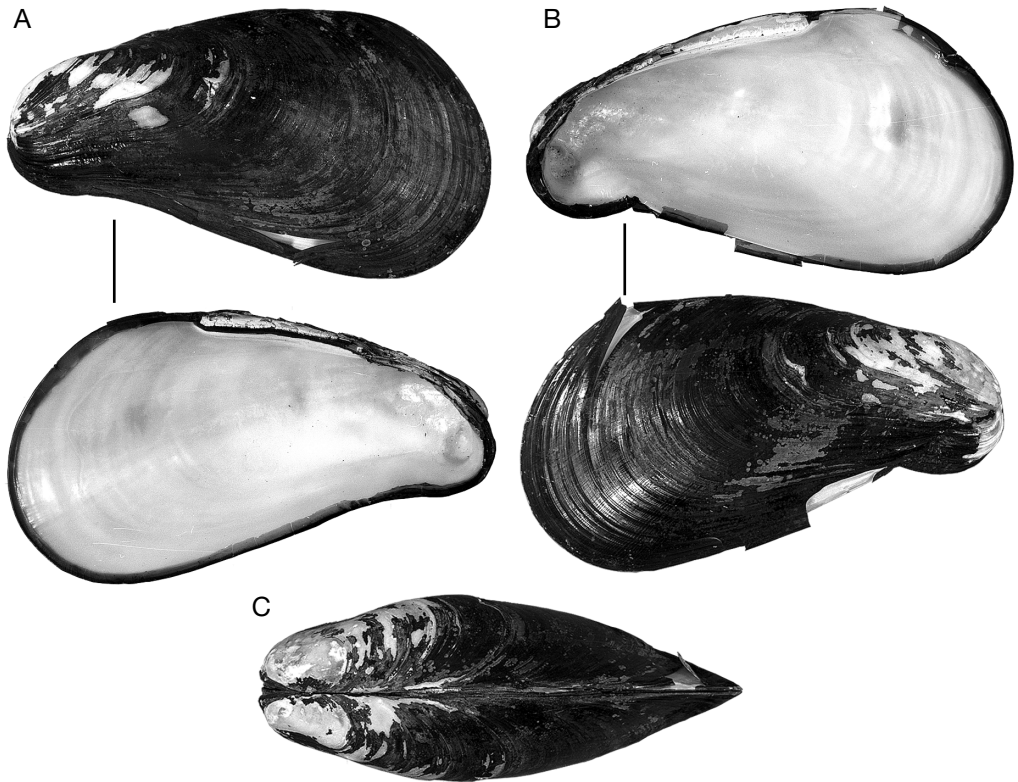


FIG. 2. — *Bathymodiolus mauritanicus* n. sp., paratype (MNHN), length 99.8 mm; **A**, exterior and interior of left valve; **B**, exterior and interior of right valve; **C**, dorsal view.

TABLE 1. — Measurements of *Bathymodiolus mauritanicus* n. sp.

Length, height, tumidity (mm)	Length/height ratio	Status
110.0 × 60.0 × 46.9	1.80	coll. Pélorce
99.8 × 53.7 × 36.5	1.86	paratype MNHN
98.3 × 54.0 × 41.4	1.82	paratype MNHN (ex coll. Poppe)
98.1 × 52.6 × 36.5	1.86	holotype MNHN
93.5 × 51.7 × 36.3	1.81	coll. Pélorce
70.1 × 36.0 × 25.8	1.94	paratype USNM
69.0 × 36.1 × 25.0	1.91	paratype NSMT
55.8 × 30.0 × 22.7	1.86	paratype NMNZ (ex coll. Poppe)

REMARKS

Among the large mussels from the Atlantic, *B. mauritanicus* n. sp. most closely resembles *Bathymodiolus childressi* Gustafson, Turner, Lutz & Vrijenhoek, 1998, from the Gulf of Mexico (Alamiños Canyon and Louisiana continental

slope) (Figs 3A; 5A, B), and an undescribed species from the Barbados Accretionary Prism, currently under study by Cosel & Olu (Fig. 5C, D). These three species are distinguished from other *Bathymodiolus* species by the comparatively small anterior adductor scar, the almost continuous

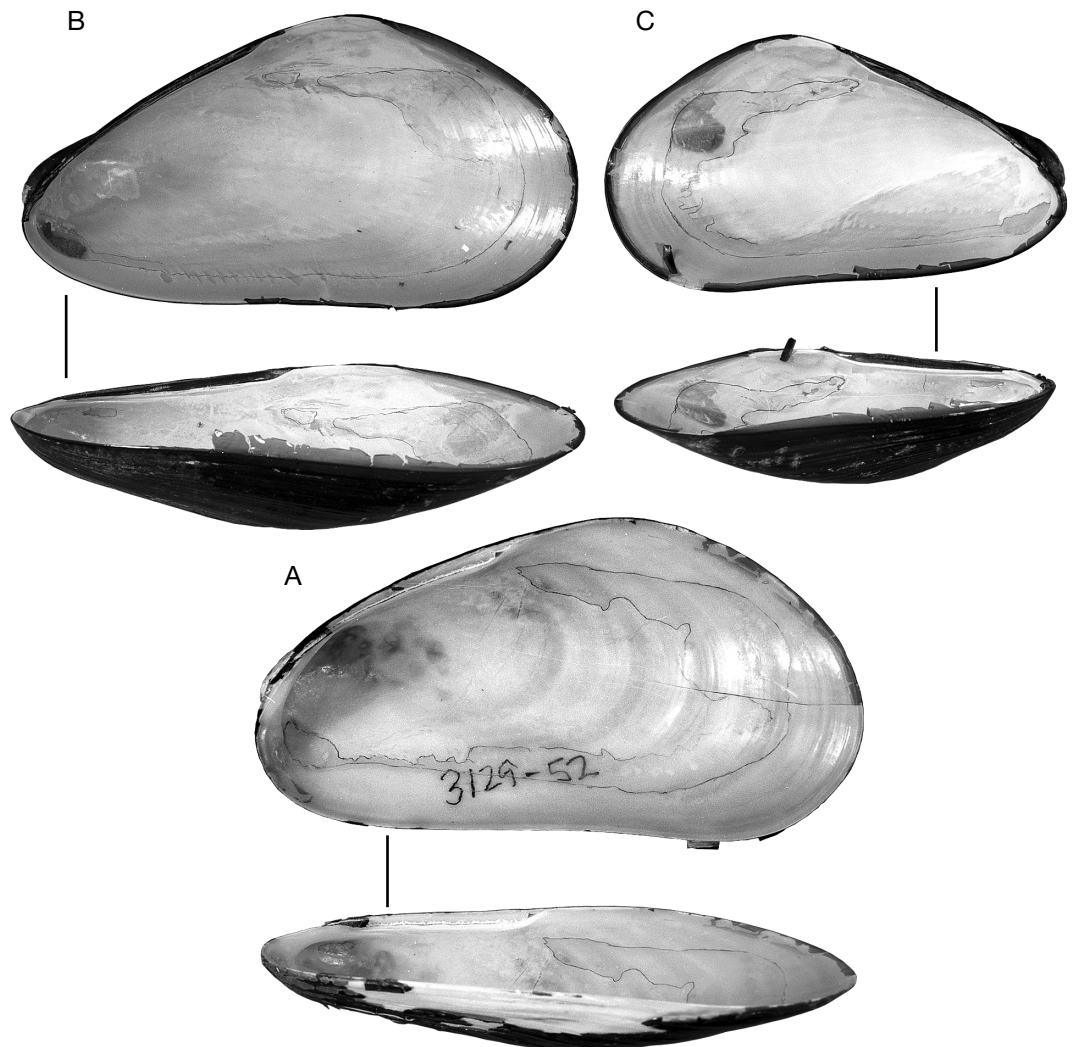


FIG. 3. — **A**, *Bathymodiolus childressi* Gustafson, Turner, Lutz & Vrijenhoek, 1998, paratype 3129-52 (MNHN), length 83.7 mm, Bush Hill hydrocarbon seep, about 210 km SSW of Grand Isle, Louisiana, 27°46.9'N, 91°30.4'W, 546 m, Johnson Sea-Link-1 cruise, dive 3129, lateral and ventral views of interior of right valve; **B**, **C**, *Bathymodiolus platifrons* Hashimoto & Okutani, 1994, paratypes (MNHN), Hatsuashima Site, Sagami Bay, 35°00.2'N, 139°13.5'E, 1170 m, Shinkai 2000, dive 666; **B**, paratype I, length 96.1 mm, lateral and ventral views of interior of right valve; **C**, paratype II, length 65.4 mm, lateral and ventral views of interior of left valve.

posterior byssus retractor scar, and the rather low and almost terminal umbones. The anterior retractor scar is placed considerably further posteriorly within the umbonal cavity than, for example, in *B. puteoserpentis* Cosel, Métiévier & Hashimoto, 1994, *B. azoricus* Cosel & Comtet, 1999, and *B. thermophilus* Kenk & Wilson, 1985. The new species is distinguished from *B. childressi* by the thick-walled valves, the narrower anterior

end, and the still more anteriorly situated umbones. This and the position of the broadest part of the valves more posteriorly than in *B. childressi* makes the shell outline of *B. mauritanicus* n. sp. appear more wedge-shaped rather than modioliform. The undescribed mussel from the Barbados Accretionary Prism also has the broadest part of the valve situated rather far back, although the anterior part is broader than in *B. mauritanicus*

TABLE 2. — Comparison of species of the *Bathymodiolus childressi* group.

	<i>B. mauritanicus</i> n. sp.	<i>B. childressi</i> Gustafson, Turner, Lutz & Vrijenhoek, 1998	<i>B. platifrons</i> Hashimoto & Okutani, 1994	<i>B. sp. I</i> (Barbados)
Shell form and outline	wedge-shaped postero-dorsal corner rounded	modioliform, juvs more wedge-shaped, postero-dorsal corner rounded	wedge-shaped, postero-dorsal corner narrowly rounded	modioliform to more wedge-shaped
Shell	rather thick and heavy	thin	thin	thin but solid to rather thick
Position of umbones	terminal	terminal to slightly subterminal	terminal	slightly subterminal to terminal
Adult hinge thickened below and anterior to umbone	yes	yes	yes but short	yes but short
Papilla on valvular siphonal membrane	–	absent	present (in one paratype MNHN very rudimentary)	almost absent
Intestine	–	very short recurrent loop	straight	short S-shaped curve to dorsal
Posterior end of ligament	tapering	abrupt	abrupt	abrupt

n. sp., and in most specimens the umbones are slightly subterminal, leaving 1/12 to 1/15 of the shell length in front of it. *Bathymodiolus* sp. I from Barbados shares with *B. mauritanicus* n. sp. the small anterior adductor scar, the continuous posterior retractor scar (Fig. 5C, D) and the posteriorly situated anterior retractor scar.

An Indo-Pacific species close to *B. mauritanicus* n. sp. is *Bathymodiolus platifrons* Hashimoto & Okutani, 1994. This also has a narrow anterior end and terminal umbones. Hashimoto & Okutani (1994: fig. 2) stated that it has an interrupted posterior byssus retractor scar, though in one of the two paratypes seen (MNHN), the impression appeared continuous; the other (larger) specimen shows a short interruption only within the scar (Figs 3B, C; 5E, F). These short interruptions were also observed in fully grown specimens of *B. mauritanicus* n. sp. and in specimens of *Bathymodiolus* sp. I (Barbados) (Fig. 5D), the continuous scar seems to become more or less broken up during ontogeny.

However, in most of the specimens of *B. mauritanicus* n. sp. and *Bathymodiolus* sp. I examined, the posterior byssus retractor scar appeared uninterrupted. In *B. platifrons*, the anterior retractor scar is situated in the posterior part of the umbonal cavity, another feature in common with the other mussels. Like *B. childressi* and unlike *B. mauritanicus* n. sp., *B. platifrons* has rather thin and light valves.

Another species, superficially resembling the four species mentioned above, with a more cuneiform shell shape with narrow anterior margin and broad posterior margin, as well as a strong multi-bundle posterior byssus retractor occurs east of the North Island of New Zealand. It is currently under description by Cosel & Marshall and will be discussed there (figured by Lewis & Marshall 1996: fig. 4A). The New Zealand mussel however is much more slender than *B. mauritanicus* n. sp., it has markedly subterminal umbones, and the highest point of the shell is still situated further backwards.

TABLE 3. — Comparison of the four groups of *Bathymodiolus* here proposed (in "size" the maximum size of the smallest and largest species of each group are given).

	<i>B. thermophilus</i> group	<i>B. brevior</i> group	<i>B. heckerae</i> group	<i>B. childressi</i> group
General shell form	moderately elongate modioliform	stout to moderately elongate, modioliform, anterior margin broad	very elongate, straight to curved	short and stout, more or less wedge-shaped, anterior margin narrow
Size	medium sized to large (to 162 mm)	medium sized to large (80 to 156 mm)	very large to extremely large (164 to 370 mm)	medium-sized (110 to 127 mm)
Shell	thin but solid	thin but solid to thin	very thin to thin (in relation of size) well subterminal	thin to rather thick and heavy
Position of umbones	subterminal	subterminal	two separate bundles at 2/3 of ligament but	almost terminal to terminal
Posterior retractor	two separate bundles	two separate bundles	variable	multibundle
Position of anterior part of posterior byssus retractor scar	under end of ligament	at 4/5 of of ligament or more forward		almost continuous scar between end of ligament (or just before) and posterior adductor scar
Position of anterior byssus retractor scar in umbonal cavity	slightly behind umbones	under umbones or in front of them	in middle of umbonal cavity, beneath or just behind umbones	in posterior part of umbonal cavity, well behind umbones
Ventral pallial line	markedly deflected	straight to deflected	straight	nearly straight
Intestine	straight	counterclockwise loop or vertically S-shaped or straight	straight	very short recurrent loop, S-shaped or straight
Mantle lobes on anterior half of ventral side	fused, very small pedo-byssal gape	separate, pedo-byssal gape very long	separate, pedo-byssal gape very long	separate, pedo-byssal gape very long
Valvular siphonal membrane	long and thin with papilla	short, with variable papilla	short, with small papilla	short, with or without papilla
Muscular longitudinal ridge on mantle lobes and visceral mass	present	absent	absent	absent
Posterior end of ligament	tapering	abrupt to tapering	tapering	abrupt
Subligamental shell ridge	strong and angular	faint to obsolete from umbone to middle, then missing, rarely more marked	faint to obsolete	faint to obsolete

DISCUSSION

Bathymodiolus mauritanicus n. sp. is the fourth species within a group of large mussels sharing several characters absent in other species of *Bathymodiolus* (see Table 3). Although the soft

parts of *B. mauritanicus* n. sp. are not available for study, shell shape and size and arrangement of the muscle scars firmly place it in this group, here termed the *Bathymodiolus childressi* group.

The group is quite homogenous, being clearly distinguished from most other *Bathymodiolus*

with short or moderately elongate shell (*B. aduroides* Hashimoto & Okutani, 1994, *B. azoricus* Cosel & Comtet, 1999, *B. brevior* Cosel, Métivier & Hashimoto, 1994, *B. brooksi* Gustafson, Turner, Lutz & Vrijenhoek, 1998, *B. elongatus* Cosel, Métivier & Hashimoto, 1994, *B. japonicus* Hashimoto & Okutani, 1994, *B. marisindicus* Hashimoto, 2001, *B. puteoserpentis* Cosel, Métivier & Hashimoto, 1994, *B. septem-dierum* Hashimoto & Okutani, 1994) by: 1) a terminal or almost terminal umbone; 2) a rather narrow anterior margin and broad posterior part giving the valves a more or less wedge-shaped outline; 3) the anterior retractor scar situated in the posterior part of the umbonal cavity; 4) a large multibundle posterior byssus retractor; 5) a continuous posterior byssus retractor scar which only in fully grown specimens occasionally tends to be interrupted by a short gap; and 6) a very small anterior adductor scar. Other features, such as presence or absence of a papilla on the valvular siphonal membrane or coiled or noncoiled digestive tract, seem to be variable and could not be verified for all species. For the differences within the *B. childressi* group, see Table 2.

In their work on some *Bathymodiolus* species, Craddock *et al.* (1995) showed that the genetic distances (Nei's D values) between *Bathymodiolus childressi* on the one hand and *B. heckerae*, *B. brooksi* and *B. thermophilus* on the other hand are not sufficient to separate *B. childressi* as a distinct genus. Accepting this, Gustafson *et al.* (1998) left *B. childressi* provisionally in *Bathymodiolus* but put the genus name in quotation marks. *Bathymodiolus mauritanicus* n. sp., *B. platifrons* and the Barbados *Bathymodiolus* sp. I are very likely to be other species of the *Bathymodiolus childressi* group, and on the grounds already cited by Gustafson *et al.* (1998), I leave *B. mauritanicus* n. sp. provisionally in the genus *Bathymodiolus*.

Some common characters may allow also to place a part of the other known *Bathymodiolus* species in three additional groups (see Table 3). They are briefly outlined here, but this suggestion is only tentative for the moment. Further research, including electrophoretic and molecular work, as

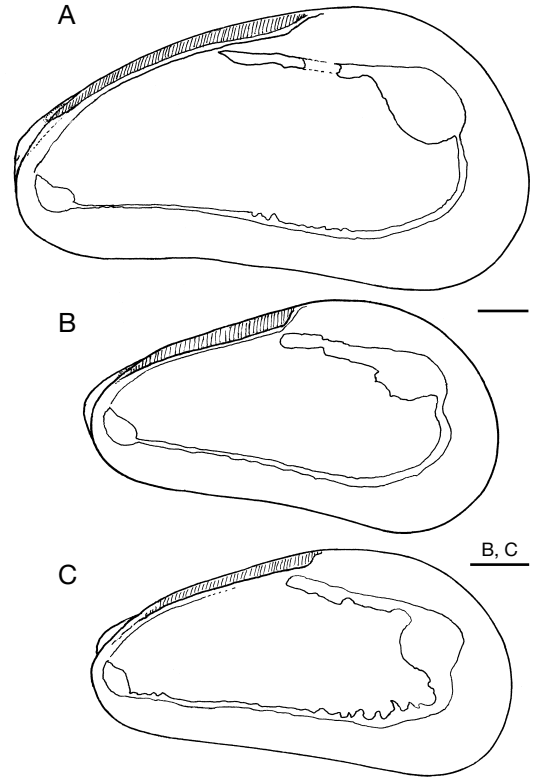


FIG. 4. — Half-schematic drawings of the insides of the right valves of *Bathymodiolus mauritanicus* n. sp.: A, holotype (MNHN); B, paratype (USNM); C, paratype (NSMT). Scale bars: 10 mm.

well as discovering of further sites with probably other mussel species will reveal if this grouping may stand:

— *B. thermophilus* group: *B. thermophilus*, *B. cf. thermophilus* from East Pacific Rise, 17°S. Shells modioliform, stout, variable, with subterminal umbones, very long valvular siphonal membrane and inner mantle lobes anteriorly fused, resulting in a small foot-byssus opening. Posterior retractor divided in two separate bundles, valvular siphonal membrane short. Eastern Pacific sites only;

— *B. brevior* group: *B. brevior*, *B. elongatus*, *B. marisindicus*, *B. puteoserpentis*, *B. septem-dierum*. Shells modioliform, stout to more slender, thin but rather robust, with subterminal umbones and anterior margin evenly and more or less broadly rounded. Posterior retractor divided in two sepa-

TABLE 4. — Comparison of the four *Bathymodiolus* species not assigned to groups.

	<i>B. azoricus</i> Cosel & Comtet, 1999	<i>B. brooksi</i> Gustafson, Turner, Lutz & Vrijenhoek, 1998	<i>B. japonicus</i> Hashimoto & Okutani, 1994	<i>B. aduloides</i> Hashimoto & Okutani, 1994
General shell form	stout to moderately elongate, modioliform, anterior margin broad	moderately elongate, modioliform, anterior margin broad	stout, somewhat wedge-shaped, anterior margin narrowly rounded	moderately elongate, modioliform, anterior margin narrow
Size	medium sized (to 119 mm)	large (to 166 mm)	medium-sized (to 106 mm)	medium-sized (to 96 mm)
Shell	thin but solid	thin and fragile	rather thick and solid	rather thick and solid
Position of umbones	subterminal but somewhat variable	subterminal	subterminal	well subterminal
Posterior retractor	two separate bundles	two separate bundles	two separate bundles	two separate bundles
Position of anterior part of posterior byssus retractor scar	under end of ligament	under end of ligament or more forward	at about 3/4 of ligament length	at about 3/4 of ligament length
Position of anterior byssus retractor scar in umbonal cavity	in anterior part of umbonal cavity, beneath umbone	in posterior portion of umbonal cavity, behind umbone	in anterior part of umbonal cavity, beneath umbone	in anterior part of umbonal cavity, beneath umbone
Ventral pallial line	straight to deflected	slightly deflected in byssal gape region	slightly to markedly deflected	deflected parallel to ventral margin
Intestine	counterclockwise recurrent loop	straight	straight	one clockwise loop
Papilla on valvular siphonal membrane	present to indistinct	present but small	absent	absent
Muscular longitudinal ridge on mantle lobes and visceral mass	absent	absent	absent	absent
Posterior end of ligament	abrupt to shortly tapering	tapering	shortly tapering	abrupt
Subligamental shell ridge	obsolete to middle of ligament, then missing	obsolete	missing	faint to obsolete

rate bundles, valvular siphonal membrane short. Atlantic, Indian Ocean and western Pacific sites; — *B. heckerae* group: *B. heckerae*, *B. boomerang*. Shells large, thin and very elongate, with subterminal umbones, protruding anterior part and well rounded anterior margin. Posterior retractor divided in two bundles, valvular siphonal membrane short. Atlantic sites;

— *B. childressi* group: *B. childressi*, *B. mauritanicus* n. sp., *B. platifrons*, *Bathymodiolus* sp. I (Barbados). Shells stout, wedge-shaped, thin to thick, with ter-

minal or almost terminal umbones, narrowly rounded anterior margin, continuous multibundle posterior retractor and short valvular siphonal membrane. Atlantic and western Pacific sites.

All characters of these groups are listed in Table 3. The species *Bathymodiolus aduloides* (western Pacific), *B. azoricus* (Atlantic, Mid-Atlantic Ridge), *B. brooksi* (Atlantic) and *B. japonicus* (western Pacific) are rather close to the *brevior* group, but more different from it than the species of the group among themselves, therefore they

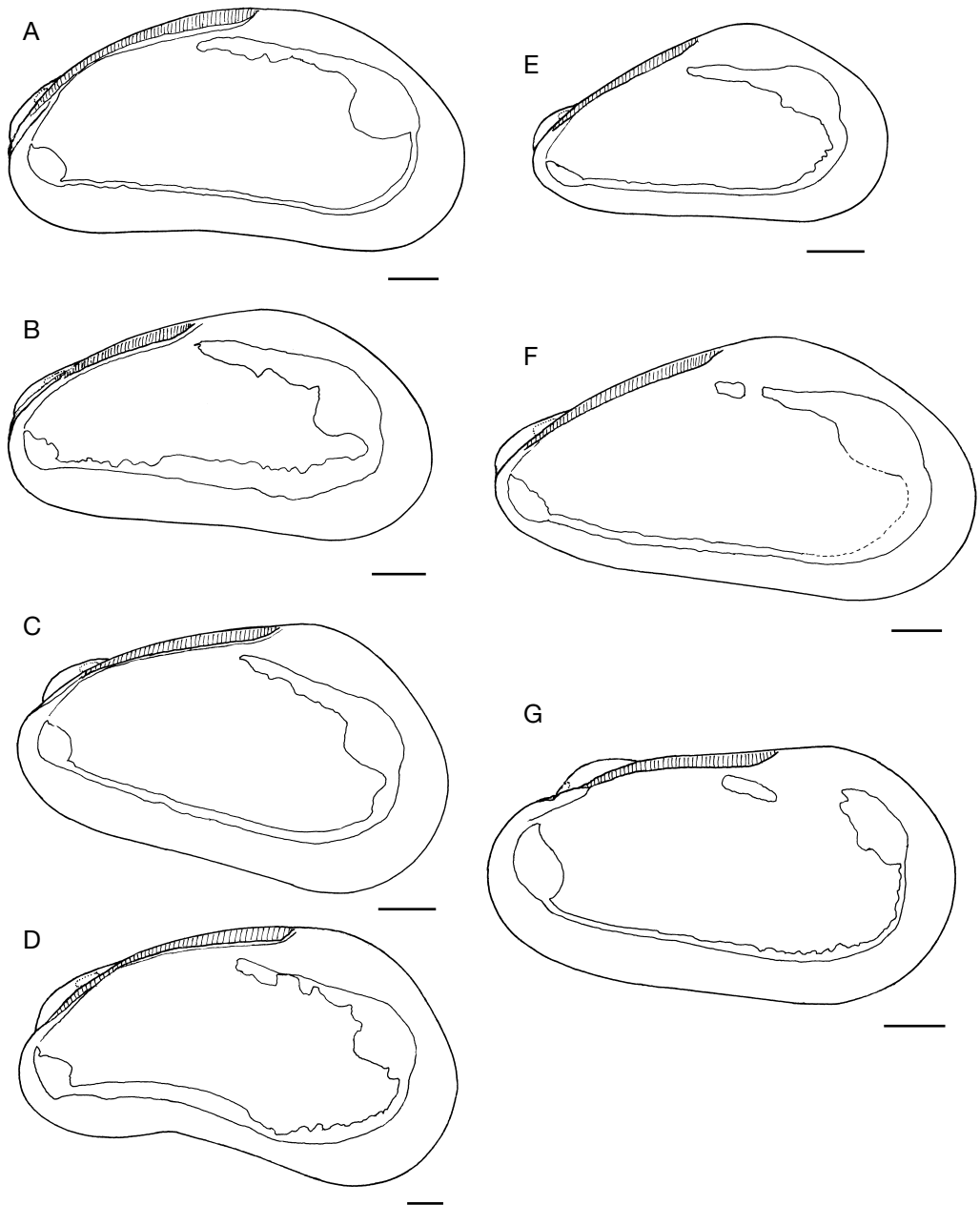


FIG. 5. — Half-schematic drawings of the insides of the right valves of *Bathymodiolus* species; **A**, *Bathymodiolus childressi* Gustafson, Turner, Lutz & Vrijenhoek, 1998, paratype 3137-21 (MNHN), Green Canyon-272, Louisiana continental slope, 27°41.1'N, 91°32.2'W, 723 m, Johnson Sea-Link-1 cruise, dive 3137; **B**, *Bathymodiolus childressi* Gustafson, Turner, Lutz & Vrijenhoek, 1998, paratype 3129-52 (MNHN); **C, D**, *Bathymodiolus* sp. I, Barbados Accretionary Prism, Orénoque site, 1688 m, Diapisub cruise, stn DS 05; **E**, *Bathymodiolus platifrons* Hashimoto & Okutani, 1994, paratype II (MNHN); **F**, *Bathymodiolus platifrons* Hashimoto & Okutani, 1994, paratype I (MNHN); **G**, *Bathymodiolus puteoserpentis* Cosel, Métivier & Hashimoto, 1994, “Les Ruches” site, Snake Pit hydrothermal field, MAR, 23°22'N, 47°57'W, 3478 m, HYDROSNAKE cruise, stn HS 10 (MNHN) (for comparison). Scale bars: 10 mm.

TABLE 5. — List of the described and some non-described species of *Bathymodiolus* (in alphabetical order). In bold, hot vent species; standard, cold seep and hydrocarbon seep species.

Species	Localities where the species was found
<i>B. adulooides</i> Hashimoto & Okutani, 1994	Sagami Bay; Minami Ensei Knoll (28°23.5'N, 127°38.4'E, 679 m) and Iheya Ridge, Mid-Okinawa Trough, 27°33.0'N, 126°58.1'E, 1389 m)
<i>B. azoricus</i> Cosel & Comtet, 1999	Mid-Atlantic Ridge: Menez Gwen (37°50'N, 850 m); Lucky Strike (37°17.6'N, 32°16.5'W, 1635-1725 m)
<i>B. brevior</i> Cosel, Métivier & Hashimoto, 1994	Vaillii hydrothermal field, Valufa Ridge, Lau Basin (22°12'-23°13'S, 176°37'-176°43'W, 1700-1750 m); N-Fiji Basin (16°59'-18°50'S, 173°29'-173°55'W, 1000-2750 m)
<i>B. boomerang</i> Cosel & Olu, 1998	Barbados Accretionary Prism (10°19.64'N, 58°53.35'W, 1697 m)
<i>B. brooksi</i> Gustafson, Turner, Lutz & Vrijenhoek, 1998	Gulf of Mexico, hydrocarbon seeps (26°21.3'N, 94°29.7'W, 2222 m; 27°46.9'N, 91°30.4'W; 546 m); W. Florida Escarpment (26°02'N, 84°55'W, 3270-3314 m)
<i>B. childressi</i> Gustafson, Turner, Lutz & Vrijenhoek, 1998	Gulf of Mexico (26°21.3'N, 94°29.7'W, 2222 m; 27°50'N, 92°10'W, 650 m)
<i>B. elongatus</i> Cosel, Métivier & Hashimoto, 1994	"Mussel Valley", North Fiji Basin (18°50'S, 173°29'W, 2765 m)
<i>B. heckerae</i> Gustafson, Turner, Lutz & Vrijenhoek, 1998	West Florida Escarpment, cold sulphur seep (26°02.2'N, 84°54.5'W, 3314 m)
<i>B. japonicus</i> Hashimoto & Okutani, 1994	Sagami Bay; Minami Ensei Knoll, Mid-Okinawa Trough (28°23.4'N, 127°38.5'E, 710 m)
<i>B. marisindicus</i> Hashimoto, 2001	Rodriguez Triple Junction, Kairei hydrothermal field, Indian Ocean (25°19.16'S, 70°02.40'E, 2442 m; 25°19.17'S, 70°02.40'E, 2432 m)
<i>B. mauritanicus</i> n. sp.	Off Banc d'Arguin, Mauritania (18°41'N, 16°45'W, about 1200 m)
<i>B. platifrons</i> Hashimoto & Okutani, 1994	Sagami Bay; Izena Caldron, Mid-Okinawa Trough (27°16'N, 127°05'E, 1340 m)
<i>B. puteoserpentis</i> Cosel, Métivier & Hashimoto, 1994	Mid-Atlantic Ridge: Snake Pit (23°22'N, 47°57'W); Broken Spur (29°10'N, 3080 m); Logatchev hydrothermal field (14°45'N, 44°58'W, 2930-3063 m)
<i>B. septendierum</i> Hashimoto & Okutani, 1994	Suyo Seamount (28°34.2'N, 140°38.6'E, 1371 m) and Mokuyo Seamount, NW Ogasawara, E-margin of Philippine Plate (28°18.9'N, 140°34.0'E, 1256 m)
<i>B. thermophilus</i> Kenk & Wilson, 1985	Galapagos Rift (00°47.89'N, 86°09.21'W, 2495 m; East Pacific Rise (9°30.9'N, 104°17.7W-12°48.6'N, 103°47.3'W, 2515-2630 m)
<i>Bathymodiolus</i> cf. <i>thermophilus</i>	South East Pacific (17-19°S) unpublished, MNHN
<i>Bathymodiolus</i> sp. I (under study by Cosel & Olu)	Barbados Accretionary Prism (10°19'N, 58°53'W)
<i>Bathymodiolus</i> sp. II (under study by Cosel & Marshall)	New Zealand, E of North Island, cold seep (40°0.8'S, 178°16'E, 1170 m)
<i>Bathymodiolus</i> sp. III (under study by Cosel & Olu)	Off northern Angola
<i>Bathymodiolus</i> sp. IV (cited by Hashimoto & Horikoshi 1989)	Kaikata Seamount, NW-Pacific
<i>Bathymodiolus</i> sp. V (cited by Craddock <i>et al.</i> 1995)	Mariana Trough (18°12.8'N, 144°42.5'E, 3589 m)

are not included therein. They are listed with their characters in Table 4.

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