



## Cirripeds (Crustacea) from the Mid-Atlantic Ridge collected by the submersible *Nautilus*

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**Abstract:** Nine species of barnacles were dredged along the Mid-Atlantic Ridge during several cruises of the French submersible *Nautilus*. They include the lepadomorph *Glyptelasma rectum*, the scalpellomorphs *Scillaelepas* sp., *Trianguloscalpellum regium*, *Arcoscalpellum michelottianum*, the verrucomorphs *Altiverruca erecta*, *A. longicarinata*, *A. obliqua*, and the balanomorph *Hexelasma americanum*. A new verrucomorph *Newmaniverruca ferruginea* sp. nov. is described. *Altiverruca erecta* and *A. longicarinata* are redescribed. All these species have a wide distribution, except *A. erecta* and *N. ferruginea* sp. nov. Based on several recent studies it now appears that Atlantic hydrothermal vents areas are not refugia for unusual relic cirripeds such as those found in the Pacific hydrothermal fields.

**Résumé :** Cirripèdes (Crustacea) de la ride Médio-Atlantique recueillis par le submersible *Nautilus*. Neuf espèces de Cirripèdes ont été recueillies sur la ride Médio-Atlantique au cours de plusieurs campagnes du submersible français *Nautilus*. Ces espèces sont le Lépadomorphe *Glyptelasma rectum*, les Scalpellomorphes *Scillaelepas* sp., *Trianguloscalpellum regium*, *Arcoscalpellum michelottianum*, les Verrucomorphes *Altiverruca erecta*, *A. longicarinata*, *A. obliqua* et le Balanomorphe *Hexelasma americanum*. Une nouvelle espèce de Verrucomorphe *Newmaniverruca ferruginea* sp. nov. est décrite ici. *Altiverruca erecta* et *A. longicarinata* sont redécrites. Toutes ces espèces ont une ample distribution, sauf *A. erecta* et *N. ferruginea*. Plusieurs études récentes indiquent que les sources hydrothermales de l'Atlantique ne sont pas des refuges de formes reliques de cirripèdes, alors que cela est le cas des sources hydrothermales du Pacifique.

**Keywords:** Cirripeds, Hydrothermal vents, Mid-Atlantic Ridge.

### Introduction

The Mid-Atlantic Ridge barnacle fauna is relatively well known from the Azores region and the Great Meteor Bank (Aurivillius, 1898; Gruvel, 1900 a, b; 1902; 1920; Young, 1998, in press). To date 28 lepadomorph, 10 verrucomorph and 1 balanomorph species have been recorded, excluding the shallow-water species from the Azores Archipelago

(Young, 1998). There are no records of barnacles from other areas of the Atlantic ridge.

The Mid-Atlantic Ridge was explored during several dives of the submersible *Nautilus*. The purpose of these dives was to study the structure of the ocean crust and the biota found in the area around hydrothermal vents. The French expeditions between June 1992 and August 1995 to fracture zones: FARANAUT (15°N fracture zone) and KANAUT (Kane fracture zone, 24°N), and to hydrothermal vent areas: GRAVINAUT (Snake Pit, 23°N) and DIVA 1 and 2 (Lucky Strike, 37°N), supplied several samples of barnacles

(Fig. 1). The barnacles collected during these dives form the basis for this study and provide insights on the endemism of the species collected.

The hydrothermal vents from the Pacific Ocean have a characteristic endemic fauna, with several species considered relics (Newman, 1985). Representative of all cirripeds groups are present: Brachylepdomorpha (*Neobrachylepas relicha* Newman and Yamaguchi, 1995), Lepadomorpha (*Neolepas zeviniae* Newman, 1979 and *N. rapanuii* Jones, 1993), Verrucomorpha (*Neoverruca brachylepadoformis* Newman, in Newman and Hessler, 1979), and Balanomorpha (*Eochionelasmus ohtai* Yamaguchi, 1990, *E. paquensis* Yamaguchi and Newman, 1997a, and *E. ohtai manusensis* Yamaguchi and Newman 1997b).

The specimens studied are deposited in the Muséum National d'Histoire Naturelle, Paris (MNHN Ci) and the

Museu Nacional, Rio de Janeiro (MNRJ) Abbreviations used are as follows: cl - capitular length; rc - rostro-carinal diameter.

## Study of the Species

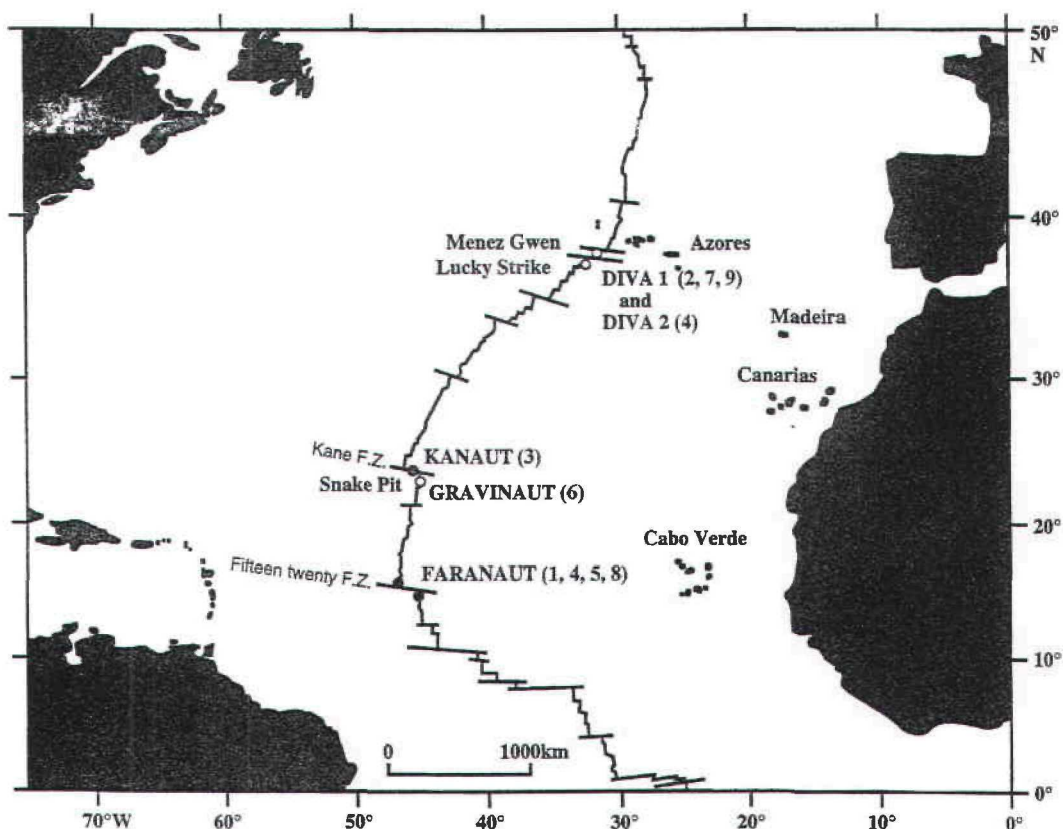
### I. Order Pedunculata Lamarck, 1818

#### 1. Suborder Lepadomorpha Pilsbry, 1916

##### *Glyptelasma rectum* (Pilsbry, 1907) (Fig. 2a-b)

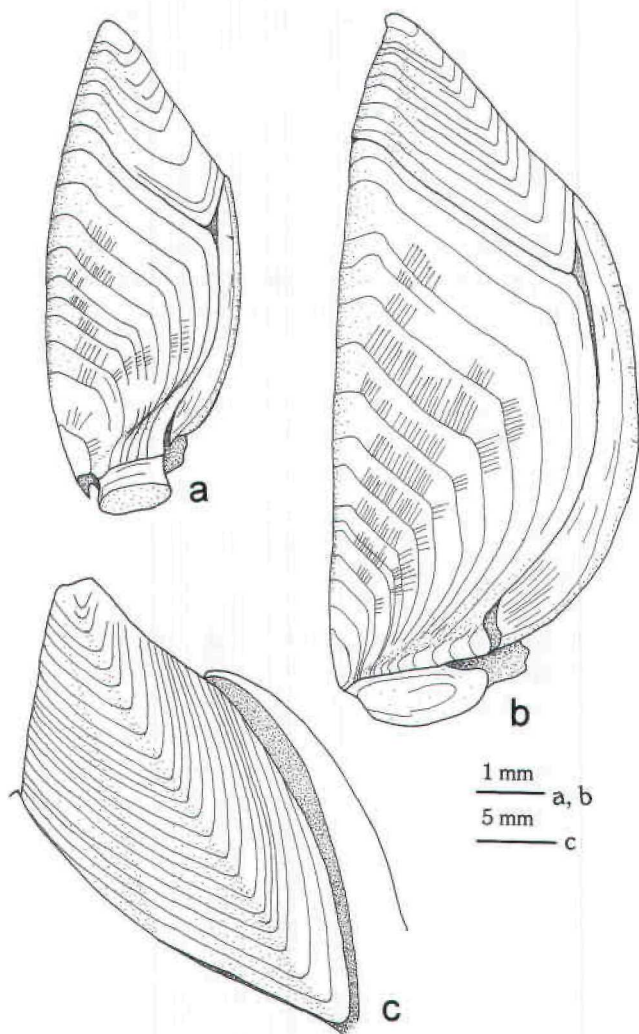
Material: Mid-Atlantic Ridge, 15°N fracture zone, north of the axial valley, FARANAUT cruise, FR-10, 15°35.33'N, 46°45.06'W, depth 3947-3375 m, 2 specimens, cl: 6 and 9 mm, (MNHN Ci 2672), (MNRJ 8841).

Remarks: the small specimen of *Glyptelasma rectum* lacks some of the characteristics described by Pilsbry



**Figure 1.** Mid-Atlantic ridge: the names of the vent areas (open circles) and the explored fracture zones (filled circles) are indicated on the left side and the names of the French cruises are indicated on the right side (IFREMER). The species collected are shown in parenthesis. 1. *Glyptelasma rectum* (Pilsbry); 2. *Scillaelepas* sp. 3. *Trianguloscalpellum regium* (Thomson); 4. *Arcoscalpellum michelottianum* (Seguenza); 5. *Altiverruca erecta* (Gruvel); 6. *A. longicarinata* (Gruvel); 7. *A. obliqua* (Hoek), 8. *Newmaniverruca ferruginea* sp. nov., 9. *Hexelasma americanum* Pilsbry.

**Figure 1.** Ride Médio-Atlantique : les noms des sites hydrothermaux (cercles ouverts) et des zones de fractures étudiées (cercles noirs) sont indiqués à gauche et les noms des campagnes françaises sont indiqués à droite (IFREMER). Les espèces recueillies sont indiquées entre parenthèses. 1. *Glyptelasma rectum* (Pilsbry) ; 2. *Scillaelepas* sp. ; 3. *Trianguloscalpellum regium* (Thomson) ; 4. *Arcoscalpellum michelottianum* (Seguenza) ; 5. *Altiverruca erecta* (Gruvel) ; 6. *A. longicarinata* (Gruvel) ; 7. *A. obliqua* (Hoek) ; 8. *Newmaniverruca ferruginea* sp. nov., 9. *Hexelasma americanum* Pilsbry.



**Figure 2.** *Glyptelasma rectum* (Pilsbry) (a, b) lateral view (MNHN Ci 2672) and (MNRJ 8841), respectively. *Trianguloscalpellum regium* (Thompson), (c) tergum (MNRJ 8842).

**Figure 2.** *Glyptelasma rectum* (Pilsbry) (a, b) vue latérale (MNHN Ci 2672) et (MNRJ 8841), respectivement. *Trianguloscalpellum regium* (Thompson), (c) tergum (MNRJ 8842).

(1907): the scutum has a convex occludent margin, the basal edge of scutum only projects slightly outward and the apico-basal ridge is inconspicuous (Fig. 2a). Alternatively, the larger specimen possesses all the characters observed by Pilsbry (Fig. 2b).

## 2. Suborder Scalpellomorpha Newman, 1987

### *Scillaelepas* sp.

Material: Lucky strike hydrothermal vents area, DIVA 1 cruise, DV 13-5, 37°50.90'N, 31°31'W, depth 696 m, 1 specimen, cl: 5 mm (MNHN Ci 2673).

Remarks: the decalcification of the specimen hinders more detailed identification. Based on the impressions of the

valves on the cuticle, the absence of a subrostrum and the presence of filamentary appendages on the prosoma are characteristic of *Scillaelepas* s.s. Five extant species of *Scillaelepas* s.s. are recognized: *S. grimaldi* (Aurivillius), *S. gemma* (Aurivillius), *S. superba* (Pilsbry), *S. fosteri* Newman, and *S. uschakovi* Zevina, the first three from the North Atlantic, the fourth from New Zealand and the last from south of Hawaii (Newman, 1980; Zevina, 1988a). Among those from the Atlantic Ocean, *S. grimaldi* (Aurivillius) was collected from near the Azores at depths between 845 and 1250 m. The locality and depths are similar to that of DIVA 1 station.

### *Trianguloscalpellum regium* (Thomson, 1873)

(Fig. 2c)

Material: Mid-Atlantic Ridge, Kane fracture zone, KANAUT cruise, KN11-4, 23°38.02'N, 45°14.34'W, depth 3900 m, 1 specimen, cl: 42 mm, (MNHN Ci 2674); KN18-6, 23°39.54'N, 45°28.05'W, depth 3808 m, 1 specimen, cl: 42 mm, and 1 specimen, cl: 16 mm, (MNHN Ci 2675), (MNRJ 8842).

Remarks: one specimen of *Trianguloscalpellum regium* is 67 mm long, one of the larger size ever recorded. The tergum, besides the medial apico-basal ridge, has a slight elevation forming a low ridge from the apex to the basilateral margin, partitioning the plate into three areas (Fig. 2c). The roof of the carina is elevated medially with low, lateral, longitudinal ribs. *T. regium* occurs along the abyssal plain of the North Atlantic. The records from the Pacific and the Indian oceans were reviewed by Young (in press). In the Atlantic it is usually recorded below 3000 m, which agrees with the depth of these samples.

### *Arcoscalpellum michelottianum* (Seguenza, 1876)

Material: Lucky Strike hydrothermal vents area, DIVA 2 cruise, PL 02, Sintra Site, 37°17.50'N, 32°16.47'W, depth 1622 m, 1 specimen, cl: 8 mm, (MNHN Ci 2676). Mid-Atlantic Ridge, 15°N fracture zone, north of the axial valley, FARANAUT cruise, FR-13, 15°28.56'N, 46°34.15'W, depth 3935-3967 m, 1 specimen, cl: 8 mm, (MNRJ 8843).

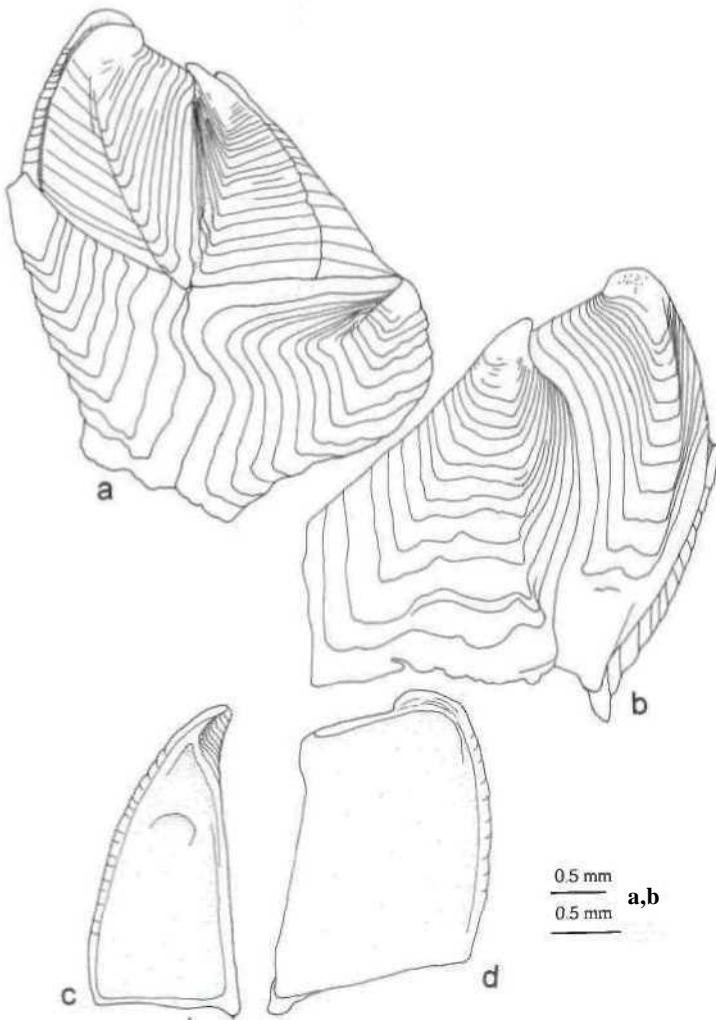
Remarks: *Arcoscalpellum michelottianum* is a common world-wide species and settles on various substrates. The present specimens are not fully developed, because adults average 40 to 50 mm in height.

## II. Order Sessilia Lamarck, 1818

### 1. Suborder Verrucomorpha Pilsbry, 1916

#### *Altiverruca erecta* (Gruvel, 1900) (Figs. 3-4)

*Verruca erecta* Gruvel, 1900b: 243; 1902: 93, pl. 5, figs. 7-8; 1905: 172, figs. 188-189.



**Figure 3.** *Altiverruca erecta* (Gruvel) (a) top view; (b) fixed-tergum and fixed-scutum, external view; (c, d) scutum and tergum, internal view (MNHN Ci 2677).

**Figure 3.** *Altiverruca erecta* (Gruvel) (a) vue dorsale ; (b) tergum et scutum fixes, vue externe ; (c d) scutum et tergum, vue interne (MNHN Ci 2677).

*Verruca erecta*, section D, *Altiverruca* of Pilsbry, 1916: 40.

*Altiverruca erecta* of Zevina, 1988b: 39; Buckeridge, 1994: 93; Young, 1998:77.

Material: Mid-Atlantic Ridge, 15°N fracture zone, north of the axial valley; FARANAUT cruise, FR-10, 15°35.33'N, 46°45.06'W, depth 3375-3947 m, 1 specimen, rc: 4.2 mm, (MNHN Ci 2677).

Description: shell (Fig. 3a-b) white, smooth, but with prominent widely spaced growth lines. Opercular plates angularly placed, more than 45° to basis. Basal margin of wall not inflected. Aperture slightly convex at basal margin

of opercular plates. Rostrum (Fig. 3a) convex, with marginal apex, suture with carina undulated and with fixed-scutum straight. Carina (Fig. 3a) convex, higher than rostrum, with apex projecting upward; suture with fixed-tergum straight. Fixed-tergum (Fig. 3b) wider medially and extending above fixed-scutum, taller than fixed-scutum, with narrow central triangular surface and two well developed alate projections. Fixed-scutum (Fig. 3b) quadrangular, apex curved toward fixed-tergum, with well developed radius-like projection to fixed-tergum with alate projection, angularly flexed at upper area to rostrum; internally smooth.

Scutum (Fig. 3a, c) with one conspicuous articular ridge and a second barely developed near first one; ridges absent at rostral area. Internally, surface concave with deep conspicuous adductor muscle pit, tergal margin straight except apex bent toward tergum. Tergum (Fig. 3b, d) larger than scutum, nearly quadrangular, apex curved toward scutum, with two articular ridges; axial conspicuous on carinal side and sloping continuously to scutum; second ridge low and marginal to upper margin. Internally, surface flat, smooth; scutal margin almost straight.

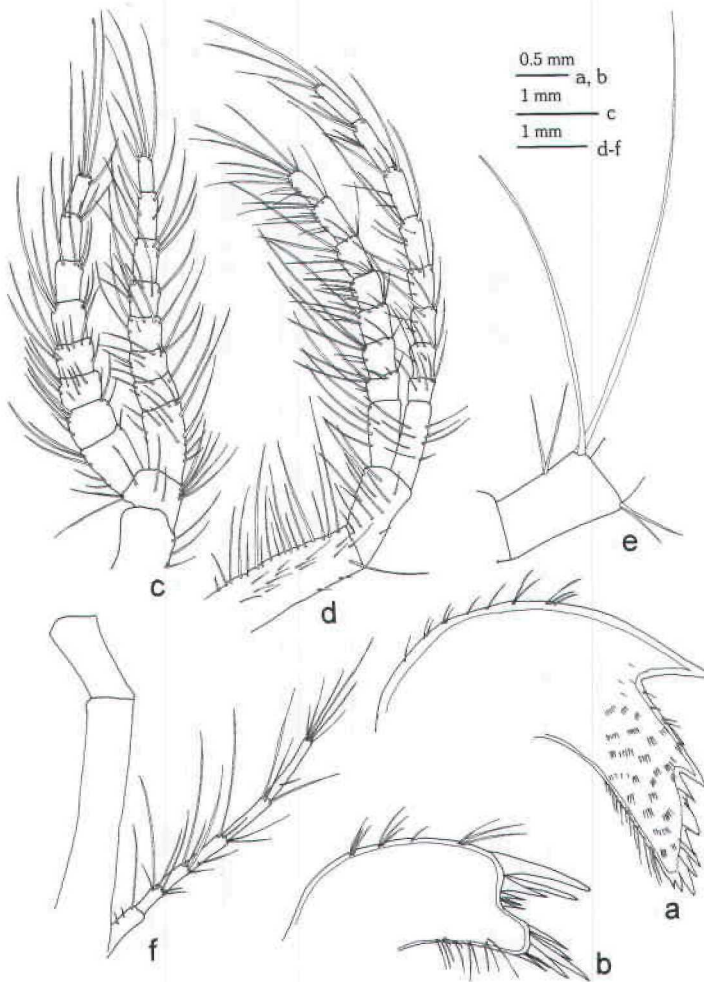
Oral cone damaged. Mandible (Fig. 4a) with three teeth; second and third with denticulated upper margin, inferior angle denticulated. Maxilla I (Fig. 4b) with lower part of cutting edge strongly projecting; with three strong spines and three small spines on upper border and with some intermediate and small spines on lower border.

Cirrus I (Fig. 4c) with equal rami, articles of both rami covered by long, simple setae. Cirrus II (Fig. 4d) with unequal rami, anterior smaller than posterior, both rami with long, finely-pinnate setae. Cirri III to VI with equal rami; median articles of cirrus VI (Fig. 4e) with one pair of long simple setae and another pair of short simple setae on anterior margin and one or two setae on posterior angle; length of articles about twice width; distal articles sometimes with long, finely-pinnate setae.

Caudal appendage (Fig. 4f) multiarticulated with 6 or 7 articles, a little smaller than protopodite; articles covered by simple setae at distal margins.

Number of articles of cirri and caudal appendage are presented in table 1.

Remarks: the specimen examined is similar to that observed by Gruvel (1902). His figure (Gruvel, 1902: pl.5, fig. 8) shows scutum with a more developed tergal area. However, the form of the shell plates, especially those of the carina and rostrum, and the details of the ridges of the opercular plates characterize this species.



**Figure 4.** *Altiverruca erecta* (Gruvel) (a) mandible; (b) maxilla I; (c) cirrus I; (d) cirrus II; (e) intermediate article of cirrus VI; (f) caudal appendage and protopodite of cirrus VI (MNHN Ci 2677).

**Figure 4.** *Altiverruca erecta* (Gruvel) (a) mandibule; (b) maxille I; (c) cirre I; (d) cirre II; (e) article moyen du cirre VI; (f) appendice terminal et protopodite du cirre VI (MNHN Ci 2677).

**Table 1.** Number of articles on cirri I-VI, and caudal appendages of *Altiverruca erecta* Gruvel (MNHN Ci 2677). I-VI, cirri I to VI; CA, caudal appendage; RC, right cirri; LC, left cirri.

**Tableau 1.** Nombre d'articles des cirres I-VI (I-VI), et des appendices caudaux (CA) de *Altiverruca erecta* Gruvel (MNHN Ci 2677); RC, cirre du côté droit; LC, cirre du côté gauche.

	I	II	III	IV	V	VI	CA
RC	8/8	8/9	15/16	19/22	25/25	26/25	6
LC	8/8	8/9	16/16	20/23	25/25	27/26	7

*Altiverruca erecta* was collected only once, from the Azores, depth 3175m. The occurrence of this species from

15°N and 46°W extends its distribution to the southern area of the Mid-Atlantic Ridge.

*Altiverruca longicarinata* (Gruvel, 1900) (Figs. 5-6)

*Verruca longicarinata* Gruvel, 1900b: 242; 1902: 91, pl. 5, figs. 3-4; 1905: 172, fig. 190.

*Verruca longicarinata*, section D, *Altiverruca* of Pilsbry, 1916: 40.

*Verruca (Altiverruca) longicarinata* of Zevina, 1987: 1305, fig. 1.

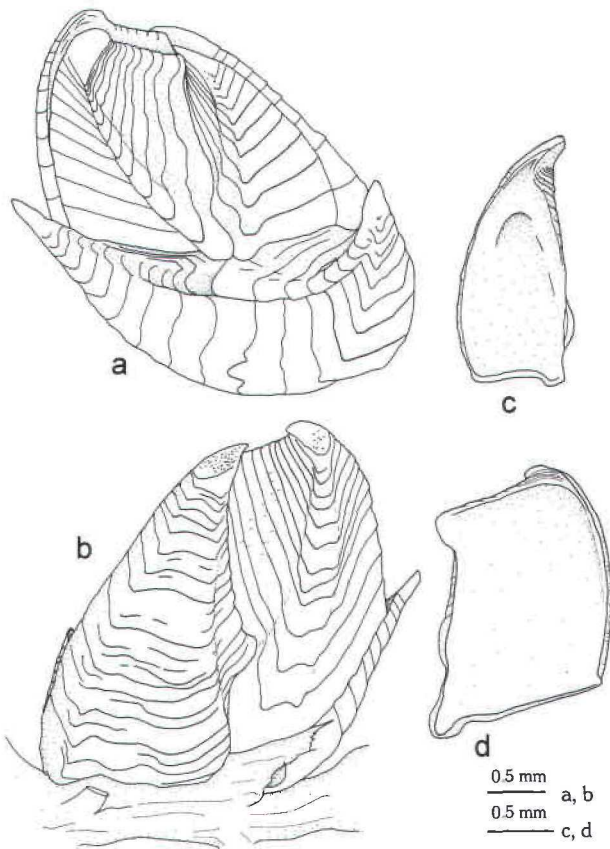
*Altiverruca longicarinata* of Zevina, 1988b: 39; Buckeridge, 1994: 93; Young, 1998: 77.

**Material:** SW of Snake Pit; GRAVINAUT cruise, GRN12, 23°19.67'N, 45°14.65'W, depth 2490 m, 2 living specimens and 7 shells, without eggs or larvae, rc: 17 to 28 mm, (MNHN Ci 2678), (MNRJ 8844).

**Description:** shell (Fig. 5a-b) white, smooth with widely spaced, unraised, growth lines. Opercular valves angulated, more than 45° to basis. Basis calcareous. Rostrum and carina (Fig. 5a) convex with apex of former projecting backward, both plates almost of same height, suture straight to sinuose, poorly distinguished from growth lines; both plates with conspicuous ridge forming essentially flat apical surface that is better developed in rostrum. Fixed-tergum (Fig. 5b) quadrangular, wider medially, higher than fixed-scutum, with central, narrow, triangular surface and two well developed alate projections. Fixed-scutum (Fig. 5b) triangular, with well developed medial radius-like projection and with an alate projection angularly inflected toward rostrum; internally smooth.

Scutum (Fig. 5a, c) smaller than tergum, basal margin 2/3 length of tergal margin; basal margins of both plates together forming slightly convex margin; with two articular ridges, and flat upper triangular area at occludent margin; axial ridge well developed, curved; rostral area smooth; apex curved toward tergum. Internally, with conspicuous adductor muscle pit; occludent margin with a small tooth at lower portion formed by second articular ridge. Tergum (Fig. 5a, d) quadrangular, with three articular ridges; conspicuous axial ridge, followed by broad and weakly developed medial ridge, and third marginal ridge extending to upper margin; apex curved toward scutum. Internally, surface smooth; occludent margin nearly straight, except upper portion rounded and projecting.

Labrum not observed. Palp (Fig. 6a) small and thin, with few simple setae at upper margin and distally. Mandible (Fig. 6b-c) with two conspicuous and large teeth, second with upper margin denticulated and inferior angle strongly denticulated. Maxilla I (Fig. 6d-e) with basal portion strongly projecting; apical edge with one or three strong



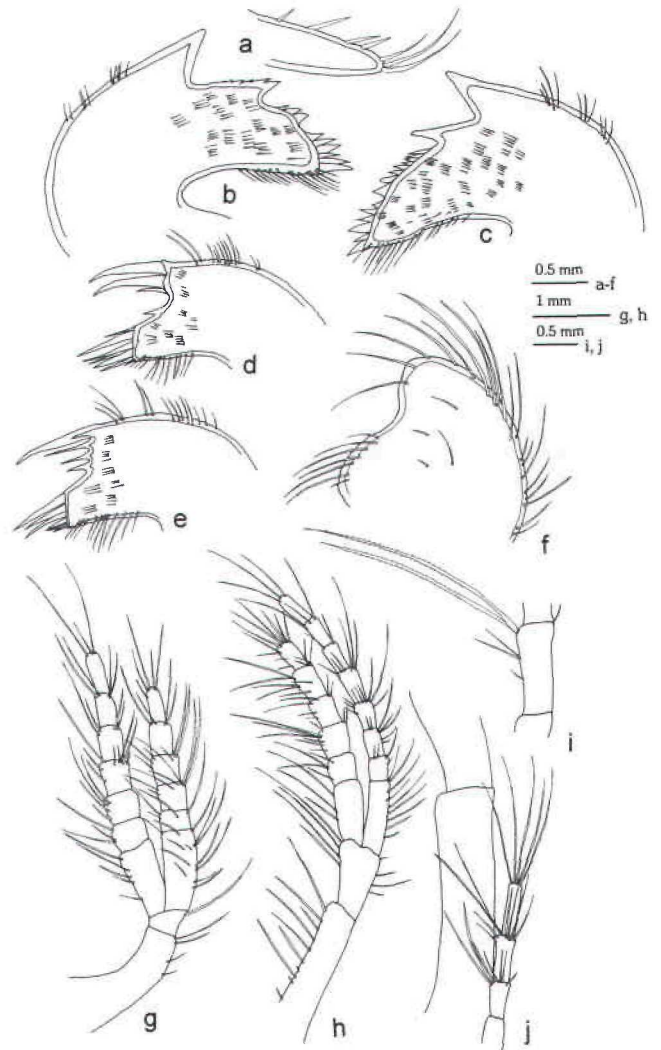
**Figure 5.** *Altiverruca longicarinata* (Gruvel) (a) top view; (b) fixed-tergum and fixed-scutum, external view; (c, d) scutum and tergum, internal view (MNRJ 8844).

**Figure 5.** *Altiverruca longicarinata* (Gruvel) (a) vue dorsale ; (b) tergum et scutum fixes, vue externe ; (c, d) scutum et tergum, vue interne (MNRJ 8844).

spines and one to three small spines with a few intermediate and small spines on lower border. Maxilla II (Fig. 6f) triangular, anterior margin concave medially, posterior margin convex; covered by long simple setae.

Cirrus I (Fig. 6g) with anterior ramus longer than posterior, articles of both rami covered by long, simple setae. Cirrus II (Fig. 6h) with unequal rami; anterior shorter than posterior with protuberant articles; both rami covered by numerous, long, simple setae. Cirri III with subequal rami, anterior shorter than posterior, both rami with long, finely-pinnate setae. Cirri IV-VI with long, equal rami. Length of median article of cirrus VI (Fig. 6i) more than twice width; with two pairs of setae; apical pair long, finely-pinnate setae, basal pair smaller and simple, followed by a single setulae, one or two short setae on distal posterior angle.

Caudal appendage (Fig. 6j) multiarticulated, with four articles, smaller than coxopodite. Penis absent. Number of articles of cirri and caudal appendage are given in table 2.



**Figure 6.** *Altiverruca longicarinata* (Gruvel) (a) palp; (b, c) mandibles; (d, e) maxilla I; (f) maxillae II; (g) cirrus I; (h) cirrus II; (i) intermediate article of cirrus VI; (j) caudal appendage and coxopodite of cirrus VI (MNRJ 8844).

**Figure 6.** *Altiverruca longicarinata* (Gruvel) (a) palpe ; (b, c) mandibules ; (d, e) maxille I ; (f) maxille II ; (g) cirre I ; (h) cirre II ; (i) article moyen du cirre VI ; (j) appendice terminal et coxopodite du cirre VI (MNRJ 8844).

**Remarks:** Gruvel (1902) described *Altiverruca longicarinata* based on three specimens attached to a bryozoan. He described only the external characters of the shell, the diagnostic characters of which are: presence of an elongated carina; unraised growth lines; suture between the carina and rostrum difficult to discern; flattened area above the single longitudinal ribs; and scutum with two ridges. The only difference between the specimens of Gruvel (1902) and the present specimens is the color of the shell: his specimens were pinkish-white, whereas all my specimens have a totally white shell.

**Table 2.** Number of articles on cirri I-VI, and caudal appendages of *Altiverruca longicarinata* Gruvel (MNRJ 8844). I-VI, cirri I to VI; CA, caudal appendage; RC, right cirri; LC, left cirri.

**Tableau 2.** Nombre d'articles des cirres I-VI (I-VI), et des appendices caudaux (CA) de *Altiverruca longicarinata* Gruvel (MNRJ 8844); RC, cirre du côté droit; LC, cirre du côté gauche.

	I	II	III	IV	V	VI	CA
RC	7/6	6/7	11/13	16/18	20/20	21/21	4
LC	7/6	6/8	12/13	16/19	20/21	21/21	4

The specimens described by Zevina (1987) have the same general appearance as the present specimens, except for the absence of a projected apex in the carina and the shape of the mandibles and caudal appendages. Zevina (1987) noted a three-toothed mandible and a 8-articulated caudal appendage twice the length of the coxopodite. In spite of these differences all the other details of the shell and opercular plates are similar to those I observed. Her specimens had a carino-rostral diameter of 3.0 mm, which is slightly larger than the specimens studied (<2.7 mm).

Foster and Buckeridge (1995a) considered *Altiverruca longicarinata* as a synonym of *A. quadrangularis* (Hoek, 1883). *A. quadrangularis* has the suture between the rostrum and carina indentated, with projecting ridges and no upper areas above the ridges. Furthermore, the axial and second ridge of the tergum have same width and are close from each other. Therefore, I consider they are distinct species.

*Altiverruca longicarinata* was described from the Sargasso Sea, depth 3432 m (Gruvel, 1900b; 1902) and from the Guyana Basin, depth 3425 m (Zevina, 1987). This new record from the Mid-Atlantic Ridge is the most eastern and the most shallow (2500 m) record in the Atlantic.

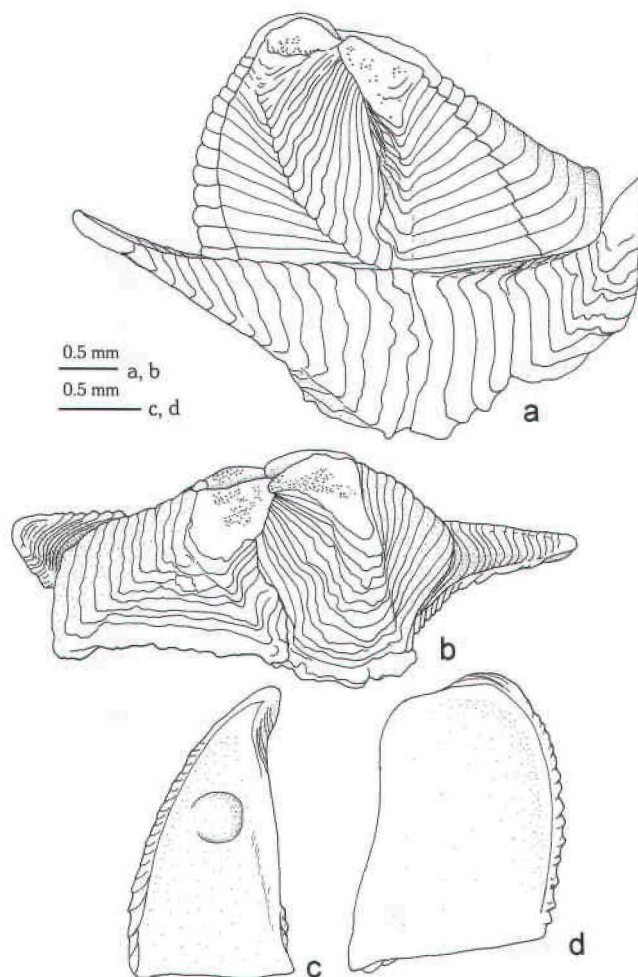
*Altiverruca obliqua* (Hoek, 1883)

**Material:** Mid-Atlantic ridge, vents at the SW Azores, DIVA 1 cruise, DV15-3, 37°49.80'N, 31°31.08'W, depth 1003 m, 1 specimen, rc: 5.9 mm, (MNHN Ci 2679).

**Remarks:** Young (1998) recently reviewed this species. *Altiverruca obliqua* is known from the Northeastern Atlantic and the present new record is the most eastern for the species.

*Newmaniverruca ferruginea* sp. nov. (Figs. 7-8)

**Material:** Mid-Atlantic Ridge, 15°N fracture zone, north of the axial valley, FARANAUT cruise, FR21, 15°37.00'N, 46°39.97'W, depth 3238-4282 m. Holotype: 1 entire specimen, rc: 4.6 mm, (MNHN Ci 2680). Paratypes: 2 broken, incomplete specimens, (MNHN Ci 2681), (MNRJ 8845).

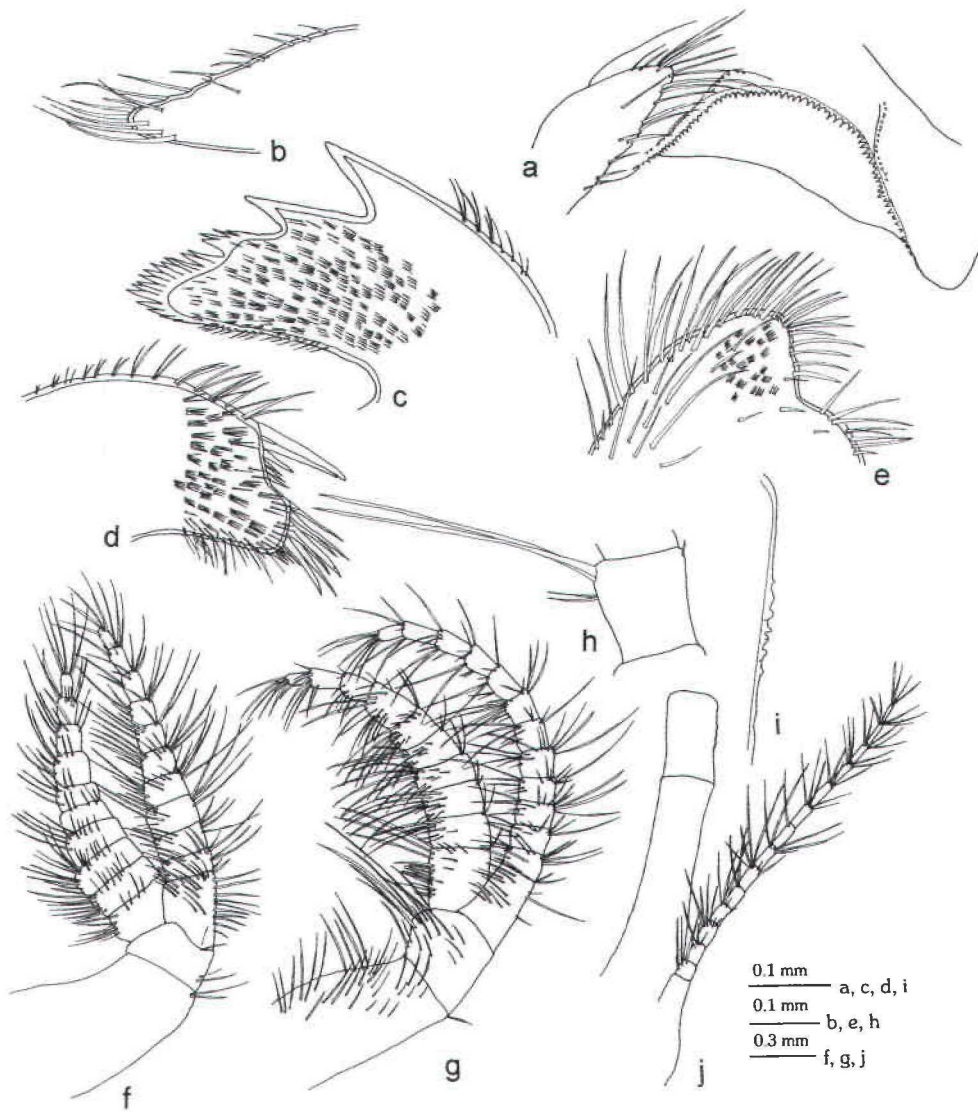


**Figure 7.** *Newmaniverruca ferruginea* sp. nov. Holotype. (a) top view; (b) fixed-tergum and fixed-scutum, external view (MNHN Ci 2680). Paratype. (c, d) scutum and tergum, internal view (MNRJ 8845).

**Figure 7.** *Newmaniverruca ferruginea* sp. nov. Holotype. (a) vue dorsale; (b) tergum et scutum fixes, vue externe (MNHN Ci 2680). Paratype. (c, d) scutum et tergum, vue interne (MNRJ 8845).

**Diagnosis:** shell without longitudinal ridges, only a ridge in each opercular plate and strongly projecting apices of rostrum and carina.

**Description:** shell (Fig. 7a-b) with dark reddish cuticle, smooth, growth lines widely spaced, well marked, and raised. Opercular valves parallel to basis. Primordial plates noticeable at apices of terga and scuta. Basis membranous. Rostrum and carina (Fig. 7a) convex with apices forming long lateral projections; suture between them nearly straight and without any radius-like projection directed toward fixed-scutum and fixed-tergum, respectively. Fixed-tergum (Fig. 7b) triangular, wider medially, higher than fixed-scutum, with two well developed alate projections. Fixed-scutum (Fig. 7b) triangular, with well developed alate



**Figure 8.** *Newmaniverruca ferruginea* sp. nov. Paratype. (a) labrum and palp; (b) palp; (c) mandible; (d) maxillae I; (e) maxillae II; (f) cirre I; (g) cirre II; (h) intermediate article of cirrus VI; (i) detail of the posterior margin of basipodite of cirrus VI; (j) caudal appendage and protopodite (MNRJ 8845).

**Figure 8.** *Newmaniverruca ferruginea* sp. nov. Paratype. (a) labre et palpe ; (b) palpe ; (c) mandibule ; (d) maxille I ; (e) maxille II ; (f) cirre I ; (g) cirre II ; (h) article moyen du cirre VI ; (i) détail du bord postérieur du basipodite du cirre VI ; (j) appendice terminal et protopodite (MNRJ 8845).

projection toward rostrum and small radius-like projection toward fixed-tergum; internally smooth, without adductor ridge.

Scutum (Fig. 7a) smaller than tergum; basal margin almost same length as tergal margin; both basal margins together forming nearly straight margin. Scutum (Fig. 7a, c) with one developed axial ridge, and with area between this ridge and occludent margin narrow and slightly undulated, but not forming ridges; apex curved toward tergum; rostral

area smooth. Internally, with conspicuous rounded pit for adductor muscle; occludent margin straight, with exception of curved apex. Tergum (Fig. 7a, d) quadrangular, with one developed axial ridge; occludent section slightly depressed near occludent margin; carinal area smooth. Internally, surface slightly smooth.

Labrum (Fig. 8a) with two series of teeth, one complete with acute teeth along all crest, and another incomplete with obtuse teeth, parallel margin of palp. Palp (Fig. 8a-b) short,



with few simple setae at upper margin and distally. Mandible (Fig. 8c) with three teeth, distance between first and second less than twice that between second and third; third tooth with upper margin denticulated; inferior angle denticulated. Maxilla I (Fig. 8d) without notch; lower anterior edge projecting; upper edge with two large and four small spines, followed by seven large spines and several small spines at lower edge. Maxilla II (Fig. 8e) triangular, anterior margin conspicuously concave medially, posterior margin convex, covered by long simple setae.

Cirrus I (Fig. 8f) with posterior ramus longer than anterior, articles of both rami covered by numerous long, simple setae. Cirrus II (Fig. 8g) with equal rami, but articles of anterior ramus broader than those of posterior, both rami covered with numerous long simple setae. Cirri III-VI with long, equal rami. Length of median article of cirrus VI (Fig. 8h) 1.4 its width, with one pair of long, simple setae and another pair of small, simple setae on anterior margin, none to two short setae on distal posterior angle. Cirri IV to VI with denticles on posterior margin of basipodite (Fig. 8i).

Caudal appendage (Fig. 8j) multiarticulated, with 15 to 18 articles. Small specimen with caudal appendage four times length of basipodite and large specimen with caudal appendage little larger than basipodite. Penis short with spaced setulae along all its length. No eggs or larvae. Number of articles of cirri and caudal appendage presented in table 3.

**Table 3.** Number of articles on cirri I-VI, and caudal appendages of *Newmaniverruca ferruginea* sp. nov. Paratype (MNRJ 8845). I-VI, cirri I to VI; CA, caudal appendage; RC, right cirri; LC, left cirri; +, broken ramus.

**Tableau 3.** Nombre d'articles des cirres I-VI (I-VI), et des appendices caudaux (CA) du paratype de *Newmaniverruca ferruginea* sp. nov. (MNRJ 8845); RC, cirre du côté droit; LC, cirre du côté gauche; +, rame cassée.

	I	II	III	IV	V	VI	CA
RC	10/11	8/13	21/28	29/24	23/16+	16+/22+	15
LC	10/10	10/13	25/22	24/24	23/23	25/30	15

**Etymology:** from the Latin *ferruginus*, referring to the dark-red color of the shell.

**Remarks:** some authors argue that the number of ridges of the scutum and tergum change during development (Foster and Buckeridge, 1995b). But, I never observed any significant change in ribs counts in the species I studied (Young, 1993, 1998; in press, and herein). In *Newmaniverruca ferruginea* sp. nov., the scutum and tergum do not undergo any change in shape over the range of sizes (height of scutum varying from 1.7 to 5.8 mm). Unfortunately, out of all the material known, only one small

shell is undamaged, which hinders observing changes in the shell plates.

By contrast there is a change in the relative length of the caudal appendage. This length when compared with the basipodite length, decreases significantly from small to large specimens, although the number of articles remains constant. Therefore, in *N. ferruginea* sp. nov. the number of articles of the caudal appendage appear to attain full number early in development. Then, during the growth, the caudal appendage to protopodite length ratio decreases.

## 2. Suborder Balanomorpha Pilsbry, 1916

### *Hexelasma americanum* Pilsbry, 1916

*Hexelasma americanum* Pilsbry, 1916: 330, pl. 69; Utinomi, 1965: 12; Young, 1998: 66 Fig. 1, 20-21.

*Aptolasma americanum* of Newman and Ross, 1971: 161 pls 22a-b, 36-37; 1976: 46.

**Material:** Mid-Atlantic ridge, Lucky Strike hydrothermal vents area, DIVA 1 cruise, DV11-4, 38°18.55'N, 30°40.15'W, depth 715 m, 1 specimen with disarticulated shell plates, (MNHN Ci 2682). DV15-3, 37°49.80'N, 31°31.08'W, depth 1003 m, 2 specimens with disarticulated shell plates, (MNHN Ci 2683), (MNRJ 8846). DV15-9, 37°49.80'N, 31°31.08'W, depth 1003 m, fragments of a shell, (MNHN Ci 2684).

**Remarks:** the specimens examined agree with the descriptions of Pilsbry (1916) and Young (1998) who recently reviewed this species. *Hexelasma americanum* was previously recorded from off South Carolina, on the Blake Plateau, depths from 512 to 770 m, and near the Azores at depths from 1235 to 1069 m (Young, 1998).

## Discussion

### The Endemism of Barnacles in the Atlantic Hydrothermal Vents

Despite intensive samplings on the six known sites of Atlantic hydrothermal vents (Van Dover, 1995) no unusual relic cirripeds were recovered. The Atlantic hydrothermal vents apparently do not have any endemic cirripeds. The *Nautile* samples present only scattered records of wide-ranging species. All these species were sampled a few times, and in small numbers, as it usually happens with deep-sea species. Van Dover (1995) observed a difference in faunal composition between the Pacific and Atlantic hydrothermal vents; tubeworms, mussels and clams dominated vents of eastern Pacific, while shrimps (family Alvinocarididae), mussels and anemones dominate in Atlantic vents.

All the lepadomorphs thus far collected have a wide distribution: *A. michelottianum* is a cosmopolite species,

*G. rectum* occurs in the Atlantic and the Indian oceans, and *T. regium* occurs in the Atlantic ocean, but doubtfully in the Pacific and Indian oceans. The species found around Pacific hydrothermal vents are considered relics, due to several plesiomorphic characteristics. They provide many clues for interpreting the evolution of barnacle lineages. The Calanticidae, which includes *Scillaelepas*, is a deep-sea basal group with several plesiomorphic characters.

The verrucomorpha have a more restricted distribution: *A. longicarinata* occurs in the North Atlantic, *A. obliqua*, in the Northeastern Atlantic, *A. erecta* and *N. ferruginea* sp. nov. are known only from the Azores region. The balanomorph *Hexelasma americanum* was the most frequently collected species by the *Nautile*, but it has a wide North Atlantic distribution.

Therefore, in contrast to the Indo-Pacific vents, the hydrothermal vents of the Atlantic appear to be colonized only by opportunistic deep-sea species and not by unusual relic species or genera such as *Neolepas* and *Eochionelasmus* which characterize the Pacific vents.

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