Zootaxa 1276: 1–31 (2006)
www.mapress.com/zootaxa/

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)
1276

Crinoidea and Holothuroidea (Echinodermata) of the abyssal Angola Basin—Results of the DIVA-1 expedition of FS "Meteor" (Cruise M48/1)

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Accepted by A. Dartnall: 5 Jul 2006; published: 31 Jul. 2006

Abstract

Agassiz trawl and epibenthic sledge samples taken at abyssal depths in the Angola Basin (south-eastern Atlantic Ocean) during the expedition DIVA-1 with FS "Meteor" in July 2000 yielded a rich variety of Echinodermata: inter alia one stalked crinoid (*Bathycrinus* cf. *aldrichianus* Wyville Thomson, 1876) and altogether nine holothurian species, two of which are subspecies. One of these, *Achlyonice longicornis* **spec. nov.**, is new to science, while all others have been described earlier: *Deima validum validum* Théel, 1879, *Psychropotes semperiana* Théel, 1882, *Peniagone purpurea* (Théel, 1882), *Molpadiodemas atlanticus* (R. Perrier, 1898), *Molpadia liska* Pawson, 1977, *Protankyra brychia* (Verrill, 1885), *Siniotrochus myriodontus* Gage & Billett, 1986 and *Neolepidotrochus parvidiscus angolensis* Bohn, 2005. All species collected are described and their known distributions are given. Finally, two crinoids and 21 holothurian species, so far known from the abyssal Angola Basin, are listed and their zoogeographical relationships are discussed.

Key words: Echinodermata; Crinoidea; Holothuroidea; South Atlantic Ocean; Angola Basin; deep-sea; taxonomy

Introduction

For a long time, the south-eastern Atlantic deep-sea remained almost unexplored (Fig. 1). The Valdivia expedition took samples in the Gulf of Guinea and along the western coast of Africa and information on the Holothuroidea collected there have been published by Ludwig & Heding (1935) and Heding (1940). Similarly to the Valdivia expedition, the Danish Deep-Sea Expedition (Galathea) explored bathyal and abyssal depths in the Gulf of Guinea and off the western coast of Africa. So far, only the elasipodid holothurians collected have been published in an excellent monograph on this group (Hansen 1975). Extensive sampling in the Cape Basin, the Angola Basin and the Guinea Basin was conducted by the French Research Institute for Exploitation of the Sea (IFREMER, Brest, France) in the course of the Walda (05–08.1971) and the Walvis (12.1978–01.1979) cruises with NO "Jean Charcot". Even though only the Asteroidea of the Walda cruise have been published so far (Sibuet 1975), data for the Holothuroidea collected are nowadays available in the IFREMER BIOCEAN Database, which is part of the Ocean Biogeographic Information System (OBIS) at www.iobis.org.

The aim of the DIVA-1 expedition with FS "Meteor" (cruise M48/1) to the Angola Basin (south-eastern Atlantic Ocean) was to investigate the biodiversity of this abyssal plain. At several stations along a transect of about 700 km samples were taken with an Agassiz trawl and an epibenthic sledge (Fig. 1).

The objective of this paper is to describe and document the Crinoidea and Holothuroidea collected in the course of the DIVA-1 expedition (other Echinodermata collected will be the subject of another publication). Based on these results and by incorporating all available other sources, a list of the hitherto known species of this deep-sea basin is compiled. Finally, zoogeographical relationships of the holothurian and crinoid fauna with other deep-sea regions are discussed.

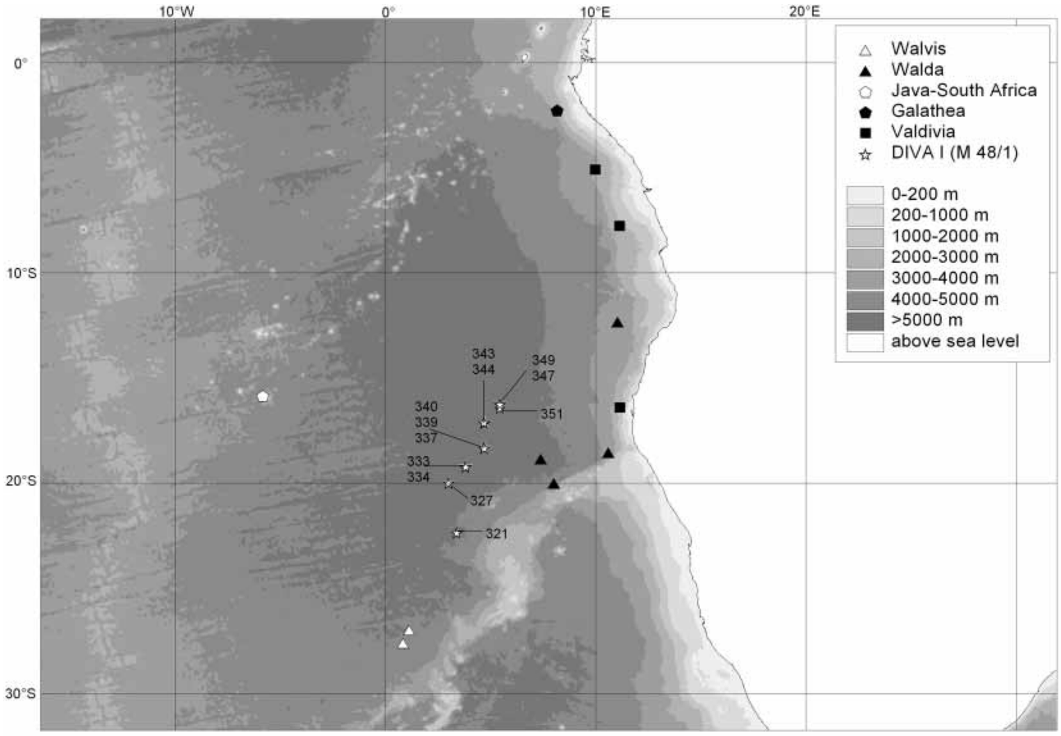

FIGURE 1. Records of Crinoidea and Holothuroidea in the Angola Basin and vicinity by the Valdivia expedition (Ludwig & Heding 1935; Heding 1940), Dr Mortensen's Java—South Africa expedition and the Galathea expedition (Hansen 1975), the Walda and Walvis cruises (IFREMER BIOCEAN) and the DIVA-1 expedition.

Material and methods

The crinoid and holothurian specimens investigated were sampled at 12 stations, deploying an Agassiz trawl or an epibenthic sledge (station details are summarized in table 1). The material from the Agassiz trawl was first fixed in buffered formalin and then transferred to ethanol for long term storage, while the epibenthic sledge samples were fixed in cold ethanol. The investigated material is deposited in the Bavarian State Collection of Zoology in Munich (ZSM).

TABLE 1. Stations, collection methods and species collected in the course of the DIVA-1 expedition with FS "Meteor" (M 48/1) to the Angola abyssal plain. *AGT*—Agassiz trawl; *EBS*—epibenthic sledge; +— fragments.

Station	Details	Species	Number of specimens
M 48/1-321	22°20.6' S, 3°23.6' E, 5126 m to 22°27.6' S, 3°27.9' E, 5121 m, AGT, 10 Jul, 2000	*Psychropotes semperiana* Théel, 1882	2
M 48/1-327	19°59.2' S, 3°00.9' E, 5448 m to 20°07.5' S, 3°07.9' E, 5439 m, AGT, 15 Jul, 2000	Bathycrinidae gen. sp.	+
M 48/1-333	19°12.9' S, 3°48.6' E, 5426 m to 19°17.4' S, 3°52.2' E, 5424 m, AGT, 19 Jul, 2000	*Deima validum validum* Théel, 1879	1
		Molpadia liska Pawson, 1977	2
M 48/1-334	19°12.5' S, 3°49.0' E, 5426 m to 19°19.8' S, 3°55.6' E, 5425 m, AGT, 19 Jul, 2000	Bathycrinidae gen. sp.	+
		Protankyra brychia (Verrill, 1885)	3
M 48/1-337	18°18.9' S, 4°42.7' E, 5393 m to 18°24.6' S, 4°45.1' E, 5392 m, AGT, 21 Jul, 2000	Bathycrinidae gen. sp.	+
		Protankyra brychia (Verrill, 1885)	1
M 48/1-339	18°19.4' S, 4°42.1' E, 5395 m to 18°25.3' S, 4°44.0' E, 5392 m, AGT, 22 Jul, 2000	Bathycrinidae gen. sp.	+
		Deima validum validum Théel, 1879	1
M 48/1-340	18°18.3' S, 4°41.3' E, 5395 m to 18°19.4' S, 4°41.9' E, 5395 m, AGT, 23 Jul, 2000	*Neolepidotrochus parvidiscus angolensis* Bohn, 2005	1

.... *to be continued*

Table 1 (continued)

Station	Details	Species	Number of specimens
M 48/1-343	17°07.5' S, 4°42.9' E, 5415 m to 17°11.6' S, 4°45.9' E, 5415 m, AGT, 25 Jul, 2000	*Deima validum validum* Théel, 1879	1
		Peniagone purpurea (Théel, 1882)	2
		Molpadiodemas atlanticus (R. Perrier, 1898)	1
		Protankyra brychia (Verrill, 1885)	1
M 48/1-344	17°06.2' S, 4°41.7' E, 5415 m to 17°07.5' S, 4°42.3' E, 5415 m, EBS, 25 Jul, 2000	Bathycrinidae gen. sp.	+
		Bathycrinus cf. *aldrichianus* Wyville Thomson, 1876	1
M 48/1-347	16°14.0' S, 5°26.7' E, 5389 m to 16°23.1' S, 5°27.0' E, 5388 m, AGT, 28 Jul, 2000	*Molpadiodemas atlanticus* (R. Perrier, 1898)	1
		Protankyra brychia (Verrill, 1885)	5
		Siniotrochus myriodontus Gage & Billett, 1986	1
M 48/1-349	16°14.8' S, 5°26.5' E, 5389 m to 16°24.7' S, 5°26.2' E, 5388 m, AGT, 29 Jul, 2000	*Molpadia liska* Pawson, 1977	4
		Protankyra brychia (Verrill, 1885)	4
M 48/1-351	16°25.2' S, 5°27.1' E, 5387 m to 16°33.2' S, 5°27.3' E, 5385 m, AGT, 30 Jul, 2000	*Achlyonice longicornis* **sp. nov.**	1
		Molpadia liska Pawson, 1977	5
		Protankyra brychia (Verrill, 1885)	7
		Siniotrochus myriodontus Gage & Billett, 1986	2

To examine the diagnostically important calcareous deposits, pieces of the body wall were macerated in 12.5 % sodium hypochlorite solution. The remaining calcareous deposits were rinsed several times in distilled water and finally air-dried. One part of the deposits was mounted in Canada Balsam on slides, to be analyzed with a Leitz microscope equipped with a video camera (380 USB 2.0 Spacec@m) and the software AxioVision LE. For SEM examinations, the other part of the deposits was transferred to aluminium stubs, sputtered with gold and studied in a LEO 1430 VP Scanning Electron Microscope.

This paper does not aim to provide a complete synonymy of the species treated; instead only the original combination and source of the name as well as its junior synonyms are given. Further details are available from the references indicating the current use of a name, including a more complete synonymy.

The data for the species distributions are based on geo-referenced localities extracted from literature (mainly expedition reports) and the IFREMER BIOCEAN database, including distribution records of species nowadays treated as junior synonyms of the species in question. Records from the IFREMER BIOCEAN database were only included when identifications were made by experienced echinoderm taxonomists like Myriam Sibuet (IFREMER, France) or Michel Roux (University of Reims, France).

Symbols used to describe crinoid ossicles and series of ossicles of arms, pinnules and the stalk conform with the abbreviations used by Roux *et al.* (2002) for stalked crinoids, which differ slightly from the symbols sometimes used to describe "stalk-less" comatulid crinoids (Roux *et al.* 2002).

Taxonomy

Class Crinoidea Miller, 1821

Family Bathycrinidae Bather, 1899

Bathycrinidae gen. sp.

Material. M 48/1-327: 1 stalk fragment (ZSM 20043082). 48/1-334: 3 stalk fragments (ZSM 20043081). M 48/1-337: 8 stalk fragments (ZSM 20043085), 1 stalk fragment (ZSM 20020069). M 48/1-339: 7 stalk fragments (ZSM 20043083). M 48/1-344: 1 stalk fragment (ZSM 20043084).

Remarks. The available stalk fragments only allowed identification to family level.

Genus *Bathycrinus* Wyville Thomson, 1872

Bathycrinus cf. *aldrichianus* Wyville Thomson, 1876
(Figs 2A, 3)

Bathycrinus aldrichianus Wyville Thomson, 1876: 47–51, fig. 1; Clark, 1977: 159–162, fig. 1 (g) [synonymy]
Bathycrinus campbellianus P.H. Carpenter, 1884: 238–240, fig. 15
Bathycrinus serratus A.H. Clark, 1908: 205–207, fig. 1

Material. M 48/1-344: 1 calyx (ZSM 20043086).

Description. The specimen is small and damaged, only the radials and arms (up to Br_{10}) are preserved, the basals and the stalk are missing (Fig. 2A). The calyx is about 1.7 mm wide. The five radials are smooth, about 0.7 mm high, have a proximal width of 0.5 mm and a distal width of 0.8 mm. Sharp-edged lateral flanges and a prominent crest-like keel characterise the first brachitaxis (IBr_1 and IBr_2) and the proximal brachials. On the axillaries (IBr_2) the keel is Y-shaped. In distal brachials the lateral flanges disappear and the crest-like keel is less prominent. The first brachitaxis is about 1.8 mm long and at the joint of IBr_1 and IBr_2 0.9 mm wide. Though indistinct, the first non-muscular joints are between brachials 1+2, 4+5 and 7+8. No pinnules were found (not developed yet?).

Remarks. Currently, there are two Atlantic *Bathycrinus* species recognized, viz *B. aldrichianus* Wyville Thomson, 1876 and *B. gracilis* Wyville Thomson, 1872 which both are similar in being "very serrated in profile" in contrast to the remaining Atlantic species which have "smooth and rounded ossicles and profiles" (Clark 1977: p. 167). The current specimen corresponds with both species in the ornamentation of the first brachitaxis and the proximal brachials, with a central keel and lateral flanges (Clark 1977, 1980; Macurda & Meyer 1976). Slight differences in the specificity of the ornamentation may be correlated with size (Clark 1977) and thus not sufficient to separate both species. The only character known to distinguish both species seems to be the position of the first pinnule on the arm. *Bathycrinus gracilis* has the first pinnule on brachials 10 to 12, while *B. aldrichianus* has the first pinnule on brachials 8 to 11 (Clark 1980). Due to the fact that the current specimen lacks pinnules, a reliable determination is not possible and the specimen is tentatively assigned to *B. aldrichianus* because of the geographical vicinity to other records of this species.

Distribution. *Bathycrinus aldrichianus* has been described from the north-western, the central and the southern Atlantic Ocean (Fig. 3), 3305–5860 m (Carpenter 1884; Clark 1908; Clark 1977; Gislén 1951; Macurda & Meyer 1976; herein), whereas *B. gracilis* seems to be restricted to the north-eastern Atlantic Ocean (Fig. 3), 2880–5330 m (Carpenter 1884; Clark 1977, 1980; Harvey et al. 1988; IFREMER BIOCEAN; Kœhler 1909).

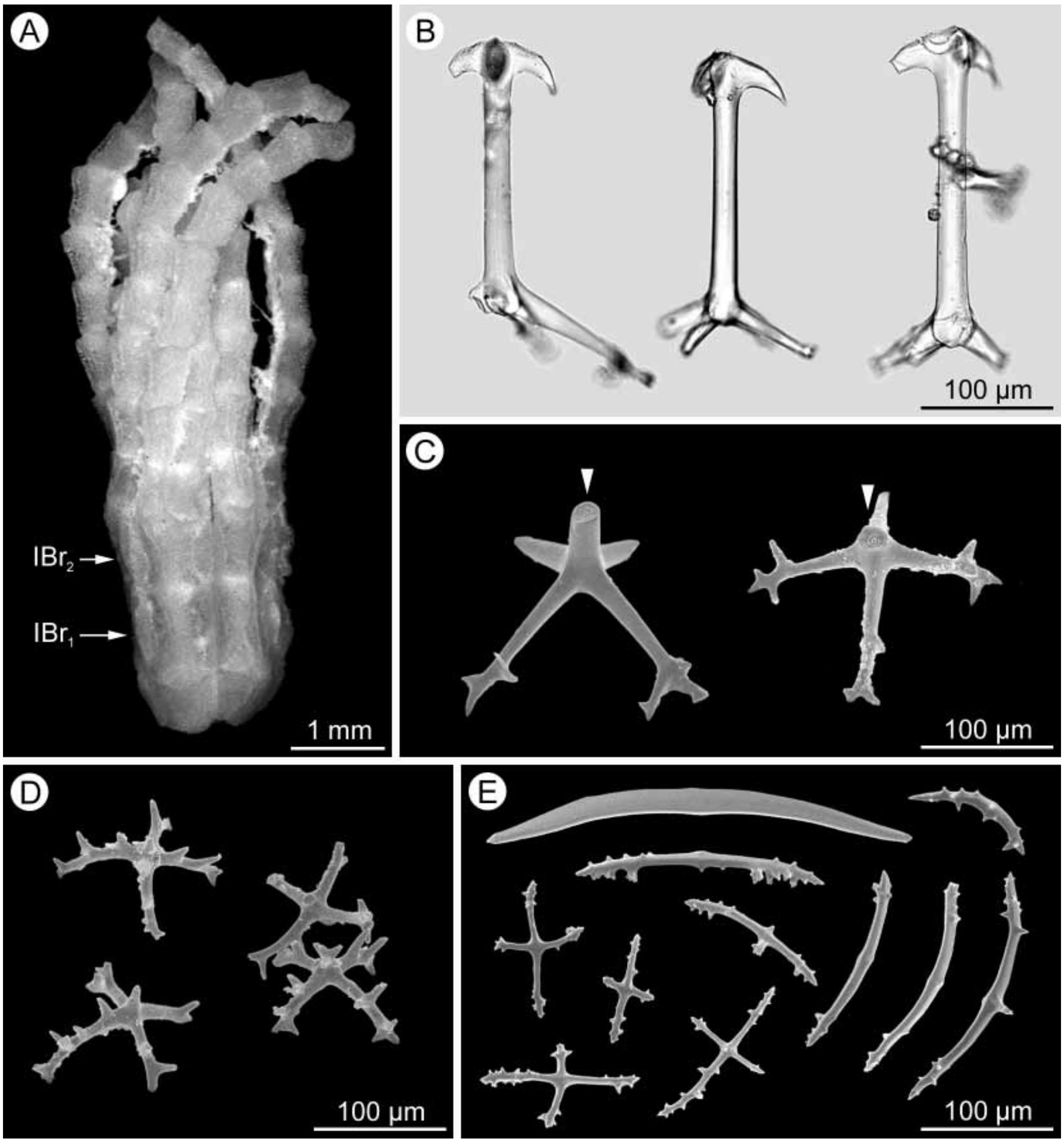

FIGURE 2. (A) *Bathycrinus* cf. *aldrichianus* Wyville Thomson, 1876. Distal part of calyx with arms, basals and stalk missing (IBr_1, IBr_2—first and second brachials of first brachitaxis). **(B–E)** *Psychropotes semperiana* Théel, 1882. Calcareous deposits. **(B)** Large crosses (damaged) from dorsal body wall, with four arms, central apophysis and downwardly bent hooks. **(C)** Large crosses (damaged) from dorsal body wall, with four arms and central apophysis (*arrowheads*). **(D)** Small crosses from dorsal body wall. **(E)** Rods and crosses from ventral body wall.

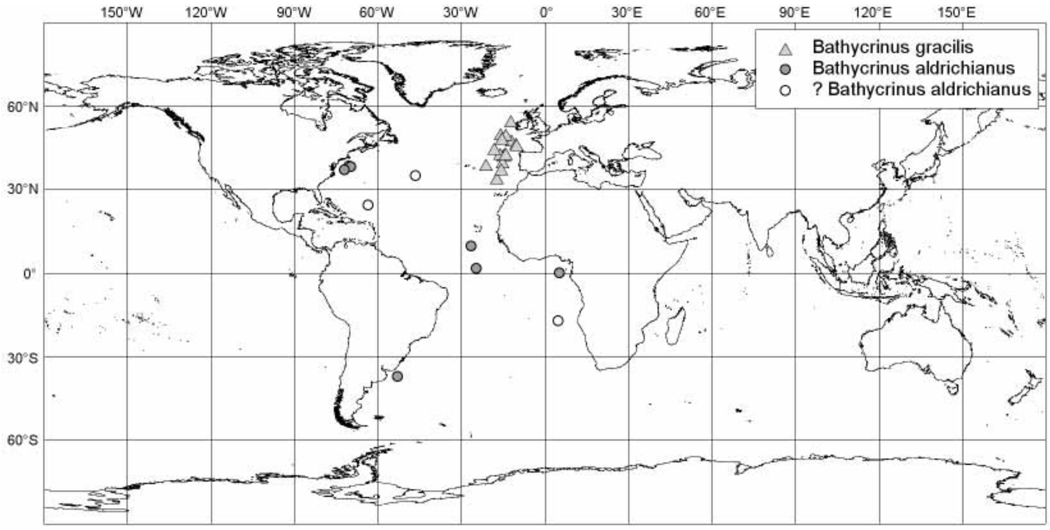

FIGURE 3. Distribution of *Bathycrinus aldrichianus* Wyville Thomson, 1876 and the closely related *B. gracilis* Wyville Thomson, 1872. Questionable records for *B. aldrichianus*, often based on stalk fragments solely, are indicated as blank circles.

Class Holothuroidea de Blainville, 1834

Family Deimatidae Théel, 1879

Genus *Deima* Théel, 1879

Deima validum validum Théel, 1879
(Fig. 4)

Deima validum Théel, 1879: 5, figs 36–38
Deima validum validum. Hansen, 1975: 17–23, fig. 1, pls 11 (fig. 1), 13 (figs 1–2), [synonymy]
Deima fastosum Théel, 1879: 5–6, figs 1–3
Deima blakei Théel, 1886b: 1–2, figs 1–2
Deima atlanticum Hérouard, 1898: 88–89, figs 1–2
Deima mosaicum Ohshima, 1915: 233–234

Material. M 48/1-333: 1 specimen (ZSM 20043072). M 48/1-339: 1 specimen (ZSM 20020018). M 48/1-343: 1 specimen (ZSM 20043071).

Remarks. The taxonomy, morphology and distribution of this subspecies has been described in detail by Hansen (1975). It is characterised by: 10–13 pairs of ventro-lateral tube feet in single rows; mid-ventral tube feet absent or rarely represented by a reduced pre-anal pair; dorsal papillae 5–10 pairs; ventro-lateral papillae 3–7 pairs; calcareous deposits are perforated plates, usually large and multilayered; dorsal plates 1.5–7.0 mm in diameter, ventral plates 0.5–4.0 mm. The investigated specimens fit with this diagnosis. The largest specimen (86 mm in length) has a single (?) small pre-anal tube foot, while there are no pre-anal tube feet present in the other specimens. This is the second record of this species for the South Atlantic Ocean and the known depth-range is increased from 4820 m to more than 5400 m.

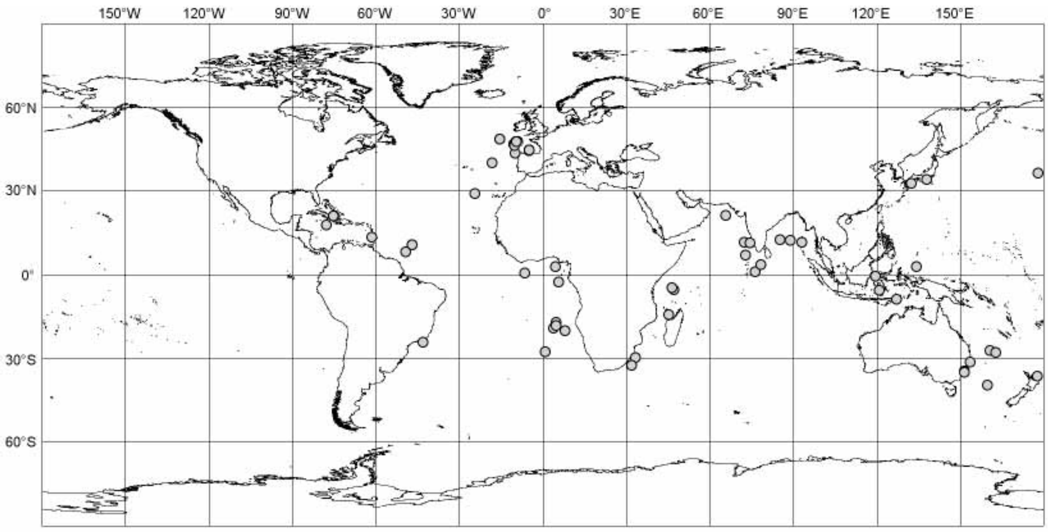

FIGURE 4. Distribution of *Deima validum validum* Théel, 1879.

Distribution. (Fig. 4) This subspecies probably has a cosmopolitan distribution, except for the Arctic and Southern Ocean, 724–5426 m (Deichmann 1940; Grieg 1921; Hansen 1975; Hérouard 1902, 1923; IFREMER BIOCEAN; Kœhler & Vaney 1905; Ohshima 1915; O'Loughlin 1998; Sibuet 1977; Sluiter 1901; Théel 1882, 1886b; herein).

Family Psychropotidae Théel, 1882

Genus *Psychropotes* Théel, 1882

Psychropotes semperiana Théel, 1882
(Figs 2B–E, 5)

Psychropotes semperiana Théel, 1882: 100–101, pl. 34 (figs 10–11); Hansen, 1975: 102–105, figs 41–42 [synonymy]
Psychropotes kerhervei Hérouard, 1902: 27–30, pl. 4 (figs 1–9)
Euphronides anchora Hérouard, 1912: 6–7, fig. 5

Material. M 48/1-321: 2 specimens (ZSM 20043075).

Description. Anteriorly, the specimens are more or less flat, while the posterior part of the body is elevated and gives rise to the unpaired dorsal appendage. The larger specimen is 79 mm long and 22 mm wide (across ventral sole), while the smaller specimen measures 53 mm in length and 17 mm across the ventral sole. Both are of a purple colour (preserved). The mouth and the anus are ventral and confined to the anterior and the posterior end of the body. There are 16 tentacles, with conspicuous, rounded discs. The ventral sole is delimited on both sides by a narrow brim (damaged for the most part), formed by basally fused tube feet. Mid-ventral tube feet are conical and restricted to a double row, which seems to be present (partly damaged) throughout the length of the ventral sole. The unpaired dorsal appendage arises from a dorsal bulge, which is situated one-seventh body length in the large specimen and one-fourth body length in the small specimen from the posterior end of the body. In both specimens, the dorsal appendage is more or less contracted and thus nothing can be said about the original size. The almost complete dorsal appendage of the large specimen ends in two long slender papillae, each about 18 mm long. Anterior to the dorsal bulge of the small specimen, are three pairs of short conical papillae (indistinct in the larger specimen).

Calcareous deposits of the dorsal body wall are crosses of two types (Figs 2B–D). The four arms of the larger type are smooth in their proximal parts and are equipped with irregularly placed spines close to their distal ends (Fig. 2C). The high central apophysis is smooth and ends in three or four downwardly bent hooks (Fig. 2B). Crosses of the second type are considerably smaller, have irregularly placed spines along the arms and a low and also spinous central apophysis (Fig. 2D). The calcareous deposits of the ventral body wall are rods and crosses with irregularly placed spines (Fig. 2E).

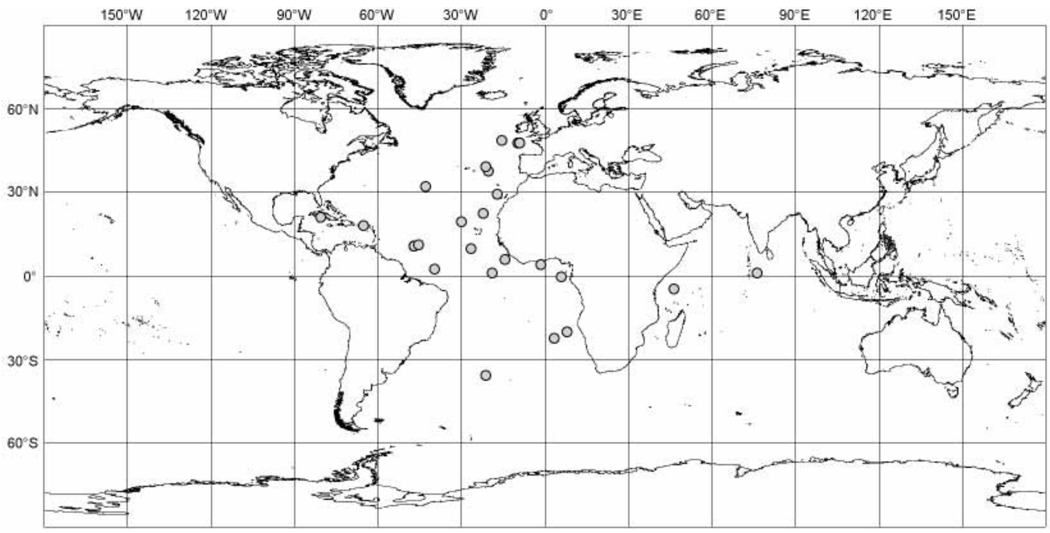

FIGURE 5. Distribution of *Psychropotes semperiana* Théel, 1882.

Remarks. The two specimens described herein conform to the detailed description given by Hansen (1975) for this species. Very characteristic are the large cross-shaped deposits of the dorsal body wall with a high and smooth central apophysis, ending in three or four downwardly bent hooks, which are unique within the genus (Hansen 1975).

Distribution. (Fig. 5) Northern and southern Atlantic Ocean, northern and western Indian Ocean, 2695–5610 m (Deichmann 1930, 1940; Hansen 1975; Hérouard 1902, 1923; IFREMER BIOCEAN; Madsen 1953; Sibuet 1977; Théel 1882; herein).

Family Elpidiidae Théel, 1879

Genus *Peniagone* Théel, 1882

Peniagone purpurea (Théel, 1882)

(Figs 6A–D, 7)

Elpidia purpurea Théel, 1882: 21–23, pls 7 (figs 4–6), 33 (figs 13–14), 44 (fig. 6)
Elpidia ambigua Théel, 1882: 27–28, pl. 33 (fig. 6)
Peniagone vexillum R. Perrier, 1900: 118
Peniagone ferruginea Grieg, 1921: 7–8, fig. 3, pl. 1 (figs 4–6)
Peniagone lacinora Agatep, 1967: 53–55, pl. 3 (figs 1–9)
Peniagone lugubris Théel, 1882. Madsen, 1953: 153–155, figs 2–3
Peniagone purpurea. Gebruk, 1990: 111–113, fig. 46 [synonymy]

Material. M 48/1-343: 2 specimens (ZSM 20043074).

Description. The body is more or less flat, with a distinct brim along the lateral edges of the body, continuous with the velum (Fig. 6A). The two specimens are 37 and 55 mm long and 12 and 24 mm wide. Preserved they are purple to dark purple (tentacle discs and around mouth). The ventral mouth is situated on an anterior bulge-like enhancement, while the posterior anus opens dorsally above the posterior tube feet. Ten conspicuous tentacles encircle the mouth (larger specimen: 7 preserved, smaller specimen: 1 preserved). The tentacle discs are large, almost circular in outline, and have an irregular margin, due to several retractile lobes. The posterior three-fifths of the ventral sole are bordered by 7–8 pairs of conspicuous conical tube feet. From anterior to posterior, they continuously decrease somewhat in size and become closer to each other. The anterior tube feet are well separated and situated on the ventral side of the specimen, while the posterior ones are in contact and are contiguous with the lateral brim. The most posterior pair of tube feet is considerably smaller than the preceding ones. The dorsal velum, continuous with the lateral brim, is conspicuous and composed of four basally fused papillae. The papillae are long and slender and the anterior pair is about twice as long as the posterior pair. A short distance from the velum there is a variable number of pairs of free papillae (1–3).

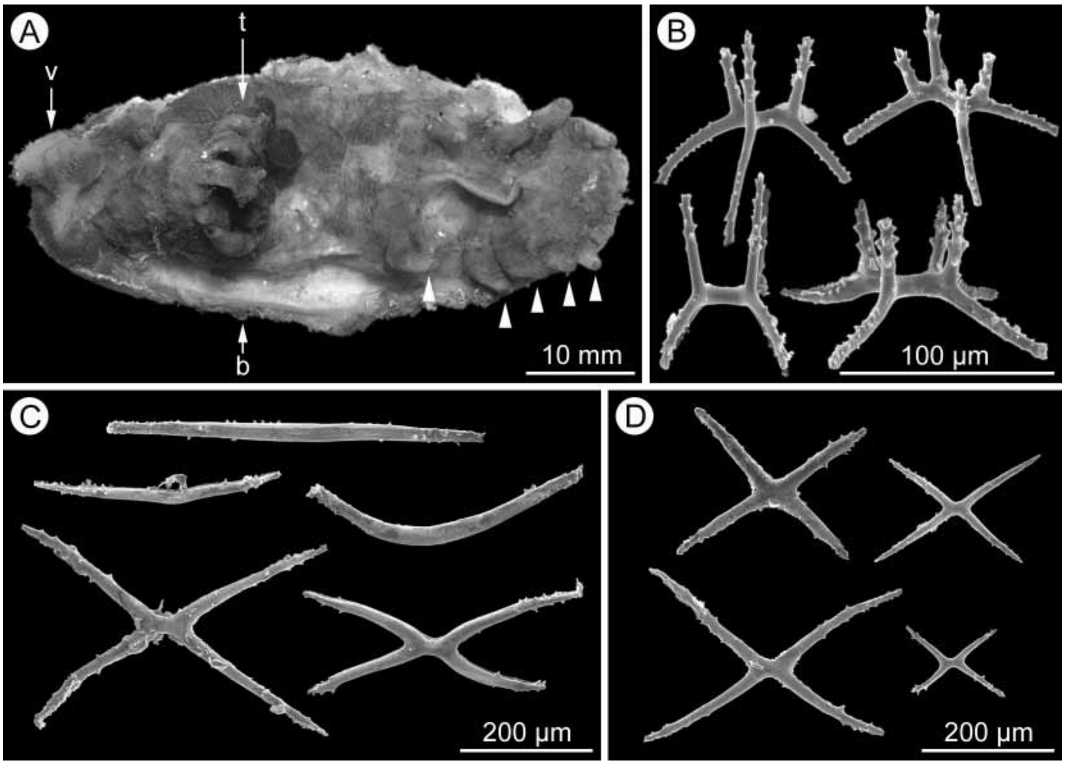

FIGURE 6. *Peniagone purpurea* (Théel, 1882). **(A)** Ventral view of a specimen, anterior end to the left (*b*—brim, *t*—tentacles, *v*—velum, *arrowheads*—tube feet). **(B)** Primary crosses from body wall. **(C)** Large crosses and rods from tentacles. **(D)** Large crosses from tube feet.

FIGURE 7. Distribution of *Peniagone purpurea* (Théel, 1882) and *Achlyonice longicornis* **spec. nov.**

The generic assignment of the new species is somewhat ambiguous. Three out of five species of the genus *Achlyonice* Théel, 1879 and all species of the genus *Ellipinion* Hérouard, 1923 are known to possess rod-shaped, often spinous deposits and a velum. *Ellipinion* species differ from *Achlyonice* by the additional presence of small C-shaped deposits and constantly 10 tentacles. Hansen (1975) characterises *Achlyonice* as follows: tentacles 10–12; deposits tripartite, rod-shaped or absent; calcareous ring consisting of five isolated pieces, each having a varying number of arms. Absence of C-shaped deposits assigns the new species to *Achlyonice* rather than to *Ellipinion*.

Within this genus there are two species, *Achlyonice monactinica* Ohshima, 1915 and *Achlyonice myriamae* Gebruk, 1997, which share some similarities with *A. longicornis*. All three have the anterior tentacles connected by a membrane and the calcareous deposits are rods (Ohshima 1915; Gebruk 1997). Most obviously, *A. longicornis* differs from *A. myriamae* and *A. monactinica* by: different tentacle numbers, both species have 12 tentacles as opposed to *A. longicornis*, which has only ten; its peculiar dominant triangular velum; the restriction of rod deposits to the tentacles, the dorsal papillae and the tube feet, which are present throughout the body wall in the other species. Furthermore, *A. myriamae* has in addition to rod deposits also tripartite deposits, which are lacking in *A. monactinica* as well as in *A. longicornis*.

Distribution. (Fig. 7) So far, this species is only known from the type locality, Atlantic Ocean, Angola Basin, 5385–5387 m.

Etymology. The name, *longicornis*, refers to the characteristic, horn-like shape of the dorsal velum.

Family Synallactidae Ludwig, 1894

Genus *Molpadiodemas* Heding, 1935

Molpadiodemas atlanticus (R. Perrier, 1898)

(Figs 9A, 10)

Pseudostichopus atlanticus R. Perrier, 1898: 1665
Molpadiodemas acaudum Heding, 1935: 78–80, pl. 6 (figs 1–2)
Molpadiodemas atlanticus. O'Loughlin & Ahearn, 2005: 153, figs 3(a–b), 4(a–d), 6(a–b) [synonymy]

Material. M 48/1-343: 1 ♀ (ZSM 20020019). M 48/1-347: 1 ♂ (ZSM 20043076).

Additional Material. 1 ♀ (ZSM 20043140), FS "Meteor", station M 3/24, Agassiz trawl 2, 42°26.8' N, 14°49.0' W to 42°40.9' N, 14°49.2' W, 5270 m, Agassiz trawl, 11 Mar, 1966, det. C.G. Ahearn (USNM), 2004.

Description. The specimens range from 76 to 100 mm in length and 24 to 54 mm in width. The body is more or less cylindrical with rounded anterior and posterior ends, of a dirty-white colour (preserved) and without encrusting foreign bodies. Mouth ventral, encompassed by 20 prominent brown tentacles, which often are retracted and thus difficult to make out. The anus is ventral in position, enclosed in an inconspicuous pygal furrow. Filiform tube feet, lacking a sucking disc, are found sparsely scattered on the ventral side (often visible as small brown spots) but could not be detected dorsally. The body wall is thick and rugose.

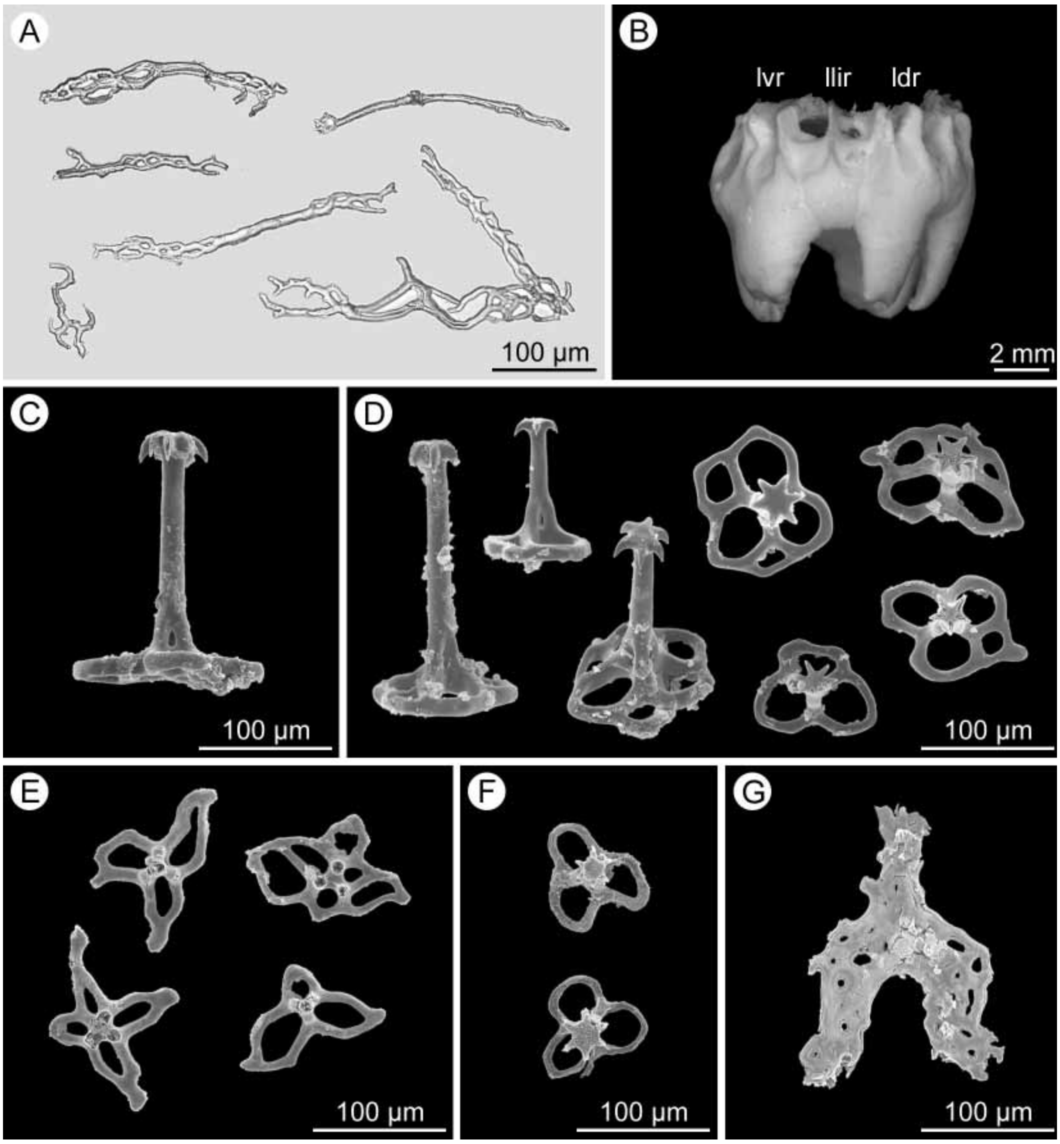

FIGURE 9. **(A)** *Molpadiodemas atlanticus* (R. Perrier, 1898). Rod-like deposits from tentacles. **(B–G)** *Molpadia liska* Pawson, 1977. **(B)** Calcareous ring, left lateral view (*ldr*— left dorso-lateral radial plate, *llir*—left lateral interradial plate, *lvr*—left ventro-lateral radial plate). **(C)** Table from body wall (JMB-01141). **(D)** Tables from body wall (JMB-01646). **(E)** Tables from tail (JMB-01141). **(F)** Tables from tail (JMB-01646). **(G)** Anal tooth (JMB-01646).

The calcareous ring is prominent. Longitudinal muscles are flat and wide. There is a single ventral polian vesicle. The gonad consists of a tuft of branching tubules on both sides of the dorsal mesentery. The intestine forms a large loop, and the respiratory trees originate with a common trunk from the right side of the cloaca.

Calcareous deposits are scarce. Isolated deposits are present in the tentacles, which are irregularly rod-like, sometimes bent, often branching and with a tendency to form an irregular network, resulting in few to several perforations (Fig. 9A). No deposits could be detected in the body wall, in the tube feet, in the gonads nor in the respiratory trees.

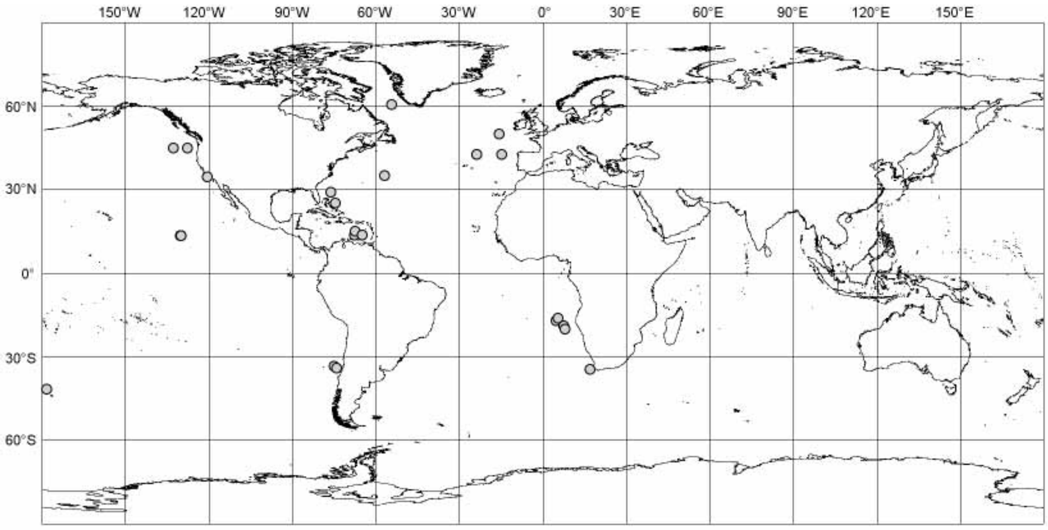

FIGURE 10. Distribution of *Molpadiodemas atlanticus* (R. Perrier, 1898).

Remarks. In an long-needed and extensive review of the pygal-furrowed Synallactidae (O'Loughlin & Ahearn 2005) all hitherto known species as well as several new species are described, and detailed information is presented, including their synonymy and distribution.

Molpadiodemas atlanticus differs from its congeners by a combination of the following characters (O'Loughlin & Ahearn 2005): body large and sac-like; even cover of tube feet, frequently inconspicuous; frequent presence of large, irregular, open mesh-like gonad ossicles. The two Angola Basin specimens are assigned to *M. atlanticus*, although they lack the characteristic calcareous deposits in the gonad. Also the third specimen investigated (see additional material), which was determined by C.G. Ahearn in 2004 as belonging to this species, lacks calcareous deposits in the gonad. According to O'Loughlin and Ahearn (2005: p. 153) the lack of calcareous deposits in tentacles or gonads is not uncommon: "…ossicles frequently abundant in tentacles and gonads, sometimes rare or absent;…". But based on the body form (large and sac-like), the inconspicuous tube feet and the overall resemblance of the Angola Basin specimens with the specimen determined by C.G. Ahearn, the author is convinced, that the specimens are conspecific.

Distribution. (Fig. 10) Northern and south-eastern Atlantic Ocean, northern and southern Pacific Ocean, 2610–5415 m (Heding 1935; IFREMER BIOCEAN; O'Loughlin & Ahearn 2005; Perrier 1902; Thandar 1999; herein).

Family Molpadiidae Müller, 1850

Genus *Molpadia* Risso, 1826

Molpadia liska Pawson, 1977
(Figs 9B–G, 11)

Molpadia liska Pawson, 1977: 115–116, figs 6 (a–g, i), 7 (a–b, d)

Material. M 48/1-333: 1 specimen (ZSM 20043068), 1 specimen (ZSM 20043069). M 48/1-349: 4 specimens (ZSM 20020025). M 48/1-351: 5 specimens (ZSM 20020028).

Description. The specimens range from 24 to 63 mm in length, and 6 to 13 mm in width (at calcareous ring). The body is approximately cylindrical, with a tapering posterior end, resulting in a very short tail (only few millimetres long). Preserved specimens are dirty-white with a tinge of pink. Fifteen retracted tentacles encompass the terminal mouth. Likewise, the anus is terminal and in each radius there are few short anal papillae.

The calcareous ring is solid, smooth and composed of five radial plates (Fig. 9B: *ldr*, *lvr*), with prominent posterior projections and five much smaller interradial plates (Fig. 9B: *llir*).

The tentacle ampullae are short. Longitudinal muscle bands are undivided. There is one tubular polian vesicle in the left ventral radius. The single stone canal is long and embedded in the dorsal mesentery and has a large oval madreporite body close to the dorsal body wall. The gonad consists of tufts of branching, tubules on both sides of the dorsal mesentery. The intestine forms a large loop (as long as body) and the respiratory trees are conspicuous.

The calcareous deposits of the body wall (Figs 9C–D) and the tail (Figs 9E–F) are exclusively tables with 3–9 holes and a large solid spire, derived from three fused pillars, with 4–6 terminal hooklets. The tables of the body wall in the current specimens on average range from 95 to 121 µm (Tab. 2) and usually have 4 or 5 holes, while the tables from the tail are smaller, on average 86 to 105 µm in diameter (Tab. 2) and have fewer holes (3 or 4). There are no phosphatic deposits, but anal teeth are present (Fig. 9G).

Remarks. The current specimens agree in all details with *Molpadia liska* as characterised by Pawson (1977): body wall and tail deposits similar, exclusively tables with solid spires composed of three fused pillars, with usually three perforations but often with more up to a maximum of eight. Table deposit diameters of the current specimens are also in accordance with the table sizes as presented by Pawson (Tab. 2). There is only one other species known to possess similar table deposits in the body wall and in the tail: *Molpadia discors* Pawson, 1977. This species differs from *Molpadia liska* by its invariable number of three holes per table, which in *Molpadia liska* may be up to eight or nine (Pawson 1977). Another closely related species, which may result in misidentifications, is *Molpadia blakei* (Théel, 1886), which with certainty is known from the northern Atlantic deep-sea (Pawson *et al*. 2001). This species differs from *M*. *liska* by the presence of fusiform rods (mean length: 256 µm) in the tail, which are perforated by large holes and have a low spire (Pawson *et al*. 2001).

TABLE 2. *Molpadia liska* Pawson, 1977. Means, standard deviations (in parentheses) and range of diameter of tables from body wall (D_{bw}, µm) and from tail (D_t, µm) compared to range of mean values as presented by Pawson (1977) for the type specimens. *n*—number of measurements.

Parameter	Specimen			Pawson (1977)
	ZSM 20020028 JMB-01144	ZSM 20020025 JMB-01141	ZSM 20043069 JMB-01233	
	(n=50)	(n=50)	(n=50)	
D_{bw}, µm	120.5 (±16.6) 75–144	120.8 (±18.4) 83–160	94.6 (±14.0) 66–129	80 to 168
	(n=50)	(n=50)	(n=41)	
D_t, µm	81.6 (±20.1) 46–136	103.5 (±27.5) 67–165	85.3 (±20.6) 49–132	75 to 144

This is the first record of this species for the Atlantic Ocean, and the known depth range is considerably increased from 4740 to more than 5420 m.

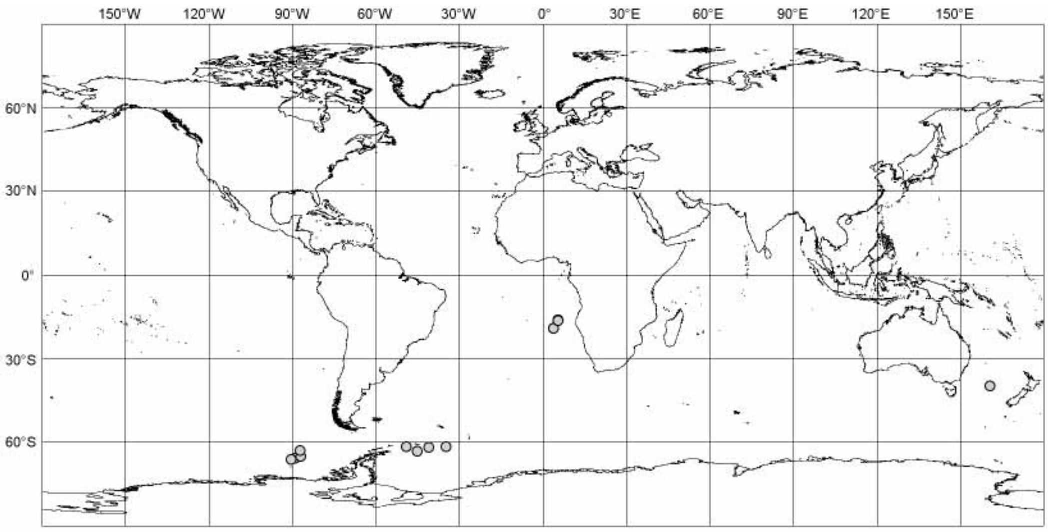

FIGURE 11. Distribution of *Molpadia liska* Pawson, 1977.

Distribution. (Fig. 11) South-eastern Atlantic Ocean, south-western Pacific Ocean and Southern Ocean, 3111–5426 m (Pawson 1977; herein).

Family Synaptidae Burmeister, 1837

Genus *Protankyra* Østergren, 1898

Protankyra brychia (Verrill, 1885)
(Fig. 12)

Synapta brychia Verrill, 1885: 539
Synapta abyssicola Théel, 1886a: 14–15, pl. 1 (fig. 11)
Synapta abyssicola var. *pacifica* Ludwig, 1894: 174–178, pl. 18 (figs 13–19)
Protankyra brychia. Pawson *et al*., 2003: 160–171, figs 1–3, 8–11 [synonymy]

Material. M 48/1-334: 1 specimen, 2 anterior fragments, 2 posterior fragments (ZSM 20043077). M 48/1-337: 1 posterior fragment (ZSM 20043079). M 48/1-343: 1 specimen, 2 posterior fragments (ZSM 20043070). M 48/1-347: 2 specimens, 1 anterior fragment, 3 posterior fragments (ZSM 20020023), 2 anterior fragments, 1 posterior fragment (ZSM 20043078). M 48/1-349: 4 specimens, 2 median fragments, 7 posterior fragments (ZSM 20020021). M 48/1-351: 4 specimens, 8 posterior fragments (ZSM 20020027), 3 anterior fragments, 1 median fragment (ZSM 20043080).

Additional Material. 1 specimen (ZSM 20043139), FS "Polarstern", ANDEEP III, station PS 67/016-5, 41°07.5' S, 9°56.3' E, 4723 m, giant box corer, 25 Jan, 2005. 6 specimens, 2 anterior fragments, 1 posterior fragment (ZSM 20043138), FS "Polarstern", ANDEEP III, station PS 67/016-11, 41°07.7' S, 9°56.3' E, 4727 m to 41°07.4' S, 9°54.8' E, 4694 m, Agassiz trawl, 26 Jan, 2005.

Remarks. This species has been excellently reviewed by Pawson *et al*. (2003) including its synonymy, morphology and distribution. A quite characteristic feature of this species are the large calcareous deposits (after Pawson *et al*. 2003): anchors usually less than 700 µm long, but sometimes up to 1000 µm, with branched stock and flukes with about six teeth; anchor plates up to 700 µm long, with 50–70 dentate holes. Pawson and his co-authors are convinced, that the giant pelagic larva, the so called *Auricularia nudibranchiata* Chun, 1896 is the larva of *P. brychia*. The specimens reported herein considerably enlarge the known distributional area of the species in the Atlantic Ocean (from about 16°S to 41°S), as well as the depth-range (from about 5000 m to more than 5400 m).

Distribution. (Fig. 12) This species probably has a cosmopolitan distribution, Atlantic Ocean, eastern and western Pacific Ocean, 869–5426 m (H.L. Clark 1908, 1920, 1924; Deichmann 1940; Gage *et al*. 1985; Harvey *et al*. 1988; Hérouard 1923; IFREMER BIOCEAN; Ludwig & Heding 1935; Madsen 1953; Pawson *et al*. 2003; Perrier 1902; Sibuet 1977; Théel 1886a; herein).

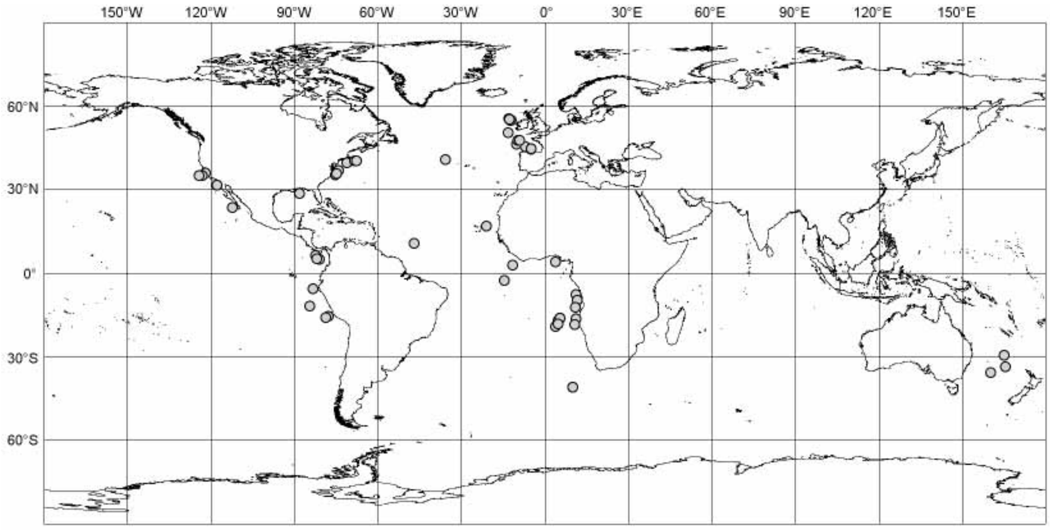

FIGURE 12. Distribution of *Protankyra brychia* (Verrill, 1885).

Family Myriotrochidae Théel, 1877

Genus *Siniotrochus* Pawson, 1971

Siniotrochus myriodontus Gage & Billett, 1986
(Figs 13A, 14)

Siniotrochus myriodontus Gage & Billett, 1986: 266–272, figs 28(C–E), 29–31; Bohn, 2005: 232–234, figs 1(A–B), 2

Material. M 48/1-347: 1 posterior fragment (ZSM 20020016). M 48/1-351: 2 posterior fragments (ZSM 20020015).

Remarks. Gage and Billett (1986) provide an excellent description of this species, including detailed information on a variety of taxonomically important wheel parameters. Given that the current specimens have already been treated in more detail (Bohn 2005) the species is only shortly outlined: body about cylindrical, up to 31 mm long and 7 mm wide; tentacles 12, with four pairs of lateral digits; calcareous ring with 5 radial and 5 interradial plates; body wall with single layer of wheel deposits of the so-called siniotrochid type (Fig. 13A); wheel diameter 414 µm (284–560 µm); hub about half the diameter of the wheel, perforated by several holes; spokes 17 (12–25); inward-pointing teeth 42 (30–67); outward-pointing primary teeth 18 (11–31); outward-pointing secondary teeth 6 (0–29) (*arrowheads* in Fig. 13A); simple rod deposits present in tentacles and around anus.

Siniotrochus myriodontus closely resembles the north-western Atlantic Ocean *S. phoxus* Pawson, 1971 from which it differs by the presence of outward-pointing secondary teeth on the wheels.

Distribution. (Fig. 14) North-eastern Atlantic Ocean (Porcupine Seabight) and south-eastern Atlantic Ocean, 3490–5389 m (Bohn 2005; Gage & Billett 1986).

TABLE 3. List of deeper bathyal and abyssal crinoids and holothurians of the Angola Basin and its vicinity, collected by the Valdivia expedition (Ludwig & Heding 1935; Heding 1940), the Java—South Africa expedition (Gislén 1933; Hansen 1975), the Galathea expedition (Hansen 1975), the Walda and Walvis cruises (IFREMER BIOCEAN) and the DIVA-1 expedition. *1*—as *Peniagone ferruginea* Grieg, 1921; *2*—as *Pseudostichopus atlanticus* R. Perrier, 1898; *3—Pseudostichopus depressus* Hérouard, 1902; *4*—as *Pseudostichopus globigerinae* Hérouard, 1923; *5*—as *Pseudostichopus villosus* Théel, 1886; *6*—determination doubtful, may be the closely related *M. liska* Pawson, 1977; *7*—as *Protankyra abyssicola* (Théel, 1886).

Species	Depth (m)	Source
Bathycrinus aldrichianus Wyville Thomson, 1876	5415	herein
Porphyrocrinus incrassatus (Gislén, 1933)	2400–2780	Gislén 1933
Deima validum validum Théel, 1879	4088–5426	IFREMER BIOCEAN; herein
Psychropotes depressa (Théel, 1882)	2270	Hansen 1975
Psychropotes longicauda Théel, 1882	2475–3244	IFREMER BIOCEAN
Psychropotes semperiana Théel, 1882	3244–5126	IFREMER BIOCEAN; herein
Peniagone diaphana (Théel, 1882)	3034	IFREMER BIOCEAN
Peniagone purpurea (Théel, 1882)	4660–5415	[1]IFREMER BIOCEAN; herein
Achlyonice ecalcarea Théel, 1879	2400–2780	Hansen 1975
Achlyonice longicornis spec. nov.	5385–5387	herein
Molpadiodemas atlanticus (R. Perrier, 1898)	4820–5415	[2]IFREMER BIOCEAN; herein
Molpadiodemas depressus (Hérouard, 1902)	3034	[3]IFREMER BIOCEAN
Molpadiodemas involutus (Sluiter, 1901)	4613	[4]IFREMER BIOCEAN
Molpadiodemas villosus (Théel, 1886)	4550–4660	[5]IFREMER BIOCEAN
Mesothuria candelabra Hérouard, 1923	5220	IFREMER BIOCEAN
Paelopatides grisea R. Perrier, 1898	3035	Heding 1940
Paroriza pallens (Kœhler, 1896)	5124	IFREMER BIOCEAN
Molpadia musculus Risso, 1826	1756–4335	IFREMER BIOCEAN
[6]*Molpadia blakei* (Théel, 1886)	4335	IFREMER BIOCEAN
Molpadia liska Pawson, 1977	5385–5426	herein
Protankyra brychia (Verrill, 1885)	2225–5426	[7]Ludwig & Heding 1935; [7]IFREMER BIOCEAN; herein
Siniotrochus myriodontus Gage & Billett, 1986	5385–5389	herein
Neolepidotrochus parvidiscus angolensis Bohn, 2005	5395	herein

Genus *Neolepidotrochus* Bohn, 2005

Neolepidotrochus parvidiscus angolensis Bohn, 2005
(Figs 13B–C, 14)

Neolepidotrochus parvidiscus angolensis Bohn, 2005: 234–237, figs 1(C–G), 3, 4

Material. M 48/1-340: Holotype (ZSM 20020017).

Remarks. This subspecies has been recently described in more detail (Bohn 2005) and is characterised by: body wall and tentacle bases with two types of wheel deposits, neolepidotrochid type wheels (Fig. 13B) and myriotrochid type wheels (Fig. 13C). Neolepidotrochid type wheels with variable number (up to 16) of outward-pointing secondary teeth (Fig. 12B: *arrowheads*), not present in all wheels, but in the majority; edge of rim between two outward-pointing primary teeth roughly straight; neolepidotrochid type wheels from anterior body smaller (mean diameter: 111 µm, range: 95–129 µm), than wheels from posterior body (mean diameter: 140 µm, range: 127–158 µm) and with higher ratio of hub diameter to wheel diameter (mean: 40 %, range: 30–47 %) compared to wheels from posterior body (mean: 29 %, range: 22–36 %). Myriotrochid type wheels have a diameter of 130 µm (75–166 µm), ratio of hub diameter to wheel diameter 21 % (18–26 %), spokes 10 (8–14).

Distribution. (Fig. 14) Angola Basin in the south-eastern Atlantic Ocean, 5395 m.

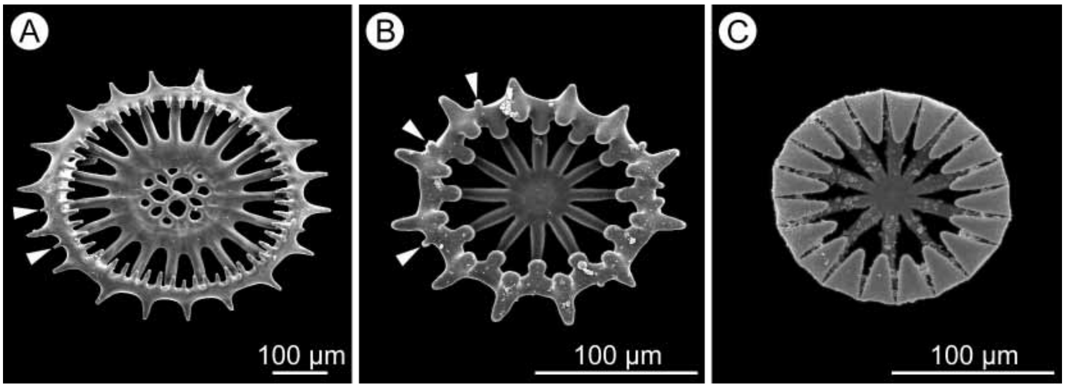

FIGURE 13. (A) *Siniotrochus myriodontus* Gage & Billett, 1986. Wheel deposit of body wall. **(B–C)** *Neolepidotrochus parvidiscus angolensis* Bohn, 2005. Wheel deposits of body wall. **(B)** Neolepidotrochid type wheel. **(C)** Myriotrochid type wheel. *Arrowheads* – outward-pointing secondary teeth.

TABLE 4. Schematic distribution of Crinoidea and Holothuroidea collected in the Angola Basin, that are known from at least two localities. *N*—North; *S*—South.

Species	Atlantic Ocean		Indian Ocean		Pacific Ocean		Southern Ocean
	N	S	N	S	N	S	
Bathycrinus aldrichianus Wyville Thomson, 1876	+	+					
Porphyrocrinus incrassatus (Gislén, 1933)	+	+					
Deima validum validum Théel, 1879	+	+	+	+	+	+	
Psychropotes depressa (Théel, 1882)	+	+			+	+	
Psychropotes longicauda Théel, 1882	+	+		+	+	+	+
Psychropotes semperiana Théel, 1882	+	+	+	+			
Peniagone diaphana (Théel, 1882)	+	+		+	+	+	
Peniagone purpurea (Théel, 1882)	+	+		+	+		+
Achlyonice ecalcarea Théel, 1879	+	+		+	+	+	
Molpadiodemas atlanticus (R. Perrier, 1898)	+	+			+	+	
Molpadiodemas depressus (Hérouard, 1902)	+	+					
Molpadiodemas involutus (Sluiter, 1901)	+	+			+	+	+
Molpadiodemas villosus (Théel, 1886)	+	+		+	+	+	+
Mesothuria candelabra Hérouard, 1923	+	+					
Paelopatides grisea R. Perrier, 1898	+	+					
Paroriza pallens (Kœhler, 1896)	+	+					
Molpadia musculus Risso, 1826	+	+	+	+	+	+	+
Molpadia blakei (Théel, 1886)	+	+					
Molpadia liska Pawson, 1977		+				+	+
Protankyra brychia (Verrill, 1885)	+	+			+	+	
Siniotrochus myriodontus Gage & Billett, 1986	+	+					

Discussion

The sampling activities of the DIVA-1 expedition focussed on the central abyssal plain of the Angola Basin. Along a transect of about 700 km, six areas were sampled, at each deploying the same variety of gears. These areas were all of a comparable depth, ranging between 5120 and 5450 m. Altogether one crinoid and nine holothurian species have been collected at 12 stations (Tab. 1), mainly with the Agassiz trawl (10 stations), and to a lesser extent also with the epibenthic sledge (two stations). Most of the species were only present at one or two stations and usually as one or two specimens. *Protankyra brychia* (Verrill, 1885) is the only species, that has been collected regularly (in 6 out of 12 stations) and also in higher specimen numbers (up to 7).

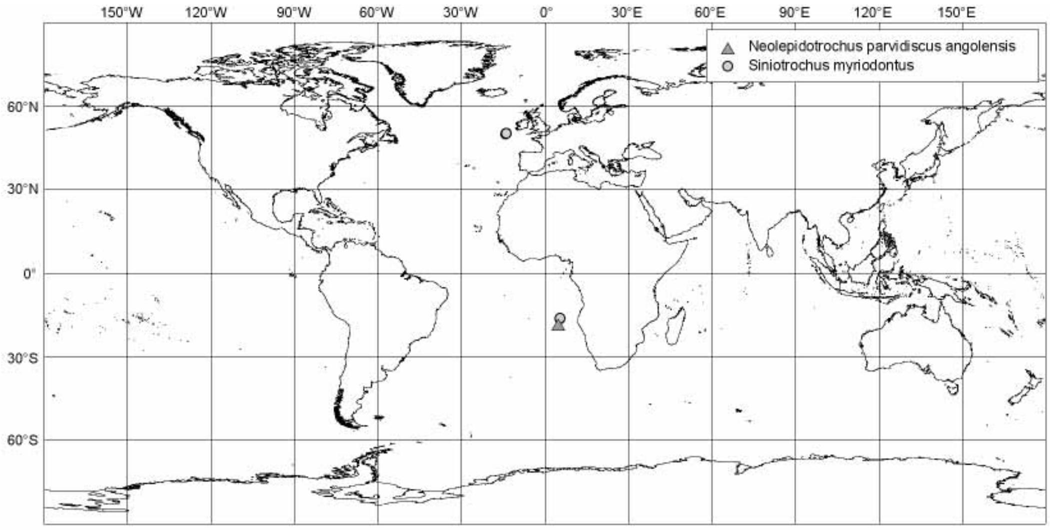

FIGURE 14. Distribution of *Siniotrochus myriodontus* Gage & Billett, 1986 and *Neolepidotrochus parvidiscus angolensis* Bohn, 2005.

Five species present in the current material are new records for the Angola Basin (Tab. 3; *Bathycrinus aldrichianus* Wyville Thomson, 1876; *Achlyonice longicornis* **spec. nov.**; *Molpadia liska* Pawson, 1977; *Siniotrochus myriodontus* Gage & Billett, 1986; *Neolepidotrochus parvidiscus angolensis* Bohn, 2005), while the five others have been found previously.

To compile a list of the known crinoid and holothurian species of the Angola Basin, first of all, the area of interested has to be circumscribed. In the east, the Angola Basin is delimited by the coast of Africa, in the south by the Walvis Ridge and in the west by the Mid-Atlantic Ridge, but a clear delimitation towards the Guinea Basin in the north is missing (see Fig. 1). So far, only few expeditions have sampled the deep-sea in this area. The sampling activities of the Valdivia and the Galathea expeditions and to a lesser extent also of the Walda cruise were limited to bathyal and abyssal areas close to the African west coast (Fig. 1). The Walvis cruise investigated bathyal and abyssal depths in the southern Angola Basin close to the Walvis Ridge, and Dr Mortensen's Java—South Africa expedition deployed one deep-sea dredge of interest off St. Helena. Finally, the DIVA-1 expedition focused on sampling the central Angola Basin.

Altogether 2 stalked crinoid species of the suborder Bourgueticrinina (Tab. 3) and 21 holothurian species (Tab. 3), belonging to the Elasipodida (8 species), the Synallactidae (7 species), the Molpadiidae (3 species) and the Apodida (3 species) have been recorded so far. These came from 24 stations, covering a depth range from 1700 m close to the African coast, to more than 5000 m in the central abyssal Angola Basin (Fig. 1, Tab. 3).

When discussing zoogeographical relationships of different deep-sea regions, it always has to be kept in mind, that current knowledge of species distribution is very limited, considering the restricted number of deep-sea samples taken so far, as well as disparate sampling activities in different geographical regions (e.g. North Atlantic compared to the South Atlantic or central Indian Ocean; see Hansen 1975: figs 108 and 109). Thus "endemism" may just be the result of these causes.

Except for the two holothurians so far restricted to the Angola Basin (Achlyonice longicornis spec. nov.; *Neolepidotrochus parvidiscus angolensis* Bohn, 2005), most of the crinoid and holothurian species of the Angola Basin have large distributional areas (Tab. 4). A close relationship to the crinoid and holothurian fauna of the northern Atlantic Basins is evident, as all species known so far, except for *Molpadia liska* Pawson, 1977 also have been found there. Currently, eight of these are restricted to the Atlantic Ocean, while all others are known from other Oceans as well. The influence of a "southern" (Subantarctic) deep-sea fauna, on the other hand seems to be negligible. Though several of the recorded species are also known from the Southern Ocean (altogether six species) only one of them might be called a "southern" species: *Molpadia liska*, which so far is restricted to the Southern Ocean, the southern Atlantic and the southern Pacific (Fig. 11), while the others are widely distributed in the Atlantic, the Indian and the Pacific Ocean.

Concerning the deep-sea Asteroidea of the Angola, the Guinea and the Cape Basins taken in the course of the Walda expedition, Sibuet (1975) found a similar situation: out of 21 Asteroidea only four species (two of them new to science) are restricted to the South Atlantic, while all others are also known from the North Atlantic Ocean. Furthermore, there seems to be no influence of the Subantarctic abyssal asteroid fauna on the asteroid fauna of the Cape Basin or the Angola Basin, which prompts Sibuet (1975) to doubt the Walvis Ridge being an effective barrier for Asteroidea, separating the Angola and the Cape Basin.

Remarkable is the almost complete absence of small (up to few cm, usually smaller) in- or epifaunal holothurians of the family Myriotrochidae that are quite abundant in other deep-sea basins. These tiny and fragile organisms are usually caught with an epibenthic sledge or a box corer. A rich variety of species has been described by Gage & Billett (1986) from the Rockall Trough area (NE Atlantic Ocean), and recent expeditions (ANDEEP I and II) to the Weddell Sea, the Scotia Sea and the Drake Passage proved the presence of several myriotrochid species in the Antarctic and subantarctic deep-sea (Gebruk *et al*. 2003). The DIVA-1 expedition only yielded one small myriotrochid specimen (*Neolepidotrochus parvidiscus angolensis* Bohn, 2005), though almost the same gears were used in the DIVA-1 and the ANDEEP expeditions.

Concluding, the crinoid and holothurian fauna of the Angola Basin is very similar to that of deep-sea basins in the North Atlantic Ocean, with a high percentage of species with a much wider distributional range including the Southern, the Indian and Pacific Ocean.

Acknowledgements

This contribution to the DIVA-1 project was supported by the Deutsche Forschungsgemeinschaft with grant RU 895/1-1. I am very grateful to the crew of FS "Meteor" and all participants of the DIVA-1 expedition. For providing material, I am indebted to Dr. Michael Türkay and his team from the Senckenberg Museum, as well as to Prof. Dr. Johann Wolfgang Wägele (Zoologisches Forschungsmuseum Alexander Koenig in Bonn) and Nils Brenke from the Ruhr-University of Bochum. I am most grateful to Dr. Olga Schmidt for her help with Russian texts. Finally, I want to thank Horst Bohn and Michael Schrödl for proof reading the manuscript and the editor Dr Alan Dartnall and two referees for valuable corrections and suggestions that considerably improved the text.

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