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Large Vesicomyidae (Mollusca: Bivalvia) from cold seeps in the Gulf of Guinea off the coasts of Gabon, Congo and northern Angola

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Abstract:

Two new genera and three new species of large Vesicomyidae are described from cold-seep sites on pockmarks and other sulfide-rich environments in the Gulf of Guinea (tropical east Atlantic) off Gabon, Congo (Brazzaville) and northern Angola, from 500 to 4000 m depth: "*Calyptogena*" (s.l.) *regab* n. sp., *Wareniconcha* (n.g.) *guineensis* (Thiele and Jaeckel 1931), *Elenaconcha guiness* n.g. n. sp., and *Isorropodon atalantae* n. sp. For two other species already taken by the R/V *Valdivia* in 1898, *Calyptogena valdiviae* (Thiele and Jaeckel 1931) and *Isorropodon striatum* (Thiele and Jaeckel 1931) new localities were discovered, and the species are rediscussed. *E. guiness* n.g. n.sp. is also recorded from off Banc d'Arguin, Mauritania, collected by commercial fishing vessels. The vesicomyid species here treated were encountered in different depth ranges along the Gabon–Congo–Angola margin, between 500 and 4000 m depth, and it was found that, in comparison with the dredge samples taken by the *Valdivia* expedition off southern Cameroon and off Rio de Oro (both at 2500 m), the same species occur in other depth ranges, in some cases with a vertical difference of more than 1000 m. .That means that the species are not confined to a given depth thought being typical for them and that the characteristics of the biotope are likely to play a major role in the distribution of the vesicomyids associated to cold seeps or other reduced environments along the West African margin.

Keywords: Vesicomyidae; Cold seeps; Gulf of Guinea; Eastern Atlantic; Systematics; New Taxa

Abbreviations: BZ, BIOZAIRE cruises; CP, beam trawl; KGS, Usnel type box corer; MNHN, Muséum national d'Histoire naturelle, Paris; PL, dive of the ROV; ROV, remote-operated vehicle (Victor 6000); SMNH, Swedish Museum of Natural History, Stockholm; ZMB, Museum für Naturkunde (formerly Zoologisches Museum) der Humboldt-Universität Berlin; ZR, ZAIROV cruise; lv, left valve; rv, right valve; sh, dead-collected specimen with both valves; spm, live-collected specimen; v, single valve

1. Introduction:

The deep water veneroid bivalve family Vesicomyidae is quite divers and still far from well known, especially in its supraspecific taxonomy but also on species level (Krylova & Sahling, 2006, therein a detailed account of the history of vesicomyid taxonomy). The size range goes from species of millimetric size (e.g. the type species *V. atlantica* E.A. Smith 1885) to very large species up to 26 cm such as *Calyptogena (s.l.) magnifica* Boss & Turner 1980. All Vesicomyidae are associated with hydrothermal vents, cold seeps and other reducing sediments or organic remains, they are chemosymbiotic and host sulphide-oxidizing chemoautotrophic bacteria in their gills (Boss & Turner, 1980, Fiala- Medioni & Felbeck, 1990, Fisher, 1990, Bennett et al., 1994, Cosel & Salas, 2001, Krylova, 2002, Krylova & Sahling, 2006). The other known chemosymbiotic bivalve families are Solemyidae, Manzanellidae, Mytilidae, Lucinidae, Thyrasiridae and Teredinidae.

Of the almost 100 described and named species of Vesicomyidae, 13 were yet reported from the eastern Atlantic, most of them from cold seeps and reducing sediments off tropical West Africa (11 species), but some also from the eastern Mediterranean and the northeastern temperate Atlantic (Boss, 1970; Cosel & Salas, 2001). The first five species of large vesicomyids from the eastern Atlantic were taken in 1898 by the German R/V *Valdivia* off West Africa, three species in the Gulf of Guinea and two from off Rio de Oro (NW-Africa), they were published by Thiele & Jaeckel (1931) at a time when hot-vent and cold-seep biotopes and the special ecology of the family were still not known. Only very recently, other Vesicomyidae, this time smaller species, were discovered in the West African realm: one species off Pointe-Noire in 150-200 m and three others off the Mauritanian coast in 900-1200 m (Cosel & Salas, 2001). During recent cruises in the course of the Ifremer/TOTAL ZAIANGO and BIOZAIRE programs on cold-seep sites on pockmarks and other deep sites more or less close to the deep Congo river channel in the Gulf of Guinea (Sibuet et al., 2002; Ondréas et al., 2005; Olu-Le Roy et al, 2007a), several unknown large Vesicomyidae were taken, as well as also the species already known from the *Valdivia* material, for which new localities were detected. One species of these is monographed elsewhere by the present authors (Cosel & Olu, 2008), the six remaining large vesicomyid species are treated herein, among them two new genera and three new species. In this new context, the *Valdivia* material is rediscussed.

2. Material and methods

The material was obtained during the Ifremer-TOTAL collaboration projects ZAIANGO and BIOZAIRE on cold seeps and at deep stations in the vicinity of the Congo channel off the coast of Gabon, Congo and northern Angola. It was collected during the cruises ZAIROV (P.I. H. Ondréas), BIOZAIRE 1, BIOZAIRE 2 (P.I. M. Sibuet) and BIOZAIRE 3 (P.I. A. Khripounoff) by the R/V "*Atalante*" with the ROV *Victor 6000* and by means of an USNEL type box corer ("KGS" in sample lists) for macrofauna. During BIOZAIRE 3, a 6 m-beam trawl ("CP" in sample lists) dedicated to megafauna sampling was employed. The material was sorted on board and in the Laboratoire Environnement Profond of IFREMER, Brest.

The sampling sites include different pockmarks characterized by methane-rich fluid emissions. The most known cold-seep site is a giant isolated pockmark, named REGAB, situated 8 km north of the Congo channel at a depth of 3150 m (Fig. 1). It is related to a deep buried paleo-channel identified by previous geophysical studies (Gay et al., 2003). It was investigated by the ROV *Victor*, giving the ground thrusting for fluid escape features (Ondréas et al., 2005), chemical characterisation of seeps (Charlou et al., 2004) and chemosynthetic communities distribution (Olu-Le Roy et al., 2007a). Large quantities of methane are released in the water column and methane hydrates were sampled in the sediment and on the seafloor. Two species of large Vesicomyidae co-occur with the mussel *Bathymodiolus aff boomerang* (Olu-Le Roy et al., 2007b) and the siboglinid tubeworm *Escarpia southwardae* Andersen, Hourdez, Marie, Jollivet, Lallier & Sibuet 2004 as large size symbiont bearing species forming habitats for macrofauna assemblages. A smaller pockmark, ASTRID, situated 80 km north to the Congo channel and about 100 km from the REGAB site at a depth of 2820 m, was explored during only one *Victor* dive. It was colonised by bushes of *E. southwardae*, and some clusters of empty vesicomyid shells were also observed. Very few samples and environmental data are available for this site.

The second main cold-seep site, named GUINESS, is situated along the Gabon margin between 580 and 670 m depth. It comprises several pockmarks, smaller and less active than that of the REGAB site. *Victor*'s dives revealed that most of them were presently inactive with carbonate precipitation and old bivalve shells, but seepages were observed on two of the pockmarks sustaining small (about 1m diameter) but dense vesicomyid clusters covered by microbial mats. Contrary to the REGAB site, where both large vesicomyid species typical for that site co-occur in the same clusters, the clusters sampled in the GUINESS area were monospecific. The two vesicomyid species occurring on GUINESS were sampled on two different pockmarks situated 2 km apart.

Four pockmarks previously identified from multibeam backscatter were surveyed during a *Victor* dive in the MPS 1 area situated about 50 km north to the Congo canyon (fig 1) at a depth of about 1500 m. However, no living chemosynthetic communities but only empty vesicomyid shells were observed on the bottom. Several other pockmarks were surveyed and sampled by the ROV *Victor* at the "BSR" (Bottom Simulating Reflector) Congo site, corresponding to the area where this reflector, visible on seismic profiles and underlying the hydrate layer, reaches the seafloor, between 750 and 800 m depth.

Further samples were obtained at two sites, situated close (ZD) or far (ZC) from the Congo channel. These deep stations, which were sampled using the beam trawl and the USNEL box corer, are situated along the 4000 m isobath respectively at 200 km and 15 km south of the Congo channel. Initially, they had been chosen to evaluate the influence of channel overflows on the benthic communities and not for a particular geological setting favouring methane seepages.

Of the live-collected vesicomyid specimens, an important part was already dissected on board and the tissues were preserved and used for biochemistry purpose or molecular research. A part of the remaining specimens were frozen before preserving which made the tissues more fragile. The specimens with soft parts are now part of the MNHN collection (for some species only few material) and will be used for detailed anatomical work in the future. In this paper, soft parts anatomy is only covered roughly. A visit at ZMB Berlin allowed examining the vesicomyids collected by the R/V *Valdivia* on the West African coast. – The denomination of hinge teeth follows Krylova & Sahling, (2006: fig. 2)

Abbreviations used in the text:

BZ	BIOZAIRE cruises
CP	beam trawl
KGS	Usnel type box corer
MNHN	Muséum national d'Histoire naturelle, Paris
PL	dive of the ROV
ROV	remote operated vehicle (*Victor 6000*)
SMNH	Swedish Museum of Natural History, Stockholm
ZMB	Museum für Naturkunde (formerly Zoologisches Museum) der Humboldt-Universität Berlin
ZR	ZAIROV cruise
lv	left valve
rv	right valve
sh	dead-collected specimen with both valves
spm	live-collected specimen
v	single valve

3. Systematics

Order Veneroida H. & A. Adams 1856

Superfamily Glossoidea Gray 1847

Family Vesicomyidae Dall & Simpson 1901

Genus *Calyptogena* Dall 1891

Type species: *Calyptogena pacifica* Dall 1891 (by monotypy)

Diagnosis and comments on the genus: see Krylova & Sahling (2006: 362).

Calyptogena valdiviae (Thiele & Jaeckel 1931)

Figs. 2 (A-G); 3 (A-I); 4 (A-I), 5 (A-F), 6 (A-B), 29(A-B)

Vesicomya valdiviae Thiele & Jaeckel, 1931: 229, pl. 9 (4), fig. 101.

Calyptogena valdiviae – Boss, 1970: 69, figs. 3, 4, 22, 25.

Calyptogena valdiviae – Krylova & Sahling, 2006: 372-374, figs 10-13 (there more citations).

Vesicomya longa Thiele & Jaeckel, 1931: 229, pl. 9 (4), fig. 103

Vesicomya (Archivesica) longa – Boss, 1970: 72, figs. 11, 23, 26

"Vesicomya" longa – Cosel & Salas, 2001: 363, fig. 106

Type material: *Vesicomya valdiviae*: lectotype ZMB Moll. 101 598a, a complete sh. (selected Boss, 1970: 69), *Valdivia* sta. 33; Rio de Oro; paralectotypes: 31 v. (ZMB Moll. 101 598b) same locality. 6 other paralectotypes (ZMB Moll. 101 599) from *Valdivia* sta. 103, off Agulhas Bank, 35°10.5'S, 23°02'E, 500 m, could not be examined by Boss (1970: 70) but are cited by Krylova & Sahling (2006: 372).

Vesicomya longa: holotype ZMB Moll.101 601, a rv, *Valdivia* sta. 33, Rio de Oro; paratypes: 5 v and 2 broken v (ZMB Moll. 101 602), *Valdivia* sta. 63, off Campo, Cameroon, 2°N, 8°043.3'E, 2492 m.

Type locality: "230 km E of Morro Garnet", Rio de Oro, West Sahara, 24°35.3'N, 17°4.7'W, 2500 m (*Valdivia* sta. 33, selected Boss, 1970)

Other material examined: Gabon: off Cap Lopez, **GUINESS** site: BIOZAIRE 2, ROV PL 148-11, 1°34.64'S, 8°32.90'E, 670-579 m, 9 spm., 7 sh. (live-collected); **MPS 1** site, Congolese slope (NE of REGAB site): 5°28'S, 10°58'E, 1490-1520 m, ZAIROV 2, sta. KZR 30, 1 lv. ("*longa*" form).

Description (refers to the specimens from BIOZAIRE): Shell medium-sized, to 64 mm long (up to 73 mm, according to Krylova & Sahling, 2006), very variable in outline (l/h ratio 1.34-1.53), from oval-oblong to elongate-elliptical, moderately thick to very thick and heavy, moderately tumid to very inflated, equivalve. Anterior margin broadly and evenly rounded. Ventral margin slightly to markedly convex. Postero-dorsal margin almost straight, postero-dorsal corner indistinct to rounded, posterior margin more or less evenly rounded. Antero-dorsal margin straight to slightly concave in the lunular area. Umbones strong and protruding; beaks prosogyrous, well in front of the vertical midline, situated at the first fourth of the valve.

Surface dull to glossy, with numerous strong and densely spaced, more or less irregular commarginal wrinkles and striae, growth lines and growth stages. Lunular incision well marked to indistinct, escutcheon deeply to very deeply inset, reaching from the umbones over the whole length of the postero-dorsal margin almost to the location of the postero-dorsal corner. Posterior angle indistinct to obsolete. Periostracum thin, dark brownish, dull, eroded mostly on the postero-dorsal half (when sticking out of the sediment) or on the middle part and persistent on the anterior and ventral part of the valves, where on fully grown specimens it may become slightly wrinkly or leafy near the margins.

Hinge line broad and strong, posterior to the beaks considerably arched, with strong and somewhat variable teeth. Right valve with a rather small but thick and protruding lower anterior cardinal (1), which is only slightly divergent from the antero-dorsal margin and with its upper end somewhat posterior to the umbo. Upper anterior cardinal 3a more or less thick at the anterior end, in ascending becoming more laminar, starting in front of the middle part of cardinal 1, ascending towards the umbo posterior to the beaks and then curving posteriorly around tooth 1 to be fused with the broad cardinal 3b which descends downwards and backwards. It consists of two almost parallel lamellate edges on both sides of a broad and shallow depression. Posterior lamellate edge of 3b very short and sometimes almost knob-like.

Left valve anteriorly with a strong and somewhat variable cardinal 2a ascending towards the umbo, where its tip is fused with the strong and prominent cardinal 2b, with which it forms an inverted "V". Posterior to it, after a narrow but deep socket to accommodate the 3a and 3b, the strong and almost horizontal, rather thick posterior cardinal 4b. Posterior nymphal ridge in the right valve rather thick to laminar. Ligament external, opisthodetic, short, strong, on a short and strong nymphal plate which posteriorly ends abruptly. No subumbonal pit. Pallial line slightly divergent from the ventral margin, more distant at the anterior part than at the posterior part, Pallial sinus absent, but an inflexion of the pallial line at the antero-ventral end of the posterior adductor scar may be regarded as a very shallow sinus. Anterior pedal retractor scar small, more or less shallow but well marked, situated on the ventral side of the anterior part of the hinge plate, separate from the anterior adductor scar. Inside of the valves with faint radial striae, stronger near the ventral margin, towards the interior often obsolete. Shallow ridge from the umbonal cavity to just in front of the posterior adductor scar.

Valves porcellanous white.

Ctenidia large, thick and fleshy, slightly longer than half the shell length (36 mm in a 62 mm specimen), with one demibranch with descending and ascending lamellae on each side. Mantle cavity ventrally open from the anterior adductor to the base of the inhalent siphon. Siphons very short, with numerous very small tentacles. Foot muscular, moderately long, laterally compressed, with a long base.

[here Table 1]

Distribution: Known from off Rio de Oro, West Sahara and the Gulf of Guinea from Cameroon to just north of the Congo river Canyon; Agulhas Bank.

Biotope:

Calyptogena valdiviae was observed living in clusters on moderately active pockmarks with cold seeps of the GUINESS area at 670-579 m. The specimens are buried in the sediment with the posterior half or third sticking out over the bottom surface (Fig. 30 a). On one of the pockmarks, they were found in small but dense clusters. Fluid emissions are much less active than on the REGAB pockmark and most of the sites are characterised by carbonate concretions and old shells and debris, evidence of past seepages. Nevertheless localized fluid emission sustain a very patchy distribution of the vesicomyids which are covered by microbial mats (Fig 30 a). Methane concentrations in one of the clusters was equivalent to those measured in vesicomyid beds at the periphery of the REGAB pockmark (1 µM, JC Caprais, unpubl.). *C. valdiviae* co-occurs in the GUINESS area with *Elenaconcha guiness* n.g. n.sp, described in this paper. However, these two species form mono-specific clusters on two separate pockmarks, with a distance of about 2 km between the two.

Remarks: This species belongs to the genus *Calyptogena* in the strict sense as defined by Krylova & Sahling (2006). Hinge configuration and other characters are the same as in the type species *C. pacifica* Dall 1891. *C. valdiviae* is a widespread and variable species. The type lot was taken by the *Valdivia* off NW Africa (Rio de Oro, West Sahara), a site still northward from the well known cold seep site W of Banc d'Arguin, Mauritania (Cosel & Salas, 2001; Cosel, 2002). The close-looking *"Vesicomya" longa* Thiele & Jaeckel 1931 was synonymized by Krylova & Sahling (2006) with *C valdiviae* because both "fall within the usual range of the intraspecific variation of vesicomyids". For the moment we follow this view of Krylova & Sahling, pending molecular analysis. Like *C. valdiviae*, *"V." longa* was also described from off Rio de Oro, but the paratypes were taken from the Gulf of Guinea in a presumably cold seep area off Campo, Cameroon at a depth of 2492 m. They were found there together with three other vesicomyid species: *"Vesicomya" chuni*, Thiele & Jaeckel 1931 *"V." guineensis* Thiele & Jaeckel 1931 and *"V."striata* Thiele & Jaeckel 1931. Up to now, the *"longa"* form was the only *C. valdiviae* known from the Gulf of Guinea. In our material from the Congo-Gabon area, only one old valve of the *longa* form was found in a piston core in 50-54 cm sediment depth at the site MPS 1 (NE of REGAB, 5°28'S – 10°58'E, ZAIROV 2, sta. KZR 30) in about 1500 m, however, the "normal" short form of *C. valdiviae* was common on the GUINESS site. This material differs from the type material from Rio de Oro by the often still thicker, shorter and stouter and more tumid shells, but it falls well into the variability of this species. The type lot of *C. valdiviae* without any doubt comes from a population separate from the Gulf of Guinea population. In its shell shape it is intermediate between the GUINESS population and the *longa* form. The *longa* form was collected together with *C. valdiviae* off Rio de Oro, whereas off Cameroon it was found alone and on both localities only as old valves. So, also because of the sparse sampling without any collecting of live animals (which is often the case in these deepwater faunas), we do not really know if the *longa* form occurs somewhere close or together with the "nominate" form. If further sampling reveals that there is a continuity in the range of morphotypes and if molecular analysis show their affinity (and gene flow) the assumption of the presence of one single species would be confirmed. So, for a definite answer to the question if *"V" longa* remains in the synonymy of *C. valdiviae*, more and live-collected material of *"V". longa* (or the *longa* form) will be necessary. - The cited locality for *C. valdiviae* off Agulhas Bank (*Valdivia* sta. 103) seems still to be isolated from the other localities, but the depth (500 m) corresponds to the depth of *C. valdiviae* on the GUINESS site (570-600 m).

"Calyptogena" (s.l.) ***regab* n. sp.**

Figs. 6 (C-D), 7 (A-I), 8 (A-I), 9 (A-F), 10 (A-C). 29 (C-F)

Type material: Holotype MNHN 20542, N of Congo Canyon, REGAB site, 5°57.85'S, 9°42.7'E, 3140-3170 m, ZAIROV 2, taken by ROV *Victor* PL 74-14 (GBT2), 1 live collected spm (animal dissected on board and not available for study). Paratypes: same locality, 5°47.78'S, 9°42.65'E, 3151-3159 m, BIOZAIRE 2, ROV PL 147, 5 spm (1 with soft parts), 1 sh MNHN 20543; same locality, 5°47.89, 9°42.64, BIOZAIRE 1, ROV PL 81-5, 1 spm, 1 sh MNHN 20544; same locality, 5°46.89'S, 9°44.65'E, 3159-3113 m, trawled R/V *Atalante*, BIOZAIRE 3, CP 20, 1 sh MNHN 20546.

Type locality: SW of Congo (Brazzaville) Republic, REGAB site, N of Congo Canyon, , 5°57.85'S, 9°42.7'E, 3140-3170 m.

Other material examined: SW of Congo (Brazzaville) Republic, **REGAB** site , BIOZAIRE 2: ROV PL 145-8, 5°47.98'S, 9°42.47'E, 3152-3151 m, 1 spm; leg. M. Sibuet. BIOZAIRE 3: 5°46.89'S, 9°44.65'E, 3159-3113 m, trawled R/V *Atalante*, CP 20, 2. I. 2004, numerous sh., v. and fragm. CP 19, 5'48.07S, 9°41.61'E, 3155-3184 m., 1 sh., several fragm., all MNHN. **ASTRID** site, same region, ZAIROV 2, ROV PL 73-13(GBT1), 4°57'S, 10°09.5'E, 2820-2840 m, 2 old v. N-Angola, W of Ambrizete, **ZC** site: trawled R/V *Atalante*, CP 14, 7°42.41'S, 10°08.39'E, 4001-4017 m, several larger fragments, 24.XII.2003. MNHN

Description: Shell large, to 122 mm long, considerably variable in outline, elongate-oval (l/h ratio 2.12-2.59), very thin-shelled to thin, fragile, moderately inflated, irregularly equivalve, frequently more or less twisted to the left. Anterior margin broadly rounded. Ventral margin slightly to markedly convex, occasionally almost straight in its middle part or even concave in the posterior half. Postero-dorsal margin almost straight, postero-dorsal corner rounded, posterior margin tapering and more or less narrowly rounded in the middle or more posterior-ventrally. Antero-dorsal margin slightly sloping. Umbones short but protruding; beaks prosogyrous, well in front of the vertical midline, situated at the first fourth of the valve.

Surface chalky, with fine and densely spaced, irregular commarginal striae and small lamellae, growth lines and stages. No lunule and no escutcheon. Posterior angle very broad, weak to obsolete. In several specimens on the posterior third or fourth or on the posterior slope commarginal, broad, wave-like undulations, mostly 2 or 3, in juvenile spms. only one, well reflected on the interior. Periostracum rather thin, dark brownish, dull, eroded on the postero-dorsal half and persistent on the antero-ventral part of the valves, where it becomes slightly leafy near the margins.

Hinge line very narrow, only slightly arched, with relatively small teeth, slightly variable (see drawings). Right valve with a small but rather thick and protruding lower anterior cardinal (1), which is almost parallel to the antero-dorsal margin and with its upper end just beneath the umbo. Cardinals 3a and 3b assumed to be fused: upper anterior cardinal 3a short, with anterior end directly under the umbo and behind and above the posterior end of cardinal 1, then curving posteriorly and downwards to be fused with the cardinal 3b posterior of it, which is larger and protruding but narrow and parallel to the ventral margin of the hinge plate, just behind the umbo. Left valve anteriorly with a short, somewhat variable cardinal 2a ascending towards the umbo. Behind this, directly beneath the umbo the vertical, broadly-triangular and promenent cardinal 2b, which is more or less fused with the posterior tip of 2a. Posteriorly to it, after a narrow but deep socket to accommodate cardinal 3b, the short to somewhat longer, laminar posterior cardinal (4b). No posterior nymphal ridge. Ligament external, opisthodetic, short, strong, on a short and broad nymphal plate which posteriorly ends abruptly. In some specimens, a structure like a small and shallow subumbonal pit is visible (Fg. 6 (C, D), but in others not, and the area is covered by a lamellar ligament layer. Pallial line close to the ventral margin, no pallial sinus, but occasionally a shallow inflexion of the posterior side of the pallial line is present (Fig. 9 C, F). Anterior adductor scar united with the anterior pedal retractor scar, the latter small and rather deep. Inside of the valves with faint, irregularly and rather widely spaced radial striae.

Valves chalky white, inside white, with light brownish hue under the beaks and in the middle of the valve.

Ctenidia elongate, with only one very thick and hypertrophied demibranch (the inner demibranch), which occupies about half the shell length (51 mm in a 99.3 mm spm), outer demibranch absent. On the ventral edge of the demibranch very shallow and narrow food-groove. Exhalent siphon very short, with small, short tentacles. Inhalent siphonal "tube" not a closed tube but open to the mantle cavity on its ventral side. Margins of inhalent siphon with close-set short tentacles on both sides towards antero-ventrally, then passing abruptly into the inner mantle fold, which is smooth. Mantle cavity ventrally open from in front of the the anterior adductor to the base of the exhalent siphon (Figs 10 B; C). Foot muscular, thick at the base, more or less laterally compressed.

[here Table 2

Distribution: Known only from two pockmarks REGAB and ASTRID, north of the Congo Canyon, Gulf of Guinea.

Biotope:

Active pockmarks with cold seeps, from 2600 to 3170 m.

"Calyptogena" (s.l.) *regab* is one of the two large vesicomyids encountered on the REGAB site. The specimens live partly buried in the sediment together with the other large species *Laubiericoncha chuni* (see below) in the periphery of the pockmark (Fig. 30 a, b), or in monospecific agglomerations in the central active part of the pockmark (Fig. 30 f). Vesicomyids were observed in the whole area of the 800 m-diameter pockmark, but like the *Bathymodiolus* and siboglinid vestimentiferan worms, the living clusters of vesicomyids were found being located along a SW-NE direction probably corresponding to a deep fault favouring fluid emissions. Outside of this active area, they

form about 1m-diameter clusters of dead shells. The vesicomyids are mostly distributed at each extremity of the active area, forming large (50x100m) fields of living and dead clusters (mean density was 51.5 in living clusters) in H_2S-rich soft sediment. They also form small clusters with high densities (up to 600 ind./m²) in the central and most active part of the pockmark. The vesicomyids were found being associated with lower methane fluxes than the mytilids (Olu-le Roy et al., 2007a). On the less explored pockmark ASTRID, only clusters of empty vesicomyid shells (both species) were observed. However, living siboglinid bushes colonised this site, which is less active as shown by lower methane concentrations above the bottom (J.L. Charlou, unpubl. data). On REGAB, methane concentrations close to vesicomyids in the clusters of *C. regab* was 4.4 µM in the central part of the pockmark, and 1 µM in clusters dominated by *L. chuni* at the periphery of the site (Olu-Le Roy et al., 2007a). The turrid gastropod *Phymorhynchus* sp., abundant among vesicomyids in the more peripheral clusters of the pockmark is a potential predator of both vesicomyid species.

Derivation of name: after the REGAB site where the species was taken, noun in apposition.

Remarks: This species is only provisionally placed in the genus *Calyptogena* (s.l.), the genus name is placed in quotation marks. It is not a *Calyptogena* in the strict sense as defined by Krylova & Sahling (2006), and it is distinguished from this genus by several characters: the thin shell, the larger size (122 mm vs. 90 mm), the narrow hinge plate, the absence of an escutcheon and of a posterior nymphal ridge and the tapering posterior part with posterior end in or just below the horizontal midline. However, one of the main distinguishing characters is the ventrally open inhalent siphonal tube. This feature was first discovered by E. Krylova and was communicated on several meetings on deep sea and reducing sediments (Krylova, pers. comm.). Moreover, the hinge dentition is also different from *Calyptogena*: in the right valve, the 3a tooth is situated above and behind the posterior end of the tooth 1, at its posterior end, the 3b is fused with the anterior tip of the 3a, giving the teeth a more linear configuration, whereas in *Calyptogena*, the anterior part of the 3a tooth is situated in front of tooth 1 and more parallel to it. In the left valve, however, the configuration is more approaching *Calyptogena*: the narrow 2a tooth is fused with the broad and roughly triangular 2b in the same way, only the 4b tooth is situated in a greater distance to 2a. Common characters with *Calyptogena* are the absence of a pallial sinus, the single demibranch on each side and the deep anterior pedal retractor scar. More thorny is the question of the subumbonal pit. In some specimens, among them the holotype, such a structure is clearly visible, very shallow, short, only slightly longer than the 4b tooth but sometimes somewhat excavated mostly in its anterior part with a sharlpy delimited dull and chalky surface and with horny ligament in it. In other specimens, this structure is hardly visible or seems to be absent. The shell outline closely reminds a *Pleurophopsis* Van Winkle 1919 as figured in Keen in Moore (1969: N663), and most shell characters listed for this fossil genus by Krylova & Sahling (2006, table 12) also correspond to our species.

A close-looking Recent species is *Ectenagena elongata* (Dall 1916), the type species of the genus *Ectenagena* Woodring 1938, from off the west coast of California at about 500 m depth. It has a similar elongate shell but is much smaller (44 mm (Dall, 1916) and 50 mm (Coan et al., 2000)) versus 122 mm of *"C."*(s.l.) *regab*. Furthermore, both species have in common the rather thin and not markedly inflated shell, the absence of a pallial sinus, of a posterior nymphal ridge and of lunule and escutcheon. Differences of *E. elongata* to *"C"* (s.l.) *regab* are the slightly broader hinge plate, the still less prominent umbones and the shallow anterior pedal retractor scar which in *"C"* (s.l.) *regab* is deep. In both species, the 3b tooth is present but in *"C"*(s.l.) *regab* it is often thinner. However in contrast to *"C"*(s.l.) *regab* the 3a tooth is absent ("completely reduced", Krylova & Sahling, 2006) in *E. elongata*. The hinge dentition of *"C"*(s.l.) *regab* is not linear as e.g. in the genus *Isorropodon* but diverging. However, as already mentioned, in the right valve a tendency towards a more linear arrangement of the teeth can be observed (see Fig 6 C). This more linear hinge teeth arrangement as well as the absence of a pallial sinus and of a posterior nymphal ridge may suggest a closer relationship to *Isorropodon*, but, as in most other Vesicomyidae, in *Isorropodon*, the inhalent siphonal tube is closed along the ventral side and not open.

Chiefly this ventrally open inhalent siphonal tube may lead to the erection of a new genus for *"C."* (s.l.) *regab* but as the soft parts of *E. elongata* have not yet been observed (Krylova & Sahling, 2006), a final decision of the position of *Ectenagena* versus “*C*” (s.l.) *regab* cannot be taken. We therefore refrain from giving *“C."* (s.l.) *regab* a separate generic status and provisionally leave the new species in *Calyptogena* (in the large sense), pending molecular results and a revision of this species in a greater context.

Wareniconcha n. g.

Type species: *Vesicomya guineensis* Thiele & Jaeckel 1931, monotypic

Derivation of name: -- This genus is dedicated to our colleague Anders Warén from SMNH in acknowledgement for long-time collaboration and for his work on molluscs of hot vents and cold seeps.

Distribution. -- Eastern Atlantic: cold seeps in the Gulf of Guinea.

Diagnosis: Shells medium-sized, rather compressed, short-oval with well convex ventral margins, and forward-pointing, rather prominent umbones situated in the first fourth of the valves or even more forward. Anterior and posterior margin narrowly rounded. Lunular incision often indistinct, escutcheon narrow and sunken. Hinge line narrow and strongly arched, in the right valve with a strong and protruding cardinal 1 and a small and short laminar cardinal 3a, which under the umbones is fused with the rather broad cardinal 3b with a shallow depression in its middle. Left valve with a short cardinals 2a and behind it the broadly-triangular and promenent cardinal 2b, more or less fused with the upper (posterior) tip of 2a. Cardinal 4b longer and laminar. Ligament external, opisthodetic, short and strong. Subumbonal pit present but variable in size. Actual pallial sinus absent, however, a very shallow inflexion of the pallial line near the vertical end of the posterior adductor scar could be considered as such. Pallial line parallel to the ventral margin. Anterior pedal retractor scar small and deep. Ctenidia rather short but high, fleshy, with only one demibranch. Blood with haemoglobin. Siphons short, fused, inhalent siphonal tube longer and somewhat thinner than exhalent siphon, both with strong and thick tentacles.

Remarks: The main differences of *Wareniconcha* to *Calyptogena* s. str. are the typical high-oval veneriform shell outline with the much narrower but strongly bent hinge plate and narrowly rounded anterior and posterior margins, the thinner and less inflated shell, the absence of a posterior nymphal ridge, the presence of a subumbonal pit, the presence of hemoglobine in the blood and the siphonal tubes with short but stout and thick tentacles, especially around the inhalent siphon. The hinge teeth configuration is roughly the same as in *C. valdiviae*: in the right valve. the 3b tooth is almost paralle to the 3a, but the anterior part of the 3a tooth is shorter and does not go very far over the dorsal tip of the tooth 1, which is thinner than in *C. valdiviae*. In the lv, 2a, 2b and 4b have about the same form and arrangemant than in *C. valdiviae*. Other common features with *Calyptogena* are the single demibranch on each side and the deep anterior pedal retractor scar.

The separation as a different genus is first based on the entirely different shell form. No other of the known vesicomyid genera has this shape. Other veneriform Vesicomyidae such as *Waisiuconcha* have a less tapering and more evenly rounded posterior margin and are more tumid. *Pliocardia* Woodring 1925 may have a shell form with tapering posterior part, but this genus has no subumbonal pit. Precisely the subumbonal pit is another differentiating character, it is present in two others of the West African species:

Elenaconcha n. g. (see next entry) and *Laubiericoncha chuni* but both are different in other key characters (see Table 7). Of the 12 vesicomyid genera examined by Krylova & Sahling (2006), 5 are known to develop a subumbonal pit, but all these have more elongate shell forms or other characters which distinguish them from *Wareniconcha.*

***Wareniconcha guineensis* (Thiele & Jaeckel 1931) nov. comb.**

Figs. 11 (A-J), 12 (A-F), 13 (A-F), 14 (A-D), 29 (G-H)

Vesicomya guineensis Thiele & Jaeckel, 1931: 229, pl. 9 (4), fig. 102

Vesicomya(Vesicomya) guineensis -- Boss, 1970: 71-72, figs. 5-6, 18-19

Type material: Lectotype (selected Boss, 1970: 71), Cameroon, W of Campo, 2°00'N, 8°4.3'E, 2492 m, 1 complete sh., ZMB Moll. 101 600. 3 paralectotypes,single valves, same locality.

Type locality: W. of Campo, Cameroon, Bight of Biafra, Gulf of Guinea, *Valdivia* sta. 63, 2°00 N, 8°043.3'E, 2492 m.

Other material examined:. Cameroon: W of Campo, Valdivia sta. 63 (type locality), associated spm., a juv. broken lv, (reg. n° ZMB 103 769). Congo (Brazzaville) Republic: WSW, N of the Congo Canyon, **ZD** site, BIOZAIRE 1, in box-corer, KGS 26, 5°50.95'S, 8°20.48'E, 3949 m, 1 spm., 9.I.2001; BIOZAIRE 2: in box-corer, KGS 41, 5°51.00'S, 8°20.00'E, 3970 m, 6 sh., 26.XI.2001, all leg. M. Sibouet; BIOZAIRE 3, trawled R/V *Atalante*, CP 10, 5°51.10'S, 8°21.51'E, 3977-3956 m, 5 spm., 15 sh., 12 v., numerous fragm.; CP 11; 5°51.76'S, 8°21.06'E, 3978-3956 m, 1 spm., 7 sh., 11 partly chipped v., numerous fragments, 24. XII. 2003. CP 12, 5°51.76'S, 8°21.06'E, 3975-3958 m, 1 spm., 9 sh, 14 v., numerous broken sh and fragm., 20. XII. 2003. W of Ambrizete, N-Angola, **ZC** site, BIOZAIRE 3, trawled R/V *Atalante*, CP 14, 7°42.41'S, 10°08.39'E, 4001-4017 m, , 3 spm, 9 sh., 11 occ. chipped v., numerous fragm, 24.XII.2003; **REGAB** site, BIOZAIRE 3, trawled R/V *Atalante,* CP 20, 5°46.89'S, 9°44.65'E, 3159-3113 m, 1 sh., 1 old sh with solidified mud, 2.I.2004; CP 15, 5°50.99'S, 9°43.93'E, few fragm.28.XII.2003,. all MNHN.

Description: Shell medium sized, to 76 mm long, quite variable in outline, more or less short-oval (l/h ratio 1.20-1.45), distinctly veneriform, moderately thick-shelled but fragile, rather compressed, equivalve. Anterior margin somewhat obliquely truncated in the middle, otherwise broadly rounded. Ventral margin markedly convex to almost semicircular. Posterior margin tapering and narrowly rounded, postero-dorsal margin slightly convex. Antero-dorsal margin slightly sloping. Umbones small and not much protruding; beaks prosogyrous, well in front of the vertical midline, situated about at the first fourth of the valve.

Surface with numerous fine and very densely spaced, somewhat irregular commarginal striae and very small lamellae, growth lines and stages. Lunular incision present but often poorly marked to indistinct, escutcheon very narrow and sunken, but not too deep. Posterior angle broad and ill-defined. Periostracum very thin, straw-coloured, dull, persistent but sometimes eroded on the earlier or umbonal part of the valves.

Hinge line narrow, strongly arched, slightly variable (see drawings). Right valve with a strong and protruding lower anterior cardinal (1), which with its upper end is just beneath the umbo. Upper anterior cardinal 3a laminar, more or less short, starting in front of the upper (posterior) end of cardinal 1, ascending towards the umbo and then curving posteriorly around tooth 1 to be fused with the rather broad cardinal 3b which descends downwards and backwards to beneath the anterior tip of the ligament. Tooth 3b consisting of two almost parallel to subparallel lamellate edges on both sides of a rather broad and rather deep to very deep depression, the posterior lamellate edge of 3b rather long and narrow. Sometimes both lamellar edges closer together, making the 3b tooth more narrow. Left valve anteriorly with a moderately short, somewhat variable cardinal 2a ascending towards the umbo, almost vertical to the longitudinal shell axis. Behind this the broadly-triangular and promenent cardinal 2b, which is more or less fused with the upper (posterior) tip of 2a. Posteriorly to it, after a deep and rather broad socket to accommodate cardinal 3b, the longer, laminar posterior cardinal (4b). Ligament external, opisthodetic, short, strong, on a short and broad nymphal plate. Subumbonal pit shallow and narrow, faintly to well marked of variable length, from slightly shorter to more than tree times the length of cardinal 4b. Pallial line parallel to the ventral margin, rather close to the ventral margin, no real pallial sinus but a small and sharply angular embayment between pallial line and posterior adductor scar, with a more or less wide angle. Anterior adductor scar well separate from the small and deep anterior pedal retractor scar. Inside of the valves smooth.

Valves chalky white, inside porcellanous white.

Animal reddish with haemoglobin in the blood. Ctenidia short but high, with one thick and hypertrophied demibranch on each side, a little less than half the shell length (23 mm in a 49.5 mm specimen and 29 mm in a 60 mm specimen). Food groove very shallov and hardly seen. Mantle cavity ventrally open from the anterior adductor to the base of the inhalent siphon. Siphons short, inhalent siphon longer, with short but large, stout and thick tentacles, in the preserved specimen with smaller diameter. Exhalent siphon with shorter and thinner tentacles. Foot rather thin and moderately long, almost circular in diameter.

[here Table 3]

Distribution: Gulf of Guinea between southern Cameroon (Campo) and northern Angola (Ambrizete).

Biotope: :

The biotope of the living specimens of *W. guineensis* sampled during the BIOZAIRE program at two sites in 4000 m depth, close (15 km) to and far (200 km) from the Congo channel was not observed by ROV. The specimens were taken with beam trawl and USNEL box corer in soft sediment, they were not found associated with particular geological settings. However, the occurrence of deep buried paleo-channels of the Congo is not excluded as the vesicomyids are densely distributed in this part of the margin (T. Marsset & H. Ondréas, pers. com.). Methane-rich fluids may come from these buried channels originating from organic matter-rich turbidic deposits.

No methane was recorded in the sediment sampled with multitube corer deployed from the ship. We expected methane in the cores if cold seeps would effectively occur, but due to the lack of accurate positioning of the multitube corer and without a ROV dive, we were not able to characterize the chemical environment at the exact spot where the *Wareniconcha* were taken. Another explanation for the presence of large vesicomyids at these stations could be large accumulations of fresh organic matter originating, at ZD, from Congo channel overflows that seem to be frequent at these depths (Khripounoff et al., 2003) or accumulations at the base of the slope at ZC. Indeed, large pieces of vegetals were collected in the same trawl hauls together with the vesicomyids. The presence of haemoglobin in the blood of *Wareniconcha* indicates an adaptation to the low oxygen concentration or to high level of sulphide. Nevertheless, if sulphide is necessarily present to sustain the symbionts of this species, its origin can be related to methane fluid emissions like at other cold-seeps occurring on pockmarks in the area or to organic matter accumulations.

It is to note that at ZC several specimens of an undescribed large species of a deep-burrowing solemyid bivalve (*Acharax* n. sp) were contained in the same hauls with the vesicomyids.

Remarks: As for the genus.

Genus ***Elenaconcha*** n. g.

Type species: *Elenaconcha guiness* n. sp. described herein, monotypic.

Derivation of name. -- This new genus is dedicated to our colleague Elena Krylova, one of the leading specialists in Vesicomyidae and other hot vent and cold seep bivalves.

Distribution. -- Eastern Atlantic: cold seeps in the Gulf of Guinea and off Banc d'Arguin, Mauritania.

Diagnosis: Shells medium-sized, very thick-shelled, elongate-tageliform, with subparallel to parallel dorsal and ventral margins, rather compressed, with small, prosogyrate umbones situated in front of the vertical midline. Anterior and posterior margin rounded. Lunule and escutcheon present and well developed. Umbones rather flattened and not prominent. Hinge of right valve with a long, strong and almost straight cardinal 1. Cardinal 3a long and with the anterior lamellate edge of 3b forming an U-shaped structure around tooth 1, posterior lamellate edge of 3b small; left valve with the anterior cardinals 2a and 2b, oblique, subparallel and more or less fused at their upper end under the beaks, posterior cardinal 4a rather small. Posterior multiple"nymphal ridges" with several additional fine, more or less irregular and often somewhat laminar ridges behind the anteriormost nymphal ridge. Ligament long and very strong, external. Subumbonal pit present, rather small. Pallial line under the posterior adductor scar bent upwards and meeting the scar about in the middle of its lower margin, thus forming a short and inflexion with the scar with a sharp and wide angle, but not a real pallial sinus. Pallial line almost parallel to the ventral margin. Anterior pedal retractor scar deep to very deep. Ctenidia with only one demibranch. Siphons very short, inhalent siphon with numerous short and very thin tentacles, exhalent siphon with fewer and shorter tentacles.

Remarks: At sea and in preliminary reports the type species was often treated as "*Archivesica* sp." but this genus is different from *Elenaconcha* in many aspects: it has a higher and more tumid shell, a shallow and broad pallial sinus and a rather narrow hinge plate. *Elenaconcha* is distinguished from other large vesicomyan genera by the very heavy and thick-shelled valves with the very broad hinge plate and hinge dentition in combination with a rather compressed shell. With their oval-oblong outline, the broadly rounded anterior and posterior margins and the very shallow umbones, the valves somehow remind those of a *Tagelus*, a shallow water soft bottom dwelling bivalve. A main reason for placing *Elenaconcha* in a separate genus is the fact that the hinge plate not only has a posterior nymphal ridge on the right valve but that there are multiple thin secondary "posterior nymphal ridges" and irregular shorter ridges intercalated in both valves, a unique character which to our knowledge is not seen in any other vesicomyid. The hinge teeth of *Elenaconcha* are divergent, but in comparison with *Calyptogena valdiviae* the anterior hinge teeth are much more prolonged and the anterior teeth situated in a lower angle to the longitudinal shell axis: in the right valve, tooth 1 is very long and strong, 3a is also prolonged, whereas 3b is small, shorter and more vertical. In the left valve, the fused 2a and 2b are oblique-U-shaped, whereas 4b is also shorter and more vertical than in *Calyptogena*. *Calyptogena* is rather close it shares with *Elenaconcha* the single demibranch, the shell size and thickness, the pallial line with absence of a "real" sinus but a small inflexion of the pallial line at the posterior adductor scar, and the impression of the retractor of the intersiphonal septum. However, apart from the already mentioned characters, the compressed shell and the "tageliform" outline distinguish it. The subumbonal pit of *Elenaconcha* is shared with *Phreagena*, *Ectenagena*, *Archivesica*, *Akebiconcha*, *Callogonia*, *Wareniconcha* n. g. and *Laubiericoncha*, and the very small, triangular inflexion of the pallial line to join the posterior adductor scar is also seen in *Wareniconcha* n.g., *Pliocardia, and Akebiconcha* (that of *Archivesica* is shallow but broad). However, none of these has secondary ridges on the hinge plate neither the peculiar shell shape as *Elenaconcha*.

Elenaconcha guiness n. sp.

Figs. 15 (A-I), 16 (A-I), 17 (A-E), 18 (A-D), 19, 20 (A-G), 29 (I-J)

Type material: Holotype MNHN 20546, a complete sh, live-collected, Gabon, off Cap Lopez, GUINESS site, 1°33.72'S, 8'33.49'E, 595-439 m, BIOZAIRE 1, ROV PL 83-7. 8 paratypes, same locality, complete sh, live collected, MNHN 20547.

Type locality: off Cap Lopez, Gabon, GUINESS site, 1°33.72'S, 8'33.49'E, 595-439 m.

Other material examined: Gabon, off Cap Lopez, GUINESS site, 1°33.72'S, 8'33.49'E, 595-439 m, BIOZAIRE 1, ROV PL 83-7, 16 spm; 1°34.64'S, 8°32.90'E, 670-579 m, BIOZAIRE 2, ROV PL 148-11, 4 spm, 8 juv. sh, 5 v. Mauritania: off Banc d'Arguin, 18°41'N, 16°45'W, 900-1200m, 13 spm and sh (all live collected, see remarks), 3 in MNHN, the others in the private collections Swinnen and Deniz Guerra.

Description: Shell moderately large, to 70 mm long, rather elongate, oval-tageliform, very variable in l/h ratio (1.88-2.46), very thick and heavy, somewhat compressed. Anterior margin quite broadly rounded. Ventral margin in its middle part straight or slightly concave. Posterior margin broadly rounded, rarely with a visible postero-dorsal corner. Antero-dorsal and postero-dorsal margin slightly sloping, postero-dorsal margin weakly convex. Umbones very shallow and hardly protruding; beaks prosogyrous, well in front of the vertical midline, just behind the first third of the valve.

Surface with rather broad, shallow and very irregular commarginal waves, wrinkles and some growth stages. Lunule long and narrow, sometimes slightly broader on the left valve, delimited by a rounded keel which may be more or less indistinct. Escutcheon long, over the whole postero-dorsal margin, narrow and rather deep, delimited by a rather sharp to slightly rounded keel. Posterior angle at the end of the escutcheon, weak to obsolete. Periostracum rather thin, light brownish, dull, stronger on the posterior part of the shell and eroded on the earlier parts, along the posteroventral margin becoming leafy. Periostracum eroded in a different way also on the posterior end which is not buried but exposed the seawater, leaving a chalky surface.

Hinge line strong and broad, arched under the beaks. Right valve with a lower anterior, long and strong, cardinal 1, which with its ventral end starts parallel to the antero-dorsal margin, then weakly curves upwards and ends slightly in front of the beaks, but directly pointing to them. Upper anterior cardinal 3a narrow, long, parallel to the anterior margin, ascending towards the umbo, then curving around the upper end of the tooth 1 to be fused with the broad cardinal 3b which descends downwards. It consists of two lamellate edges on both sides of a broad and shallow depression. Anterior lamellate edge of 3b almost parallel to tooth 1, posterior lamellate edge short and broad, descending vertically or only slightly inclined towards ventrally, beneath the anterior end of the ligament with posterior limit almost vertical. Left valve anteriorly with the long, strong and almost straight linear tooth 2a ascending towards the umbo, then sharply curving down and forward in the shorter and thicker cardinal 2b; upper end ("curve") just under the umbo. Posteriorly to it, after a deep socket for cardinal 3b the shorter and posteriorly ill-defined, almost vertical posterior cardinal 4b. Posterior nymphal ridge present, behind it on both valves hinge plate continuing being very broad, with irregular, inclined laminar sculptures parallel to the nymphal ridge along the ligament length, appearing as additional "multiple" nymphal ridges which towards posterior become more and more horizontal, often more irregular and merged and sometimes becoming dense, irregular wrinkles. Ligament external, opisthodetic, rather short, very strong, on a well developed, more or less broad and strong nymphal plate which posteriorly ends abruptly. Small subumbonal pit present. Pallial line posteriorly slightly closer to the ventral margin than anteriorly. Pallial line ending in the middle of the posterior adductor scar forming a very short and indistinct inflexion with the scar with a sharp but rather wide angle, but not a real pallial sinus. Anterior pedal retractor scar deep to very deep, well separated from the anterior adductor scar. Inside of the valves with very faint, irregular and rather widely spaced radial striae, mostly near the pallial line.

Valves dirty white, with a brownish hue near the umbones and fading away beneath them towards ventrally. Inside pure porcellanous white.

Ctenidia with one thick and fleshy demibranch on each side, rather slender, with length of more than half the shell length (44.5 mm x 14.5 mm in a 68.4 mm specimen). Food groove narrow, in the preserved specimens not always well visible. Blood without haemoglobine. Mantle cavity ventrally open from the anterior adductor to the base of the inhalent siphon. Siphons very short, inhalent siphon broad, with numerous short tentacles, exhalent siphon slightly shorter and with smaller diameter, with tentacles of about the same size. Foot short, with a long base, laterally somewhat compressed, with a rounded ventral keel.

[here Table 4]

Distribution: Cold seeps off the coast of tropical West Africa. Known from the GUINESS site SW of Cap Lopez, Gabon,in the Gulf of Guinea and from presumed seeps off Banc d'Arguin, Mauritania.

Biotope:
E. guiness was observed in living clusters on moderately active pockmarks with cold seeps at 670-579 m. Within the clusters they live often more or less scattered about 2/3 buried in the sediment, only the posterior third is visible (Fig. 30 b, c). *E. guiness* occurs together with *C. valdiviae* in areas with moderate and very localised fluid emissions. Nevertheless both species were observed living in separate clusters which are located on two different pockmarks about 2 km apart. However, juvenile shells and a few living juvenile specimens were also found in a cluster dominated by *C. valdiviae*. This suggests that *C. valdiviae* and

E. guiness may have different requirements for sulfide, as observed for other vesicomyid species living in the same type of cold seep sites (Barry et al., 1997; Goffredi & Barry, 2002). Methane concentrations measured in one of the clusters covered by microbial mats (Fig 30b) were high (9.4 – 30.1 µM) (JC Caprais, unpubl. data) compared to other vesicomyid clusters on GUINESS (*C. valdivia*e) or REGAB, and equivalent to concentrations measured in mytilid beds on REGAB (Olu-Le Roy et al., 2007a). In this cluster, most of the specimens of *E. guiness* had almost the same size, suggesting the existence of only one cohort probably linked to recent seepage re-activation. Nevertheless, at another site (Fig 30 c), the seeps seem to be less active with no microbial mats. At this site, a large spider crab was observed as a potential predator of *E. guiness*.

Derivation of name: After the site GUINESS in the Gulf of Guinea, where the species was first collected. Noun in apposition.

Remarks:
This species is unique among the Vesicomyidae, the very thick and heavy elongate shell and the peculiar hinge line with somewhat a sort of multiplication of the posterior hinge teeth or posterior nymphal ridges distinguish it from any other vesicomyid bivalve. The species shows a remarkable growth allometry. Very juvenile specimens are short-oval-veneriform, then the shell outline becomes with growth gradually more elongate-veneriform and finally tageliform with the broadly rounded anterior and posterior margin. Of the "additional" posterior nymphal ridges, only very few are present in the juveniles, the others appear one after the other with growth (Figs 19; 20 (A)-(D)).

Besides the Gulf of Guinea population there exists a second population on presumed cold seeps near the Mauritanian coast off Banc d'Arguin at about 18°41'N, 16°45'W, said to be from 900 to 1200 m depth. The specimens were taken by a commercial fishing boat trawling for deep water shrimps, together with *Bathymodiolus mauritanicus* Cosel 2002 and four other vesicomyid bivalves, among them *Isorropodon curtum* Cosel & Salas 2001 and

Callogonia mauritanica Cosel & Salas 2001 (see Cosel & Salas, 2001). These presumed cold seeps sites have not yet been exploited scientifically, and the material appeared only subsequently on the collectors' shell market. The specimens from Mauritania are quite variable, from significantly more slender (l/h ratio 2.46) than the GUINESS site specimens to higher and shorter (l/h ratio 1.96) and thus being within the variety range of the GUINESS specimens (l/h ratio 1.88 to 2.13), with all kinds of intermediates. They attain almost the same size, although in average they are slightly smaller. In spite of the differece in depth (900-1200 m off Mauritania vs 600 m in the Gulf of Guinea), we consider the Mauritanian population falling within the variability of *E. guiness* n. sp., pending molecular analysis.

Genus *Laubiericoncha* Cosel & Olu, 2008

Type species: *Laubiericoncha myriamae* Cosel & Olu, 2008, by original designation.

Diagnosis, see Cosel & Olu (2008: 931)

***Laubiericoncha chuni* (Thiele & Jaeckel, 1931)**

Fig. 21 (A-D), 29 (K-L)

Vesicomya chuni Thiele & Jaeckel, 1931: 228, pl. 9 (4), fig. 100.

Vesicomya (Callogonia) chuni – Boss, 1970: 68-69, figs. 1, 2, 21, 24.

"Vesicomya" chuni – Cosel & Salas, 2001: 356-358, figs 74-75, 96-97, 107.

Laubiericoncha chuni – Cosel & Olu, 2008: 936-942, figs. 3, 4, 5A,B, 7B,C

Type material. -- Lectotype ZMB, (reg. N° ZMB Moll.77848a), lv (selected Boss, 1970: 68), 1 paralectotype, same locality, rv, same N° ZMB Moll.77848a, trawled R/V *Valdivia*. The numerous additional valves from the same locality (ZMB Moll. 77848b) were not mentioned by Boss (1970) apparently he may not have seen them. These valves are also paralectotypes.

Type locality: W of Campo, Cameroon, 2°00'N, 8°4.3'E, 2492 m.

Description and measurements: see Cosel & Salas (2001) and Cosel & Olu (2008)

Distribution: Gulf of Guinea from Ghana (4°56'N), Cameroon (2°N) to the Congo Canyon (REGAB site, 5°46'S).

Material examined: cruises BIOZAIRE 1, BIOZAIRE 2: REGAB site, taken by ROV *Victor*. BIOZAIRE 3, REGAB site, trawled R/V *Atalante*, CP 20, 5°46.89'S, 9°44.65'E, 3159-3113 m, few spm., numerous sh. + v (for details, see Cosel & Olu, 2008).

Biotope: This is the other large vesicomyid sampled on the REGAB pockmark together with "*Calyptogen* "(s.l.) *regab* and with up to 120 mm the largest vesicomyid of the West African Margin (for details, see above under that species and in Cosel & Olu (2008).

Remarks: This species belongs to *Laubiericoncha* Cosel & Olu, 2008, a new vesicomyid genus described very recently. From all species here treated, it is principally distinguished by its gills with two demibranchs on each side and by the thin shell with the posteriormost point on or above the horizontal midline and a well developed pallial sinus. Other distinguishing features are marked on Table 7.
&

Genus *Isorropodon* Sturany 1896

Type species: *Isorropodon perplexum* Sturany 1896, by monotypy.

Diagnosis: see Cosel & Salas (2001: 343).

Isorropodon atalantae n. sp**.**

Figs. 22 (A-H), 23 (A-D), 24 (A-C), 28 (A-B); 29 (M-N)

Type material: Holotype MNHN 20548: REGAB site, 5°46.89'S, 9°44.65'E, 3159-3113 m, a complete sh., BIOZAIRE, 3 CP 20, trawled R/V *Atalante*, 2. I. 2004. Paratypes: same locality: paratype 1, an old subrecent sh with solidified mud on it; paratype 2, a rv; paratype 3, a subrecent, slightly chipped lv with hinge region of rv adhering by solidified mud, MNHN 20549.

Type locality: SW of Congo (Brazzaville) Republic, REGAB site N of Congo Canyon, 5°46.89'S, 9°44.65'E, 3159-3113 m.

Material examined: The type material only.

Description: Shells medium-sized, to almost 47 mm long, little variable in outline (l/h ratio 1.37-1.40), oblong-oval, thin but rather strong, well inflated, equivalve. Anterior margin evenly but narrowly rounded. Ventral margin well convex, often in its middle part less convex and parallel to the dorsal margin (Fig. 22 (A-B), (C-D)). Dorsal margin behind umbones slightly convex, postero-dorsal corner rounded but distinguishable, posterior margin broadly tapering and narrowly rounded in the middle. Antero-dorsal margin sloping. Umbones somewhat globose and protruding, pointing forward, parallel to the longitudinal shell axis; beaks prosogyrous, well in front of the vertical midline, situated at the first fifth of the valve.

Surface chalky, with fine and densely spaced, irregular commarginal growth lines and stages. Lunule short and broad, delimited by a well-marked lunular incision, escutcheon deep but limits rounded and indistinct. Postero-dorsal area with two shallow and rounded ridges, the more ventral of them being the posterior angle, the more dorsal forms part of the delimitation of the escutcheon. Periostracum not seen in the examined specimens.

Hinge line short, well arched. Right valve with a very small and narrow but protruding, curved anterior tooth (1) parallel to the inside margin, a long and narrow, almost thin and laminar tooth 3a and a short, very narrow and less high posterior tooth 3b. Tooth 3a running from above or over the end of the anterior tooth 1 backwards to beneath the anterior point of the ligament. Cardinals 3a and 3b not completely fused. Deep horizontal socket between the teeth. Left valve with a rather long and narrow undulate tooth parallel to the dorsal margin and situated below the umbo consisting of the fused short and laminar cardinal 2a and the longer but also laminar cardinal 2b and ending below the first third of the long and narrow but strong posterior cardinal 4b, situated parallel to the dorsal margin. Ligament external, opisthodetic, rather short, strong, on a short and broad nymphal plate which posteriorly ends abruptly. Pallial line close to the ventral margin, posterior pallial line under the posterior adductor scar slightly deflected inwards to almost straight, but not forming a pallial sinus. Anterior pedal retractor scar small, shallow but well marked, almost touching the anyerior adductor scar. Inside of the valves smooth.

Soft parts not seen.

[here Table 5]

Distribution: Known only from the REGAB pockmarks N of the Congo Canyon, Gulf of Guinea.

Biotope: On cold seeps, but only known from dead shells, rare.

Derivation of name: after the RV *Atalante* from which the species was taken.

Remarks: This species is in size, outline and tumidity strikingly resembling species of the genus *Pliocardia*, however, the hinge dentition is typically vesicomyid, that means parallel like in *Isorropodon* and *Callogonia* (Cosel & Salas, 2001; Krylova & Sahling, 2006) and different from that of *Pliocardia*, which have a diverging dentition (see Krylova & Janssen, 2006). This hinge in combination with the posterior pallial line without a defined sinus places the species without doubt in the genus *Isorropodon*. From the other known species of the genus, *I. atalantae* n. sp. is distinguished by the rather solid shell and the broadly tapering posterior margin with the typical broad radial depression on the postero-dorsal slope; the posterior margin of the other species of *Isorropodon* is evenly and more or less broadly rounded. - Behind *I. striatum* (see next entry), this is the second largest known *Isorropodon*.

Isorropodon striatum (Thiele & Jaeckel 1931)

Figs. 25 (A-E), 26 (A-C), 27 (A-C), 28 (C-G), 29 (O-P)

Vesicomya striata Thiele & Jaeckel, 1931: 230 (72), pl. 4, fig. 104.

Vesicomya (Vesicomya) striata Thiele & Jaeckel, 1931 - Boss, 1970: 73-74, fig. 11, 23, 26.

Isorropodon striatum - Cosel & Salas, 2001: 351-353, fig. 63-65 (holotype)

Type material: Holotype ZMB, (reg. n° ZMB Moll. 77811a, a live-taken spm, one valve broken. Soft parts (ZMB Moll. 77811b) separated from the shell and not seen.

Type locality: Niger Delta, Bight of Biafra, W of Campo, Cameroon (2,0°N/8°4,3'E), 2492 m.

Other material examined: WSW of Congo (Brazzaville) Republic, N of Congo Canyon, **ZD** site, BIOZAIRE 3, trawled R/V "*Atalante*"; CP 10, 5°51.10'S, 8°21.51'E, 3977-3956 m, 1 juv. spm; CP 11, 5°51.76'S, 8°21.06'E, 3978-3956 m, 1 broken sh., numerous fragments. CP 12, 5°51.76'S, 8°21.06'E, 3975-3958 m, 1 juv spm., 2 sh, 1 fragm., all 20. XII. 3003, leg. R. von Cosel, all MNHN. W of Ambrizete, N-Angola, **ZC** site, BIOZAIRE 3, trawled R/V "*Atalante*", CP 14, 7°42,41'S, 10°08.39'E, 4001-4017 m, 1 juv spm. 24.XII.2003, leg. R. von Cosel, MNHN.

Description: see Cosel & Salas (2001: 351).

[here Table 6]

Biotope: This species was collected by beam trawl from soft mud and vegetal debris on the two deep stations ZC and ZD together with *W. guineensis* and the solemyid *Acharax* n. sp. but is much rarer. It seems to require the same reducing conditions as the other two species.

Remarks: The large specimens collected on the site ZD are different in outline from the holotype of *I. striatum* (see Fig. 27 (A) and Cosel & Salas, 2001, fig. 63-65), with a l/h ratio of 1.41-1.55, they are slightly longer, the ventral margin is more straight, dorsal and ventral margin are almost parallel, and the posterior margin is more broadly rounded, giving these specimens a more "rectangular" appearance. In the holotype, the ventral margin is much more rounded and evenly convex, the posterior margin is also more evenly rounded. However, the two juvenile specimens from ZD and ZC are approaching the holotype in outline (Figs. 26 (B), 27 (B) and l/h ratio (1.26 and 1.39 vs. 1.35 in the holotype). Moreover, the specimens from BIOZAIRE are larger: the smaller specimen from CP 12 is 51.4 mm long with a tumidity 27.2 mm, the larger specimen has a shell length of 65.2 mm with a tumidity of 38.5 mm, another partly broken shell from CP 11 suggests almost 70 mm in length, the tumidity is 37 mm, the shell length of the holotype is 47 mm. As also observed in *Elenaconcha* (see above) we assume a certain growth allometry in this big *Isorropodon*, the largest *Isorropodon* currently known. Nevertheless and in spite of the different depth ranges of *I. striatum* from the *Valdivia* and our material from ZC and ZD, a vertical distance of 1500 m, we provisionally consider our specimens as falling within the variability of *I. striatum* unless more material and live-collected specimens of both "morphs" will become available.

4. Discussion

All Vesicomyidae here treated live on and around cold seeps or agglomerations of organic matters, and they have been found on different and well-defined depth ranges corresponding to the site or the series of sites where they have been sampled (500-1500m, 600m, 2800-3200m, 4000m; see Table 8, 9). It is known that species of *Calyptogena* and other large vesicomyid bivalves are normally confined to their proper depth ranges (Olu et al., 1996, Kojima and Ohta, 1997, Goffredi and Barry, 2002). However, this "rule" cannot be strictly maintained any more. The specimens collected by the R/V *Valdivia* consderably augment the depth ranges that were observed from the samples of the ZAIANGO/BIOZAIRE program. The *Valdivia* had sampled a live specimen of *I. striatum* and dead valves of *"Vesicomya" guineensis* on a site off southern Cameroon in 2500 m, whereas our specimens of those species come from the sites D and C in almost 4000 m, that means1500 deeper (Table 8). Moreover, the same sample of the *Valdivia* contained also valves of *"Vesicomya" chuni* which during our cruises was taken on the REGAB site in about 3100 m depth, about 600 m deeper than the depth in which the *Valdivia* samples were dredged. It is obvious that the *Valdivia* with only one dredge haul, by chance hit another site with large Vesicomyidae possibly near cold seeps, other reducing sediments or organic remains in the Gulf of Guinea, more northern and more eastern than our sites REGAB, ZC and ZD. Judging from the *Valdivia* catch, this site situated at intermediate depth with four species shows a higher diversity of vesicomyids than most of our sites. Furthermore, *C. valdiviae* that has been sampled by the *Valdivia* off West Sahara (Rio de Oro) at 2500 m and, in the "*longa*" form, also on the "famous" 2493 m site off southern Cameroon, whereas at GUINESS, during the

ZAIROV and BIOZAIRE cruises, the species was found confined to a depths more than 1800 m shallower.

Hovewer, slight differences between species in the *Valdivia* material and those from our material may indicate that there might be limited gene-flow or not at all that our populations are now isolated from that hit by the *Valdivia*. This is not sure and would have to be proved by DNA sequencing. With this, we could be able to test the role of bathymetric segregation in isolation and divergence of these species, as it has been suggested for the "*pacifica-lepta*" species complex in the Monterey Bay (Goffredi et al., 2003).

The large species of vesicomyids which co-occur in the same or in separate clusters of the two mainly explored cold-seep sites, REGAB and ASTRID (*L. chuni* and "C."(s.l.) *regab*) and GUINESS (*C. valdiviae* and *E. guiness*), are likely to have a different physiology regarding to sulfide, as already demonstrated for species living in the Monterey Bay (California) cold-seeps (Barry et al., 1997, Goffredi & Barry, 2002). This could explain the fact that *C. valdiviae* and *E. guiness* colonize different pockmarks within the GUINESS area, which may have different activities. Preliminary chemical characterization of the sampling sites obtained during the BIOZAIRE cruises suggested that "C."(s.l.) *regab* can be associated to higher methane fluxes than *L. chuni* (4.4 µM versus 0.9 µM), which dominates the clusters in the periphery of the REGAB pockmark (Olu-Le Roy et al., 2007a). A similar contrast was observed in the GUINESS area between a monospecific cluster of *E. guiness* located in areas of higher methane concentrations (9.4 to 30.1 µM) which also is colonised by dense microbial mats, and clusters of *C. valdiviae* (1 µM) (JC Caprais, unpubl.). Nevertheless, *E. guiness* was also observed in areas that seemed to be less active (Fig 30c). Further ecological studies are needed, particularly of sulfide concentrations or sulfide fluxes inside the sediment to explain the occurrence of pluriscpecific clusters in the REGAB site and the environmental factors that constrain the distribution of *L. chuni and* "C."(s.l.) *regab* in this giant pockmark which is characterised by a high habitat heterogeneity.

The family Vesicomyidae is very diverse in shell form, size and species number: up to now, 98 described and named Recent and Tertiary Vesicomyid species are recensed (Cosel, unpublished), however, there are still several unnamed species, most of them recently discovered with the growing knowledge of hot vents, cold seeps, hydrocarbon seeps and other reducing bottoms (e.g. whale carcasses and their surroundings); some of these species were already passed through DNA analysis. So, alone the number of living vesicomyid species is expected to be more than 100. Phylogenetic relationships were examined among some of these Vesicomyidae species using COI DNA sequences revealing cryptic species and inconsistencies with the attributions of the generic names *Calyptogena* and *Vesicomya*. (Vrijenhoek et al., 1994; Kojima et al., 1995; Peek et al., 1997).

Premilinary phylogenetic analyses of two of the species described in this paper, based on the COI mitochondrial gene, indicate that *C. valdiviae* is close to the *Calyptogena pacifica*/*Vesicomya lepta* cryptic-species complex (Olu-Le Roy et al., 2005). Its symbiont's 16S gene displays similar phylogenetic relationships (Nadalig et al. submitted), and is consistent with the co-speciation hypothesis. *C. valdiviae* could be the unique representative of the C. *pacifica/V.lepta* complex so far known in the Atlantic. However, the morphology, particularly the more elongated shell suggest that this *Calyptogena* is clearly distinct from the Pacific *pacifica*/*lepta* complex. closest relative of *"Calyptogena"* (s.l.) *regab*(Olu-Le Roy et al., 2005). However, *"C". magnifica* has two demibranchs (Boss & Turner, 1980), whereas in "C." *regab* only one is present.

The composition of the vesicomyid fauna in the Gulf of Guinea and, in a larger sense, the eastern Atlantic is surprisingly different from that of vesicomyid faunas from other regions of the world. Three of the species (*"C."* (s.l.) *regab*, *W. guineensis* and *E. guiness*) found in that area show combinations of characters which are exclusively known from species in the tropical eastern Atlantic, e.g. the multiple posterior nymphal ridges in *Elenaconcha*. This shows that many Vesicomyidae need very special biotopes which are quite isolated from each other. On the contrary, the fourth species in that fauna, *"Vesicomya" chuni*, is also quite distinct from other Vesicomyidae and likewise belongs to a new genus (described by Cosel & Olu, 2008, in press). However, in contrast to the other two new genera *Elernaconcha* and *Wareniconcha*, this genus is widely distributed: the four species definitively uncluded in the genus live each in a different of the large zoogeographical provinces: eastern Atlantic, western Atlantic, Panamic-Pacific Province, western Pacific. It is to note that, on the contrary to the amphiatlantic bathymodioline mussels (Olu-Le Roy et al, 2007b).these four vesicomyid species are well distinguishable, that means that presumably they are isolated already for a long time. Only two of the Gulf of Guinea species (*C. valdiviae* and *E. guiness*) are also known from Mauritania or West Sahara. We do not know if there is still or recently was a certain gene-flow between the two zones, but very slight differences may indicate that the populations may now be almost isolated. The other species (“*Calyptogena”* (s.l.) *regab*, *W. guineensis, I. striatum* and *I. atalantae*) are confined to the different sites in the Gulf of Guinea. Only further sampling and molecular analysis of specimens from more cold seep sites along the West African margins would give clear answers on the distribution of these genera according to depth and biotope. Comparisons with samples from the Nigerian slope, where at active seep sites vesicomyids have recently been sampled together with bathymodioline mussels, (Fisher, Brooks, unpubl. data; Cordes et al. 2007) would be quite informative, according to its intermediate geographical position between the Congo-Angola margin and the West Sahara/Mauritania sites.

[here Table 7, Table 8 and Table 9]

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References

Andersen, A.C., Hourdez, S., Marie, B., Jollivet, D., Lallier, F.H., Sibuet, M., 2004. *Escarpia southwardae* sp. nov., a new species of vestimentiferan tubeworm (Annelida, Siboglinidae) from West African cold seeps. Canadian Journal of Zoology 82, 980-999.

Barry, J.P, Kochevar, R.E, Baxter, C.H., 1997. The influence of pore-water chemistry and physiology in the distribution of vesicomyid clams at cold seeps in Monterey Bay : implications for patterns of chemosynthetic community organization. Limnology and Oceanography 42, 318-328.

Bennett, B.A., Smith, C.R., Glaser, B., Maybaum, H.L., 1994. Faunal community structure of a chemoautotrophic assemblage on whale bones in the deep northeast Pacific ocean. Marine Ecology Progress Series 108, 205-223.

Boss, K.J., 1970. Redescription of the Valdivia *Vesicomya* of Thiele and Jaeckel. Mitteilungen des Zoologischen Museums in Berlin 46(1), 67-84.

Boss, K.J., Turner, R.D. 1980. The giant white clam from the Galapagos Rift, *Calyptogena magnifica* species novum. Malacologia 20, 161-194.

Charlou, J.L., Donval, J.P., Fouquet, Y., Ondréas, H., Knoery, J., Cochonat, P., Levaché, D., Poirier, Y., Jean-Baptiste, P., Fourre, E., 2004. Physical and chemical characterization of gas hydrates and associated methane plumes in the Congo-Angola Basin. Chemical Geology 205, 405.

Coan E. V., Scott P. V. & Bernard F. R. 2000. -- *Bivalve Seashells of Western North America. Marine Bivalve Mollusks from Arctic Alaska to Baja California.* Santa Barbara Museum of Natural History, Santa Barbara. 764 pp., 123 pls.

Cordes, E.E., Bergquist, D.C., Redding, M.L., Fisher, C.R., 2007. Patterns of growth in cold-seep vestimentiferans including *Seepiophila jonesi:* a second species of long-lived tubeworm. Marine Ecology 28, 160-168.

Cosel, R. von, 2002. A new species of bathymodioline mussel (Bivalvia: Mytilidae) from Mauritania (West Africa), with comments on the genus *Bathymodiolus.* Zoosystema 24 (2) 259-271

Cosel, R. von, Olu, K., 2008. A new genus and new species of Vesicomyidae (Mollusca: Bivalvia) from cold seeps on the Barbados accretionary prism, with comments on other species. Zoosystema 30 (4): 929-944.

Cosel, R. von, Salas, C., 2001. Vesicomyidae (Mollusca: Bivalvia) of the genera *Vesicomya*, *Waisiuconcha, Isorropodon* and *Callogonia* in the eastern Atlantic and the Mediterranean. Sarsia 86, 333-366.

Fiala-Médioni, A, Felbeck, H., 1990. Autotrophic processes in invertebrate nutrition: bacterial symbiosis in bivalve molluscs. Comparative Physiology 5, 49-69.

Fisher, C.R., 1990. Chemoautotrophic and methanotrophic symbioses in marine invertebrates. Reviews in Aquatic Sciences 2, 399-436.

Gay, A., Lopez, M., Cochonat, P., Sultan, N., Cauquil, E., Brigaud, F., 2003. Sinuous pockmarks belt as indicator of a shallow buried turbiditic channel on the lower slope of the Congo Basin, West African Margin. Geological Society London Special Publications 216, 173-189.

Goffredi, S.K., Barry, J.P., 2002. Species-specific variation in sulfide physiology between closely related vesicomyid clams. Marine Ecology Progress Series, 225, 227-238.

Goffredi, S.K., Hurtado, L.A., Hallam, S, Vrijenhoek, R.C., 2003. Evolutionary relationships of deep-sea vent and cold seep clams (Mollusca: Vesicomyidae) of the "*pacifica/lepta*" species complex. Marine Biology 142, 311-320.

Keen, A.M. 1969. Family Vesicomyidae Dall, 1908. In: Moore, R.C. (ed.), Treatise on Invertebrate Paleontology, N, 2, Mollusca 6, Bivalvia. University of Kansas, Geological Society of America, Boulder, Colorado, pp N663, N664.

Khripounoff, A., Vangriesheim, A., Babonneau, N., Crassous, P., Dennielou, B., Savoye, B., 2003. Direct observation of intense turbidity current activity in the Zaire submarine valley at 4000 m water depth. Marine Geology 194, 151-158.

Kojima, S., Ohta, S., 1997. Bathymetrical distribution of the species of the genus *Calyptogena* in the Nankai Trough, Japan. Venus, Japanese Journal of Malacology 56, 293-297.

Kojima, S., Segawa, R., Kobayashi, T., Hashimoto, T., Fujikura, K., Hashimoto, J., Ohta, S., 1995. Phylogenetic relationships among species of *Calyptogena* (Bivalvia: Vesicomyidae) collected around Japan revealed by nucleotide sequences of mitochondrial genes. Marine Biology 122, 401-407.

Krylova, E. M., 2002. Bivalvia. In: Gebruk, A.V. (ed.) Biology of hydrothermal systems. KMK Press, Moscow, 208-223 (in Russian).

Krylova, E. M., Janssen, R., 2006. Vesicomyidae from Edison Seamount (South West Pacific): Papua New Guinea: New Ireland fore-arc basin) (Bivalvia: Glossoidea). Archiv für Molluskenkunde 135 (2), 231-261.

Krylova, E. M., Sahling, H. 2006. -- Recent bivalve molluscs of the genus *Calyptogena* (Vesicomyidae). Journal of Molluscan Studies 72: 359-395.

Nadalig, T, Roussel, E, Delage, E, Olu, K, Duperron, S, Caprais, J.C, Boetius, A, Sibuet, M, Cambon Bonavita, M (submitted). Distribution of AOM aggreagates and microbial diversity associated to different faunal assemblages in a giant pockmark of Gabon continental margin. Deep-Sea Research II, this volume.

Olu, K., Duperret, A., Sibuet, M., Foucher, J.-P., Fiala-Médioni, A.,1996. Structure and distribution of cold seep communities along the Peruvian active margin: relationship to geological and fluid patterns. Marine Ecology Progress Series 132, 109-125.

Olu- Le Roy, K., Cosel, R. von, Jollivet, D., Duperron, S., Sibuet, M. 2005. Trans-Atlantic faunal linkages inferred by taxonomy and molecular studies of mytilid and vesicomyid bivalves and their symbionts of the Gulf of Guinea cold seeps. Third International Symposium on hydrothermal Vent & Seep Biology, Scripps Institution of Oceanography, La Jolla (USA), September12-16, 2005.

Olu-Le Roy, K., Caprais, J.C., Fifis, A., Fabri, M.C., Galéron, J., Budzinski, H., Le Ménach, K., Khripounoff, A., Ondréas, H., Sibuet, M., 2007a. Cold seep assemblages on a giant pockmark off West Africa: spatial patterns and environmental control. Marine Ecology. An evolutionary perspective, Special topics volume: Ecology and evolution of vent, seep and whale fall organisms. 28, 115-130.

Olu-Le Roy, K., Cosel, R. von, Hourdez, S., Carney, S.L., Jollivet, D., 2007b. Amphi-Atlantic cold-seep *Bathymodiolus* species complexes across the equatorial belt. *Deep* Sea Research Part I: Oceanographic Research Papers 54, 1890-1911.

Ondréas, H., Olu-Le Roy, K., Fouquet, Y., Charlou, J.L., Gay, A., Dennielou, B., Donval, J.P., Fifis, A., Nadalig, T., Cochonat, P., Cauquil, E., Sibuet, M., 2005. ROV study of a giant pockmark on the Gabon continental margin. Geo-Marine Letters 25 (5), 281-292.

Peek, A.S., Gustafson, R.G., Lutz, R.A., 1997. Evolutionary relationships of deep-sea hydrothermal vent and cold-water seep clams (Bivalvia: Vesicomyidae): results from the mitochondrial cytochrome oxidase subunit I. Marine Biology 130, 151-161.

Sibuet, M., Galeron, J., Khripounoff, A., Menot, L., Olu-Le Roy, K., Durrieu, J., Miné, J., Caprais, J.C., Crassous, P., Fabri, M.C., Vangriesheim, A., Desneulin, J., Savoye, B., Cochonat, P., Ondréas, H., Etoubleau, J., Loubrieu, B., Dinet, A., von Cosel, R., 2002. -- Deep-Sea ecosystems on the Equatorial African Margin: First results on a pluridisciplinary environmental programme and discovery of chemosynthetic based ecosystem. Proceedings of the Sixth international conference on health, safety & environmental in Oil and Gas exploration and production, Kuala-Lumpur. 16 p.

Thiele, J., Jaeckel, S., 1931. Muscheln der Deutschen Tiefsee-Expedition. Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition auf dem Dampfer "*Valdivia*" 21(1), 159-268, 5 pls: Gustav Fischer, Jena.

Vrijenhoek, R.C., Schutz, S.J., Gustafson, R.G., Lutz, R.A., 1994. Cryptic species of deep-sea clams (Mollusca: Bivalvia: Vesicomyidae) from hydrothermal vent and cold-water seep environnements. Deep-Sea Research 41,1171-1189.

Figure legends

Fig. 1. Map of the Gulf of Guinea with the BIOZAIRE stations

Fig. 2. *Calyptogena valdiviae* (Thiele & Jaeckel 1931). (A-E) Lectotype (Boss, 1970) of *Vesicomya valdiviae* Thiele & Jaeckel 1931, 59.2 mm, ZMB Moll.101 598a. (A) Exterior of rv. (B) Interior of rv, (C) Interior of lv. (D) Exterior of lv. (E) dorsal view. (F-G) Holotype of *Vesicomya longa* Thiele & Jaeckel 1931, 70.6 mm, ZMB Moll. 101 602. (F) Exterior of rv. (G) Interior of lv.

Fig. 3. *Calyptogena valdiviae* (Thiele & Jaeckel 1931). (A-F) W Cap Lopez, Gabon, 1°34.64'S, 8°32.90'E, 670-579 m, GUINESS site, BIOZAIRE 2, ROV PL 148-11/GBT 1, (A-D) 56.6 mm, (A) exterior of rv, (B) interior of rv, (C) interior of lv, (D) exterior of lv. (E-F) 57.1 mm, (E) dorsal view, (F). Exterior of rv, (G-I) "*longa*" form. NE of REGAB site, 5°28'S, 10°58'E, 1490-1520 m, MPS 1 site ZAIROV 2 KZR 30. 64.4 mm. (G) interior of lv, (H) rxterior of lv, (I) dorsal view.

Fig. 4. *Calyptogena valdiviae* (Thiele & Jaeckel 1931). (A-D) not completely adult with more rounded shell form GUINESS site, BIOZAIRE 2, ROV PL 148-11/GBT 1, 43.2 mm. (A) exterior of rv, (B) interior of rv, (C) interior of lv, (D) exterior of lv. (E-G) abnormally thick and tumid spm, same locality, 47.6 mm. (E) dorsal view, (F) exterior of lv, (G) anterior view. (H-I) very thick-shelled and slightly abnormal specimen from the type locality, 41.9 mm, *Valdivia* sta. 33, Rio de Oro, West Sahara, 24°35.3'N, 17°4.7'W, 2500 m. ZMB Moll. 101 598b. (H) interior of lv, (I) exterior of lv.

Fig. 5. *Calyptogena valdiviae* (Thiele & Jaeckel 1931). (A-E) Semischematic line drawings of the interiors of valves. (A) Lectotype (ZMB Moll, rv). (B-D) spms from BIOZAIRE 2,

ROV PL 148-11, rv. (E) "longa" form, MPS 1 site ZAIROV 2 KZR 30, lv. (F) Holotype (ZMB Moll. 101601) of *Vesicomya longa* Thiele & Jaeckel 1931, lv. – Scale: 1 cm.

Fig. 6. Hinges of *Calyptogena*. (A-B) *Calyptogena valdiviae* (Thiele & Jaeckel 1931), same spm as on Fig. 4 (A-D). (C-D) "*Calyptogena"* (s.l.) *regab* n. sp., holotype.

Fig. 7. "*Calyptogena"* (s.l.) *regab* n. sp. (A-E) holotype, MNHN, 95.6 mm, W of Congo River mouth, N of Congo Canyon, 5°57.85'S, 9°42.7'E, 3140-3170 m REGAB site, ZAIROV 2, ROV PL 14(GBT2). (A) exterior of rv, (B) interior of rv, (C) interior of lv, (D) exterior of lv. (E) dorsal view. (F-G) paratype, MNHN, 105.3 mm, 5°47.78'S, 9°42.65'E, 3151-3159 m, BIOZAIRE 2 ROV Pl 147-10 (F) exterior of rv, (G) interior of rv. (H-I) paratype, MNHN; 105.6 mm, 5°47.89'S, 9°42.64'E, 3151-3127 m, BIOZAIRE 1, ROV PL 81-5. (H)) interior of lv, (I) exterior of lv. Note sculpture on inside.

Fig. 8. "*Calyptogena"* (s.l.) *regab* n. sp., different shell forms. All from N of Congo Canyon, REGAB site, 5°46.89'S, 9°44.65'E, 3159-3113 m, BIOZAIRE 3, trawled R/V *Atalante*, CP 20, 2. I. 2004. (A-B) 109.6 mm, interior and exterior of lv. Note evenly convex ventral margin. (C-D) 100.0 mm (C) exterior of lv, (D) interior of rv. Note the waves on the posterior part on in- and outside. (E-F) 114.0 mm (E) exterior of lv, (F) ventral view. Note the laterally bent ventral side. (G) 1176 mm, exterior of rv. (H) 74.0 mm, exterior of lv. Note concave ventral margin. (I) 99.8 mm, exterior of both valves. Note the strong waves on the posterior part.

Fig. 9. "*Calyptogena"* (s.l.) *regab* n. sp. Semischematic line drawings of the interiors of valves. (A-B) rv and lv of holotype. (C-F) N of Congo Canyon, REGAB site, 5°46.89'S, 9°44.65'E, 3159-3113 m, BIOZAIRE 3, trawled R/V *Atalante*, CP 20. (C) lv, (D-F) rv. Note differnt forms of ventral margin. Scale: 1 cm.

Fig. 10 "*Calyptogena"* (s.l.) *regab* n. sp. (A) paratype, shell length 99.3 mm, view of soft parts from the right with ctenidia, foot adductors and mantle lobes. (B) another spm, PL 145-8, shell length 89.9 mm, general view, mantle lobe removed. (C) Close-up view of the posterior end with the siphons. aa, anterior adductor; ct, ctenidium, inner demibranch; es, exhalent siphon; f, foot; imf, inner mantle fold; is, inhalent siphon; mc, mantle cavity; ml, mantle lobe; pa, posterior adductor; t, tentacles on edge of open inhalent siphonal tube

Fig. 11. *Wareniconcha guineensis* (Thiele & Jaeckel 1931). (A-C) Lectotype (Boss, 1970) of *Vesicomya guineensis* Thiele & Jaeckel 1931, 59.7 mm, ZMB Moll. 101 600. (A) exterior of rv, (B) dorsal view, (C) interior of rv. (D-E) 53.1 mm, W of Congo River mouth, ZD site, 5°51.00'S, 8°20.00'E, 3970 m BIOZAIRE 2, KGS 41, (D) exterior of rv, (E) interior of rv, (F-H) 58.8 mm, same site, 5°50.95'S, 8°20.48'E, 3949 m, BIOZAIRE 1, KGS 26. (F) exterior of rv, (G) dorsal view, (H) interior of rv. (I-J) 64.5 mm, N of Congo Canyon, REGAB site, 5°46.89'S, 9°44.65'E, 3159-3113 m, BIOZAIRE 3,trawled R/V *Atalante*, CP 20. (I) exterior of rv, (J) interior of rv.

Fig. 12. *Wareniconcha guineensis* (Thiele & Jaeckel 1931). (A-B) 73.3 mm, ZD site, 5°51.10'S, 8°21.51'E, 3977-3956 m, BIOZAIRE 3, trawled R/V "*Atalante*", CP 10, (A) exterior of rv, (B) interior of rv. (C-D) 68.3 mm, ZD site, 5°51.76'S, 8°21.06'E, 3975-3958 m, BIOZAIRE 3, trawled R/V "*Atalante*" CP 12, (C) exterior of rv, (D) interior of rv. (E-F) 68.5 mm, ZC site, 7°42.41'S, 10°08.39'E, 4001-4017 m, BIOZAIRE 3, trawled R/V "*Atalante*" CP 14 (E) exterior of rv, (F) exterior of lv.

Fig. 13. *Wareniconcha guineensis* (Thiele & Jaeckel 1931). Semischematic line drawings of the interiors of valves. (A) Lectotype ZMB. (B) BZ3, ZD, CP 10, (C) BZ 3, ZD CP 11, (D) BZ 3, ZD CP 12, (E) lv, BZ 3, ZC, CP 14 (F) BZ 1, KGS 26, ZD, (A-D, F) rv, (E) lv.

Fig. 14. *Wareniconcha guineensis* (Thiele & Jaeckel 1931). Hinges and soft parts. (A-B) ZD site, 5°51.00'S, 8°20.00'E, 3970 m BIOZAIRE 2, KGS 41(A) rv, (B) lv. Shell length 63.2

mm. (C-D). ZC site, 7°42.41'S, 10°08.39'E, 4001-4017 m, , BIOZAIRE 3 CP 14, (C) soft parts seen from right, mantle lobe removed. shell length 49.8 mm (D) Close-up view of the siphons, spm slightly inclined. Inhalent siphon appearing thinner than exhalent siphon but that seems to be an artefact. aa, anterior adductor; ct, ctenidium, inner demibranch; es, exhalent siphon; f, foot; is, inhalent siphon; pa, posterior adductor; t, tentacles.

Fig. 15. *Elenaconcha guiness* n.g. n.sp. (A-E) holotype, MNHN, 66.8 mm, Gabon: GUINESS site, 1°33.72'S, 8°33.49'E, 595-439- m, BIOZAIRE 1, ROV PL 83-7, (A) exterior of rv, (B) interior of rv, (C) interior of lv, (D) exterior of lv, (E) dorsal view. (F-I) paratype, MNHN, 69.5 mm, same locality, (F) interior of lv, (G) exterior of lv, (H) exterior of rv, (I) dorsal view.

Fig. 16. *Elenaconcha guiness* n.g. n.sp. Off Banc d'Arguin, Mauritania, about 18°41'N, 16°45'W, 900 to 1200 m depth. (A-C) 65.7 mm, MNHN. (A) exterior of rv, (B) exterior of lv, (C) interior of lv. (D) 60.6 mm, exterior of rv, coll. Swinnen. (E)-(H) 59.1 mm, MNHN; (E) exterior of rv, (F) interior of rv, (G) interior of lv, (H) exterior of lv. (I) 59.6 mm, Mauritania coll. Swinnen, exterior of rv.

Fig. 17. *Elenaconcha guiness* n.g. n.sp. Semischematic line drawings of the interiors of valves. (A-B) holotype. (A) lv, (B) lv. (C-D) Mauritania, MNHN, rv. (E) , Gabon: GUINESS site, 1°33.72'S, 8°33.49'E, 595-439- m, BIOZAIRE 1, ROV PL 83-7; rv

Fig. 18. *Elenaconcha guiness* n.g. n.sp. (A-D) soft parts seen from left. (A-B) W Cap Lopez, Gabon, 1°34.64'S, 8°32.90'E, 670-579 m, BIOZAIRE 2, ROV PL 148-11. Shell length 68.8 mm. (A) soft parts showing ctenidia, mantle lobes removed. (B) close-up view of siphons. Mantle lobe cut. (C-D) same locality, 1°33.72'S, 8'33.49'E, 595-439 m, GUINESS site, BIOZAIRE 1, ROV PL 83-7. Shell length 69.3 mm. (C) soft parts, left gill removed, (D) close-up view of siphons. Note broad inhalent siphons with the well visible tentacles; aa,

anterior adductor; ct, ctenidium, inner demibranch; es, exhalent siphon; f, foot; is, inhalent siphon; ml, manthl lobe (cut for making siphons visible); pa, posterior adductor; t, tentacles.

Fig. 19. *Elenaconcha guiness* n.g. n.sp.. Semischematic drawings of the interiors of valves. W Cap Lopez, Gabon, 1°34.64'S, 8°32.90'E, 670-579 m, GUINESS site, BIOZAIRE 2, ROV PL 148-11. Growth row of juvenile specimens. Scale: 1 cm.

Fig. 20. *Elenaconcha guiness* n.g. n.sp. (A-D) juvenile spm, 6.6 mm, W Cap Lopez, Gabon, 1°34.64'S, 8°32.90'E, 670-579 m, GUINESS site, BIOZAIRE 2, ROV PL 148-11. (A) exterior of rv, (B) interior of rv, (C) interior of lv. (D) exterior of lv. (E-F) hinges, spm from Mauritania (MNHN), shell length 59.1 mm (E) hinge of rv, (F) hinge of lv. Note the small subligamental pit. (G) hinge (rv) of spm. from GUINESS site, paratype , shell length 65.6 mm.

Fig. 21. "*Vesicomya*" *chuni* Thiele & Jaeckel 1931. 83.0 mm, N of Congo Canyon, REGAB site, 5°46.89'S, 9°44.65'E, 3159-3113 m, BIOZAIRE 3,trawled R/V *Atalante*, CP 20. (A) exterior of lv, (B) interior of rv, (C) hinge of lv, (D) hinge of rv.

Fig. 22. *Isorropodon atalantae* n. sp. (A-E). Holotype, MNHN, 30.7 mm, W of Congo River mouth, N of Congo Canyon, REGAB site, 5°46.89'S, 9°44.65'E, 3159-3113 m, BIOZAIRE 3,trawled R/V *Atalante*, CP 20, (A) exterior of rv, (B) interior of rv, (C) dorsal view, (D) interior of lv. (E) exterior of lv. (F-G) paratype, MNHN, 33.4 mm, (F) interior of rv, (G) exterior of rv. (H) anterior part of rv. Note the fine irregular commarginal vermiculations on the anterior slope.

Fig. 23. *Isorropodon atalantae* n. sp. (A-B) paratype, MNHN, 46.6 mm, (A) interior of lv, (B) exterior of lv with agglomeration of soldified mud. (C-D) paratype, MNHN, 38.4 mm, (C) exterior of lv, (D) hinge of both v, ventral view, lower is lv.

Fig. 24. *Isorropodon atalantae* n. sp. Semischematic drawings of the interiors of valves. (A-B) holotype, (A) lv, (B) rv, (C) paratype, rv. Scale: 1 cm.

Fig. 25. *Isorropodon striatum* (Thiele & Jaeckel 1931) 51.4 mm. (A-E) .W of Congo River mouth, ZD site, 5°51.76'S, 8°21.06'E, 3975-3958 m, BIOZAIRE 3, trawled R/V "*Atalante*" CP 12, (A) interior of lv, (B) exterior of lv, (C) exterior of rv. (D) interior of rv, (E) dorsal view.

Fig. 26. *Isorropodon striatum* (Thiele & Jaeckel 1931)..). (A) 65.2 mm, W of Congo River mouth, ZD site, 5°51.76'S, 8°21.06'E, 3975-3958 m, BIOZAIRE 3, trawled R/V "*Atalante*" CP 12, exterior of lv. (B-C) juvenile spm, 27.3 mm, ZD site, 5°51.10'S, 8°21.51'E, 3977-3956 m, BIOZAIRE 3, trawled R/V "*Atalante*" CP 10, (B) exterior of rv, (C) interior of rv. [(D-F) juvenile spm, 17.6 mm, ZC site, 7°42.41'S, 10°08.39'E, 4001-4017 m, BIOZAIRE 3, trawled R/V "*Atalante*" CP 14, (D) dorsal view, (E) exterior of rv, (F) exterior of lv.

Fig. 27. *Isorropodon* cf. *striatum* (Thiele & Jaeckel 1931). Semischematic drawings of the interiors of right valves. (A) holotype of *Vesicomya striata* Thiele & Jaeckel 1931, ZMB Moll. 77811a, rv. (B) juvenile spm, W of Congo River mouth, ZD site, 5°51.10'S, 8°21.51'E, 3977-3956 m, BIOZAIRE 3, trawled R/V "*Atalante*" CP 10 (C) ZD site, 5°51.76'S, 8°21.06'E, 3975-3958 m, BIOZAIRE 3, trawled R/V "*Atalante*" CP 12. Scale: 1 cm.

Fig. 28. Hinges of *Isorropodon* spp. (A-B) *I. atalantae* n. sp., holotype , (A) lv, (B), rv. (C-G) *I. striatum* (Thiele & Jaeckel 1931), (C-D, G) .W of Congo River mouth, ZD site, 5°51.76'S, 8°21.06'E, 3975-3958 m, BIOZAIRE 3, trawled R/V "*Atalante*", CP 12. (C) lv, (D) rv, shell length 51.4 mm, (G) lv, shell length 65.2 mm. (E) ZD site, 5°51.76'S, 8°21.06'E, 3978-3956 m, BIOZAIRE 3, trawled R/V "*Atalante*",CP 11, broken shell, ventral view of hinge. (F) juvenile spm, 27.3 mm, ZD site, 5°51.10'S, 8°21.51'E, 3977-3956 m, BIOZAIRE 3, trawled R/V "*Atalante*" CP 10, rv.

Fug. 29. Semischematic drawings of hinges. Left: lv; right: rv.

(A-B) *Calyptogena valdiviae* (Thiele & Jaeckel 1931). BIOZAIRE 2, PL 148-11. Shell length 56.4 mm..

(C-D) *Calyptogena* (s.l.) *regab* n. sp. Holotype.

(E-F) *Calyptogena* (s.l.) *regab* n. sp. BIOZAIRE 3, CP 20. Shell length 104.4 mm

(G-H) *Wareniconcha guineensis* (Thiele & Jaeckel 1931). BIOZAIRE 1, KGS 26. Shell length 58.4 mm.

(I-J) *Elenaconcha guiness* n.g. n.sp. Holotype

(K-L) *Laubiericoncha chuni* Thiele & Jaeckel 1931. BIOZAIRE 3, CP 20, Shell length 104.6 mm.

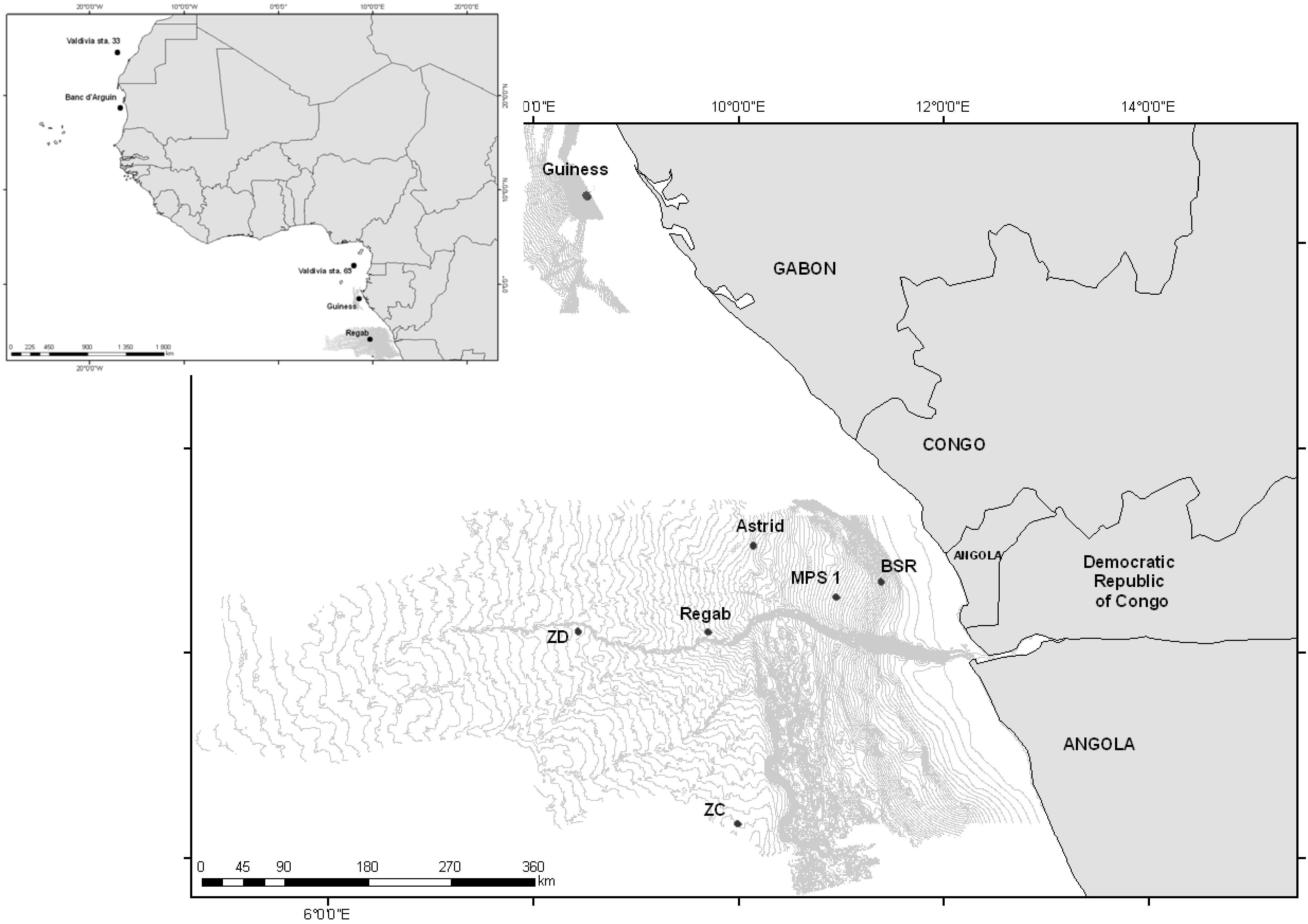
(M-N) *Isorropodon atalantae* n. sp. Holotype.

(O-P) *Isorropodon* cf. *striatum* (Thiele & Jaeckel 1931). BIOZAIRE 3, CP 12. Shell length 51.4 mm.

Fig. 30. (A-F) *In situ* photos of the vesicomyid species from GUINESS and REGAB.

(A) *Calyptogena valdiviae* among microbial mats, on a pockmark of the GUINESS area. (B) *Elenaconcha guiness* on another pockmark of the GUINESS area on an active site together with microbial mats. (C) *Elenaconcha guiness*, on another site of the same pockmark with abundant empty shells and where several crabs were observed in vesicomyid clusters. (D) Vesicomyid cluster (V1) on the REGAB site, dominated by *Laubiericoncha chuni* with abundant *Phymorhynchus* sp. (E) *Calyptogena regab* in another cluster of the REGAB pockmark. (F) *Calyptogena regab* among carbonate concretions in the central part (V3 site) of the pockmark; synaptid holothurians and alvinocharid shrimps are abundant among the bivalves.

Fig 1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Banc d'Arguin
Valdivia sta. 63
Guiness
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Guiness
GABON
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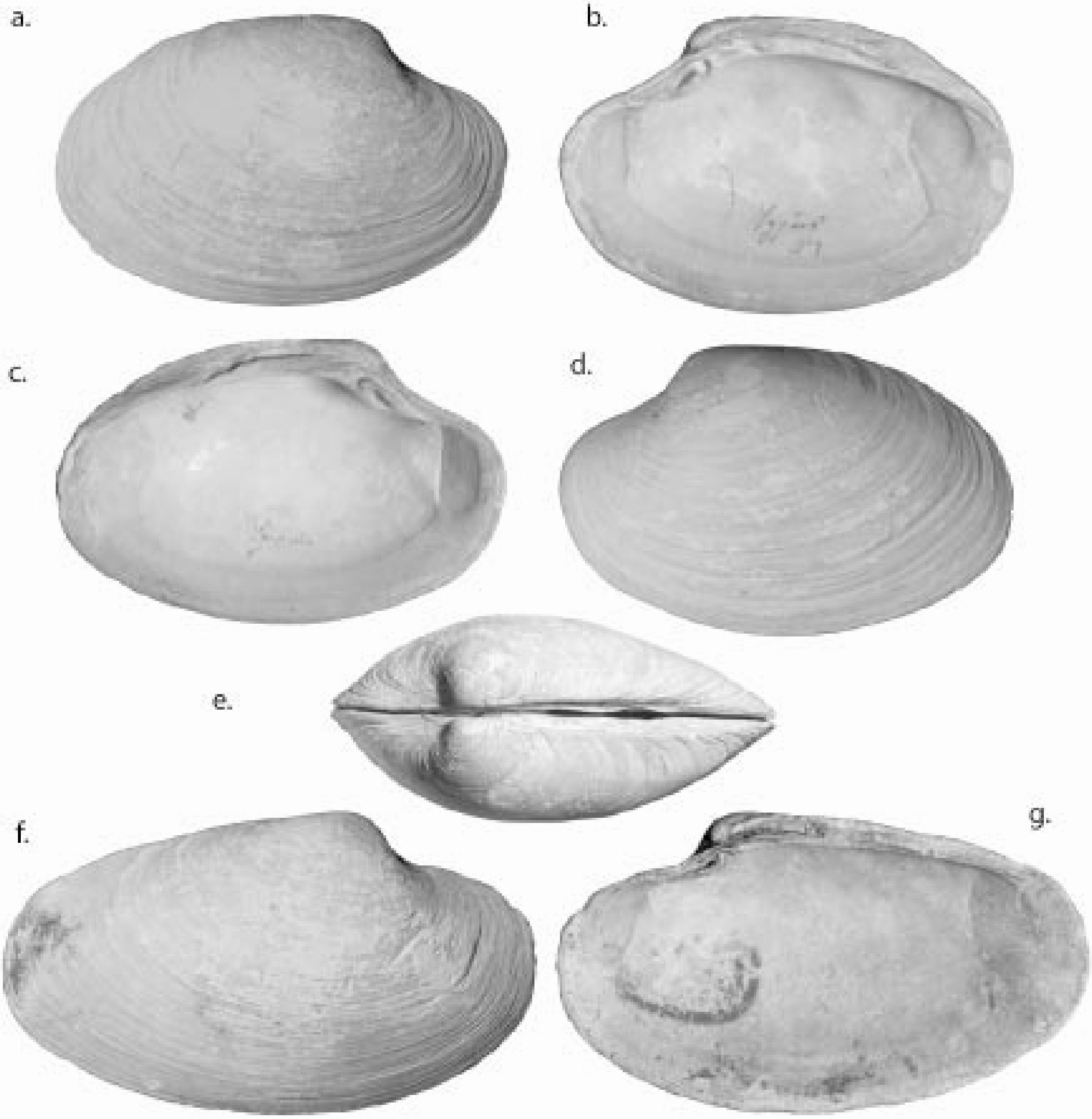
Fig2



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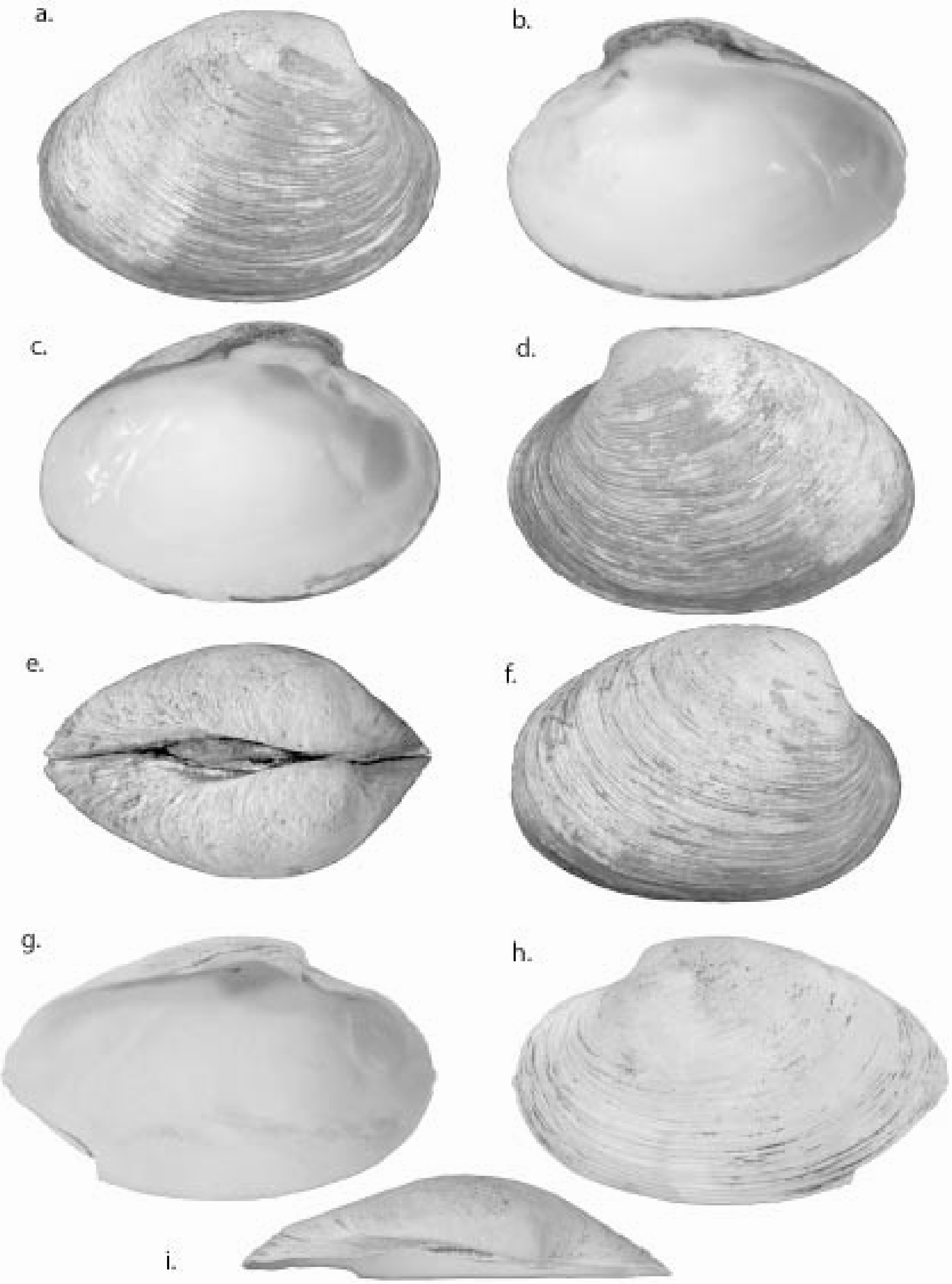

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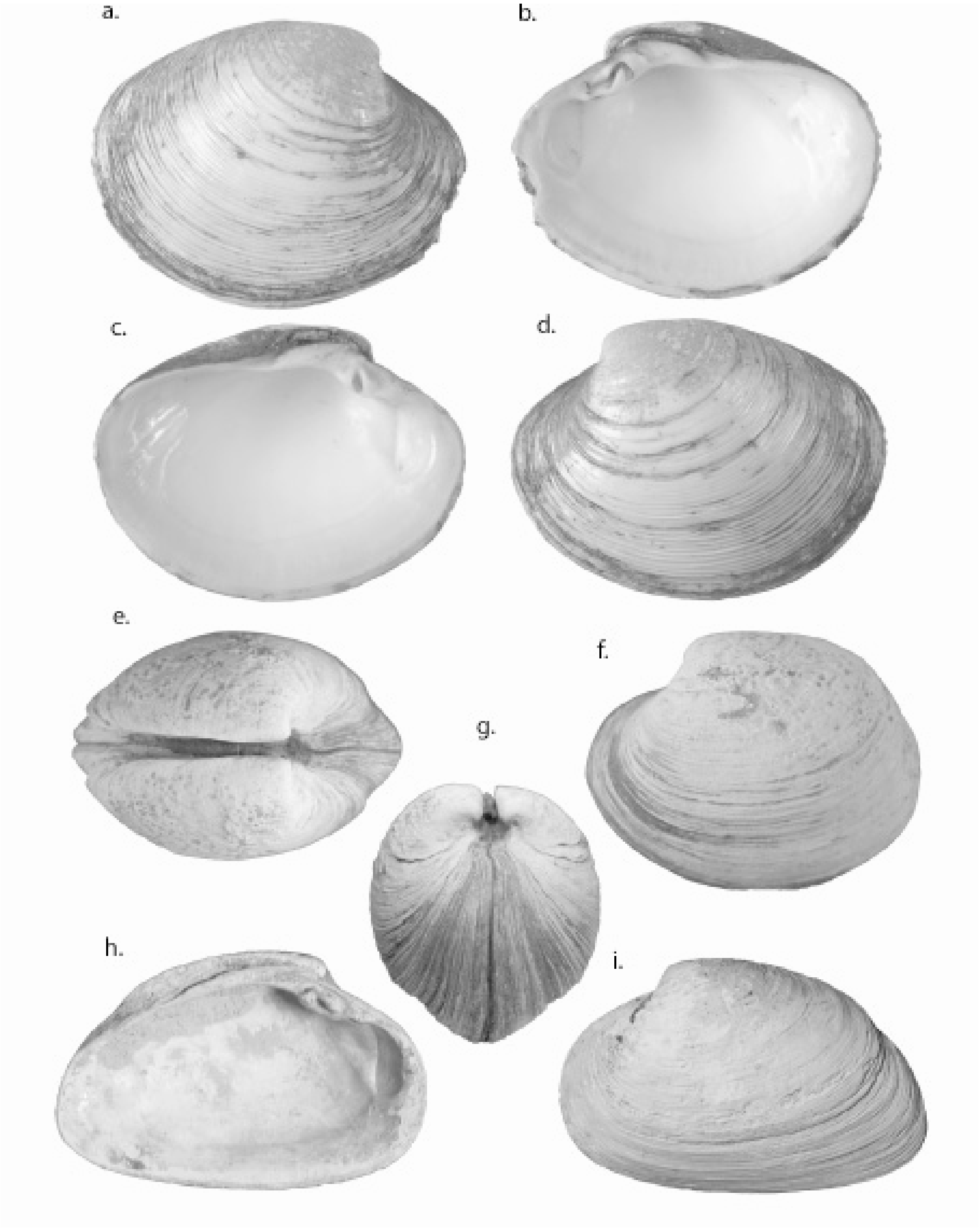

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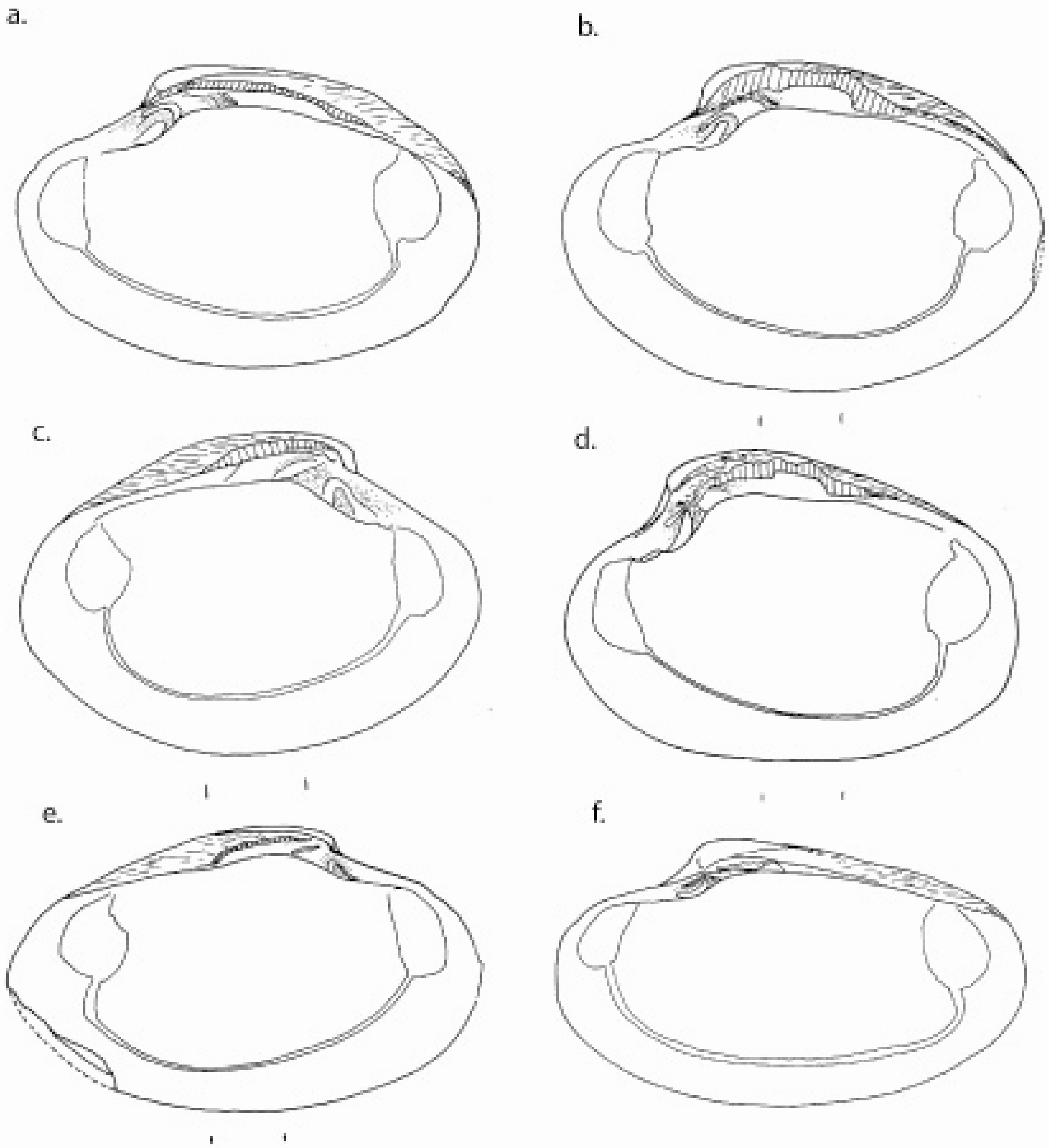

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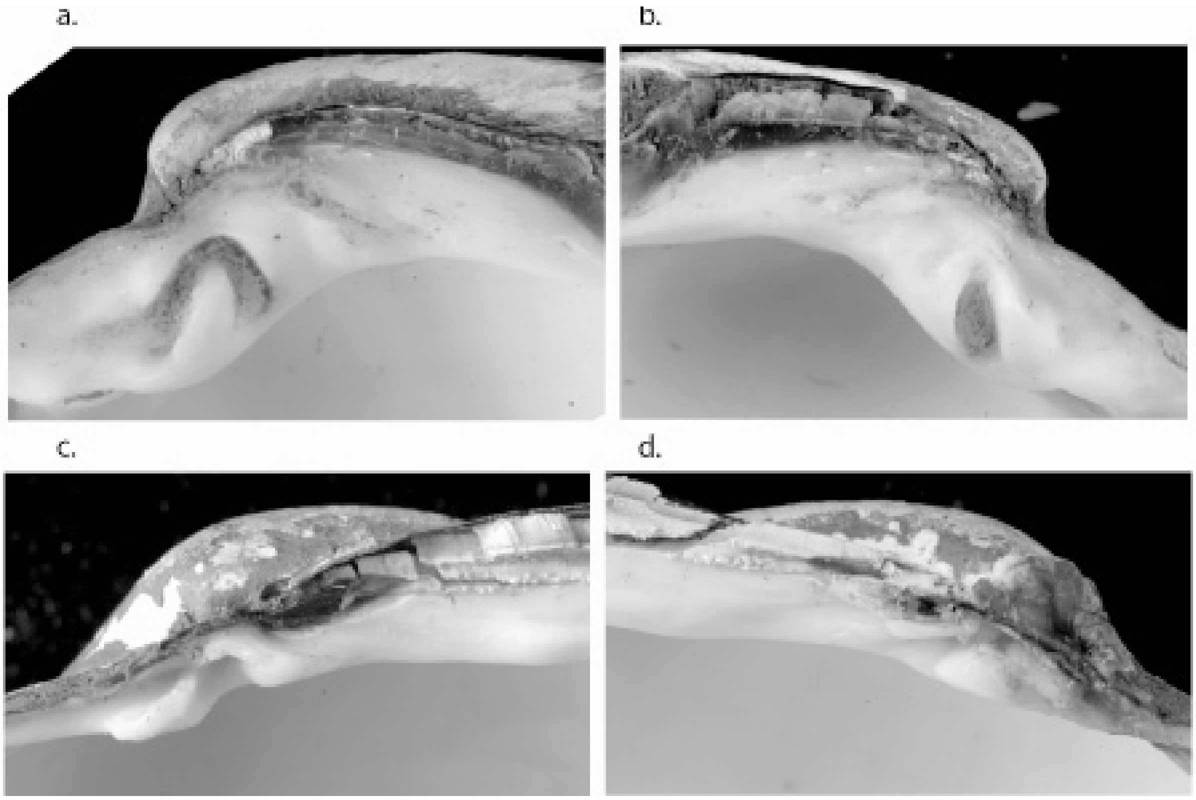

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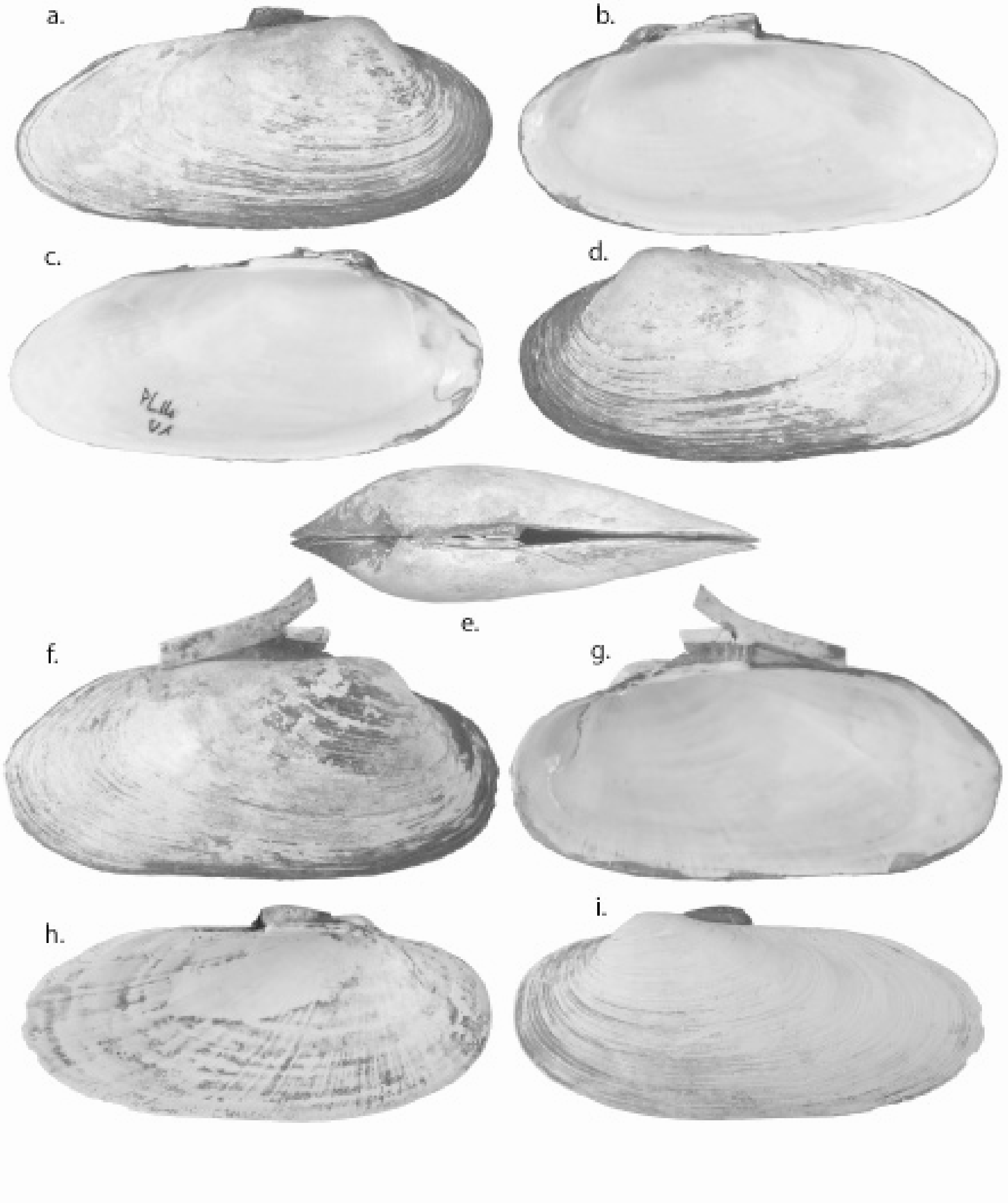

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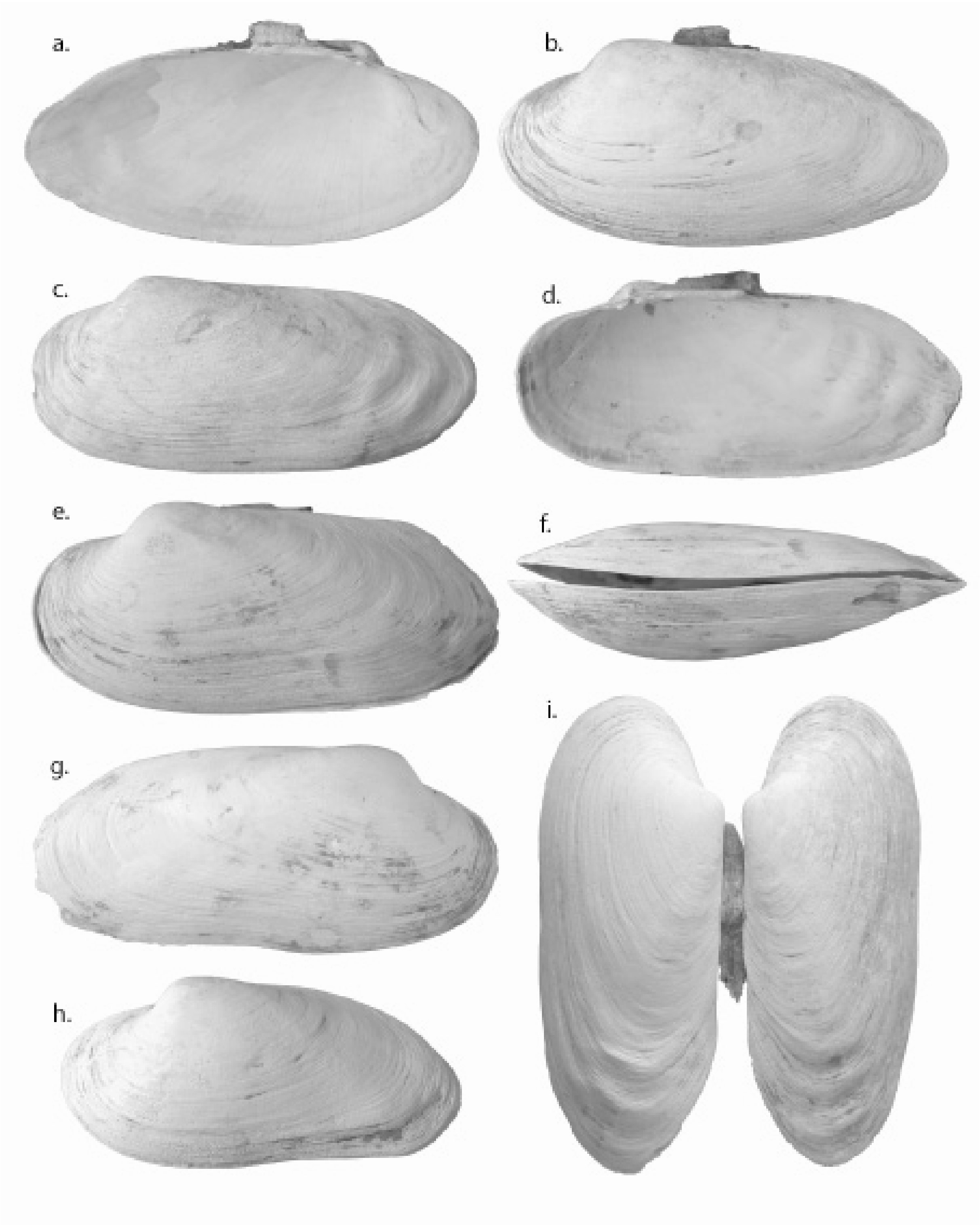

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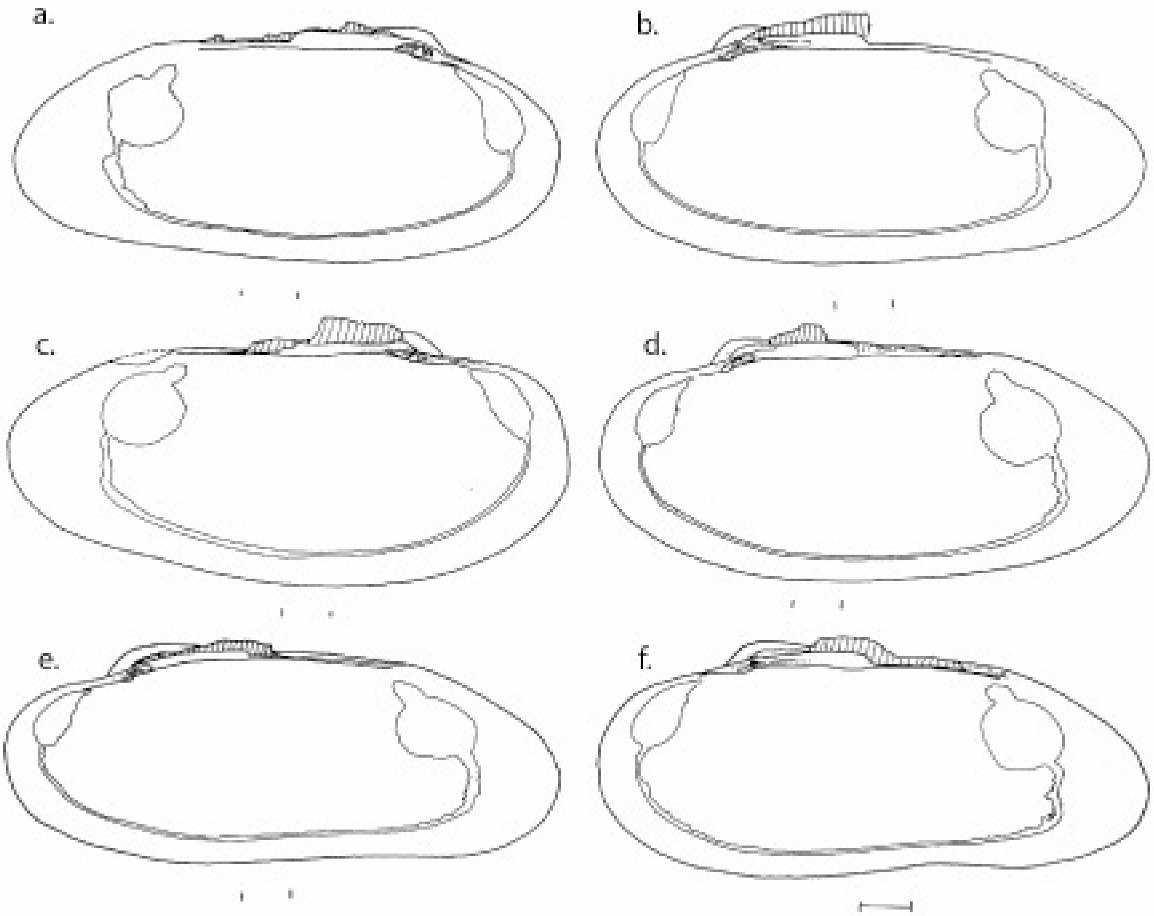

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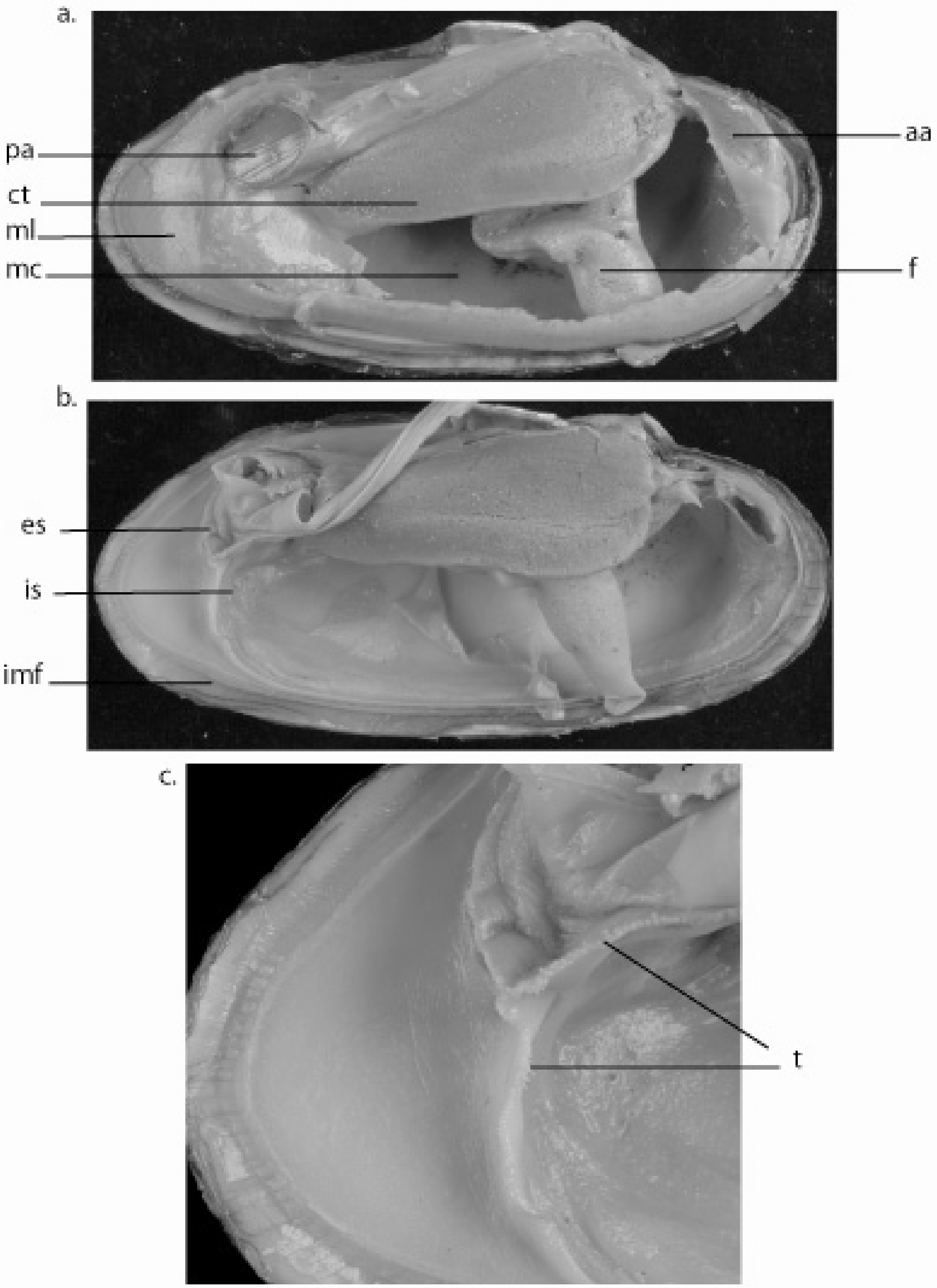

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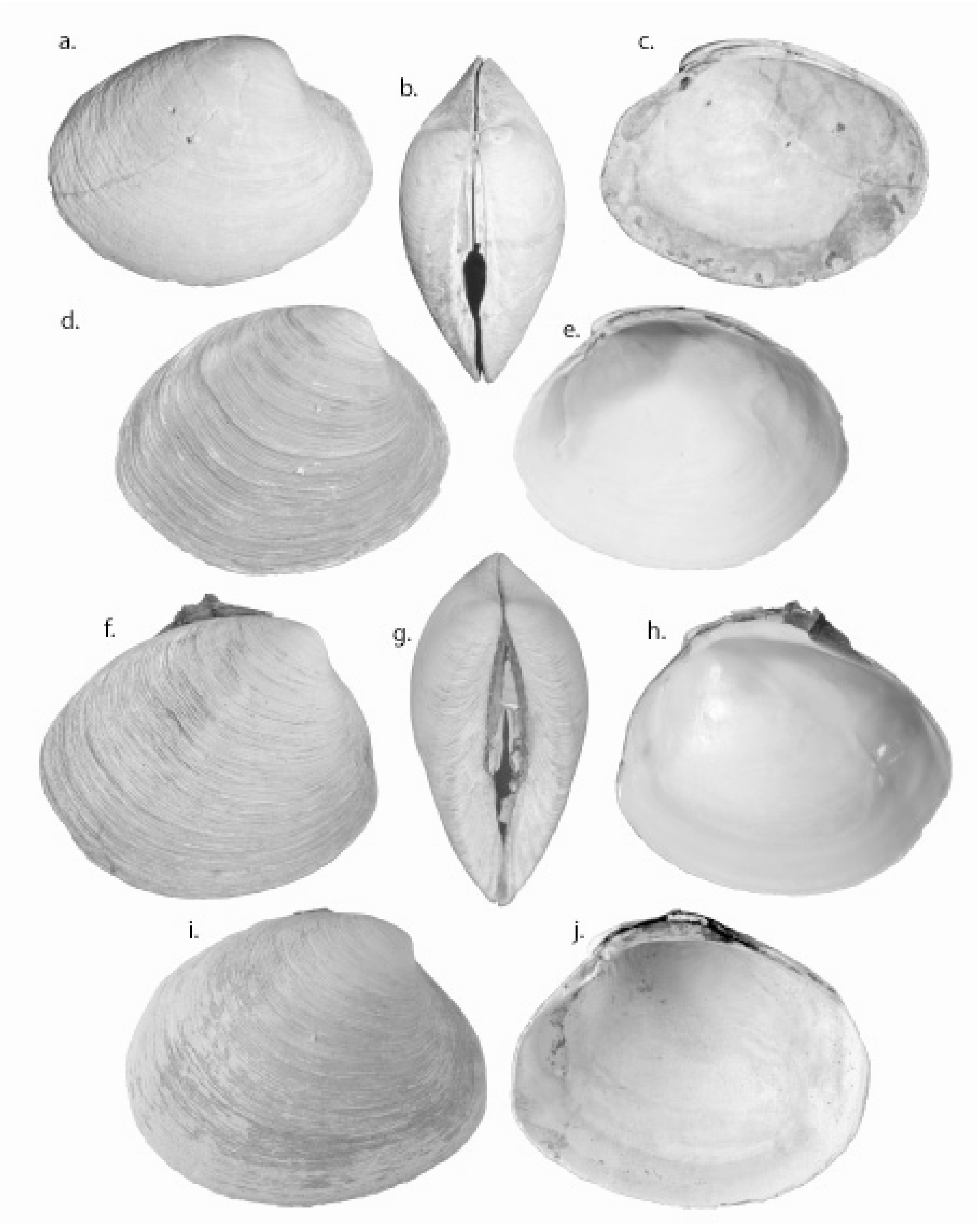

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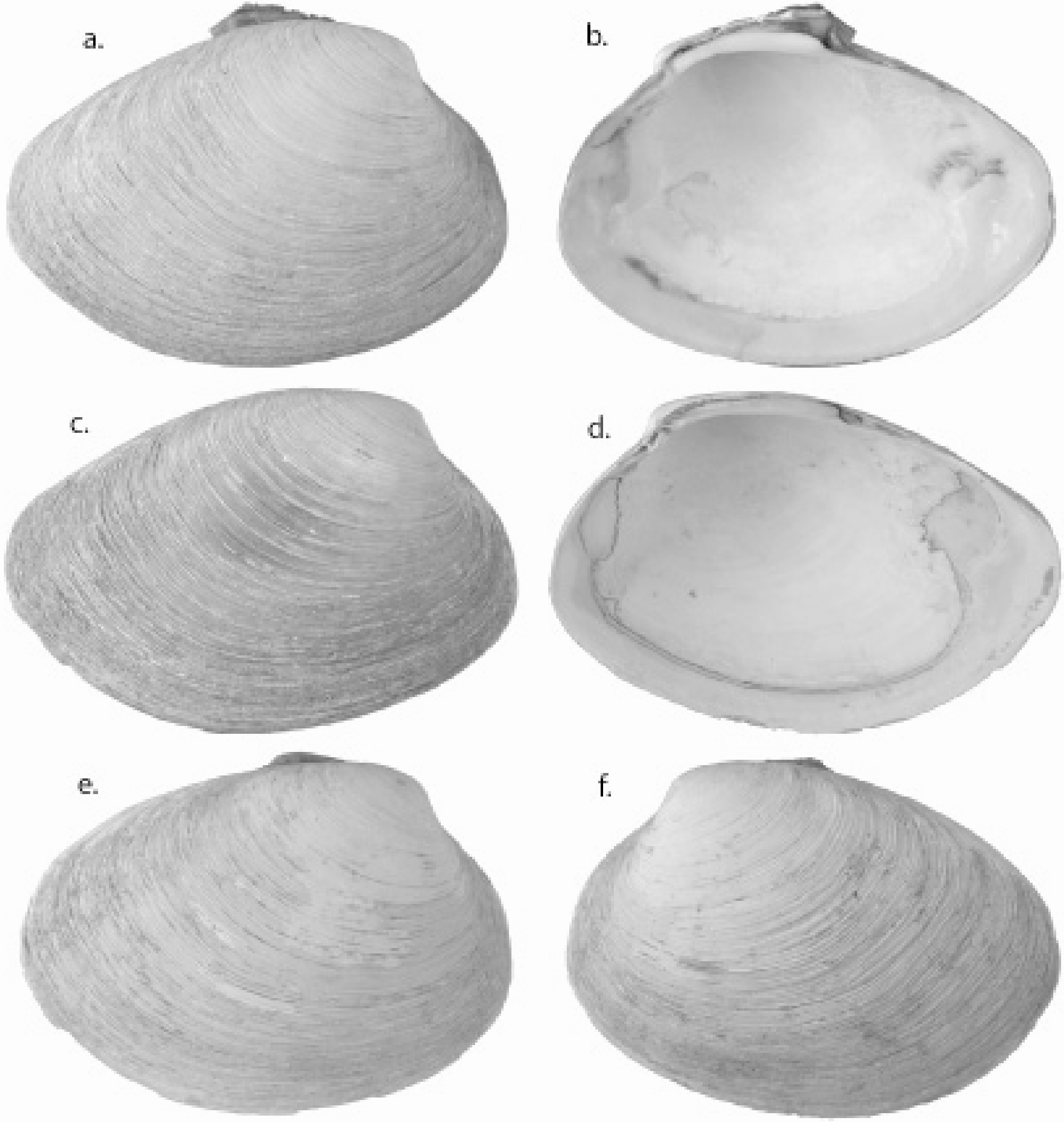

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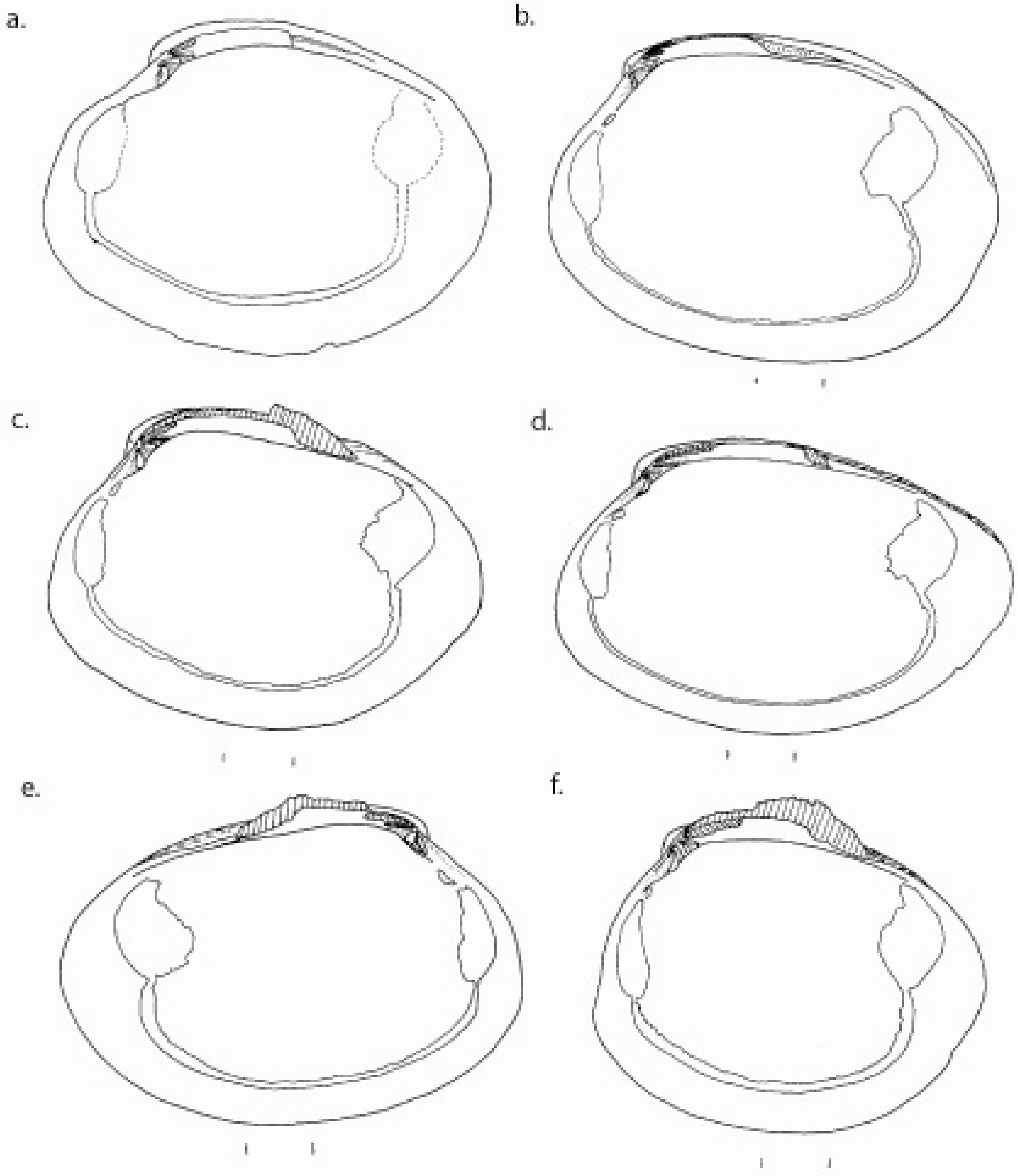

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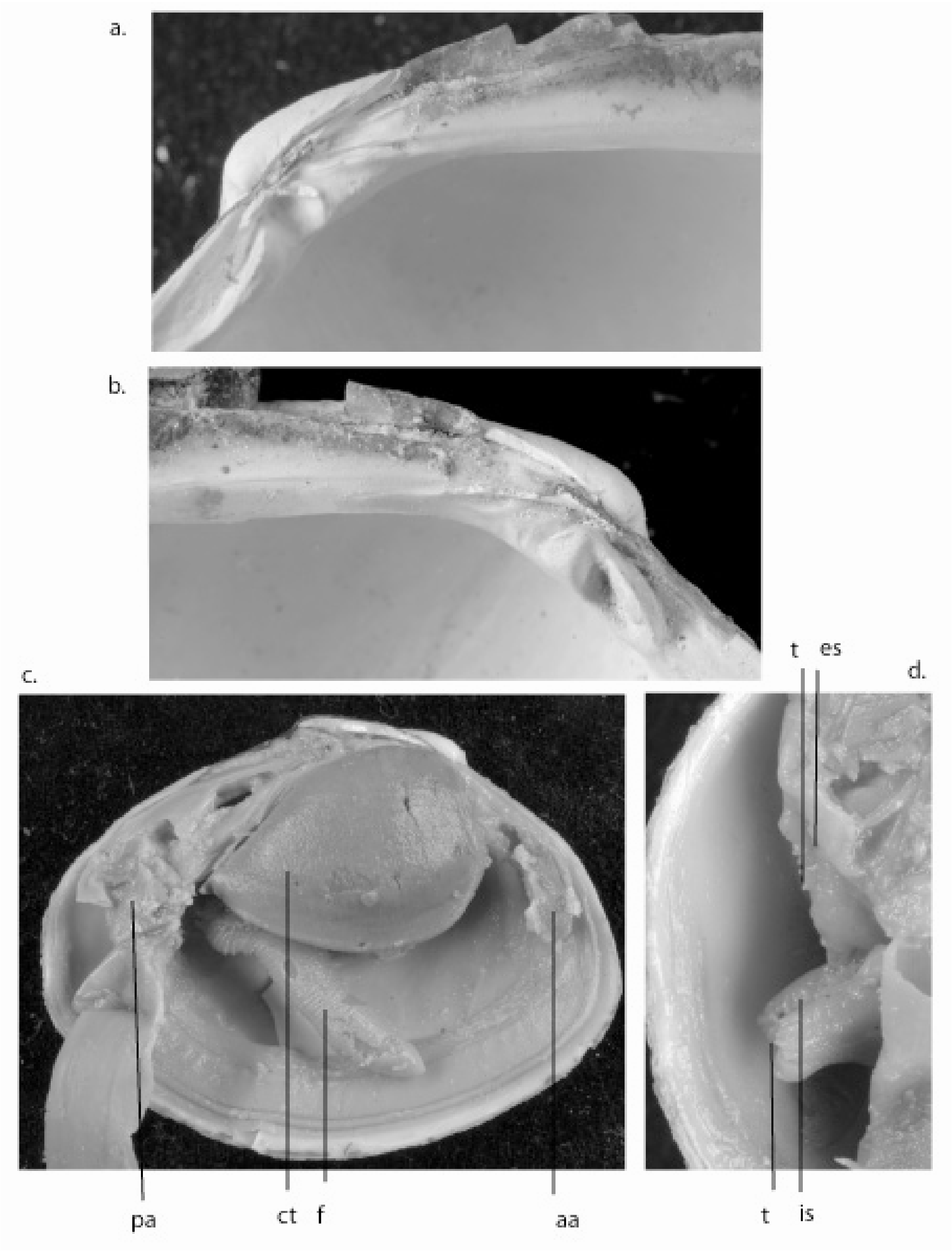

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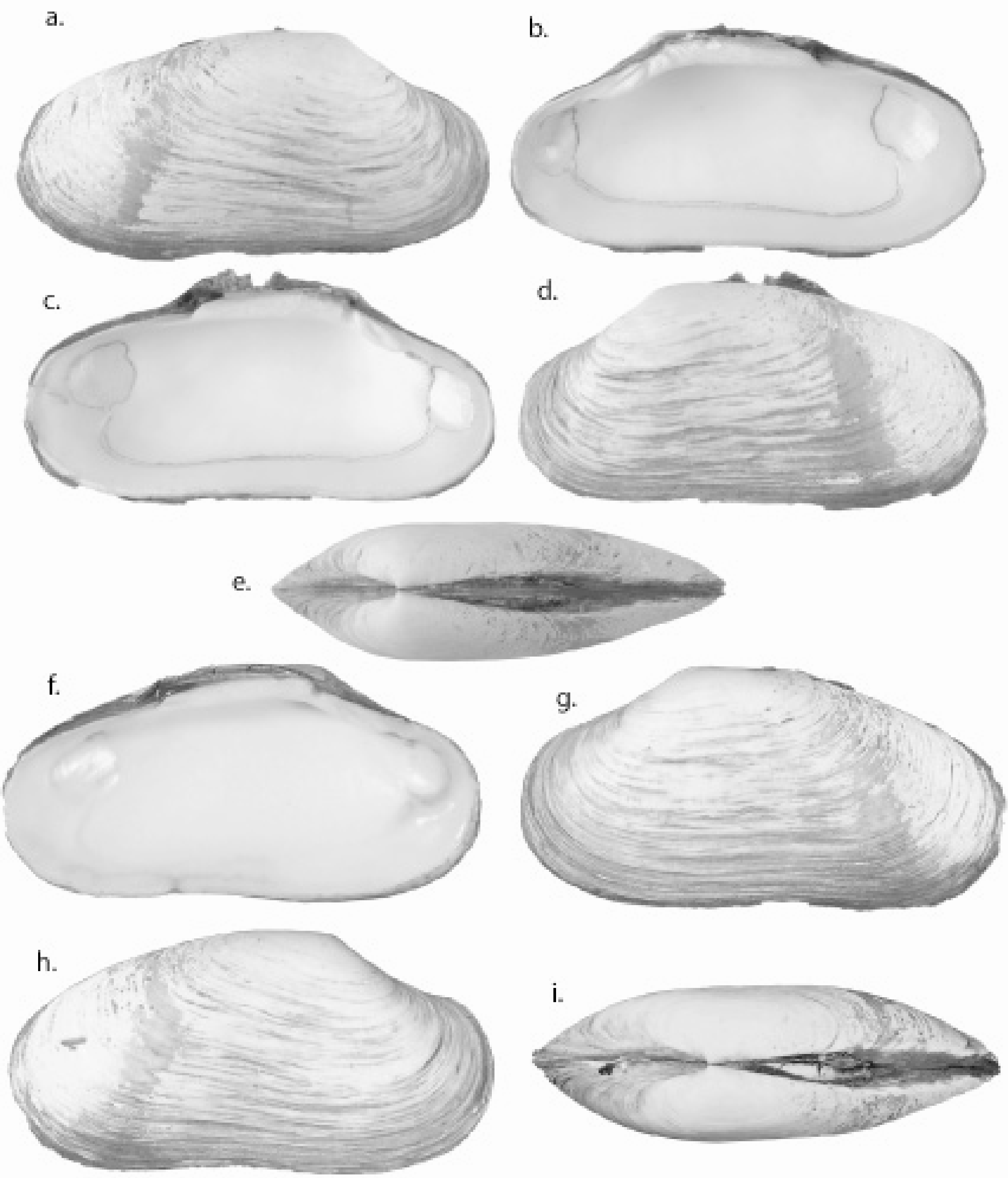

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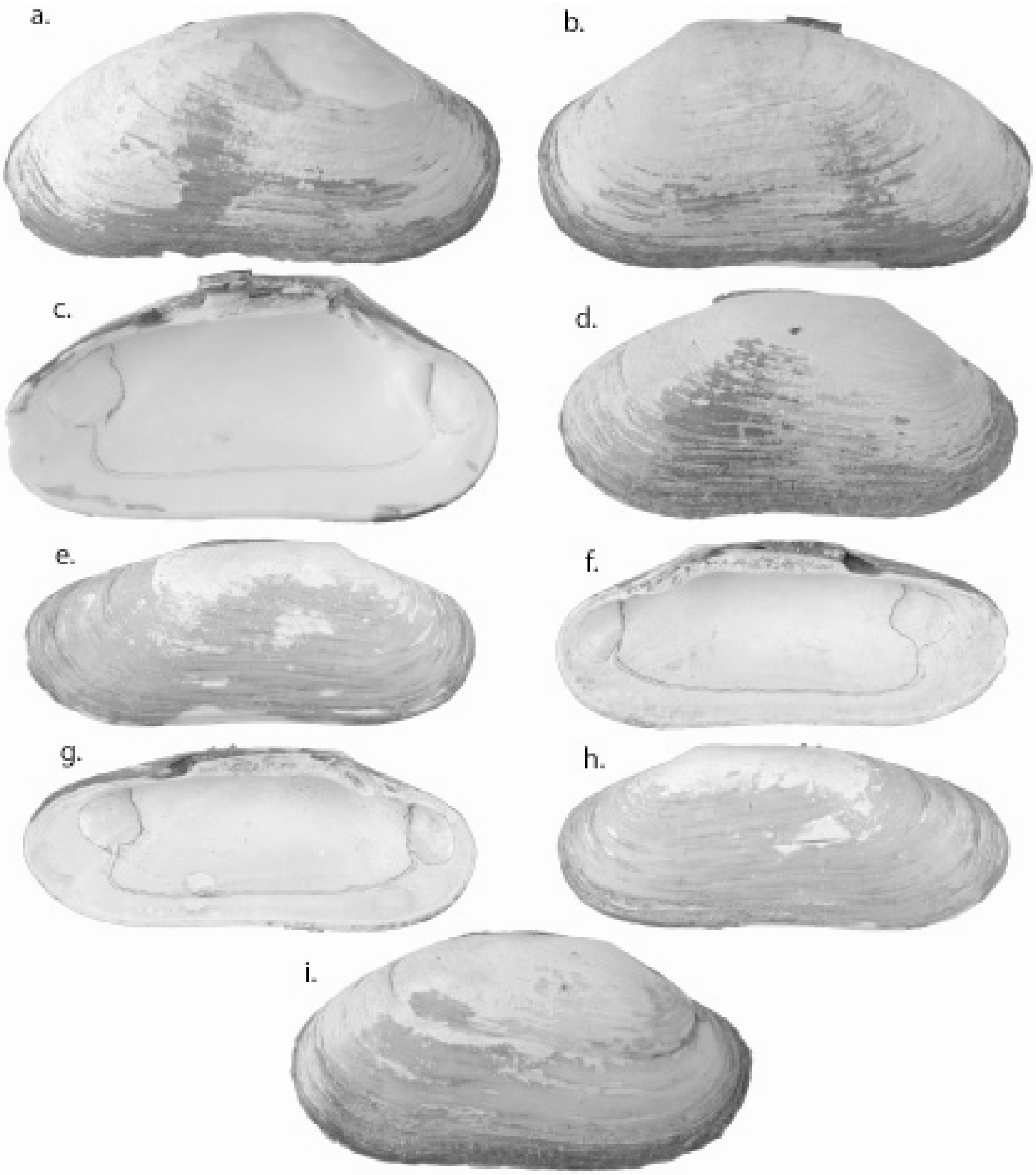

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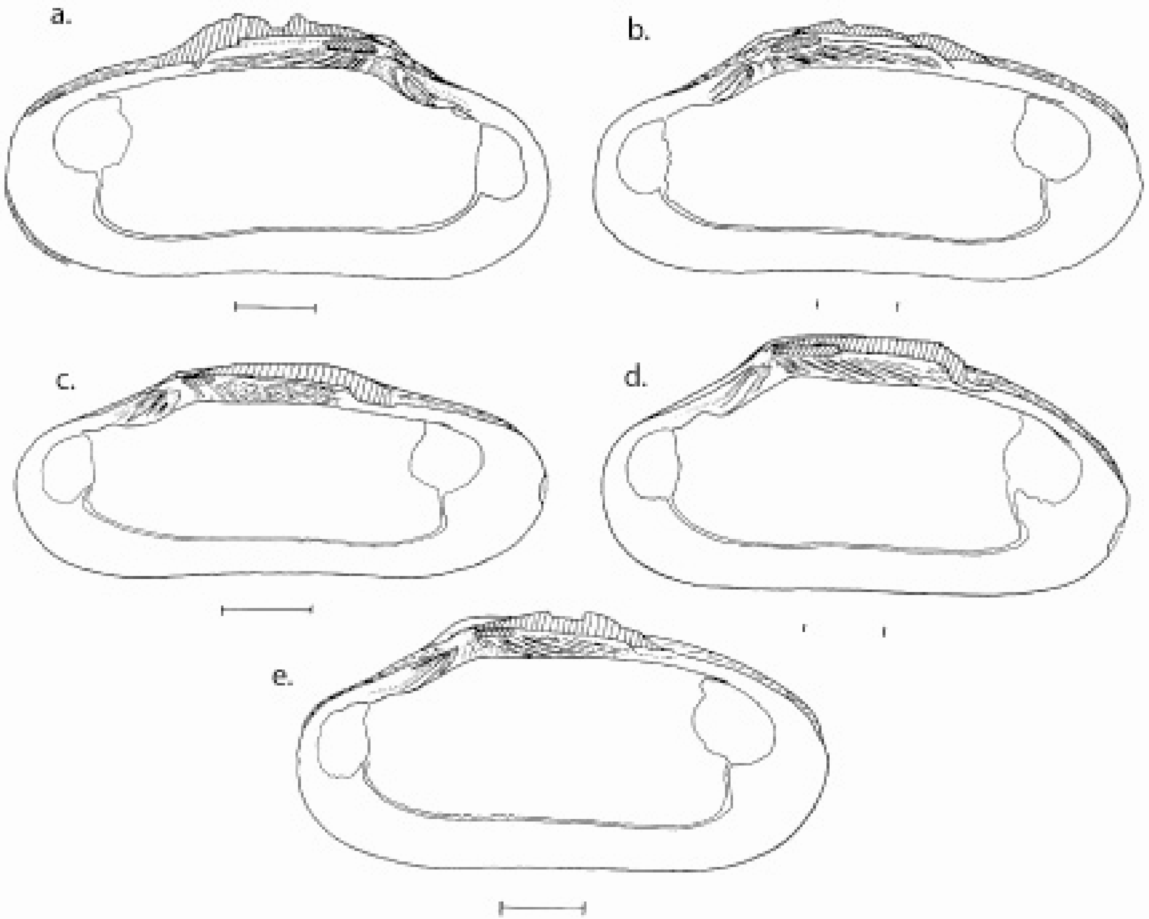

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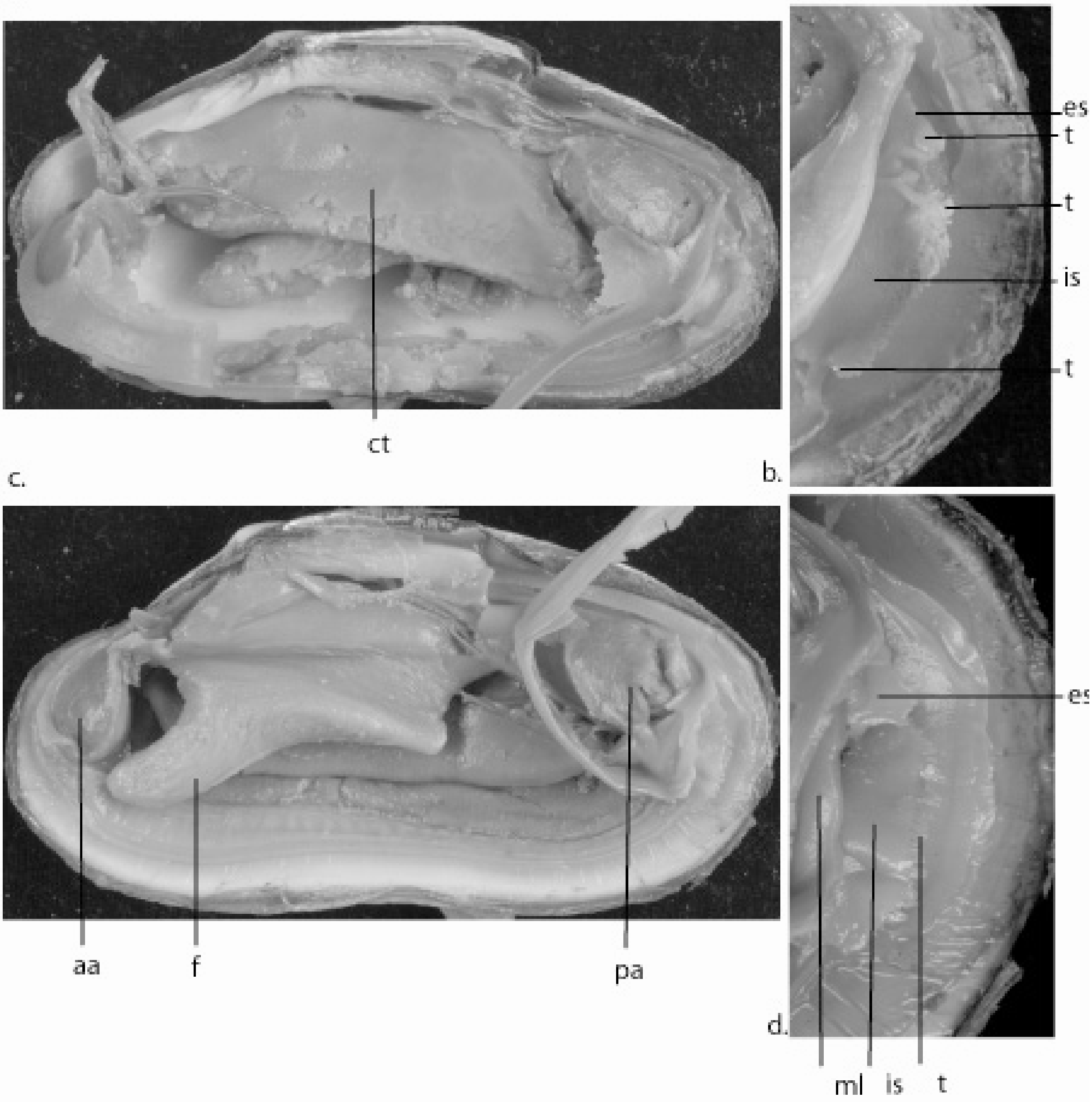

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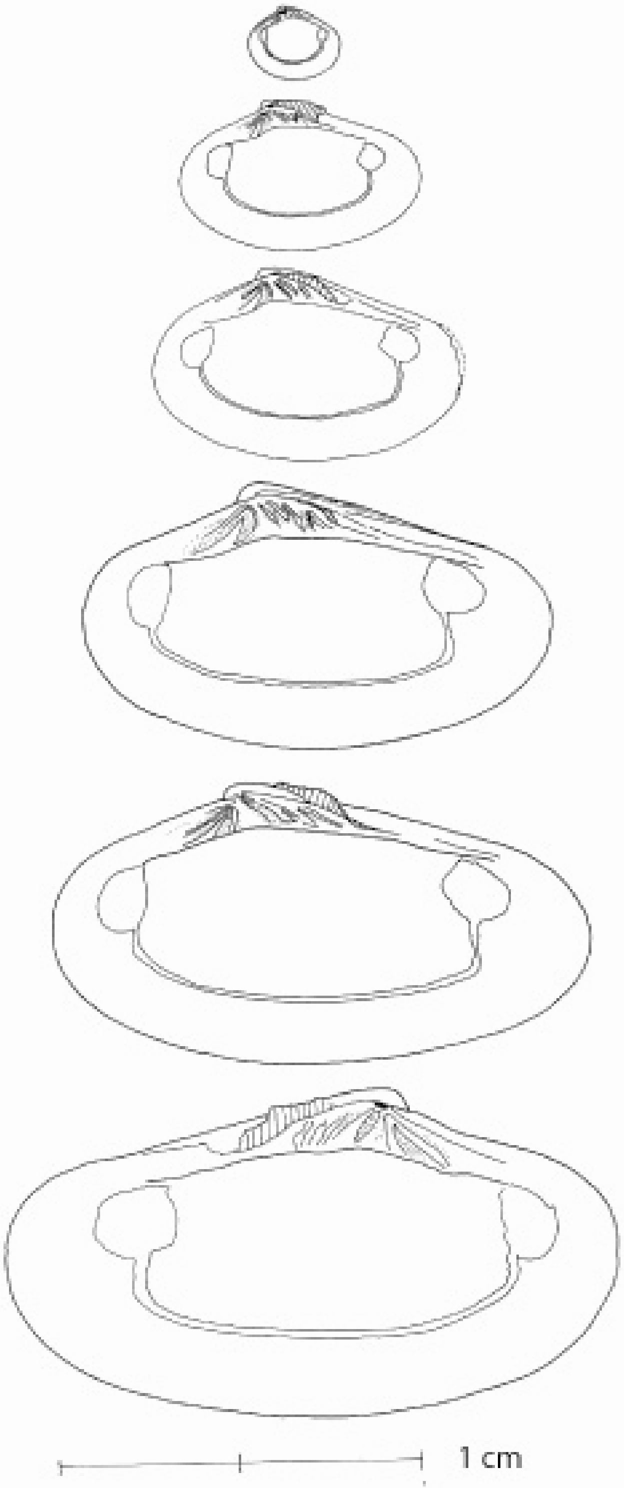

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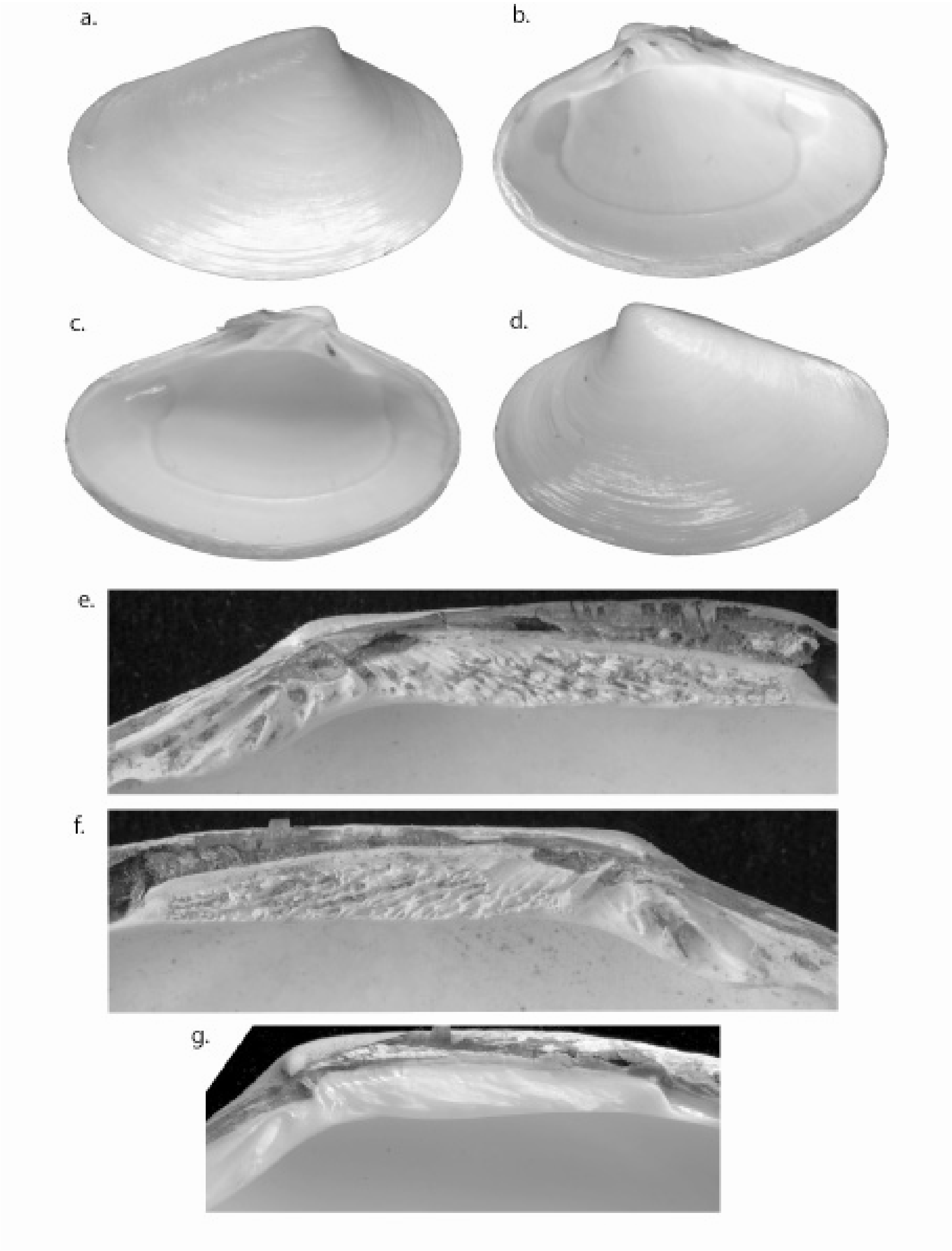

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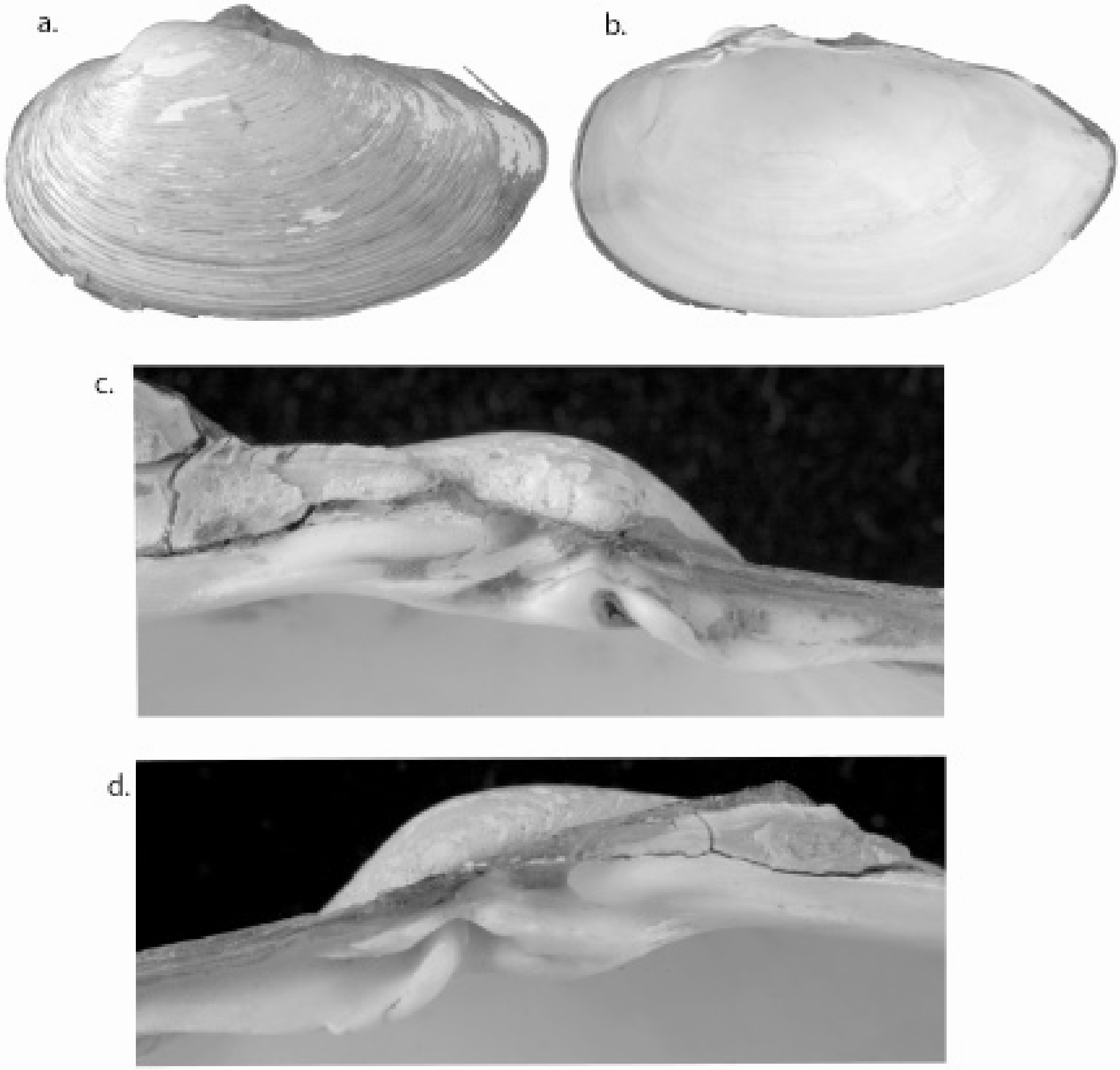

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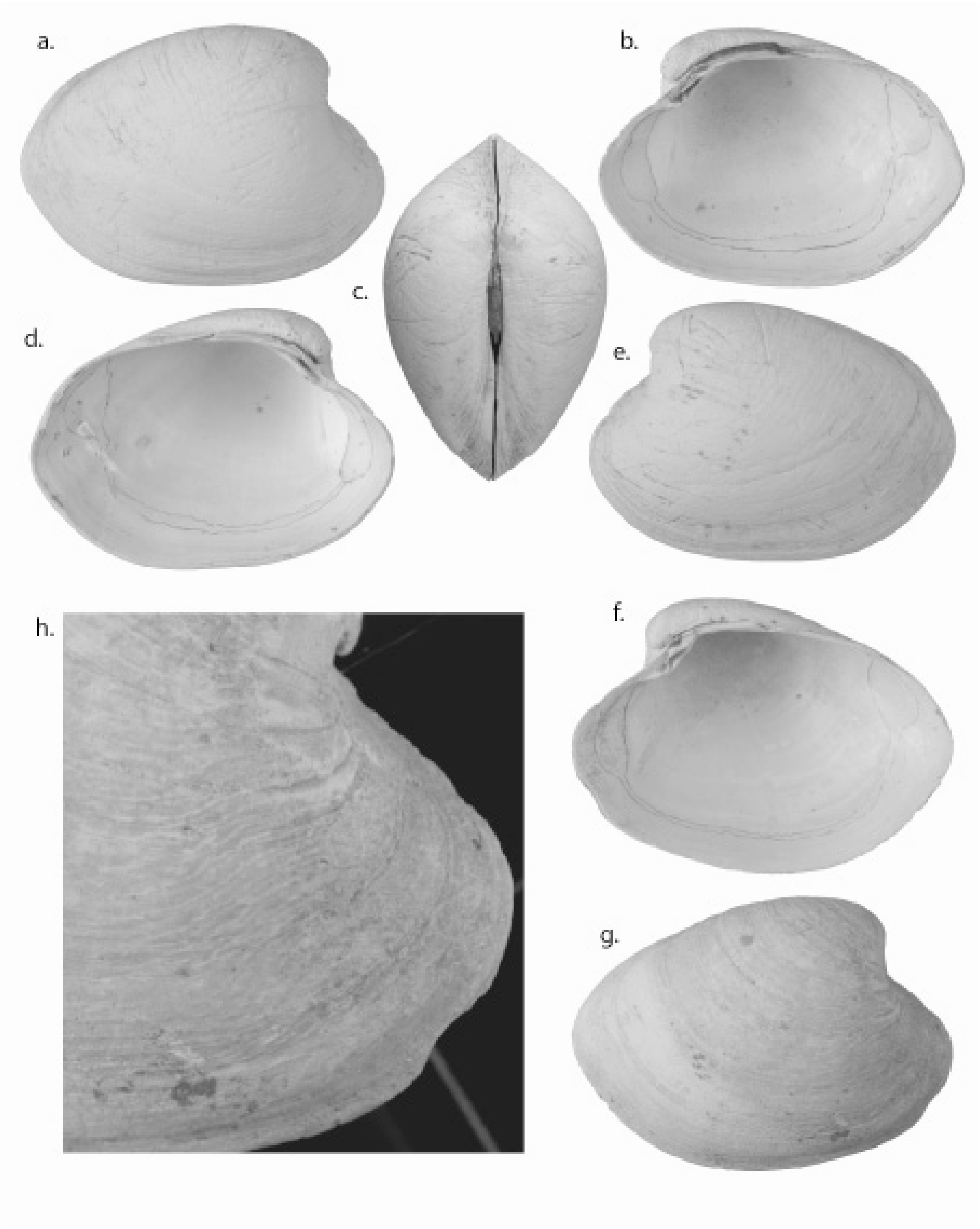

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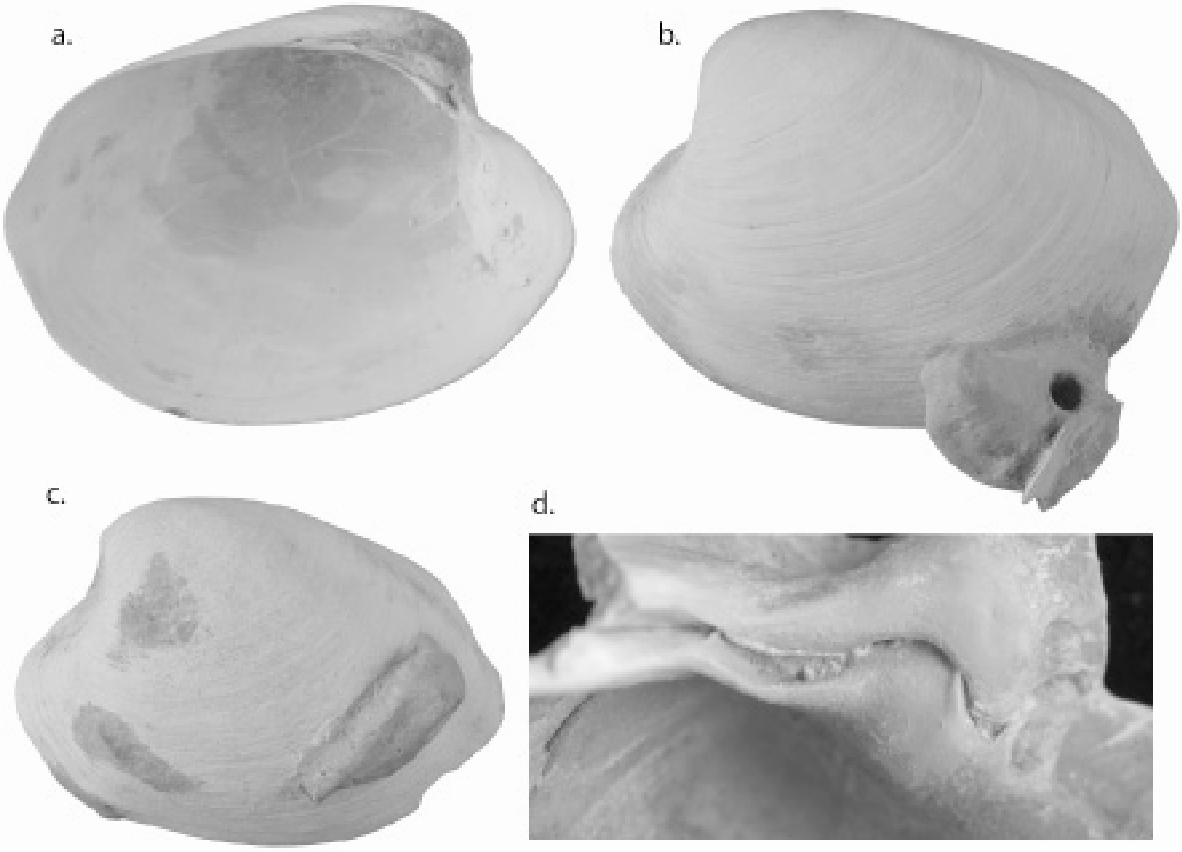


Fig24

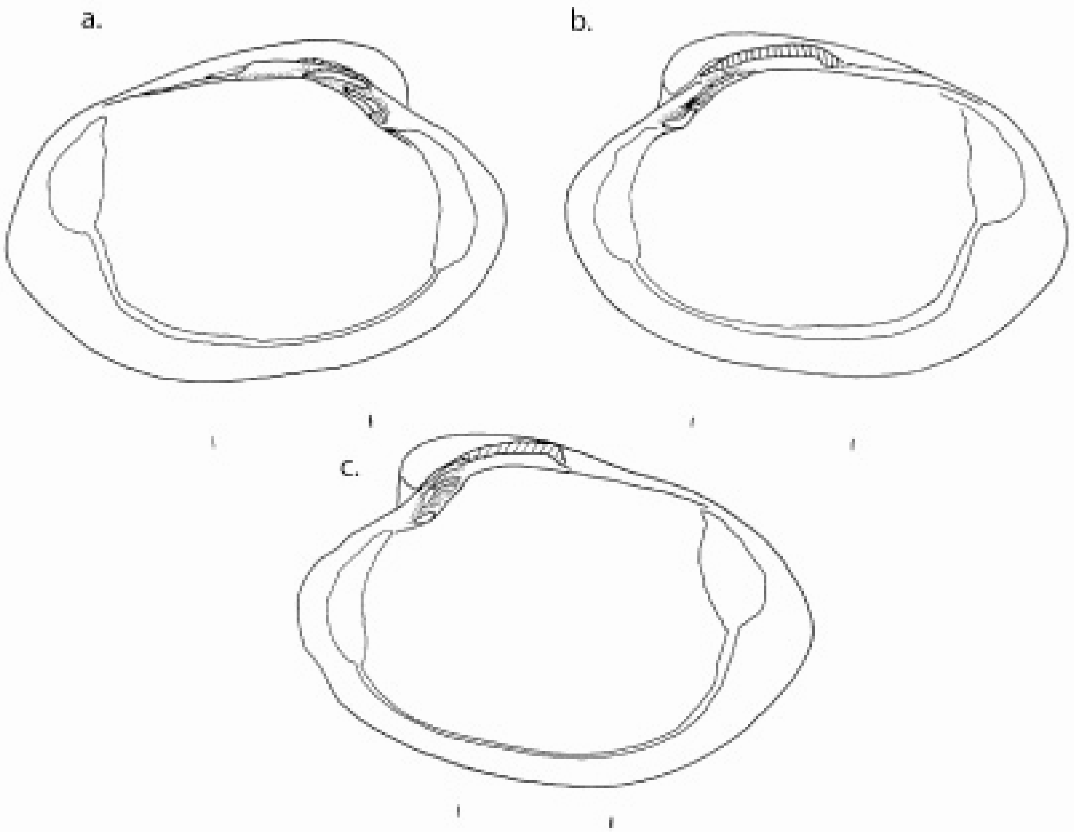


Fig25

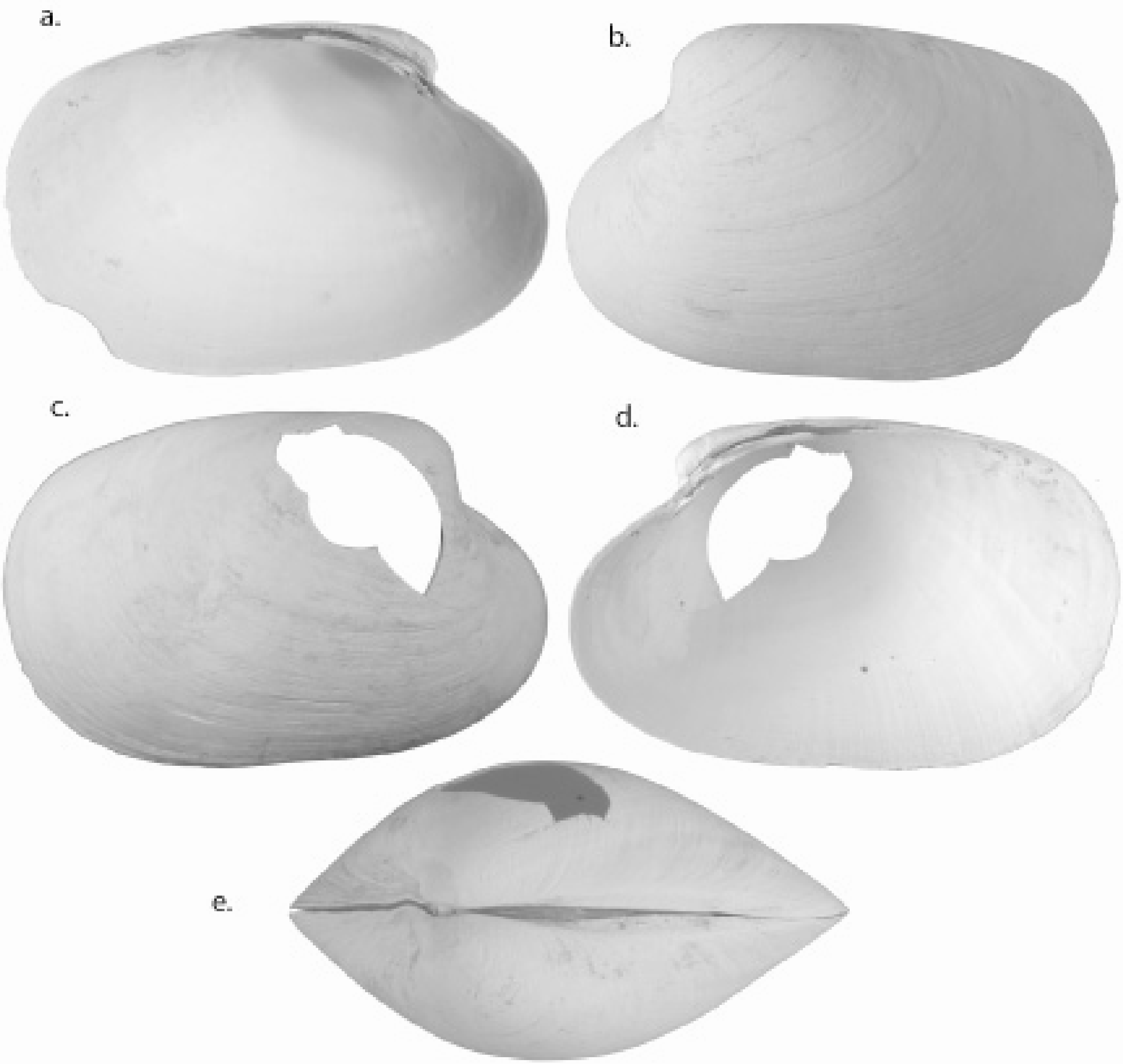


Fig26

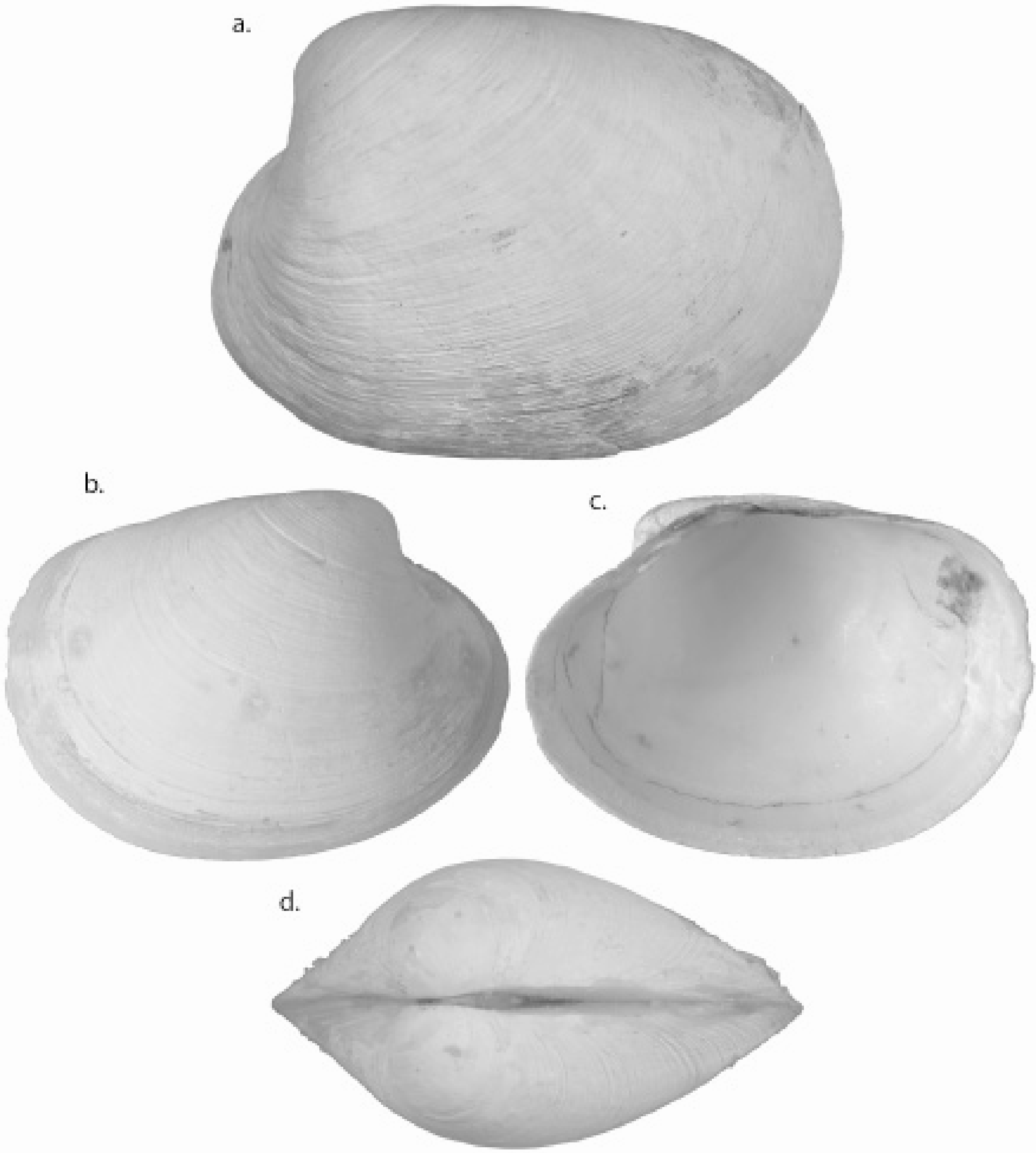


Fig27

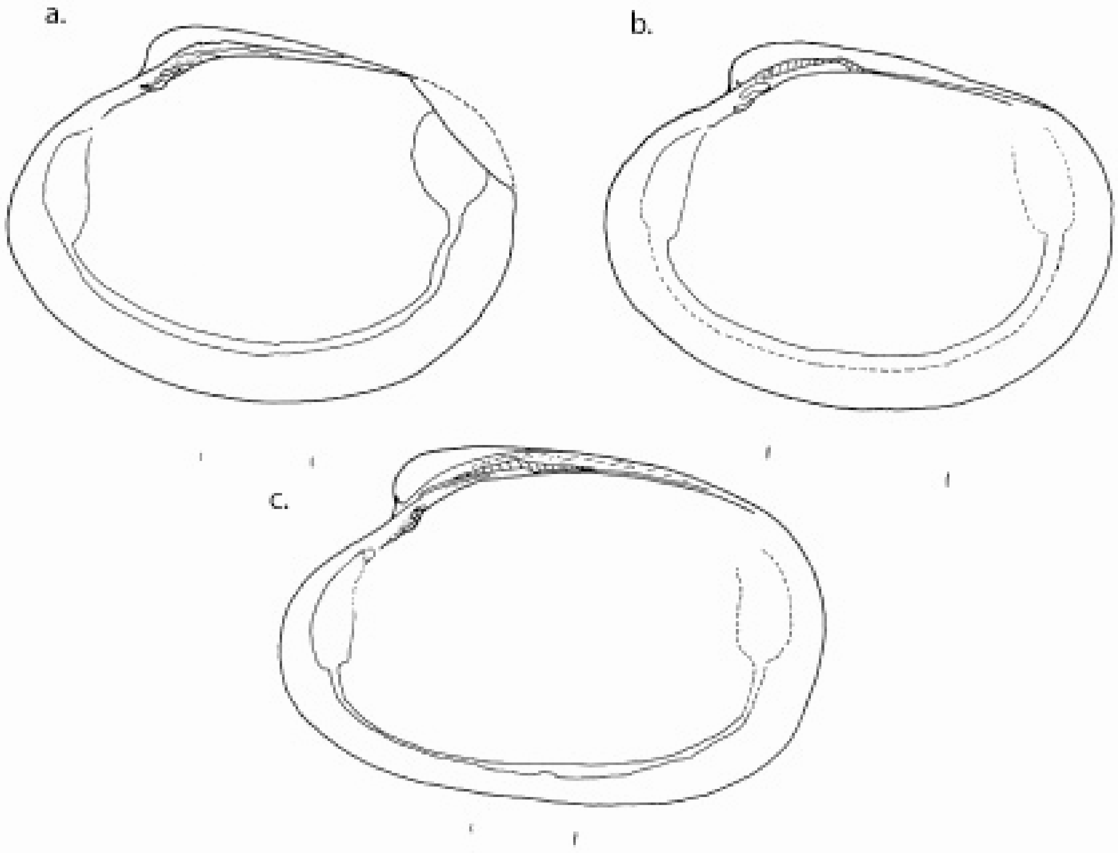


Fig28

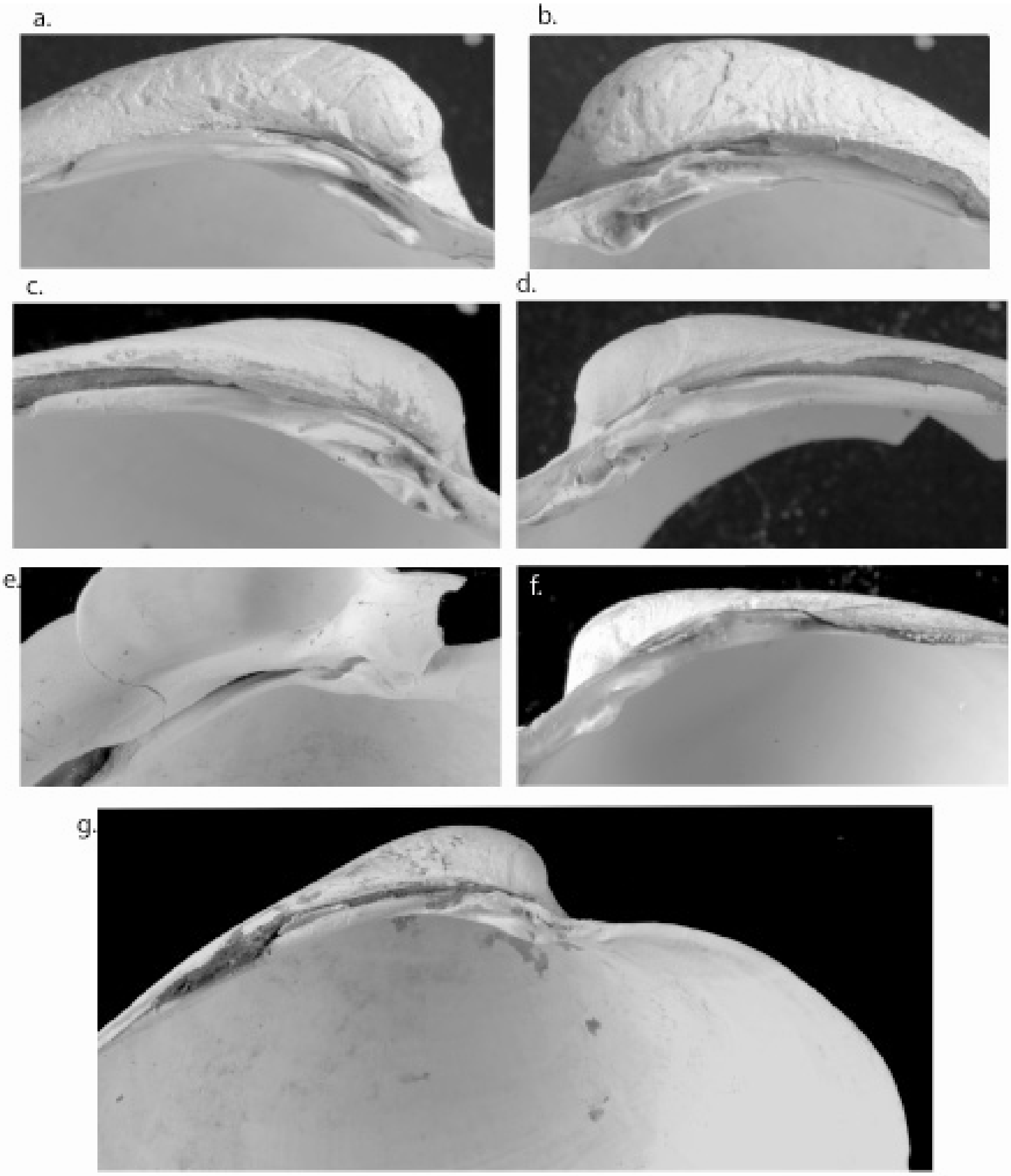


Fig29

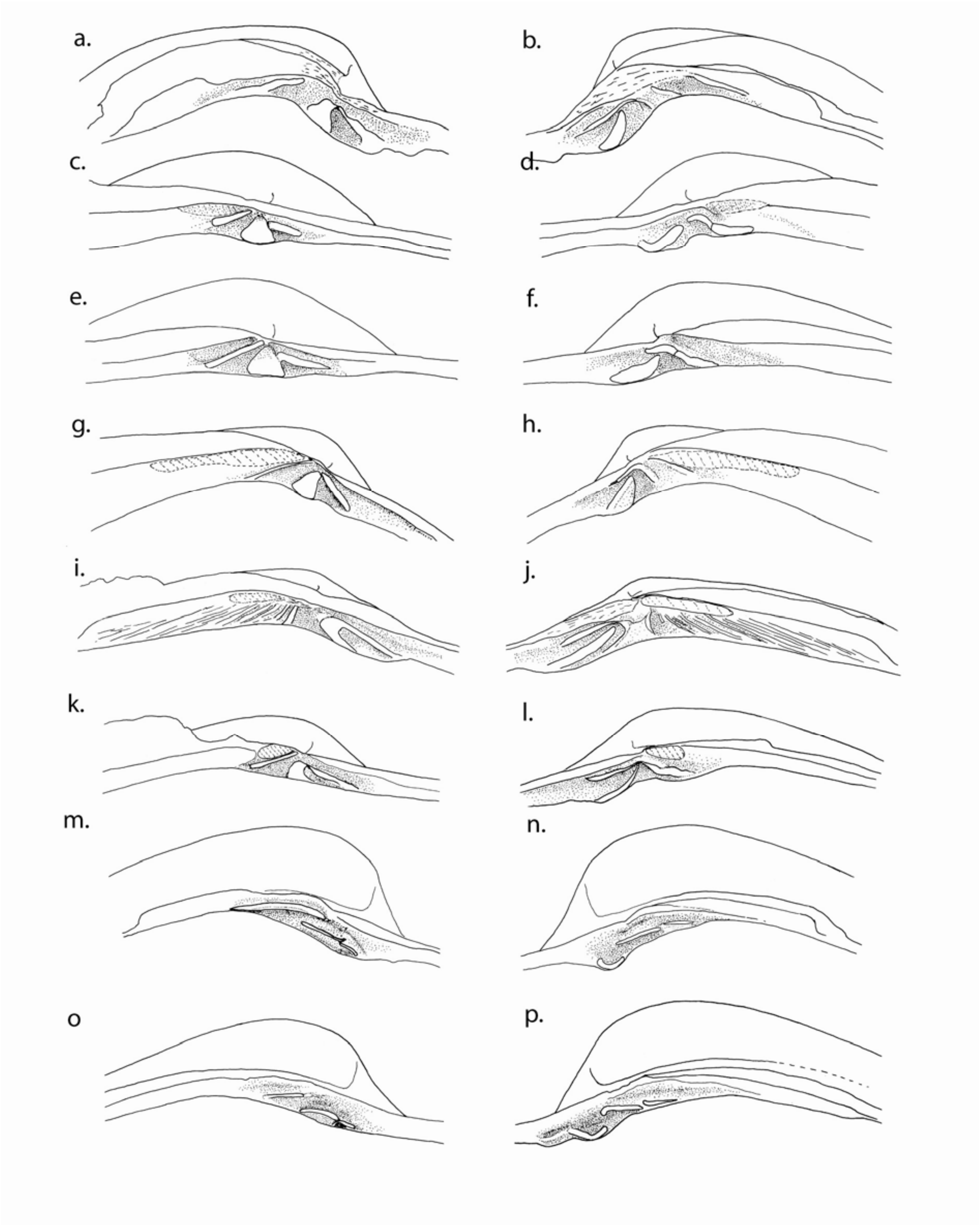
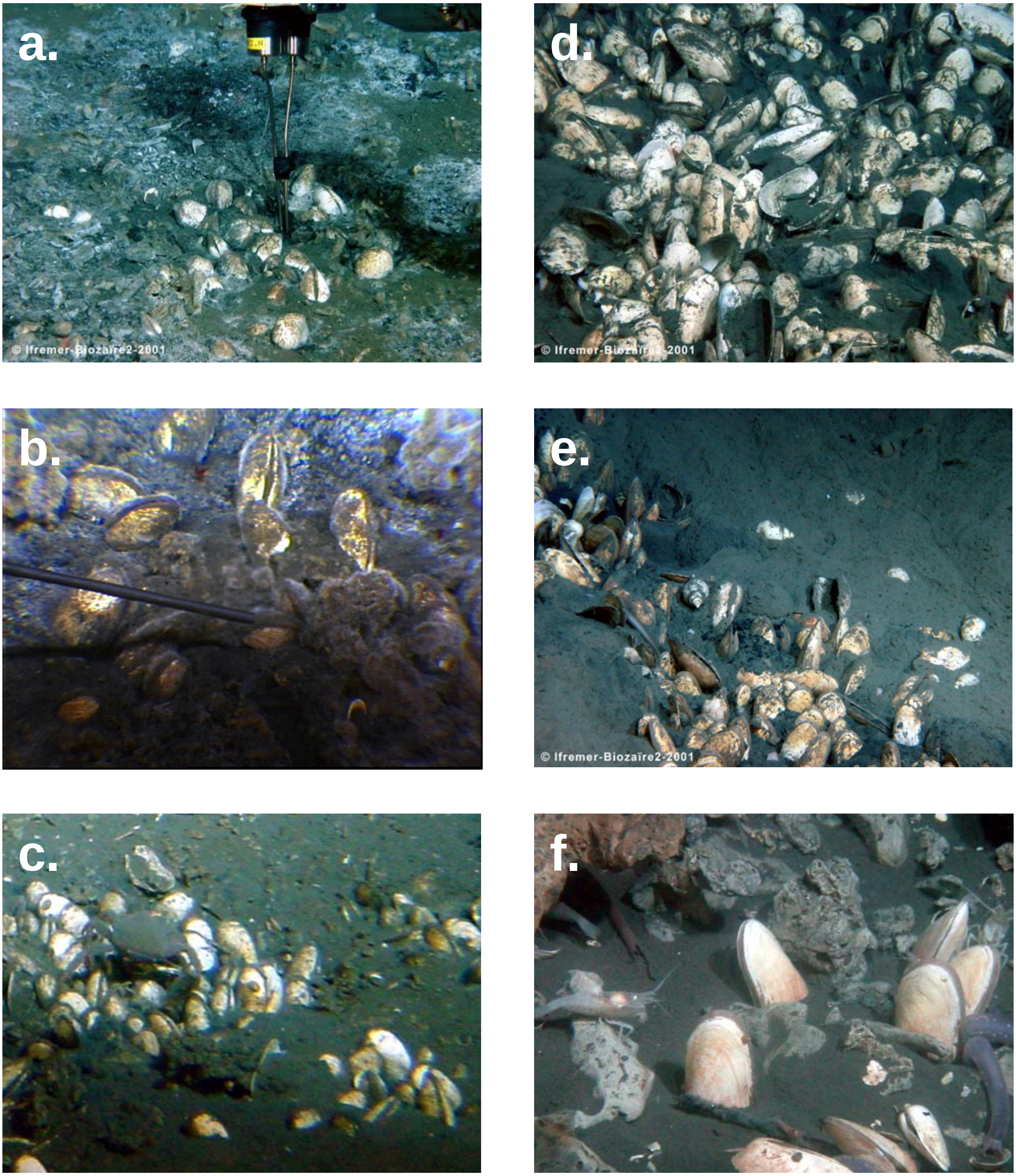


fig30


a.
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b.
e.
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c.
f.

Table 1

Calyptogena valdiviae, selected measurements with length/height ratio:

70.6 x 40.7 x --- mm	1.73	holotype ZMB of *V. longa*
64.5 x 39.5 x --- mm	1.53	KZR 30 ZR 2 ("*longa*"-form)
62.0 x 41.7 x 29.4 mm	1.49	PL 148 BZ 2
60.4 x 42.5 x 31.2 mm	1.42	PL 148
59.2 x 38.4 x 27.1 mm	1.54	Lectotype ZMB
59.1 x 40.2 x 31.2 mm	1.47	PL 148
57.1 x 41.2 x 31.7 mm	1.39	PL 148
57.0 x 40.4 x 28.4 mm	1.41	PL 148 BZ 2
56.4 x 40.6 x 33.4 mm	1.39	PL 148
53.7 x 40.0 x 31.6 mm	1.34	PL 148 (abnormous form
53.7 x 38.5 x 32.1 mm	1.39	PL 148 (abnormous form)
50.5 x 35.2 x 23.4 mm	1.43	PL 148
49.3 x 35.2 x 26.0 mm	1.40	PL 148
46.2 x 33.2 x 22.2 mm	1.39	PL 148
45.3 x 32.6 x 22.2 mm	1.39	PL 148
43.4 x 32.4 x 21.6 mm	1.34	PL 148
35.1 x 25.4 x 14.8 mm	1.38	PL 148

Table 2

"Calyptogena"(s.l.) *regab* n. sp., selected measurements with length/height ratio:

122.6 x 54.0 x --- mm	2.27	CP 20 BZ 3
122.2 x 47.1 x 37.2 mm	2.59	PL 81 BZ 1 paratype
115.0 x 52.4 x --- mm	2.29	CP 20 BZ 3
114.7 x 50.7 x --- mm	2.26	CP 20 BZ 3
114.4 x 45.7 x 31.1 mm	2.50	CP 20 BZ 3
107.1 x 45.7 x --- mm	2.34	CP 20 BZ 3
105.3 x 46.2 x 30.4 mm	2.28	PL 81 BZ 1 paratype
105.1 x 47.2 x --- mm	2.23	PL 147 BZ 2 paratype
104.0 x 45.2 x 31.1 mm	2.30	CP 20 BZ 3 paratype
101.4 x 43.8 x --- mm..	2.32	PL 147 BZ 2
102.0 x 46.1 x 31.6 mm	2.21	PL 147 BZ2 paratype
95.6 x 42.0 x 28.5 mm	2.28	PL 74-14 ZR 2 holotype
99.3 x 46.9 x 32.3 mm	2.12	PL 147 BZ2 paratype in alcohol
94.1 x 43.2 x .--- mm.	2.18	PL 147 BZ2 paratype (1 v broken)
89.5 x 41.1 x 27.9 mm	2.18	PL 147 BZ2 paratype
72.6 x 33.0 x --- mm	2.32	PL 73 ZR 2

Table 3

Wareniconcha guineensis, selected measurements with length/height ratio:

76.2 x 56.2 x 30.1 mm	1.36	CP 10 BZ 3
73.3 x 50.6 x 30.1 mm	1.45	CP 10 BZ 3
67.8 x 48.7 x 31.7 mm	1.39	KGS 41 BZ 2
67.3 x 49.4 x 26.6 mm	1.36	CP 10 BZ 3
64.8 x 50.0 x 26.8 mm	1.30	KGS 41 BZ 2
64.6 x 48.3 x 25.4 mm	1.34	CP 10 BZ 3
59.7 x 45.8 x 29.0 mm	1.30	Lectotype ZMB
58.4 x 48.5 x 25.7 mm	1.20	KGS 26 BZ 1
58.4 x 42.4 x 23.2 mm	1.38	KGS 41 BZ 2
53.6 x 41.5 x 24.0 mm	1.29	KGS 41 BZ 2
53.1 x 40.7 x 23.0 mm	1.30	CP 10 BZ 3
46.5 x 35.3 x 20.7 mm	1.32	CP 10 BZ 3

Table 4

Elenaconcha guiness n. sp., selected measurements with length/height ratio:

71.4 x 33.6 x 21.8 mm	2.12	PL 83 BZ1
70.5 x 37.5 x 24.7 mm	1.88	PL 83
70.2 x 33.6 x 20.5 mm	2.09	PL 83 paratype
69.9 x 34.6 x 22.8 mm	2.02	PL 83
69.9 x 33.8 x 20.8 mm	2.07	PL 83
69.6 x 34.4 x 22.4 mm	2.02	PL 83 paratype
68.8 x 35.3 x 24.9 mm	1.95	PL 83 paratype
67.5 x 33.1 x 20.2 mm	2.04	PL 83 paratype
67.5 x 33.4 x 21.4 mm	2.02	PL 83
67.4 x 33.8 x 21.5 mm	1.99	PL 83
67.1 x 32.9 x 21.5 mm	2.04	PL 63 paratype
66.8 x 32.0 x 22.0 mm	2.09	PL 83
66.8 x 31.4 x 20.1 mm	2.13	PL 83 Holotype
66.2 x 34.6 x 22.1 mm	1.91	PL 148
65.7 x 33.2 x 21.0 mm	1.98	Mauritania (MNHN)
65.6 x 33.0 x 20.5 mm	1.99	PL 83 paratype
65.2 x 33.2 x 22.3 mm	1.96	PL 83 paratype
65.1 x 32.0 x 21.1 mm	2.03	PL 148
65.1 x 31.6 x 21.1 mm	2.05	PL 83 paratype
65.0 x 31.6 x 20.0 mm	2.06	Mauritania (coll. Swinnen)
64.0 x 32.8 x 21.4 mm	1.95	PL 83
63.1 x 32.3 x --- mm	1.95	PL 148
61.5 x 25.8 x --- mm	2.38	Mauritania (coll. Swinnen)
60.6 x 30.0 x 18.3 mm	2.02	Mauritania (coll. Swinnen)
60.4 x 29.3 x 19.4 mm	2.06	Mauritania (coll. Swinnen)
60.5 x 30.8 x --- mm	1.96	PL 148

59.6 x 30.4 x 19.1 mm	1.96	Mauritania (coll. Swinnen)
59.1 x 24.0 x 14.3 mm	2.46	Mauritania (MNHN)
58.2 x 25.4 x --- mm	2.29	Mauritania (coll. Swinnen)
57.6 x 28.6 x --- mm	2.01	PL 148
51.5 x 21.6 x 13.0 mm	2.38	Mauritania (MNHN)

Table 5

Isorropodon atalantae n. sp., measurements with length/height ratio:

46.6 x 34.0 x 28.2 mm	1.37	paratype 1
38.4 x 27.6 x -- mm	1.39	paratype 3
33.4 x 24.1 x -- mm	1.39	paratype 2
30.7 x 22.0 x 19.4 mm	1.40	holotype

Table 6

Isorropodon striatum (Thiele & Jaeckel 1931), selected measurements with length/height ratio:

17.6 x 14.0 x 9.6 mm	1.26	ZC
27.3 x 19.7 x 15.0 mm	1.39	ZD
47.0 x 34.9 x 26.4 mm	1.35	holotype Cameroon
51.4 x 33.2 x 27.2 mm	1.55	ZD
65.2 x 46.1 x 38.5 mm	1.41	ZD
70.0 x 47.4 x 37.0 mm	1.48	ZD

Table 7. Comparison of the Gulf of Guinea Vesicomyidae (following Krylova & Sahling, 2006, table 12)

	Calyptogena valdiviae	*"Calyptogena"* (s.l.) *regab*	*Wareniconcha guineensis*	*Elenaconcha guiness*	*Laubiericon chuni*	*Isorropodon atalantae*	*I*
Maxi. shell length	64.0 mm ("longa") 62.0 mm	122.6 mm	76.2 mm	71.4 mm	120.2 mm	46.6 mm	7
Outline	oval-veneriform	elongate lutrariform	short-oval, veneriform	elongate tageliform	elongate lutrariform	oval, tapering posterior end	o e
Tumidity	well to very inflated	moderate	not inflated	not inflated	moderate	inflated	v i
Shell thickness	thick to very thick and heavy	thin	moderately thixk but fragile	very thick and heavy	thin	thin but strong	t f
Teeth orientation	diverging	diverging	diverging	diverging	diverging	parallel	p
Subumbonal pit	absent	? absent	present	Present	present but small	absent	a
3a tooth	present	short, thin	thin	long thin	present	present	p
3b tooth	broad	thin	broad	broad	thin	thin	t
post. nymph. ridge	present	absent	absent	multiple	absent	absent	a
Pallial sinus	absent	absent	very small directly under scar	very small	well developed, triangular	absent	a
Demibranchs	one	one	one	one	two	? (one)	o
Anterior pedal retractor scar	quite deep	deep, united wit anterior add. sca	quite deep	deep	quite deep	shallow	s

Table 8.

Bathymetric distribution of the Vesicomyidae collected during the ZAIANGO Project (cruises ZAIROV 2, ZAIANGO BIOL, BIOZAIRE 1, 2, 3) in comparison with the depths of the *Valdivia* material in the Gulf of Guinea, ordered by stations from shallow to deep

Depth zones ZAIANGO + BIOZAIRE	site	species	Depth *Valdivia*	Depth difference of *Valdivia* compared with ZAIANGO+BZ
500-800 m	BSR Congo	*Isorropodon bigoti*	----	----
		Calyptogena valdiviae (fragn	2500 m	- 1800 m
		(?*Callogonia* sp.) juv.	---	----
579-670 m	GUINESS	*Elenaconcha guiness* n. sp.	---	----
		C. valdiviae	2500 m	- 1800 m
1490-1520 m	MPS 1	C. *valdiviae*	2500 m	-1000 m
2820-2840 m	ASTRID	*Laubiericoncha chuni* (juv.)	2492 m	+ 400 m
		"Calyptogena" regab n. sp.	---	----
		(old v.)	---	----
		Callogonia sp.		
3140-3200 m	REGAB	*Laubiericoncha chuni*	2492 m	+ 800 m
		"Calyptogena" regab n. sp	---	
		Isorropodon atalantae n.	---	
		sp.(valves)	2492 m	+ 800 m
		Wareniconcha. guineensis (o		
		v.)		
3950-4017 m	ZC and ZD	*Wareniconcha. gineensis*	2492 m	+ 1300 m
		Isorropodon striatum	2492 m	+ 1300 m

Table 9.

Tropical Eastern Atlantic Vesicomyidae collected during the ZAIANGO Project and their depth ranges, ordered by species

species	site or locality	depth ranges ZAIANGO, BIOZAIRE,Mauritania	depth ranges *Valdivia*
Calyptogena valdiviae	BSR Congo GUINESS MPS 1	500-800 m 579-670 m 1490-1520 m	2500 m
"Calyptogena" (s.l.) *regab*	ASTRID REGAB	2820-2840 m 3140-3200 m	-----
Wareniconcha guineensis	REGAB ZC ZD	3140-3200 m 3950 m 4017 m	2492 m
Elenaconcha guiness	GUINESS Mauritania	579-670 m 900-1200 m	-----
Laubiericoncha chuni	REGAB ASTRID	3140-3200 m 2820-2840 m	2492 m
Isorropodon atalantae	REGAB	2820-2840 m	-----
Isorropodon striatum	ZC ZD	3950 m 4017 m	2492 m
Isorropodon bigoti	BSR Congo	500-800 m	-----